NORTH CAROLINA'S ENERGY FUTURE: ELECTRICITY, WATER, AND TRANSPORTATION EFFICIENCY

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Disclaimer: *While several organizations, including Summit Blue Consulting, ICF International, Synapse Energy Economics, and Potomac Resources, Inc., assisted ACEEE in the completion of this analysis and report, the ultimate viewpoints and recommendations expressed herein are those of ACEEE.*

Contents

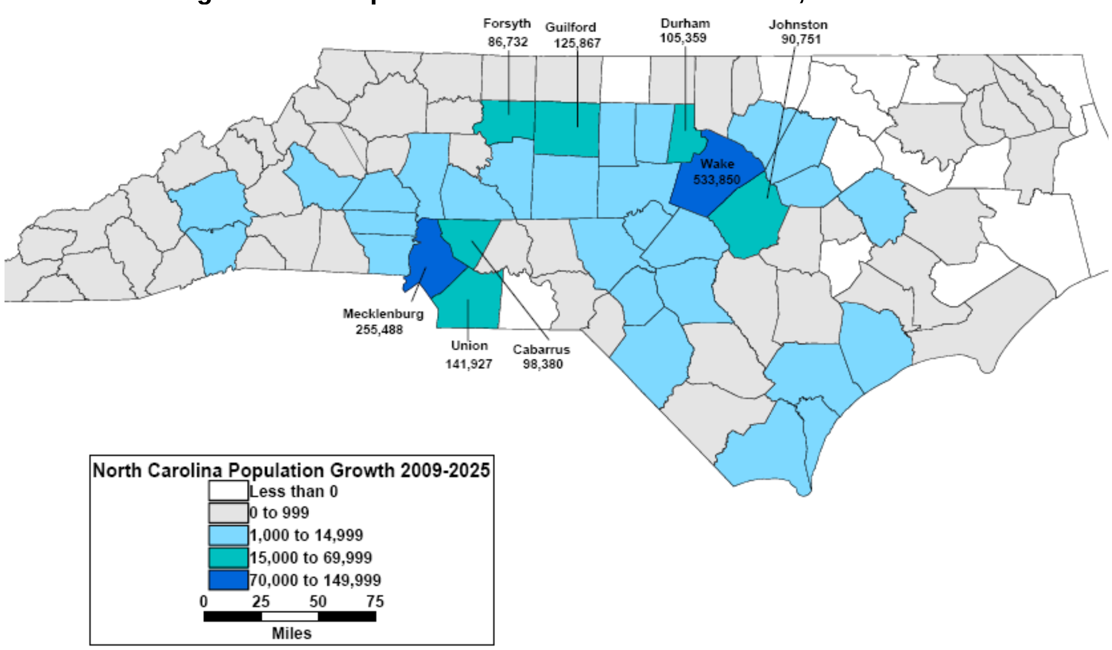
EXECUTIVE SUMMARY

North Carolina stands at a turning point in its energy future. As leadership at the national level increasingly focuses on the benefits of energy efficiency to create jobs and spur economic growth, North Carolina is poised to embrace energy efficiency and position the state as a national leader in the expansion of clean energy development and deployment. North Carolina stands in the middle of the pack (26th out of the 50 states) in ACEEE's *The 2009 State Energy Efficiency Scorecard*, which ranks states on a broad set of energy efficiency policies. While the state has already taken some steps toward its clean energy future and has a strong and growing base of clean energy businesses, our analysis finds that significant potential for energy efficiency as a resource will remain untapped over the next 15 years if the state continues on a business-as-usual track.

This report presents a suite of policies and programs that have the potential to meet nearly a quarter of the state's electricity needs and about 11% of transportation fuel by 2025. And by making these significant investments in energy efficiency technologies and practices, the state stands to gain 38,000 net jobs in 2025 and save consumers a net $3.6 billion cumulative by 2025 in lower energy and water bills.

As one of the fastest growing states in the nation, North Carolina can especially take advantage of the benefits of energy efficiency through high-efficiency new buildings and land-use planning for livable communities—both are strategies that "lock in" energy savings for years to come. Improving the efficiency of existing infrastructure becomes costly and difficult, making efficient new construction practices and transportation planning vital to the state's economy and long-term energy planning. As the state rebounds from the economic downturn, growth will be highly concentrated in twenty-three counties in five major urban areas, as shown in Figure ES-1, which suggests that some policies can be targeted to high growth areas. And while some policies can have a geographic approach, energy efficiency policies and programs are statewide opportunities to help homeowners, business owners, and manufacturers benefit from energy efficiency through lower energy bills and job creation.

Figure ES-1. Population Growth in North Carolina, 2009-2025



Electricity, Water, and Transportation Policy Options

North Carolina has already taken several steps to improve energy efficiency for households, businesses, and industry. This analysis attempts to both capture existing efficiency efforts and model a suite of new or expanded electricity, water, and transportation efficiency policy options based on successful models implemented in other states plus in-depth consultation with stakeholders in North Carolina. The Energy Efficiency Resource Standard (EERS) represents the core of these policies, providing a foundation upon which others may build to achieve the greatest savings. Our analysis includes a medium case scenario and a high case scenario, which both include policies listed in Table ES-2, but differ in penetration rates of programs and levels of customer incentives. We estimate that these policies have the potential to meet 24% of North Carolina's electricity needs and 11% of oil needs for transportation by 2025 in the medium case scenario, while federal vehicle efficiency standards will contribute additional savings by 2025.

Table ES-1. Summary of Electricity, Water, and Transportation Efficiency Policies

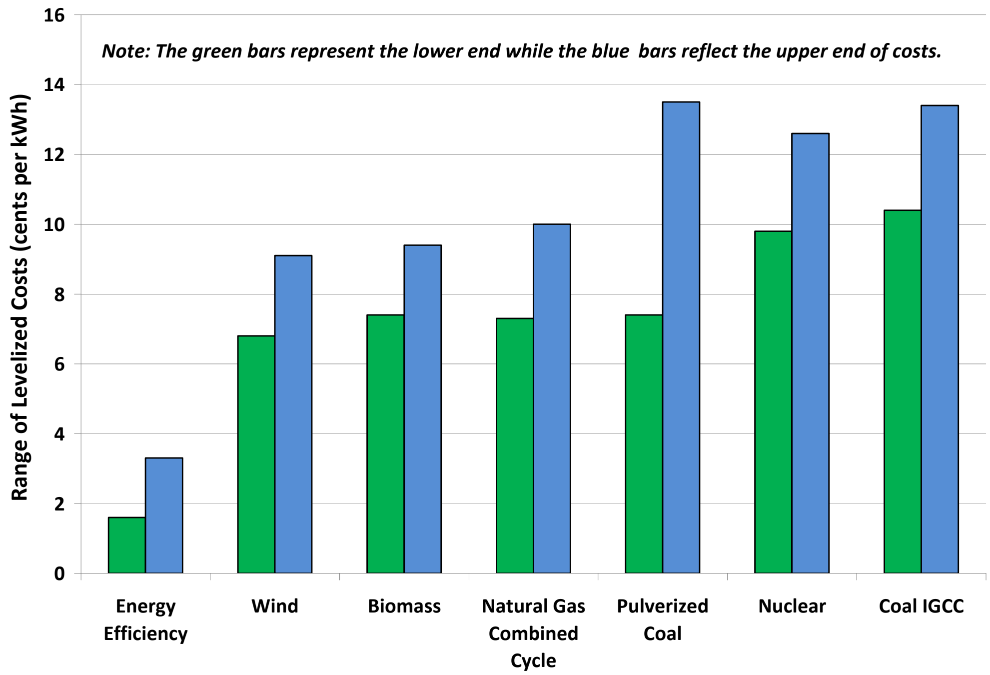
Electricity	Water	Transportation
1 Energy Efficiency Resource Standard 2 Manufacturing Initiative 3 Rural and Agricultural Initiative 4 Building Energy Codes and Enforcement 5 Advanced New Building Initiative 6 Behavioral Initiative 7 Public Facilities Performance Contracting 8 Manufactured Homes Initiative 9 Combined Heat and Power 10 Expanded Demand Response Programs 11 Consumer Financing	1 Plumbing Efficiency Standards 2 Replacement of Inefficient Plumbing in Pre-1995 Homes 3 Utility System Water Loss (Leakage) Reduction 4 Water Efficient Landscape Irrigation 5 Conservation Pricing of Water and Sewer Service	1 Heavy-Duty Vehicle Efficiency Incentive Package 2 Freight Intermodal Investments 3 Pay-As-You-Drive Insurance (PAYD) 4 Truck Stop Electrification 5 Land Use Planning Reforms 6 Vehicle Electrification

Electricity

Cost-effective energy efficiency offers a way to minimize energy price increases, help consumers lower energy bills, and create new jobs. A series of analyses confirms that at the national level, energy efficiency investments for electricity usage will cost consumers and businesses at least half the cost of conventional electricity generation supplies (Friedrich et al. 2009; Laitner 2009; AEF 2010). Figure ES-2, for example, shows a significant cost difference between energy efficiency improvements and almost any new electricity generation supply.

Several energy efficiency market potential studies have been done for North Carolina over the past few years to assess the state's cost-effective potential for energy efficiency. We conducted a meta-analysis of these studies done for the state, as well as regional and national assessments. Overall, the findings suggest that the state has the potential for 1.4 to 2% electricity savings per year of achievable, cost-effective energy efficiency resources, or 22 to 32% total savings by 2025. The electricity policies and programs included in our analysis and shown in Table ES-1 are designed to ramp-up from 2010 to 2025 to capture these levels of cost-effective energy efficiency savings.

Figure ES-2. Levelized Utility Electricity Resource Cost in 2008



Sources: Lazard (2008), except for (a): Energy efficiency program costs are the estimates of levelized costs of saved energy (CSE) for program administrator costs (PAC) as described in Friedrich et al. (2009).

Table ES-2. Summary of Electricity Savings by Policy or Program in the Medium Case

	Total Annual Electricity Savings by Policy (GWh)	**2015**	**2025**	**Total Savings in 2025** (%)**
1	Energy Efficiency Resource Standard (EERS)*	3,614	22,311	12.9%
	Proven Programs: Residential & Commercial	*3,007*	*18,803*	*11.8%*
2	*Manufacturing Initiative*	*439*	*1,789*	*1.1%*
3	*Rural & Agricultural Initiative*	*61*	*150*	*0.1%*
4	Building Energy Codes	1,341	4,496	2.8%
5	Advanced Energy-Efficient Buildings Initiative	284	1,828	1.1%
6	Behavioral Initiative	107	1,570	1.0%
7	Public Facilities Performance Contracting	733	2,835	1.8%
8	Manufactured Homes Initiative	120	1,545	1.0%
9	Combined Heat & Power (CHP)	334	1,455	0.9%
	New Federal Appliance Efficiency Standards	942	3,184	2.0%
	Electricity Savings from Water Efficiency Policies	42	176	0.1%
	Total Savings	**7,517**	**37,830**	**24%**
	Remaining Electricity Needs (GWh)	127,894	121,745	

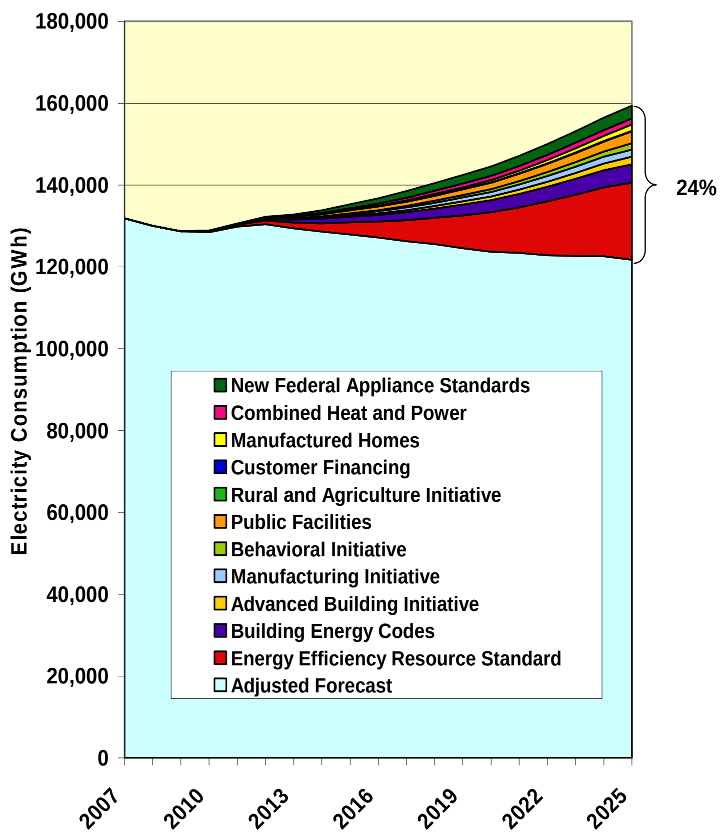
Notes: * The Energy Efficiency Resource Standard will allow flexibility in the types of programs that are used to achieve the energy savings targets. In this scenario, we allocate savings from proven residential & commercial programs, and discrete manufacturing and rural & agricultural initiatives, as described below.
** We present total savings in 2025 as a percentage of forecasted electricity sales in 2025 in the reference case.

Policy Analysis

Table ES-2 and Figure ES-3 show the contribution of the individual policies and utility programs we have recommended in the medium case scenario. Our suite of energy efficiency policies will contribute savings of 37,830 GWh, or 24% of North Carolina's electricity needs, by 2025. In the high case scenario, a similar suite of policies with more aggressive funding levels and penetration rates achieves 32% electricity savings by 2025.

Our analysis also finds that a suite of demand response (DR) programs, which focus on shifting energy usage from peak periods to off-peak periods and reducing electricity needs during periods with the highest demand, is a critical component of reducing peak demand in North Carolina. We estimate that by 2025 the combined effects of energy efficiency and demand response can reduce peak demand by 31% in the medium case compared to business as usual.

Figure ES-3. Share of Electricity Needs Met from Energy Efficiency Policies in Medium Case



Water

Policy Analysis

To assist North Carolina's public water supply and wastewater treatment systems to meet the growing demand for water and wastewater service cost-effectively, we suggest a suite of water efficiency policies as presented above in Table ES-1.[1]

In addition, we assume that electric utility efficiency programs will direct a portion of their customer incentives to the purchase of energy- and water-efficient clothes washers, and have estimated the water savings that will result. We further estimate the water savings that may be achieved by new, pending federal efficiency standards for clothes washers. We also estimate the electricity savings that result from each water efficiency measure, both at the customers' location and at water and wastewater utilities that pump and treat less water as a result of these policies. As shown in Table ES-3, we estimate that the suggested water policies in the medium case can reduce water consumption by 76 million gallons per day in 2025 and also save 176 GWh of electricity consumption. To put these savings in perspective, the water savings under the medium and high case for 2025 equates to about 8% and 10%, respectively, of the total water withdrawals of 921 mgd reported for North Carolina's public water suppliers in 2005.

[1] Water savings from conservation pricing were not quantified, but we recommend its inclusion in state water policy in order to address current rate structures that may promote excessive water consumption.

Table ES-3. Summary of Water and Electricity Savings by Water Efficiency Policy

Annual Water Savings by Policy (mgd)	Medium Case		High Case	
	2015	2025	2015	2025
Statewide Plumbing Efficiency Standards	4.1	15.0	4.1	15.0
Inefficient Plumbing Replacement	3.8	8.8	5.8	16.8
Utility System Water Loss Reduction	0.7	7.0	1.2	12.5
Water Efficient Landscape Irrigation	4.6	13.2	6.3	18.3
Water Conserving Rate Structures	—	—	—	—
Electric Utility Clothes Washer Incentives	1.4	4.2	1.9	4.9
New Federal Clothes Washer Standards	1.3	27.9	1.3	27.9
Total Estimated Water Savings (mgd)	**15.9**	**76.1**	**20.6**	**95.4**
Annual Electricity Savings (GWh)				
On-Site Electricity Savings—Statewide Plumbing Efficiency Standards	25.1	94.8	25.1	94.8
Offsite Electricity Savings—All Policies	16.5	81.3	21.1	99.6
Total Electricity Savings from Water Efficiency	**41.6**	**176.1**	**46.2**	**194.4**

Notes
1. Recommended, but potential water savings not quantified.
2. Clothes washer water savings shown here; clothes washer energy savings are included in Utility Program electricity savings.
3. Indoor water use reductions yield off-site electricity savings of 3,239 KWh/mg; outdoor water use reductions yield off-site electricity savings of 2061 KWh/mg.

Efficiency Impacts on Power Plant Water Use

Our analysis also makes a first-order estimate of the impact that successful energy efficiency measures would have on the use of cooling water by thermoelectric power plants in North Carolina. Power plant cooling is the largest off-stream use of water in North Carolina, by far. The operations of base load power plants will be largely unaffected by energy efficiency programs, but electricity savings will result in reduced generating hours at load-following plants. We estimate that energy efficiency policies under the medium case could reduce water withdrawals by nearly 600 million gallons per day (mgd) in 2015 and over 3,000 mgd in 2025. Reductions are likely to be larger than these averages in summer months and lower than these averages in winter months. Reductions in total withdrawals could be particularly notable in the Catawba River Basin, where reductions of 140 mgd in 2015 and 700 mgd in 2025 may result from implementation of the medium case efficiency measures described in this report.

Energy savings will also reduce consumption of water by power plants, which also carries important implications for water resource management. Given the distribution of the principal load-following thermoelectric plants in the state, we estimate that the bulk of these energy savings (80%) can be attributed by river basin to power plants. We have not assigned dollar values to these savings, but suggest that improvements in stream flows and attendant reliability of water supplies for drinking water, fish and wildlife, and power generation itself are likely to result.

Transportation

North Carolina's gasoline and diesel fuel consumption has grown rapidly in recent decades. In 2007 the transportation sector consumed 766,904 billion Btus of energy, approximately 28% of total energy use in the state and 2.6% of total energy consumed by the U.S. transportation sector.

North Carolina's ability to slow such unsustainable fuel use lies in addressing not only vehicle fuel efficiency but also the overall efficiency of the transportation system. The six transportation efficiency policies outlined in this report take advantage of the savings potential for both diesel and gasoline fuels. However, the varying demographic make-up of North Carolina necessitates tailored transportation policy packages based on population and accessibility factors. Policies applicable to metropolitan areas may not be suitable for the swathes of the state consisting of highly rural communities. As a result, a number of our policies are focused on the primary metropolitan regions in the state.

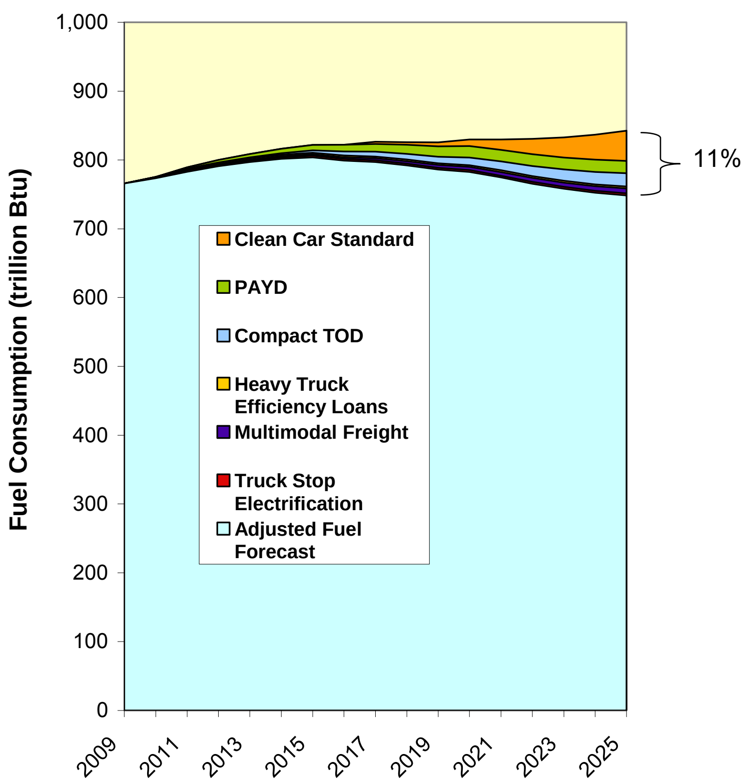
Table ES-4. Summary of Transportation Savings by Policy or Program in the Medium Case

	Cumulative Transportation Savings by Policy (thousand barrels)	2015	2020	2025	Savings in 2025 (%)
1	Clean Car Standard	0	1,814	8,417	6.7%
2	Pay-As-You-Drive Insurance	1,567	3,228	3,412	2.7%
3	Transit Expansion / Concentration of Urban Development	609	2,140	3,693	2.9%
	Total Gasoline Savings	**2,217**	**7,051**	**14,954**	**11.9%**
5	Truck Stop Electrification	486	545	595	1.9%
6	Heavy Truck Efficiency Package	396	444	485	1.5%
7	Freight Intermodal Investments	366	790	1,278	4.0%
	Total Diesel Savings	**1,229**	**1,744**	**2,307**	**7.2%**

The total combined (diesel and gasoline) fuel savings are estimated to be approximately 10.8% by 2025 under the medium case scenario.

In the high case, transportation efficiency policies and programs have the potential to reduce energy consumption by 15.7% by 2025.

Figure ES-5. Share of Fuel Needs Met from Energy Efficiency Policies in the Medium Case



Impacts on Employment and the Economy from Energy, Water, and Transportation Efficiency Policies

While energy savings from energy and water efficiency policies and programs savings will require some public and customer investments, by 2025 they can save consumers a net cumulative $3.6 billion on energy and water bills. These savings are the result of two effects. First, participants in energy and water efficiency programs will install efficiency measures, such as more efficient appliances or heating equipment, therefore lowering their electricity and water consumption and electric and water bills. In addition, because of the current volatility in energy prices, efficiency strategies have the added benefit of improving the balance of demand and supply in energy markets, thereby stabilizing regional electricity prices for the future.

Investments in efficiency policies and programs can also help create new, high-quality clean energy jobs in North Carolina while increasing both wages and GSP. Our analysis shows that energy efficiency investments can create 38,000 new, local jobs in North Carolina by 2025 (see Table ES-5), including well-paying trade and professional jobs needed to design, install, and operate energy efficiency measures. These new jobs, including both direct and indirect employment effects, would be equivalent to about 300 new manufacturing facilities locating to the state.

Table ES-5. Economic Impact of Energy Efficiency Investments in North Carolina

Macroeconomic Impacts	2015	2020	2025
Net Jobs (Actual)	5,077	24,003	38,129
Cumulative Net Energy-Water Bill Savings (Million $2007)	$12	$270	$3,640
Wages (Million $2007)	$119	$832	$1,252
GSP (Million $2007)	-$70	$554	$589

Conclusions

North Carolina is poised to take the next steps toward planning its energy future. While all of the options for the state's energy future bear costs, this analysis suggests that making greater and sustained investments in cost-effective energy efficiency as a demand-side resource will create positive returns to citizens and businesses in the state. Efficiency is a win-win strategy to meet the state's growing electricity, water, and transportation needs while creating a net benefit to the economy in lower energy bills and net job creation.

While North Carolina has already begun to plan and implement energy efficiency programs and policies, significant potential will remain untapped on the state's current path. Strong leadership and sustained investments to energy efficiency in North Carolina, however, can position the state as a national leader in the advancement of clean energy technology. And as energy efficiency earns greater attention at the national policy level, North Carolina is uniquely positioned as a hub for clean energy innovation to make the most of both local and national investments. These investments in energy efficiency will strengthen the economy by saving consumers money and creating jobs.

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ABOUT THE AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY

ACEEE is a nonprofit organization dedicated to advancing energy efficiency as a means of promoting economic prosperity, energy security, and environmental protection. For more information, see aceee.org. ACEEE fulfills its mission by:

- Conducting in-depth technical and policy assessments
- Advising policymakers and program managers
- Working collaboratively with businesses, public interest groups, and other organizations
- Organizing conferences and workshops
- Publishing books, conference proceedings, and reports
- Educating consumers and businesses

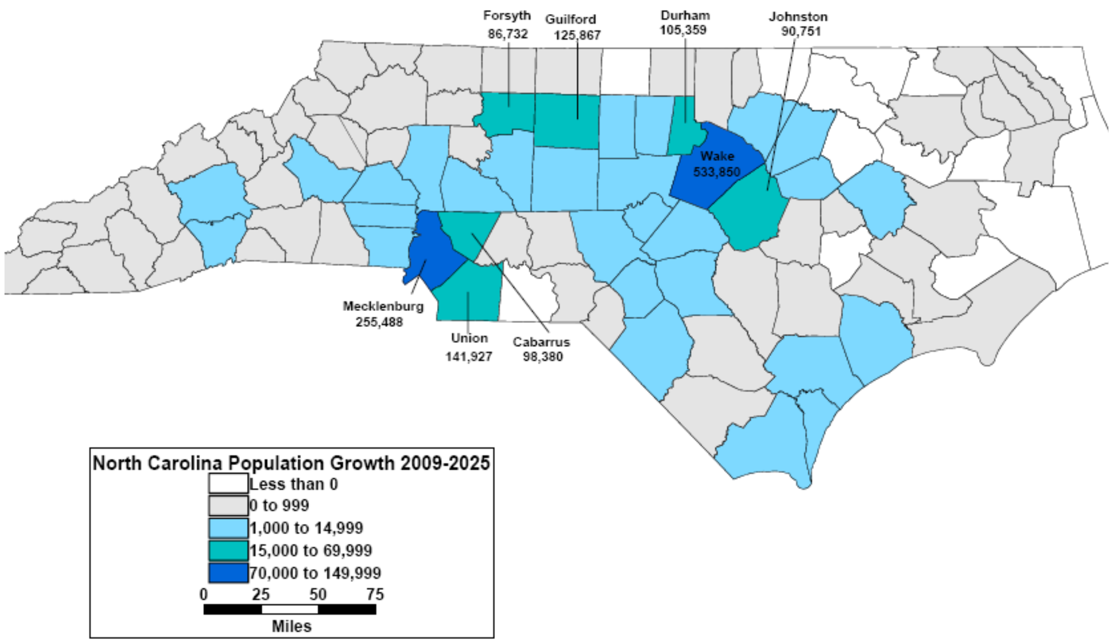
Projects are carried out by staff and selected energy efficiency experts from universities, national laboratories, and the private sector. Collaboration is key to ACEEE's success. We collaborate on projects and initiatives with dozens of organizations including federal and state agencies, utilities, research institutions, businesses, and public interest groups.

Support for our work comes from a broad range of foundations, governmental organizations, research institutes, utilities, and corporations.

CHAPTER ONE: INTRODUCTION

Between 2009 and 2025, North Carolina's population is expected to grow from 9.4 million to 12 million, or about 1.5% per year (OSBM 2009). As one of the fastest growing states in the nation, North Carolina faces many energy challenges in the coming decades as demand for energy and water exceed available resources, putting the state's economy at risk. This imperative extends to the transportation sector as well. The nearly 3 million new people in the state are expected to be highly concentrated in thirteen counties (see Figure 1.1). This highly concentrated population growth and the attendant growth in vehicle traffic in a few metropolitan areas and freight corridors lead to major concerns about economic and environmental sustainability. While the current economic recession has slowed the pace of expected growth in energy consumption somewhat, both energy demands and energy prices are still projected to increase.

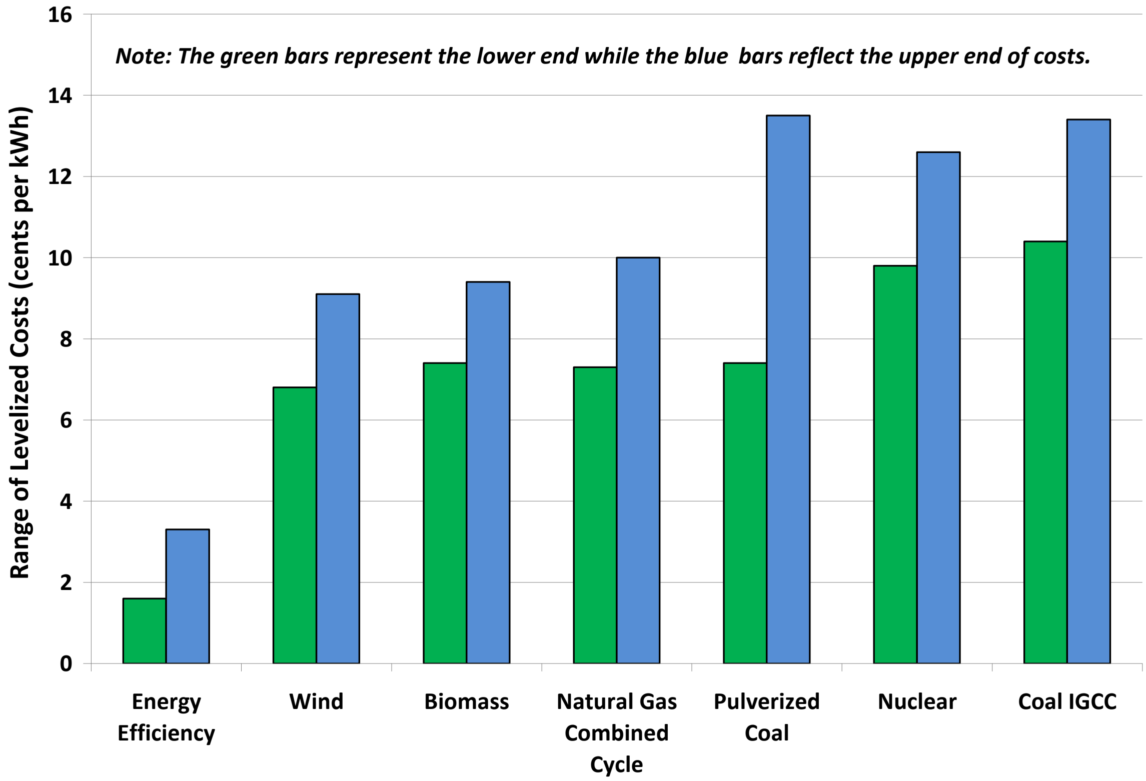
Figure 1.1. Population Growth in North Carolina, 2009-2025



Cost-effective energy efficiency offers a way to minimize energy price increases, help consumers lower energy bills, and create new jobs. A series of analyses confirms that energy efficiency investments at all levels will cost consumers and businesses about half the cost of conventional energy supplies (Friedrich et al. 2009; Laitner 2009; AEF 2010). Figure 1.2, for example, shows a significant cost difference. Similarly, improved water efficiency by public water systems and their customers can reduce the cost of water and wastewater service, enhance the reliability of supply, and add to the energy savings and emission reductions of energy efficiency programs.

North Carolina stands in the middle of the pack (26th out of the 50 states) in ACEEE's *The 2009 State Energy Efficiency Scorecard*, which ranks states on a comprehensive set of energy efficiency policies. The state has a history of leadership on energy efficiency, and has again begun taking a number of steps toward improving energy efficiency, including utility-run energy efficiency programs for customers and commitment to the energy efficiency of state facilities, emerging as a leader in the Southeast. Although some steps have been taken, much more can be done to tap into the state's efficiency potential, helping to balance the state energy resource portfolio, save consumers money, and stimulate the state's economy and job growth. And recent federal stimulus funding for energy efficiency provides a great opportunity for North Carolina to both spur near-term investments and build a foundation for a long-term clean energy future.

Figure 1.2. Levelized Utility Electricity Resource Cost in 2008



Source: Lazard (2008), except for (a): Energy efficiency program costs are the estimates of levelized costs of saved energy (CSE) for program administrator costs (PAC) as described in Friedrich et al. (2009).

In addition to electricity demands, two urgent energy issues identified by stakeholders that ACEEE interviewed are water and transportation. The competition for water, an integral resource for both population growth and electricity generation, represents a pressing economic threat to the state. Similarly, transportation infrastructure is becoming overtaxed in the economic corridor from the Triangle to the Charlotte metro region, with delays imperiling future economic growth. This concern relates closely to transportation energy use in that enabling compact development patterns and expanding public transit and other energy-efficient modes to serve it will be a key strategy for sustainable growth. Increasing the urgency of this issue are changes in federal air quality targets[2] that will likely place Charlotte and the Triangle into severe non-attainment for ambient air quality.

Because the energy policy choices North Carolina makes now will define its energy future for years to come, it is important that the legislature and other policymakers be aware of the policy opportunities available to them. While efficiency offers the potential for innumerous near-term economic benefits, it will also help to define North Carolina's long-term strategy toward a cleaner energy future.

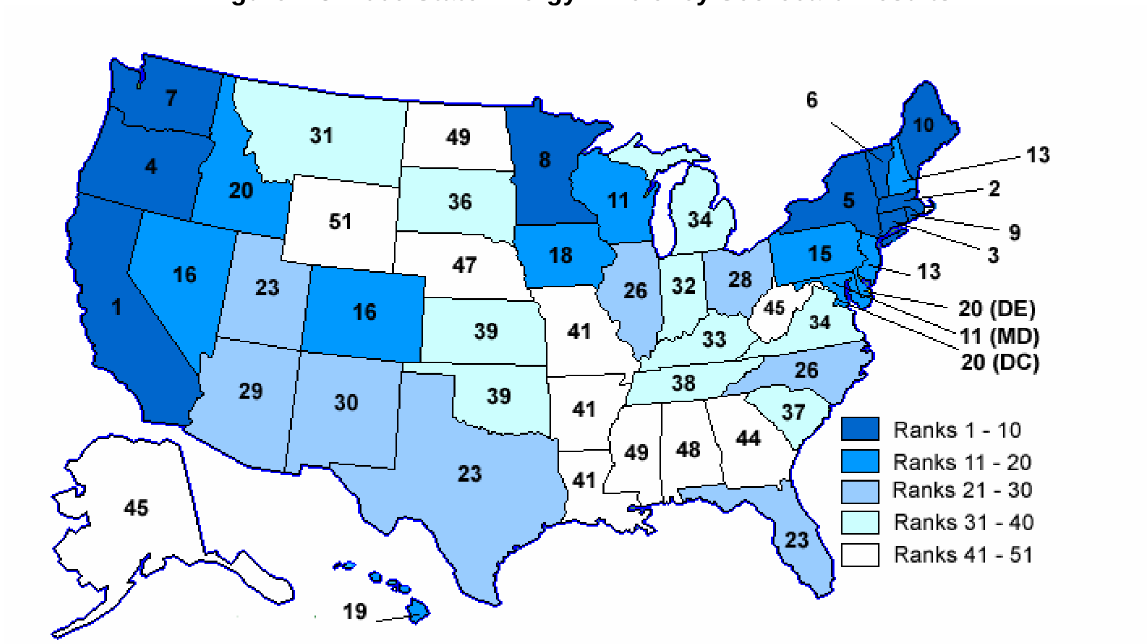
[2] The U.S. EPA changed the target for ground-level ozone and related petrochemical oxidants from 1 hour to 8 hours average in 2008 resulting in some regions no longer being able to comply with national ambient air quality standards (NAAQS) for ozone (Federal Register 2008).

Project and Methodology Overview

Overall Project Context: Why We Chose North Carolina

This report is one in a series of energy efficiency studies by ACEEE as part of our State Clean Energy Resource Project. We choose to work with states that currently show signs of progress toward new and expanded energy efficiency efforts. This emerging class of states has been identified in our annual *State Energy Efficiency Scorecard,* which ranks states on a comprehensive set of energy efficiency policies and programs, including: (1) Utility and Public Benefits Efficiency Programs and Policies; (2) Transportation Policies; (3) Building Energy Codes and Compliance; (4) Combined Heat and Power; (5) State Government Initiatives; and (6) Appliance Efficiency Standards (see Figure 1.3). There are many indications that North Carolina is poised to rise as a leader in efficiency in the Southeast, making it a ripe candidate for our work.

Figure 1.3. 2009 State Energy Efficiency Scorecard Results



Source: Eldridge et al. (2009)

The goal of this study is to inform policymakers and stakeholders of the opportunities for energy efficiency in electricity end-uses and the transportation sector, demand response, and water efficiency in North Carolina, and to suggest specific policies based on best practices nationally that the state could implement to facilitate the development of these resources. These policy suggestions are made with an eye to honoring the state's own unique characteristics and needs as much as possible. The suggestions are intended as a guide to inform the state's future decision-making. Many states in the country are already moving forward and leadership taken by North Carolina can help propel it to the forefront of those states fashioning good energy policy that can pay off in added economic competitiveness.

In addition to preparing an analysis for North Carolina, as part of this project ACEEE experts are also prepared to provide technical assistance for up to one year following the release of this report to aid policy implementation. We intend this report to be used as a roadmap to guide future efficiency resource decisions, and plan to remain available to stakeholders to help in whatever capacity is necessary to help make an energy-efficient future a reality for the state.

Stakeholder Engagement

Building an awareness of the demographics and political climate in North Carolina was an integral part of the formulation of the policy options analyzed in this report. Each state is different and we do not presume that any one policy or set of policies will work universally. Identifying and engaging a wide variety of stakeholders in North Carolina, therefore, was imperative to the acceptance and usefulness of our analysis and final report. We met or spoke with as many representative groups as possible in order to better understand North Carolina's political climate, energy structure, and economic needs. This included utilities, the North Carolina Utilities Commission (NCUC) and Public Staff, business and industry representatives, the environmental community, the Energy Policy Council, State House and Senate offices, state government representatives including the NC State Energy Office, and members of the Governor's staff.

Analysis Methodology and Report Outline

The remainder of the report is organized into the following chapters. Here, we provide a brief methodology of each section. Details to resources for most of these chapters can be found in the technical appendices that accompany the body of this report.

Chapter Two: Electricity

- ***Reference Case:*** The first step in this analysis was to collect data and to characterize the state's current and expected patterns of electricity consumption and peak demand over the time period of the study (2009–2025). The reference case for electricity was vetted with stakeholders. This section also includes a reference case for utility-avoided costs in North Carolina, which was prepared by Synapse Energy Economics, and a forecast for retail electricity prices in the state.

- ***Meta-Analysis of Energy Efficiency Potential Studies for Electricity:*** Stakeholders informed us of numerous recent energy efficiency potential studies completed for North Carolina. Rather than develop a new assessment of the cost-effective resource potential, we chose to review and summarize key information from recent studies for North Carolina, the greater Southeast region, and the nation. From these studies we collected data on the economic potential scenarios and reported these findings as both raw totals (kWh/Btu) and on a percentage basis. We reviewed and summarized the variances in both assumptions and scope of the studies that led to a range of projected energy savings potentials. The range of findings provides insight into the level of savings that North Carolina can expect from pursuing cost-effective energy efficiency.

- ***Efficiency Policy Analyses:*** For this analysis, we developed a suite of energy efficiency policies based on successful models implemented in other states and in consultation with stakeholders in North Carolina. These policies were vetted with our stakeholders in order to garner feedback on their economic and political feasibility. This analysis includes two scenarios—a medium and a high case—that assume reasonable program and policy penetration rates to capture the cost-effective and achievable resource potential characterized by the meta-review. This section presents the electricity and peak demand impacts from energy efficiency as well as the reductions in thermoelectric cooling requirements attributable to the implementation of energy efficiency measures. We also presented the associated costs and an evaluation of program costs using two cost-effectiveness tests. Finally, this section includes an estimation of carbon dioxide emissions impacts.

- ***Demand Response Analysis:*** This section, prepared by Summit Blue Consulting, assesses current demand response activities in North Carolina, uses benchmark information to assess the potential for expanded activities in the state, and offers policy options that could foster DR contributing optimally to the resource needs in North Carolina. Potential load reductions are estimated for a set of DR programs that represent the technologies and customer types that span a range of DR efforts, and are in addition to the demand reductions resulting from expanded energy efficiency investments.

Chapter Three: Water Efficiency

- ***Efficiency Policy Analyses:*** Evaluates the six potential policies that North Carolina could adopt to capture cost-effective opportunities for public water systems and their customers to save water. This section presents potential water savings for public water systems and estimates the resulting onsite electricity savings. The costs associated with each policy and estimates of their cost-effectiveness are also presented. This section also includes estimates of the impact of projected electricity savings on the cooling requirements of North Carolina's principal load-following thermoelectric power plants.

Chapter Four: Transportation Efficiency

- ***Efficiency Policy Analyses:*** Evaluates six policy options that North Carolina could adopt to improve light- and heavy-duty vehicle efficiency, reduce passenger and freight vehicle miles traveled, and coordinate land-use and transportation planning in the state. The savings and costs for each policy are also presented along with adjusted gasoline and diesel consumption projections that reflect implementation of the policies.

Chapter Five: Combined Macroeconomic and Emissions Impacts from Electricity, Water, and Transportation Policies

- ***Macroeconomics:*** Based on the electricity, water, and gasoline savings; program costs; and private investments made as a result of the policies, we ran ACEEE's macroeconomic model, DEEPER, to estimate the overall impacts of the policy options on jobs, wages, and gross state product in North Carolina.
- ***Emissions impacts:*** This section includes an estimation of potential carbon dioxide emissions reductions in North Carolina from improved efficiency in the electricity and transportation sectors.

Discussion and Conclusions

Background

North Carolina consumed about 2.7 trillion Btus of energy in 2007, which represents nearly 3% of total energy consumption in the nation. This report focuses on end-user energy efficiency opportunities for the state's residential, commercial, industrial, and transportation sectors, which represent 27%, 21%, 24%, and 28% of total energy consumption in the state, respectively. For the residential, commercial, and industrial sectors, we examine only end-use electricity consumption because it represents the vast majority of energy consumption for these sectors (80-90% of consumption in residential and commercial buildings and 50% in industrial facilities). Natural gas also represents a significant energy source, heating about 25% of households. Natural gas utilities in the state such as Piedmont have begun to examine expanded energy efficiency program portfolios for their customers. Natural gas efficiency programs will play another critical role in the state's comprehensive plan for a clean energy future, though outside the scope of this analysis.

The electricity, water, and transportation sectors offer several linkages. While the report discusses each sector in a separate chapter, we also tie in connections with other sectors in each discussion. Some key linkages include: water needs for electricity generation; electricity needs for wastewater treatment and distribution; end-use electricity savings from household water efficiency measures;

future electricity needs for plug-in electric vehicles; and the impact of transit-oriented development on reduced building energy consumption.

Finally, the chapter on macroeconomic impacts ties together all sectors by showing how investing in electricity, water, and transportation efficiency can contribute to improving North Carolina's clean energy economy. An important facet of expanding energy and water efficiency in the state is the need for a trained workforce capable of identifying, implementing, and operating efficiency improvements. From auditors to operators, curtailing electricity and water demand will create tens of thousands of new, local, high quality "clean energy" jobs, a number that will grow over time as efficiency programs intensify and become more ubiquitous.

CHAPTER TWO: ELECTRICITY

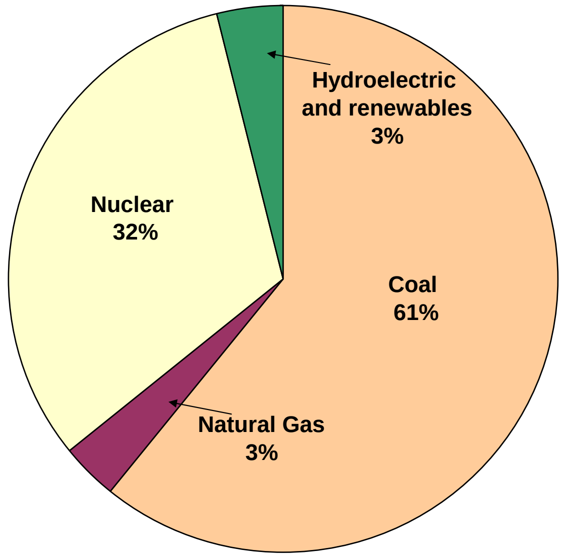
Background

Residents of North Carolina are heavily dependent on electricity. About 50% of households use electricity for home heating, for example, and most homes have air conditioning. While coal-fired (62%) and nuclear power plants (31%) are the major electricity generation sources in the state (see Figure 2.1) according to data from the Energy Information Administration, Duke and Progress Energy's electricity service territories overlap South Carolina and North Carolina and the states share two key utilities generation facilities, so the actual average generation mix is close to a 50-50 split between nuclear and coal. The fact is reflected in North Carolina being a net importer of electricity while South Carolina is a net exporter.

North Carolina retail electricity customers are served through three types of providers: investor-owned utilities (IOUs), electric cooperatives, and municipal electric suppliers (see Figure 2.2). The three IOUs are Duke Energy (43% of sales), Progress Energy (29%), and Dominion Power (3%).

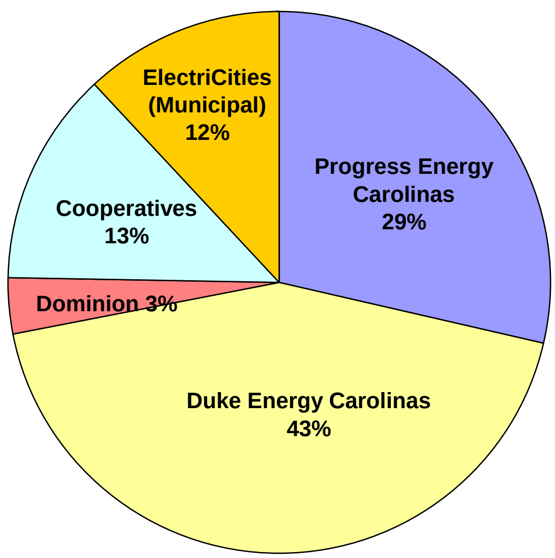
In 2007, electricity generation in North Carolina reached 130,115 GWh, which is the 11^{th} highest in the country. Total electricity demand reached 144,291 GWh, meaning that the state is a net importer of electricity (see Figure 2.3).

Figure 2.1. North Carolina Electricity Generation (GWh) by Fuel Type in 2008[3]



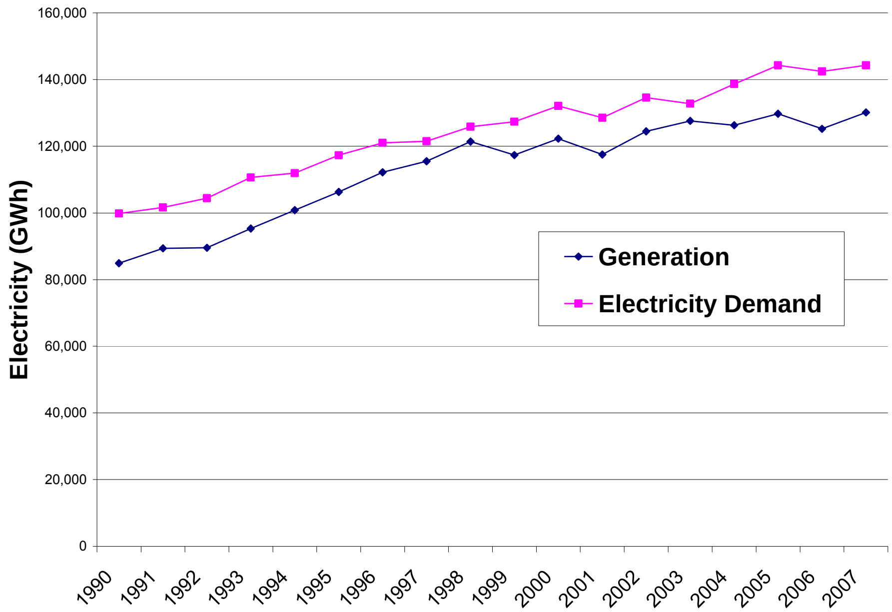
Source: EIA (2009a)

Figure 2.2. North Carolina Electricity Sales (GWh) in 2007 by Utility



[3] EIA data on electricity generation by fuel type is based on generation resources geographically located in North Carolina. However, nuclear power plants located just across the state line in South Carolina also serve retail customers in North Carolina. Duke and Progress estimate that generation resources are split 50-50 between coal and nuclear.

Figure 2.3. Historical Electricity Demand and Generation in North Carolina, 1990–2007



Source: EIA (2008)
Notes: Electricity demand includes retail sales, line losses, and direct use.

Harnessing North Carolina's Electricity Efficiency Potential

While updating generation resources and transmission/distribution infrastructure in the state will continue to be important for North Carolina's energy future, especially as older generation units are retired, new investments are becoming less attractive. Increasing costs of construction, lack of access to capital, and potential federal climate legislation make investments in coal-fired power plants particularly less attractive. These variables, along with a recent flattening in the electricity demand growth in the state as a result of the recession, will heavily influence utilities' investment decisions. Recently, Progress Energy made plans to retire eleven coal plants that do not have flue-gas desulfurization controls (i.e. scrubbers) by the end of 2017 (Progress 2009a).

Energy efficiency and demand response can provide critical relief from short-term market impacts because they represent the least-cost resources available and are the quickest to deploy. And unlike supply-side electricity resources, efficiency and demand response are the only resources that can begin to reduce electric bills by decreasing overall consumption, which will save the state and its consumers money that can then be reinvested in North Carolina's economy. North Carolina utilities have already begun to offer some energy efficiency and demand response programs to electricity consumers, but there is potential for much more.

In August 2007, North Carolina enacted comprehensive energy legislation[4] that established a Renewable Energy and Energy Efficiency Portfolio Standard (REPS), which became the first such legislation in the Southeast. The REPS enables greater penetration of renewable energy and energy efficiency into utility resource mixes, providing the overarching framework for the projected level of alternative supply side and demand side resources. The REPS requires that investor-owned utilities reach 12.5% of its electricity supply through renewable energy resources by 2021 and that electric cooperatives and municipal utilities reach 10% by 2018. IOUs can meet up to 25% of the standard with energy efficiency through 2021 and up to 40% after 2021. Electric cooperatives and municipalities do not have a limitation on energy efficiency contributions. Progress Energy and Duke Energy have already begun to roll out energy efficiency programs, and Duke plans to reach about 2%

[4] Senate Bill 3

cumulative annual electricity savings by 2015 relative to 2009 sales, which is equivalent to about 0.35% incremental savings each year (Duke 2009)[5]. To help define and meet the REPS goals, the N.C. Electric Cooperatives have established GreenCo Solutions (2010). Combined, these steps would mark significant improvement in utility energy efficiency offerings in the state, however additional opportunities remain untapped. Leading states, for example, are achieving 1%-2% incremental savings per year (Kushler et al 2009).

The state has also been given an opportunity to build a foundation for long-term commitments to energy efficiency with funds appropriated through the *American Recovery and Reinvestment Act*. In June 2009, the U.S. DOE approved North Carolina's $75.9 million State Energy Program (SEP) plan to improve energy efficiency, promote renewable energy resources, and create jobs. The plan includes six areas to be administered by the State Energy Office. The state is expected to receive an additional $58 million for Energy Efficiency and Conservation Block Grants (EECBG) for local projects with $37 million designated to 32 of the state's larger cities and counties and the Cherokee Indian reservation. The State Energy Office will distribute the remaining $21 million to the state's smaller communities and other state and local agencies on a competitive basis. ARRA also designates $5 billion for weatherization projects nationwide through the Weatherization Assistance Program (WAP), which allocates $132 million to North Carolina over the next three years for low-income programs. The 30 social-service agencies throughout the state handle weatherization work for low-income households. Stimulus funding should provide enough to upgrade about 25,000 homes over three years in the state.

The State Energy Office in the Department of Commerce already runs a number of programs to help homeowners and businesses improve energy efficiency, such as energy efficiency performance contracting for state facilities and Upgrade and Save, which aims to improve efficiency in manufactured homes. In partnership with the SEO, the Waste Reduction Partnership through the NC Department of Environment and Natural Resources is another energy efficiency program model, which has provided energy efficiency and pollution management technical assistance to over 1,000 manufacturers, businesses, schools and institutions and achieved savings of over 145 GWh over the past 10 years (WRP 2010). These existing program examples will be important to consider as the state begins to use its stimulus funding to provide successful existing programs and start new ones.

While North Carolina utilities, state agencies, and private firms have made several strides toward greater energy efficiency, significant potential will remain untapped at the current pace of program delivery and policy mechanisms. This report serves as a guide to help policymakers and program implementers in North Carolina harness this additional potential.

Reference Case

The first task in this project is to develop a reference case forecast of electricity consumption, peak demand, and electricity prices in the state for a "business as usual" scenario. In this section we report the reference case assumptions for the analysis time period, 2009–2025. One caveat to note in any forecasts is that all projections are subject to uncertainty, particularly during a time when the economic outlook is a major unknown. It is important to understand that while the forecast will affect the report numbers, it has no impact on the effectiveness of the proposed policies. In other words, the delta values for energy savings and economic impacts are not appreciably affected by the forecast assumptions.

Electricity (GWh) and Peak Demand (MW)

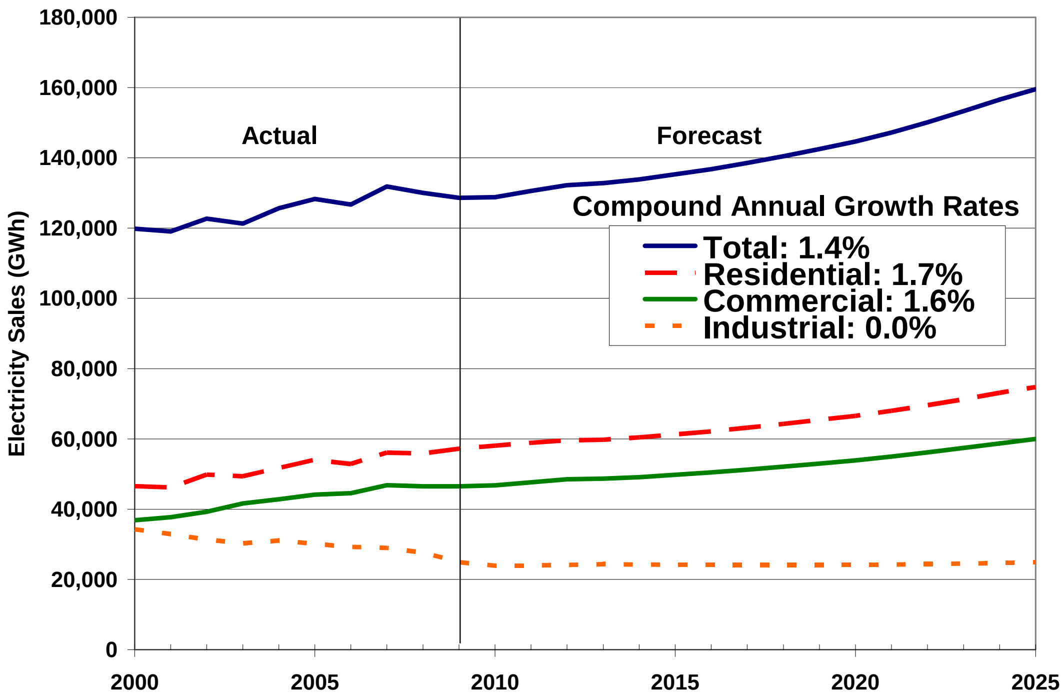
The reference case forecast for electricity sales growth in North Carolina is the foundation of the quantitative analysis of electricity efficiency policies in this analysis. The base year for electricity sales in the state is 2008, the most recent year for which sales have been reported to the Energy Information Administration (EIA 2009b), and is projected through 2025 based on forecasts from

[5] According to the utility's 2009 IRP base case.

electric utility integrated resource plans (IRPs) filed in 2009 (Duke 2009; Progress 2009b; Dominion 2009; NCEMC 2009). Historical sales are based on data from EIA (EIA 2009b). Federal appliance and lighting standards enacted in the 2007 are assumed to be accounted for in the utility forecasts, as are impacts from energy efficiency programs that were delivered prior to 2009.

To estimate projected electricity sales, we first derived annual growth rates by sector from each electric utility IRP. We then estimated statewide annual weighted-average growth rates for each sector, which we applied to the statewide sales data reported by the EIA for 2008. Utilities indicated that impacts from planned energy efficiency and demand response programs were included in their forecasts, and Duke Energy indicated that federal efficiency standards were also accounted for in their forecast. Using this methodology, we estimate that total electricity consumption in the state will grow at an average annual rate of 1.4% between 2009 and 2025, and 1.7%, 1.6%, and 0.0% in the residential, commercial, and industrial sectors, respectively (see Figure 2.4).

Figure 2.4. Electricity Sales Forecast, 2008–2005



Sources: EIA (2009c); Duke (2009); Progress (2009b); Dominion (2009); NCEMC (2009)

To estimate statewide peak demand, Synapse Energy Economics applied a system load factor, which we assumed to be 62.7% from on a Progress Energy FERC filing, to the electricity sales forecast. Using this methodology, we estimate peak demand growing at a compound annual rate of 1.4% over the 2009–2025 period. In 2009, peak demand is estimated at 26,170 MW, increasing to 32,470 MW in 2025.

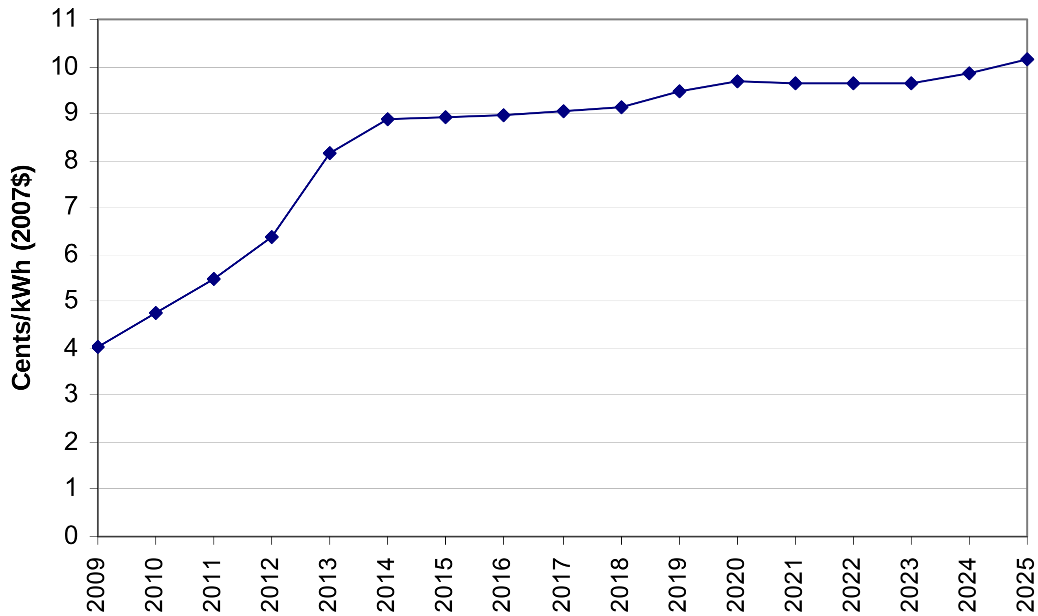
Utility Costs in Reference Case

Synapse Energy Economics developed high level projections of utility production and avoided marginal costs in the reference case and policy case scenarios. These cost estimates are important because they reflect the cost-effectiveness threshold to utilities for investments in energy efficiency rather then investments in new electricity generation. ACEEE used the results from this analysis to estimate the cost-effectiveness of energy efficiency policy and program measures and assess macroeconomic impacts to the state. Readers should note that the avoided cost estimates are based upon a number of simplifying assumptions, including use of a single annual average marginal energy cost to evaluate the economics of energy efficiency measures rather than different costs for energy efficiency measures with different load shapes.

The utility costs analysis assumes an estimated cost of carbon, which is reflected in the form of additional operating costs to fossil fuel generation plants. Synapse examined over a dozen reports by federal, academic, and non-governmental organizations to assess the factors influencing allowance prices and estimate three forecasts of carbon allowances: a low, medium, and high case. For this report, Synapse used their medium case, which estimates a base-level cost of carbon at $15/ton starting in 2013, increasing to around $54/ton by 2030 (Schlissel et al. 2008).

In the reference case, avoided resource cost estimates start out at about 5 cents per kWh in 2010, quickly increase to about 9 cents per kWh by 2014, and reach 10 cents per kWh by 2025 (see Figure 2.5). Several new capacity additions in the state planned for 2011-2013 account for the rising marginal costs in the near-term. A detailed discussion of the assumptions and marginal cost estimates can be found in Appendix A.1.

Figure 2.5. Estimates of Annual Marginal Resource Costs for North Carolina Utilities in Reference Case



Source: Synapse Energy Economics

These projections are a highly stylized representation of costs, so we suggest that a more detailed assessment of costs be undertaken as part of North Carolina's energy planning process in order to reflect the locational and temporal variations across the state and throughout the year.

Retail Price Forecast

ACEEE also developed a possible scenario for retail electricity prices in the reference case. Readers should note the important caveat that we do not intend to project actual electricity prices in North Carolina for either the short or the long term. Rather, our goal is to suggest a possible scenario, based on data from credible sources, and to use that scenario to estimate impacts from energy efficiency on electricity customers in North Carolina.

Table 2.1 shows 2007 electricity prices in North Carolina (EIA 2008) and our estimates of retail rates by customer class over the study period. This price scenario is based on two key factors. First, we use the average electricity production cost in North Carolina over the study period as calculated by

Synapse Energy Economics (unlike the marginal costs described above, the production costs include both existing and new resource generation). Next, we use estimates of retail rate adders (the difference between generation costs and retail rates, which accounts for transmission and distribution costs) from the *Annual Energy Outlook* for the Southeastern Electric Reliability Council (SERC) (EIA 2009d).

Table 2.1. Retail Electricity Price Forecast Scenario in Reference Case (cents per kWh in 2007$)

	2007	2010	2015	2020	2025	Average
Residential	9.4	9.0	10.6	11.4	12.1	**10.6**
Commercial	7.4	7.9	9.3	10.0	10.6	**9.3**
Industrial	5.5	5.8	7.3	7.9	8.5	**7.1**
All Sector Average	**7.8**	**7.8**	**9.4**	**10.0**	**10.7**	**9.2**

Note: These figures are in real, 2007-year dollars and therefore do not take into account inflation. 2007-year prices are actual.

Meta-Analysis of Electricity Energy Efficiency Potential Studies

We conducted a meta-analysis to review and summarize key information from several energy efficiency market potential studies that have already been conducted in North Carolina, the greater Southeast region, and the nation as a whole. This meta analysis supplants the sector-specific economic potential analyses we have conducted in our previous reports on other states.

Here, we provide a summary of the results for North Carolina studies and for national studies. Based on the findings of the state, regional, and national efficiency potential studies, we estimate that cost-effective energy efficiency potential in North Carolina is in the range of 1.5 to 2% incremental electricity savings per year over the time period of our report. See Appendix A.2 for a detailed description of the findings of the meta analysis.

North Carolina Energy Efficiency Potential

Studies prepared by La Capra/GDS Associates and Appalachian State University reported average annual efficiency potential in the range of 1.3-1.4% at a cost of saved energy that is currently cost effective. By extrapolating this average annual efficiency potential across 16 years, cost effective potential reaches about 22% by 2025. In the GDS achievable potential scenario, which did not limit savings potential to measures with a cost less than 5 cent per kWh, savings increased to 2.0% average annual efficiency potential, or 32% electricity savings extrapolated through 2025. The level of savings found in these studies is in keeping with the efficiency potential that ACEEE has found in other states and the nation as a whole. Still, it is important to note that each of the studies ACEEE reviewed in the meta-analysis varied in their methodology and the list of measures included. Therefore, we recommend that the meta-analysis serve as an estimation of the overall electricity efficiency potential rather than a prescriptive guide or roadmap for specific efficiency policies.

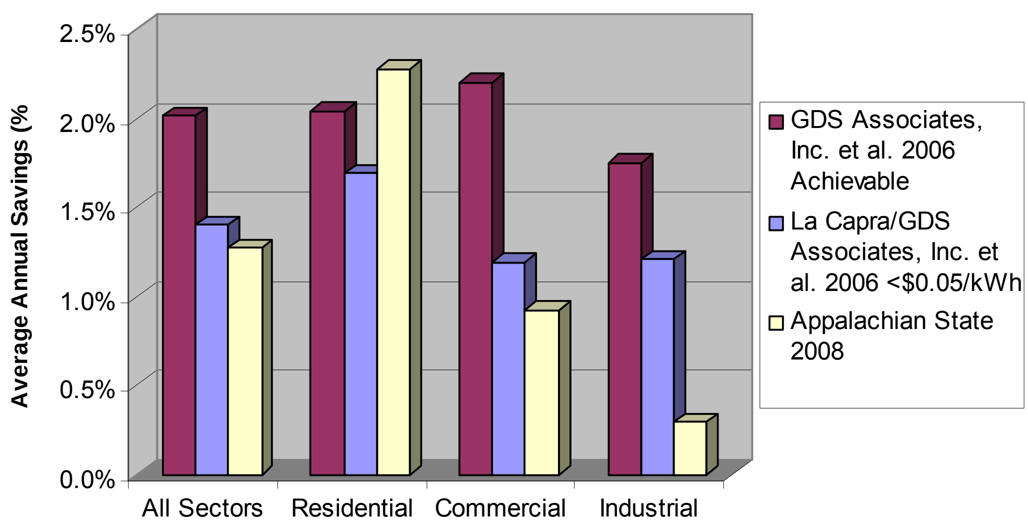
Our meta-analysis included three studies: La Capra/GDS, Appalachian State, and ORNL. We included two efficiency potential scenarios from the GDS report in our analysis: the Achievable Potential, which included measures with a levelized cost of less than about $0.10/kWh, and the Achievable Cost Effective Potential, which included only measures with a levelized cost of less than $0.05/kWh. The Appalachian State study included measures with a levelized cost of $0.06/kWh or less. Our review of avoided utility electricity costs finds that current marginal avoided costs for new supply side resources are in the range of $0.05 to $0.06 per kWh, however these are likely to quickly rise to $0.09 per kWh by 2014 and $0.10 per kWh by 2025. For this reason, we also included an evaluation of both the Achievable and Achievable Cost Effective potentials from the La Capra/GDS study. The La Capra/GDS and Appalachian State studies evaluated efficiency potential in the residential, commercial, and industrial sectors, while ORNL evaluated only the residential and commercial sectors. Because of the limited scope of the ORNL study, we have not included it in our comparisons of overall efficiency potential for North Carolina.

National Energy Efficiency Potential

Our meta-analysis of national energy efficiency potential studies examines one recent nationwide study conducted by McKinsey & Company, and two meta-analyses conducted by ACEEE in 2004 and 2008. Combined, these meta-analyses evaluated 49 statewide, regional, and national energy efficiency potential studies, providing a useful perspective on both the range and average potential energy savings across the country. The McKinsey & Company study projected annual average electricity savings of 1.0%, while the 2004 and 2008 meta-analyses found 1.5% and 1.9%, respectively. Extrapolating these average annual savings potentials across 16 years results in an efficiency potential in the range of 16-30% through 2025.

Energy efficiency potential varies from state to state, so it is impossible to pinpoint the potential for North Carolina based solely on a survey of national efficiency potential studies. However, because of their broad scope, the findings in these studies serve to underscore the savings potential found in the North Carolina studies.

Figure 2.6. Average Annual Savings Potential for North Carolina



Energy Efficiency Policy Analysis

In this section we present the suite of policy options that we analyzed for North Carolina implement in order to enhance electric efficiency in the state. We then estimate the resulting energy savings, costs, and consumer energy bill savings ($) that can be realized from their implementation, though costs and benefits are quantified only for nine of the electric policies.[6] Each policy is analyzed within two scenario frameworks: our medium case scenario reflects a significant commitment to efficiency and is the scenario on which we focus the publication of our results; and our high case scenario represents a more aggressive approach where the state takes greater advantage of its available, cost-effective resource potential.

[6] The Workforce Development Initiative is not analyzed quantitatively as it is an enabling policy and does not have direct savings associated with it. Our Expanded Demand Response (DR) policy is assessed separately in the policy analysis by Summit Blue Consulting. The Energy Efficiency Resource Standard is an aggregation of eight of the policies and contributions from proven utility programs, so its benefits and costs are not individually quantified.

Policy Scenario Descriptions

The two scenarios are shown in the matrix below (see Table 2.2) for our electricity efficiency policy analyses. Following the policy discussions we estimate the resulting energy savings, costs, and consumer energy bill savings ($) that can be realized from their implementation. At the end of this section we briefly examine the sorts of programs that utilities can implement in order to satisfy the remaining savings obligation as stipulated by our EERS policy.

Table 2.2. Matrix of Electricity Efficiency Policies in Medium and High Case Policy Scenarios

Electricity		Medium Case Scenario	High Case Scenario
1	Energy Efficiency Resource Standard (EERS)	Enact a stand-alone EERS requiring 1.0% incremental electricity savings per year by 2015; 1.5% per year by 2019; and 2% per year by 2025	Enact a stand-alone EERS requiring 1.0% incremental electricity per year by 2013; 1.5% per year by 2016; 2% per year by 2022
2	Manufacturing Initiative	Train engineers to provide up to 100 energy assessments per year; savings contribute to EERS	More aggressive manufacturing initiative combined with economic development incentives; savings contribute to EERS
3	Rural & Agricultural Initiative	Expanding the Farm Energy Efficiency Project (FEEP) audits and assistance to facilitate USDA REAP funding proposals	Combine expanded FEEP services with a pool of funding to match REAP funding and support projects the do not receive REAP funding
4	Building Energy Codes	Increase building energy code by 30% by 2012; enhance code enforcement and compliance to reach 90% compliance by 2015.	Increase code by 30% by 2012 and 50% by 2021; enhance code enforcement and compliance
5	Advanced Energy-Efficient Buildings Initiative	Program to build market for beyond-code savings (50% beyond current code) in new residential and commercial buildings	Same as medium scenario plus greater participation rates and savings—target net zero homes
6	Behavioral Initiative	Enable customer end-use information provided through utility billing statements	Same as Scenario Two plus greater participation and savings + feedback mechanisms, e.g., smart meters
7	Public Facilities Performance Contracting	Achieve 20% savings in all state and local facilities by 2025	Medium scenario plus expanded ESCO initiative and increased savings to 30% and 100% penetration by 2025
8	Manufactured Homes Initiative	Build on current levels of funding for Upgrade and Save and WAP to weatherize 1000 homes in 2010 and ramp up to 13,000 in 2025.	Medium case scenario plus greater participation rates/savings
9	Combined Heat & Power (CHP)	Removal of disincentives toward CHP	Expanded removal of disincentives toward CHP
10	Expanded Demand Response Programs	Expand existing portfolio of utility demand response programs	Expanded deployment
11	Customer Financing for Energy Efficiency*	Enabling Policy: Encourage local implementation of municipal financing such as Property Assessed Clean Energy (PACE) programs	Enabling Policy

*These policies are included in the suite of policies, but ACEEE does not quantify costs or savings.

Energy Efficiency Policy Scenario Results

This section describes results from our policy analysis, including estimated total annual electricity savings and peak demand impacts from efficiency in 2015 and 2025 for both the medium and high case scenarios. More detailed results, assumptions, and analysis of costs and benefits are shown in

Appendix A. The demand response potential and impacts on peak demand are covered in the next section and in Appendix D.

Medium Case Scenario

The estimated total electricity savings in 2015 and 2025 for the medium case scenario are shown by policy/program in Table 2.3. Under this scenario, North Carolina sets an electricity savings target, or EERS, toward which residential, commercial, and industrial programs will contribute. Several additional policies work to achieve additional savings and enable greater penetration of program participation. Under these conditions, we estimate that North Carolina can meet 24% of forecasted electricity needs in 2025 and combined with greater demand response efforts can reduce peak demand by about 32%.

Table 2.3. Summary of Electricity Savings by Policy or Program in the Medium Case

	Total Annual Electricity Savings by Policy (GWh)	**2015**	**2025**	**Total Savings in 2025** (%)**
1	Energy Efficiency Resource Standard (EERS)*	3,614	22,311	12.9%
	Proven Programs: Residential & Commercial	*3,007*	*18,803*	*11.8%*
2	*Manufacturing Initiative*	*439*	*1,789*	*1.1%*
3	*Rural & Agricultural Initiative*	*61*	*150*	*0.1%*
4	Building Energy Codes	1,341	4,496	2.8%
5	Advanced Energy-Efficient Buildings Initiative	284	1,828	1.1%
6	Behavioral Initiative	107	1,570	1.0%
7	Public Facilities Performance Contracting	733	2,835	1.8%
8	Manufactured Homes Initiative	120	1,545	1.0%
9	Combined Heat & Power (CHP)	334	1,455	0.9%
	New Federal Appliance Efficiency Standards	942	3,184	2.0%
	Electricity Savings from Water Efficiency Policies	42	176	0.1%
	Total Savings	7,517	37,830	**24%**
	Remaining Electricity Needs (GWh)	127,894	121,745	

Notes: * The Energy Efficiency Resource Standard will allow flexibility in the types of programs that are used to achieve the energy savings targets. In this scenario, we allocate savings from proven residential and commercial programs, and discrete manufacturing and rural & agricultural initiatives, as described below.
** We present total savings in 2025 as a percentage of forecasts electricity sales in 2025 from the reference case.

Figure 2.7. Share of Electricity from Energy Efficiency Policies in Medium Case

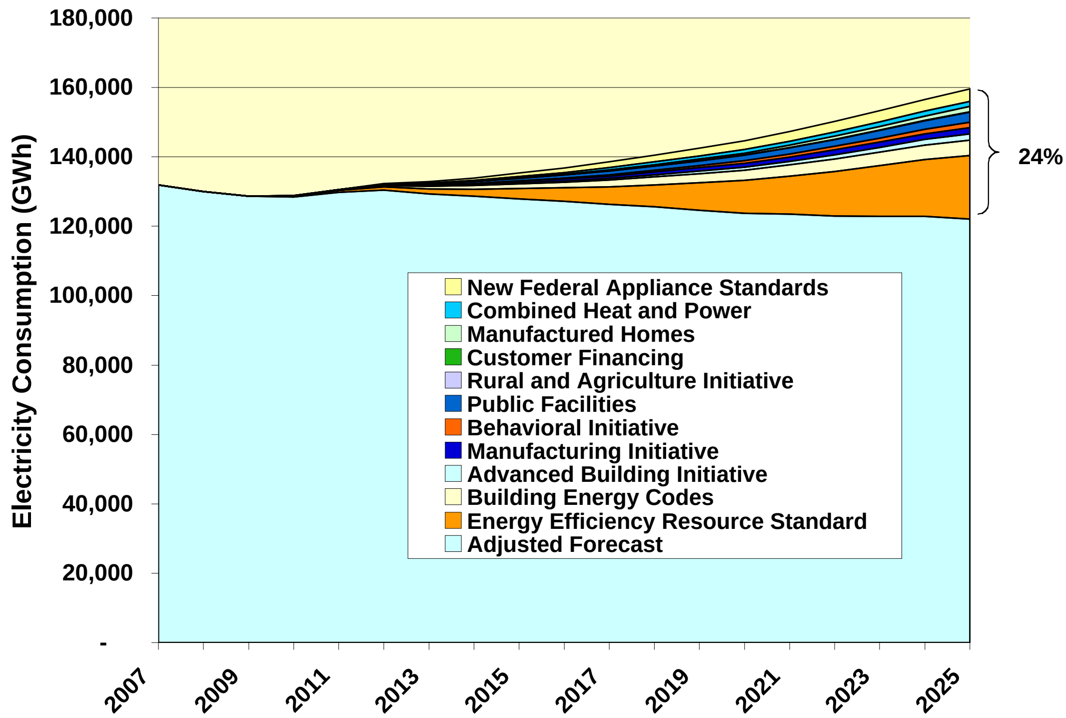
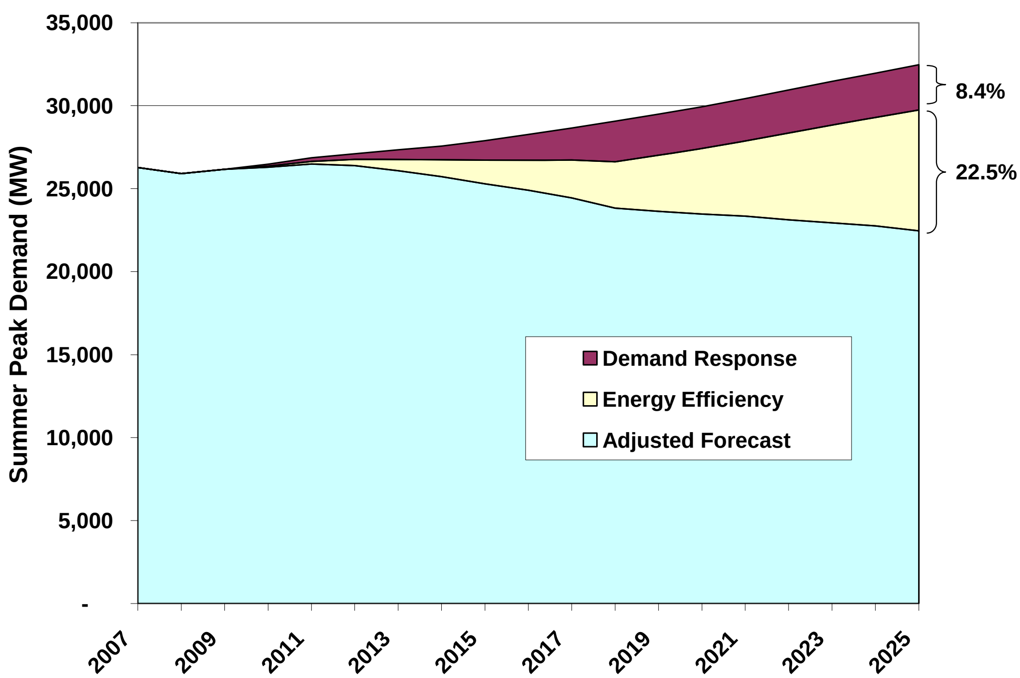


Figure 2.8. Summer Peak Demand Reductions from Energy Efficiency and Demand Response in Medium Case



High Case Scenario

In our high case scenario, savings penetration increases to an achievable potential of an average 2% per year over the study time period. This is achieved by a stronger EERS that reaches 2% per year by 2022 (relative to a 2009 base year), improved building codes in 2021 to achieve 50% beyond the IECC 2006, increased penetration of cost-effective CHP due to the removal of additional barriers, among several enhancements to programs and policies in the medium case scenario. The table and figures below show the results of the high case scenario, which meets 32% of the state's electricity's needs by 2025 and combined with expanded demand response program achieves a 44% reduction in peak demand by 2025.

Table 2.4. Summary of Electricity Savings by Policy or Program in the High Case

	Cumulative Electricity Savings by Policy (GWh)	**2015**	**2025**	**Total Savings in 2025 (%)**
1	Energy Efficiency Resource Standard (EERS)	4,814	25,072	16%
	Proven Programs: Residential and Commercial	*4,078*	*22,193*	*14%*
2	*Manufacturer's Initiative*	*655*	*2,680*	*1.7%*
3	*Rural & Agricultural Initiative*	*81*	*200*	*0.1%*
4	Building Energy Codes	1,341	5,360	3.4%
5	Advanced New Buildings Initiative	417	3,526	2.2%
6	Behavioral Initiative	107	2,243	1.4%
7	Public Facilities Performance Contracting	960	3,492	2.2%
8	Manufactured Homes Initiative	128	2,393	1.5%
9	Combined Heat & Power (CHP)	1,856	6,380	4.0%
	New Federal Appliance Efficiency Standards	942	3,184	2.0%
	Electricity Savings from Water Efficiency	47	194	0.1%
	Total Savings	**10,612**	**51,843**	**32%**
	Adjusted Electricity Forecast (GWh)	**124,692**	**107,727**	

Figure 2.9. Share of Electricity from Energy Efficiency Policies in High Case

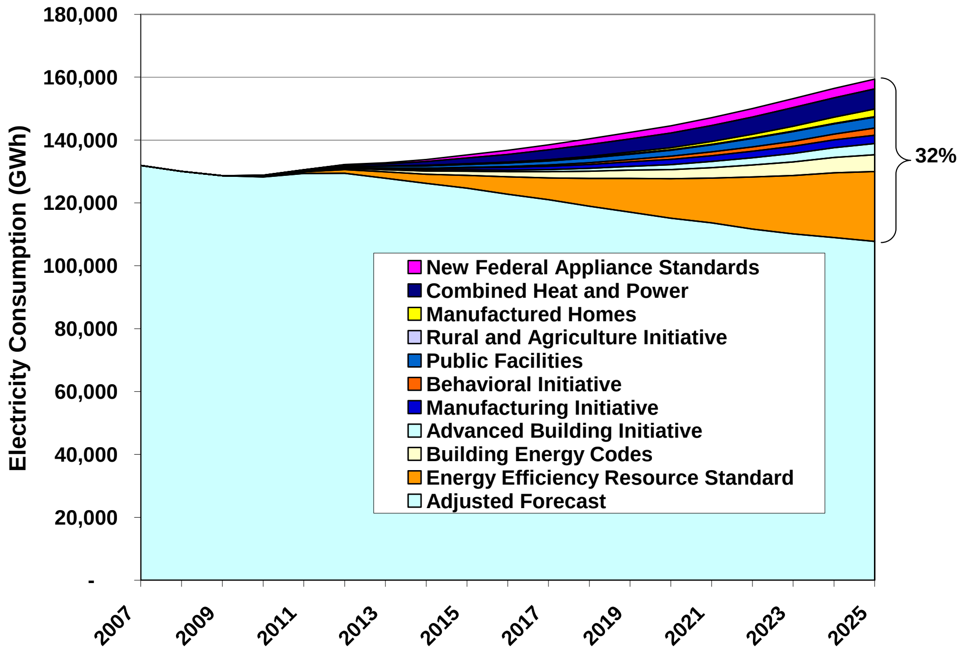
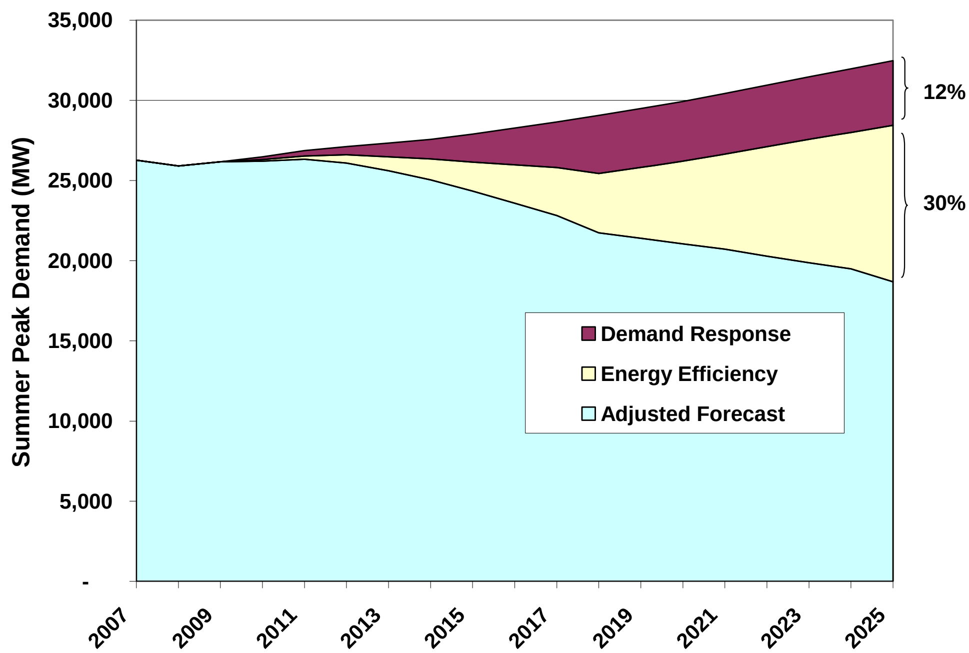


Figure 2.10. Summer Peak Demand Reductions from Energy Efficiency and Demand Response in High Case



Discussion of Electricity Efficiency Policies

Energy Efficiency Resource Standard

An Energy Efficiency Resource Standard (EERS) is a quantitative, long-term energy savings target for utilities that is met by implementing energy efficiency programs to help customers save energy in their homes and businesses. Typically, investor-owned utilities are required to meet this target, though electric cooperatives and municipal utilities are sometimes given the choice to opt in. Some states appoint a state agency or non-utility third-party administrator to implement programs. Currently twenty-two states have enacted mandatory energy savings goals through legislation or regulatory order and another four states have pending targets[7]. The EERS approach differs from many earlier state-legislated efficiency targets that were set in terms of funding levels rather than energy savings levels. Other models that set energy savings targets were short-term, setting goals for only one year, whereas EERS targets require multi-year, long-term savings. EERS targets are typically set independently of specific program, technology, or market targets in order to give utilities maximum flexibility to find the least-cost path toward meeting the targets (Nadel 2007; ACEEE 2010).

In 2007, North Carolina enacted SB-3 to establish a *Renewable Energy and Energy Efficiency Portfolio Standard* (REPS). The standard requires investor-owned utilities in the state to supply 12.5% of retail electricity sales in 2020 with renewable energy resources. Energy efficiency is an eligible resource under this current construct.

Nationwide, the recent trend has been to establish separate energy efficiency resource standards (EERS) and renewable energy portfolio standards (RPS). Since 2007, about ten states have adopted stand-alone EERS policies. And several states that had already enacted a combined EERS/RES have adopted legislation to divide these into two separate standards (Pennsylvania, Connecticut, and Hawaii). In Pennsylvania, for example, energy efficiency was allowed as an eligible resource in the state's Renewable Portfolio Standard (RPS); however, the targets were set low enough that existing resources could achieve the goals, with the result that new energy efficiency savings were not needed. Lack of clear guidance on energy efficiency has motivated these states to separate their energy efficiency and renewable energy targets.

In North Carolina, clear guidance on energy efficiency targets and which program activities qualify would benefit the state's commitment to least-cost energy planning by achieving cost-effective energy efficiency as a resource. We suggest establishing a separate EERS that requires both energy savings and peak demand targets for all investor-owned, cooperative, and municipal utilities in the state. In the medium case scenario, utilities meet a savings target of 1% by 2015, 1.25% by 2017, 1.5% by 2019, and 2% by 2025. In the high case scenario, savings targets reach 1% by 2013, 1.5% by 2016, 1.75% by 2018, and 2% per year by 2022. Based on our medium case scenario, the peak demand targets could require a total annual peak reduction of 3% by 2012, 9% by 2015, and 18% by 2018 from energy efficiency and demand response efforts.

The EERS has the greatest potential to reach significant energy savings for the state. We suggest that a set of proven residential and commercial building programs, such as those of the National Action Plan for Energy Efficiency's Rapid Deployment Energy Efficiency (RDEE)[8] toolkit (see text box), would achieve the majority of the savings because they have the greatest savings potential. In this analysis, a statewide manufacturing initiative and an agricultural initiative, described next, also contribute to the savings target from the industrial sector, as shown in Tables 2.3 and 2.4. Combined, the EERS would meet about 13% and 16% of the state's electricity needs in the medium case and high case, respectively.

This analysis does not attribute savings from the other discrete policy and program suggestions toward the EERS targets, but layers these additional options on top of the core EERS policy. We

[7] See: http://aceee.org/energy/state/policies/utpolicy.htm.
[8] http://www.epa.gov/RDEE/documents/rdee_toolkit.pdf

recognize, however, that there could be overlap in the savings opportunities in proven buildings/industrial programs and the other policy suggestions. Utilities could pursue broader savings options to meet EERS requirements. For example, utility activities related to improving implementation and enforcement of building energy codes could be counted towards the EERS. Also, energy efficiency utilities might pursue aggressive energy efficiency program savings in state and local public facilities. For purposes of our analysis, however, we attributed the energy savings resulting from state and local public facilities to the Energy Savings Performance Contracting policy discussed later in this section. The state may wish to allow savings from these and other policies to count toward the EERS, but if so the targets could be increased to account for the additional saving potential.

There are many examples of program designs that have proven successful over the past three decades. In the box below, we present several of these program types along with specific examples of successful implementations that are drawn from the National Action Plan for Energy Efficiency's Rapid Deployment Energy Efficiency toolkit. ACEEE's report *Compendium of Champions: Chronicling Exemplary Energy Efficiency Programs from across the U.S.* also provides a number of examples (York, Kushler, and Witte 2008). Utilities in North Carolina have already begun to run some of these energy efficiency programs; however they are far from achieving the levels of savings outlined in this EERS policy analysis. This policy would guarantee well-run, comprehensive, and cost-effective utility energy efficiency portfolio over the long-term.

ACEEE has recently created guidance language for creating an EERS, illustrating basic provisions that should be considered for inclusion in a state-level EERS, with accompanying explanations for each provision. This example is intended to provide state legislators, regulators, and other stakeholders with a starting point in drafting a state-specific EERS and as an initial framework from which the negotiation process may advance, taking into consideration the regulatory environment of the individual state. ACEEE's guidance language is available on ACEEE's website.[9]

Third-Party Administrator Model

While most states have relied upon utilities to implement electric efficiency programs, a few states with an EERS have chosen to take advantage of an existing state agency or private firm to run energy efficiency programs rather than require utilities to administer programs. The third-party administrator model has both benefits and challenges.

Having one program administrator focused solely on delivering energy efficiency programs removes some of the conflict that exists if incentives to electric utilities are not well-aligned with encouraging their customers to use electricity more efficiently. A single program administrator also has the advantage to streamline program operations for the entire state with the potential for creating economies of scale. This would also benefit some the economically disadvantaged regions of the state that are not served by the state's two IOUs, Duke and Progress, who could develop the robust infrastructure needed to deliver effective programs. An independent administrator would be able to develop the infrastructure to serve all consumers in the state with consistent energy efficiency programs.

Setting up an independent administrator can be a daunting task. In cases where a third-party administrator has been successful, such as in Vermont and New York, the agency or company was already running successful programs prior to the enactment of EERS legislation. In other cases, such

Examples of Proven Residential and Commercial Efficiency Programs: The National Action Plan's Rapid Deployment Energy Efficiency Toolkit

[9] www.aceee.org/energy/state/toolkit.htm. Given that the energy industry is becoming increasingly more dynamic, this document will continue to change and will consistently be a "work in progress," attempting to capture the most recent developments in energy efficiency resources standards.

As described in: http://www.epa.gov/RDEE/documents/rdee_toolkit.pdf

ENERGY STAR Labeled Products: This residential and small commercial sector program promotes efficient lighting (CFLs and fixtures) and appliances through a variety of incentive structures including direct rebates to the customer as well as upstream incentives. This program generally targets the broad residential and small commercial market place. Particular products may be selected for inclusion, such as lighting products or home appliances. Savings will depend upon the products included. Typical savings range from approximately 0.5 to 3.0 million British thermal units (MBtu) per participant.

Residential Energy Audit and Direct Installation: This program targets the same market and works with the same set of contractors as Home Performance with ENERGY STAR (see below); the key difference is a more basic audit and a less-extensive and lower-cost set of measures, such as CFLs, hot water heater wraps, pipe insulation, and low flow showerheads. Typical savings are approximately 3 to 6 MBtu per participant.

Home Performance with ENERGY STAR: This residential sector program offers whole home retrofits using qualified contractors, established home assessment protocols, and incentives from the program sponsor. This program can be a good strategy particularly for older pre-code constructed homes. The program is estimated to reduce home energy bills by 20 percent on average.

Residential Efficient HVAC: This program targets HVAC contractors and homeowners to increase sales and proper installation of ENERGY STAR qualified HVAC equipment, such as air conditioners and furnaces.[7] Savings are very sensitive to local climate conditions, but the minimum savings range per participant is approximately 5 to 20 MBtu.

Non-Residential Prescriptive Rebates: This program provides incentives to the commercial, institutional, and industrial market for upgrade or retrofit of equipment with new, more energy-efficient equipment, such as lighting, HVAC equipment, and products like motors and refrigerators. Particular equipment and products may be selected for inclusion in this program, such as lighting; savings depend upon the equipment and products included. Generally, a large percentage of program savings come from lighting retrofits.

Non-Residential Retrocommissioning: Retrocommissioning offers building owners a systematic process for evaluating a structure's major energy-consuming systems and identifying opportunities to optimize equipment operation. Retrocommissioning tunes-up existing buildings, improving their energy efficiency and operational procedures. It is typically carried out through local networks of commissioning providers. Typical savings range from approximately 4,000 to 20,000 MBtu per participant.

Commercial Food Service Equipment Incentives: This program rebates energy-efficient commercial food service equipment such as refrigerators, freezers, steamers, fryers, hot food holding cabinets, ice machines, dishwashers, ovens, and other technologies, primarily aiming to influence the buyer to purchase more efficient equipment when their existing equipment has failed. Typical savings range from approximately 20 to 60 MBtu per participant.

Non-Residential Custom Incentives: A commercial and industrial (C&I) Custom Program supports C&I customers in identifying and implementing site-specific and complex energy efficiency opportunities, which often require calculations to determine energy savings. A typical project may involve industrial process efficiency, chillers/boilers, data center efficiency, or electric motor retrofits, or projects that otherwise fall outside of the prescriptive program. Savings per project can be very large, but vary widely by state/industry.

Non-Residential Benchmarking and Performance Improvements: This program works with commercial facility operations staff and owners to benchmark, monitor, and improve building energy performance using tools such as ENERGY STAR Portfolio Manager and building sub-metering equipment, as well as to recommend energy efficiency upgrades based on analyses of building performance data. This program is estimated to reduce building energy use by 10 to over 30%.

Non-Residential On-Site Energy Manager: This program assists larger customers by providing an On-Site Energy Manager (OEM) to work with them for a six-month period or longer. During their tenure with a business, the OEM will evaluate facilities' energy use and work with maintenance staff to reduce energy usage and costs. Long-term energy and cost savings of 10 to 15 percent are achievable, largely through behavioral changes.

as Oregon and Wisconsin, a new independent administrator was created, but this took several years and was only possible because of the availability of a large number of local people with energy efficiency experience who could staff the start-up. This latter situation might apply to North Carolina and therefore the independent administrator model could be a valid option for the state, with the cautionary note that it could take several years to develop capacity. Even the Vermont Energy Investment Corporation (VEIC), who was already running some utility efficiency programs at the time it was charged with implementing statewide programs for Efficiency Vermont, took about four years to reach statewide savings of 1% of electricity needs per year.

The state has a number of options short of a fully independent administrator. One option for North Carolina might be to continue its track of ramping up utility-run programs while a third-party administrator develops capacity and takes over some of program administration in the future. Alternately, the utilities across the state could work together to offer the same programs statewide. Several states are examples of this, including Connecticut, Massachusetts, and California, and Indiana is moving toward this approach. To enable collaboration, the state could set up a coordinating entity similar to the Northeast Energy Efficiency Partnerships (NEEP) that has provided shared administration and marketing for some northeast utility programs such as rebates over the past 14 years (NEEP 2010). The electric cooperatives in North Carolina have already started something similar with GreenCo Solutions to help them define and meet their energy efficiency and renewable energy goals (GreenCo 2010). This effort or a parallel entity might be scaled up to ensure that all parts of the state have equal access to energy efficiency services. The key, whichever path the state elects to pursue, is to engage all stakeholders in a discussion of how most effectively and efficiently can the states meet its needs for energy efficiency services.

Manufacturing Initiative

Manufacturing accounts for about 20% of North Carolina's gross state product and electricity use. While this sector can be difficult to address in terms of energy efficiency policies and programs, it is crucial to improving employment and energy efficiency in the state. An effective statewide program will require leadership and collaboration between the government, industry leaders, and the education system.

Based on discussions with a broad range of stakeholders involved with the manufacturing sector, we propose a government/utility/industrial collaborative we are calling the "North Carolina Efficient Manufacturing Initiative." The goal of the initiative would be to address the three key barriers to expanded industrial energy efficiency identified by the stakeholders:

1. The need for assessments that identify energy efficiency opportunities;
2. Access to industry-specific expertise; and
3. The need for an expansion of the trained manufacturing workforce with energy efficiency experience.

The initiative would establish "Manufacturing Centers of Excellence" in the model of the U.S. Department of Energy's Industrial Assessment Center (IAC)[10] program, where university engineering students are trained to conduct energy audits at industrial sites. The IAC program is a highly respected program with a proven track record of reducing energy costs for manufacturers and training the next generation of energy engineers. North Carolina has a longstanding IAC center at North Carolina State University, operating since 1992. An additional center could be established at another major engineering university such as the University of North Carolina Charlotte or Western Carolina University. Expanding beyond the IAC model, these centers could partner with the 58 branches of the North Carolina Community College System to bring their students into the larger network centered around the local Center of Excellence. These nearby satellite centers would extend training and associated materials to the community college partners, and offer the opportunity for student to join the audits they conduct. This approach would allow training not just of engineers, but also technicians and equipment installers, both of which are essential to preserving energy efficiency savings in the long run.

[10] For more information on the IAC program, visit: http://iac.rutgers.edu/.

It is important that program developers evaluate programs currently doing assessments and/or training in North Carolina and elsewhere to learn what works and what doesn't. Collaborating and networking with organizations such as the Industrial Extension Service (IES) (also located at NCSU), the Manufacturing Extension Partnership (managed by IES), Waste Reduction Partnerships[11] the North Carolina Chamber Manufacturing Council, and manufacturing trade associations, the Efficient Manufacturing Initiative could provide outreach to manufacturing companies that might not otherwise be aware of energy efficiency programs. Further collaboration with the North Carolina State Energy Office's industrial energy efficiency programs would let the program rely on existing infrastructure and expertise on sustainability, energy, and job creation.

This initiative would provide multiple benefits to the state:

- Meet the needs of North Carolinas manufacturers for a trained technical workforce;
- Provide valuable real-world work experience to students interested in working in manufacturing energy management and equipment installation and operation;
- Meet the need of manufacturing facilities for reliable, knowledgeable, and affordable consultation with regard to their energy usage and opportunities for improved productivity; and
- Build capacity at educational facilities and in the MEP outreach efforts that connect North Carolina's manufacturers to the wealth of knowledge and proficiency that resides in the state.

This initiative would also be able to leverage the resources and tools developed by the U.S. DOE's *Save Energy Now* (SEN) program.[12] We also encourage the state to support an expanded federal manufacturing initiative similar to what has been suggested in recent congressional discussions[13] These proposals would represent an opportunity to leverage successful national efforts to benefit the state's manufacturers.

IAC program and implementation results recorded over the last 20 years show that this program could identify 10-20% electricity savings per facility and achieve a 50% implementation rate. Program costs for the IAC program are about $1 for every $10 saved by industry. We factor in another $0.25 per $10 saved to account for additional education costs. Under these assumptions we estimate cumulative savings of 440 GWh in 2015 and 1,790 GWh in 2025, or 7% of projected industrial electricity consumption in 2025. Pursuing this policy more aggressively would yield savings 660 GWh by 2015 and 2,680 GWh by 2025, or 11% of projected electricity consumption in 2025.

We also suggest that the state explore complementary policies that could leverage economic development programs to reduce North Carolina's industrial energy consumption. One area that North Carolina is particularly well suited to take advantage of is *smart manufacturing*[14]. Smart manufacturing, also called "active efficiency" or "information/communication technology" (ICT) among other names, involves the application of sensors, controls, and information networks to provide real-time feedback and automated adjustments to improve efficiency, quality, safety, and productivity. These advanced sensor and control systems allow for the optimization of not just equipment, but process lines, entire plants and even value chains. Several leadings firms in this area already have manufacturing or research facilities in North Carolina, including Rockwell Automation, Eaton, Siemens, and ABB. Strategic partnerships with these firms and the state's research universities and innovation resources could have the dual benefit of increased R&D funding for these and other firms as well as helping other North Carolina manufacturers take advantage of new advances in smart manufacturing. In addition to being a technical focus for the Efficient Manufacturing Initiative outlined above, smart manufacturing can be an important economic development tool, as will be discussed in a later section on clean energy innovation.

[11] For more information on Waste Reduction Partnerships, see www.wastereductionpartners.com
[12] For more information on SEN program, visit http://www1.eere.energy.gov/industry/saveenergynow/
[13] See http://aceee.org/industry/iac.htm.
[14] For more information and a roadmap on smart manufacturing, see http://www.oit.ucla.edu/nsf-evo-2008/

We encourage the various stakeholder groups to work together strategically to ensure a robust manufacturing economy for North Carolina. Funding for the Efficient Manufacturing Initiative could come from a number of sources, but one option is through government grants for "green jobs," such as those funds distributed to the states through the ARRA. If similar funds are made available in the future, as is likely through "jobs bill" legislation being considered now by Congress, we encourage government, industry, and educational stakeholders to support funding for manufacturing efficiency and workforce programs such as this one.

Rural and Agricultural Initiative

The agricultural sector is one of the most energy-intensive industries, relying on direct sources of energy, such as fuels or electricity to power farm activities, and on indirect energy resources contained in fertilizers or other agricultural chemicals. When energy prices are unstable or increasing, farmers and rural communities are impacted as agriculture becomes less profitable. Fertilizer, manufactured through an energy-intensive process, accounts for nearly 15% of total farm cash production expenses.[15]

In rural areas, such as western and northeastern North Carolina, updates to modernize the electric grid are expensive, and investing in on-farm energy efficiency or renewable energy is a more cost-effective option—a near-term resource available to respond to immediate energy challenges in rural communities.

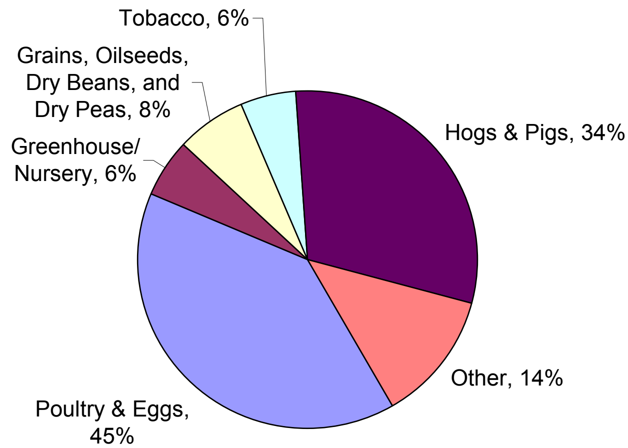
A conservative analysis of the energy cost saving potential in the agricultural industry in the U.S. shows these savings to be over 34 trillion Btus and one billion dollars per year (Brown and Elliott 2005). This analysis covers the direct benefits from energy savings, but does not include non-energy benefits, such as increased financial stability due to reduced energy cost exposure. The 2005 ACEEE study referenced above estimates significant savings by increasing energy efficiency in the production several commodity crops—4.5 trillion Btu and $67.6 million per year in the poultry industry, and an amazing 17.1 trillion Btu and $167.7 million dollars per year in grain and oilseed operations.

Agriculture by the traditional definition of crops and livestock makes up a little more than 2% of North Carolina's industrial sector electricity use, averaging 670 GWh per year. North Carolina's agricultural sector includes several energy-intensive industries, including many large-scale poultry farms producing commercial broilers in the Piedmont region as well as large-scale swine operations, field and nursery crops. In recent years North Carolina reached new record highs in livestock production, recording 10,200,000 hogs in 2007 and 769,100,000 commercial broilers in 2008.[16] Major sources of energy use for these types of livestock operations include lighting, ventilation, and heating/cooling.

[15] USDA. 2006. 2007 Farm Bill Theme Paper: Energy and Agriculture. www.usda.gov/documents/Farmbill07energy.pdf

[16] North Carolina Department of Agricultural & Consumer Services. 2009. Agricultural Statistics—2009 Statistics Book: Livestock, Dairy and Poultry. www.agr.state.nc.us/stats/2009AgStat

Figure 2.11. Estimated Electricity Consumption of North Carolina Commodity Crops (2007)



Source: USDA (2007)

Up until the 1990s, electric utilities, in conjunction with groups such as Advanced Energy and the cooperative extension service and experiment station system provided extensive technical assistance on energy efficiency to these important agricultural markets (Elliott 1993). As electricity prices fell, utilities explored deregulation and extension budgets fell during the 1990s, many of these efforts declined or were discontinued, mirroring a national trend. As a result, significant infrastructure for delivering energy efficiency faded.

In the past decade we have seen renewed interest in agricultural energy efficiency as energy prices soared and the U.S. Congress passed an energy title as part of the *2002 Farm Bill*. Organizations specifically dedicated to improving farm and rural small business energy efficiency have emerged to fill this space. Existing energy efficiency programs are widening their focus to include agricultural energy efficiency issues and to provide more on-line and on-farm audits, as well as both technical and financial support. The Energy Title (IX) of the *2008 Farm Bill* provides more funding than previous legislative efforts to the Rural Energy for America Program (REAP, formerly Section 9006), which provides technical assistance and audits, as well as grants and loan guarantees for energy efficiency and renewable energy projects to farms, ranches, and rural small businesses. Of 1,524 REAP awards in 2009, 61 were for projects within North Carolina, totaling $1,881,096 in grants and loan guarantees.[17] REAP funding was initially restricted to rural agricultural applications, however beginning in 2010 funding is available to all agricultural producers, regardless of location.[18] Although there is more money and awareness today, many states still lack the internal structure to aid their farmers, ranchers, and rural small businesses in leveraging these *Farm Bill* funds.

The *2008 Farm Bill* also authorized a new program that will provide financial assistance toward increasing the energy self-sufficiency of rural communities. The *Rural Energy Self Sufficiency Initiative* will fund energy assessments, help create blueprints for reducing energy use from conventional sources, and install community-based renewable energy systems.[19]

The initiatives described below are meant to build capacity within the state of North Carolina in order to better provide energy efficiency-related knowledge, assessments, technical assistance and funding for rural small businesses and agricultural operations.

[17] From the Environmental Law and Policy Center (ELPC) http://farmenergy.org/news/2009-reap-award
[18] Note: Small businesses still must be located in rural areas in order to receive funding.
[19] See Title VI, Energy Efficiency and Renewable Energy Programs for related program information: http://www.ers.usda.gov/FarmBill/2008/Titles/titleVIRural.htm#rural1.

1. Develop an educational program to be administered through the Rural Electric Cooperatives, the North Carolina Farm Bureau and the Extension Service

The North Carolina Department of Agriculture, in conjunction with the North Carolina Farm Bureau, the North Carolina State Extension Service, and the North Carolina Rural Electric Cooperatives should establish an educational program that would disseminate information on energy efficiency best practices for farmers, ranchers and rural small businesses. This effort could take the form of a partnership with national organizations, such as the Rural Electricity Resource Council (RERC)[20] or the USDA-RD.

Several examples of state-specific educational programs exist that North Carolina can use as models. Southern California Edison utility runs an agriculture program that "promotes energy-efficient solutions for small and large farms, ranches, and dairies."[21] Their Web site provides information on a number of topics, including the Agricultural Technology Application Center (AGTAC). The latter, an "educational resource energy center," includes hands-on displays and exhibits which are open to public; demonstrations of energy-efficient technologies; educational seminars and free workshops; and provides information regarding scheduling consultations with energy experts. AGTAC "connects customers to energy-related technology solutions that are energy efficient, positive for the environment, and cost competitive."[22]

In the Midwest, the Iowa Energy Center funded a project looking at the "Development of an Energy Conservation Education Program for Iowa's Livestock and Poultry Industry."[23] The work products of the study will include a curriculum, with day-long training sessions for farmers, fact-sheets and a reference manual covering energy efficiency techniques, and a training regimen for extension agricultural field specialists, to assist with the distribution of the educational materials.

North Carolina recently initiated a Sustainable Local Food Advisory Council (via Senate Bill 1067 in 2009), with the goal of building a local food economy which will create jobs, save energy and revitalize local communities.[24] Although in the nascent stage, the Council's next meeting will develop a Farm to Fork Strategic Plan. ACEEE recommends that the Advisory Council prominently include energy efficiency in its future local food initiatives.

2. Further leverage the USDA-REAP program

North Carolina utilities and extension services should make every effort to leverage the reauthorized USDA REAP program, which has $255 million dollars in mandatory funding for 2009–2012, to expand energy efficiency and renewable energy efforts throughout the state. ACEEE recommends that these entities provide on-site audits to farmers, ranchers, and rural small businesses as a preliminary step in the REAP application process. Pinpointing areas where a farmer could save energy or implement an energy efficiency project is the first step toward identifying a successful REAP project.

Mississippi is one of many REAP success stories. Poultry and egg production is the top agricultural commodity in Mississippi, with 2,800 producers and over $2 billion dollars in annual sales. Energy costs can reduce broiler producer's revenue by 20% due to inefficient energy use in poultry housing. The Mississippi State Poultry Science Department held educational workshops and provided application assistance to producers, resulting in REAP funding for over 80 projects between 2003 and 2007, totaling around $3 million dollars.[25]

[20] RERC's Web site, www.rerc.org, provides materials on energy efficiency and is a national center for information on rural electricity topics.
[21] http://www.sce.com/b-rs/agriculture/
[22] http://www.sce.com/b-sb/energy-centers/agtac/
[23] http://www.energy.iastate.edu/Efficiency/Agricultural/cs/harmon_conserv.htm
[24] Learn more about the North Carolina Sustainable Local Food Advisory Council at http://ncagr.gov/localfood.
[25] http://farmenergy.org/success-stories/energy-efficiency/mississippi-poultry-growers

Alliant Energy operates a rebate and audit program for livestock and grain operations in Iowa, Minnesota and Wisconsin. The program has been in effect for more than 20 years, with over four hundred participating farms in 2006 and annual savings of 8-10 million kWh. The program also assists customers in applying for USDA funding, offering assistance for both grant application and project implementation. Specifically, the on-farm audit identifies energy waste, potential energy-efficient technologies to reduce energy usage, recommends efficient equipment specific to the operation, and provides information on available agricultural rebate programs. Operators can also earn cash back for purchasing recommended equipment.[26]

North Carolina has already begun to offer this important service, providing low-cost farm energy audits under the auspices of the Farm Energy Efficiency Project (FEEP). Funded by the N.C. Tobacco Trust Fund Commission and managed by the North Carolina Farm Bureau, FEEP participants have seen average savings of $16,157 and 733 mmBtu. The N.C. Farm Bureau administers the program through a number of contractors who perform the audits, including EnSave. EnSave, a for-profit entity based in Vermont, works in a number of states implementing programs that range from dairy efficiency and diesel emission reduction to programs that operate farm energy audits and provide rebates for implementation of on-farm energy efficiency measures. As part of their work in North Carolina for FEEP, EnSave is not only administering audits, but is also working to educate participating farmers, collecting data on farm energy use and training in-state data collectors.[27]

3. Create a pool of matching funds for USDA grants

To further promote the implementation of energy-efficient technologies and projects, North Carolina could consider establishing a pooling matching fund for these USDA-REAP grants. Availability of these funds could prove vital for successful REAP applications, as the USDA is considering availability of non-REAP funding as a criterion for the application ranking process. This funding pool could be established through the utilities, with savings from the efforts credited to the state REPS or EERS as suggested in this report, or from another funding source.

The New York State Energy Research and Development Authority (NYSERDA) runs the *FlexTech* program, providing cost-sharing of energy audits or feasibility studies of improvements and load management techniques that would save money on farmers' energy bills. The NYSERDA program is open to all sectors, but could be adapted in North Carolina to focus exclusively on agricultural operations as a tie-in with the USDA-REAP program funding. Across all sectors, *FlexTech* realizes $5 in energy savings and $17 in implementation/construction costs for every dollar spent on feasibility studies (Brooks and Elliott 2007).

Building Energy Codes

North Carolina's current building energy codes are relatively stringent compared to other southeastern states, and the state is poised to update its energy codes in the spring of 2010 that go beyond efficiency levels of the national model code. Building energy codes are a foundational statewide energy efficiency policy to ensure that energy efficiency is integrated into all new buildings in North Carolina. If efficiency is not incorporated at the time of construction, the new building stock represents a "lost opportunity" for energy savings because efficiency is difficult and expensive to install after construction is completed. Because builders have little incentive to maximize energy efficiency in new construction, mandatory building energy codes are one way to ensure energy efficiency by requiring a minimum level of energy efficiency for all new residential and commercial buildings. Although enforcing compliance with energy codes can be difficult and costly, simple and transparent codes, which allow contractors to follow either performance-based or various prescriptive-based paths, help facilitate greater compliance.

North Carolina is estimated to add an additional 33,000 homes in 2010 or another 1% to its existing housing stock of around 4 million. This pace is expected to increase to 1.8% growth in housing units

[26] More information on the Alliant Energy-IPL Farm Energy Audit program can be found on their Web site: http://alliantenergy.com/docs/groups/public/documents/pub/p014750.hcsp.
[27] www.ensave.com/north-carolina-farm-project.html

per year by 2014 (Moody's 2009). Based on employment forecasts, which is expected to be flat in 2010 and steadily increase its pace thereafter, we estimate commercial construction to grow on average at about 2% per year between 2011 and 2025 (Economy.com 2009).

The North Carolina State Building Code Council (SBCC) is responsible for developing statewide codes and the state legislature has final authority to adopt code criteria. North Carolina's current energy code is based on the 2006 International Energy Conservation Code (IECC) with state amendments, which was adopted by the Code Council and became effective in 2009. The residential building code primarily addresses space heating and cooling energy consumption by requiring improved insulation, window technologies, heating and cooling systems, and sealed air and duct leaks. In March 2010, the North Carolina Building Codes Council accepted amendments for the 2012 residential and commercial building energy codes, which were based on the 2009 IECC with additional North Carolina amendments. The updated codes are estimated to go beyond IECC 2009 to achieve 30% savings compared to the IECC 2006. In June, the council will hold public hearings on the updated codes and in September the council will vote for final approval before going to rules review by the state legislature. If adopted, the codes become effective in 2012.

The Codes Council is demonstrating commitment to improve efficiency in the state's new buildings by working to achieve savings beyond the national model code. The Council can continue this trend by pursuing a 50%-beyond IECC 2006 code in the next code adoption cycle, joining a national effort to achieve this level of savings by 2018. In fact, the North Carolina code council in March approved the formation of a committee to begin research on a 'green building code' for the state. The committee will use the International Green Construction Code (IGCC) public version 1.0 as its starting point, and will continue to follow the IGCC updates in 2012. The international green code addresses broad energy and environmental factors, include water conservation, materials, land-use planning, and could have stronger end-use energy efficiency requirements. As a fast growing state, North Carolina stands to achieve significant energy savings and economic benefits by pursuing these more aggressive building energy codes for new construction.

Compliance and enforcement are critical in achieving the full savings potential from new building energy codes. Currently Appalachian State University holds training sessions for builders and inspectors to work toward this end. Through a competitive grant from the Department of Energy to update the state's building energy codes, the University has identified several training needs: training new performance features of the code: hands-on training session in the classroom and field; web-based training; photo handouts; and technical assistance by phone. There is also a need for greater compliance surveys of new buildings and a dedicated funding source for biannual survey reports is needed to support this effort. Also, dedicated energy code inspectors should be hired in areas with the highest levels of construction.

In our medium case scenario, we assume that the updated North Carolina building code with amendments is adopted in 2010, becomes effective in 2012, and would reduce energy consumption by 30% in new residential and commercial construction relative to the 2006 IECC. Code enforcement and training efforts are expanded to achieve 70% compliance in 2012, ramping up to 90% compliance by 2014. Under these assumptions, we estimate cumulative savings of 2.290 GWh and 3,120 GWh by 2025 for the residential and commercial sectors, respectively, for a total of 5,400 GWh or 3.4% of the state's electricity needs.

Our high case scenario builds upon the medium case to include the adoption of the 2018 IECC in 2019, effective 2021, which would reduce energy consumption by 50% relative to the 2006 IECC. Under these assumptions, we estimate cumulative savings of 2,800 GWh and 3,700 GWh in by 2025 for the residential and commercial sectors, respectively, for a total of 6,500 GWh.

New building codes require a commitment by the state to enforce the higher standards and must be given time to ramp up. Assuming that resources are dedicated to these efforts, we estimate enforcement of each code begins at 70% compliance in the first year, 80% in the second year and 90% in the third and subsequent years.

Advanced New Buildings Initiative

An Advanced New Building Initiative would encourage high efficiency, beyond-code new residential and commercial buildings. Because this market has been very slow to develop on its own due to split incentives (builders do not pay the energy bills for the home or building) and higher up-front costs, this initiative would enable the market by providing technical assistance and financial incentives to encourage high efficiency new construction. Several utilities in North Carolina currently offer incentives for new ENERGY STAR homes, which achieve 15% savings beyond typical new homes. This new initiative could direct builders to ENERGY STAR new home incentives, but would predominately be charged with achieving 30% and 50% beyond code savings and net-zero energy homes. The goal of the program is to increase market share for high performance new building practices while preparing the market for updated building energy codes.

There are several excellent resources on how to model an effective advanced new buildings program. The U.S. Department of Energy, for instance, has developed materials on how to achieve significant savings in new and existing buildings.[28] Another useful source of information is the New Buildings Institute, which has a Web site on "Getting to Fifty" [percent savings].[29] ENERGY STAR also publishes a breadth of information on energy efficiency in commercial buildings and industrial plants.[30] Providing financial incentives to contractors or building owners will be crucial to guaranteeing that efficiency measures are implemented beyond what is already required by code. The Energy Policy Act of 2005 included a $1.80/square foot tax deduction for commercial building owners for each building constructed that uses 50% less than a new building designed to a national model reference code. Commercial contractors can also visit the Tax Incentives Assistance Project (TIAP) Web site for federal tax incentives for commercial energy efficiency investments: www.energytaxincentives.org.

The medium case scenario assumes that an Advanced New Buildings Initiative targets beyond-code energy savings to reach 50% electricity savings in new residential and commercial buildings, starting at 3% of new buildings in 2011 and reach 30% of new buildings by 2025. In the medium case scenario, building energy codes are updated to 30% beyond the 2006 IECC, making this new buildings initiative go beyond code and prepare builders to eventually meet 50% savings in all new buildings. This program meets about 1% of the state's electricity needs in 2025.

In the high case, the program first achieves 50% savings in half of all new buildings by 2020 in advance of the new code taking effect in 2021, which mandates 50% savings in new buildings. Starting in 2021, the Advanced New Buildings program targets 'net-zero energy' homes for 2% of new construction and reaches 6% new homes by 2025. The program also targets residential sales, so that upon turnover reach 50% savings beyond the 2006 IECC. The initiative might target high growth or home sales areas or counties only. We estimate that 25 counties represent 80% of population growth, and the program could ramp up from 50% of growth to 80% by 2025. This assumes 30% compliance of the program ramps up to 50% compliance by 2020.

Behavioral Initiative

Guided by research in social psychology from the past several decades, utilities and the energy industry have recently come to appreciate the power of providing consumers with localized, comparative information on household energy consumption to influence their behavior and encourage energy conservation. Comparative information, in the form of periodic reports, is equivalent to having an in-home energy monitor that provides information such as seasonal variations of energy use and goes a step further by providing a comparison of one household's consumption pattern to similar households. When households are given information on how they perform relative to their peers, they are motivated to follow suit. Robert Cialdini, a social psychologist, regards this as "social proof," or an instinct akin to peer pressure (Tsui 2009).

[28] http://www.eere.energy.gov/buildings/highperformance/
[29] http://www.advancedbuildings.net/
[30] http://www.energystar.gov/index.cfm?c=business.bus_index

A company called OPOWER has this "social norms" concept to improve energy efficiency among residential customers. They have shown that mailing utility customers periodic reports on their household electricity consumption and comparing that usage to other customers with similar demographics and housing characteristics in the same neighborhood can reduce household consumption between 1.5% and 3.5%. The personalized reports show monthly electricity usage that compares one's usage patterns to similar neighbors as well as to those neighbors that are relatively more successful (or unsuccessful) in achieving energy savings in their home. Based on individual household consumption patterns, the reports also make efficiency recommendations—ranging from simple steps like turning down your thermostat to more time- or dollar-intensive steps like purchasing ENERGY STAR products[31]—that quantify the potential savings, both in kilowatt-hour and dollar terms. Rebate coupons targeting a household's more energy-intensive end-uses are simultaneously issued with the reports, increasing the probability that consumers will respond to the efficiency recommendations.

The suggested behavioral initiative for North Carolina households is based on OPOWER's program illustrated above, though we acknowledge that other private sector companies are developing similar online resources to encourage behavioral change. Readers should note several caveats to this program. First, as this policy is intended primarily to impact consumer behavior, we assume that the only costs incurred are for program and administrative purposes, such as marketing and the issuing of reports. Any investment costs, such as purchasing efficient equipment or incentives provided by utilities, are borne by utilities through their efficiency programs. Second, we also assume a one-year persistence rate, i.e., that savings realized in one year are not perpetually generated unless the participant stays in the program. While savings may persist longer, results from these types of programs are still relatively new and we therefore assume a one-year persistence.

In our medium scenario, we assume a five-year pilot program, where participation is steady at 2.5% for those five years and savings begin at 0.5%, increasing by 0.5% for the first three years and by 1% for the final two, peaking at 3.5%. Per-household savings then remains at 3.5% for the remainder of the analysis period, while participation in the program increases by 2.5% annually, culminating in 60% participation by 2025. Under these assumptions, we estimate the program meets about 1% of the state's electricity needs in 2025.

Both Progress and Duke are currently exploring the launch of behavioral program offerings. We treat the savings from the statewide behavior initiative as additional to the EERS, so if a behavioral component were to be allowed to count toward the utility targets, the target levels could be adjusted. In the medium case, for example, the EERS could be adjusted to 1.5% incremental annual savings by 2017 and 2% incremental annual by 2020. Because the initiative ramps up over time, the near-term EERS targets would not change significantly.

Discussions with OPOWER revealed that a more advanced program could be facilitated by the integration with smart metering, where consumption information could be collected at the end-use level, such as HVAC, lighting, water heating, etc., allowing for more detailed reports and efficiency recommendations. For our high case scenario we assume the same initial five-year pilot program with the same participation and savings rates. Participation increases by 2.5% annually from 2015 through the remainder of the analysis, for a final participation rate of 60%. Per-household savings reaches 5% by 2020 and we again assume a one-year persistence rate. Under these assumptions, we estimate the program meets 1.4% of the state's electricity needs in 2025.

Public Facilities Energy Savings Performance Contracting

Federal, state, and local governments have used a strategy known as "leading by example" to encourage adoption of energy efficiency measures within their constituencies. In this approach, governments make efficiency improvements to public buildings to demonstrate achievable savings and increase market share of emerging and high efficiency technologies. In North Carolina,

[31] Presently, OPOWER has 150 different conservation/efficiency recommendations that it can cycle through or present depending on household consumption patterns.

government buildings account for about 30 percent of the commercial electricity demand, so efficiency improvements to these buildings can save significant amounts of energy. To this end, North Carolina has undertaken a series of performance contracting projects to improve the efficiency of these buildings.

Passed in 2007, North Carolina Session Law 2007-546 mandates that all State agency buildings and State institutions of higher learning reduce energy consumption 20 percent by 2010 and 30 percent by 2030 relative to consumption for the 2003-04 fiscal year. These agencies and institutions must develop yearly objective plans to increase energy and water efficiency. The State has created a training program for facility managers to teach them cost effective means of reducing energy and water consumption.

Another recent law, SL 2009-375, passed in 2009, raised the cap for public spending on performance contracting from $100 million to $500 million. To date, North Carolina has completed three major performance contracting projects: the North Carolina Museum of Art, the DOA Downtown Complex, and the UNC Greensboro campus. The Museum of Art, now in its second guarantee period, has seen dramatic energy savings in the range of 60 percent. One other project, Appalachian State University, is under construction, and another dozen projects are in various stages of the application process. Funding for these projects comes exclusively from bank loans that typical require 10-15 year terms. While these terms allow project managers to include some measures with medium longer term payback periods, the majority of measures included must have quick paybacks. With longer term loans, projects could incorporate more capital intensive work such as addressing the building infrastructure that can have longer payback periods (Hoey 2010).

In the South-Atlantic region, government buildings account for 30 percent of commercial electricity consumption. Both our medium case and high case scenarios build off of the energy savings mandate from North Carolina Session Law 2007-546. Our medium case scenario assumes 20% percent savings from 80 percent of all state and local facilities by 2025. We project that participation gradually ramps up, resulting in 179 GWh savings in 2011, and increasing to 412 GWh in 2025. This results in a cumulative 2880 GWh savings through 2025. Costs are based on average utility program costs of $0.23 per first year kWh in the commercial sector. These savings have a 13-year average lifetime and a levelized cost of $0.025 (Friedrich et al. 2009). We assume that administrative costs will add 10 percent to this measure's cost, resulting in a total cost of $106 million in 2025.

Our high case scenario assumes 30 percent savings for government buildings, and ramps up at a greater rate, reaching 100 percent participation in 2025. This results in a savings increasing from 214 GWh in 2011 to 639 GWh in 2025, and a cumulative savings of 5400 GWh. Total costs are projected to reach $165 million in 2025 for the high case scenario.

Manufactured Homes Initiative

There are about 600,000 manufactured homes in North Carolina, which represents 14 percent of the total housing stock (Census 2008). In rural areas of the state, manufactured housing accounts for a large percentage of housing (Conlin 2010). Despite the fact that these homes are generally smaller than site-built homes, their energy costs can often be much higher. In fact, manufactured homes can be about 25% more energy intensive than site-built homes. Additionally, many manufactured homes in use today were constructed before 1976 when the HUD Code (the federal code mandating the minimum standard for manufactured housing) was enacted.

Replacing pre-HUD Code homes with new ENERGY STAR units can save an average of 6200 kWh per year and 175 therms of natural gas annually (Levy 2009). Many pre- and post-HUD code homes are also excellent candidates for cost effective efficiency retrofits including duct sealing, insulation improvements, and HVAC upgrades. Contractor experience in North Carolina has shown duct leakage can reach as high as 30 percent, but through sealing can be reduced to as little as 3 percent (Conlin 2010). This measure alone can drastically reduce the heating and cooling loads of these homes.

Currently, there are two programs that address energy efficiency in manufactured homes in North Carolina, the Weatherization Assistance Program (WAP) and Upgrade and Save. Upgrade and Save is a statewide North Carolina initiative aimed at increasing market penetration ENERGY STAR manufactured homes with heat pumps. The program provides a $500 incentive per home to manufactured home retailers to install heat pumps in ENERGY STAR-labeled homes prior to sale. These homes are typically about 30 percent better than a standard HUD-Code certified home and provide about $600 in annual savings to homeowners (Duncan 2009). Upgrade and Save also offers a limited number of incentives to homeowners of recently purchased homes (built 2003 and later) to upgrade to heat pumps. These homeowners can receive up to a $1500 match to upgrade electric furnaces to heat pumps. Currently, funding is set to expire for Upgrade and Save because the source of funding is running out. Subject to program evaluation, it may be advisable for North Carolina to extend funding for Upgrade and Save to enhance market penetration of heat pumps in manufactured homes.

WAP is a national program that provides funding to low-income residents for home retrofits to improve energy efficiency. For 2010, WAP has an operating budget of $3.2 million from DOE. DOE funding has varied over the past decade between $2.8 million and $9.8 million, but is usually in the area of $4 million. Additionally, WAP will receive $132 Million from ARRA, to be used through March 31, 2012. ARRA grants significantly enhance the scope of WAP, but this boon is short-term. Typically, about 30 percent of this funding goes towards weatherization of manufactured homes. WAP spends an average of $3000 per home on weatherization, but with the incorporation of ARRA funding, this level will temporarily expand to about $4000 (Taylor 2009). Program administrators have found that this level of funding has been sufficient to meet current program goals, but increased funding could lead to more comprehensive retrofits or the ability to raise the minimum income level for recipients (Taylor 2009). As community action agencies in North Carolina administer weatherization projects in manufactured homes, it is important to evaluate the quality to work to ensure that maximum potential savings are achieved and that high quality construction is assured. In order for North Carolina to meet its energy efficiency potential, rigorous assessment of delivered energy savings is essential. Furthermore, residents' satisfaction with weatherization projects is important in maintaining trust and credibility among constituents and future recipients of weatherization assistance.

One challenge to administering efficiency programs for the manufactured housing stock involves the income "sandwich." Only homeowners with incomes of 200 percent or less of the Federal poverty limit or those receiving cash assistance payments under Work First or Supplemental Security Income can qualify for WAP. Homeowners with the means to afford a new home can benefit from an ENERGY STAR certified home with a heat pump through the Upgrade and Save program. However, about 50 percent of manufactured homeowners fall into the middle of these two categories- they do not qualify for low-income assistance, but can neither afford to purchase a new home nor make the necessary modifications to make their homes more energy efficient. These homeowners may greatly benefit from an on-bill loan program or a bank loan that allows them to repay through energy savings.

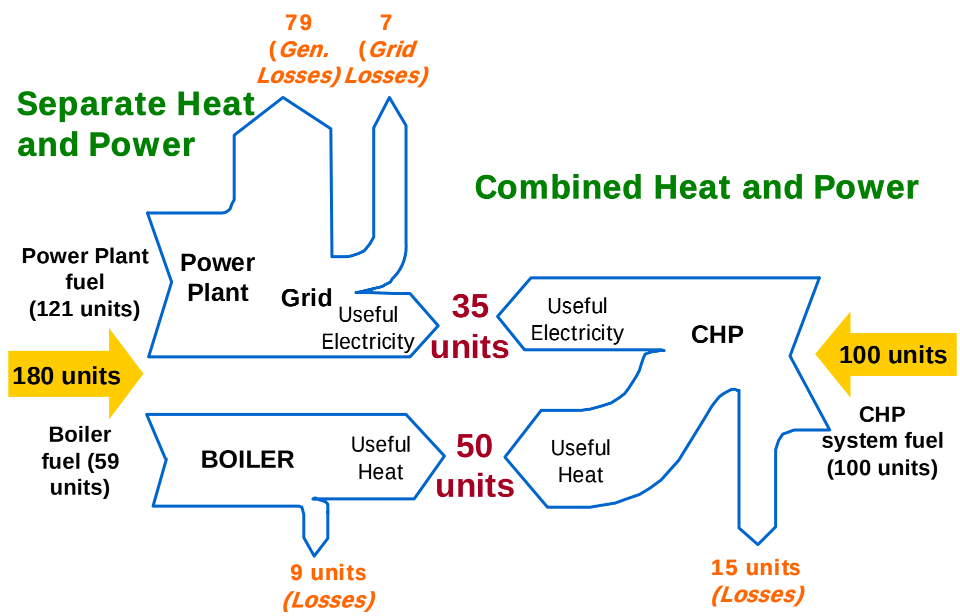
Both our medium case and high case scenarios build on current levels of funding for Upgrade and Save and WAP. Our analysis only included WAP funding for manufactured homes. Our medium case scenario assumes a gradual ramping up of homes weatherized from 1000 in 2010 to 13,000 in 2025, resulting in 97,000 homes, or 15 percent of the manufactured housing stock by 2025. Homes are weatherized at a cost of $4000 per home through March 2013 until ARRA funding ends, and then at a cost of $3000 per home through 2025. Home weatherizations will save about 25 percent per home with the additional funding from ARRA and 20 percent per home thereafter. This will save a projected 5 GWh in 2010 and cumulative 1,454 GWh by 2025 at a cost of $73 million in 2025. For Upgrade and Save, our projections build off of the reported 288 homes upgraded in 2009 and gradually ramp up to 2500 homes in 2025. Given that ENERGY STAR manufactured homes with heat pumps use about 30 percent less energy than homes meeting the HUD code minimum efficiency standards, this measure will save 1.5 GWh in 2010 and 11 GWh in 2025. Cumulatively, our projections show the potential for Upgrade and Save to realize 89 GWh in energy savings through 2025 at a cost of $1.25 million.

For our high case scenario we again assume 1000 homes weatherized in 2010, ramping up at a greater rate and reaching 26,000 homes in 2025. This amounts to a total of 167,000 homes weatherized through 2025, or 25 percent of the manufactured housing stock by 2025. Assuming the same funding per home and same level of savings as our medium case scenario, this measure will save 455 GWh in 2025 and a cumulative 2,265 GWh at a cost of $152 million. Likewise, our high case scenario for Upgrade and Save ramps up participation at a greater rate than our medium case scenario from 350 homes in 2010 to 4,000 homes in 2025, or about 74 percent of projected sales. At 30 percent savings per home, this will realize about 17 GWh in savings in 2025 and a cumulative 130 GWh at a cost of $2.0 million in 2025.

Combined Heat and Power

Combined heat and power improves efficiency by combining usable thermal energy (e.g., chilled water and steam) and power production (e.g., electricity). This co-generation process bypasses most of the thermal losses inherent in traditional thermal electricity generation, where half to two-thirds of fuel input is rejected as waste heat. By combining heat and power in a single process, CHP systems can produce fuel utilization efficiencies of 65% or greater (Elliott and Spurr 1999).

Figure 2.12. Schematic Comparing a Combined Heat and Power System to Separate Heat and Power Systems



While CHP can represent an attractive energy efficiency opportunity, it can face significant regulatory and market barriers that can inhibit it implementation. Among the key barriers are:

- Electric utility interconnections standards and implementation policies;
- Utility tariffs with respect to backup and supplemental power;
- Uncertainty about fuel prices;
- The inherent capital intensive nature of CHP projects; and
- Air emissions regulations that do not recognize the emissions benefits of increased energy. Efficiency.

While some of these barriers can be addressed through state regulations and policies, others are imbedded in market realities and utility operating practices that can effectively discourage implementation of CHP systems (Elliott and Spurr 1999; Shipley et al. 2008). In general, North Carolina has more favorable policies toward CHP than many other states in the Southeast. CHP is explicitly included in the state's SB-3 REPS, allowing for substantial market certainty for CHP developers. But there are other policy areas in which CHP could be better supported by the state.

North Carolina's interconnection standards that apply to CHP were adopted in 2008 and include three different tiers of interconnection. The smaller tiers are clearly defined and offer expedited processing. However, they apply to systems below two megawatts, which will generally not cover most CHP systems in the state. The top tier, which applies to systems of two megawatts and greater, appears to lack some clarity, leaving larger systems subject to a "study process," which creates cost and schedule uncertainty for these projects.

The 2007 SB-3 establishing the state's REPS also directs the North Carolina Utilities Commission to develop interconnection standards covering systems up to 10 MW in size[32]. Though such interconnection standards have yet to be developed, the Commission has been given clear direction and could certainly increase support for CHP by establishing such interconnection standards.

North Carolina does little to encourage CHP through its standby rates. Duke Energy Corporation's applicable standby rates are not favorable toward CHP, as they charge actual usage through a very high demand rate. Progress Energy Carolinas has a slightly less penalizing rate, but it is still only seen as neutral toward CHP—certainly not actively encouraging such systems. Because standby rates can so dramatically impact the economics of a CHP system, we suggest that the North Carolina Utilities Commission encourage the development of more favorable standby rates among its regulated utilities in the near future as specific rate cases arise. The United States Environmental Protection Agency offers substantial guidance for the development of "good" standby rates.[33]

North Carolina does not have any financial incentives that specifically target CHP projects, nor does it offer any tax incentives for such projects beyond the 10% Federal Investment Tax Credit that will be available through 2016.[34] Programs such as the North Carolina Green Business Fund may be used for CHP, but it does not explicitly target CHP. The state also offers the North Carolina Energy Improvement Loan Program, which offers loans up to $500,000 at 3% for energy efficiency projects, including CHP.[35]

Finally, output-based emissions regulations (OBR) are essential to the equitable treatment of CHP systems. These air quality regulations take the useful energy output of CHP systems into consideration when quantifying a system's criteria pollutant emissions. Many states employ emissions regulations for generators by calculating levels of pollutants based upon the fuel input into a system. For CHP systems, electricity *and* useful thermal outputs are generated from a single fuel input; therefore, calculating emissions based solely on input ignores the additional power created by the system, using little or no additional fuel. Output-based emissions acknowledge that the additional useful energy output was created in a manner generally cleaner than separate generation of electricity and thermal energy.[36]

The Division of Air Quality (DAQ) at DENR has not implemented regulations that embrace the OBR guidance issued by U.S EPA. We suggest that DAQ review its CHP regulations and consider adopting U.S. EPA's most recent guidance.

While the state appears to have many some of the policies in place to encourage, the reality on the ground is that other barriers proving an impediment for CHP implementation. Currently, there are fifty-nine CHP plants operating in North Carolina that represent about 1500 MW of capacity (ICF 2010). New installations are not occurring statewide however. The 13 sites installed in North Carolina over

[32] The legislation can be found here: http://www.ncleg.net/Sessions/2007/Bills/Senate/PDF/S3v6.pdf
[33] Additional information can be found here: http://www.epa.gov/chp/state-policy/utility.html.
[34] For more information on the Federal CHP tax credit, visit: http://energytaxincentives.org/business/chp.php.
[35] http://www.energync.net/funding/eilp.html
[36] Additional information on OBR is available from EPA's *CHP Partnership* website: http://www.epa.gov/chp/state-policy/output.html.

the past five years are almost all in ElectriCities territory—that is, they are not subject to the same regulations as systems in investor-owned utility (IOU) territories. These CHP systems are also almost all located in the eastern part of the state, where a company called PowerSecure works with municipal utilities and electric cooperatives to contract with IOUs for the purchase of electricity. These IOU contracts include a significantly punitive coincidental peak clause, encouraging the use of distributed generation for reducing peak demand. The new CHP projects are also all PURPA qualifying facilities, further allowing them to circumvent regulatory hurdles (McAllister 2010).

CHP systems in North Carolina, particularly smaller systems also currently face economic challenges from high and uncertain natural gas prices and low electric prices when combined with the cost imposed on the projects by market and regulatory barriers. Our analysis suggests that the energy economics are likely to improve in the coming years as electric prices rise faster than natural gas prices.

This market reality suggests that regulators, including the NCPUC and DENR continue to have a role to play in improving utility and emissions regulations. Our analysis estimates a significant potential for increased CHP systems in the state.[37] In a business-as-usual scenario, North Carolina could expect to see an additional 135 MW of CHP systems come online. In the medium case energy efficiency policy scenario with removal of some of the regulatory and market disincentives, there is potential for about 340 MW of new capacity beyond the BAU scenario. This potential could increase to 1025 MW of new capacity in the high case scenario. These levels of CHP are equivalent to 1% and 4% of the state's electricity needs in 2025 in the mid and high case, respectively.

Customer Financing for Energy Efficiency

The up-front costs required for energy efficiency investments can often deter property owners from pursuing efficiency projects, especially during periods of economic uncertainty when consumer confidence is low. An important goal of policies and programs is to help minimize the initial costs of energy efficiency projects or upgrades so owners are encouraged to invest in efficiency. Below we discuss several options that either encourage consumers to purchase more efficient homes or allow property owners to make energy efficiency retrofits by reducing up-front costs while ensuring that they maximize savings.

For homebuyers, a key strategy is making sure that energy-efficient mortgages are available for purchasers of energy-efficient homes and manufactured houses. Energy-efficient mortgages should be attractive to lenders by reducing the risk of the loan because energy bills are a major household expense, particularly for moderate income households, and lowering energy bills frees up more income to make mortgage payments. To date, we have seen very little interest in the mortgage lending community in North Carolina (Tingen 2010). With increased prevalence of home ratings such as ENERGY STAR, both for new and existing homes, identification of qualifying properties should not be a barrier. The state is in a position to encourage lending practices that take efficiency into consideration.

One important aspect of financing mechanisms is that the debt can be spread out over the course of several years, if not decades, which decreases the annual costs thereby increasing the annual savings from the efficiency improvements substantially. Energy efficiency improvements to a property also help to increase the overall property value, and improve the cash flow of property owners (from reduced liability relative to the upfront costs), and improve resale value.

- On-Bill Financing (Collecting): This loan mechanism allows property owners to repay their debt through a fee on their electric bill or in some cases on other utility bills such as water or sewer. The loan can be financed either by the utility or a third-party financer, although the fee would be collected by the utility. The loan may be attached to the property.

[37] The analysis of CHP was done by Energy Environmental Analysis, a division of ICF International.

- Property Tax Financing (Collecting): This is a similar model to on-bill financing, except that instead of using utility bills as the collection mechanism, the local government issues a surcharge on the annual property tax bill. The financing entity in this case would be the local government, which again could work with a third-party financer.

- Property Assessed Clean Energy (PACE) Bond Financing: A PACE bond is a debt that is backed by assessments against residential, commercial or industrial property that allows the owners to pay the expense of retrofitting their homes, buildings, or facilities through assessment payments normally connected with their property taxes. The bonds can be issued by municipal financing districts or other financing entities, of which the proceeds from the bonds are used to finance energy retrofits (efficiency and renewables). The assessments are then repaid over 15–20 years through annual assessments on property tax bills.

All three of these financing options would help create jobs immediately; jobs necessary to meet the demand for energy retrofits spurred by lower up-front costs.

In 2009, the North Carolina legislature enacted tow bills that authorize the community energy finance programs including revolving funds and assessment backed bonds for financing energy efficiency. While no programs have yet to be implemented, a handful of cities are pursuing use of some of their ARRA block grant funding for community energy efficiency financing (Hughes 2010). The City of Asheville is perhaps furthest along toward implementation of a program, and their board has passed a somewhat cautious resolution to implement a program by approving a research stage to investigate the needs for actual implementation.

Some of the barriers to implementation could include the number of local government staff hours required to administer a program and the need for partnerships with banks both for capital and to deal with administrative needs such as application processing. Banks have been reluctant to partner on these efficiency projects, which is a sentiment heard by several project stakeholders in North Carolina, including the electric utility and builder communities.

North Carolina as a Clean Energy Innovation Hub

North Carolina has a half-century legacy of promoting innovation. This involvement began with establishment of the Research Triangle Park (RTP) led by Gov. Sanford's administration that leveraged and enhanced the existing academic research capabilities of UNC, NCSU and Duke University. With sustained support from the legislature and subsequent administrations, the RTP established North Carolina as an innovation leader, attracting leading computer, pharmaceutical, environmental sciences and high tech companies, and government research laboratories. The innovation environment also spawned many homegrown companies, such as SAS Institute, which went from a modest spin-off from UNC and NCSU to a global information technology powerhouse. Over this period, the innovation spread statewide from the Medical School at ECU in Greenville through the Triad and Charlotte in the piedmont region to Ashville in the western part of the state.

The State is again poised to be a global innovation player in the clean energy revolution. The energy activities of the past 30 years uniquely position North Carolina to be a leader in this market. The North Carolina Advanced Energy Corporation (Advanced Energy), celebrating its 30th anniversary this year, has been a national leader in exploring the frontiers of energy efficiency in buildings and industrial equipment. In addition, the universities are noted for their energy efficiency work, including Industrial Extension Service (IES), Future Renewable Electric Energy Delivery and Management Systems (FREEDM) Center and N.C. Solar Center at NCSU, the Nicholas School for the Environment and the Nicholas Institute at Duke, and the Energy Center at Appalachian State University. In addition to these academic resources, the state offers many attractive resources for nurturing innovation such as the Fuqua Business School at Duke, the Keenan School at UNC and the Center for Creative Leadership (CCL) in Greensboro. These resources combined with a progressive business environment have created a friendly environment for innovation. Importantly, a clean energy business advocate has already emerged in the state in the form of the North Carolina Sustainable Energy

Association (NCSEA), which has expanded beyond its roots in the solar community to encompass a broader clean energy scope.

The state is already attracting many global leaders in clean energy technology, such as Ingersoll Rand and ABB, which are headquartered in Davidson and Raleigh respectively. In addition other leading international corporations such as Bosch, Dow Chemicals, Eaton, Honeywell, Johnson Controls, Rockwell Automation, and Siemens have presences in the state, along with firms such as CISCO and IBM that have been part of the past innovation waves, but are now looking to play in this new area of opportunity. The existing clean energy activities in the state are already stimulating homegrown innovation companies. Perhaps most visible is CREE, which has gone from a spin-off from NCSU School of Engineering to a global leader in solid-state lighting employing more than 1700 at its Durham research and manufacturing facility, with additional contract manufacturing in the Charlotte area. CREE is by no means unique, with many other firms across the state such as BREEZEPLAY, Consert and Southern Energy Management (SME) active in selling energy efficiency products and services. .

North Carolina could expand its clean energy activities further by becoming a leader in transportation electrification. With the growing national interest in plug-in hybrid electric vehicles (PHEVs) and all-electric vehicles (EVs) as a fuel-efficient mode of transport, and one that can dramatically reduce petroleum dependence, electric drive component and system production and integration represent important opportunities for market growth. Duke and Progress Energy are both already factoring vehicle electrification into their smart grid planning. With the presence of an already impressive array of high tech businesses and industries and proximity to a premier research and development resources, attracting advanced vehicle research companies and parts manufacturers to North Carolina is a logical expansion of clean energy innovation policies. Key to the success vehicle electrification will be battery technologies. The resulting arrival of battery researchers and manufacturers will act as a stimulus for job creation and economic prosperity. The resulting battery innovations can also play important roles in other clean energy markets such as renewable technologies and demand response products. The potential vertical integration of these manufacturers with other industries in the state will additionally mark North Carolina as a national leader in clean energy and efficiency technologies.

While clean energy innovations are already occurring in North Carolina, the state can play an important and more focused role facilitating development of this new area of innovation. The Governor, along with important innovation leaders such as the Research Triangle Foundation, and local leaders from across the state should consider convening a clean energy innovation summit that could bring the innovation and clean energy players in the state to develop a plan, much as was done a half century ago with the founding of the RTP. A number of supplemental policies exist to ensure that clean energy businesses flock to the state. These range from the use of tax credits, exemptions and reductions against corporate income and property levies to the provision of low-interest loan and grant programs.

The State of North Carolina would benefit doubly from becoming a clean energy innovation hub:

1. The innovations developed by these activities would help meet the State's energy efficiency goals at a lower cost and with greater non-energy benefits to consumers that implement the technologies and practices; and
2. The state can become a global leader in the development and implementation of clean energy technologies, benefiting from expansion of clean energy spending in other states spurred by state and federal energy and climate regulation, and globally as other countries seek to become more energy secure and respond to global climate policies.

With leadership, North Carolina can become a global player in clean energy benefiting the state and creating economic opportunities for the coming century as was done 50 years ago.

New Federal Appliance and Equipment Efficiency Standards

The Energy Independence and Security Act (EISA) enacted by Congress in 2007 set a number of required federal appliance and equipment standards. We assume savings from these standards are already accounted for in the reference case electricity forecast because at least one major utility in North Carolina captured the standards in their forecast and because the Energy Information Administration's *Annual Energy Outlook* has also accounted for the standards in its national forecasts since 2008. The Department of Energy is actively developing additional standards and is scheduled to implement standards on over two dozen new products by 2013.[38] North Carolina stakeholders can play a role in the federal standards process by encouraging the Department of Energy to adopt standards that maximize energy efficiency for these products, thereby lowering energy bills fir consumers in North Carolina. Both the mid and high case policy analyses include estimated savings of about 2% by 2025 from these new standards based on an analysis by the Appliance Standards Awareness Project (ASAP) and ACEEE (Neubauer et al. 2009).

Costs and Benefits of Energy Efficiency Policies in Medium Case Scenario

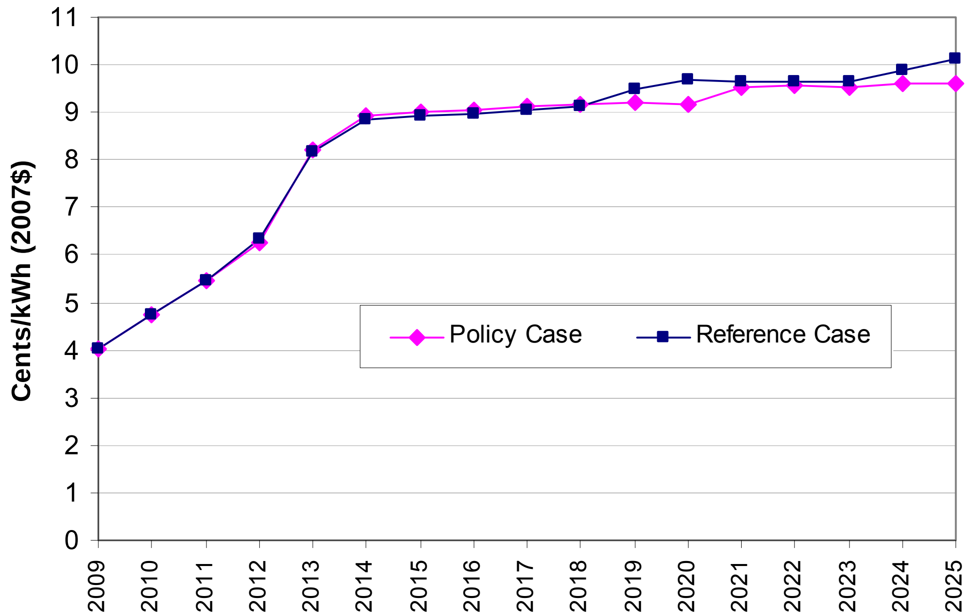
In this section we estimate the utility marginal costs, policy costs, and benefits of the medium case energy efficiency policy scenario to determine overall cost-effectiveness. There is no single answer to whether an energy efficiency measure or program is cost-effective, but rather there are multiple perspectives analysts use to determine cost-effectiveness. Here, we examine our policy analysis using two cost-effectiveness tests: the Total Resource Cost (TRC) test and the Participant Cost Test (PCT). We do not do an equivalent analysis for the demand response policy scenario, which is discussed in the next section, due to the difficulty in evaluating the dollar savings benefits to consumers from demand response measures.

Utility Marginal Costs

As might be anticipated, the energy efficiency policy case, which is described later, produced modestly lower marginal utility resource costs than the reference case because lower energy demand in the policy case requires fewer utility investments in new electricity generation. While near-term capacity additions are the same in both scenarios, over the long-term, the energy efficiency case can avoid new capacity additions. A detailed discussion of the assumptions and utility cost estimates can be found in Appendix A.

[38] The Department of Energy is scheduled to implement new federal appliance and equipment standards, as well as update current standards, for 26 products between 2009 and 2013. Included are standards for fluorescent and incandescent reflector lamps, central air conditioners and heat pumps, furnace fans, and residential water heaters, which represent some of the most energy-intensive appliances and equipment on the market. The analysis of the potential savings of these standards can be found in an analysis by the Appliance Standards Awareness Project (ASAP) and ACEEE report *(*Neubauer et al. 2009).

Figure 2.13. Estimates of Annual Marginal Resource Costs for North Carolina Utilities in Reference Case and Efficiency Policy Case



Policy Costs

Table 2-5 shows the estimated technology investments (in the form of both customer costs and program incentives) and administrative or marketing costs needed to implement the efficiency policies and programs suggested in this analysis and to achieve the estimated electricity savings impacts. The technology investments might include any combination of incentives paid to customers or direct customer costs.

Table 2-5. Annual Energy Efficiency Costs in Medium Case Policy Scenario (Millions of 2007$)

	2015	2025
Customer Investments	$ 500	$ 1,030
Incentives Paid to Customers	$ 220	$ 490
Admin/Marketing Costs	$ 90	$ 220
Total Costs	$ 810	$ 1,740

Costs and Benefits in the Medium Case Energy Efficiency Policy Scenario

Chapter 5 on macroeconomic impacts uses the above cost figures to estimate impacts of the efficiency policies on the North Carolina economy, including benefits to customers. Here, we report a net present value (NPV) analysis of costs and benefits to society and to participants. The next two tables (see Tables 2.6 and 2.7) show results from the TRC test and the Participant Cost test, respectively, with a breakdown of total costs and benefits (present value in 2007$) by policy type and by sector over the study time period (2010–2025). Readers should note that although the study time period ends in 2025, we estimate savings from the efficiency measures as they persist over the lifetime of each specific measure. Without accounting for these additional savings beyond the study time period would yield a more conservative estimate of benefits and therefore a lower benefit/cost ratio.

The TRC test, as shown in Table 2.6, evaluates the net benefits of energy efficiency to the region as a whole. This test considers total costs, including investments in efficiency measures (whether incurred by customers or through incentives) and administrative or marketing costs. Benefits in the

TRC test are the marginal utility avoided costs, which are the marginal costs that utilities avoid by reducing electricity consumption through energy efficiency. The marginal energy resource costs were determined by the analysis by Synapse Energy Economics (see Appendix A). The TRC test, which shows an overall benefit-to-cost ratio of 2.0, suggests a net positive benefit to North Carolina as a whole from implementing these efficiency programs and policies. Without accounting for savings beyond the study time period would yield a benefit/cost ratio of 1.2, which means that even without capturing the full benefits of energy efficiency investments made by 2025, the policy scenario still achieves a net benefit.

Table 2.6 Total Resource Cost (TRC) Test (2010–2025) (Millions of 2007$)

By Policy/Program	NPV Costs	NPV Benefits	Net Benefit	B/C Ratio
Energy Efficiency Resource Standard (EERS)*				
Proven Programs: Residential and Commercial	$6,013	$10,352	$4,339	1.7
Manufacturing Initiative	$332	$1,159	$827	3.5
Rural & Agricultural Initiative	$33	$108	$75	3.2
Building Energy Codes	$1,005	$3,262	$2,257	3.2
Advanced Energy-Efficient Buildings Initiative	$1,059	$1,130	$70	1.1
Public Facilities Performance Contracting	$458	$1,641	$1,183	3.6
Manufactured Homes Initiative	$251	$673	$422	2.7
Combined Heat & Power (CHP)	$441	$1,029	$588	2.3
Total	**$9,593**	**$19,353**	**$9,760**	**2.0**
By Sector	**NPV Costs**	**NPV Benefits**	**Net Benefit**	**B/C Ratio**
Residential	$5,206	$8,393	$3,187	1.6
Commercial	$3,688	$9,178	$5,490	2.5
Industrial	$766	$2,205	$1,440	2.9
Total	**$9,593**	**$19,353**	**$9,760**	**2.0**

Note: Behavioral Initiative costs and benefits are embedded in the EERS residential programs.

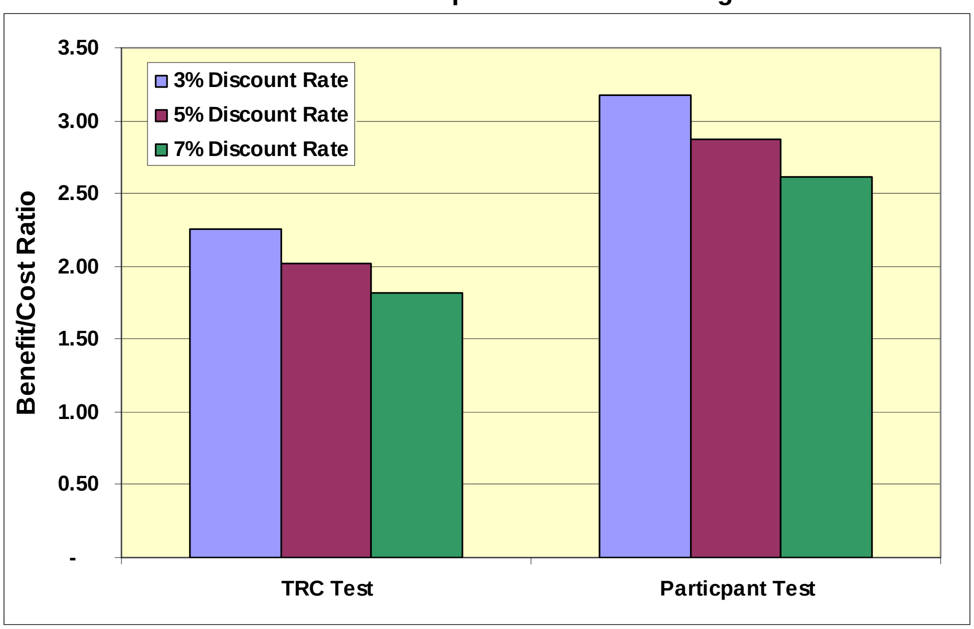
The Participant Cost test, as shown in Table 2.7, takes the perspective of a customer installing an energy efficiency measure in order to determine whether the participant benefits. The costs are the costs to customers for purchasing or installing energy efficiency and the benefits are the savings on customers' electricity bills due to reduced consumption plus any incentives paid to the customers. Again, this analysis takes into account costs through 2025 and benefits through the life of the measures. Accounting for savings over the life of the efficiency measures yields a benefit/cost ratio of 2.9. Without accounting for the benefits that persist after measures are installed in 2025, the Participant Cost test still yields a positive benefit to participants, with a benefit/cost ratio of 1.8.

Table 2.7. Participant Cost Test (2010–2025) (Millions of 2007$)

By Policy/Program	NPV Costs	NPV Benefits	Net Benefit	B/C Ratio
Energy Efficiency Resource Standard (EERS)*				
Proven Programs: Residential and Commercial	$5,241	$14,533	$9,292	2.8
Manufacturing Initiative	$320	$999	$679	3.1
Building Energy Codes	$990	$3,739	$2,748	3.8
Advanced Energy-Efficient Buildings Initiative	$883	$1,315	$432	1.5
Public Facilities Performance Contracting	$417	$1,786	$1,369	4.3
Rural & Agricultural Initiative	$27	$106	$79	4
Manufactured Homes Initiative	$202	$961	$759	4.8
Combined Heat & Power (CHP)	$436	$989	$553	2.3
Total	**$8,515**	**$24,428**	**$15,912**	**2.9**
By Sector	**NPV Costs**	**NPV Benefits**	**Net Benefit**	**B/C Ratio**
Residential	$4,513	$11,407	$6,895	$4,513
Commercial	$3,258	$11,031	$7,773	$3,258
Industrial	$744	$1,989	$1,245	$744
Total	**$8,515**	**$24,428**	**$15,912**	**2.9**

Note: Behavioral Initiative costs and benefits are embedded in the EERS residential programs.

Figure 2.14. Results of TRC and Participant Cost Tests Using Three Discount Rates



Note: Savings account for the lifetime of energy efficiency measures

Assessment of Demand Response Potential

This section defines Demand Response (DR) and Smart Grid, assesses current DR activities in North Carolina, identifies policies in the state that impact DR, uses benchmark information to assess DR potential in North Carolina, and identifies barriers in the state that might keep DR contributing appropriately to the resource mix that can be used to meet electricity needs. The analysis concludes with identification of specific policy recommendations regarding DR.

Defining Demand Response

DR focuses on shifting energy from peak periods to off-peak periods and clipping peak demands on days with the highest demands. Within the set of demand-side options, DR focuses on clipping peak demands that may allow for the deferral of new capacity additions and enhance operating reserves to mitigate system emergencies. Energy efficiency focuses on reducing overall energy consumption with attendant permanent reductions in peak demand growth. Taken together, these two demand-side options can provide opportunities to more efficiently manage growth, provide customers with increased options to manage energy costs and develop least cost resource plans.

DR resources are usually grouped into two types: 1) load-curtailment activities where utilities can "call" for load reductions; and 2) price-based incentives which use time-differentiated and/or dispatchable rates to shift load away from peak demand periods and reduce overall peak-period consumption. Interest in both types of DR activities has increased across the country as fuel input prices have increased, environmental compliance costs have become more uncertain, and the substantial investment in overall electric infrastructure needed to support new generation resources.

The summary of DR potential presented on 1 focuses on load-curtailment and backup generation and does not include savings resulting from price-based incentives. Residential load-curtailment typically involves direct load control (DLC) of air conditioners—although this can also cover appliances—as well as temperature offsets, which increase thermostat settings for a certain period of time. Commercial and industrial applications of DR focus on load control of space conditioning equipment, however this depends on customer size: self-activated load reductions are usually more prudent for larger customers. Backup generation for commercial and industrial applications involves generators with start-up equipment that allows them to come online with short notice from utilities, relieving the additional demand on the system during peak hours.

Role of Smart Grid

Significant confusion exists between energy efficiency, demand response and Smart Grid. While all are important energy policies, they are separate and complementary. Smart Grid has become an umbrella term for a range of technologies and strategies that bring two-way communication and intelligence to electric utility systems. A SmartGrid can reduce utility operating costs by reducing the cost of meter reading, helping to pinpoint outages, identifying consumption abnormalities and obtaining information about current customer usage. SmartGrid also plays an important role in enabling energy efficiency and demand response by providing information, such as price signals and other important information. The SmartGrid can be used to deploy enhanced DLC without the need for dedicated infrastructure and could offer the ability in the future to interface with smart appliances, smart buildings and smart manufacturing to maximize the efficiency of operations. Deployment of SmartGrid could also allow for more efficient and effective distributed energy, CHP and distributed renewables.

Installation of the SmartGrid by itself will unfortunately not lead to maximized benefits for customers unless utilities and regulators implement smart rates and other policies. It will be important that regulators and all stakeholders engage in a discussion of these regulations and policies in parallel with the deployment of SmartGrid and not wait for its deployment.

Rationale for Investigating Demand Response

DR alternatives can be implemented to help ensure that a utility continues to provide reliable electric service at the least cost to its customers. Specific drivers often cited for DR include the following:

- **Ensure reliability—**DR provides load reductions on the customer side of the meter that can help alleviate system emergencies and help create a robust resource portfolio of both demand-side and supply-side resources that meet reliability objectives.

- **Reduce supply costs—**DR may be less expensive per megawatt than other resource alternatives.
- **Manage operational and economic risk through portfolio diversification—**DR capability is a resource that can diversify peaking capabilities. This creates an alternative means of meeting peak demand and reduces the risk that utilities will suffer financially due to transmission constraints, fuel supply disruptions, or increases in fuel costs.
- **Provide customers with greater control over electric bills –**DR programs would allow customers to save on their electric bills by shifting their consumption away from higher cost hours and/or responding to DR events.
- **Address legislative/regulatory interest in DR—**The State approved the Renewable Energy and Energy Efficiency Portfolio Standard (REPS) that considers DR to be an eligible activity for cooperative and municipal utilities.

Demand Response in North Carolina—Background

A sound strategy for development of DR resources requires an understanding of North Carolina's demand and resource supply situation, including projected system demand, peak-day load shapes, and existing and planned generation resources and costs.

North Carolina utilities serve a population of over 9.2 million, and generate approximately 144 million megawatt hours of electricity. The system peak load was almost 26,270 MW in 2007 (ACEEE base case for North Carolina). Electricity demand has grown an average of 2% per year over the past 20 years, fluctuating moderately—with 3 of the past ten years having negative growth (EIA 2009a).

North Carolina has been and likely will continue to be a modest importer of energy and likewise be dependent on out-of-state capacity. In 2007, in-state generation provided 90% of total North Carolina retail sales, thus requiring import of approximately 10% (EIA 2009a). North Carolina's in State Implied Reserve Margin averaged 5.4% over the 10 year period from 1998-2007 (EIA 2009a).

Role of Demand Response in North Carolina's Resource Portfolio

The DR capabilities deployed by North Carolina utilities can become part of a long-term resource strategy that also includes resources such as traditional generation resources, power purchase agreements, options for fuel and capacity, and energy efficiency and load management programs. Objectives include meeting future loads at lower cost, diversifying the portfolio to reduce operational and regulatory risk, and allow North Carolina customers to better manage their electricity costs.

The 2005 Energy Policy Act provisions for Demand Response and Smart Metering has lead to a number of states and utilities piloting and implementing a Smart Grid, or sometimes referred to as Advanced Metering Infrastructure (AMI). Smart Grid is a transformed electricity transmission and distribution network or "grid" that uses robust two-way communications, advanced sensors, and distributed computers to improve the efficiency, reliability and safety of power delivery and use. For energy delivery, the Smart Grid has the ability to sense when a part of its system is overloaded and reroute power to reduce that overload and prevent a potential outage situation. Principal benefits of Smart Grid technologies for DR include increased participation rates and potentially lower costs.

The growth of renewable energy supply (and plans for increased growth) can also increase the importance of DR in the portfolio mix. For example, sudden renewable energy supply reductions (e.g., from an abrupt loss in wind) may be mitigated quickly with DR.

Assessment of Demand Response Potential in North Carolina

Table 2.8 shows the resulting load shed reductions possible for North Carolina, by sector, for years 2015, 2020, and 2025. Load impacts grow rapidly through 2018 as program implementation takes hold. After 2018, the program impacts increase at the same rate as the forecasted growth in peak demand.

These estimates are based on assumptions regarding growth rates, participation rates, and program design. In developing these DR potential estimates, the integration of DR with select energy efficiency activities was considered to help ensure that load impacts were not double counted. The estimated load reduction per program participant is conservatively estimated to account for increased energy efficiency in the future. See Appendix D for detailed information on methodology and assumptions.

The high scenario DR load potential reduction is within a range of reasonable outcomes in that it has an eleven year rollout period (beginning of 2010 through the end of 2020), providing a relatively long period of time to ramp up and integrate new technologies that support DR. A value nearer to the high scenario than the medium scenario would make a good MW target for a set of DR activities.

The high scenario results show that a reduction in peak demand of 1,746 MW is possible by 2015 (6.4% of peak demand); 3,719 MW is possible by 2020 (12.7% of peak demand); and 4,031 MW is possible by 2025 (12.4% of peak demand).

The more conservative medium scenario results show that a reduction in peak demand of 1,177 MW is possible by 2015 (4.3% of peak demand); 2,509 MW is possible by 2020 (8.6% of peak demand); and 2,722 MW is possible by 2025 (8.4% of peak demand).

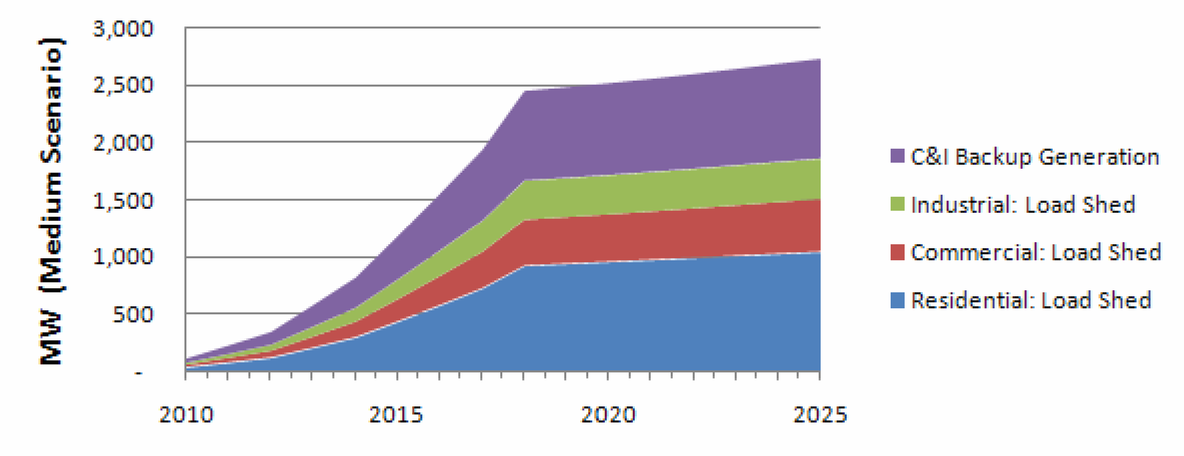
Table 2.8. Summary of Potential DR in North Carolina, by Sector, for Years 2015, 2020, and 2025[a]

	Low Scenario			Medium Scenario			High Scenario		
	2015	**2020**	**2025**	**2015**	**2020**	**2025**	**2015**	**2020**	**2025**
Load Sheds (MW):									
Residential	263	576	628	438	960	1,047	613	1,344	1,465
Commercial	72	155	173	191	414	461	359	777	865
Industrial	76	151	155	170	339	349	302	603	620
C&I Backup Generation (MW)	283	597	649	377	796	865	472	995	1,081
Total DR Potential (MW)	693	1,479	1,605	1,177	2,509	2,722	1,746	3,719	4,031
DR Potential as % of Total Peak Demand	2.5%	5.1%	5.0%	4.3%	8.6%	8.4%	6.4%	12.7%	12.4%

[a]. *See Section 3 for underlying data and assumptions.*

Figure 2.15 shows the resulting load shed reductions possible for North Carolina, by sector, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 2.15. Potential DR Load Reductions in North Carolina by Sector (Medium Scenario)



Recommendations

Key recommendations include:

- Set utility demand response targets for the high scenario.

- Implement programs focused on achieving firm capacity reductions as this provides the highest value demand response. These efforts should include establishing appropriate customer expectations and conducting program tests for DR programs in each year. These tests should be used to establish expected DR program impacts when called and to work with customers each year to ensure that they can achieve the load reductions expected at each site.

- Structure appropriate financial incentives for the North Carolina's utilities either for programs administered directly by the utilities or for outsourcing DR efforts to aggregators. The basic premise is that a utility's least-cost plan should also be its most profitable plan.

- Integrate DR programs with the delivery of EE programs. For example, Duke Energy's "Residential Power Manager Program" that allows utility control of air conditioning loads is also used as a gateway for Duke Energy to offer free, in-home energy audits to help inform home owners of additional energy saving opportunities. Many gains in delivery efficiency are possible by combining and cross-marketing EE and DR programs. These can include new building codes and standards that include not only energy efficiency construction and equipment, but also the installation of addressable and dispatchable equipment. This can include addressable thermostats in new residences and the installation of addressable energy management systems in commercial and industrial buildings that can reduce loads in select end-uses across the building/facility. In addition, energy audits of residential or commercial facilities can also include an assessment of whether that facility is a good candidate for participation in a DR program through the identification of dispatchable loads. Furthermore, building commissioning and retro-commissioning EE programs that are becoming popular in many commercial and industrial sector programs have the energy management system as a core component of program delivery. At this time, the application of auto-DR can be assessed and marketed to the customer along with the EE savings from these site-commissioning programs.

- Pricing should form the cornerstone of an efficient electric market. North Carolina has a history of time-differentiated rates. Increasing pricing programs (and participation) including

Daily TOU pricing and day-ahead hourly pricing will increase overall market efficiency by causing shifts in energy use from on-peak to off-peak hours every day of the year. However, this does not diminish the need to have dispatchable DR programs that can address those few days that represent extreme events where the highest demands occur. These events are best addressed by dispatchable DR programs.

- Customer education should be included in DR efforts. There is some perceived lack of customer awareness of programs and incentives. In addition, new programs will need marketing efforts as well as technical assistance to help customers identify where load reductions can be obtained and the technologies/actions needed to achieve these load reductions. Also, high level education on the volatility of electricity markets helps customers understand why utilities and other entities are promoting DR and the customers' role in increasing demand response to help match up with supply-side resources to achieve lower cost resource solutions when markets become tight

- Increase clarity and coordination between the Federal and State agencies and programs. While states have primary jurisdiction over retail demand response, the FERC has jurisdiction over demand response in wholesale markets. Greater clarity and coordination between the Federal and State programs is needed.

CHAPTER THREE: WATER EFFICIENCY

In this chapter, we first present background information on the links between electricity and water consumption and set the context of water efficiency for public suppliers and customers. Next, we present a suite of six water efficiency policies that we suggest North Carolina implement in order to enhance water efficiency in the state. We have estimated the resulting water savings, costs, and consumer water bill savings ($) that can be realized from their implementation. Finally, we estimate the impacts of electricity savings presented in Chapter 2 on power plant water use in North Carolina.

Background

Water and electricity are interconnected in two important ways:

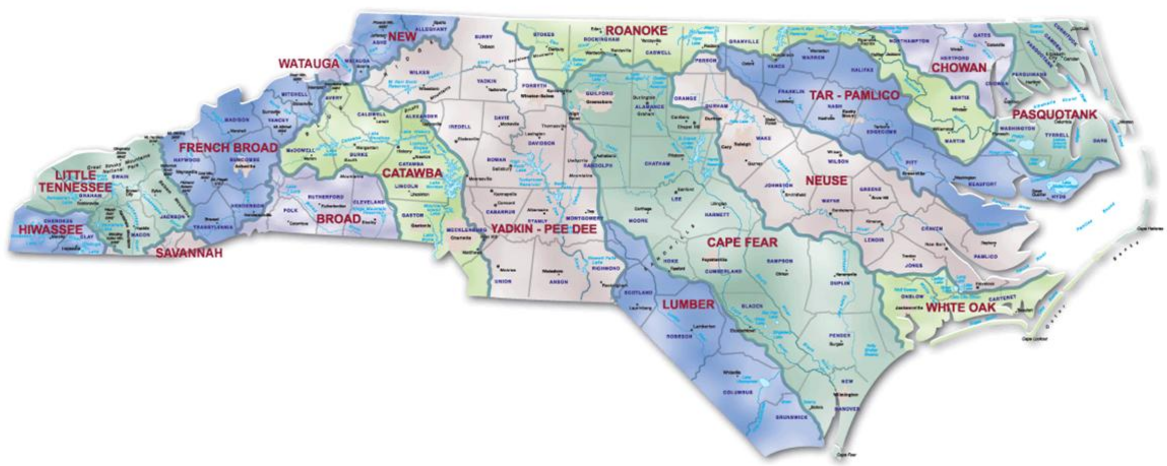
1. Water is a very electric-intensive resource. Electricity is required to source, treat, transport potable water and to collect, transport, treat and discharge wastewater. Water and wastewater can account for more than half of many municipalities' electricity bills (Elliott 2005). As a result, water efficiency—using less water to meet consumers needs—can represent an important electric efficiency opportunity.
2. Water is a critical resource required for most electric power generation, both as feedwater for boilers and as cooling water for condensers for steam systems, whether fueled by coal, natural gas or nuclear fuel. Thus, water requirements for electric generation compete with other uses for and users of the resource.

While North Carolina has been blessed in the past with ample water resources, the past decade has seen that situation changes as sustained droughts have resulted in low flow levels in several river basins particularly the Cape Fear and Yadkin—Pee Dee (Figure 3.1) have forced utilities to scale back power plant operations due to lack of cooling water (Weiss 2008; Muraski 2007). In 2008, the Legislature passed the *Drought/Water Management Recommendations Act*,[39] which directed the Environmental Management Commission (EMC) to set standards for water use efficiency. With the state's sustained rapid growth, demand for both water and electricity are projected to increased, placing demands on these resources into direct conflict, particularly in rapidly growing areas such as the Triangle and Charlotte.

[39] North Carolina State Law 2008-143.

This competition for water and energy resources has now taken on an interstate color as the state of South Carolina has expressed concerns over both municipal and energy-related water use in the Charlotte area and the resulting impacts on rivers in South Carolina (U.S. Water News 2007; Henderson 2009).

Figure 3.1. North Carolina River Basins



Electricity Generation and Water Consumption Link

The two most water-intensive sources of electric power generation are thermal (or steam driven) generators powered by nuclear fission or coal combustion. In 2007, about two-thirds of the electric power generated in the United States was powered by coal and nuclear fuel (48.5% and 19.4%, respectively). However, over 90% of the electricity generated in North Carolina in 2007 came from coal and nuclear fuel (EIA 2009b). Thus, electricity generation in North Carolina is significantly more water intensive than that of the nation as a whole.

Power plant cooling is the single largest offstream[40] use of water in North Carolina, by far. In 2005, thermoelectric water use came to 9,900 million gallons per day (mgd), or 77% of all offstream uses, compared with 921 mgd (or 7.1%) for all reported use by public water supply systems. Although cooling requirements vary somewhat from plant to plant depending on the combustion cycle and the cooling system, the water requirement for cooling North Carolina's thermoelectric generating stations recently averaged 29,130 gallons per MWh, based on reported generation and water use in 2000 and 2005.

Table 3.1. Water Intensity of Thermoelectric Power Generation in North Carolina

Year	Thermoelectric* Generation (MWh)	Thermoelectric Water Use (million gallons)	Water Intensity (gallons/MWh)
2000	118,801,995	3,456,550	29,095
2005	123,902,833	3,613,500	29,130
Average 2000 & 2005			

* Thermoelectric = coal, petroleum, natural gas, nuclear, wood, and other biomass.
Source: EIA (2009c); USGS (2004, 2009)

Water withdrawn for use in a once-through or open-loop cooling system is discharged back to receiving waters at a temperature that is typically 20 degrees F warmer or more. While nearly all the original volume of water is returned, the evaporation induced by the higher temperature results in

[40] Offstream use is water withdrawn or diverted from a groundwater or surface—water source for public water supply, industry, irrigation, livestock, thermoelectric power generation or other uses.

levels of consumptive use estimated at 100, 300, and 400 g/MWh for natural gas combined cycle, coal, and nuclear generation, respectively. Withdrawals for closed-loop cooling systems such as cooling towers or ponds are markedly lower, ranging from approximately 230 g/MWh for cooling natural gas combined cycle generation to as much as 1,100 g/MWh for nuclear generation, although most of this water is consumed by evaporation (DOE 2006). The rate of cooling water withdrawal in North Carolina is indicative of the prevalence of once-through cooling for power generation. At typical rates of evaporation, the consumptive use of water for utility thermoelectric cooling can be estimated to average about 120 mgd statewide, with rates somewhat lower in winter months and higher in summer months.

Water Efficiency by Public Water Supplies and Customers

Public supply comprises the third largest offstream use of water in North Carolina (closely following water withdrawn for aquaculture). Although, as noted above, thermoelectric cooling involves much larger total withdrawals, there are several reasons to assign high priority to improving water use efficiency in the public supply sector.

- Public supply withdrawals are large and growing. From 1995 to 2005, reported withdrawals for public supply rose nearly 20%, or an average annual growth rate of over 1.8%. Drought curtailments, conservation activities, and the economic slowdown are likely to have tempered this growth since 2005. Nevertheless, the consumptive portion of public supply usage may easily be larger than the consumptive portion of thermoelectric use during critical summer months.[41]

- Public supply makes greater use of groundwater than does thermoelectric use. Groundwater resources must be carefully managed in many areas of the state, as indicated by the state's system of groundwater control areas.

- Public supply carries the highest requirements for reliability and quality, in order to meet safe drinking water standards and maintain public health.

- To achieve high levels of reliability and quality, public supplies require the highest levels of treatment, resulting in substantial embedded energy and financial costs for the construction and operation of drinking water treatment and distribution systems and wastewater collection and treatment systems.

Public water supply and wastewater treatment systems are large users of electric power. Nationwide, their use has been estimated at 75 billion KWh per year, or about 3% of U.S. energy consumption (EPRI 1994, in EPA 2008b). More recent estimates (TIAX 2006) have placed the operating requirements of public water systems for pumping and potable treatment at 2,290 KWh/mg, or 437 gal per KWh. Wastewater treatment requirements are estimated to be 1,682.5 KWh/mg or 594 gal per KWh. For purposes of this report, the portions of power requirements that vary with flow (and thus might be reduced with the implementation of water efficiency measures) are most relevant. We estimate 90% of water supply and 70% of wastewater treatment power requirements are flow–related, yielding a variable energy cost of 2,061 KWh/mg for public water supply and 1,178 KWh/mg for wastewater treatment. For reductions in outdoor water use, the water supply savings alone would apply, while reductions in indoor water use would yield combined savings of 3,239 KWh/mg.

[41] During peak summer months, outdoor water use may make up 25 to 50% of total water use, and the majority of water applied outdoors will be lost to evaporation, drift, or evapotranspiration (ET) from landscape plant materials. For example, if public supply withdrawals average 1,100 mgd during summer months, with one-third of this total applied outdoors and one-half of that amount lost to evaporation and ET, public supply consumptive use would reach 180 mgd, as large or larger than the consumptive use by thermoelectric cooling.

North Carolina's Water and Wastewater Needs

Newly developed public water supply is high cost water, and reducing or deferring investment in new public infrastructure offers a substantial financial benefit to local communities. Most publicly-supplied service areas produce wastewater discharges as well, and reductions in wastewater flows help achieve water quality objectives and hold down infrastructure costs that are in many cases as large as the cost of developing potable water supplies. With many communities depending on a limited supply of state and federal financial assistance for improvements in their water supply or wastewater treatment systems, the case for water efficiency is strong. Water efficiency programs can have noticeable effects on the size and timing of certain infrastructure investments. More communities can be assisted more quickly with a given amount of funds if improvement projects are sized and timed to take full advantage of water conservation savings.

Several categories of infrastructure investment are somewhat sensitive to changes in average flows or peak volumes that can be influenced by water efficiency programs. Among the range of investment needs articulated by EPA and the states for drinking water infrastructure, those most likely to be responsive to efficiency measures are:

- **Treatment**—facilities for the removal of microbial contaminants, inorganic and organic chemicals, and the harmful byproducts of disinfection.

- **Storage**—facilities such as tanks and small reservoirs within water systems, needed to maintain positive water pressure throughout the system and accommodate peak demands for water.

- **Source**—facilities to collect raw water, including dams, impoundments, intakes, and wells.

- **Transmission**—large diameter pipe that transmits water from the system's source to its treatment works, and then again from the treatment works to the smaller diameter distribution system.

All of the above, to a greater or lesser degree, carry costs that vary with the volume of storage or flow. A large remaining investment category—the small-diameter distribution system—is not considered a flow-related investment, although the reduction of water leaks that accompanies distribution system replacement can be a significant benefit.

Regarding wastewater treatment, the categories of investment most likely to be flow-related are:

- **Secondary treatment**—facilities to provide the minimum permissible level of treatment to attain specified levels of total suspended solids and biochemical oxygen demand in wastewater prior to discharge.

- **Advanced treatment**—facilities providing advanced treatment needed to remove unconventional pollutants or to reduce conventional pollutants to a greater degree than provided by secondary treatment.

- **Interceptor Sewers**—major sewer lines, consisting of large diameter pipe and associated pumping stations that convey wastewater from networks of smaller collector sewers to a treatment plant and/or other interceptor sewer.

- **Combined Sewer Overflow Controls**—measures to reduce the frequency, duration, and volume of untreated discharges of sanitary wastewater and storm water from combined storm and sanitary sewer systems.

Categories of wastewater investment considered unresponsive to changes in fluid volume include small-diameter collector sewers, solids handling facilities, and most investments in non-point source pollution control.

Recent estimates of the capital requirements for water and wastewater infrastructure facing North Carolina's communities total well over one billion dollars, as indicated in the following table.

Table 3.2. Flow-Related Water and Wastewater Infrastructure Needs in North Carolina

Water Supply Flow-Related Infrastructure Needs	2007 dollars (millions)
Treatment	2,238
Storage	1,033
Source	671
Transmission	2,012*
Subtotal—Water Supply Needs	5,954
Wastewater Flow-Related Infrastructure Needs	**2004 dollars (millions)**
Secondary treatment	311
Advanced treatment	1,651
Interceptor sewers	1,419
Combined sewer overflow controls	3
Subtotal—Wastewater Treatment Needs	3,384
Total Flow-Related Infrastructure Needs	**2007$ (million)**
Water and Wastewater Infrastructure	9,667

Sources: Water (EPA 2009a); Wastewater (EPA 2008a)
* Value estimated at 1/3 of reported combined need for transmission and distribution.

The degree to which any individual system can reduce or defer capital costs by implementing water efficiency measures is subject to a system specific evaluation. Tools are available for determining an individual water or wastewater utility's avoided cost of water, which equates to the value of saved water to the utility (CUWCC 2006). For purposes of this report, the value of saved water will be conservatively estimated to be equal to the current average retail cost of water to residential customers. Based on the average reported rates in effect on July 1, 2008 in fifteen North Carolina communities (AWWA-Raftelis 2008), the value assigned to indoor water savings is $6.05 per thousand gallons and the value assigned to outdoor water savings is $2.50 per thousand gallons. Based on trends reported for utilities in North Carolina and across the country, these rates are assumed in this report to increase at 5% per year through 2025.

Water Efficiency Policy Analysis

In this section we present the suite of six water efficiency policies that we suggest North Carolina implement in order to enhance water efficiency in the state. We have estimated the resulting water savings, costs, and consumer water bill savings ($) that can be realized from their implementation, though costs and benefits are quantified only for five of the water policies. We also estimate water savings in North Carolina from pending federal rulemakings for clothes washer efficiency standards. The policies were analyzed within a two-scenario framework: our medium case scenario reflects a significant commitment to efficiency and is the scenario on which we focus the publication of our results; our high case scenario represents a more aggressive approach where the state takes greater advantage of its available, cost-effective resource potential.

Water Efficiency Policy Options for Public Water Supplies

Just as state policies and utility investments can yield cost-effective electricity savings, similar approaches to technology and policy can yield cost-effective water savings for North Carolina's public water systems, wastewater service providers, and their customers. Water-efficient plumbing products and household appliances offer substantial savings at relatively modest incremental cost. Attention to soil preparation, plant selection, and irrigation efficiency can reduce the water requirements of new ornamental landscapes. Acoustic monitoring can help pinpoint leaks in utilities' water distribution systems and reduce the frequency and cost of water main breaks. Finally, sending effective price signals to consumers by metering water deliveries and setting rational and understandable water rates enhances both the equity and the efficiency of water use.

The five policies or programs to improve water use efficiency are summarized in Table 3.3 and are discussed below. See Appendix B for additional details and assumptions.

Table 3.3 Policy Descriptions

Water		Medium Case Scenario	High Case Scenario
1	Plumbing Efficiency Standards	Adopt efficiency standards for new residential toilets, faucets, and showerheads beginning 2012—statewide	Same as medium case scenario
2	Replacement of Inefficient Plumbing	Replace inefficient plumbing upon resale of homes in 10 largest counties	Same as medium case scenario but in 20 largest counties
3	Water Loss (Leakage) Reduction	Consistent annual reporting of water losses—statewide; elimination of 50% of economically recoverable water losses by 2025 in 10 largest water utilities	Same as medium case scenario but eliminating 90% of economically recoverable water losses by 2025
4	Water Efficient Landscape Irrigation Ordinances	Adopt water-efficient ordinance applicable to newly-installed landscapes in 10 fastest growing counties	Same as in medium case scenario but in 20 fastest growing counties
5	Conservation Pricing of Water & Sewer Service*	Policy Discussion	Policy Discussion

* Savings from this policy were not quantified, but we include a discussion of the piece as its inclusion in state water policy is extremely important in order to address the current rate structures in the state that do not dissuade excessive consumption.

Statewide Plumbing Efficiency Standards

Nationwide standards for the water efficiency of plumbing products, including toilets, urinals, showerheads, and faucets were enacted in 1992 and took full effect by 1997. These standards apply to all new plumbing product sales and imports throughout the United States, and as originally enacted, preempted any state or local efficiency standards applying to such products. However, under the terms of current law, federal preemption has lapsed, and states and localities are now free to set more stringent efficiency standards than the federal minimums. The US EPA's voluntary *WaterSense* program has adopted higher performance specification for products earning the *WaterSense* label.[42] Two states, California and Texas, have recently enacted more stringent efficiency standards for new toilets, with effective dates beginning in 2012, and Georgia is currently considering similar legislation.

The measure evaluated here for both the medium and high case scenarios is the adoption of statewide standards for the efficiency of new residential plumbing products sold or installed in North Carolina beginning January 1, 2012, as follows:

- Tank-type toilet — 1.28 gallons per flush (gpf)
- Showerheads — 2.0 gallons per minute (gpm)
- lavatory faucets and faucet aerators — 1.5 gallons per minute (gpm)

[42] Specifications for tank-type toilets were adopted in January 2007; lavatory faucets and faucet aerators in October 2007; and showerheads in March 2010 (EPA 2010).

Statewide adoption of efficiency standards for new products provides the simplest approach to administration and enforcement, allowing suppliers and installers a single set of criteria that will not vary across county lines, and extending the benefits of water efficiency to consumers throughout the state.

The standard suggested for tank-type toilets applies to all sales and installations after January 1, 2012, including installations during major renovation and simple replacement as well as new construction. Tank-type toilets are used in nearly all residential applications and in some commercial applications, although we have not attempted to quantify the costs and benefits of the standard for the commercial sector. This suggested standard does not extend to the valve-type toilets found in most other commercial applications, since test protocols and performance metrics for high efficiency valve-type toilets are still under development.

The standards suggested for showerheads, lavatory faucets, and faucet aerators apply to installations in new construction beginning January 1, 2012, but do not apply to installations during renovation and replacement. High efficiency showerheads should be matched with pressure- or temperature-balancing shower control valves to reduce the risk of sudden temperature changes and the attendant risk of shower accidents. Such control valves were not required by code in new homes until the late 1980s, and the unrenovated showers in many older homes would require shower valve replacement that could be costly. Regarding lavatory faucets, the hot water distribution plumbing in many existing homes serves to limit the water-saving potential of high efficiency faucets, due to extended wait times for hot water to reach the sink in remote lavatories. As with tank-type toilets, showerheads and lavatory faucets have many commercial applications, but we have not attempted to quantify the costs and benefits of the standard for the commercial sector.

Statewide water savings are estimated to reach 4.1 million gallons per day (mgd) in 2015 and 15.0 mgd in 2025. Water and sewer bill savings for residential customers will total $10.8 million per year in 2015 and $50.3 million in 2025. The direct statewide electricity savings attributable to the showerhead and faucet efficiency standards are estimated to reach 25.1 GWh per year in 2015 and 94.8 GWh in 2025. The indirect statewide electricity savings attributable to the energy embedded in water and wastewater service are estimated to reach 4.8 GWh per year in 2015 and 17.7 GWh in 2025.

Replacement of Inefficient Plumbing in Existing Residences

As noted above, national standards for the water efficiency of new plumbing products were enacted in the *Energy Policy Act of 1992* (EPAct) and took effect for residential products in January 1994. These standards applied to products manufactured or imported as of that date; distributors and contractors were allowed to continue to sell and install non-conforming products remaining in stock until such supplies were exhausted. However, the plumbing supply chain generally does not carry extensive quantities of finished products in inventory. Thus, housing constructed from 1995 forward is likely to contain only EPAct-compliant fixtures, while housing constructed before that date still contains inefficient fixtures, reduced in number by the rate of remodeling and replacement.

The measure evaluated here is the adoption of a countywide requirement to take effect in 2012 for the replacement of inefficient toilets (defined as those not meeting EPAct standards) with toilets meeting currently applicable standards upon the sale of any residence built before 1995. In this way, existing homeowners remain undisturbed in their property, but the water efficiency of the existing housing stock is enhanced at a moderate but steady rate as existing homes are sold to new owners. The mechanism for requiring and documenting the retrofit is up to the local jurisdiction. For example, documentation of toilet replacement may be required as a precondition of settlement, or as a condition for opening a new utility service account in the name of the new owner. In either case, flexibility may be provided by allowing the retrofit to be completed by the new owner within the first six months of ownership.

Consistent with the recommendation above, inefficient tank-type toilets would be replaced with units that operate with a maximum of 1.28 gpf.

The medium case scenario assumes that this policy will be applied by the ten largest counties in North Carolina. The high case scenario assumes that this policy is adopted by the state's twenty largest counties.

Under the medium case scenario, water savings for the ten largest counties are estimated to total 3.8 mgd in 2015 and 8.8 mgd in 2025. The high case savings total 5.8 mgd in 2015 and 16.8 mgd in 2025 for the twenty largest counties.

Under the medium case, the additional electricity savings attributable to the energy embedded in water and wastewater service are estimated to total 4.5 GWh in 2015 and 10.4 GWh in 2025. Under the high case, the additional electricity savings attributable to this embedded energy are estimated to total 6.9 GWh in 2015 and 19.9 GWh in 2025.

Reduction of Water Losses from Utility Distribution Systems

Leakage from utility distribution systems can be a major source of lost water, wasting both the resource itself and the costs of pumping and treating the water to potable standards. All pressurized water distribution systems leak, with the rate and location of leakage depending on community-specific factors such as pipe composition and age, water and soil chemistry, street traffic and vibration, the quality of original installation, and water system pressures, both average pressures and transient spikes in pressure. In addition, purposeful releases of water at unmetered points in the system, such as for firefighting, line flushing, or construction access, as well as unauthorized uses, including theft of water, can complicate the careful analysis of water losses that is necessary for an effective leak reduction program.

In August 2003, the American Water Works Association (AWWA) Water Loss Control Committee published "Applying Worldwide Best Management Practices in Water Loss Control" in *Journal AWWA*, describing water loss best practices developed by the International Water Association (AWWA 2003). In 2009, AWWA completed a thorough revision of its manual M-36 pertaining to water audits and loss control programs (AWWA 2009). Today, any water utility has access to free water audit software that provides a standardized approach to accounting for water deliveries and losses, and facilitates the assessment and improvement of the reliability of water delivery data.[43]

The measure evaluated here calls for consistent annual reporting of water losses by drinking water suppliers statewide through the use of the currently available AWWA software,[44] together with the carefully targeted investments by the ten largest water utilities in North Carolina to reduce water losses.[45] Under the medium case scenario, economically recoverable water losses—losses that by definition are cost-effective for the utility to eliminate—are reduced by 50% by 2025. Under the high case scenario, economically recoverable water losses are reduced by 90% by 2025 by these same 10 utilities.

Under the medium case scenario, water savings are estimated to reach 0.7 mgd in 2015 and 7.0 mgd in 2025. Under the high case, water savings for these same utilities are estimated to total 1.2 mgd in 2015 and 12.5 mgd in 2025.

Under the medium case, the additional electricity savings attributable to the energy embedded in water service are estimated to total 0.5 GWh in 2015 and 5.3 GWh in 2025. Under the high case, the

[43] Version 4.0 of AWWA's "Free Water Audit Software" is available for download at www.awwa.org/Resources/WaterLossControl.cfm?ItemNumber=48511&navItemNumber=48158.

[44] See, for example, Title 2 Sec. 16.0121 of the Texas Water Code, which requires that retail public water utilities file a standardized water audit once every five years with the Texas Water Development Board (TWDB). TWDB also *recommends* that utilities compile a water audit annually on the same business year cycle as the financial audits that many utilities perform.

[45] Seven out of ten of these water suppliers reported having a leak detection program of some sort in 2007 (NCDENR 2009).

additional electricity savings attributable to this embedded energy are estimated to total 0.9 GWh in 2015 and 9.4 GWh in 2025.

Water Efficient Landscape Irrigation Ordinances

A large portion of the drinking water supplied by water utilities to customers in North Carolina is used for landscape irrigation. Water consumption for ornamental irrigation varies with such factors as plant selection, soil preparation, slope, and the knowledge and skill of landscape and irrigation system designers, installers, maintenance workers, and homeowners. Currently, the state offers useful tools and information to help make commercial and residential landscape irrigation more efficient.[46] While no one strategy can improve performance in all these areas simultaneously, many opportunities to achieve significant savings through improved design and installation of new landscapes are available at the time of initial installation or major renovation.

The measure evaluated here is the adoption of water-efficient landscape ordinances applicable to newly installed landscapes. Such ordinances may be prescriptive, such as barring placement of high water use plants in narrow strips or on steep slopes that are difficult to irrigate efficiently, or requiring rain shut-off valves on any newly installed in-ground irrigation system.[47] Or the ordinance might be performance based, such as assigning an overall water budget to each new landscape, Or it could be a combination of the two approaches. The ordinances modeled here would be designed to reduce average outdoor water usage by 15 to 20% during the six months most directly influenced by irrigation water use. While applicable to both residential and commercial landscape installations, only the residential water savings are estimated here. Under the medium case scenario, this policy will be adopted by the ten fastest growing counties in North Carolina. The high case scenario assumes that this policy is adopted by the twenty fastest growing counties.

Under the medium case scenario, water savings within the ten fastest growing counties are estimated to reach 4.6 mgd in 2015 and 13.2 mgd in 2025. The high case savings total 6.3 mgd in 2015 and 18.3 mgd in 2025 in the twenty fastest growing counties.

Under the medium case, the additional electricity savings attributable to the energy embedded in water service are estimated to total 3.5 GWh in 2015 and 9.9 GWh in 2025. Under the high case, the additional electricity savings attributable to embedded energy are estimated to total 4.7 GWh in 2015 and 13.8 GWh in 2025.

Conservation Pricing of Water & Sewer

Water management professionals have long recognized that the pricing of water is central to managing the demand for water (Chesnutt 1998). While the demand for water may be relatively inelastic in the short run, a utility's pricing structure sends important signals to consumers that can influence discretionary uses of water and customers' willingness to repair leaks and invest in water-efficient products and services.

Several of North Carolina's major public water suppliers still maintain declining block rate structures, where the unit price of water (or wastewater service) declines with increased levels of metered water consumption (AWWA-Raftelis 2009). In an earlier era, such rates may have accurately reflected a

[46] NC State University's Center for Turfgrass Environmental Research & Education makes extensive information available for turf maintenance and irrigation. The TIMS Water Management Program is available to North Carolinians to calculate and track irrigation use. Using the NC Climate Office current weather data, TIMS can tell homeowners and turf managers in number of minutes how long to water their lawn. The center estimates that use of the system can cut irrigation use by 25% (NCSU 2009).

[47] For example, Florida Statutes, Sec 373.62, requires that new automatic sprinkler systems be installed and operated with "technology that inhibits or interrupts operation of the system during periods of sufficient moisture." In addition to rain sensors, the statute allows for soil moisture sensors to fulfill this requirement, and directs the establishment of a uniform exemption process for systems so equipped from local day-of-the-week water use restrictions.

trend that allowed rising demand to be served by abundant supplies at declining costs. Today, however, rising demand and increasing capital and operating costs associated with higher regulatory requirements have clearly placed the cost of both water and wastewater service on an upward trend. While the establishment of rate structures is necessarily a utility-specific exercise and beyond the scope of this report, we know that declining block rates work at cross purposes with efforts to encourage consumers to use water more efficiently. Conversely, uniform or increasing block rates can meet utility revenue requirements and maintain equity among consumers while complementing other water conservation programs. We encourage North Carolina's utility managers to take a fresh look at traditional declining block rates and eliminate incentives for water consumption that are no longer economically justified.

Electric Utility Clothes Washer Incentives

Among the proven energy efficiency programs available to electric utilities in North Carolina, customer incentive programs for new and more efficient lighting and appliances are among the most widely deployed around the country. Indeed, under the *American Recovery and Reinvestment Act of 2009*, all states have been encouraged to establish programs to incentivize the purchase of new ENERGY STAR appliances. Looking beyond this short-term federal program, the utility programs for electricity savings presented in this report envision an ongoing program of customer incentives for energy-saving new products.

We assume that incentives for energy- and water-efficient clothes washers will be a significant part of the electric utility program offering, with 5% of customer incentives supporting new washer purchases. For purposes of evaluating the water saving policies open to the state, this is significant. Between 20 and 25% of indoor water use in most American households is attributable to washing clothes (Mayer 1999). New models of washers on the market today can cut water used for washing clothes in half.

Based on the levels of electric utility investments in efficiency programs, we estimate the water savings that will result from clothes washer incentives in the medium case to reach 1.4 mgd in 2015 and 4.2 mgd in 2025. In the high case, water savings reach 1.9 mgd in 2015 and 4.9 mgd in 2025. The on-site electricity savings from these incentives, which are substantial, are included in the projected electric utility program savings described elsewhere in this report. The off-site electricity savings attributable to the energy embedded in water and wastewater service are estimated to total 1.7 GWh in 2015 and 5.0 GWh in 2025 in the medium case. Under the high case, the additional electricity savings attributable to embedded energy are estimated to total 2.2 GWh in 2015 and 5.8 GWh in 2025.

New Federal Clothes Washer Efficiency Standards

In addition to the savings that will result from electric utility incentive programs for clothes washers (noted above), the adoption of stronger minimum energy and water efficiency standards for washers by the US Department of Energy can achieve even greater savings. The on-site energy savings resulting from a new standard[48] are part of the energy savings attributable to new federal standards described elsewhere in this report, and are the same for both the medium case and high case scenarios. The water savings are estimated here to reach 1.3 mgd in 2015 and 27.9 mgd in 2025 in both the medium and high case. The off-site electricity savings attributable to the energy embedded in water and wastewater service are estimated to reach 1.5 GWh per year in 2015 and 33.0 GWh in 2025.

[48] The new federal standard for residential clothes washers is assumed here to be a modified energy factor (MEF) of at least 2.0 and a water factor (WF) of not more than 6.0, applying to all washers manufactured or imported on or after January 1, 2015.

Costs and Benefits of Water Efficiency Policies

Each of the water efficiency policies for which quantified savings estimates have been prepared has been found to be cost effective. Key assumptions regarding costs, savings, and other program metrics are listed in Appendix B. The policies described above can be seen to achieve the following savings over the period of analysis.

To put these savings in perspective, the water savings estimated here under the High Case for 2025 (95.4 mgd) equates to 10.4% of the total water withdrawals of 921 mgd reported for North Carolina's public water suppliers in 2005.

Table 3.4. Summary of Water and Electricity Savings by Water Efficiency Policy

	Annual Water Savings by Policy (mgd)	**Medium Case**		**High Case**	
		2015	**2025**	**2015**	**2025**
	Statewide Plumbing Efficiency Standards	4.1	15.0	4.1	15.0
	Inefficient Plumbing Replacement	3.8	8.8	5.8	16.8
	Utility System Water Loss Reduction	0.7	7.0	1.2	12.5
	Water Efficient Landscape Irrigation	4.6	13.2	6.3	18.3
1	Water Conserving Rate Structures	--	--	--	--
2	Electric Utility Clothes Washer Incentives	1.4	4.2	1.9	4.9
2	New Federal Clothes Washer Standards	1.3	27.9	1.3	27.9
	Total Estimated Water Savings (mgd)	**15.9**	**76.1**	**20.6**	**95.4**
	Annual Electricity Savings (GWh)				
	Statewide Plumbing Efficiency Standards	25.1	94.8	25.1	94.8
2	Electric Utility Clothes Washer Incentives	--	--	--	--
2	New Federal Clothes Washer Standards	--	--	--	--
	On-Site Electricity Savings	**25.1**	**94.8**	**25.1**	**94.8**
3	**Offsite Electricity Savings—All Policies**	**16.5**	**81.3**	**21.1**	**99.6**
	Total Electricity Savings from Water Efficiency	**41.6**	**176.1**	**46.2**	**194.4**

Notes
1. Recommended, but potential water savings not quantified.
2. Clothes washer water savings shown here; clothes washer energy savings are included in Utility Program electricity savings.
3. Indoor water use reductions yield off-site electricity savings of 3239 KWh/mg; outdoor water use reductions yield off-site electricity savings of 2061 KWh/mg.

Efficiency Impacts on Power Plant Water Use

As noted at the beginning of the chapter, thermoelectric power plants dominate the electricity generation mix in North Carolina. Cooling requirements for such plants are determined by heat input and hours of operation. The electricity savings opportunities identified in Chapter 2 of this report are of sufficient magnitude to support a first-order estimate of their impacts on both consumptive and non-consumptive water use for electric power generation.

Operating hours will not be reduced at all power plants as a result of energy efficiency measures. The physical and economic characteristics of base load plants necessitate their operation around the clock to the maximum extent possible, subject to annual or seasonal maintenance requirements. All nuclear power plants and many large coal-fired power plants are operated as base load plants. Opportunities for reduced hours of operation, and thus reduced water consumption, occur at "load-following" plants, those facilities where production is ramped up or down in concert with the daily ebb and flow of electricity demand. For purposes of this report, generating plants reporting an annual capacity utilization factor of less than 65% are considered load following. Most natural gas plants and some coal plants are operated as load-following plants. Some of these natural gas plants are powered by simple combustion turbines without requirements for cooling water (although water may be required if inlet air foggers are used to boost generation during hot weather). Others operate as combined cycle plants with the turbine exhaust being harnessed to a steam cycle to produce additional electricity. Thus, the primary effect on cooling water requirements will be seen at combined-cycle natural gas plants and coal-fired plants being operated in the load-following mode.

Based on the patterns of operation shown by North Carolina's electric generating fleet in 2005, we consider nineteen power plants to be the major load-following thermoelectric plants in the state. See Appendix Table B-1 for the list of principal load-following thermal plants.

The electricity savings from energy efficiency policies presented in Chapter 2 are summarized in Table 3.5. Demand response programs are not listed, as their principal benefit is the reduction of peak demand. Some electricity savings are likely, but are not quantified here.

Table 3.5. Summary of Electricity Savings (GWh)

	Medium Case		High Case	
	2015	2025	2015	2025
Energy Efficiency State Policies	6,426	34,470	9,623	48,464
New Federal Energy Efficiency Stds.	942	3,184	942	3,184
Water policies and programs	42	176	46	194
Total (GWh)	**7,410**	**37,838**	**10,611**	**51,842**

Based on these electricity savings and the average water intensity of thermoelectric power generation in the state (previously noted at 29,130 g/MWh), we estimate that implementation of the energy efficiency policies under the medium case could reduce water withdrawals by nearly 600 million gallons per day (mgd) in 2015 and over 3,000 mgd in 2025. Reductions are likely to be larger than these averages in summer months and lower than these averages in winter months. Reductions in total withdrawals could be particularly notable in the Catawba River Basin, where reductions of 140 mgd in 2015 and 700 mgd in 2025 may result from implementation of the medium case efficiency measures described in this report.

Energy savings will also reduce consumptive use of water by power plants, which also carries important implications for water resource management. Given the distribution of the principal load-following thermoelectric plants in the state, we estimate that the bulk of these energy savings (80%) can be attributed to power plants by river basin, as shown in Table 3.6, and again note that these water use reductions are likely to be higher in summer months. We have not assigned dollar values to these savings, but suggest that improvements in stream flows and attendant reliability of water supplies for drinking water, fish and wildlife, and power generation itself are likely to result.

Table 3.6 Estimated Reductions in Thermo-Electric Cooling Water Consumptive Use Resulting from Energy Efficiency, by Basin (mgd)

River Basin	Medium Case		High Case	
	2015	2025	2015	2025
Broad	0.643	3.283	0.921	4.500
Cape Fear	0.917	a	1.314	a
Catawba	1.430	7.296	2.046	9.999
French Broad	0.429	2.189	0.614	3.000
Lumber	0.136	a	0.195	a
Neuse	0.364	a	0.521	a
Roanoke	0.156	0.796	0.223	1.091
Yadkin	0.437	2.231	0.626	3.056

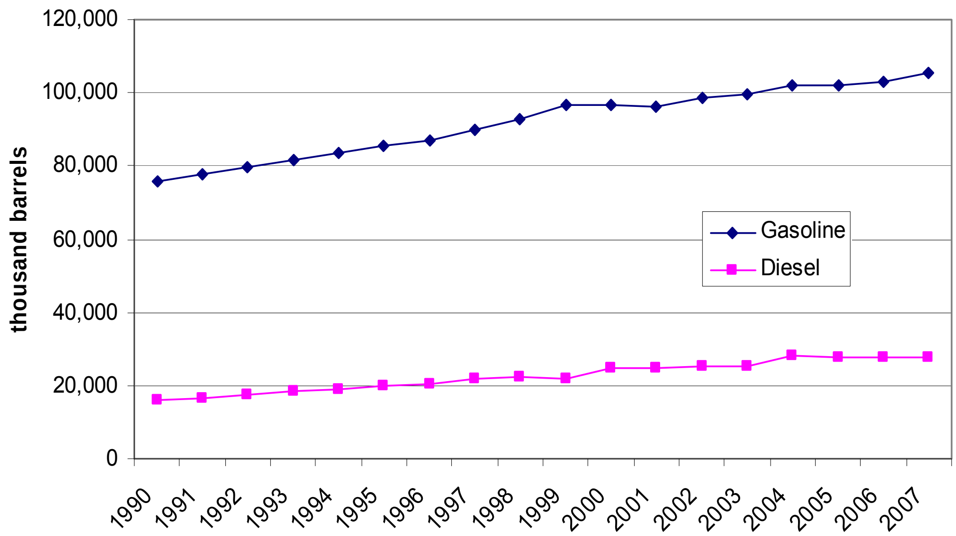
[a] Consumptive use of water for power generation will be further reduced by the announced retirement of 11 Progress Energy coal-fired units at four locations in these basins by the end of 2017.

CHAPTER FOUR: TRANSPORTATION EFFICIENCY

Background

North Carolina's population is expected to grow by almost 33% by 2030, making it the 7th largest state in the country with approximately 12.8 million residents. With this large increase in population, the state will continue to face a number of transportation-related challenges. In 2007, the transportation sector consumed 766,904 billion Btus of energy, 28% of total energy use in the state and about 2.6% of total transportation energy consumption in the United States (EIA 2010). The 2.4% yearly growth in North Carolina's transportation fuel consumption of the 1990s slowed to an average of 1.05% over the past decade, but even this more moderate trend increases the state's vulnerability to high fuel prices and its emissions of global warming emissions.

Figure 4-1. Historical Gasoline and Diesel Consumption in North Carolina, 1990-2007



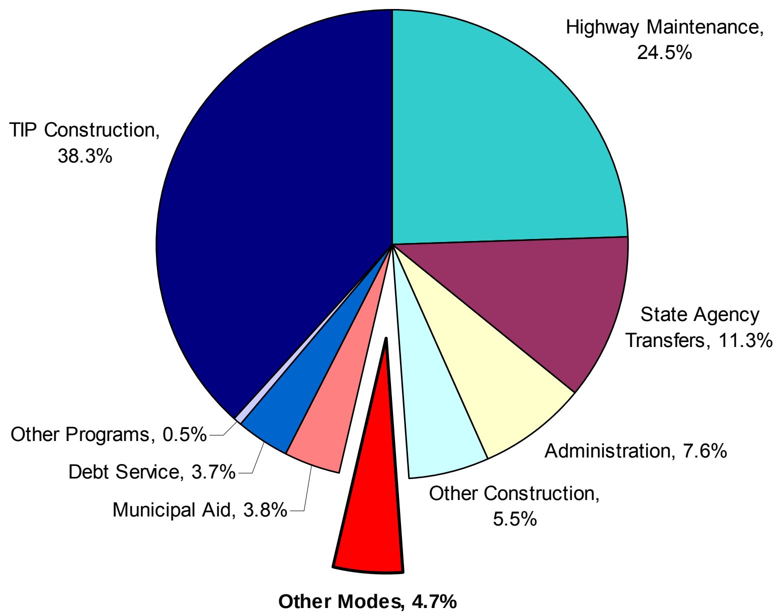
Source: EIA (2009c)

North Carolina's geographic and demographic diversity presents a challenge to statewide transportation policy. Policies applicable to urban, high density areas may not be suitable for the swathes of the state consisting of highly rural communities.

For decades, the preponderance of the state's transportation dollars has been poured into large-scale highway projects, while transit and other non-auto modes have received little. Figure 4-2 below shows that highway construction and highway maintenance occupy the bulk of NCDOT's annual budget while alternative modes of transportation are allocated only 5% of total finances.

Increasing congestion and climate change have made addressing transportation challenges a growing priority for the state, however. The recent passage of H.B. 148 is an indication that the state of North Carolina is taking a new approach to transportation issues. The statute allows counties with existing transit facilities to implement a ½ percent local option sales tax to provide the local share of transit expansion financing. Nevertheless, many additional steps are required to attain an energy-efficient transportation sector in the state. This chapter will discuss a number of strategies that can be implemented to take advantage of existing efficiency potential in the transportation sector.

Figure 4-2. NC DOT Federal and State Expenditures by Focus Area



Source: NCDOT (2008)

Reference Case

All gasoline and diesel savings reported in this chapter are above and beyond the "business as usual" transportation scenario, or reference case. In this section, we report the major assumptions underlying the reference case for the time period of this study—2009 to 2025.

We calculated gasoline consumption in North Carolina as a product of population, vehicle miles traveled per capita, and fuel consumption per mile. To project future consumption, we used VMT per capita forecasts from the 2003 State Energy Outlook, state population as projected by the North Carolina Office of State Budget and Management and expected average fuel consumption rates for the U.S. vehicle stock. ACEEE estimates of gasoline consumption are almost equivalent to actual gasoline consumption as reported by the Energy Information Administration (EIA) for 2007. Diesel consumption figures for 2000-2007 were obtained from North Carolina's State Energy Outlook and then projected forward until 2020 using regional diesel consumption growth rates from EIA's 2010 Annual Energy Outlook. The reference case also uses Office of State Budget and Management's county-level projections of population growth to determine average residential density by county.

The transportation reference case takes into account the increase in federal fuel economy standards that will occur in 2011, as well as the major increases proposed jointly by the U.S. EPA and the National Highway Transportation Safety Administration (NHTSA) for the period 2012 to 2016. Those standards, which will be finalized in March 2010, would require a 34.1 mile-per-gallon average for cars and light trucks sold nationwide in 2016. The strategies outlined in this chapter will produce gasoline savings above and beyond savings achieved through these federal programs. The Energy Independence and Security Act (EISA) of 2007 requires that fuel economy standards be set for work trucks and heavy trucks as well. No assumptions of increased fuel economy have been made for these vehicles, however, because the level of standards to be proposed is unknown.

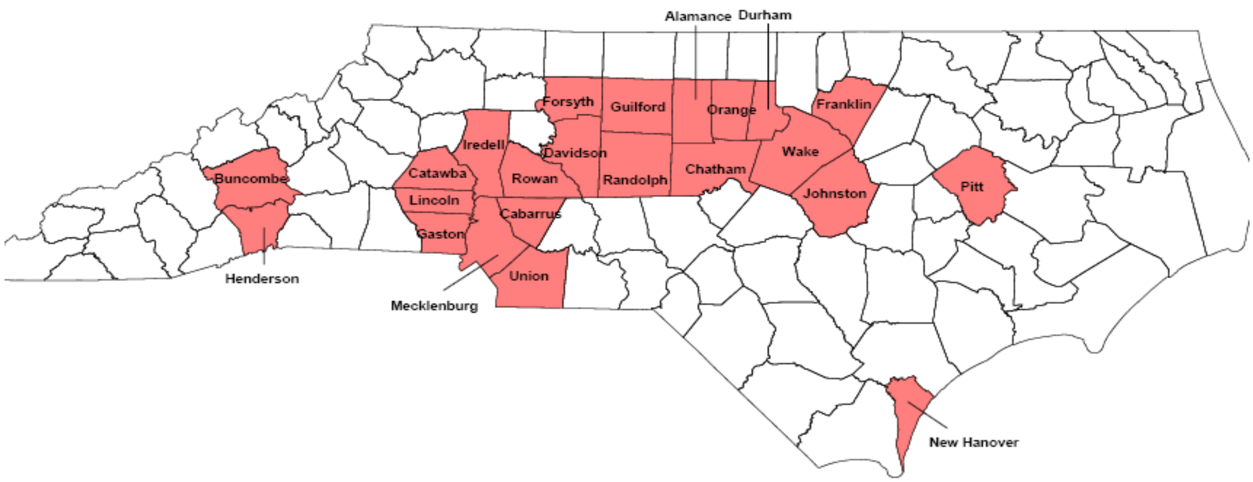
It should be noted that, while there is substantial uncertainty regarding future trends in vehicle purchases, vehicle miles per capita, and other key factors in transportation energy use, the difference between fuel use in the reference case and fuel use in the policy scenarios will be relatively insensitive to modest changes in these trends.

Energy Efficiency Policy Analysis

Policy Scenario Descriptions

The two scenarios are shown in the matrix below (see Table 4-1) for our transportation efficiency policy analysis. The medium case scenario described below includes policies that we believe North Carolina can reasonably achieve cost-effectively. The high scenario is in some cases somewhat more aggressive in its attempt to capture the maximum energy efficiency potential in North Carolina; in other cases the high scenario reflects instead an assumption of greater efficacy for a given measure than assumed in the medium case. Figure 4-3 highlights the high growth counties referenced in the matrix below in the medium case scenario.

Figure 4-3. High Growth Counties in North Carolina



Following the policy discussions and estimates of the resulting savings, we estimate the costs and fuel savings ($) that can be realized from their implementation.

Table 4-1. Matrix of Transportation Efficiency Policies in Medium and High Case Policy Scenarios

Transportation		Medium Case Scenario	High Case Scenario
1	Clean Car Standard	211 g/mile CO2 by 2020	178 g/mile CO2 by 2025
2	Heavy Truck Efficiency Package	Incentives for SmartWay-type improvements for long-distance trucks registered in North Carolina	Mandated SmartWay-type improvements for long-distance trucks registered in North Carolina
3	Freight Intermodal Investments	10% diversion of long-haul truck freight to rail	10% diversion of long-haul truck freight to rail
4	Pay-As-You-Drive Insurance	Mileage-based insurance for high growth counties in the state	Mileage-based insurance statewide
5	Truck Stop Electrification	Low-interest loan programs for truck stops in North Carolina	Low-interest loan programs for truck stops in North Carolina
6	Transit Expansion / Concentration of Urban Development	Transit expansion plus half of metro growth to transit stops; assume 15% reduction in VMT from doubling density around rail stations	Transit expansion plus half of metro growth to transit stops; assume 25% reduction in VMT from doubling density around rail stations
7	Vehicle Electrification	Policy Discussion	

Energy Efficiency Policy Scenario Results

This section describes results from our policy analysis, including estimated total annual fuel savings from transportation efficiency policies in 2015 and 2025 for both the medium and high case scenarios. More detailed results, assumptions, and analysis of costs and benefits are shown in Appendix C.

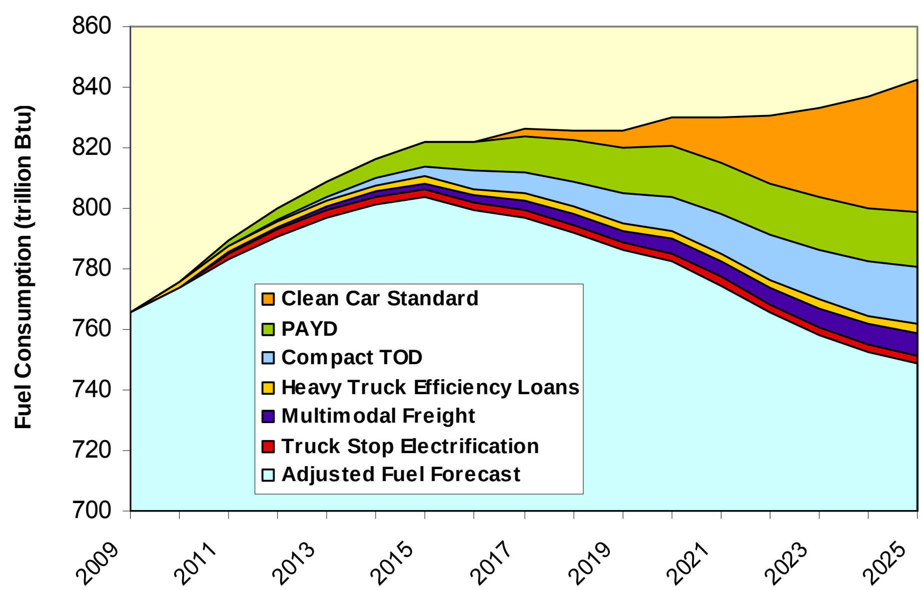
Medium Case Scenario

The estimated total fuel savings in 2015 and 2025 for the medium case scenario are shown by policy/program in Table 4-2. Under this scenario, we estimate that North Carolina will see combined fuel savings of approximately 10.8% by 2025.

Table 4-2. Summary of Transportation Savings by Policy or Program in the Medium Case Scenario

	Annual Transportation Savings by Policy (thousand barrels)	2015	2025	Savings in 2025 (%)
1	Clean Car Standard	0	8,417	6.7%
2	Pay-as-you-drive Insurance	1,567	3,412	2.7%
3	Transit Expansion / Concentration of Urban Development	609	3,693	2.9%
	Total Gasoline Savings	**2,217**	**14,954**	**11.9%**
4	Heavy Truck Efficiency Package	404	485	1.5%
5	Truck Stop Electrification	486	595	1.9%
6	Freight Intermodal Investments	366	1,278	4.0%
	Total Diesel Savings	**1,229**	**2,307**	**7.2%**

Figure 4-4. Total Gasoline and Diesel Savings from Transportation Efficiency Policies in Medium Case Scenario



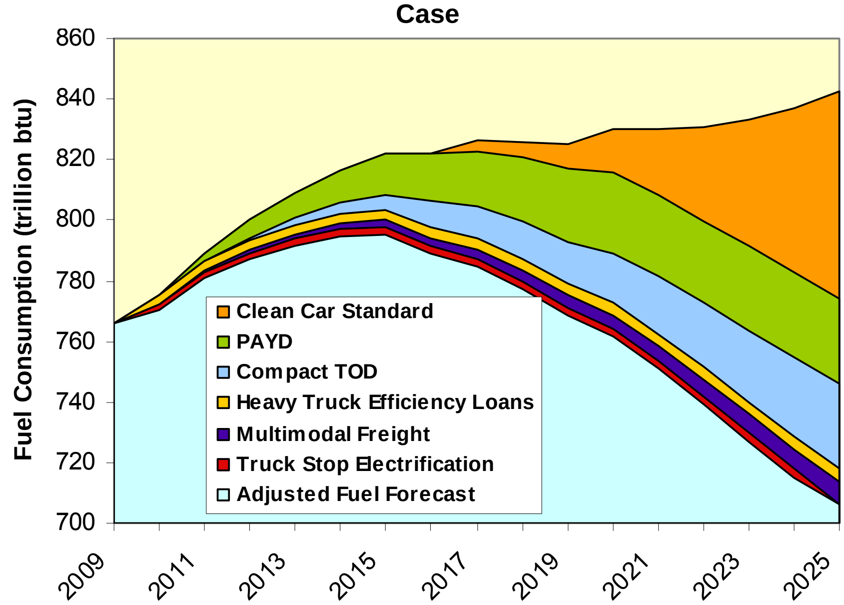
High Case Scenario

In our high case scenario, energy savings in the transportation sector come largely from the more aggressive target included as part of the Clean Car Standard. Under this scenario, North Carolina can achieve combined fuel savings of 15.7% savings from the reference case.

Table 4-3. Summary of Transportation Savings by Policy or Program in the High Case

	Annual Transportation Savings by Policy (thousand barrels)	2015	2025	Savings in 2025 (%)
1	Clean Car Standard	0	13,155	10.4%
2	Pay-as-you-drive Insurance	2,561	5,350	4.2%
3	Transit Expansion / Concentration of Urban Development	987	5,351	4.2%
	Total Gasoline Savings	**3,576**	**22,535**	**17.9%**
4	Heavy Truck Efficiency Package	419	514	2.3%
5	Truck Stop Electrification	486	595	1.9%
6	Freight Intermodal Investments	366	1,278	4.0%
	Total Diesel Savings	**1,421**	**2,535**	**7.9%**

Figure 4-5. Total Gasoline and Diesel Savings from Transportation Efficiency Policies in High Case



Discussion of Transportation Efficiency Policies

Clean Car Standard

The energy efficiency of gasoline-fueled automobiles relates directly to their emissions of carbon dioxide, the dominant greenhouse gas (GHG). While states are not permitted to set fuel economy standards, they can adopt greenhouse gas standards for vehicles, and many have done so. To date, 16 states have adopted a clean car standard, introduced first in California, that will reduce greenhouse gas emissions from new vehicles by 30% from 2002 levels by 2016 while cutting emissions of traditional pollutants as well. These states are Arizona, California, Connecticut, the District of Columbia, Florida, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont and Washington.

In May 2009, the Obama Administration issued an order to establish harmonized federal standards for fuel economy and greenhouse gas emissions for model years 2011 to 2016 that will match California's standards in stringency. A joint rulemaking by the EPA and the U.S. Department of Transportation (DOT) is underway. Nevertheless, California retains the right to set more stringent standards for the period beginning in 2017 and has committed to doing so as part of the implementation of the state's greenhouse gas reduction program. The California Air Resources Board (CARB) is currently in the process of determining the appropriate level for tailpipe emission standards for this next stage of the clean car standard. In 2009, CARB suggested preliminarily a level of 211 grams per mile, the equivalent of 42 miles per gallon for gasoline vehicles, as a level achievable by 2020 (CARB 2008). A more stringent standard with a longer phase-in is also a possibility. Under the Clean Air Act, other states have the option to adopt California's tailpipe standards.

The policy analyzed here is North Carolina's adoption of the clean car standard. The harmonization of federal and California standards means this action will have no impact on vehicle efficiency before 2017. Under the medium case scenario, we assume that North Carolina, along with other states adopting the clean car standard, would require new vehicles on average to achieve greenhouse gas emissions equivalent (for gasoline vehicles) to 42 miles per gallon by 2020. The high scenario assumes that the clean car standard will reach a more aggressive target equivalent to 50 miles per gallon by 2025. The primary pathway to meeting these standards in the earlier years will be accelerated penetration of technologies already available, such as variable valve timing, direct injection, turbocharging, more efficient transmissions, and perhaps diesel engines. In the later years, greater use of lightweight materials, hybrid-electric vehicles, and plug-in electric vehicles is likely.

Gasoline savings from the clean car standard will be zero in 2015 (relative to the reference case) but will reach 8.4 million barrels in 2025 under the medium case scenario, amounting to almost 7% of total gasoline consumption in 2025. In the high scenario, savings in 2025 will be 13.2 million barrels, over 10 percent of gasoline consumption.

If the prospect of a clean car standard is unappealing as an efficiency policy, North Carolina may want to consider the implementation of a feebate. A feebate is a market-based approach to promoting vehicle efficiency, in which a consumer is subject to a fee or granted a rebate upon purchase of a vehicle, depending on the vehicle's fuel economy. Part of the rationale for a feebate is that consumers tend to undervalue fuel economy when they are choosing a vehicle. A feebate can be designed to be "revenue-neutral," i.e. so that the implementing entity incurs no net cost or revenue. Another positive feature of feebates is that they provide an incentive for greater fuel efficiency in vehicles of any efficiency level and continue to do so as long as the program remains in place.

Pay-As-You-Drive Insurance

One reason that people use their vehicles as much as they do is that a high percentage of vehicle-related costs are "fixed", i.e. independent of the number of miles the vehicle is driven. The impacts of vehicles, however, are very dependent on how much people drive. One approach to reducing miles driven is to convert fixed costs to variable costs. This can be accomplished in part by Pay-As-You-Drive (PAYD) insurance.

PAYD insurance ties the rate paid by an individual to the number of miles driven over a fixed period of time. Drivers would pay a portion of their premiums up front, and the remainder would be charged in proportion to mileage, as determined by a global positioning device or periodic odometer readings. Converting fixed insurance costs to variable costs through PAYD insurance could reduce vehicle use by as much as 8% given varying insurance rates (Bordoff & Noel 2008.) A PAYD program could be an insurance company policy or product, but in North Carolina some action on the part of state may be required to remove regulatory obstacles to changing the basis for premiums or to promote the program (Guensler et al. 2003).

The policy proposed here is to phase in PAYD insurance in North Carolina, starting with a pilot program. For three years beginning in 2010, the state would offer incentives for insurance companies to offer policies based largely on miles driven. More specifically, the state would grant $200 to insurance agencies for each one-year policy they write for which 80 percent or more of the pre-program policy cost is scaled by the ratio of miles driven to the state or regional average miles driven. The incentive is necessary so long as PAYD is optional; without it, insurance companies may be concerned about losing revenues from the low-mileage customers who would choose such a policy without being able to offset these costs with higher premiums for high mileage customers. Assuming the pilot program is successful, mandatory PAYD insurance would be phased in over the next ten years.

Like other pricing policies designed to reduce miles driven and promote alternative travel modes, PAYD insurance may raise questions of equity, especially in rural areas, where alternatives to driving are not readily available. Insurance premiums are generally lower in rural areas than in urban areas, however, so high mileage premiums would be smaller there. Moreover, a PAYD program could be designed to compare a rural driver's annual mileage to that of other rural drivers for purposes of determining the insurance premium. Also, low-income drivers generally drive less than higher-income drivers, and low-income drivers as a group consequently would be net beneficiaries of pay-as-you-drive insurance programs (Bordoff & Noel 2008.)

Nonetheless, given potential objections to PAYD in rural areas, we assume for the medium case that PAYD is required only in the 23 higher-density counties to which the Compact/Transit-Oriented Development policy applies. PAYD is projected to save 1.6 million barrels of gasoline in 2015 and 3.4 million barrels in 2025. In the High Case, PAYD insurance would be required statewide and would save 2.6 and 5.4 million barrels in 2015 and 2025, respectively.

To maximize the benefits of PAYD insurance, drivers must have access to alternative modes of transportation. The recent passage of a local option ½-cent sales tax in the North Carolina legislature gives counties with existing transit systems a leg up on financing for expansion and improvement. In addition to the tax revenues, counties opting in would have access to state matching funds for transit.

PAYD insurance is one of many pricing policies that could be adopted to reduce vehicle miles traveled. Others include fees to enter metropolitan areas, parking pricing, congestion pricing, and vehicle-miles-traveled fees. PAYD insurance is used here to exemplify the importance of pricing strategies in a comprehensive approach to transportation system efficiency.

Compact, Transit-Oriented Development

The increasing congestion in North Carolina's metropolitan areas that is causing many to question the wisdom of current development patterns is symptomatic of upward transportation energy trends as well.

A substantial reduction in vehicle miles traveled (VMT) is a critical component of achieving maximum energy efficiency potential. Yet North Carolina's VMT is expected to grow by 36% between 2010 and 2025, while population growth is projected at only 26% over that same period (OSBM 2009).

Integrating transportation and land use planning, along with the provision of viable alternatives to the automobile for certain trips, is essential to achieving reducing the growth in driving and transportation energy use. Yet in North Carolina as in other states, zoning and regulation of land use is a function of local government, which has a limited role in transportation infrastructure. Transportation planning falls under the jurisdiction of the North Carolina Department of Transportation (NCDOT), the state's 17 Metropolitan Planning Organizations (MPOs) and the 18 Regional Planning Organizations. These entities will need to greatly increase their coordination to reverse the trend of growing VMT.

North Carolina's current MPO structure is highly fragmented, however, often failing to encompass expanding metro regions and making coordination difficult between the various agencies that cover the region. The Charlotte metropolitan area, for example, is covered by four MPOs in addition to the numerous rural planning organizations that tackle transportation planning in the areas immediately outside the metro region. North Carolina's fractured MPO structure is actually a deterrent to sound land use and transportation planning (SELC 2009.)

Over half of population growth projected to occur by 2025 is expected in the Charlotte, Raleigh and Greensboro metropolitan areas as well as in and around Asheville and Wilmington. A lot remains to be done to provide residents with transportation choices outside of their personal vehicles, and most metropolitan areas have begun putting together long-range transportation plans that incorporate rail transit services as well expanded bus routes. With the successful launch of Charlotte's first light rail line (the LYNX line) in 2008 and companion policies to maximize its use, the state is primed to promote compact growth and transit-oriented planning on a larger scale. Nationally, the demand for transit-oriented development is growing rapidly. By 2025, an estimated 14.6 million households will be looking to rent or buy homes near transit stops (Reconnecting America 2008a).

Transit-oriented development provides several non-energy benefits that are important to consider. It can boost the economic productivity of communities by attracting a number of new and varied businesses to the area. Additionally, transit expansion and the subsequent reduction in vehicle miles traveled and gasoline consumption translate to less money being shipped outside of the local economy to pay for fuel resources and increased job creation within the state, particularly in industries responsible for the physical construction of new rail lines and multi-family housing (Reconnecting America 2008b.)

In this analysis, we represent a policy package achieving compact, transit-oriented development through the assumption that one-half of all population growth in 23 counties in six metropolitan areas occurs within a half-mile of existing and future transit stops. Extensive transit expansion is also assumed in all six areas. These conditions would result in substantial VMT and gasoline savings, due both to the proximity of transit for these new residents and to the increased density of the areas in which the population growth is concentrated.

This concentration of growth would strongly support elements of development plans adopted or proposed by some of North Carolina's metropolitan regions. For example, the Charlotte area's draft development plan envisions 70 percent of multi-family housing and 75 percent of new office space will occur in the centers and corridors containing transit lines (Charlotte-Mecklenburg Planning Department 2008). Similarly, Greensboro's Connections 2025 Comprehensive Plan envisions "compact development patterns that incorporate mixed land uses and densities which encourage transit, biking and walking as convenient alternatives to automobile use." (City of Greensboro 2003.)

According to a recent National Academy of Sciences study, research to date indicates that doubling density in urban areas reduces residents' VMT by between 5 and 12 percent and, if coupled with complementary policies such as improved public transportation, by as much as 25 percent (TRB 2009). We assume a 15 percent drop in VMT near a transit stop for each doubling of density in the medium case, and a 25 percent drop in the High Case. For this policy, only those living within a half-mile of transit are assumed to reduce fuel consumption. As a result, fuel savings represent only a modest percentage of statewide gasoline consumption by 2025. Continuing this concentration of growth in areas that provide alternatives to driving and enhanced accessibility to jobs, shopping, and other common destinations would result in a major reduction in VMT in the long term, however.

The Charlotte Area Transit System (CATS) is taken as the model transit system for the metropolitan areas throughout the state, in that we assume systems in other areas reach sizes similar to the projected size of CATS in proportion to their populations. CATS plans to build 4 additional light rail transit (LRT) lines by 2025, with an additional 37 stops. While other regions' transit systems are far less developed, the state's other metro areas have proposed major transit expansions. The Raleigh-Durham region's Regional Transit Infrastructure Blueprint recommends a comprehensive package of transit infrastructure and service improvements that includes:

- Rail investments connecting:
    a. Chapel Hill to East Durham using LRT
    b. North, West and Downtown Raleigh using 12 miles of LRT
    c. RTP, Cary, Durham and Raleigh using and existing regional connector and Amtrak services (STAC 2008)
- Circulators (potentially trolleys and streetcars)
- Enhanced region-wide bus network

In addition to these investments, the Triangle J Council of Governments and the Triangle Transit Authority have banded together to launch the Land Use and Community Infrastructure Development Program (LUCID) to guarantee the successful implementation of the Raleigh-Durham Regional Transit Infrastructure Blueprint by focusing on (i) land use that matches the transit investments, and (ii) supporting infrastructure (such as sidewalks) and policies (such as Transportation Demand Management) that make transit readily accessible and more convenient for travelers, as two of four critical elements guiding the program (STAC 2008).

The Greensboro Long-Range Transportation plan proposes an even more ambitious program to provide residents with alternatives to driving. In addition to expanding service on existing bus routes in the region, the comprehensive plan proposes a commuter rail line that caters to commuters from the suburbs into downtown Greensboro, bus rapid transit (BRT) routes that extend to the east, south and west of the county and a network of express bus routes (Greensboro Urban MPO 2009).

To encourage individuals to move into transit-oriented communities, state and municipal governments can introduce a variety of supplemental policies. Some of the greatest barriers to more compact, transit-oriented developments are local zoning regulations across much of the country (TRB 2009.) Traditional zoning practices in the United States have historically been derived from the need to prevent overcrowding in urban centers but have resulted in the patterns of sprawl development typical immediately outside urban centers across the country. States can play an important role in providing incentives to local governments that encourage the appropriate use of higher-density zoning, effectively meeting the growing demand for and allowing for the creation of TOD communities to reduce state-wide VMT. Massachusetts, for instance, adopted in 2004 the Smart Growth Zoning Overlay District Act, under which municipalities can propose new high density zoning provisions for consideration to the state. Areas that will implement this up-zoning must be located near transit stations and provide a certain percentage of affordable housing. If the zoning is approved, the municipality receives an initial payment from the Commonwealth Trust, plus additions funding for each unit built in the rezoned district. (EOHED 2010)

Another existing barrier to compact, transit-oriented developments is the perpetuation of parking subsidies for urban centers. Nationally, parking subsidies are estimated to amount to between $125 billion and $375 billion annually and subsequently lead to increased VMT as commuters are encouraged to drive more (Shoup 2005). Removing these subsidies will encourage commuters to use more energy efficiency travel alternatives and, in effect, serve as incentive for the creation of compact, transit-oriented communities around primary urban centers in North Carolina.

Additional policies to encourage the creation of and movement to high density communities could include tax credits for the purchase of multi-family homes in these districts as well as integrated street design to improve street connectivity and allow easy access to commercial areas. North Carolina recently passed a Complete Streets policy package that aims to do just that in metro areas across the state (NCSC 2009).

Gasoline savings from the reduced VMT due to compact, transit-oriented growth as described above in the medium case reach 609 thousand barrels in 2015 and rises to 3.7 million barrels by 2025. In the High Case, which assumes a greater VMT reduction with increased density, savings would reach 987 thousand barrels in 2015 and 5.3 million barrels in 2025.

Heavy Truck Efficiency Package

Diesel fuel consumed by heavy trucks accounts for over 20 percent of all transportation fuel use in North Carolina. Tractor-trailers in turn dominate heavy truck fuel usage, due to their high annual mileage and relatively low fuel economy. Trucking companies are sensitive to fuel costs, which are typically second only to labor among their business expenses; a tractor-trailer may consume well in excess of $50,000 of fuel annually. Truck manufacturers may therefore be more aggressive in improving the fuel economy of their products than are light-duty vehicle manufacturers. Yet substantial barriers to fuel efficiency do exist in the truck market, including the rapid turnover of trucks from first to second owner and the lack of standardized information on truck fuel economy.[49] Consequently, there are numerous technologies and strategies available to improve fuel economy that are not fully utilized. Indeed, average fuel economy for new tractor-trailers could be raised by over 50 percent through a variety of cost-effective existing technologies, including aerodynamics of tractor and trailer, engine improvements, low rolling resistance tires, transmission enhancements, and weight reduction (NESCCAF 2009).

The heavy truck efficiency policy analyzed here would establish a low-interest loan program, beginning in 2010, to promote the purchase of new tractor-trailers or the retrofit of existing tractor-trailers with approved energy efficiency technologies and equipment. In particular, equipment in the efficiency package identified by U.S. EPA's SmartWay Transport Partnership would be eligible for loans to truck owners in North Carolina. This SmartWay upgrade kit, which includes aerodynamic add-ons for trailers, efficient tires, and auxiliary power units (APUs) allowing long-distance truckers to eliminate overnight idling, has been found to reduce fuel consumption by 15 percent or more while reducing emissions. The federal government's adoption of fuel economy standards for heavy trucks will likely result in universal adoption of technologies in the SmartWay package among new trucks, reducing the efficacy of the loan program in the latter part of the analysis period. The loan program should in that case be adjusted to incentivize early adoption of technologies not needed to achieve the federal standards.

The incentive in the medium case scenario to adopt this standard package of improvements would become a requirement in the High Case. Such a requirement has been adopted in California and will apply not only to fleets registered in California but also to those operating there. We did not have the data on out-of-state trucks necessary to evaluate this broader requirement, but savings in this case would clearly be far larger.

We estimate the low-interest loan program to yield diesel savings of 396 thousand barrels by 2015 and 485 thousand barrels by 2025 under the medium case scenario. Under the high scenario, savings rise to 419 thousand barrels in 2015 and 514 thousand barrels in 2025.

Truck Stop Electrification

Another opportunity to save diesel fuel consumption is by reducing idling of long-haul trucks passing through North Carolina but registered elsewhere. Long-haul tractor-trailers typically idle several hours per day to produce heating, cooling and power for drivers when their vehicles are stationary. Various devices are available or under development to eliminate the need for extended idling, including direct-fired heaters, auxiliary power units (APUs), and truck stop electrification. None is yet widely used in the U.S.

The Truck Stop Electrification policy would establish a low-interest loan program to promote electrification of parking spaces at truck stops in North Carolina, allowing drivers to turn off their trucks when stopped for extended periods. Truck stop electrification (TSE) can be done using on-board or off-board systems. An on-board system simply provides power outlets for trucks that have electrical heating/ventilation/air conditioning (HVAC) systems and an electrical plug, while an off-board system brings HVAC to the truck, requiring no special equipment on the truck. For this discussion, we assume off-board systems will be used, since this would place no requirements on the out-of-state trucks that are the primary users of truck stops. On-board systems would be far less expensive to truck stop owners, however, and the number of trucks manufactured with electric HVAC systems will increase, so the best strategy might be a mixture of the two system types.

For this policy, the medium and high case scenarios are the same. Assuming that all truck stops in North Carolina are electrified by 2020, we estimate that diesel consumption savings will reach 486 thousand barrels in 2015 and 595 thousand barrels in 2025.

[49] Fuel economy standards do not currently exist for heavy trucks but are being formulated pursuant to the 2007 Energy Independence and Security Act (EISA)

Intermodal Freight Investment

A concerted effort to pursue the opportunities available to improve the intermodal freight network in North Carolina could bring substantial energy savings through greater reliance on modes less energy-intensive than trucks. Achieving the full benefit of a modally diverse system of goods movement would require steps from expanding rail and marine infrastructure to guiding the locations of industrial facilities to adjusting the tax code, and would need to be integrated into development strategies at every level of government.

The Intermodal Freight Investment policy included in the package of transportation energy efficiency improvements is assumed to divert 10 percent of long-distance truck miles in North Carolina to rail by 2025. This is in general terms an objective that has been cited in various contexts as consistent with the potential to increase rail's share of total U.S. freight without dramatic changed in our goods movement system. Along the Northeast/Southeast Corridor, which passes through North Carolina along I-77, I-85, and I-95 and the parallel rail corridors, intermodal services currently capture only two percent, in contrast to the 72 percent intermodal share in the primary Southern California/New York/New Jersey corridor (AASHTO 2002). The Mid-Atlantic Rail Operations Corridor Study undertaken by the I-95 Corridor Coalition for the region stretching from New Jersey through Virginia considered a program of rail freight investments that would reduce long-distance truck miles by 7.5 percent, shifting primarily dry van goods and automobiles traveling over 400 miles to rail (I-95 Corridor Coalition 2004).

Fully specifying the policies and projects necessary to achieve the assumed mode shift is beyond the scope of our analysis, but we include this element to show the magnitude of savings that might be expected to follow from a strong intermodal freight program. A key ingredient of a policy to bring about such a shift would be state investments in individual infrastructure projects that have already been presented and well-received in forums seeking to rationalize the transportation system in North Carolina. Heavily-traveled interstates such as I-85, I-40, I-77, and I-95 carry large volumes of long-distance truck trips that could in principle be served by intermodal rail. Other types of rail services, such as shuttles serving inland ports or trailers on flatcar, could provide relief to key highway links as well. Landside facilities such as logistics hubs and intermodal terminals are also essential to greater use of rail and intermodal services. The 21st Century Transportation Committee's final report emphasized the importance of projects in each of these categories. Three important examples of near-term intermodal freight investments are:

1) Crescent Rail Corridor (Norfolk Southern)—This multi-state project of Norfolk Southern includes the Greensboro-Charlotte corridor and would compete with trucks traveling on I-77 and I-85.
2) Intermodal facility at Charlotte airport; logistics hubs in Charlotte and Greensboro—Expansion of the capacity of the Norfolk Southern intermodal facility to approximately 250,000 lifts per year is proposed for a 300 acre tract at Charlotte Douglas International Airport. The North Carolina Statewide Freight Logistics Plan characterizes this as "by far the most important" rail project in the state. More generally, both Greensboro and Charlotte, which hosted some of the first inland ports in the country, should be developed as logistics hubs serving both international and domestic freight shipments.
3) National Gateway Corridor (CSX)—The National Gateway Corridor would provide improved rail connections from the East Coast's international deepwater ports and population centers to Midwestern manufacturing centers. It includes a portion of CSX's major north-south line and would draw traffic from I-95 as well as other major north-south routes. National Gateway also includes the Charlotte-Wilmington line (Carolina Corridor) serving the port.

Fuel savings are likely to take a back seat to economic development as a driver of these projects, which will require investments by both public and private sector and the participation of players beyond North Carolina's borders. Nonetheless, a concerted effort to follow through on the freight strategies recommended by the 21st Century Committee would bring substantial fuel savings. For example, Norfolk Southern projects that truck trip diversion in North Carolina due to the Crescent

Corridor will reach 476,000 annually in 2015 (Norfolk Southern 2009), resulting in fuel savings of 9.3 million gallons per year. This amounts to 13 percent of the savings target for the Intermodal Freight Investment policy.

Reaching the full 10 percent diversion of long-haul truck freight to rail would save 4 percent of diesel fuel statewide. We assume 1 percent diesel savings will be achieved by the Intermodal Freight Investment policy by 2015 and the full 4 percent by 2025 under both the medium and high scenarios.

Light-Duty Vehicle Electrification in North Carolina

Plug-in hybrid electric vehicles (PHEVs) are generating much excitement, while all-electric vehicles (EVs) are making a comeback in the United States after effectively disappearing in the early 2000s. As part of his campaign, President Obama announced his goal to have 1 million PHEVs on the road by 2015. With the amount of interest in electric vehicles building steadily, North Carolina is primed to become a center of electric vehicle use.

A range of incentive programs are available to encourage the purchase of electric vehicles. Tax credits are often the easiest way to incentivize the purchase of electric vehicles. Several states such as South Carolina, Louisiana, and a variety of East Coast states have implemented a tax credit policy that reduces the up-front cost of an alternative fuel or hybrid electric vehicle (HEV). In most cases, electric vehicles are covered under tax credits for alternative fuel vehicles (AFVs).

While the state does not currently have a tax credit program for such vehicles, North Carolina has implemented a range of policies and efforts that target the deployment of electric vehicles. The state currently has an Alternative Fuel Vehicle Fund that is financed by the sale of Energy Policy Act (EPAct) credits. Money from this fund can be used by the state to offset the incremental costs of purchasing AFVs or alternative fuels, or to provide the necessary infrastructure. Additionally, Progress Energy and Advanced Energy have recently partnered with Nissan to advance electric vehicles in Raleigh by developing an electric vehicle charging network and policies that help streamline the deployment and maintenance of the charging network. The city of Raleigh and the Research Triangle region have also partnered with the Rocky Mountain Institute's Project Get Ready Program to facilitate the adoption of electric vehicles in the state by providing solid infrastructure and educating potential customers on the viability of EVs.

If North Carolina were to successfully implement a set of policies that encourage the purchase of PHEVs and EVs in addition to promoting EV research and component production and integration (see "North Carolina as a Clean Energy innovation Hub" for more information, ACEEE estimates that by 2015 and 2025 the population of electric vehicles will be as highlighted in the table below under the medium and high case scenarios.

Electric Vehicle Populations in North Carolina under Medium and High Case Scenarios

	2015	2025
Mid	15,773	162,822
High	50,473	1,276,382

Gasoline savings that result from the above penetration scenarios will amount to 42 thousand barrels in 2015 and 567 thousand million barrels in 2025. Under the high scenario, savings in 2015 and 2025 will reach 200 thousand gallons and 9.7 million gallons respectively.

CHAPTER FIVE: COMBINED MACROECONOMIC AND EMISSIONS IMPACTS FROM ELECTRICITY, WATER, AND TRANSPORTATION POLICIES

Chapters 2 through 4 of this report examined several policies to stimulate greater levels of energy efficiency in North Carolina. The evidence suggests that smart policies and programs can drive more productive investments in energy-efficient technologies, and they can do so in ways that reduce the state's total energy bill. But the question remains, what does this mean for the state economy? Do the higher gains in energy productivity—that is, do the increased levels of efficiency investment with their concomitant reduction in the need for conventional energy resources—create a net economic boost for North Carolina? Or, does the diversion of revenues away from energy-related industries negatively impact the economy? In this chapter, we explore those issues and we present the analytical results of an economic model used to evaluate the impact of efficiency investments on jobs, income, and the overall size of the economy.

A recent meta-review of some past 48 energy policy studies done within the United States suggests that if investments in more efficient technologies are cost-effective, the impacts on the economy should be small but net positive (Laitner and McKinney 2008). As shown elsewhere in the report, from a total resource cost perspective, the benefits (i.e., the energy and water bill savings) outweigh both the policy costs and investments by a factor of two. In other words, the water and energy efficiency, policy recommendations highlighted in the policy scenario result in a substantial savings for households and businesses compared to the costs of implementing the policies. As we also discuss below, this consumer energy bill savings can drive a significant increase in the number of net new jobs within North Carolina.[50] In fact, continued investments in energy efficiency resources would maintain the energy resource benefits for many years into the future, well beyond the period of analysis examined in this report.[51] The state therefore has the opportunity to transition its economy to a more sustainable pattern of energy production and consumption in ways that benefit consumers and businesses.

The results in Table 5.1 below detail the benefits that will accrue to the state of North Carolina when policies encourage a more efficient use of energy resources. Further discussion in this section will provide an overview of the DEEPER model and more detailed background information for the state of North Carolina.

Table 5.1. Economic Impact of Energy and Water Efficiency Investments in North Carolina

Macroeconomic Impacts	2015	2020	2025
Net Jobs (Actual)	5,077	24,003	38,129
Wages (Million $2007)	$119	$832	$1,252
GSP (Million $2007)	-$70	$554	$589

Methodology

This macroeconomic evaluation consists of three steps. First, we calibrate ACEEE's economic assessment model called DEEPER (or the Dynamic Energy Efficiency Policy Evaluation Routine) to reflect the economic profile of the North Carolina economy (IMPLAN 2009). This evaluation is done for the period 2007 (the base year of the model) through 2025 (the last year of this particular analysis). In this respect, we incorporate the anticipated investment and spending patterns that are suggested by the standard forecast modeling assumptions. These patterns range from typical spending by businesses and households in the analytical period to the anticipated construction of new electric power plants and other energy-related spending that might also be highlighted in the forecast. Second, we transform the set of key efficiency scenario results from the policy analysis into the direct inputs which are needed for the economic model. The resulting inputs include such parameters as:

- The level of annual policy and/or program spending that drives the key policy scenario investments;

[50] As we use the term here, the word "consumer" refers to any one who buys and uses energy. Thus, we include both households and businesses as among the consumers who benefit from greater investments in energy efficiency.

[51] As we note elsewhere, the policy analysis ends in the year 2025. Yet, many of the investments we describe have a technology of perhaps 15 years. This means that investments made in 2025 would continue to pay for themselves through perhaps the year 2040 and beyond; and none of those ongoing energy or water bill savings is reflected in the analysis described in this chapter.

- The capital and operating costs associated with more energy-efficient technologies;
- The energy bill savings that result from the various energy efficiency policies described in the main body of the report; and
- Finally, a set of calibration or diagnostic model runs to check both the logic and the internal consistency of the modeling results.

So that we can more fully characterize the analysis that was completed for this report, we next provide a simplified working example of how the modeling is done. We first describe the financial assumptions that underpin the analysis. We then highlight the analytical technique by showing the kinds of calculations that are used and then summarize the overall results in terms of net job impacts. Following this example, we then review the net impacts of the various policies as evaluated in our DEEPER model.

Illustrating the Methodology: North Carolina Jobs from Efficiency Gains

To illustrate how a job impact analysis might be done, we will use the simplified example of installing one hundred million dollars of efficiency improvements within large office buildings throughout North Carolina. Office buildings—traditionally large users of energy due to heating and air-conditioning loads, significant use of lighting and electronic office equipment, and the large numbers of persons employed and served—provide substantial opportunities for energy-saving investments. The results of this example are summarized in Table 5.2.

Table 5.2. Illustrative Example: Job Impacts from Commercial Building Efficiency Improvements

Expenditure Category	Amount (Million $)	Employment Coefficient	Job Impact
Installing Efficiency Improvements in Year One	$100	12	1,200
Diverting Expenditures to Fund Efficiency Improvements	-$100	10	-1,000
Energy Bill Savings in Years One through 15	$200	10	2,000
Lower Utility Revenues in Years One through 15	-$200	4	-800
Net 15-Year Change	$0.0		1,400

Note: The employment multipliers are adapted from the appropriate sector multipliers within the North Carolina version of the DEEPER model. The benefit-cost ratio is assumed to be 2.0. The column marked "job impact" is the result of multiplying the row change in expenditure by the row multiplier. The sum of these products yields a working estimate of total net job-years over the 15-year time horizon. To find the average annual net jobs in this simplified analysis we would divide the total job-years by 15 years which, of course, gives us an estimated net gain of 93 jobs per year for each of the 15 years.

The assumption used in this example is that the investment has a positive benefit-cost ratio of 2.0. In other words, the assumption is that for every dollar of cost used to increase a building's overall energy efficiency, the upgrades might be expected to return a total of two dollars in reduced electricity and natural gas costs over the useful life of the technologies. This ratio is similar to those cited elsewhere in this report. At the same time, if we anticipate that the efficiency changes will have an expected life of roughly 15 years, then we can establish a 15-year period of analysis. In this illustration, we further assume that the efficiency upgrades take place in the first year of the analysis, while the electricity bill savings occur in years one through 15.

The analysis assumes that we are interested in the net effect of employment and other economic changes. This means we must first examine all changes in household and business expenditures—both positive and negative—that result from a movement toward greater levels of energy efficiency.

Although more detailed and complicated within the DEEPER model, for this heuristic exercise we then multiply each change in expenditures by the appropriate sector employment coefficient as they are adapted from the IMPLAN (2009) data. The sum of these products will then yield the net result for which we are looking.

In our example above, there are four separate changes in expenditures, each with their separate impact. As Table 5.2 indicates, the net impact of the scenario suggests a cumulative gain of 1,400 jobs in each of the 15-year period of analysis. This translates into an average net increase of 93 jobs each year for 15 years. In other words, the $100 million efficiency investment made in North Carolina's office buildings is projected to sustain an average of 100 jobs each year over a 15-year period compared to a "business-as-usual" scenario.

The economic assessment of the alternative energy scenarios was carried out in a very similar manner as the example described above. That is, the changes in energy expenditures brought about by investments in energy efficiency and renewable technologies were matched with their appropriate employment multipliers. There are several modifications to this technique, however.

First, it was assumed that only 80% of the energy bill savings are spent within North Carolina. We base this ratio on the consumer spending patterns reflected in the IMPLAN (2009) dataset as it describes local purchase patterns that typically now occur in the state. We also anticipate that 90% of the efficiency installations are likely (or could be) carried out by local contractors and dealers. If the set of policies encourages greater local spending so that the in-state consumer share was increased to 90%, for example, the net jobs might grow another 25% compared to our standard scenario exercise. At the same time, the scenario also assumes North Carolina provides only 60% of the manufactured products consumed within the state. But again, a concerted effort to build manufacturing capacity for the set of clean energy technologies would increase the benefits from developing a broader in-state clean energy manufacturing capability.

Second, an adjustment in the employment impacts was made to account for assumed future changes in labor productivity. As outlined in the Bureau of Labor Statistics Outlook 2008–2018, productivity rates are expected to vary widely among sectors (BLS 2009). For instance, drawing from the BLS data we would expect that electric utilities might increase labor productivity by 2.8% annually while the economy as a whole might increase productivity by 1.9% per year. This means, for example, that we might expect a one million dollar expenditure for utility services in the year 2025 would support only 61% of the jobs that the same expenditure would have supported in 2007 (the base year of the model), while other sectors of the economy would support only 71% of the jobs as in 2007.

Third, for purposes of estimating energy bill savings, it was assumed that retail electricity prices in North Carolina would follow the same growth rate as that described in the reference case section. Fourth, it was assumed that the efficiency investments' upgrades are financed by bank loans that carry an average 7% interest rate over a five-year period. To limit the scope of the analysis, however, no parameters were established to account for any changes in interest rates as less capital-intensive technologies (i.e., efficiency investments) are substituted for conventional supply strategies, or in labor participation rates—all of which might affect overall spending patterns. Fortunately, however, it is unlikely that these sensitivities would greatly impact the overall outcome of this analysis.

While the higher cost premiums associated with the energy efficiency investments might be expected to drive up the level of borrowing (in the short term), and therefore interest rates, this upward pressure would be offset to some degree by the investment avoided in new power plant capacity, exploratory well drilling, and new pipelines. Similarly, while an increase in demand for labor would tend to increase the overall level of wages (and thus lessen economic activity), the job benefits are small compared to the current level of unemployment or underemployment in the state. Hence the effect would be negligible.

Fifth, as described in the previous chapters for the buildings, industrial, and transportation end-use sectors it was assumed that a program and marketing expenditure would be required to promote market penetration of the efficiency improvements. Since these vary significantly by policy bundle we don't summarize them here but payment for these policy and program expenditures were treated as if new taxes were levied on the state commensurate with the level of energy demands within the state. Hence, the positive program spending impacts are offset by reduced revenues elsewhere in the economy.

Sixth, it should be noted that the full effects of the efficiency investments are not accounted for since the savings beyond 2025 are not incorporated in the analysis. Nor does the analysis include other benefits and costs that can stem from the efficiency investments. Non-energy benefits can include increased worker productivity, comfort and safety, and water savings, while non-energy costs can include aesthetic issues associated with compact fluorescent lamps and increased maintenance costs due to a lack of familiarity with new energy efficiency equipment (NAPEE 2007, 3–8). Productivity benefits, for example, can be substantial, especially in the industrial sector. Industrial investments that increase energy efficiency often result in achieving other economic goals such as improved product quality, lower capital and operating costs, increased employee productivity, or capturing specialized product markets (see, for example, Worrell et al. 2003).

To the extent these "co-benefits" exceed any non-energy costs, the economic impacts of an energy efficiency initiative in North Carolina would be more favorable than those reported here. Finally, although we show in Table 5.2 above just how the calculations would look from an employment perspective, we don't show the same kind of data or assumptions for either income or for impacts on the Gross State Product (GSP, or the sum of value-added contributions to the North Carolina state economy). Nonetheless, the approach is very similar to that described for net job impacts.

Impacts of Recommended Energy Efficiency Policies

For each year in the analytical period, the given change in a sector spending pattern (relative to the reference scenario) was matched to the appropriate sector impact coefficients. Two points are worth special note: first, it was important to match the right change in spending to the right sector of the North Carolina economy; and second, these coefficients change over time. For example, as previously suggested, labor productivity changes mean that there may be fewer jobs supported by a one million dollar expenditure today compared to that same level of spending in 2025. Both the negative and positive impacts were summed to generate the estimated net results shown in the series of tables that follow. Presented here are two basic sets of macroeconomic impacts for the benchmark years of 2010, 2015, 2020, and 2025. These include the financial flows that result from the policies described in the previous chapters. They also include the net jobs, income, and GSP impacts that result from the changed investment and spending patterns.

Table 5.3 presents the changes in consumer expenditures that result from these policies. While the first row in the table presents the full cost of the energy efficiency policies, programs and investments, the utility customers will likely borrow all or at least a portion of the money to pay for these investments. Thus, "annual consumer outlays," estimated at $113 million in 2010, rise to nearly $3,821 million in 2025. These outlays include actual "out-of-pocket" spending for programs and investments, along with money borrowed to underwrite the larger technology investments. The annual energy and water bill savings reported here are a function of reduced energy purchases from the many North Carolina electric, natural gas, and water utilities within the state.

As we further highlight in the table that follows, the annual energy bill savings begins with a modest first year net benefit of $137 million. As more investments are directed toward the purchase of more energy- and water-efficient technologies, the net annual consumer savings rise to about $3.1 billion by 2025.

Table 5.3. Financial Impacts from Energy Efficiency Policy Medium Case Scenario

(Millions of 2007 Dollars)	2015	2020	2025
Annual Consumer Outlays	$1,183	$3,585	$5,647
Annual Energy-Water Bill Savings	$1,191	$3,587	$7,145
Annual Net Consumer Savings	$8	$2	$1,499
Cumulative Net Energy-Water Bill Savings	$12	$270	$3,640

- 'Annual' refers to the total that is reported in the benchmark year while 'Cumulative' is the total from previous years beginning in 2010 through the benchmark year.
- Annual consumer outlays include administrative costs to run programs, incentives provided to consumers, investments in efficiency devices and interest paid on loans needed to underwrite the needed efficiency investments.
- Annual energy-water bill savings is the reduced expenditures for water and energy services that benefit both households and businesses within a given year. The net savings is the difference between savings and outlays.

Readers should note from Table 5.3 that in the early years and especially as the policies ramp up quickly to stimulate a greater level of efficiency improvements, the net energy bill savings start out modest. As the investments are paid back in lower energy bills, however, the net cumulative savings quickly build up, reaching an estimated $1.5 billion net annual savings in 2025. Cumulative net energy bill savings reach about $3.6 billion for consumers in North Carolina by 2025.

Now that we have estimates of how financial flows are distributed across the end-use sectors, we can assess the impacts on the state economy using the DEEPER model. The model evaluates impact on jobs and wages sector by sector, and evaluates their contribution to North Carolina's Gross State Product, which is a sum of the net gain in value-added contributions provided by the energy productivity gains throughout all sectors of the state economy. As with the previous table on financial impacts, for reader convenience, Table 5.4 repeats the net economic impacts.

Table 5.4. Economic Impact of Energy Efficiency Investments in North Carolina

Macroeconomic Impacts	2015	2020	2025
Net Jobs (Actual)	5,077	24,003	38,129
Wages (Million $2007)	$119	$832	$1,252
GSP (Million $2007)	-$70	$554	$589

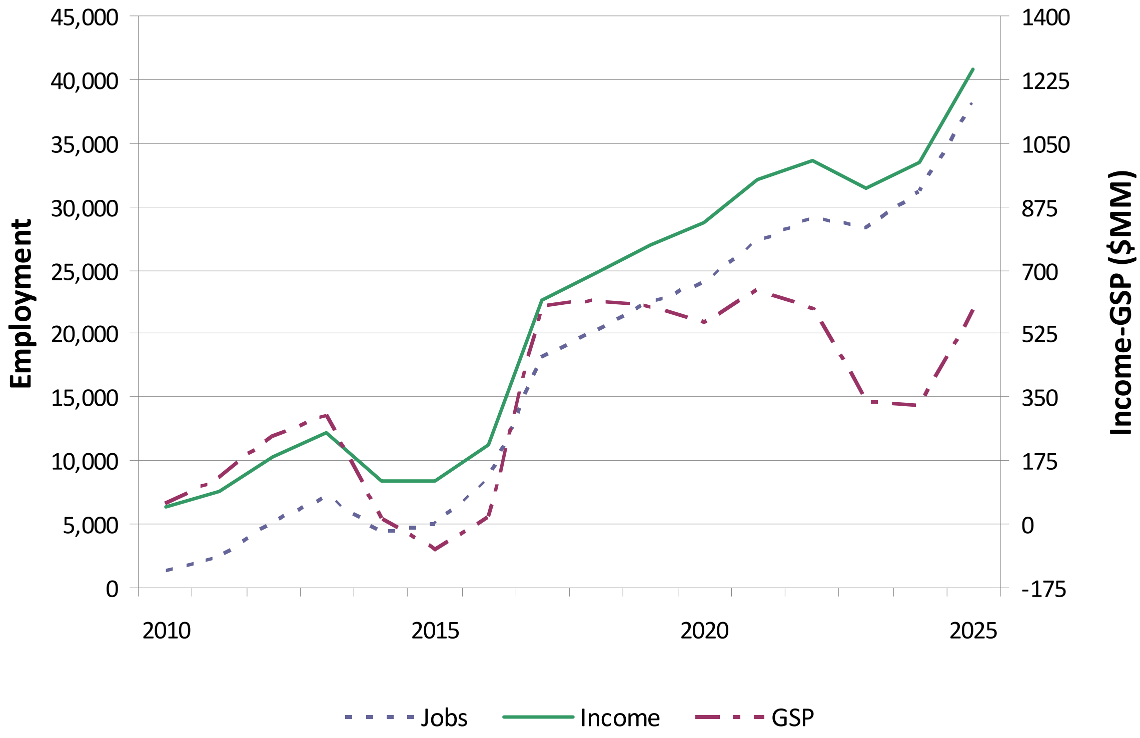
Given both the financial flows and the modeling framework, the analysis suggests a net contribution to the state's employment base as measured by full-time jobs equivalent. In the year 2015 we see a net increase of about 5,000 jobs which increases to a significantly larger total of 38,000 jobs in 2025.

In North Carolina, the electric power and the natural gas service sectors directly and indirectly employ about 7.3 jobs for every $1 million of spending. But, all other sectors, including those vital to energy efficiency improvements like manufacturing and construction, utilize 14.7 jobs per $1 million of spending. Once job gains and losses are netted out in each year, the analysis suggests that, by diverting expenditures away from non-labor intensive energy sectors, the cost-effective energy policies can positively impact the larger North Carolina economy—even in the early years, but especially in the later years of the analysis as the energy savings continue to mount.

To highlight the results of this analysis in a little more detail, Figure 5.1 provides year-by-year impacts of the energy efficiency policies on net jobs in North Carolina and the anticipated net gain to the state's wage and salary compensation and Gross State Product, both measured in millions of 2007 dollars.

Figure 5.1 highlights the anticipated net gain to the state's wage and salary compensation and Gross State Product, both measured in millions of 2007 dollars.

Figure 5.1. Net Employment, Wages, and Gross State Product Impacts for North Carolina in Medium Case Policy Scenario (2010–2025)



The results of the policy analysis suggests that an early program stimulus that drives a higher level of efficiency investments can actually increase the robustness of the North Carolina economy, creating about 5,000 net new jobs in 2015, and rising to 44,000 net new jobs in 2025. This is roughly equivalent to the employment that would be directly and indirectly supported by the construction and operation of 300 small manufacturing plants within North Carolina. As indicated by Figure 5.1, these investments also increase both wages and gross state product throughout North Carolina.[52]

In short, the more efficient use of energy and water resources provides a cost-effective redirection of spending away from less labor-intensive sectors into those sectors that provide a greater number of jobs throughout North Carolina. Similarly, cost-effective energy productivity gains also redirect spending away from sectors that provide a smaller rate of value-added into those sectors with slightly higher levels of value-added returns per dollar of revenue. The extent to which these benefits are realized will depend on the willingness of business and policy leaders to implement the recommendations that are at the heart of this report and found earlier in this assessment. Indeed, to

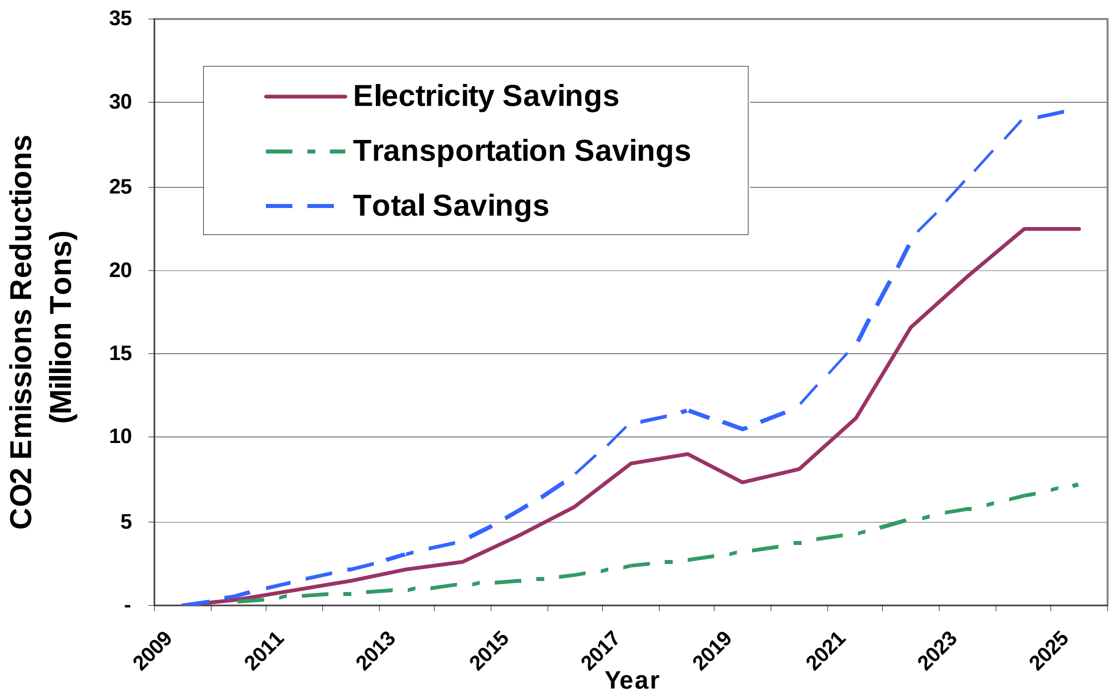
[52] Readers will observe in the jobs chart a modest valley although still a net positive economic and employment impact in the years 2013 through 2016. The reason for this is that the reference case assumes a significant construction program for new power plants in roughly that same period of time. Avoiding or deferring that utility-related construction activity during the 2013-2017 period in the policy scenario temporarily diminishes the net employment gains in those years. And because electric utilities are more capital-intensive then other sectors of the economy, the avoided construction also has a pronounced impact on wages and Gross State Product. Note, however, that all three sets of economic impacts remain strongly net positive for North Carolina.

the extent that business and policy leaders go beyond the recommendations described here, the evidence further suggests an even greater net positive impact on the North Carolina economy.[53]

Emissions Impacts

Energy efficiency represents a cost-effective strategy to reduce carbon dioxide emissions that contribute to climate change. The combined package of electricity and transportation efficiency policies suggested in our medium case scenario has the potential to save about 30 million tons of carbon dioxide annually in 2025, as shown in Figure 5.2. Readers should note that because North Carolina is a net importer of electricity (because electric utility service territories overlap in North and South Carolina) emissions savings from avoided electricity generation overlaps with South Carolina emissions.

Figure 5.2 Carbon Dioxide Emissions Savings from Electricity and Transportation Policies



CHAPTER SIX: DISCUSSIONS AND RECOMMENDATIONS

Need for Regionally Balanced Energy Efficiency Policies

North Carolina is one of the fastest growing states in the country. Growth however is not uniform across the state. Many of the rural parts of the state have been economically stagnant for over a decade, while the urban parts of the state, particularly the I-85 crescent from the Triangle to Charlotte are growing very rapidly. These differences in growth mean that a one-size-fits-all suite of energy efficiency policies is inappropriate to meet the state's diverse energy needs. It is thus necessary to

[53] As a further thought experiment, we ran the DEEPER model to test the potential impact of both greater in-state spending that might result from the set of policies characterized in this analysis, and from the inclusion of non-energy benefits that are likely to follow from this policy scenario. Following an analysis by Laitner and Lung (2009), we assumed a set of non-energy benefits that might be about 40% of the electricity bill savings throughout the economy. And we increased the in-state consumer spending from 67% to 80%. With those two assumptions added into the DEPER Model, the net employment impacts rose from 44,000 jobs in the year 2025 to 56,000 jobs in that same year.

provide policies that address the needs of the rural areas of the state and also provide policies that are tailored to the needs of the fast-growing parts of the state. With the suite of suggested electric, water and transportation efficiency policies have attempted to respond to the needs of the different regions.

For the rapidly growing portions of the state, energy building and plumbing codes and enforcement together with advanced building programs represent some of the most important policies, because every building that is built to a lower energy standard represents a lost opportunity. It is more difficult to retrofit a building to make it more efficient than it is to build it efficient from the start. For rural areas, these codes are important but their impacts are less because construction is occurring at much slower level. In these rural regions, weatherization of existing buildings along with measures for manufacturing homes (which in many rural regions account for a majority of the new homes) represent more significant policies. These policies also have a social equity aspect because energy costs represent a larger share of the average household budget in these regions. Improved energy efficiency can make a real contribution to the sustained quality of life by freeing income for other needs.

A similar dichotomy exists with transportation policies. We suggest that the land-use, alternative transportation, VMT and PAYD are targeted at the fast-growing areas of the state where congestion has become a liability to future economic growth and regional air quality. These policies make far less sense in low-density, rural areas where residents are forced to drive due to the low density of the area. In all areas encouraging a shift to more efficient vehicles benefits all consumers. Since with higher VMT in rural areas the cost savings accrue more rapidly, while in dense parts of the state, greater fuel efficiency translates into lower emissions.

Nexus between Electricity, Water and Transportation

A strong linkage exists between electricity, water and transportation usage. As was discussed in the water chapter, electric generation requires water and water requires electricity, and as we see greater electrification of transportation, as is discussed in the transportation chapter we see these interrelationships increasing. In the rapidly growing regions of the state, increases in population put stress on all three resources creating the potential for future economic disruptions as demands exceed the ability of the infrastructure to meet needs.

The energy efficiency policies suggested in this report can help balance demands for these three resources. Water efficiency can contribute to reducing demands for electricity, freeing up water for other uses. Electric efficiency can reduce demand for water associated with electric power generation. Transportation VMT reduction policies such as those that encourage compact, transit-oriented developments, not only improve transportation system efficiency by providing residents with various affordable alternative to driving but also encourage the construction of multi-family buildings, which are inherently more energy-efficient that single-family homes, thus improving the overall efficiency of the residential sector (TRB 2009).

Similarly, the truck anti-idling and light-duty vehicle electrification policies impact not only the transportation fuel use but also electricity consumption in that decreased fuel consumption is offset by the additional electricity use necessary for the implementation of these policies. However, given that electricity providers are already making the transition from coal-generated to nuclear-generated electricity and that the future electricity grid in North Carolina is anticipated to be significantly cleaner and more energy-efficient, the net efficiency gains for both the electric and transportation sectors are substantial.

While this report does not address natural gas efficiency, the suggested policies offer significant opportunities for gas savings as well. Many electric efficiency measures will also produce significant natural gas savings, and gas is poised to become a much more important electric generation fuel in the future so reductions in electricity consumption offer an important opportunity for gas savings. A 2006 ACEEE study (Elliott 2006) suggested that electric efficiency represents the most important opportunity to save natural gas. Proposal for use of natural gas as a transportation fuel, further extend the linkages between electricity, water and transportation to natural gas.

Energy Efficiency as an Economic Driver

In general, energy efficiency policies promote economic growth in the state by freeing up dollars spent on energy bills for other purposes, while creating new jobs associated with energy efficiency investments. Some of these investments will occur in North Carolina and will create local jobs, but other investments will occur in other portions of the country and the state is positioned to benefit from expanded national energy efficiency investments by becoming an exporter of efficient products and knowledge. If the state can become a major manufacturer of clean energy products, portions of the state that have not benefit from economic growth seen in the fast-growing regions of the state can begin to share more in the growth.

The suggested energy efficiency policies will help the state become even attractive as a home for business. Energy efficiency would create a more attractive and stable energy cost structure for firms doing business in the state. Other more targeted policies would help firms implement greater efficiency in their manufacturing plants, buildings and farms, producing both direct cost savings together with greater non-energy productivity benefits that result from new investments.

The suggested transportation policies will have the result of reducing congestion, with reductions time costs associated with delays. Investments in freight infrastructure will further enhance the attractiveness of North Carolina as a business environment, making it easier and more reliable to get products to market. In addition, by implementing planning policies that encourage livable communities, North Carolina can retain and attract the skilled workforce that will be needed to insure continued economic growth.

CHAPTER SEVEN: CONCLUSIONS

North Carolina is uniquely poised to invest in energy efficiency to enhance the state's energy security and spur economic growth. Our analysis shows that the state can create 38,000 net new jobs in 2025 by making commitments to energy efficiency in the state's buildings, manufacturing, and transportation sectors. While North Carolina imports most of its energy resources, including transportation fuels, electric generation fuel, and home heating fuels, energy efficiency offers a way to invest in local projects that can directly contribute to the growth of the state's economy.

North Carolina is among the most rapidly growing states in the country. Projected population growth of 1.5% per year will strain electric power resources, water supplies, and transportation infrastructure. Energy efficiency can play a critical role in managing this growth by:

- meeting the expanding need for electricity while minimizing the need for new, expensive electric generation and transmission investments that will raise electric rates in the state;
- reducing demands for water, thus freeing resources to meet demands of growing populations and economic activities; and
- managing transportation congestion through policies and infrastructure investments that will produce more livable communities.

Numerous policies and programs outlined in this report can help the state achieve these goals. For example, efficient building energy codes and long-term planning policies are critical to a rapidly growing state such as North Carolina because they lock in efficient systems and equipment that would otherwise be costly to retrofit. Building and planning things "right" the first time will pay dividends for decades to come.

Energy Efficiency as a Resource

As economic growth creates competition for water between power generation and residential and business needs, efficiency can address both challenges by reducing demands for electricity, thus freeing up water resources that would otherwise be used for power plant cooling. Using water more efficiently in homes and businesses can in turn reduce wastewater and water treatment electricity consumption, effectively negating the need for new treatment plans as the state's population continues to grow and freeing up public funds for other purposes.

The energy efficiency policies in this report have the potential to meet about a quarter of the state's electricity needs in 2025, and can therefore facilitate the modernization of the state's electric generation fleet by enabling the retirement of older plants to allow for new, more efficient and cleaner generation facilities. North Carolina is current planning to transform the generation mix in the state through an increasing number of renewable energy resources by retiring aging coal plants. Also, new natural gas plants require less water than older coal plants, which further frees up scarce water resources to meet the needs of a growing, vibrant economy. Putting strong energy efficiency policies in place today buys the state time to consider what energy resources will be needed in the future, thus helping to protect the state's consumers from paying for unnecessary capacity investments.

Emissions and Economic Benefits

Greater energy efficiency also reduces air pollutants from electric infrastructure and mobile vehicle sources, which, when combined with reduced demands for energy, can put the state on a more sustainable environmental path. North Carolina faces more stringent federal ozone regulations in urban areas, and the prospect of federal greenhouse gas emissions regulation appears likely in the near future. Energy efficiency investments in all sectors represent a first response to these environmental concerns, containing the costs of compliance while producing positive economic benefits to the state.

Efficiency will help keep consumer energy and water purchases more affordable. Consumers and business that make efficiency investments benefit from reduced energy and water use, and thus lower their energy bills. However, all consumers benefit from efficiency investments because efficiency resources are less expensive than the alternative investments in electric, water, and transportation infrastructure that would otherwise have to be made and paid for through higher electric and water prices, and increased taxes and fees.

Investments in energy efficiency in North Carolina described in this analysis can create 38,000 net new jobs in 2025. And the potential for additional job creation is even greater. North Carolina's world-renowned research facilities and energy efficiency companies position the state to become a world leader in the production and deployment of clean energy technologies. The state will benefit not only by making clean energy innovations available to the residents and businesses in the state, but also by creating an export market for products and services nationally and globally. As tight energy resource markets and concerns about climate change create a need for alternatives to conventional energy resources, national and global markets will increasingly demand clean energy solutions.

North Carolina is poised to be become a leader in energy efficiency. Adoption of the energy efficiency policies suggested in this report would put the state on the path to greater economic, energy, and environmental sustainability. Changing the state's energy path can create more livable communities that will be able to accommodate the expected population boom over the next 15 years. Efficiency will allow North Carolina to maintain the vibrant economy and quality of life that have characterized the state over the past half century. In addition, efficiency can help benefit residents who have not shared in the economic wealth created in the urban core through stabilized energy prices and reduced energy expenditures. Efficiency disproportionately benefits lower income consumers for whom energy represents a higher fraction of income. A clean energy industry also creates new jobs statewide that can help fill the holes created by the departure of tobacco, textiles, and furniture jobs. All that is needed to make this future a reality is for the state's leaders to embrace the policies that will result in an efficient future.

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APPENDIX A: ELECTRICITY

A.1 Marginal Avoided Utility Costs

Background

ACEEE has initiated a series of state-specific "Clean Energy" potential studies through which it will work with key stakeholders in order to build a common understanding of, and consensus on, the role that clean energy resources, i.e., energy efficiency and demand response, can play in meeting the future electricity end-use requirements in each state, the economic benefits of treating those resources as the "first fuel" for meeting future requirements and the policies for maximizing reliance upon those resources. The time horizon for the studies is through 2025.

In each of those studies ACEEE will evaluate the cost effectiveness of reductions from energy efficiency and demand response, and will also demonstrate the benefits of those reductions to all consumers in the state by estimating retail prices in the long-term under a clean energy Policy Case.

ACEEE retained Synapse to provide three deliverables to support these studies:

- Projections of long-term wholesale electricity supply prices under a reference, or business-as-usual case;
- Credible, consistent, "high level" estimates of avoided electric energy ($/kWh) and capacity costs ($/kW-year); and
- Projections of long-term electricity supply prices under a clean energy policy case.

In light of time and budget constraints, and the policy nature of these studies, ACEEE requested that Synapse develop and apply an electricity planning and costing model that would produce accurate "high level" estimates of each of these deliverables in a well-documented, transparent manner.

In order to satisfy the ACEEE request, Synapse had to develop an electricity planning and costing model that would be:

- Applicable to planning and costing from a state perspective, although most electric utility operations cross state boundaries;
- applicable from state to state, although some states are part of deregulated multi-state markets while others operate under traditional utility regulation;
- applicable using public data;
- inexpensive to setup and run; and
- Relatively transparent.

Synapse has developed an EXCEL based planning and costing model with these characteristics.

Methodology

The model begins with an analysis of actual physical and cost data for a base year, develops a plan for meeting projected physical requirements in each future year of the study period and then calculates the incremental wholesale electricity costs associated with that plan. (Incremental to electricity supply costs being recovered in current retail rates).

Base Year Data

The actual data for the base year, and prior years, provides our starting point. That dataset contains historical data in the following categories:

1. Recent year summary statistics.

2. Listing of the ten largest plants in the state.
3. Top five providers of retail electricity
4. Electric capability by primary energy source.
5. Generation by primary energy source.
6. Fuel prices and quality.
7. Emissions.
8. Retail sales and revenues by customer class.
9. Retail sales by various provider types.
10. Supply and distribution of electricity.

This data enables us to characterize the electric supply system and its costs for a given state. For example the capacity, generation and capacity factor, average heat rate and fuel costs for different classes of resources. We can also calculate the retail margin from this data, i.e. the margin between average retail rates and variable production costs. The retail margin reflects the transmission and distribution costs being recovered in retail rates plus the fixed generation costs being recovered in those rates. This data is a very broad brush since the resources are grouped by fuel type and their operation is not characterized in great detail.

Future Years

We begin with the forecast of annual demand and energy in each future year provided by the ACEEE stakeholder group. Next we develop a physical plan to meet the load in each of those future years. This is done in the model via the following steps:

1. Derive annual capacity and generation requirements from forecast of retail annual demand and energy, and reserve margins,
2. Determine the relative quantities of annual capacity and generation to be provided by in-state and out-state resources based on the current mix of in-state and out-of state resources,
3. Estimate resource retirements. It is quite difficult to predict the timing of actual plant retirements, but it is reasonable to assume that some older facilities will be retired during the study period. We assume gradual retirement of existing resources over time based on typical operating lifetimes. This is explicitly specified in the input data section and can easily be modified if more specific data becomes available.
4. Estimate the capacity, timing and timing of new generation additions, in-state and out of state. Our model is not a capacity expansion model and therefore does not make capacity additions "automatically". Instead, after we include "planned" capacity additions, we add enough "generic" capacity additions to maintain the reserve margin. Our generic additions are a mix of peaking, intermediate and baseload units that maintains the historical mix of those categories in the state. This approach is transparent as the additions are explicitly specified in the input data section.
5. Calculate the quantity of annual generation from each category of capacity, existing and new, in-state and out of state. The estimated quantity of generation from each category of capacity is derived from the operating capacity factors. These are generally based upon economic dispatch, i.e. dispatch from each category in order of increasing variable production costs

Calculate Average Production Costs (Average Supply Costs)

The model calculates the average production costs, i.e., energy plus capacity, for the particular case in the Production Model worksheet.

STATES WITH REGULATED WHOLESALE MARKETS

For states with regulated wholesale markets the Production Model worksheet calculations are made as follows:

6. Calculate total cost of generation from existing in-state resources, purchases from out-of-state resources, and new in-state resources.
   a. The unit production costs of existing in-state generation includes variable operating costs plus fixed costs. The aggregate cost of generation from these resources decline over time as existing coal, oil and gas plants are retired, while the existing nuclear plants with low operating costs continue operation;
   b. The unit production costs of new in-state generation consists of the levelized capital cost of new capacity additions plus their variable operating costs. The capacity cost of new capacity additions are levelized using the capital recovery factors developed in the Capital Recovery Calculation (CRC) worksheet.
   c. The cost of power imported or exported is indexed to the generation-weighted average cost of generation from the in-state resources, i.e., existing and new. That is, the base-year import/export price changes in parallel with the in-state cost, e.g. an x% change of in-state production costs is reflected in an x% change of import/export prices. The rationale is that relative changes of in-state costs will be reflected outside the state as well.

STATES WITH DE-REGULATED WHOLESALE MARKETS

For states with de-regulated wholesale markets the Production Model worksheet calculations are made as follows:

7. The first step is to calculate the reference year market prices for the state being studied. The next step is to calculate the relationship between those state prices and market location for which future prices are available. The third step is to then apply that relationship to the futures prices to produce a forecast for market prices in the study state.

Calculate Avoided Costs

STATES WITH REGULATED WHOLESALE MARKETS

For states with regulated wholesale markets the Production Model worksheet calculates the total avoided costs, avoided capacity costs and avoided energy costs via the following steps:

8. Total Avoided Costs. The worksheet calculates "all-in" avoided costs that include both energy and capacity costs.
   a. Years 1 to 5. For the first five years the avoided costs are a mix of avoided dispatch of existing resources and avoided total cost of new resources that would otherwise come-on-line during that period. The percentage of new resources included in that mix is phased-in, starting at 0% in year 1 and rising to 100% in year 5.
   b. Year 6 onward. After year 5 the avoided costs in each year equal the average total costs of new resources in that year. This calculation assumes that the capital costs of new resources are avoidable either through avoiding their actual construction or through recovery from revenues from off-system sales.
9. Avoided capacity cost. To estimate the avoided cost of capacity only we use the proxy plant approach which is used by several ISOs. This avoided capacity cost is based upon cost of "capacity only" from a new gas combustion turbine "peaker" unit. Basing avoided capacity cost on the capital cost of a new peaker is a commonly accepted method.
10. Avoided Energy Cost. The avoided energy cost is the total avoided cost from step 8 minus the avoided capacity cost from step 9

STATES WITH DE-REGULATED WHOLESALE MARKETS

For states with de-regulated wholesale markets the Production Model worksheet calculates the total avoided costs, avoided capacity costs and avoided energy costs differently for different time-periods.

11. Near-term years for which futures prices are available, e.g. first 4 to 5 years.
    a. Avoided energy cost—This is calculated from the energy futures market prices with appropriate historic-based adjustments for the state service area.
    b. Avoided capacity cost—This is based on the available appropriate capacity market results.
    c. Total avoided cost—This is obtained by combining the avoided energy cost with the avoided capacity cost using the base year system load factor to arrive at the combined total avoided cost on a per MWh basis.
12. Long-term years for which futures prices are not available. After the period for which futures are available, the total avoided costs, avoided capacity cost and avoided energy cost are developed in the same manner as for regulated states, in steps 8, 9 and 10.

DEEPER Worksheet

The DEEPER model is a macroeconomic model that is used by ACEEE to calculate the impacts of energy costs and energy investments on the state economy. The avoided cost model provides three sets of inputs for the DEEPER model:

1. Annual incremental investments in new resources,
2. Annual O&M and fuel costs,
3. Annual fuel prices for electric generation

A.2 Meta-Analysis of Electricity Energy Efficiency Potential Studies

North Carolina Energy Efficiency Potential

The meta analysis of the energy efficiency market potential studies for North Carolina includes three studies conducted between 2003 and 2008. For this review we focused on the achievable and cost-effective potential of energy efficiency measures. When this type of scenario was not specifically included in the study, we evaluated the scenario that most closely resembled the methodology and savings potential of a cost-effective, achievable scenario.

Our analysis found that previous studies have estimated achievable, cost-effective potential for North Carolina at around 15% of electricity consumption by 2020. For several reasons, however, it is not possible to make direct comparisons from one study to another. First, each study featured a different period of analysis, ranging from 10-20 years, although all of the studies projected savings through around the year 2020. Second, the studies included different sets of efficiency measures and used different methodologies for estimating cost-effective potential. Efficiency measures were considered cost-effective at a range of $0.05 to $0.06 per kWh for two of the studies, and one study did not specify the threshold for cost effectiveness. Our review of avoided utility electricity costs finds that current marginal avoided costs for new supply side resources are in the range of $0.05 to $0.06 per kWh, however these are likely to quickly rise to $0.09 per kWh by 2014 and $0.10 per kWh by 2025. For this reason, we also included an evaluation of efficiency potential from GDS study including measures with a cost of less than about $0.10 per kWh.

Finally, not all studies examined the same end use sectors. The ORNL study examined only the residential and commercial sectors, while the others examined residential, commercial, and industrial sectors. Also, the ORNL study is not a complete analysis of energy efficiency potential in North Carolina, but rather a "scoping exercise to determine the relative impacts and begin the process for a more definitive study at a later date." To avoid potential confusion arising from its different methodology and comparatively low projections, we have omitted the ORNL study from our graphical representations of efficiency potential. Also, due to the varying study time periods used in the studies we examined, we have displayed savings potential on an annual percentage basis, allowing for the best available comparison between studies.

Of note, all of these studies were conducted prior to the passage of the Energy Independence and Security Act of 2007 (EISA). This bill included several federal energy efficiency appliance and lighting standards, including updated lighting standards, which will take effect between 2012 and 2014. ACEEE has estimated that the lighting standards in EISA will reduce electricity consumption in North Carolina by about 1.2% total annual savings in 2025 (Neubauer et. al. 2009). As such, the studies in this meta review may overestimate efficiency potential because they do not account for this reduced energy load in their base cases. The degree to which each study could overestimate savings depends on the years included in the forecast. For example, any savings projected to accrue between now and introduction of the lighting standards will remain, but those projected to accrue after these standards will not.

La Capra/GDS Study

The energy efficiency potential forecast for the La Capra study was based on the results of the GDS study, and as such the following analysis applies to both studies.

The La Capra/GDS study examined the potential for energy efficiency as part of a renewable portfolio standard for the residential, commercial, and industrial sectors in North Carolina over the ten year period of 2008 to 2017. Three scenarios were evaluated, including Technical Potential, Achievable Potential, and Achievable Cost Effective Potential. We have included the Achievable and Achievable Cost Effective Potentials in this meta review.

Achievable Cost Effective Potential

In the Achievable Cost Effective Potential, GDS projected a 1.8% annual growth rate in reference case electricity consumption for all three sectors, resulting in 180,400 GWh demand in 2017 as a base case scenario. GDS then examined the technical, achievable, and achievable cost effective potentials for energy efficiency.

Including only measures with a cost of saved energy of less than $0.05 per kWh, GDS projected that the achievable cost effective potential would reach 14% of sales (1.4% annual average), or 25,132 GWh by 2017. Of these savings, approximately 48% would come from the residential sector, 28% from the commercial sector, and 26% from the industrial sector. GDS defined the achievable cost effective potential as "the potential for the realistic penetration of energy-efficient measures that are cost-effective according to a calculation of the levelized cost per lifetime kWh saved, and would be adopted given aggressive funding levels, and by determining the level of market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market interventions." GDS assumed an achievable market penetration rate of 80% for all end use sectors, GDS examined 127 measures, including 34 residential measures, 81 commercial measures, and 12 industrial measures. The average levelized cost of saved energy for all sectors was $0.029 per kWh in the achievable cost-effective scenario.

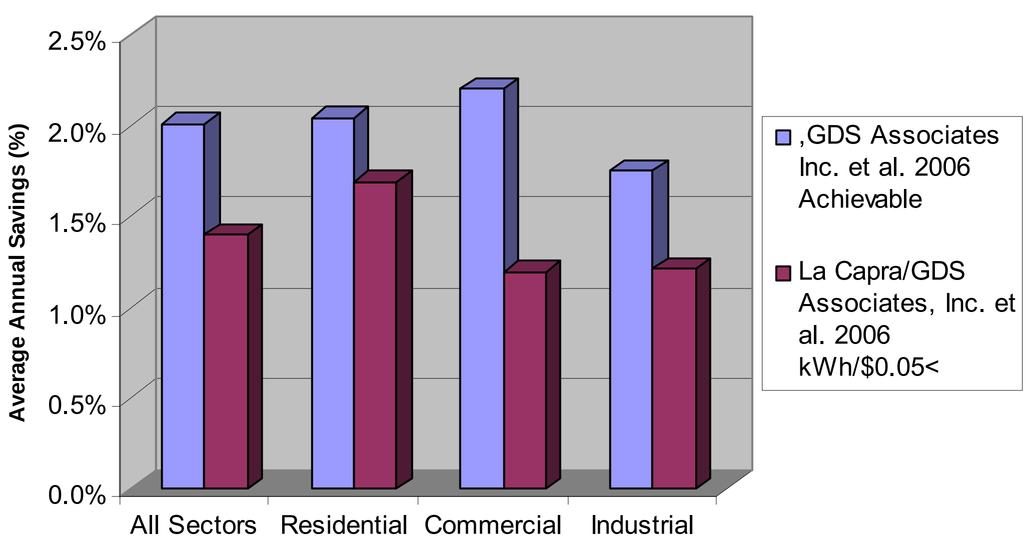
A large percentage (about 33%) of the achievable cost effective potential for the residential sector in the GDS study came from ENERGY STAR windows. Due to several assumptions in the GDS methodology, this projection exceeds the level of savings that ACEEE typically attributes to high efficiency windows. As such, the GDS study may overestimate the potential for this measure. However, this study and the other studies in this meta review do not purport to include all available cost effective measures. While savings may be overestimated for this measure, the overall savings potential that GDS projected for North Carolina is in line with that which ACEEE has found to be cost effective in other states. Furthermore, there are other available measures such as solid state lighting that are not included in the analysis. LED costs have decreased in recent years are projected to be in the range of $3-7 per kilolumen by 2025, depending on the lamp's color rendering index (CRI), a measure of light quality. Current costs are in the range of $100 per kilolumen (Navigant 2009). As a point of comparison, fluorescent and incandescent bulbs cost about $1 per kilolumen today. While LEDs are currently an emerging technology, their potential for broader adoption over the next 16 years is significant.

Achievable Potential

The annual avoided resource costs for North Carolina utilities are currently about $0.05 per kWh and are projected to rise to just over $0.10 per kWh in 2025 in our base case forecast according to the analysis by Synapse Energy Economics. Therefore, while it is logical to focus on energy efficiency measures with a levelized cost of saved energy of $0.05 and below at the present time, it will become cost effective to employ measures with a greater cost in the future. For this reason we have included the La Capra/GDS Achievable Potential in our meta review to provide a more complete assessment of the cost effective energy efficiency potential in North Carolina. The average annual efficiency potential is likely fall somewhere between the La Capra/GDS Achievable and Cost Effective Achievable scenarios, or 1.4–2.0% annually (see Figure A.2.1).

The Achievable Potential analysis represented "the achievable penetration of an efficient measure that would be adopted given aggressive funding, and by determining the achievable market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market interventions." Using this methodology, the Achievable Potential included efficiency measures with a levelized cost of saved energy of $0.10 or less per kWh, resulting in savings of 20.1% of sales, or 36,234 GWh through 2017. This results in an average annual potential of 2.0% (see Figure A.2.1). The residential sector provides the majority (40%) of this potential, followed by the commercial sector (35%) and the industrial sector (25%).

Figure A.2.1. Average Annual Savings in La Capra/GDS Scenarios

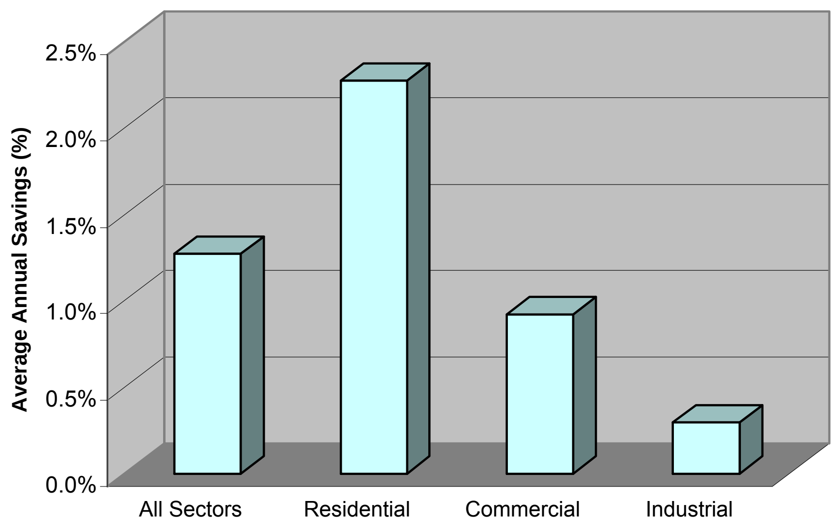


Appalachian State

In their analysis of energy efficiency potential in North Carolina, ASU examined a 13 year window from 2007-2020. The study assessed three energy efficiency potential scenarios—low impact, medium impact, and high impact—in the residential, commercial, and industrial sectors. Their base case scenario projected an annual increase in electricity demand of about 2%, resulting in a projected demand of 176,511 GWh in 2020.

The ASU study did not include a "cost-effective achievable" analysis, so we included the high impact scenario in our meta analysis, which assumed a 90% market penetration rate and average payback periods ranging from 4.4 to 5.7 years for efficiency measures. The high impact scenario projected electricity savings to reach 29,235 GWh, or 16.6% of projected demand in 2020. This represents an average annual efficiency potential of 1.3%. The residential sector provided a large majority, nearly 70%, of total electric savings potential. The commercial sector accounted for another 23% and the industrial sector contributed about 7% of the total potential. The majority of measures included in the study had a cost of saved energy of less than $0.06 per kWh, including 21 out of 37 residential measures.

Figure A.2.2. Average Annual Savings in Appalachian State Study



Oak Ridge National Laboratory

Unlike the other studies in the North Carolina meta review, the ORNL report evaluated energy savings in Btu, not kWh. For ease of comparisons we have converted their findings in Btu to kWh.

ORNL examined energy efficiency potential in the residential and commercial sectors, but not the industrial sector, as the other studies from North Carolina did. The base case for the study was derived from the Department of Energy's Annual Energy Outlook 2003 which projected total energy demand to increase by 1.4% annually between now 2000 and 2020, resulting in 118,782 GWh electricity demand for the residential and commercial sectors. The base case scenario assumed a residential electricity price of $0.076 per kWh and a commercial electricity price of $0.069 per kWh.

ORNL evaluated 4 potential scenarios: lowered discount rates, high technology, lowered discount rates plus high technology, and best technology. The best technology scenario is effectively a technical potential scenario that projected the maximum potential for energy savings based on complete adoption of the best available technologies. The lowered discount scenario was based on research conducted in DOE's *Clean Energy Futures* study, which assumed "increased concern by society on energy efficiency but not to the point of fiscal policies such as taxes or direct subsidies." The high technology scenario assumed adoption of more efficient end-use equipment. For our analysis we have included the lowered discount rate plus high technology scenario, which most closely resembles an economic potential analysis. Of note, ORNL did not conceive of their study as a complete analysis of energy efficiency potential in North Carolina, but rather as a "scoping exercise to determine the relative impacts and begin the process for a more definitive study at a later date."

ORNL estimated that the potential savings for the residential and commercial sectors would reach 9.1% of projected demand in 2020, or 10,870 GWh. This amounts to an average annual savings of

0.5%. A little over half (56%) of this potential was attributable to the residential sector while the commercial sector provided the remaining 44% of savings potential. ORNL did not specify a cost of saved energy threshold at which measures would be included in the study.

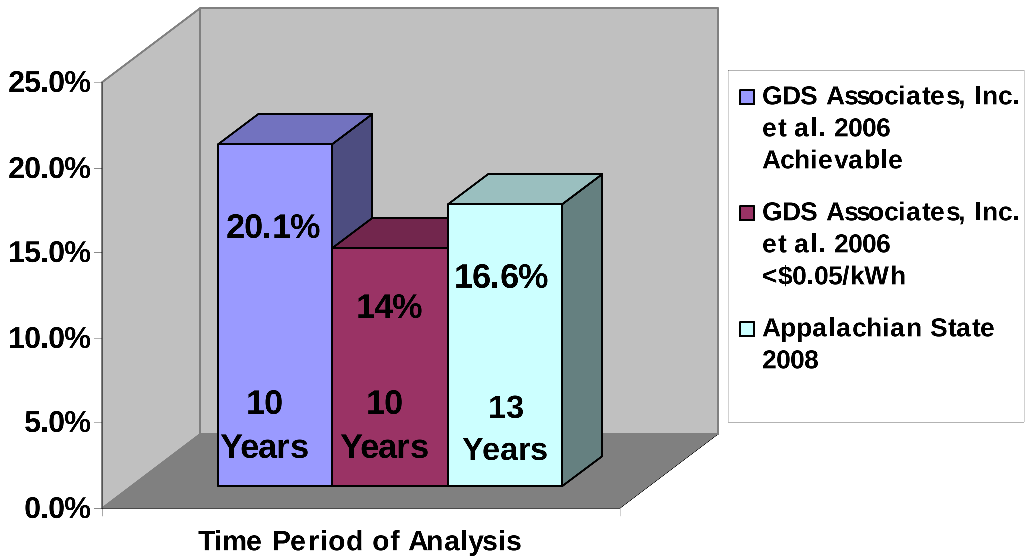
Summary

Table 2.1 and Figure 2.3 summarizes the results of these three North Carolina energy efficiency market potential studies. Average annual percent savings results from the "bottoms-up" analyses of energy efficiency measures show a range of 1.3 to 2% savings potential per year; however, for the reasons stated above these studies are not directly comparable. Based on the findings of the state, regional, and national efficiency potential studies, we estimate that North Carolina energy efficiency potential is in the range of 1.5 to 2% per year over the time period of our report. The average annual savings potential projections in our meta analysis vary from 0.7% on the low end to 2.0% on the high end, and most fall within the range of 1.5 to 2.0%.

Table A.2.1. Summary Results of North Carolina Energy Efficiency Potential Studies

Study	Base Case (GWh)	Efficiency Potential (GWh)	Percent Savings	Average Annual Savings	Cost of Saved Energy	Time Frame
La Capra/GDS Achievable Cost Effective (<$0.05/kWh)	180,400	25,132	14%	1.4%	<$0.05	2008-2017, 10 years
GDS Achievable	180,400	36,234	20.1%	2.0%	Mostly <$0.10	2008-2017, 10 years
Appalachian State	176,511	29,235, high impact scenario	16.6%	1.3%	<$0.06	2007-2020, 13 years
ORNL (Residential and Commercial Potential Only)	118,782	10,870	9.1%	0.5%	N/A	2000-2020, 20 years

Figure A.2.3. Total Energy Efficiency Potential and Time Period of Analyses



Regional Energy Efficiency Potential

Our meta-analysis of regional energy efficiency potential evaluates two studies in two different regions, but both of these studies included all or part of North Carolina. As with the statewide potential assessments, it is not possible to draw definitive conclusions about potential for North Carolina by comparing or averaging these two analyses, due to their variations in scope and methodology.

Southeast Energy Efficiency Alliance

The Southeast Energy Efficiency Alliance (SEEA) analyzed the economic energy efficiency potential for the Appalachian region, spanning all of West Virginia and parts of Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia. This region contains nearly 8% of the U.S. population. Using 2006 as a baseline for energy use, SEEA projected that the Appalachian region's energy consumption would increase from 7.94 quadrillion Btu to 10.14 quadrillion Btu in 2030, a nearly 28% growth in demand. This region currently uses nominally more energy per capita than the nation as a whole; however, the projected rate in demand growth is significantly higher than the 19% growth forecast for the entire United States.

The analysis covered four end-use sectors (residential, industrial, commercial, and transportation) and three fuel types (electricity, natural gas, and fuel oil). Cumulatively, SEEA projected that the measures included in this study would save about 23.2 quadrillion Btu through 2030, a 32.6% savings over the base case scenario, or 1.6% average annual savings. Cost of saved energy was not provided, but all measures included were deemed cost effective. To determine cost effectiveness, the study assessed the benefit/cost ratio, and "[i]f the net present value of [the participants] benefits is greater than the net present value of their costs, then the benefit/cost ratio is greater than 1.0 and the policy is cost-effective."

The commercial sector offers the greatest potential for energy savings, with an estimated 45.6% potential over the base case scenario. The transportation and residential sectors are projected to save 30.1% and 18.7% over the base case, respectively. The industrial could realize between 21.7 and 27.9% savings over the base case scenario.

Southeast Energy Opportunities

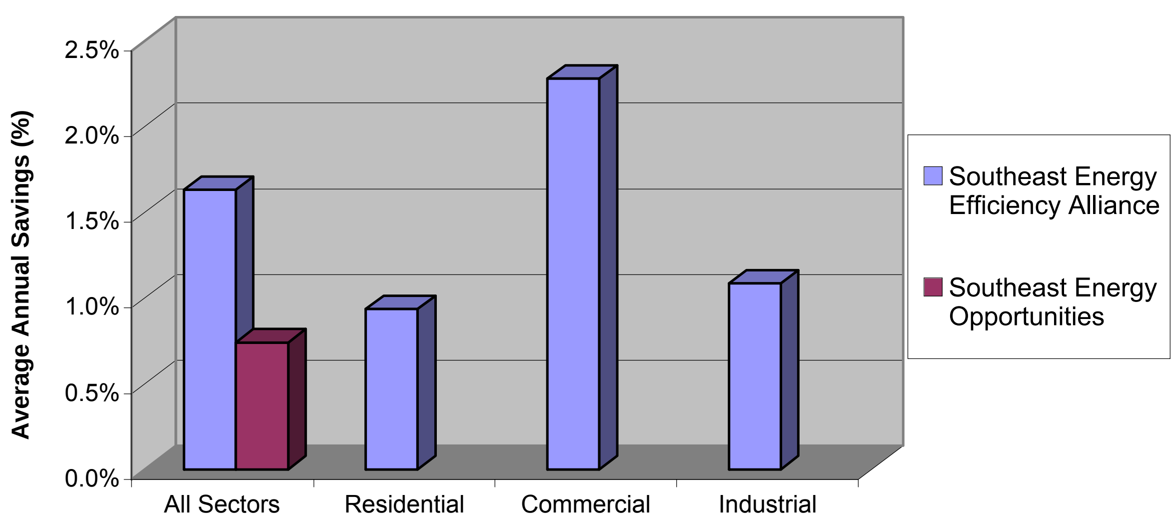
In its April 2009 WRI Issue Brief, Southeast Energy Opportunities (SEO) assessed the potential for energy efficiency to help meet electricity demand in the Southeastern United States, consisting of Georgia, Florida, North Carolina, and Virginia. The report evaluated electricity use in 3 sectors—residential, commercial, and industrial, while acknowledging that future development of electric cars could increase electricity demand and offer the potential for further energy efficiency savings. Across these three sectors, the region currently uses about 20% more electricity per capita than the nation as a whole, and in the residential sector alone, per capita energy use is nearly 40% greater than the nationwide average. The SEO projected that electricity demand would grow from 922,000 GWh in 2005 to 1,220,000 GWh in 2025, a 32% increase in 20 years. Through 2025, energy efficiency potential was projected to reach 20% (0.7% average annual savings), or 80% of the growth in demand. These savings amount to 244,000 GWh at a cost of saved energy of less than $0.05 per kWh.

A forthcoming study published jointly by Georgia Tech and Duke University incorporates the findings of this Southeast Energy Opportunities study into a broader analysis of the energy efficiency potential of the Southern United States. This study is expected in the spring of 2010 and will cover the geographic area defined as the South by the U.S. Census Bureau (Taube 2010).

Table A.2.2. Summary Results from Regional Energy Efficiency Potential Studies

Study	Base Case	Efficiency Potential (GWh)	Percent Savings	Average Annual Savings	Cost of Saved Energy	Time Frame
Energy Efficiency in Appalachia	10.14 quadrillion Btu	23.2 quadrillion Btu cumulative savings	32.6%	1.6%	N/A	2010-2030, 20 years
Southeast Energy Opportunities	1,220,000 GWh	244,000 GWh	20%	0.7%	<$0.05 per kWh	2009-2025, 17 years

Figure A.2.4. Regional Average Annual Energy Efficiency Potential



National Energy Efficiency Potential

This meta-analysis of national energy efficiency potential studies examines one recent nationwide study conducted by McKinsey & Company, and two meta analyses conducted by ACEEE in 2004 and 2008. Combined, these meta analyses evaluated 49 statewide, regional, and national energy efficiency potential studies, providing a useful perspective on both the range and average potential energy savings across the country.

McKinsey & Company

The McKinsey & Company study evaluated the energy efficiency potential across the residential, commercial, and industrial sectors in the U.S., and calculated both end use energy savings and primary energy savings (the BTUs of coal, natural gas, or oil prior to their transmission into "secondary" forms of energy such as electricity). In the interest of consistency, we have focused on the study's evaluation of end use energy savings in this meta analysis. Using a 7% discount rate, this study examined only the economic potential (net present value positive) for efficiency, not the technical or achievable potentials.

The base case scenario assumed that energy demand in the nation would grow at an annual rate of 0.7% from 2008 to 2020, reaching 39.9 quadrillion BTUs. With an upfront investment of $520 billion, overall energy efficiency potential across the three sectors reaches 23% or 9.1 quadrillion BTUs (1.0% average annual savings). This investment would realize $1.2 trillion in savings over the 22 year period. The industrial sector currently consumes the majority (51%) of energy, yet comprises only 40% of the efficiency potential. Residential energy use provides consumes another 29% of energy and offers 35% of the efficiency potential, while the final 20% of energy use and 25% of efficiency potential comes from the commercial sector. The average cost of saved energy for residential efficiency measures in McKinsey's analysis was $4.40/Btu, 68% less than the business-as-usual cost of energy in 2020, as projected in the EIA Annual Energy Outlook 2008.

ACEEE 2008

This 2008 meta-analysis, conducted by ACEEE, examined the economic potential in 48 statewide, regional, and national energy efficiency potential studies. The periods of analysis ranged from 5 to 26 years, with an average of 12 years. Likewise, efficiency potential also varied greatly from 6% to 33% over the base case projections. The average efficiency potential was 23% (1.9% average annual savings), with an average benefit-cost ratio of 1.95, meaning that efficiency improvements generally resulted in savings of about double the cost of investment.

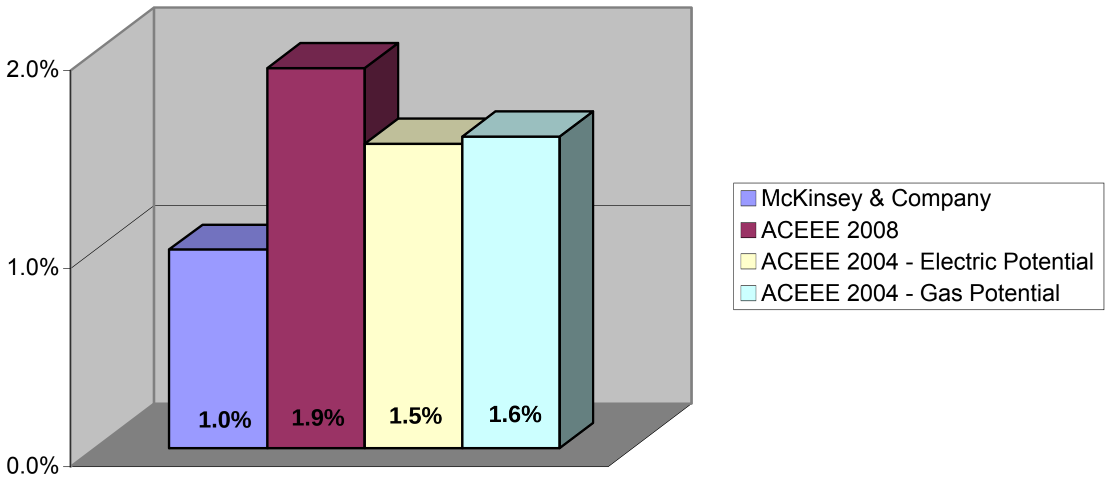
ACEEE 2004

For this 2004 meta-analysis, ACEEE in 2004 reviewed 11 energy efficiency potential studies released between 2000 and 2004. Across these studies, the average efficiency potential for electric and gas measures was about equal, reaching 21.5% and 22% respectively. This amounts to average annual savings of about 1.5% for electricity and 1.6% for natural gas. Residential measures offered an average of 27% savings over the base case scenario, while commercial measures provided another 14% savings over business-as-usual energy consumption.

Table A.2.3. Summary of Results from National Energy Efficiency Potential Studies

Study	Base Case (GWh)	Efficiency Potential (GWh)	Percent Savings	Average Annual Savings	Cost of Saved Energy	Time Frame
McKinsey & Company	39.9 quadrillion Btu	9.1 quadrillion Btu	23%	1.0%	$4.40/MMBtu for Residential Measures	2008-2020, 23 years
ACEEE 2008	N/A	N/A	23%	1.9%	N/A	12 year average
ACEEE 2004 Electric Potential	N/A	N/A	21.5%	1.5%	N/A	14 years
ACEEE 2004 Gas Potential	N/A	N/A	22%	1.6%	N/A	14 years

Figure A.2.5. National Average Annual Energy Efficiency Potential



A.3 Energy Efficiency Policy Analysis

Estimated Electricity Savings, Peak Demand Reductions, and Costs in Policy Analysis

Table A.3.1. Electricity Savings from the Medium Case Scenario

	Annual Electricity Savings by Policy (GWh)	2010	2015	2020	2025	Total Savings in 2025 (%)*
1	Energy Efficiency Resource Standard	348	3,614	11,546	22,311	14.0%
	EERS: Proven Residential and Commercial Programs	*330*	*3,007*	*9,626*	*18,803*	*11.8%*
2	*EERS: Manufacturing Initiative*	*0*	*439*	*1,114*	*1,789*	*1.1%*
3	*EERS: Rural & Agricultural Initiative*	*10*	*61*	*107*	*150*	*0.1%*
4	Building Energy Codes	0	1,341	2,940	4,496	2.8%
5	Advanced New Buildings Initiative	0	284	909	1,828	1.1%
6	Behavioral Initiative	7	107	699	1,570	1.0%
7	Public Facilities Performance Contracting	0	733	1,587	2,835	1.8%
8	Manufactured Homes	12	120	516	1,545	1.0%
9	Combined Heat and Power	0	334	1,045	1,455	0.9%
	New Federal Appliance Efficiency Standards	0	942	2,295	3,184	2.0%
10	Electricity Savings from Water Efficiency Policies	0	42	114	176	0.1%
	Total Savings	368	7,517	21,651	37,830	24%
	Remaining Electricity Needs (GWh)	128,452	127,894	123,683	121,745	
	Notes					
	* Percent relative to reference case forecast.					
1	A stand alone Energy Efficiency Resource Stand (EERS) would require that all electric utilities reach 1% incremental annual electricity savings by 2015 (relative to 2009 annual retail sales). Starting in 2016, annual targets are set relative to prior-year sales (for this analysis we adjust the sales forecast to account for program savings in prior years and for federal efficiency standards). The incremental annual targets continue as follows: 1.25% per year by 2017; 1.5% per year by 2019; 1.75% by 2022; and 2% per year by 2025. Estimated costs are based on a meta-analysis of utility-sector energy efficiency programs from the past five years, which identified an average total resource cost (TRC) of $0.43 per first-year kWh saved (Friedrich et al. 2009). TRC costs include incremental costs for energy-efficient products (whether incurred by customers or in the form of incentives) and administrative or marketing costs needed to run programs. The meta-review identified that program costs accounted for $0.23 per first-year kWh saved, and that on average 76% of program costs were allocated to incentives and 24% to administrative or operations costs (Friedrich et al. 2009). The EERS analysis backs out projected savings from Duke Energy's energy efficiency programs in their IRP base case scenario to avoid double counting (Duke 2009).					

	Annual Electricity Savings by Policy (GWh)	2010	2015	2020	2025	Total Savings in 2025 (%)*
2	The medium case scenario assumes that a manufacturing initiative achieves 25 industrial assessments in the first year, ramping up to 100 in the third and each subsequent year. The analysis assumes that each assessment identifies 15% electricity savings and that 50% of identified savings are implemented. Project costs assume the average investment cost per kWh from the industrial sector analysis ($0.28/kWh) and program cost is assumed to be 12.5% of projected cost savings to the end-user.					
3	This program analysis is based on similar programs and data from the State of Wisconsin Focus on Energy 2007 Semiannual Report. We assume the average cost of conserved energy is $0.025/kWh, that program & administrative costs are 24% of the cost of investment, and that customers cover half of the investment cost.					
4	We assume that the pending upgrade to the North Carolina building energy code is adopted in 2010 and becomes effective in 2012, which would reduce energy consumption by 30% in new residential and commercial construction relative to the 2006 IECC. The national model code, the 2012 IECC, is then adopted in 2013 and effective 2015, reducing energy consumption by 30% in new residential and commercial construction relative to the 2006 IECC. Savings apply only to end-uses covered by building codes, which are heating, cooling, ventilation, lighting, and water heating end-uses, or 50% of electricity consumption in new residential construction and nearly 60% of electricity consumption in commercial buildings. We assume enforcement of each code starts at 70% compliance in the first year, 80% in second year, and 90% in the third and subsequent years with a robust code training an enforcement program. Residential construction costs are based on an analysis by the National Renewable Energy Laboratory (NREL), which found in a recent case study that new homes reaching 30% savings beyond code have an average payback of 5.5 years and homes reaching 50% savings have an average payback of 11.2 years (Billman 2009).					
5	This initiative targets new construction for both residential and commercial buildings. Residential analysis for new construction assumes 50% savings beyond current code (IECC 2006). Savings from building energy codes to achieve 30%-beyond code are backed out to avoid double counting. In 2011 we assume an initial participation rate of 3%, gradually ramping up throughout the analysis period and reaching 30% participation in 2025. Savings from new commercial construction again assumes 50% savings beyond North Carolina's current code. In 2011 we assume an initial participation rate of 3%, gradually increasing to reach 30% of new buildings by 2025.					
6	We assume a five-year pilot program, where participation is steady at 2.5% for the first five years and savings begin at 0.5%, increasing by 0.5% for the first three years and by 1% for the final two, peaking at 3.5%. Participation in the program increases by 2.5% annually from 2015 through the remainder of the analysis period. We also assume a one-year persistence rate, i.e., that savings realized in one year are not perpetually generated and therefore do not accumulate.					
7	North Carolina Session Law 2007-546 mandates that all State agency buildings and State institutions of higher learning reduce energy consumption 20 percent by 2010 and 30 percent by 2030 relative to consumption for the 2003-04 fiscal year. We assume 20% percent savings from 80 percent of all state and local facilities by 2025. We project that participation gradually ramps up, resulting in 179 GWh savings in 2011, and increasing to 412 GWh in 2025. This results in a cumulative 2880 GWh savings through 2025. Costs are based on average utility program costs of $0.23 per first year kWh in the commercial sector and savings have a 13-year average lifetime (Friedrich et al. 2009). We assume that administrative costs will add 10 percent to this measure's cost.					

	Annual Electricity Savings by Policy (GWh)	2010	2015	2020	2025	Total Savings in 2025 (%)*
8	Our medium case scenario builds on the 288 homes upgraded through Upgrade and Save in 2009. We assume that this number will increase steadily through 2025, funding provided. We assume 350 homes will be upgraded in 2010, increasing to by 100 homes each year through 2017, when 1050 homes are upgraded. The number of homes upgraded annually then increases by 150 through 2020, and 200 through 2025, peaking at 2500 homes upgraded per year in 2025. We assume 30% savings over baseline new homes for ENERGY STAR certified new homes upgraded through Upgrade and Save. In addition to the Upgrade and Save program, our medium case includes weatherization for manufactured homes through WAP. Based on current funding levels, we assume that 1000 homes will be weatherized through WAP in 2010. The number of homes upgraded annually ramps up each year, reaching 4500 homes weatherized in 2015, 8000 homes in 2020, and 13000 homes in 2025. Due to additional funding for weatherization provided by ARRA, we assume 25% savings for homes weatherized by WAP through March of 2011 when ARRA funding runs out. After March of 2011 we assume savings of 20% for weatherizations.					
9	Savings potential for CHP are based on the market potential analysis prepared by ICF Consulting. Their analysis assumes a $500 incentive per MW for CHP facilities, which we use as a proxy for quantifying removal of regulatory disincentives.					

Table A.3.2. Summer Peak Demand Reductions from the Energy Efficiency and Demand Response Medium Case Scenario (MW)

Summer Peak Reductions (MW)	2010	2015	2020	2025	% Reduction
Energy Efficiency	73	1,423	3,952	7,294	22%
Demand Response	111	1,177	2,509	2,722	8%
Total Savings (MW)	**185**	**2,599**	**6,461**	**10,016**	**31%**
% Reduction (relative to forecast)	**1%**	**9%**	**22%**	**31%**	

Table A.3.3. Total Resource Costs* from the Medium Case Scenario (Million 2007$)

Policy/Program	2010	2015	2020	2025
Energy Efficiency Resource Standard (EERS)	$166	$495	$772	$1,048
Proven Programs: Residential and Commercial	$0	$40	$40	$40
Manufacturer's Initiative	$0	$95	$117	$113
Building Energy Codes	$0	$26	$51	$70
Advanced Energy-Efficient Buildings Initiative	$1	$2	$11	$16
Behavioral Initiative	$0	$41	$48	$105
Public Facilities Performance Contracting	$0	$0	$0	$0
Rural & Agricultural Initiative	$4	$11	$35	$74
Manufactured Homes Initiative	$1	$44	$63	$76
Combined Heat & Power (CHP)	$166	$495	$772	$1,048
Total	$172	$754	$1,136	$1,543

*Note: Total Resource Costs include total investments in energy efficiency, whether made by customers or through program incentives, plus program administrative/marketing costs.

Table A.3.4. Electricity Savings from the High Case Scenario

	Annual Electricity Savings (GWh)	2010	2015	2020	2025	Total Savings in 2025 (%)
1	Energy Efficiency Resource Standard	344	4,814	14,344	25,072	16%
	EERS: Proven Residential and Commercial Programs	*330*	*4,078*	*12,534*	*22,193*	*14%*
2	*EERS: Manufacturing Initiative*	*0*	*655*	*1,667*	*2,680*	*1.7%*
3	*EERS: Rural & Agricultural Initiative*	*14*	*81*	*143*	*200*	*0.1%*
4	Building Energy Codes	0	1,341	2,940	5,360	3.4%
5	Advanced New Buildings Initiative	0	417	1,589	3,526	2.2%
6	Behavioral Initiative	*0*	*107*	*999*	*2,243*	*1.4%*
7	Public Facilities Performance Contracting	0	960	1,880	3,492	2.2%
8	Manufactured Homes	10	128	695	2,393	1.5%
9	Combined Heat and Power	233	1,856	4,648	6,380	4.0%
	New Federal Appliance Efficiency Standards	0	942	2,295	3,184	2.0%
10	Electricity Savings from Water Efficiency Policies	0	47	128	194	0.1%
	Total Savings	588	10,594	29,523	51,748	32%
	Remaining Electricity Needs (GWh)	128,225	124,711	115,112	107,835	
	Notes					
1	A stand alone Energy Efficiency Resource Stand (EERS) would require that all electric utilities reach 1% incremental annual electricity savings by 2013 (relative to 2009 annual retail sales). Starting in 2016, annual targets are set relative to prior-year sales (for this analysis we adjust the sales forecast to account for program savings in prior years and for federal efficiency standards). The incremental annual targets continue as follows: 1.5% per year by 2016; 1.75% by 2018; and 2% per year by 2022. Estimated costs are based on a meta-analysis of utility-sector energy efficiency programs from the past five years, which identified an average total resource cost (TRC) of $0.43 per first-year kWh saved (Friedrich et al. 2009). TRC costs include incremental costs for energy-efficient products (whether incurred by customers or in the form of incentives) and administrative or marketing costs needed to run programs. The meta-review identified that program costs accounted for $0.23 per first-year kWh saved, and that on average 76% of program costs were allocated to incentives and 24% to administrative or operations costs (Friedrich et al. 2009). The EERS analysis backs out projected savings from Duke Energy's energy efficiency programs in their IRP base case scenario to avoid double counting (Duke 2009).					
2	The high case scenario assumes that a manufacturing initiative achieves 30 industrial assessments in the first year, ramping up to 150 in the third and each subsequent year. The analysis assumes that each assessment identifies 15% electricity savings and that 50% of identified savings are implemented. Project costs assume the average investment cost per kWh from the industrial sector analysis ($0.28/kWh) and program cost is assumed to be 12.5% of projected cost savings to the end-user.					

	Annual Electricity Savings (GWh)	2010	2015	2020	2025	Total Savings in 2025 (%)
3	Identical to the medium case scenario, this policy is based on similar programs and data from the State of Wisconsin Focus on Energy 2007 Semiannual Report. We assume the average cost of conserved energy at $0.025/kWh, that program & administrative costs are 24% of the cost of investment, and that customers cover half of the investment cost.					
4	We again assume that the pending upgrade to the North Carolina building energy code is adopted in 2010 and becomes effective in 2012, reducing energy consumption by 30% in new residential and commercial construction relative to the 2006 IECC. The national model code, the 2018 IECC, is then adopted in 2019 and effective 2021, reducing energy consumption by 50% in new residential and commercial construction relative to the 2006 IECC. Other assumptions are the same as described in medium case scenario.					
5	This initiative targets new construction for both residential and commercial buildings. Residential analysis for new construction assumes 50% savings beyond current code (IECC 2006). Savings from building energy codes to achieve 30%-beyond code are backed out to avoid double counting. In 2011 we assume an initial participation rate of 3%, gradually ramping up throughout the analysis period and reaching 30% participation in 2025. Savings from new commercial construction again assumes 50% savings beyond North Carolina's current code. In 2011 we assume an initial participation rate of 3%, gradually increasing to reach 30% of new buildings by 2025.					
6	We assume a five-year pilot program, where participation is steady at 2.5% for the first five years and savings begin at 0.5%, increasing by 0.5% for the first three years and by 1% for the final two, peaking at 3.5%. Savings peaks at 5% by 2020 and remains at 5% for the remainder of the analysis period. Participation in the program reaches 5% by 2015 and increases by 2.5% annually for the remainder of the analysis, reaching 30% in 2025. We again assume a one-year persistence rate.					
7	Our high case scenario assumes 30 percent savings for government buildings, and ramps up at a greater rate, reaching 100 percent participation in 2025.					
8	As with our medium case scenario, our high case scenario builds on the 288 homes upgraded through Upgrade and Save in 2009. We assume that this number will increase steadily through 2025, funding provided. We assume 350 homes will be upgraded in 2010, increasing to by 150 homes each year through 2013, when 800 homes are upgraded. The number of homes upgraded annually then increases by 200 through 2021, and 400 through 2025, peaking at 4000 homes upgraded in the year 2025. As with our medium case scenario, we assume 30% savings over baseline new homes for ENERGY STAR certified new homes upgraded through Upgrade and Save. Again as with our medium case scenario, our high case scenario includes weatherization for manufactured homes through WAP in addition to the Upgrade and Save new homes initiative. Based on current funding levels, we assume that 1000 homes will be weatherized through WAP in 2010. The number of homes upgraded annually ramps more aggressively than in our medium case scenario, reaching 4500 homes weatherized in 2015, 14000 homes in 2020, and 26000 homes in 2025. Due to additional funding for weatherization provided by ARRA, we assume 25% savings for homes weatherized by WAP through March of 2011 when ARRA funding runs out. After March of 2011 we assume savings of 20% for weatherizations.					
9	Savings potential for CHP are based on the market potential analysis prepared by ICF Consulting. Their analysis assumes a $500 incentive per MW for CHP facilities, which we use as a proxy for quantifying removal of regulatory disincentives.					

Table A.3.5. Summer Peak Demand Reductions from the High Case Scenario (MW)

Summer Peak Reductions (MW)	2010	2015	2020	2025	% Reduction
Energy Efficiency	102	1,807	5,164	9,757	30%
Demand Response	165	1,746	3,719	4,031	12%
Total Savings (MW)	267	3,553	**8,883**	13,788	**42%**
% Reduction (relative to forecast)	**1%**	**13%**	**30%**	**42%**	

APPENDIX B: WATER EFFICIENCY: KEY ASSUMPTIONS

While peer reviewed analyses of the costs and benefits of utility water conservation programs in the Southeast are scarce, enough is known about the cost and performance of key technologies and practices to make a first-order estimate of potential savings. Key assumptions listed below. Those without attribution were made specifically for this report.

Statewide Plumbing Efficiency Standards

- Average North Carolina household size is 2.6 persons per household (Moody's 2009)[54]
- Average household size for a new home is 3.0 persons per household
- There are 1.73 bathrooms per housing unit in the Southeast (2005 RECS) (EIA 2009e)
- Newly constructed housing contains 2.5 bathrooms per housing unit
- Toilet product life is 25 years, yielding an annual replacement rate of 4%
- Residential toilet usage is 5 flushes per person per day.
- Toilets meeting the specification will save 0.32 gallons per flush.
- Showerhead product life is 15 years
- Showerheads meeting the specification will save 0.25 gpm.
- Residential shower usage is 8.2 minutes per shower and 0.67 showers per day (EPA 2010)
- Lavatory faucets and faucet aerators meeting the specification will save 0.2 gpcd[55] (EPA 2007d)
- Lavatory faucet life is 25 years
- 70% of residential faucet water use is hot water (EPA 2007d)
- 73% of residential shower water use is hot water (EPA 2010)
- 47% of households in the Southeast use electricity to heat domestic hot water (EIA 2009e)
- Hot water at 120˚ uses 0.18 KWh per gallon (EPA 2010)
- Market share of conforming products in 2011: tank-type toilets: 32%; lavatory faucets and faucet aerators: 50%; showerheads: 20%.
- Incremental cost of conforming products in 2012: tank-type toilets: $0; Lavatory faucets and faucet aerators: $0; showerheads: $10, declining by $1 per year thereafter.

Replacement of Inefficient Plumbing in Existing Residences

- Pre-1995 toilets average 4.0 gallons per flush.
- Replacement toilets average 1.28 gpf, for savings of 2.72 gpf.
- Pre-1995 toilets in pre-1995 housing are already being replaced at the rate of 4% per year.
- Sales of existing homes average 6.1% per year (based on projected North Carolina statewide figures from Economy.com for 2012 through 2025)
- Multifamily buildings with rental units are sold at 1/2 the rate of other homes (3.05%).
- 10% of residences sold in a year would have bathrooms remodeled within 6 months before or after a sale regardless of this policy.
- Net replacement of pre-1995 toilets attributable to this policy is 5.5% per year for sf homes and condos and 2.75% per year for multifamily buildings with rental units.
- Cost of replacement is $345 per dwelling unit (≈ $120/toilet x 1.73 toilets per unit + 2hr labor @ $60 + $10 per toilet for disposal).
- 80% of customers pay cost of replacement. Utilities pay replacement cost for 20% of customers based on income criteria.

[54] Note: The latest U.S. Census Bureau estimate (American Community Survey) for North Carolina is 2.56 persons per household.
[55] This is one-third the rate of savings claimed in the reference, which also included savings attributable to improvements in kitchen faucet efficiency, which is not proposed for change here.

- Medium case scenario assumes the policy is applied to the top ten counties based on current population: Wake; Mecklenburg; Guilford; Forsyth; Cumberland; Durham; Buncombe; Gaston; Union; and New Hanover (OSBM 2009).
- High case scenario assumes the policy is extended to the top twenty counties based on current population: Cabarrus; Onslow; Johnston; Davidson; Pitt; Iredell; Catawba; Alamance; Randolph; and Rowan (OSBM 2009).

Reduction of Water Losses from Utility Distribution Systems

- A portion of water lost to distribution system leakage is assumed to be economically recoverable. This portion is estimated to equal 4% of current (2007) withdrawals by public water suppliers.
- Water suppliers will begin standardized annual water loss accounting in 2011 and take four years to improve the quality of water delivery data to a level to support decisions to invest in water loss reduction measures.
- In the medium case, to save 50% of economically recoverable losses, public water suppliers will invest in cost-effective water loss reduction measures to save 0.2% per year, beginning in 2015 and continue through 2025 to reach 2% savings.
- In high case scenario, to save 90% of economically recoverable losses, public water suppliers will invest in cost-effective water loss reduction measures to save 0.33% per year, beginning in 2015 and continue through 2025 to reach 3.6% savings.
- In medium case, benefits are assumed to exceed costs by 2 to 1.
- In high case, benefits are assumed to exceed costs by 1.5 to 1.

Water Efficient Landscape Irrigation Ordinances

- Ordinance will reduce outdoor water use of new single-family residential customers by 10,000 gallons per year (90% during 6 warmest months at 1,500 gallons per month).
- Costs will average $250 per house covering materials and labor.
- Medium case scenario assumes the policy is applied to the top ten counties based on expected population growth from 2010-2025: Wake; Mecklenburg; Union; Guilford; Durham; Cabarrus; Johnston; Forsyth; Gaston; and Iredell (OSBM 2009).
- High case scenario assumes the policy is extended to the top twenty counties based on expected population growth: Pitt; Brunswick; Alamance; Harnett; Onslow; Buncombe; New Hanover; Davidson; Rowan; Catawba.

Electric Utility Clothes Washer Incentives

- In both the medium case and the high case, 5% of the total amount of customer incentives offered to residential and commercial customers by the Electric Utility Programs are devoted to high efficiency clothes washers.
- Incentive level is $150 for the purchase of a qualified new clothes washer.
- The efficiency levels of new clothes washers qualifying for the incentive are MEF 2.0/WF 6.0 from 2009 through 2014, and MEF 2.2/WF 4.5 from 2015 through 2025.
- The water efficiency levels of base models are WF 12.5 in 2009–2010, WF 9.5 in 2011–2014; and WF 6.0 in 2015–2025.
- The proportion of washer sales in the state that will already meet the qualifying efficiency levels without the program's customer incentives are 35% in 2009 growing 1% per year to 40% in 2014; and 10% in 2015 growing 1% per year to 20% in 2025.
- The number of washers installed is determined by the available utility program dollars (@ $150 per machine), but will go no higher than 100,000 washers per year (a level reached in 2019 in the medium case scenario and 2016 in the high case).

Federal Energy and Water Efficiency Standards for Clothes Washers

- New federal standard is adopted taking effect in 2015, with a water factor (WF) of 6.0.
- 40% of projected sales in 2015 will already have a WF of 6.0 or better regardless of the standard.

Table B.1. Principal Load-Following Thermal Plants in North Carolina (2005)

Plant name	Plant Operator Name	County	No. of Generators	Plant Primary Fuel Category	Plant Capacity Factor	Plant Nameplate Capacity (MW)	Plant Annual Net Generation (MWh)	River Basin
Ashville	Progress Energy	Buncombe	4	Coal	0.3392	837.1	2,487,381.0	French Broad
Buck	Duke	Rowan	7	Coal	0.3965	474.4	1,647,566.0	Yadkin
Butler-Warner	Fayetteville PWC	Cumberland	9	Nat Gas	0.0417	303.4	110,835.0	Cape Fear
Cape Fear *	Progress Energy	Chatham	8	Coal	0.4977	430.5	1,876,749.0	Cape Fear
Cliffside	Duke	Cleveland	5	Coal	0.5457	780.9	3,733,245.0	Broad
Dan River	Duke	Rockingham	6	Coal	0.1911	387.8	649,164.0	Dan--Roanoke
G. G. Allen	Duke	Gaston	5	Coal	0.6341	1,155.0	6,415,484.0	Catawba
L. V. Sutton *	Progress Energy	N Hanover	6	Coal	0.4615	762.9	3,084,371.0	Cape Fear
Lee *	Progress Energy	Wayne	7	Coal	0.4602	508.4	2,049,623.0	Neuse
Lincoln Combustion	Duke	Lincoln	16	Nat Gas	0.0016	1,753.6	24,543.0	Catawba
Primary Energy Roxboro	Primary Energy	Person	1	Coal	0.3440	67.5	203,409.6	Hyco—Roanoke
Primary Energy Southport	Primary Energy	Brunswick	2	Coal	0.2595	135.0	306,886.8	Cape Fear
Richmond	Progress Energy	Richmond	8	Nat Gas	0.1519	1,628.4	2,167,402.0	Yadkin
Riverbend	Duke	Gaston	8	Coal	0.3486	601.2	1,835,733.0	Catawba

Plant name	Plant Operator Name	County	No. of Generators	Plant Primary Fuel Category	Plant Capacity Factor	Plant Nameplate Capacity (MW)	Plant Annual Net Generation (MWh)	River Basin
Rockingham County CT Station	Duke	Rockingham	5	Nat Gas	0.0084	809.0	59,317.0	Dan--Roanoke
Rosemary	Dominion Va	Halifax	3	Nat Gas	0.0685	180.0	107,977.0	Roanoke
Rowan	Southern Power	Rowan	6	Nat Gas	0.0486	1,192.0	507,723.0	Yadkin
W. H. Witherspoon *	Progress Energy	Robeson	7	Coal	0.2663	342.1	798,119.0	Lumber
Wayne County	Progress Energy	Wayne	4	Nat Gas	0.0172	847.2	127,342.0	Neuse

Source: EPA (2007a)

APPENDIX C: TRANSPORTATION EFFICIENCY

C.1 Clean Car Standard

C.1.1 Efficiency Potential Methodology

The Clean Car Standard adopted by California and 15 other states to date requires that the average new vehicle's greenhouse gas emissions be below a certain gram-per-mile level, which declines each model year. Vehicles' GHG emissions can be reduced through changes to the air conditioning system and use of reduced-carbon fuels; but the primary means of lowering GHG emissions in the near to medium term will be to increase vehicle fuel efficiency. The Clean Car Standard for 2016 is roughly equivalent to a fuel economy standard of 35.5 miles per gallon, although manufacturers can reduce their vehicle efficiency obligations to some extent by reducing vehicles' air conditioning-related GHG emissions.

Improvements in the fuel economy of new vehicles take many years to spread throughout the vehicle stock. For a given efficiency gain among new vehicles, ACEEE uses a "stock model" to calculate the resultant increase in average efficiency of all vehicles over time. In the case of the Clean Car Standard, this increase in stock efficiency leads to the reductions in fuel consumption shown in Table xx below relative to the consumption that would have occurred in the absence of the standards.

The Clean Car Standard was set on the basis of an examination of existing and emerging vehicle efficiency technologies that could be applied cost-effectively to new vehicles. The assessment assumed that the distribution of vehicles among size classes will not be affected by implementation of the standards. Pursuant to California's global warming statute (AB32), the California Air Resources Board made a preliminary assessment of future cost-effective vehicle GHG reductions in the post-2016 period; this is the basis for the Clean Car Standard analyzed for North Carolina in the Medium Case (CARB 2008). These GHG standards reach their maximum, corresponding to about 42 miles per gallon, in 2020, and as new, efficient vehicles penetrate the vehicle stock gradually over the following years, the bulk of energy savings occur after 2020. The High Case represents a more aggressive standard that does not reach its peak of about 50 miles per gallon until 2025, and delivers most of its savings in subsequent years.

C.1.2 Cost Methodology

The California Air Resources Board (CARB) estimated the increase in the purchase cost of the vehicles as their standards kick into effect in the years 2009-2016. By 2015, the purchase cost of the average vehicle is expected to increase by $822. For the post-2016 period, we assume that the average cost increase per vehicle reaches approximately $1,900 by 2020 in the Medium Case and $3,000 by 2025 in the High Case. Using these cost estimates and assuming that vehicle sales in North Carolina grow according to data obtained from Economy.com projections, we estimate that investments for the clean car standard will total $7.7 billion in 2007 dollars in the medium scenario and $9.4 billion in the high scenario.

To calculate program costs for the clean car standard, we assume that the state of North Carolina will require one administrator for the program and 5 additional staff to assist in implementation and subsequent monitoring. ACEEE estimates that program costs will amount to $1 million annually (2007 dollars).

C.2 Pay-as-you-drive Insurance

C.2.1 Efficiency Potential Methodology

Estimates of the reduction in vehicle-miles traveled (VMT), and therefore energy use, resulting from a PAYD policy depend upon the price elasticity of travel demand, i.e. the percent change in travel resulting from each percent increase in the cost of travel. Estimates of elasticity vary considerably among those who study them, and differ also according to the time elapsed between the change in cost and the response to it. We use here a value of -0.15 for the long-term elasticity of driving with respect to travel cost; that is, over 10-15 years, we assume there is a 1.5 percent reduction in driving for a 10 percent increase in the cost of travel (Greene & Lieby 2006; Litman 2007; Bordoff & Noel 2008.) The average per-mile cost of gasoline between 2010 and 2025 is approximately 14 cents per mile given a steady increase in the number of miles driven annually by a given vehicle. The cost of the average insurance policy in North Carolina in 2005 was $596, which we keep constant through 2025. This means that the average insurance cost per mile over the same time period is 5 cents per mile.

If 80 percent of the cost of the insurance premium were charged on a per-mile basis, the variable cost per mile of driving would then be increased by 4 cents per mile, or by an average of 28 percent between 2010 and 2025. An elasticity of -0.15 implies a corresponding reduction in driving of 4.3 percent. Thus 100 percent adoption of PAYD insurance would be expected to reduce car and light truck energy use in North Carolina by 4.3 percent over 10-15 years. This is our High Case. In the Medium Case, PAYD insurance would be required in high growth counties only, lowering statewide VMT and fuel use reductions to 2.7 percent.

The pay-as-you-drive insurance program we analyzed for North Carolina begins with a three-year pilot program subsidized by the State. The State would offer insurance companies a $200 incentive per PAYD policy, with goals of 2,000 policies in 2010, 10,000 policies in 2011, and 20,000 policies in 2012. A mandatory program would then be phased in over the next ten years. Miles driven would be monitored using the odometer or an added tracking device. Numbers would periodically be reported back to insurance companies to ensure compliance with regulations.

An alternative approach to reduce VMT through monetary incentives would be increasing the state gas tax. North Carolina's gas tax stands at 30.2 cents per gallon (FHWA 2008). As noted above, PAYD insurance would in effect increase the variable cost of driving by 4 cents per mile. Achieving the same cost-per-mile increase today by raising the gas tax would require an increase of $0.82 per mile in the gas tax, something the North Carolina legislature may be reluctant to propose.[56] Also, a gas tax increase, unlike PAYD insurance, would increase the tax burden in aggregate unless offset by reductions in other taxes such as income tax.

C.2.2 Cost Methodology

Direct costs to the state would be $200 per PAYD policy in the first three years. This means costs of $400,000 in 2010, $2 million in 2011, and $4 million in 2012 assuming the goals are met (in 2007 dollars.)

To estimate the total cost to the insurance companies that are required to undertake PAYD policies, we assume that each PAYD policy costs the insurance company $40 in additional expenses during the pilot period. This may include the reorganization of services to cater to such policies or even the installation of tracking equipment in each insured vehicle. Once the pilot period ends, this cost of implementation falls to $10 per policy as we assume that insurance companies have had sufficient adjustment time to reduce their overall costs. Costs to insurance companies will amount to $257 million between 2010 and 2025.

C.3 Compact, Transit-Oriented Development

C.3.1 Efficiency Potential Methodology

The approach to reducing vehicle miles traveled through compact development and expanded transit focuses on the 23 high growth counties in North Carolina. These include a number of counties along the I-85 corridor as well as the Asheville, Greenville and Wilmington metro areas.

[56] A gas tax increase of $0.82 per gallon would in fact reduce fuel consumption by more than a PAYD policy in the long-term because it would affect not only the amount people drive but also their choice of vehicle. We are proposing other mechanisms to increase vehicle efficiency, however.

According to a recent National Academy of Sciences study, the amount that people drive is related to the population density of the area in which they live: a doubling of density alone would typically mean 5 to 12 percent lower vehicle miles traveled per person (TRB 2009). This reduction in VMT can be far larger, up to 25 percent, with supporting policies such as improved transit and improved connectivity between streets. [As a result, for the medium scenario, we assume that doubling density within a ½ mile of transit stops achieves a 15% reduction in VMT per person in that immediate area. Under the high scenario, we assume that VMT reduction stands at 25% for each doubling of density.

For this policy, we assumed that 50% of the annual population growth in the Charlotte metropolitan area would occur within a half-mile of an existing or planned light rail, commuter rail, or bus rapid transit stop. For other high growth counties, we assume that transit systems were built up, starting in 2016, to be comparable to Charlotte's system in 2020 and beyond. Movement into the areas to be served by transit ramps up incrementally between 2012 and 2020, after which 50% of new county residents are assumed to move to these transit-oriented developments.

We calculated the resultant increase in density in the areas within a half-mile of transit stops and used the TRB results to project a reduction in vehicle miles traveled for residents of these higher density areas relative to VMT per capita elsewhere in the county. Specifically, given the proximity to transit, we assumed that each doubling of density would reduce VMT, and therefore fuel use, by 15 percent in the medium scenario and by 25 percent in the high scenario. VMT for residents outside these transit-served areas would remain unchanged.

Information on transit expansion initiatives was obtained for the three major metro areas: Charlotte, Raleigh and Greensboro. This information was then scaled to accommodate population growth in the remaining metro regions.

C.3.2 Cost Methodology

Transit infrastructure investment costs for this policy were estimated based on the cost of the existing Charlotte Lynx Blue Line. Annual capital and operating costs amount to $32.3 million. This value was adjusted to estimate cost of completing and operating the entire system planned by the Charlotte Area Transit System (CATS.) These transit infrastructure investment costs were then scaled to arrive at a final cost figure consistent with our assumption that all 6 metropolitan areas will have extensive transit systems. Total costs equal $6.8 billion between 2012 and 2025 under both the medium and high scenarios.

The recent passage of HB 148 in North Carolina allows for the implementation of a ½ percent sales tax in counties with established transit systems in an effort to provide municipalities with additional transit financing options. If we assume that all high growth counties in the state implement this additional sales tax in an effort to finance transit expansion, total costs can potentially be offset by $2.9 billion dollars in collected revenue between 2012 and 2025.

Focusing new development in the vicinity of transit stops has many implications for investment, which we do not explore here. The cost of non-transit infrastructure, including roads and water/wastewater systems, would be generally lower in this compact development scenario than in the reference case, however. We do however, consider the incentives that will likely be necessary in order to encourage movement into transit-oriented communities. We assume that each new additional housing unit built in these areas will be given a subsidy of $5000, bringing total incentive costs under both the medium and high scenario to $302 million in 2015 and $1.5 billion in 2025.

To finalize the administrative costs associated with this VMT reduction policy, we assumed that each high growth county transit agency would require 3 additional staff to administer such a program at a cost of $90,000 per individual. In addition to personnel expenses, the state will likely undertake a large-scale educational campaign to support their transit investments. We estimate that this campaign will cost $840,000. Annual program costs will be $18.63 million (2007 dollars).

C.4 Truck Stop Electrification

C.4.1 Efficiency Potential Methodology

We estimate the fuel savings resulting from the loan program for truck stop electrification using the following assumptions. We assume that the number of truck stops in the state grows annually at the same rate as heavy-duty VMT per capita. If the average installation size is 25 TSE spaces, then there will be 5,700 spaces available by 2025. Idling of a heavy truck consumes about one gallon per hour (Stodolsky et al. 2000). Assuming each space is used for two 6-hour periods per day, fuel savings would be 486 thousand barrels in 2015 and 595 thousand barrels by 2025. The power requirement of the truck while using the TSE system is approximately 2.1 kW (Lutsey 2003). Therefore, the net savings would be 2,902 billion Btu annually by 2025.

C.4.2 Cost Methodology

The cost of truck stop electrification is about $15,000 per space for an off-board system (EPRI 2004). We assume all spaces are converted by 2020. Investment costs over the period 2010 and 2025 total $86 million under both the medium and high scenarios. Annual program costs are approximately $2 million each year.

C.5 Heavy-Duty Efficiency Incentive Package

C.5.1 Efficiency Potential Methodology

Trucks that might use auxiliary power units (APUs) to eliminate overnight idling are long-distance trucks of Classes 7 and 8 (i.e., those having gross vehicle weight rating of 26,000 lbs. or more). Here we define "long-distance" as those having a primary range of operation over 500 miles; these trucks would frequently be away from their home bases at night. To determine the number of these trucks registered in North Carolina, we used the 2002 Vehicle Inventory and Use Survey data (Census 2004). Of the state's approximately 8,400 such trucks, we estimate that 40 percent already have anti-idling technology, leaving 5,040 trucks eligible to acquire auxiliary power units. Fuel consumption at idle is roughly one gallon per hour, and typical annual hours of idling is 1,830 per year. A diesel-fueled APU uses on the order of 0.18 gallons per hour, resulting in net savings for each truck of 1,500 gallons per year (Stodolsky, Gaines & Vyas 2000.)

The other efficiency equipment in the SmartWay upgrade kit, namely energy-efficient tires and trailer side skirts, is beneficial to the somewhat larger set of combination trucks with box trailers that travel largely at highway speeds. We assume that trucks typically driving 200 or more miles per day travel at high speeds; there are 15,300 such tractor-trailers registered in North Carolina. We assume that efficient tires and side skirts reduce fuel consumption by 4 percent each (EPA 2009) and that 25 percent of the relevant truck population already has this equipment.

The EPA has demonstrated that a low-interest loan program would allow truckers purchasing equipment in the SmartWay package to realize fuel cost savings that would exceed their monthly loan payments. We assume that usage of the loan program ramps up over five years, reaching all trucks eligible for the various types of equipment by 2012 under the high scenario. The medium scenario assumes that 2/3 of eligible vehicles participate in the program. .

Fuel savings from the program of SmartWay upgrades total about 1.5 percent of all truck fuel consumption in the medium scenario. Under the high scenario, in which we assume the SmartWay program is mandatory, this percentage increases to 2.3 percent.

C.5.2 Cost Methodology

Administrative cost values are based on the assumption that the program will be centrally administered and that North Carolina requires one administrator costing $150,000 and 2 additional staff costing $90,000 each. Annual administrative costs amount to $330,000 in 2007 dollars.

Regarding investment costs, the typical SmartWay upgrade kit costs $16,500. Based on the percent fuel savings associated with that package and lifetime truck miles, we estimate that the total investments between 2011 and 2025 amount to $453 million. Program spending for the same period totals $5 million. In the High Case, total investments are approximately $680 million.

C.6. Intermodal Freight Investment

C.6.1 Efficiency Potential Methodology

We assume that, in North Carolina, long-haul trucks are responsible for 60 percent of diesel consumption, which is the case nationally,[57] and that rail consumes on average one-third the fuel per ton-mile consumed by truck. Then diverting 10 percent of long-haul truck freight to rail would reduce diesel consumption by 4.0 percent by 2020. We assume that the infrastructure investments leading to increased rail share of freight movement will be phased in over fifteen years, starting in 2010.

C.6.2. Cost Methodology

The rail projects leading to diversion of 10 percent of long-haul truck miles were not fully specified in this policy. As a rough estimate of the cost of infrastructure investment needed to realize the assumed shift in mode, we calculate a cost per gallon saved from the Charlotte Intermodal Terminal. The Terminal is projected to cost $100 million, and we assume savings of 4.7 million gallons of diesel annually for 10 years based on Norfolk Southern's estimate of fuel savings in North Carolina from the Crescent Corridor. This leads to an estimate that investment costs for the intermodal policy described in this report would total $859 million between 2010 and 2025.

Administrative costs were calculated based on the assumption that the state-wide program would require one administrator and 3 additional staff to run at the respective costs of $150,000 and $90,000. Annual administrative and program costs are estimated to be $19 million.

[57] Calculated from the 2002 Vehicle Inventory and Use Survey data (US Census Bureau 2002).

APPENDIX D: DEMAND RESPONSE

Introduction

This report defines Demand Response (DR), assesses current DR activities in North Carolina, identifies policies in the state that impact DR, uses benchmark information to assess DR potential in North Carolina, and identifies barriers in the state that might keep DR contributing appropriately to the resource mix that can be used to meet electricity needs. The analysis concludes with identification of policy recommendations regarding DR.

Objectives of this Assessment

This assessment develops estimates of DR potential for North Carolina. Potential load reductions from DR are estimated for the residential, commercial, and industrial sectors. The assessment also includes discussions of reductions possible from other DR programs, such as DR rate designs.

Role of Demand Response in North Carolina’s Resource Portfolio

The DR capabilities developed by North Carolina utilities will become part of a resource strategy that includes resources such as traditional generation resources, renewable energy, power purchase agreements, options for fuel and capacity, energy efficiency and load management programs. Objectives include meeting future loads at lower cost, diversifying the portfolio to reduce operational and regulatory risk, and allow North Carolina customers to better manage their electricity costs. The growth of renewable energy supply (and plans for increased growth) can increase the importance of DR in the portfolio mix. For example, sudden renewable energy supply reductions (e.g., from an abrupt loss in wind) may be mitigated quickly with DR.

Summary of DR Potential Estimates in North Carolina

Table D.1 shows the resulting load shed reductions possible for North Carolina, by sector, for years 2015, 2020, and 2025. Load impacts grow rapidly through 2018 as program implementation takes hold. After 2018, the program impacts increase at the same rate as the forecasted growth in peak demand.

The high scenario DR load potential reduction is within a range of reasonable outcomes in that it has an eleven year rollout period (beginning of 2010 through the end of 2020), providing a relatively long period of time to ramp up and integrate new technologies that support DR. A value nearer to the high scenario than the medium scenario would make a good MW target for a set of DR activities.

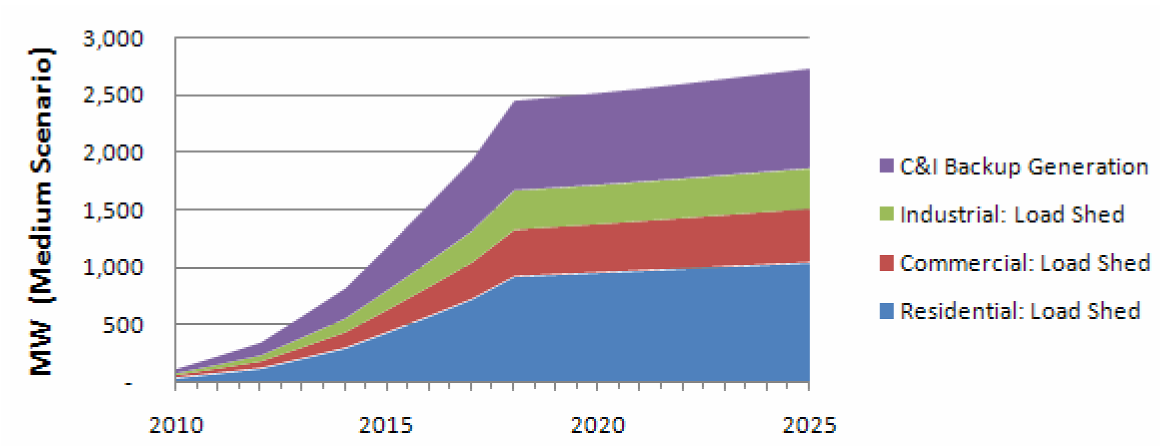
The high scenario results show a reduction in peak demand of 1,746 MW is possible by 2015 (6.4% of peak demand); 3,719 MW is possible by 2020 (12.7% of peak demand); and 4,031 MW is possible by 2025 (12.4% of peak demand).

The more conservative medium scenario results show a reduction in peak demand of 1,177 MW is possible by 2015 (4.3% of peak demand); 2,509 MW is possible by 2020 (8.6% of peak demand); and 2,722 MW is possible by 2025 (8.4% of peak demand).

Table D.1. Summary of Potential DR in North Carolina, By Sector, for Years 2015, 2020, and 2025[a]									
	Low Scenario			Medium Scenario			High Scenario		
	2015	2020	2025	2015	2020	2025	2015	2020	2025
Load Sheds (MW):									
Residential	263	576	628	438	960	1,047	613	1,344	1,465
Commercial	72	155	173	191	414	461	359	777	865
Industrial	76	151	155	170	339	349	302	603	620
C&I Backup Generation (MW)	283	597	649	377	796	865	472	995	1,081
Total DR Potential (MW)	693	1,479	1,605	1,177	2,509	2,722	1,746	3,719	4,031
DR Potential as % of Total Peak Demand	2.5%	5.1%	5.0%	4.3%	8.6%	8.4%	6.4%	12.7%	12.4%
a. See Section 3 for underlying data and assumptions.									

Figure D.1 shows the resulting load shed reductions possible for North Carolina, by sector, from year 2010, when load reductions are expected to begin, through year 2025.

Figure D.1. Potential DR Load Reductions in North Carolina by Sector (Medium Scenario)



These estimates reflect the level of effort put forth and utilities are recommended to set targets for the high scenarios. These estimates are based on assumptions regarding growth rates, participation rates, and program design. These factors are discussed in Chapter 4. In developing these DR potential estimates, the integration of DR with select energy efficiency activities was considered to help ensure that load impacts were not double counted. The estimated load reduction per program participant is conservatively estimated to account for increased energy efficiency in the future.

Defining Demand Response

DR focuses on shifting energy from peak periods to off-peak periods and clipping peak demands on days with the highest demands. Within the set of demand-side options, DR focuses on clipping peak demands that may allow for the deferral of new capacity additions, and it can enhance operating reserves available to mitigate system emergencies. Energy efficiency focuses on reducing overall energy consumption with attendant permanent reductions in peak demand growth. Taken together, these two demand-side options can provide opportunities to more efficiently manage growth, provide customers with increased options to manage energy costs, and develop least cost resource plans.

DR is an increasingly important tool for resource planning as power plant siting has grown more difficult and the costs of peak power have increased. Through development of DR capability, utilities can complement existing energy efficiency programs with a set of offerings that provide, at a minimum, 1) enhanced reliability, 2) cost savings, 3) reduced operating risk through resource diversification, and 4) increased opportunities for customers to manage their electric bills.

DR resources are usually grouped into two types: 1) load-curtailment activities where utilities can "call" for load reductions; and 2) price-based incentives which use time-differentiated and/or dispatchable rates to shift load away from peak demand periods and reduce overall peak-period consumption. Interest in both types of DR activities has increased across the country as fuel input prices have increased, environmental compliance costs have become more uncertain, and investment in overall electric infrastructure is needed to support new generation resources.

The mechanisms that utilities may use to achieve load reductions can range from voluntary curtailments to mandatory interruptions. These mechanisms include, but are not limited to:

- Direct load control by the utility using radio frequency or other communications platforms to trigger load devices connected to air conditioners, electric water heaters, and pool pumps;
- Manual load curtailments at commercial and industrial (C&I) facilities, including shutting off production lines and dimming overhead lighting;
- Automated DR ("Auto-DR") technologies utilizing controls or energy management systems to reduce major C&I loads in a pre-determined manner (e.g., raising temperature set points and reducing lighting loads); and
- Behavior modifications such as raising thermostat set points, deferring electric clothes drying in homes, and reducing lighting loads in commercial facilities.

Rationale for Demand Response

DR alternatives can be implemented to help ensure that a utility continues to provide reliable electric service at the least cost to its customers. Specific drivers often cited for DR include the following:

- **Ensure reliability—**DR provides load reductions on the customer side of the meter that can help alleviate system emergencies and help create a robust resource portfolio of both demand-side and supply-side resources that help meet reliability objectives.
- **Reduce system costs—**DR may be a less expensive option per megawatt than other resource alternatives. DR resources compete directly with supply-side resources and other resource investments in many regions of the country. Portfolios that help lower the increase in customers' expenditures on electricity over time represent an increasingly important attribute from the perspective of many energy customers.
- **Manage operational and economic risk through portfolio diversification—**DR capability is a resource that can diversify peaking capabilities. This creates an alternative means of meeting peak demand and reduces the risk that utilities will suffer financially due to transmission constraints, fuel supply disruptions, or increases in fuel costs.
- **Provide customers with greater control over electric bills –**DR programs would allow customers to save on their electric bills by shifting their consumption away from higher cost hours and/or responding to DR events. The ability to manage increases in energy costs has increased in importance for both residential and commercial customers. Standard residential and commercial tariffs provide customers with relatively few opportunities to manage their bills.
- **Address legislative/regulatory interest in DR—**The North Carolina Utilities Commission decided not to adopt PURPA Standard 14 ("Time-Based Metering and Communications") as enacted in EPACT 2005 because "…the Commission and the utilities have been actively promoting time-based rates for at least the last three decades." Rather, the State approved the Renewable Energy and Energy Efficiency Portfolio Standard (REPS) that considers DR to be an eligible activity for cooperative and municipal utilities; however, public utilities may not use DR to meet the REPS. In 2009, utility regulators in North Carolina approved

unprecedented rate cases that allow Duke Energy to earn the same rate of return for reducing demand as it does for increasing supply.

DR is gaining greater acceptance among both utilities and regulators in the United States. A 2006 FERC survey found that 234 "entities" were offering direct load control programs and the FERC's assessment noted that "there has been a recent upsurge in interest and activity in DR nationally and, in particular, regional markets" (FERC 2006).[58] The recent proliferation of DR offerings has been promoted in part by utilities hoping to reduce system peaks while offering customers more control over electric bills and in part by regulators. Although federal legislation has not been the driver behind the trend, it is one of many indications, at all levels of government and industry, of the growing support for DR.[59]

Many states experience significant reductions in peak demand from Demand-Side Management (DSM) programs (which include DR programs). Regulatory filings show that California experienced 495 MW in peak demand reductions in 2005 (1% of total peak demand); New York experienced 288 MW reductions in 2005 (1% of total peak demand); and Texas experienced 181 MW in reductions in 2005 (1% of total peak demand) from DSM programs. These results are annual values that do not consider the cumulative (i.e., year-to-year) impacts that accrue over the lifetimes of the conservation measures. Therefore, cumulative percentage reductions in peak demand are much higher than the annual figures stated.

Assessment Methods

As has been shown in numerous other jurisdictions across North America, well-designed DSM programs incorporating DR strategies represent an effective and affordable option for reducing peak demand and meeting growing demand for electricity. This effort estimated conservative peak demand reduction for North Carolina using local energy use characteristics, demographics, and forecast peak demand, assuming relatively basic DR strategies comprising responsive reductions in demand. The following research approach was used to conduct the analysis:

- Review of existing information regarding North Carolina's customer base including:
- Customer counts and average annual energy consumption by market segment;
- Forecasts of future energy consumption and customer counts by market segment;
- Previous DSM planning and potential studies.
- Review of additional publicly-available secondary sources including:
- U.S. DOE's Commercial Building Energy Consumption Survey (CBECS) and Residential Energy Consumption Survey (RECS) data;
- Previous studies relevant to the current effort completed by Summit Blue in other regions as well as entities in other jurisdictions.

[58] The FERC report uses the term "entities" to refer to all types of electric utilities, as well as organizations such as power marketers and curtailment service providers.

[59] The federal Energy Policy Act of 2005 (EPAct) directs the Secretary of Energy to "identify and address barriers to the adoption of demand response programs," and the Act declares a U.S. policy in support of "State energy policies to provide reliable and affordable demand response services." EPAct directed FERC to conduct its survey of DR programs and also directed the U.S. Department of Energy to report on the benefits of DR and how to achieve them (DOE, 2006). Separately, a *National Action Plan for Energy Efficiency,* which advocates DR and other efficiency efforts, was developed by more than 50 U.S. companies, government bodies, and other organizations, including co-chairs Diane Munns, President of NARUC and Jim Rogers, President and CEO of Duke Energy (U.S. Environmental Protection Agency, 2006). Other utility industry members of the Leadership Group included Southern Company, AEP, PG&E, TVA, PJM Interconnection, ISO New England, and the California Energy Commission.

- Development of baseline profiles for residential and commercial customers. These profiles include current and forecast numbers of customers by market segment and electricity use profiles by segment.
- Incorporation of ACEEE baseline data and reference case into analysis.
- Obtaining state-level data when possible and estimation of information for the State of North Carolina, when state-level data was not available.
- Development of a spreadsheet approach for estimating peak demand reduction potential associated with the DR programs/technologies deemed to be most applicable to North Carolina. Estimates are developed for three scenarios—low, medium and high case scenarios.
- Telephone calls with ACEEE staff and industry professionals to discuss assessment processes and legislative, regulatory, and other factors specific to the State of North Carolina.
- Incorporation of all sources of information and references into report, noting on each figure the source of the information.
- Revision of draft report based on comments from ACEEE, industry specialists and utility commenters.

The DR potential estimated used historical data and experience to obtain curtailment levels. This potential is assumed to be the achievable potential that would be cost effective, given the range of incentives that are typically required and the range of the utilities' avoided costs. A cost-effectiveness analysis was not performed for this study. Sufficient incentives could be provided to customers to encourage load reductions while maintaining a cost-effective program given avoided costs of approximately $76 per kW (based on the analysis reference case).

STATE OF NORTH CAROLINA—BACKGROUND

A sound strategy for development of DR resources requires an understanding of North Carolina's demand and resource supply situation, including projected system demand, peak-day load shapes, and existing and planned generation resources and costs.

North Carolina utilities serves a population of over 9.2 million, and generates approximately 144.3 million megawatt hours of electricity, that had a system peak load of almost 26,270 MW in 2007 (ACEEE base case for North Carolina). Electricity demand has grown an average of 2% per year over the past 20 years, fluctuating moderately—with 3 of the past ten years having negative growth (EIA 2009).

North Carolina has been and likely will continue to be a modest importer of energy and likewise be dependent on out-of-state capacity. In 2007, in-state generation provided 90% of total North Carolina retail sales, thus requiring import of approximately 10% (EIA 2009). North Carolina's in State Implied Reserve Margin had an average of 5.4% over the 10 year period from 1998-2007 (EIA 2009).

71% of the total sales in North Carolina are attributed to 2 retailers: Duke Energy Carolinas and Progress Energy Carolinas. The five largest electricity retailers in North Carolina are the following entities, with percent contribution in parentheses:

- Duke Energy Carolinas, LLC (43%)
- Progress Energy Carolinas Inc (28%)
- Virginia Electric & Power Co (3%)
- EnergyUnited Elec. Member Corp (2%)
- Public Works Comm.—City of Fayetteville (2%)

Assessment of Utility DR Activities

This section outlines existing DR programs offered to customers in North Carolina, by utility. The most successful programs include residential DLC and interruptible tariffs for the Medium and Large C&I classes. The state also has a significant portion of price-induced DR, and has some success with DR programs targeting large commercial and industrial customers (FERC 2009).

Duke Energy

The following DR programs, as described in The Duke Energy Carolinas Integrated Resource Plan (Duke 2008) and in USDOE 2009, are designed to provide a source of interruptible capacity to Duke Energy Carolinas:

Demand Response—Load Control Curtailment Programs

- Residential Air Conditioning Direct Load Control. Participants receive billing credits during the billing months of July through October in exchange for allowing Duke Energy Carolinas the right to interrupt electric service to their central air conditioning systems.

Demand Response—Interruptible Programs

- Interruptible Power Service. Participants agree contractually to reduce their electrical loads to specified levels upon request by Duke Energy Carolinas. If customers fail to do so during an interruption, they receive a penalty for the increment of demand exceeding the specified level.
- Standby Generator Control. Participants agree contractually to transfer electrical loads from the Duke Energy Carolinas source to their standby generators upon request by Duke Energy Carolinas. The generators in this program do not operate in parallel with the Duke Energy Carolinas system and therefore, cannot "backfeed" (i.e., export power) into the Duke Energy Carolinas system. Participating customers receive payments for capacity and/or energy, based on the amount of capacity and/or energy transferred to their generators.
- On-Site Generation Service Program. Duke Energy offers its large commercial customers the On-Site Generation Service Program, which targets customers that do not currently own back-up generation but would like to. Duke will install, own, and operate new generators (300 kW or larger) for participants willing to let the company use them in times of grid stress or high wholesale prices. There is a monthly service fee for this rate based on the levelized cost to own and operate the equipment. (USDOE 2009)

Demand Response—Time of Use Programs

- Residential Time-of-Use. This category of rates for residential customers incorporates differential seasonal and time-of-day pricing that encourages customers to shift electricity usage from on-peak time periods to off-peak periods. In addition, there is a Residential Water Heating rate for off-peak water heating electricity use.

- Commercial and Industrial Time-of-Use. PowerShare, Duke's customized DR program for large commercial and industrial customers, offers incentives based on a time-of-use planning and curtailment of energy usage. This reduced electric rate class was approved by the State Utility Commission in February 2009, with an initial budget of $34.6 Million and predicted timeframe of 2009-2013. For Duke customers already participating in either the Interruptible Service or Standby Generation Control programs, transition to the PowerShare program is be voluntary. PowerShare® is a non-residential curtailable program consisting of two options, an Emergency Option and a Voluntary Option. The Emergency Option customers will receive capacity credits monthly based on the amount of load they agree to curtail during utility-initiated emergency events. Customers enrolled in the Emergency Option may also be enrolled in the Voluntary Option and eligible to earn additional credits. Voluntary Option customers will be notified of pending emergency or economic events and can log on to a Web site to view a posted energy price for that particular event. Customers will then have the option to nominate load for the event and will be paid the posted energy credit for load curtailed.

- Hourly Pricing for Incremental Load. This category of rates for general service and industrial customers incorporates prices that reflect Duke Energy Carolinas' estimation of hourly marginal costs. In addition, a portion of the customer's bill is calculated under their embedded-cost rate. Participants are alternatively credited or charged, based on the hourly price, for usage below or above a pre-determined customer baseline load profile. (USDOE 2009).

Demand Response—Future Programs

- With a total planned investment of $1 billion, Duke Energy is pursuing a 5-year path to develop smart grid infrastructure across their service territory (Convergys 2009). In an effort to accelerate that timeline, Duke has also made at least 2 requests for aid from Federal stimulus funds. In August 2009, Duke requested $200 million for its smart meter programs in Indiana and Ohio, and another $14 million specifically for SG demonstration projects in North and South Carolina (Duke Energy 2009a). In 2009, Duke started the process of selecting long-term partners—most notably Cisco Systems, Convergys, and Ambient—to help pull together its Smart Grid deployment (SmartGrid News 2009).
- Power Manager is a residential load control program. Participants receive billing credits during the billing months of July through October in exchange for allowing Duke Energy Carolinas the right to cycle their central air conditioning systems and, additionally, to interrupt the central air conditioning when the Company has capacity needs. Information about the Power Manager program will be provided in bill inserts and on Duke Energy Carolinas' Web site, but the program will not be actively marketed until two-way communication is available. The Residential Power Manager Program is backed by a $32/year incentive ($8/mo for 4 months). Approved by the State Utility Commission in February 2009, this program had a budget of $18.9 Million and predicted timeframe of 2009-2013. The program is also used as a gateway for Duke Energy to offer free, in-home energy audits to help inform home owners of additional energy saving opportunities.

- Advanced Power Manager Program. This is a potential pilot research and development program to evaluate new technologies, advanced metering, and new rate structures to study the feasibility of an energy management system that enables customers to participate in demand-side management without disrupting their lifestyle or normal business operations. This program would include three phases: (1) a technology trial to determine the operating characteristics of the equipment and prove its viability; (2) a customer trial to determine the appropriate offer structure that benefits customers and accomplishes program goals; and (3) a product roll-out, provided the technology and customer trials are successful. Additionally, this program will test demand response load aggregation concepts for non-residential customers. New offers and rate structures developed for this pilot will be filed with the Commission for approval as they are developed.

Although largely driven by basic energy efficiency programs, within four years Duke Energy hopes that the combined savings from EE and DR programs will displace the need for 1,700 megawatts of capacity, or about 745,000 megawatt hours of production. As the results from these programs are realized, Duke specified that it plans to retire older coal plants, significantly reducing their net, system wide air emissions. (Duke Energy 2009b)

Because many of the Electric Membership Corporations (EMCs) in North Carolina work closely with Duke Energy, programs run by Duke Energy tend to have an indirect impact on customers of the EMCs as well.

Progress Energy Carolinas (PEC)

PEC offers the following DR programs to their customers, as described in their IRP (Progress 2008a):

- Time-of-Use Rates. PEC has offered voluntary Time-of-Use (TOU) rates to all customers since 1981. These rates provide incentives to customers to shift consumption of electricity to lower-cost off-peak periods and lower their electric bill.
- Thermal Energy Storage Rates. PEC began offering thermal energy storage rates in 1979. The present General Service (Thermal Energy Storage) rate schedule uses 2-period pricing with seasonal demand and energy rates applicable to thermal storage space conditioning equipment.
- Real-Time Pricing. PEC's Large General Service (Experimental) Real Time Pricing tariff was implemented in 1998.This tariff uses a two-part real time pricing rate design with baseline load representative of historic usage. Hourly rates are provided on the prior business day. A minimum of 1 MW load is required. This rate schedule is presently fully subscribed. Participants are notified, a day in advance, of the hourly energy prices for the following day, and are charged or credited at these rates for any usage above or below a "customer baseline load" (CBL) that is based on their historical use.
- Curtailable Rates. PEC began offering its curtailable rate options in the late 1970s, and presently offers two tariffs whereby industrial and commercial customers receive credits for PEC's ability to curtail system load during times of high energy costs and/or capacity constrained periods.
- Voltage Control. This procedure involves reducing distribution voltage during periods of capacity constraints, representing a potential system reduction of 78 MW. This level of reduction does not adversely impact customer equipment or operations.
- New Programs.
- "EnergyWise" is a new residential load-control (DLC) program that enables PEC to remotely adjust the air-conditioning units of voluntary customer participants during periods of peak electricity demand. Customers participating in the program receive an annual $25 bill credit as an incentive. "EnergyWise" was approved by the State Utility Commission in October 2008, with an initial budget of $55.4 Million and predicted timeframe of 2008-2012. (NCUC 2009) Summer peak demand reductions are expected to reach over 120 MWH by 2012. (Progress 2008b)
- Progress' attempt to introduce a distribution system demand response (DSDR) program was not initially passed by the energy commission because it was deemed to be more of an EE program than a DR program. As part of the ongoing review process, the commission also concluded that the cost recovery mechanism for the DSDR program should included all impacted customers. (NCUC 2009)
- Progress Energy has a new Commercial, Industrial, Government (CIG) DR program, designed to provide education and incentives to CIG customers to encourage participation in voluntary load management. As part of the program, Progress Energy installs communication technologies that enable PEC to remotely control and monitor a variety of electrical equipment during periods of peak demand. This automated system was approved by the State Utility Commission in August 2009, with an initial budget of $12.9 Million and predicted timeframe of 2009-2013. (NCUC 2009)
- Progress Energy announced on August 12, 2009 that it has applied for $200 million in federal infrastructure funds in support of the company's investment in an electric Smart Grid in the Carolinas and Florida.
- PEC was awarded the Smart Grid Grant under the Recovery Act. They are awarded $200 million to build a green Smart Grid virtual power plant through conservation, efficiency and

advanced load shaping technologies, including installation of over 160,000 meters across its multi-state service area. (USDOE 2009)

Blue Ridge Electric Membership Corp.

As of January 2008, Blue Ridge EMC had 16,450 customers participating in a utility controlled switching program that targets water heaters, and 2,350 participants in a similar program for switching of air conditioners. Blue Ridge EMC also maintains a program for electric thermal storage units that had 1,119 participants as of January 2008. These three programs combined have a total peak demand reduction potential of 18.9 MW (NCUC 2009).

Dominion

Dominion currently provides three rate tariff options for customers willing to curtail peak loads upon request. This tariff structure has allowed Dominion to cut 27 MW of summer peak demand and 29 MW of winter peak demand (NCUC 2009).

North Carolina Electric Membership Corp. (NCEMC)

NCEMC has 21 member utilities that collectively called on 110 MW of peak demand reduction in 2007 using a system of radio controlled switching on residential air conditions, water heaters heating systems, and customer-owned generation. This radio based system was installed in the mid 1980s and is now considered obsolete. NCEMC is evaluating new options for upgrading and expanding its DR capabilities (NCUC 2009).

Piedmont Electric Membership Corp.

Piedmont EMC offers time-of-use rates to both residential (430 participants) and commercial customers (23 participants). Piedmont EMC maintains control of 9,300 air conditioners and 6,200 water heaters for DR purposes. These measures provide 9.5 MW of peak summer and 6.8 MW of winter demand reduction (NCUC 2009).

Rutherford Electric Membership Corp.

Rutherford EMC's demand response programs include time-of-use rates and control switches. Rutherford's control switching program includes 8,836 air conditioners and 14,072 water heaters, providing a potential for 8 MW of demand reduction (NCUC 2009).

Assessment of Current State Policies Affecting DR

Section 1252 of the Energy Policy Act of 2005 (EPACT) includes demand side management provisions (in the form of a new PURPA Standard on Demand Response and Advanced Metering) and directed States and other bodies with authority over utilities to determine whether utilities under their jurisdiction to implement such. In August 2007, the North Carolina Utilities Commission decided not to adopt PURPA because "…the Commission and the utilities have been actively promoting time-based rates for at least the last three decades." Both Progress Energy and Duke Energy, for example, "already offer a variety of programs essentially identical to all but one of those suggested by" EPACT 1252. Furthermore, in February 2007 the Commission's Staff also recommended declining adoption of EPACT 1252." (DRCC 2009)

Many states have put in place renewable portfolio standards (RPS) to ensure that a minimum amount of renewable energy is included in the portfolio of the electricity resources serving a state. Many RPS include demand side options among the means by which the standards can be met. In August 2007 Governor Easley signed a Commission approved Renewable Energy and Energy Efficiency Portfolio Standard (REPS) that considers demand response to be an eligible activity for cooperative and municipal utilities; however, public utilities may not use demand response to meet the REPS.

The REPS for cooperatives and municipalities is:

- 2012: 3% of 2011 North Carolina retail sales
- 2015: 6% of 2014 North Carolina retail sales
- 2018 and thereafter: 10% of 2017 North Carolina retail sales

The REPS for public utilities is:

- 2012: 3% of 2011 North Carolina retail sales
- 2015: 6% of 2014 North Carolina retail sales
- 2018: 10% of 2017 North Carolina retail sales
- 2021 and thereafter: 12.5% of 2020 North Carolina retail sales (DRCC 2009)

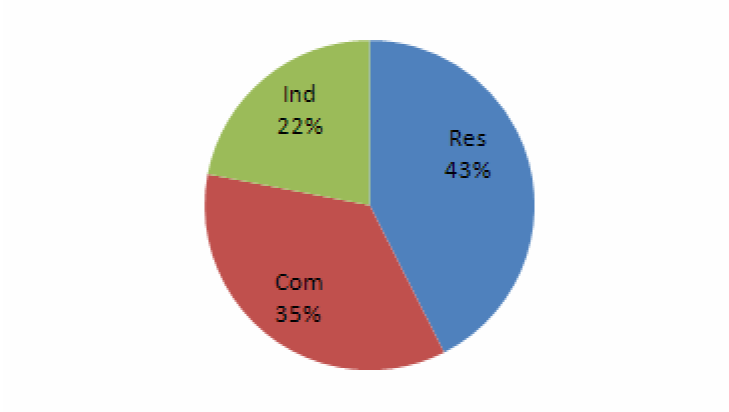
Utilities filed their first REPS compliance plan in September 2008, and beginning in 2009, each utility is required to file an annual REPS compliance report. Utilities that are required to file integrated resource plans are to file their REPS compliance plan as part of them. (DRCC 2009)

In March 2008, the Commission issued an Order terminating Duke Energy and Progress Energy's the fixed-payment programs because they found these programs led to increased energy use and that customers on the rate contributed more to peak demand than customers not on the rate. The Commission, however, established a grandfather clause, allowing customers already on the flat rates, or who applied to participate in the programs, to remain on them. (DRCC 2009)

Energy and Peak Demands

Use of energy in North Carolina is distributed to end use categories as follows: 43% residential, 35% commercial, and 22% industrial sectors (see Figure D.2).

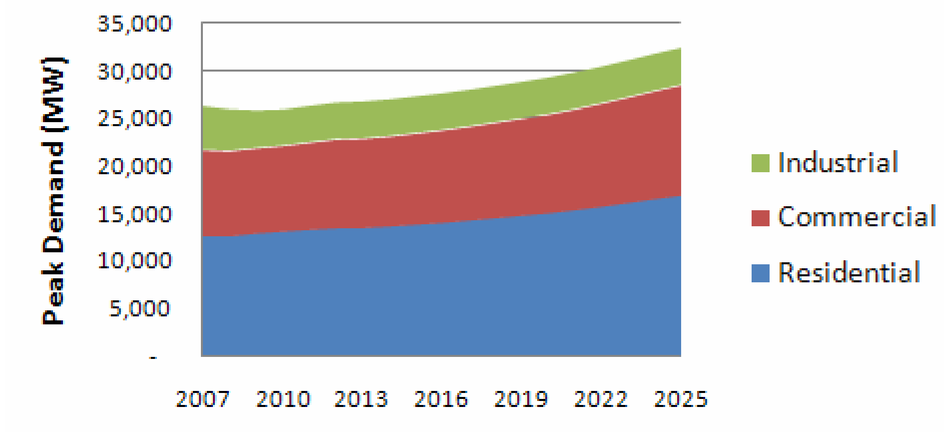
Figure D.2. Energy Sales in North Carolina by Sector (2007)



Source: ACEEE North Carolina Reference Case

In 2007, the total summer peak load was 26,256 MW and is projected to grow an average of 1.18% per year through 2025. Figure D.3 displays peak demand by sector. In 2007, residential peak demand was estimated at 12,738 MW; commercial was 8,994 MW; and industrial was 4,524 MW.

Figure D.3. Peak Demand by Sector in North Carolina (MW)



Source: ACEEE Reference Case for North Carolina

Smart Grids and Advanced Metering Infrastructure (AMI)

The EPACT provisions for DR and Smart Metering have lead to a number of states and utilities piloting and implementing a Smart Grid, or sometimes referred to as Advanced Metering Infrastructure (AMI).

Smart Grid is a transformed electricity transmission and distribution network or "grid" that uses robust two-way communications, advanced sensors, and distributed computers to improve the efficiency, reliability and safety of power delivery and use. For energy delivery, the Smart Grid has the ability to sense when a part of its system is overloaded and reroute power to reduce that overload and prevent a potential outage situation. The end user is equipped with real-time communication between the consumer and utility allowing optimization of a consumer's energy usage based on environmental and/or price preferences (for example, critical peak pricing and time of use rates).

AMI provides:

- Two-way communication between the utility and the customer through the customer's smart meter.
- More efficient management of customer outages (location, re-routing).
- More accurate meter reading (minute, 15 minute intervals).
- More timely collection efforts (real time).
- Improved efficiency in handling service orders.
- More detailed, timely information about energy use to help customers make informed energy decisions (real time).
- Ability to reduce peak demand.
- More innovative rate options and tools for customers to manage their bills.

Smart Energy Pricing provides:

- Incentives to customers to shift energy away from critical peak periods
- The ability to for customers to save on their electricity bills.
- Lower wholesale prices for capacity and transmission—in the longer term.
- Improved electric system reliability, as demand is moderated.
- Potential to defer new transmission and generation.

The Smart Grid is comprised of multiple communication systems and equipment, which interoperability is crucial. Not all communication protocols are applicable to every utility's geography; therefore, pilots are essential in testing the equipment and communication software for various geographies. Furthermore, the identification of those geographic regions with the best return on investment during a pilot will aid the staged implementation plan. Standards are continuing to be researched through organizations including: 1) IntelliGrid—Created by the Electric Power Research Institute (EPRI); 2) Modern Grid Initiative (MGI) is a collaborative effort between the U.S. Department of Energy (DOE), the National Energy Technology Laboratory (NETL), utilities, consumers, researchers, and other grid stakeholders; 3) Grid 2030—Grid 2030 is a joint vision statement for the U.S. electrical system developed by the electric utility industry, equipment manufacturers, information technology providers, federal and state government agencies, interest groups, universities, and national laboratories; 4) GridWise—a DOE Office of Electricity Delivery and Energy Reliability (OE) program; 5) GridWise Architecture Council (GWAC) was formed by the U.S. Department of Energy; and 6) GridWorks—A DOE OE program.

Principal benefits of Smart Grid technologies for DR include increased participation rates and lower costs. In 2009, Dominion plans to deploy 200,000 smart meters as part of a large demonstration program of smart grid technology in urban and rural areas of Dominion's service territory. Dominion expects to improve customer service and business operations through advanced system control, real-time outage notification, and power quality monitoring. As part of this program, Dominion is deploying a number of smart thermostats for a residential critical peak pricing pilot during the summer of 2008. Dominion will measure customer responsiveness to changing energy prices and the impact on energy demand during peak usage periods (Utility Products 2008).

These developments in technology allowing real time signaling and automated response will improve DR capabilities. However, existing technology exists for successful DR implementation and it is important to point out that there are no technology obstacles to effective DR.

Assessment of DR Potential in North Carolina

This section examines and quantifies DR potential in North Carolina. Section 3.1 outlines the general DR program categories, while Sections 3.2 and 3.3 outline the DR potential in the residential and commercial /industrial sectors, respectively. Section 3.4 discusses the load reduction potential from backup generation and Section 3.5 explains the issues surrounding rate pricing, even though benefits from this form of DR are not quantified in this analysis. Section 3.6 concludes with a summary of DR potential in North Carolina.

Demand Response Program Categories

For the purposes of assessing DR alternatives, the following programs could be employed in North Carolina to achieve the DR potential we outlined in this report:

Resource Category	Characteristics
Direct Load Control (DLC)	Direct load control (DLC) programs have typically been mass-market programs directed at residential and small commercial (<100 kW peak demand) air conditioning and other appliances. However, an emerging trend is to target commercial buildings with what has become known as Automated Demand Response or Auto-DR. Increased use and functionality of energy management systems at commercial sites and an increased interest by commercial customers in participating in these programs is driving growth in automated commercial curtailment in response to a utility signal. The common factor in these programs is that they are actuated directly by the utility and require the installation of control and communications infrastructure to facilitate the control process.

Callable Customer Load Response	With this type of program, utilities offer customers incentives to reduce their electric demand for specified periods of time when notified by the utility. These programs include curtailable and interruptible rate programs and demand bidding/buyback programs. Curtailable and interruptible rate programs can be used as "emergency demand response" if the advanced notice requirements are short enough. All customer load response programs require communications protocols to notify customers and appropriate metering to assess customer response.
Scheduled Load Control	This is a class of programs where customers schedule load reductions at pre-determined times and in pre-determined amounts. A variant on this theme is thermal energy storage which employs fixed asset technology to reduce air conditioning loads consistently during peak afternoon load periods.
Time-Differentiated Rates	Pricing programs can employ rates that vary over time to encourage customers to reduce their demand for electricity in response to economic signals—in some cases these load reductions can be automated when a price trigger is exceeded. An example is a critical peak price which is "called" by the utility or system operator. In response to this critical price, residential customers can have AC cycling or temperature setbacks automatically deployed. Similar automated responses can be deployed by commercial customers. These rate programs are not analyzed for this assessment, but are further discussed in Section 3.5.

DR for Residential Customers

Air conditioner and other appliance direct load control (DLC) is the most common form of non-price-based DR program in terms of the number of utilities using it and the number of customers enrolled. According to FERC's 2006 assessment of DR and advanced metering, there are 234 utilities (including municipalities, cooperatives, and related entities) with DLC programs across the United States. Approximately 4.8 million customers are participating in DLC programs across the country (FERC 2006).

The prominent and growing role of air conditioning in creating system peaks makes it a high profile candidate for DR efforts. The advances in DR technology that make AC load management economically viable make AC load control a high priority program—one that has been proven reliable and effective at many utilities. Pool pumps are also a relatively easy and non-disruptive load that can be controlled for DR purposes.

Residential Control Strategies

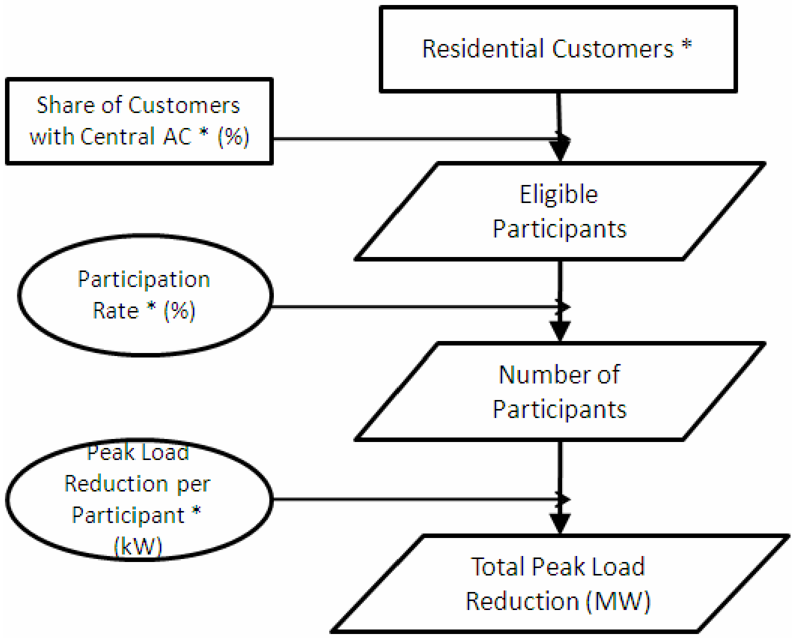
There are two basic types of control strategies: AC cycling and temperature offset. AC cycling limits ACs being on to a certain number of minutes than they otherwise would have been on. Some techniques limit ACs to being on for 50% of the minutes they would otherwise have been on. A temperature offset increases the thermostat setting for a certain period of time, for a certain number of degrees higher than it would have otherwise been set. This essentially causes the AC compressor to cycle as the temperature set-back reduces the AC demand. Sequential thermostat setbacks, i.e., one degree in a hour one, two degrees in hour two, three degrees in hour three, and four degrees in hour four can mimic an AC cycling strategy.

Cycling strategies have evolved where an optimal impact on peak kW demand may be obtained by varying the cycling time across the hours of an event. For example, there may be one hour of pre-cooling followed by 33% cycling in the first hour, 50% cycling in the second hour, 66% cycling in the third hour and dropping back to 33% in the fourth hour. Strategies like this have been deployed in pilot programs at Progress Energy Carolinas (PEC) and in PSE&G's MyPower pilot program. This type of strategy requires that forecasters accurately predict the hour(s) in which the peak system demand will occur.

Assessment of DR Potential in Residential Homes in North Carolina

For North Carolina, estimates for possible load reductions for residential housing units were obtained by applying the methodology displayed in Figure D.4.

Figure D.4. Residential Peak Load Reduction



* Input data by Single Family and Multi-Family Residences, and by Existing Home and New Construction.

The figure shows how load reductions and participations rates are applied to housing data. Items listed in rectangular shapes are factual inputs; items in circular shapes are assumptions; and items in parallelogram shapes are results. The analysis conducted for this study was based on demand response for summer loads, especially air conditioning, since North Carolina's major utilities are summer-peaking. However, it should be noted that some mountainous regions in the western portion of the state are winter peaking, and DR programs have targeted electric space and water heating loads.

Load Reductions

Recent surveys show that DLC programs are being implemented by a number of utilities. Load impacts are dependent on many variables. The control strategy used, the outdoor temperature, the time of day, the customer segment, ease of and ability to override control, reliability of communication signals, age and working condition of installed equipment, and local AC use patterns all have significant effects on the load impact. Even within a single program, there is variability in impacts across event days that cannot yet be fully explained. Measuring impacts typically requires expensive monitoring equipment and as a result is often done on small sample sizes.

Even with this variability, a review of reported impacts does show some general consistencies. As expected, impacts increase as the duty cycle goes up. Table D.2 shows the average reported kW impact based on 20 load control impact studies for programs based on the duty cycle used. These results support the oft-quoted rule-of-thumb that the load impact for 50% duty cycling is 1 kW per customer, which is the impact used in this analysis. However, many homes will experience an impact greater than I kW, especially newer homes.

Table D.2. Average Load Impacts by Cycling Strategy for AC DLC Programs

Cycling Strategy	Average Load Impact KW/Customer
33%	0.74
45%	0.81
50%	1.04
66%	1.36

Source: Summit Blue (2007b)

Customer type also makes a difference. In a few cases where single-family and multi-family impacts were measured separately, multi-family impacts were 60% of single-family, and thus a 0.6kW load reduction is applied in this analysis for multi-family units (Summit Blue 2007b).

Eligible Residential Customers

All residential customers with central air-conditioning that live in areas that can receive control signals are considered eligible for the direct load control program. This includes single family and multi-family housing units. Residential accounts without central AC are assumed to have no participation. The ACEEE reference case reports that 81% of all housing units have CAC in North Carolina—both single family and multi-family.

Multi-family housing units often have building tenants which are not the account holders, therefore accounts are often aggregated into buildings. Some accounts have a master meter for the entire building, including tenants. Some accounts are for the "common" building loads (i.e., those loads that are part of a building account such as elevators, A/C (if applicable), lobby lighting, etc.), but individual tenants in these buildings have their own accounts. There, multi-family units often have fewer units with central AC than single family. However, in this analysis, due to data constraints, 81% was applied to both single and multi-family customers, and leads to a more conservative estimate of impacts.

Residential Participation Rates

Participation rates experienced in AC DLC programs vary across utilities typically from 7% of eligible customers to 40%, depending upon the effort made in maintaining and marketing the program (Summit Blue 2007a). The utilities with the low levels of participation had essentially stopped marketing the program in recent years. Utilities with programs with sustained attention to customer retention or recruitment show higher participation rates than utilities with one-time or intermittent promotion. In Maryland, BG&E's Demand Response Service program anticipates a residential participation rate of 50%, or approximately 450,000 controlled units (BGE 2007). The pilot phase of this program was conducted from June 1 through September 30, 2007, and 58% received a "smart" load control switch, and 42% had a "smart" thermostat installed (BGE 2007). One study examined 15 AC DLC programs nationwide and found an average of 24% participation for eligible customers (Summit Blue 2008b).[60] For this analysis, 3 typical yet conservative scenarios were used: a low scenario of 15% for eligible customers; a medium scenario of 25%; and a high scenario of 35%.

Results

Table D.3 displays the input data and results. In summary, the results for residential programs reveal that a medium scenario reduction of 438 MW is possible by 2015 (with 263 MW possible by the low

[60] Programs where participants are included in a program unless they chose to "opt-out" experience much higher participation rates. One utility is proposing a "hybrid" program for new construction, where existing customers must opt-in and new construction customers must opt-out. This program assumes that 70% of new construction customers will enroll in the initial years, and 80% in later years (Summit Blue 2008b).

scenario, and 613 MW by the high). By 2020, 960 MW is achievable through the medium scenario (with 576 MW possible by the low scenario, and 1,344 MW by the high).

Table D.3. Potential Load Reduction from AC-DLC In North Carolina Residential Homes, in Years 2015 and 2020

INPUTS	**2015**	**2020**
Residential Peak Demand (MW)	13,920	15,119
Residential Customers (in thousands) [a]: Total	4,634	5,079
Single Family	3,842	4,201
Multi-Family	792	878
Eligible Residential Customers: Single and Multi-Family[b]	81%	
Load Reduction per AC-DLC per Single-Family Unit (kW)	1.0	
Load Reduction per AC-DLC per Multi-Family Unit (kW)	0.6	
DR Participation Rates of eligible customers:		
Low Scenario	25%	
Medium Scenario	25%	
High Scenario [c]	35%	
RESULTS	**2015**	**2020**
Residential Potential DR Load Reduction (MW):		
Low Scenario	263	576
Medium Scenario	438	960
High Scenario	613	1,344

Notes:

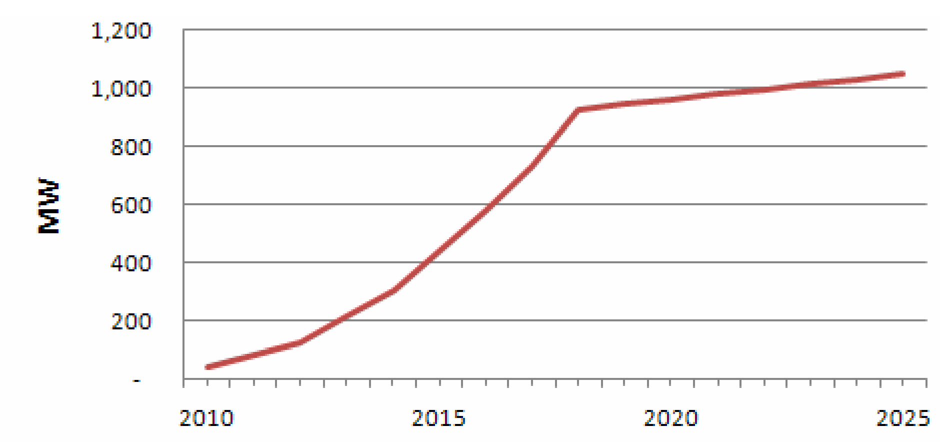
a. Residential customers reflect number of housing units, as reported from Economy.com.

b. Analysis assumes residences with central AC are eligible. Residential accounts without central AC are assumed to have no participation. Central AC percents obtained from ACEEE reference case.

c. Higher participation than applied in the High Scenario is possible through design of program features, such as "opt-out" participation where participants are included in a program unless they chose to "opt-out".

Figure D.5 shows the resulting residential load shed reductions possible for North Carolina, from year 2010, when load reductions are expected to begin, through year 2025.

Figure D.5. Potential Residential Load Shed in North Carolina (Medium Scenario)



Room Air Conditioners

Other DR residential programs could involve tapping into the potential for callable load reductions from room air conditioners. At least one prominent DR provider is exploring the possibility of having manufacturers of room AC units embedding a home-area-network communication device into new units. This would enable cycling of room air conditioners without the need to install radio frequency load switches commonly used for residential direct load control applications. Callable load reductions from room air conditioners would provide a significant boost to load control capability and these reductions would be dispatchable in less than ten minutes. Some utilities are projecting to add a large number of new room air conditioners in the next five to ten years. The additional participation of a fraction of these room AC units could provide a substantial increase to the AC DLC program.

Other Appliances

Based on the experiences of other utilities, expanding the equipment controlled to other equipment beyond AC units can produce additional kW reductions. This could include electric hot water heaters and pool pumps. However, the saturation of electric hot water heaters is lower than for air conditioning, and control of hot water heaters generally produces only about one-third the load impact of air conditioners, especially in the summer when North Carolina utilities would most likely be calling DR events.

Commercial and Industrial DR Potential in North Carolina

Appropriate commercial sector DR programs will vary according to customer size and the type of facility. Direct load control of space conditioner equipment is a primary DR strategy intended for small commercial customers (e.g., under 100 kW peak load), although TOU rates combined with promising new thermal energy storage technologies could prove an effective combination. Mid-to-large commercial customers and smaller industrial customers could best be targeted for a curtailable load program requiring several hours of advanced notification or, where practical, for an Auto-DR program that can deliver load reductions with no more than ten minutes of advance notice. Thermal energy storage and other scheduled load control programs may also be applicable for some larger buildings or water pumping customers. In this assessment of DR potential, the focus is on the use of direct load control and curtailable load response programs. Studies have shown that pricing programs, specifically dispatchable pricing programs such as critical peak pricing (CPP) programs can provide similar impacts. These pricing programs are discussed in Section 3.2. However, for the purposes of this assessment, a focus on these load response programs is believed to be able to fully represent the DR potential, even though pricing programs could be used instead of these curtailable load programs with equal, or in some cases, greater efficiency.

The following DR program descriptions apply to both commercial and industrial customers:

- Small business direct load control (air conditioning)—Small commercial customers (under 100 kW peak load) account for a majority of customer accounts but typically only about one-quarter of total commercial load. Due to the nature of small businesses, particularly their small staffs for which energy management is a relatively low priority, it is not practical to rely on active customer response to load control events. Thus, small businesses may best be viewed in the same way as residential customers for purposes of DR.
- Curtailable load program—This program would be applicable to commercial and industrial customers willing to commit to self-activated load reductions of a minimum of perhaps 50 kW in response to a notice and request from a utility. The minimum curtailment threshold is designed to improve program cost-effectiveness by ensuring that recruitment and technical assistance costs are used for customers who can deliver significant load reductions. Advanced notice requirements would likely be two hours— long enough to allow customers an opportunity to prepare but short enough to maintain the DR resource as a viable resource that can be dispatched by operations staff. Enabling technologies would vary greatly, but

utilities would educate customers about alternatives and could work with equipment vendors to facilitate equipment acquisition and installation. Incentives would be paid as capacity payment (in $/kW-month) or a discount on the customers' demand charges. Utilities could also offer a voluntary version of the program to attract greater participation. Customers would not commit to load reductions, but incentives would be lower and would be paid only on the reductions achieved during curtailment events.

- Automated demand response (Auto-DR)—This program would be marketed to facilities such as high rise office buildings and large retail businesses that have energy management and control systems (EMCS) that monitor and control HVAC systems, lighting, and other building functions. The benefits of Auto-DR over curtailable load programs include customer loads curtailments with as little as ten minutes notice and greater assurance that customers will reduce loads by at least their contracted amount. Incentives would be paid as either capacity payments or demand charge discounts, but would be greater than for curtailable load program participants due to the additional technology investment that may be required and the allowance of curtailments on relatively short notice. UTILITIES would offer extensive technical assistance in setting up Auto-DR capability and would potentially provide financial assistance as well for customers making long-term commitments.
- Scheduled load control programs (including thermal energy storage)—Scheduled load control can help reduce utility peak demand, especially through shifting of space cooling loads enabled by thermal energy storage technologies. Large-customer TES systems could be promoted along with customer commitments to reduce operation of chillers or rooftop air conditioners during specified peak hours. Customers' return on investment can be increased by encouraging migration to a TOU rate, which would offer a rate discount for many of the hours that TES systems are recharging cooling capacity. Water pumping systems are typically good candidates for scheduled load control programs and utilities can investigate opportunities in the municipal water supply and irrigation sectors. Other, less traditional, opportunities may also be available, such as the leisure/resort industry's limiting recharging of electric golf carts to off-peak hours.
- Emergency under-frequency relay (program add-on)—Under-frequency relays (UFRs) automatically shut off electrical circuits in response to the circuits exceeding pre-set voltage thresholds specified by the utility. Use of UFRs is a valuable addition to a DR portfolio because the load response is both automatic and virtually instantaneous. UFRs can best be integrated into another DR program where participants are already engaging in load curtailment activities. It is expected that some customers who might consider participating in a DR program will not be willing to allow loads to be controlled via UFR since they would not receive any advanced notice. Incentives would also need to be greater to attract participants and provide acceptable compensation. However, the benefits of UFRs warrant their consideration as part of a utility's proposed DR portfolio.

Commercial DR Potential in North Carolina

To estimate potential load reductions for commercial units, a straight-forward approach of applying load shed participation rates and curtailment rates directly to commercial peak demand.

First, assumptions were made on the percentage of commercial customers who are willing to participate in DR programs. One study applied commercial participation rates ranging from 11% to 48% for commercial customers (Summit Blue 2008a). Table D.4 displays participation rates for various types of commercial customers, disaggregated into two different peak demand categories (<300kW and >300kW).

Table D.4. Examples of Commercial Load Shed Participation Rates		
	Peak Category	
Customer Segment	<300kW	>300kW
Office Buildings	11% - 15%	45% - 48%
Hospitals	13%	48%
Hotels	14%	45%
Educational Facilities	13%	43%
Retail	11%	42%
Supermarkets	12%	33%
Restaurants	11%	39%
Other Government Facilities	15%	44%
Entertainment	13%	41%
Source: Summit Blue (2008a)		

Because facility-specific data was not available for North Carolina, three conservative scenarios for participation rates were applied. A medium scenario load participation rate of 20% was applied as it appears to be an average participation rate found by utilities with DR programs in place. A low scenario of 10% and a high scenario of 30% are applied.

Then, assumptions were made for curtailment rates, based on existing estimates of the fraction of load that has been shed by commercial customers enrolled in event-based DR programs callable by the utility. Table D.5 displays curtailment rates for various types of commercial customers, which range from 13% to 43%. For the purposes of this analysis, 3 conservative scenarios were applied: a low curtailment rate of 15%, a medium curtailment rate of 20%, and a high rate of 25%.

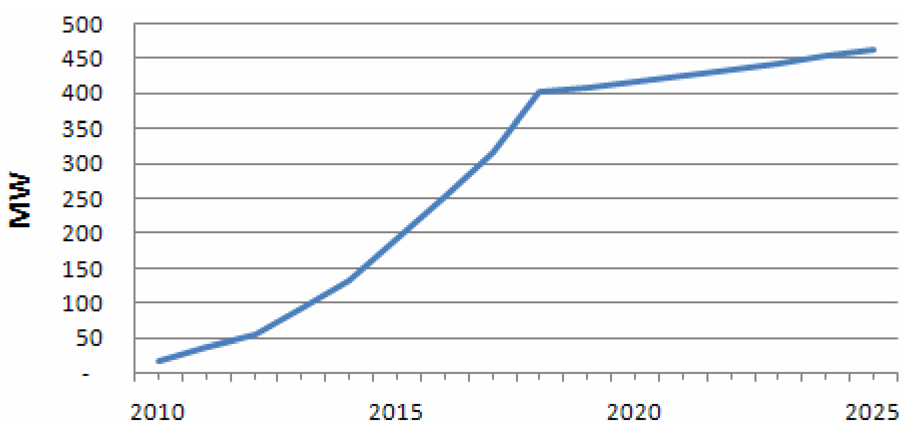
Table D.5. Examples of Commercial Curtailment Rates	
Customer Segment	Average Curtailment Rate
Office Buildings	21%
Hospitals	18%
Hotels	15%
Educational Facilities	22%
Retail	18%
Supermarkets	13%
Restaurants	17%
Other Government Facilities	38%
Entertainment	43%
Source: Summit Blue (2008a)	

Table D.6 displays the input data and results. In summary, the commercial sector results reveal that a medium scenario reduction of 191 MW is possible by 2015 (with 72 MW possible by the low scenario, and 359 MW by the high). By 2020, 414 MW is achievable through the medium scenario (with 155 MW possible by the low scenario, and 777 MW by the high).

Table D.6. Potential Commercial Load Shed in North Carolina, in Years 2015 and 2020		
INPUTS	**2015**	**2020**
Commercial Peak Demand (MW)	9,569	10,359
Load Shed Participation Rates:		
Low	10%	
Medium	20%	
High	30%	
Curtailment Rates:		
Low	15%	
Medium	20%	
High	25%	
RESULTS	**2015**	**2020**
Commercial DR load reductions (MW):		
Low	72	155
Medium	191	414
High	359	777

Figure D.6 shows the resulting commercial load shed reductions possible for North Carolina, from year 2010, when load reductions are expected to begin, through year 2025.

Figure D.6. Potential Commercial Load Sector in North Carolina (Medium Scenario)



DR programs that move towards the auto-DR concept can typically provide some load sheds that only require ten-minute notification or less. While some customer surveys have shown that most customers would prefer longer notification periods, many of these customers have not put in place the technologies to automate DR both load shed within a facility and the startup of emergency generation (ConEd 2008). The value of DR and the design of DR programs should take into account system operations. Ten-minute notice DR can be valuable in helping defer some investment in T&D. While not all customers may choose to provide ten-minute notice response, there should be an increasing number of customers that will provide this type of response in the future and programs should be designed to acquire this resource. This type of DR is often a more valuable form of DR with higher savings for the utility, and utilities are often ready to pay up to twice as much to customers for this short-notice responsiveness.

Industrial DR Potential in North Carolina

A similar analysis was conducted for the industrial sector: load shed participation rates and curtailment rates were applied to industrial peak demand. A previous study found industrial participation rates to vary from 25% for facilities <300kW, to 50% for >300kW (Summit Blue 2008a).

For this study, the following rates were applied to participation: Low (20%); Medium (30%); and High (40%).

Previous studies have found industrial curtailment rates to vary from 17% (Quantec 2007), to 30% (Consortium 2004), to 75% (Nordham 2007), resulting in a mean of 41%. The following conservative rates were applied to curtailment for this study: Low (20%); Medium (30%); and High (40%). With these participation rates and potential load curtailments, the high load reduction potential for the overall industrial sector loads is 16% (i.e., 40% participation and 40% of that load participating).

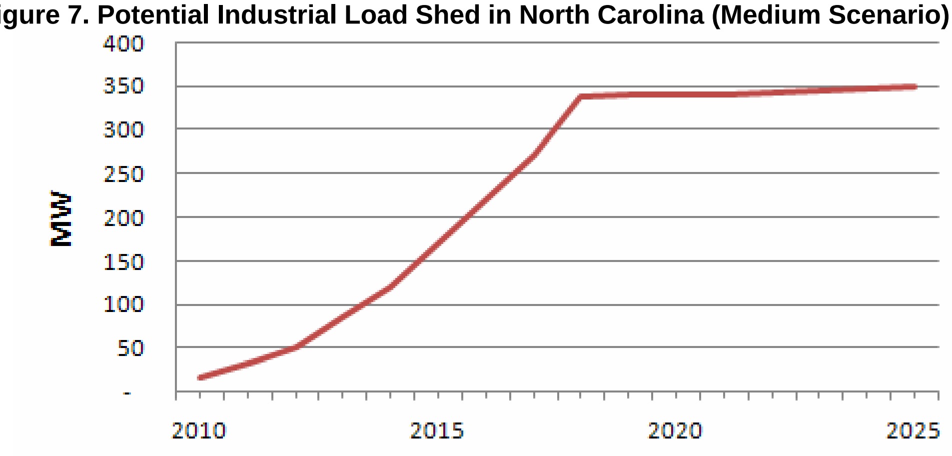
Table D.7 displays the input data and results. In summary, the industrial sector results reveal that a medium scenario reduction of 170 MW is possible by 2015 (with 76 MW possible by the low scenario, and 302 MW by the high). By 2020, 339 MW is achievable through the medium scenario (with 151 MW possible by the low scenario, and 603 MW by the high).

Table D.7. Potential Industrial Load Shed in North Carolina, in Years 2015 and 2020

INPUTS	**2015**	**2020**
Industrial Peak Demand (MW)	3,779	3,770
Load Participation Rates:		
Low	20%	
Medium	30%	
High	40%	
Curtailment Rates:		
Low	20%	
Medium	30%	
High	40%	
RESULTS	**2015**	**2020**
Industrial DR load reductions (MW):		
Low	76	151
Medium	170	339
High	302	603

Figure D.7 shows the resulting industrial load shed reductions possible for North Carolina, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 7. Potential Industrial Load Shed in North Carolina (Medium Scenario)



The largest load reductions, and often the most cost-effective, may be found in North Carolina's largest commercial and industrial customers. Data concerning these largest facilities were not available in North Carolina so estimates are not quantified separately from the industrial analysis given in the previous section.

It is a topic of concern how the economic downturn could potentially affect DR, particularly in the commercial and industrial sectors. Industry communications reveal that DR efforts have not slowed down with the economy. Many utilities are supporting DR programs, even if capacity is not a current driver. Progress Energy is continuing ahead with their DR programs and recently received approval for their C&I DR program (see Section "Assessment of Utility DR Activities").

Commercial and Industrial Backup Generation Potential in NC

Emergency backup generation is a prominent component of a callable load program strategy. Some of the emergency generators not currently participating in DR programs may not be permitted for use as a DR resource and regulations may further limit the availability of emergency generation for DR. In some cases, backup generators may not be equipped with the start-up equipment to allow the generator to participate in short-term notification programs. Utilities could consider a program to assist customers with equipment specification and set-up to promote DR program participation by backup generators.

In some instances, there may be environmental restrictions on emergency generation. Emissions of emergency generation may be regulated, and the future of such regulations may add some uncertainty. However, some areas have been able to have such restrictions lifted during system emergencies.

Two approaches can increase the amount of emergency generation in DR programs: 1) facilitating customer-owned generation, and 2) utility ownership of the generation, which is used to provide additional reliability for customers willing to locate the equipment at their facilities.

Customer-Owned Emergency Generation

To increase customer-owned emergency generation, utilities may assist customers with ownership of grid-synchronized emergency generation. Utilities may offer to pay for all equipment necessary for parallel interconnection with the utility grid, as well as all maintenance and fuel expenses. Once operational, the standby generators can be monitored and dispatched from a utility's control center, and they can also provide backup power during an outage. An additional benefit to the customer relative to typical backup generation is the seamless transition to and from the generator without the usual momentary power interruption.

Utility-Owned Emergency Generation

A second approach to increasing the availability of emergency generation for DR is by locating generation at customer sites that can be owned by a utility. Through this type of program, the customer receives emergency generation capability during system outages in exchange for paying a monthly fee consisting of both levelized capital costs and operation and maintenance costs. Participants would likely receive capacity payments ($/kW-month) and/or energy payments ($/kWh) in exchange for granting a utility to dispatch the units for a limited number of events and total hours per year.

Backup Generation in North Carolina

Total North Carolina back-up generation capacity for 2015 is estimated at approximately 1,887 MW.[61] Additional analysis revealed that the commercial and industrial back-up capacity, each, is

[61] Back-up generation capacity in North Carolina was estimated from form EIA-861 filings submitted by utilities nationwide (EIA, 2007). However, only utilities providing approximately one-quarter of total kWh report these numbers. It was assumed that the prevalence and usage of distributed generation in the remaining 75% of utilities is similar.

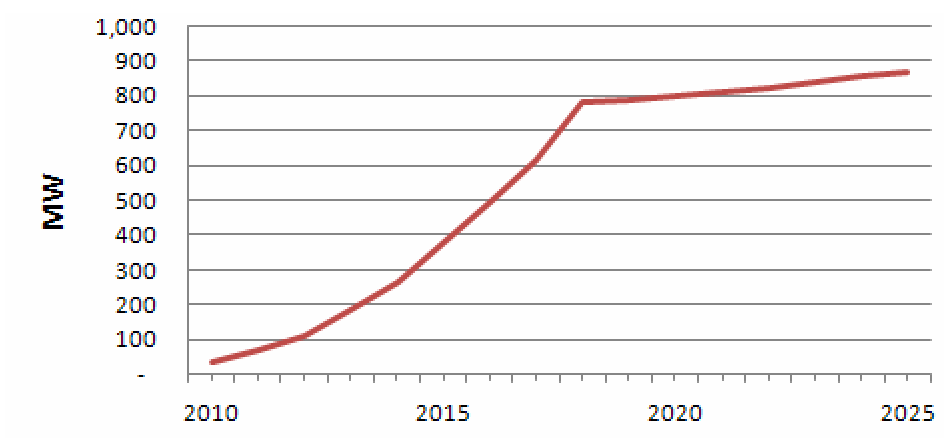
approximately half of the total capacity, 945 MW.[62] Assuming a medium scenario that 40% of the total backup in North Carolina is available for load shed, then 377 MW of backup generation is available by 2015 and 796 MW is available by 2020 (see Table D.8). The low scenario estimates a 283 MW reduction by 2015 and a 597 MW reduction by 2020. The high scenario estimates a 472 MW reduction by 2015 and a 995 MW reduction by 2020.

Table D.8. Potential Reductions from C&I Backup Generation in North Carolina, in Years 2015 and 2020[a]

INPUTS	**2015**	**2020**
Total Backup Generation Capacity (MW)	1,887	1,990
Backup Generation Potential (%):		
Low	30%	
Medium	40%	
High	50%	
RESULTS	**2015**	**2020**
Potential Reduction from C&I Backup Generation (MW):		
Low	283	597
Medium	377	796
High	472	995

Figure D.8 shows the resulting commercial and industrial backup generation reductions possible for North Carolina, from year 2010, when load reductions are expected to begin, through year 2025.

Figure D.8. Potential Reductions from C&I Backup Generation (Medium Scenario)



Pricing and Rates

In this assessment of DR potential, the focus is on the use of direct load control and curtailable load response programs callable by the utility. Studies have shown that pricing programs, specifically dispatchable pricing programs such as critical peak pricing (CPP) programs can provide similar impacts; however, for the purposes of this assessment, a focus on the these load response programs is believed to be able to fully represent the DR potential, even though pricing programs could be used instead of these curtailable load programs with equal, or in some cases, greater efficiency.

New rates may be introduced as part of a DR program, and may include real-time prices, or other time-differentiated rates, for commercial and industrial customers, and a modification of any existing

[62] The analysis first determined the back-up generator population nation-wide, and then scaled the data down to the Southeast region (CBECS resolution), accounting for proportional differences in building stock nation-wide and region-wide. The region-wide results were then scaled down to North Carolina specifically using the ratio of North Carolina population to regional population.

residential time-of-use (TOU) rates. Any new rate structures would be designed to reduce system demand during peak periods and provide an opportunity for customers to reduce electric bills through load shifting.

Critical peak pricing (CPP) is a viable option for inclusion in a DR portfolio. In FERC's 2006 survey of utilities offering DR programs (citation below), roughly 25 entities reported offering at least one CPP tariff. However, many of the tariffs were pilot programs only, and almost all of the 11,000 participants were residential customers. The apparent lack of commercial CPP programs is supported by a 2006 survey of pricing and DR programs commissioned by the U.S. EPA (below), which found only four large-customer CPP programs, all of them in California. The pilot programs in California linked the CPP rate with "automated demand response" technologies that provide most of the impact. The CPP rate itself, and the price incentive that it creates, is not the driver behind the load reductions.

As stated, rate pricing options were not analyzed in this analysis. Event-based pricing programs achieve impacts very similar to the callable load programs presented above. Pilot studies and tariff evaluations of TOU-CPP programs[63] show the load reductions for called events are similar in magnitude to air conditioning DLC programs. This is not surprising in that most TOU-CPP participants use a programmable-automated thermostat to respond to CPP events in a manner similar to a DLC strategy. One difference is that the customer response is less under the control of the program or system operator that could change cycling strategies or thermostat set points across different events or different hours within an event. Similarly, demand-bid programs are simply calls for target load sheds, i.e., those bid into the program.

In general, the direct load shed programs seem to provide greater MW of participation and more reliable reductions. However, the use of either TOU-CPP or a demand-bid program represents a point of view or policy position that price should be a centerpiece of the DR effort and help customers see prices in the electricity markets. From a point of view of simplicity and attaining firm capacity reductions, the direct load shed programs may offer some advantages. Ultimately, the choice between these direct load shed programs and pricing programs may come down to customer preferences and decisions by policy makers on the emphasis of DR efforts.

A time-differentiated rate is another option to consider that may not be "callable." Such rates include day-ahead real-time pricing (RTP), two-part RTP tariffs, and standard TOU rates. Although they are not "callable" in that the rate is generally in effect every day, there may be synergies between time-differentiated rates and callable load programs. In general, an RTP option will result in customers learning how to reduce energy consumption on essentially a daily basis when prices tend to be high (e.g., summer season afternoons and early evenings). Customers do not tend to track exact hourly prices, but they know when prices are likely to be higher (e.g., summer season afternoons with higher prices on hot days).[64] The benefits to the customer come from reducing consumption across many summer days when prices are high, rather than a focus on reduction during system event days. In general, the reductions on system peak days are roughly the same as on any summer day when prices are reasonably high. As a result, an RTP option can provide substantial benefits by increasing overall market and system efficiency through shifting loads from high priced periods to periods with lower prices. However, these tariffs may not provide the needed load relief on system-constrained event days.[65, 66]

[63] See Public Service Electric and Gas Company, "Evaluation of the MyPower Pricing Pilot Program," prepared by Summit Blue Consulting, 2007; and the California Energy Commission, "Impact evaluation of the California Statewide Pricing Pilot—Final Report," March 16, 2005. Web reference: http://www.energy.ca.gov/demandresponse/documents/index.html#group3.

[64] See evaluations of the hourly pricing experiment offered by ComEd and the Chicago Energy Cooperative performed by Summit Blue Consulting (2003 through 2006).

[65] One way to make an RTP tariff more like an event-based DR program is to overlay a critical peak pricing (CPP) component on the RTP tariff where unusually high prices would be posted to customers with some notification period. Otherwise, it is unlikely that the high levels of reduction needed for system-event days would be attained.

Summary of DR Potential Estimates in North Carolina

Table D.9 shows the resulting load shed reductions possible for North Carolina, by sector, for years 2015, 2020, and 2025. Load impacts grow rapidly through 2018 as program implementation takes hold. After 2018, the program impacts increase at the same rate as the forecasted growth in peak demand.

The high scenario DR load potential reduction is within a range of reasonable outcomes in that it has an eleven year rollout period (beginning of 2010 through the end of 2020), providing a relatively long period of time to ramp up and integrate new technologies that support DR. A value nearer to the high scenario than the medium scenario would make a good MW target for a set of DR activities.

The high scenario results show a reduction in peak demand of 1,746 MW is possible by 2015 (6.4% of peak demand); 3,719 MW is possible by 2020 (12.7% of peak demand); and 4,031 MW is possible by 2025 (12.4% of peak demand).

The more conservative medium scenario results show a reduction in peak demand of 1,177 MW is possible by 2015 (4.3% of peak demand); 2,509 MW is possible by 2020 (8.6% of peak demand); and 2,722 MW is possible by 2025 (8.4% of peak demand).

Table D.9. Summary of Potential DR in North Carolina, By Sector, for Years 2015, 2020, and 2025[a]

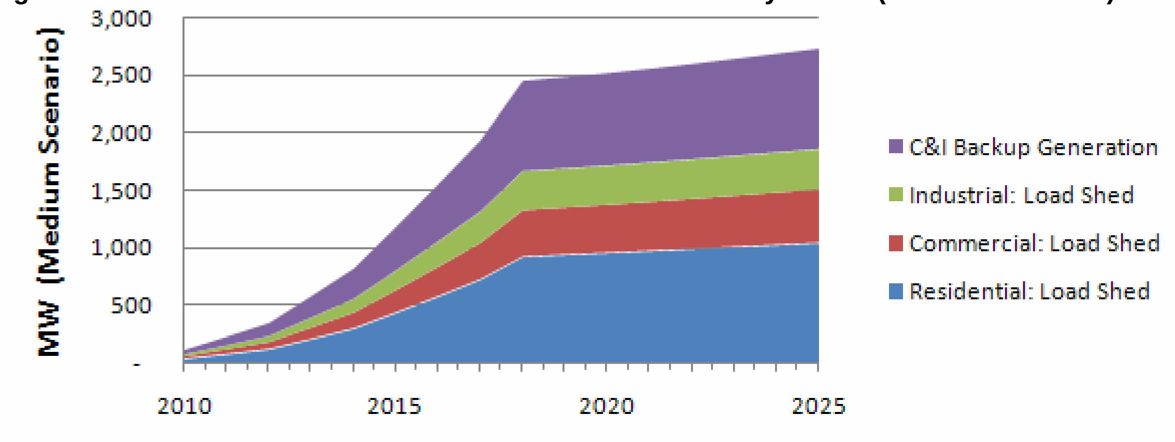
	Low Scenario			Medium Scenario			High Scenario		
	2015	**2020**	**2025**	**2015**	**2020**	**2025**	**2015**	**2020**	**2025**
Load Sheds (MW):									
Residential	263	576	628	438	960	1,047	613	1,344	1,465
Commercial	72	155	173	191	414	461	359	777	865
Industrial	76	151	155	170	339	349	302	603	620
C&I Backup Generation (MW)	283	597	649	377	796	865	472	995	1,081
Total DR Potential (MW)	693	1,479	1,605	1,177	2,509	2,722	1,746	3,719	4,031
DR Potential as % of Total Peak Demand	2.5%	5.1%	5.0%	4.3%	8.6%	8.4%	6.4%	12.7%	12.4%

a. See Section 3 for underlying data and assumptions.

Figure D.9 shows the resulting load shed reductions possible for North Carolina, by sector, from year 2010, when load reductions are expected to begin, through year 2025.

[66] The complementary of event-based load shed programs with RTP tariffs is assessed in: Violette, D., R. Freeman, and C. Neil. "*DR Valuation and Market Analysis—Volume II: Assessing the DR Benefits and Costs*," Prepared for the International Energy Agency, TASK XIII, Demand-Side Programme, Demand Response Resources, January 6, 2006. Updated results are presented in: Violette, D. and R. Freeman; "*Integrating Demand Side Resource Evaluations in Resource Planning*;" Proceedings of the International Energy Program Evaluation Conference (IEPEC), Chicago, August 2007 (also at www.IEPEC.com).

Figure D.9. Potential DR Load Reductions in North Carolina by Sector (Medium Scenario)



These estimates reflect the level of effort put forth and utilities are recommended to set targets for the high scenarios. These estimates include assumptions based on utility experience regarding growth rates, participation rates, and program design, among others, and will adjust accordingly if differing assumptions are made. The assumptions made are believed to be conservative, and reflect minimum achievable DR potential. For example, participation rates for all of the sectors are based on experience in other states, and are based primarily on customer awareness, the ability to have automated response, and the adequacy of reward. If the statewide education program now required in North Carolina promotes DR programs and adequate incentives are offered, then participation rates higher than the medium scenario are entirely realistic.

Comparison of Estimated DR Potential with Results from Other Studies

These estimated reductions in peak demand are within a range to be expected for a population of North Carolina's size. Estimates of DR in other states show that the estimates calculated here for North Carolina are reasonable: 15% reductions in peak demand in Florida are possible by 2023 (Elliot et al. 2007a), and 13% are possible in Texas, also by year 2023 (Elliot et al. 2007b). DR potential for a utility in New York was estimated to be 9.3% of peak demand in 2017 (Summit Blue 2008a). This finding is similar to that of a recent analysis estimating that peak load reductions from DR nationwide will be 8.2% of system peak load in 2020 and 14% by 2030 (EPRI and EEI 2009). Estimation methods differ among the studies, but nonetheless show that the 8% to 12% reductions in North Carolina are realistic and achievable with institutional and economic commitments.

A FERC Staff Report released in the Summer of 2009 on DR potential concludes that from 10% to 17% reductions are feasible in North Carolina, from the "Expanded Business as Usual" and "Achievable Potential" scenarios for 2019 (FERC 2009). The FERC Staff Report results include significant contributions from innovative pricing and rates, and are based on higher participation rates and a quicker rollout, and consequently are higher than those estimated in this report and ramp up more quickly.

As stated in the "Pricing and Rates" section of this report, the DR potential estimates focus on the use of direct load control and curtailable load response programs callable by the utility. This focus is believed to be able to fully represent the DR potential, even though pricing programs could be used instead of these curtailable load programs with equal, or in some cases, greater efficiency. Whereas the FERC estimates gain most benefits from pricing programs, this report did not examine aggressive pricing scenarios or complete restructuring of rates (covering all customers) where prices would be responsive to market effects and have considerable impact on peak demand. This report examined cases involving 10%-40% of customer load participating in DR programs. Newer visions for pricing options enabled by a smart grid infrastructure have larger numbers of customers facing real-time market pricing, resulting in greater decrease in peak demand. The FERC report's "Achievable

Potential" is realized if all customers have dynamic pricing tariffs as their default tariff and 60%-75% of customers adopt this default tariff. Therefore, the estimates derived in the FERC study give further support that the results from this report are reasonable and achievable through traditional DR programs.

RECOMMENDATIONS

This assessment indicates that the system peak demand can be reduced by approximately 8.6% or 2,509 MW in 2020 in the medium case and 12.7% or 3,719 MW in the high case. The high case is considered to be within a reasonable range if aggressive action begins by the end of 2009, providing for a twelve-year rollout of the DR efforts (at the beginning of 2010 through the end of 2020). Key recommendations include:

- Implement programs focused on achieving firm capacity reductions as this provides the highest value demand response. This is accomplished through establishing appropriate customer expectations and by conducting program tests for each DR program in each year. These tests should be used to establish expected DR program impacts when called and to work with customers each year to ensure that they can achieve the load reductions expected at each site.

- Structure appropriate financial incentives for the North Carolina's utilities either for programs administered directly by the utilities or for outsourcing DR efforts to aggregators. The basic premise is that a utility's least-cost plan should also be its most profitable plan.
- Integrate DR programs with the delivery of EE programs. For example, Duke Energy's "Residential Power Manager Program" that allows utility control of air conditioning loads is also used as a gateway for Duke Energy to offer free, in-home energy audits to help inform home owners of additional energy saving opportunities. Many gains in delivery efficiency are possible by combining and cross-marketing EE and DR programs. These can include new building codes and standards that include not only energy efficiency construction and equipment, but also the installation of addressable and dispatchable equipment. This can include addressable thermostats in new residences and the installation of addressable energy management systems in commercial and industrial buildings that can reduce loads in select end-uses across the building/facility. In addition, energy audits of residential or commercial facilities can also include an assessment of whether that facility is a good candidate for participation in a DR program through the identification of dispatchable loads. Furthermore, building commissioning and retro-commissioning EE programs that are becoming popular in many commercial and industrial sector programs have the energy management system as a core component of program delivery. At this time, the application of auto-DR can be assessed and marketed to the customer along with the EE savings from these site-commissioning programs.

- Pricing should form the cornerstone of an efficient electric market. North Carolina has a history of time-differentiated rates. Increasing pricing programs (and participation) including Daily TOU pricing and day-ahead hourly pricing will increase overall market efficiency by causing shifts in energy use from on-peak to off-peak hours every day of the year. However, this does not diminish the need to have dispatchable DR programs that can address those few days that represent extreme events where the highest demands occur. These events are best addressed by dispatchable DR programs.

- Customer education should be included in DR efforts. There is some perceived lack of customer awareness of programs and incentives. In addition, new programs will need marketing efforts as well as technical assistance to help customers identify where load reductions can be obtained and the technologies/actions needed to achieve these load reductions. Also, high level education on the volatility of electricity markets helps customers understand why utilities and other entities are promoting DR and the customers' role in increasing demand response to help match up with supply-side resources to achieve lower cost resource solutions when markets become tight. PEC is showing increased activity in this area of customer education. On December 29, 2009 they, along with Progress Energy Florida, released a Request For Proposal for an Energy Efficiency Behavior Program to utilize behavioral approaches for influencing energy-related behaviors and investments.

- Increase clarity and coordination between the Federal and State agencies and programs. While states have primary jurisdiction over retail demand response, the FERC has jurisdiction over demand response in wholesale markets. Greater clarity and coordination between the Federal and State programs is needed.

APPENDIX E: COMBINED HEAT AND POWER

E.1. Technical Potential for CHP

This section provides an estimate of the technical market potential for combined heat and power (CHP) in the industrial, commercial/institutional, and multi-family residential market sectors. The analysis focused on the potential market for natural gas fueled CHP in North Carolina. Natural gas is by far the predominant fuel used for CHP in the U.S, representing 72 percent of the 84,300 MW of installed CHP capacity in the country. Natural gas is the fuel of choice for most CHP applications because of its competitive price, ease of use, reliability of supply, relatively low criteria pollutant emissions, and increasingly, its low carbon content in comparison to coal and oil. If properly designed and operated, natural gas CHP can provide significant benefits in terms of energy efficiency and reduced CO_2 emissions.

Two different types of CHP markets were included in the evaluation of technical potential, markets that employ the CHP thermal energy for boiler loads only and markets that employ the thermal energy for both boiler loads and air conditioning. Both of these markets were evaluated for high load factor (80% and above) and low load factor (51%) applications resulting in four distinct market segments that are analyzed.

E.1.1. Traditional CHP

Traditional CHP electrical output is produced to meet all or a portion of the base load for a facility and the thermal energy is used to provide steam or hot water. Depending on the type of facility, the appropriate sizing could be either electric or thermal limited. Industrial facilities often have "excess" thermal load compared to their on-site electric load. Commercial facilities almost always have excess electric load compared to their thermal load. Two sub-categories were considered:

High load factor applications: This market provides for continuous or nearly continuous operation. It includes all industrial applications and round-the-clock commercial/institutional operations such colleges, hospitals, hotels, and prisons.

Low load factor applications: Some commercial and institutional markets provide an opportunity for coincident electric/thermal loads for a period of 3,500 to 5,000 hours per year. This sector includes applications such as car washes and health clubs.

E.1.2. Combined Cooling Heating and Power (CCHP)

All or a portion of the thermal output of a CHP system can be converted to air conditioning or refrigeration with the addition of a thermally activated cooling system. This type of system can potentially open up the benefits of CHP to facilities that do not have the year-round thermal load to support a traditional CHP system. A typical system would provide the annual hot water load, a portion of the space heating load in the winter months and a portion of the cooling load in during the summer months. Two sub-categories were considered:

Low load factor applications. These represent markets that otherwise could not support CHP due to a lack of thermal load. This market includes applications such as office buildings, retail, education, and government buildings

High load factor applications: These markets represent round-the-clock commercial/institutional facilities with cooling and heating loads. This market includes hotels, hospitals, nursing homes, and data centers.

E.1.3. Overview of Methodology and Results

The estimation of technical market potential consists of the following elements:

- Identification of applications where CHP provides a reasonable fit to the electric and thermal needs of the user. Target applications were identified based on reviewing the electric and thermal energy consumption data for various building types and industrial facilities.
- Quantification of the number and size distribution of target applications. Several data sources were used to identify the number of applications by sector that meet the thermal and electric load requirements for CHP.
- Estimation of CHP potential in terms of megawatt (MW) capacity. Total CHP potential is then derived for each target application based on the number of target facilities in each size category and sizing criteria appropriate for each sector.
- Subtraction of existing CHP from the identified sites to determine the remaining technical market potential.

The technical market potential defines the sites that have the physical electric and thermal loads that could support CHP with the defined loads in the four market segments. Technical potential does not consider screening for economic rate of return, or other factors such as ability to retrofit, owner interest in applying CHP, capital availability, natural gas availability, and variation of energy consumption within customer application/size class. The technical potential as outlined is useful in understanding the potential size and size distribution of the target CHP markets in the state. Identifying technical market potential is a preliminary step in the assessment of market penetration.

The basic approach to developing the technical potential is described below:

- *Identify existing CHP in the state.* The analysis of CHP potential starts with the identification of existing CHP. In North Carolina, there are 59 operating CHP plants totaling 1,509 MW of capacity. Of this existing CHP capacity, 75% of the sites and 96% of the capacity are in the industrial sector. The portion of this existing CHP capacity that is used to meet on-site loads is deducted from any identified technical potential. A summary of the existing CHP capacity by industry is shown in Table E.1.1. Coal is the predominant CHP fuel in North Carolina (59% of existing capacity), followed by renewables and waste (20%), and natural gas (16 %.) There are about 10-12 recent diesel gen-set installations included in this list that have self-certified as qualifying facilities, though they appear to be standby and peak-shaving only with no heat recovery.

- *Identify applications where CHP provides a reasonable fit to the electric and thermal needs of the user*. Target applications were identified based on reviewing the electric and thermal energy (heating and cooling) consumption data for various building types and industrial facilities. Data sources include the DOE EIA *Commercial Buildings Energy Consumption Survey (CBECS),* the DOE *Manufacturing Energy Consumption Survey (MECS)* and various market summaries developed by DOE, Gas Technology Institute (GRI), and the American Gas Association. Existing CHP installations in the commercial/institutional and industrial sectors were also reviewed to understand the required profile for CHP applications and to identify target applications.

- *Quantify the number and size distribution of target applications*. Once applications that could technically support CHP were identified, the Dun & Bradstreet *Selectory Database* and the *Major Industrial Plant Database* (MIPD) from IHS were utilized to identify potential CHP sites by SIC code or application, and location. The *Selectory Database* is based on the Dun and Bradstreet financial listings and includes information on economic activity (8 digit SIC), location (metropolitan area, county, electric utility service area, state) and size (number of employees) for commercial, institutional and industrial facilities. The data on number of employees is used to calculate the electric and thermal loads of the facility based on detailed estimates of energy use per employee. The MIPD has detailed energy and process data for 16,000 of the largest energy consuming industrial plants in the United States. The *Selectory Database* and MIPD were used to identify the number of facilities in target CHP applications and to group them into size categories based on average electric demand in kilowatt-hours.

- *Estimate CHP potential in terms of MW capacity.* Total CHP potential was then derived for each target application based on the number of target facilities in each size category. It was assumed that the CHP system would be sized to meet the average site electric demand for the target applications unless thermal loads (heating and cooling) limited electric capacity. Tables E.1.2, E.1.3 and E.1.4 present the specific target market sectors, the number of potential sites and the potential MW contribution from CHP. There are two distinct applications and two levels of annual load making for four market segments in all. In traditional CHP, the thermal energy is recovered and used for heating, process steam, or hot water. In cooling CHP, the system provides both heating and cooling needs for the facility. High load factor applications operate at 80% load factor and above; low load factor applications operate at an assumed average of 4500 hours per year (51%) load factor.

- *Estimate the growth of new facilities in the target market sectors.* The technical potential included economic projections for growth through 2025 by target market sectors in North Carolina. The growth factors used in the analysis for growth between the present and 2025 by individual sector are shown in Table E.1.5. These growth projections provided by ACEEE were used in this analysis as an estimate of the growth in new facilities. In cases where an economic sector is declining, it was assumed that no new facilities would be added to the technical potential for CHP. Based on these growth rates the total technical market potential is summarized in Table E-6.

Table E.1.1. North Carolina Existing CHP Facilities

SIC	Application	Sites	Capacity (MW)
20	Food And Kindred Products	9	112
21	Tobacco Products	5	120
22	Textile Mill Products	11	394
24	Lumber And Wood Products	1	5
25	Furniture And Fixtures	1	0
26	Paper And Allied Products	5	258
27	Printing And Publishing	1	3
28	Chemicals And Allied Products	9	339
30	Rubber And Misc. Plastics Products	2	209
35	Industrial Machinery And Equipment	1	4
49	Electric, Gas, And Sanitary Services	2	14
54	Food Stores	6	2
80	Health Services	2	6
82	Educational Services	1	28
91	Executive, Legislative, And General	1	3
97	Nat'l Security And International Affairs	2	8
	Total	59	1504

Table E.1.2. North Carolina Market Potential for CHP in Existing Facilities—Industrial Sector

SIC	Application	50-500 kW (Sites)	50-500 kW (MW)	500-1 MW (Sites)	500-1 MW (MW)	1-5 MW (Sites)	1-5 MW (MW)	5-20 MW (Sites)	5-20 MW (MW)	>20 MW (Sites)	>20 MW (MW)	Total (Sites)	Total (MW)
20	Food	279	46.6	35	25.9	46	97.7	6	38.7	1	20.9	367	229.8
22	Textiles	264	50.0	74	53.1	98	200.7	21	164.1	1	45.8	458	513.6
24	Lumber and Wood	532	74.8	28	21.7	23	41.8	4	39.2	0	0.0	587	177.5
25	Furniture	45	8.4	6	3.9	0	0.0	0	0.0	0	0.0	51	12.4
26	Paper	140	29.9	39	26.5	53	124.3	13	129.7	2	51.4	247	361.8
27	Printing	34	5.0	1	0.6	0	0.0	0	0.0	0	0.0	35	5.6
28	Chemicals	265	50.2	61	43.0	97	216.2	31	321.5	4	174.1	458	805.1
29	Petroleum Refining	49	9.4	6	3.5	8	15.5	2	22.1	1	62.2	66	112.6
30	Rubber/Misc Plastics	180	29.8	15	10.1	8	16.3	1	14.4	0	0.0	204	70.7
32	Stone/Clay/Glass	15	2.7	7	5.5	5	7.4	0	0.0	0	0.0	27	15.6
33	Primary Metals	29	3.4	5	3.5	4	10.0	1	7.6	0	0.0	39	24.6
34	Fabricated Metals	30	3.5	0	0.0	0	0.0	0	0.0	0	0.0	30	3.5
35	Machinery/Computer Equip	10	1.8	1	0.6	2	4.6	0	0.0	0	0.0	13	6.9
37	Transportation Equip.	64	11.2	15	10.4	7	14.6	3	21.3	0	0.0	89	57.5
38	Instruments	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4
39	Misc. Manufacturing	19	2.8	2	1.8	1	1.1	0	0.0	0	0.0	22	5.7
	Total	**1,956**	**329.9**	**295**	**210.2**	**352**	**750.2**	**82**	**758.5**	**9**	**354.3**	**2,694**	**2,403.2**

Table E.1.3. North Carolina Market Potential for CHP in Existing Facilities—Commercial, Traditional CHP

SICs	Application	50-500 kW (Sites)	50-500 kW (MW)	500-1 MW (Sites)	500-1 MW (MW)	1-5 MW (Sites)	1-5 MW (MW)	5-20 MW (Sites)	5-20 MW (MW)	>20 MW (Sites)	>20 MW (MW)	Total (Sites)	Total (MW)
Commercial, Multifamily(Traditional, High Load Factor)													
6513	Multifamily Buildings	96	24.0	35	26.3	5	10.0					136	60.3
4952	Water Treatment	61	7.5	5	3.4							66	10.9
8221	College/Univ.	91	18.4	25	16.6	14	24.3	3	30.7	2	44.6	135	134.6
9223	Prisons	88	14.4	5	3.6							93	18.0
	Total C/I High LF	**336**	**64.3**	**70**	**49.9**	**19**	**34.3**	**3**	**30.7**	**2**	**44.6**	**430**	**223.8**
Commercial (Traditional, Low Load Factor)													
7211	Laundries	39	7.3	3	1.9							42	9.1
7542	Car Washes	46	3.2									46	3.2
7991	Health Clubs	79	7.7									79	7.7
7997	Golf/Country Clubs	187	24.1									187	24.1
8412	Museums	19	2.5									19	2.5
	Total C/I Low LF	**370**	**44.8**	**3**	**1.9**							**373**	**46.7**
	Total C/I Traditional	**706**	**109.1**	**73**	**51.7**	**19**	**34.3**	**3**	**30.7**	**2**	**44.6**	**803**	**270.4**

Table E.1.4. North Carolina Market Potential for CHP in Existing Facilities—Commercial, Cooling

SICs	Application	50-500 kW (Sites)	50-500 kW (MW)	500-1 MW (Sites)	500-1 MW (MW)	1-5 MW (Sites)	1-5 MW (MW)	5-20 MW (Sites)	5-20 MW (MW)	>20 MW (Sites)	>20 MW (MW)	Total (Sites)	Total (MW)
Commercial Cooling, High Load Factor													
4222	Refrigerated Warehouses	17	1.9	1	0.8							18	2.7
7011	Hotels	624	67.5	15	9.5	10	15.6					649	92.5
7374	Data Centers	35	4.7	5	3.3	3	4.4					43	12.4
8051	Nursing Homes	415	61.1	4	2.3	1	2.2					420	65.7
8062	Hospitals	91	18.5	41	28.3	42	77.9	6	52.6	1	32.3	181	209.7
	Total Cooling High LF	**1,182**	**153.8**	**66**	**44.2**	**56**	**100.1**	**6**	**52.6**	**1**	**32.3**	**1,311**	**383.0**
Commercial Cooling, Low Load Factor													
5411	Food Stores	711	73.6	1	0.7			1	5.3			713	79.7
5812	Restaurants	949	100.8	2	1.1	2	7.4					953	109.4
43	Post Offices	14	1.7									14	1.7
4581	Airports	10	1.2	1	0.6							11	1.8
52	Retail	629	103.9	9	6.0	4	7.5					642	117.4
7832	Movie Theaters	1	0.1									1	0.1
6512	Office buildings	1,615	403.8	646	484.5	161	322.0					2,422	1,210.3
8211	Schools	1,868	181.9	3	2.0	4	6.9					1,875	190.8
9100	Government Buildings	463	62.5	45	29.4	27	48.8	3	23.8			538	164.5
	Total Cooling Low LF	**6,260**	**929.4**	**707**	**524.4**	**198**	**392.7**	**4**	**29.2**			**7,169**	**1,875.7**
	Total Cooling	**7,442**	**1,083.2**	**773**	**568.5**	**254**	**492.9**	**10**	**81.8**	**1**	**32.3**	**8,480**	**2,258.7**
	Total C/I All Types	**8,148**	**1,192.4**	**846**	**620.3**	**273**	**527.1**	**13**	**112.5**	**3**	**76.9**	**9,283**	**2,529.1**

Table E.1.5. North Carolina Sector Growth Projections through 2030

SIC Code	Market Sector	2008-2030 Real Growth
20	Food	5.20%
22	Textiles	0.00%
24	Lumber and Wood	0.00%
25	Furniture	28.20%
26	Paper	0.00%
27	Printing/Publishing	0.00%
28	Chemicals	73.30%
29	Petroleum Refining	73.30%
30	Rubber/Misc. Plastics	73.30%
32	Stone/Clay/Glass	46.90%
33	Primary Metals	75.20%
34	Fabricated Metals	75.20%
35	Machinery/Computer Equip	119.40%
37	Transportation Equip.	25.00%
38	Instruments	46.90%
39	Misc. Manufacturing	46.90%
43	Post Offices	38.20%
4581	Airports	18.44%
6512	Office Buildings	64.60%
6513	Apartments	38.20%
7542	Carwashes	18.44%
7832	Movie Theaters	95.70%
8412	Museums	18.44%
4222, 5142	Warehouses	18.44%
4941, 4952	Water Treatment/Sanitary	98.44%
52,53,56,57	Big Box Retail	185.60%
5411, 5421, 5451, 5461, 5499	Food Sales	185.60%
5812, 00, 01, 03, 05, 07, 08	Restaurants	95.70%
7011, 7041	Hotels	95.70%
7211, 7213, 7218	Laundries	18.44%
7991, 00, 01	Health Clubs	18.44%
7992, 7997-9904, 7997-9906	Golf/Country Clubs	18.44%
8051, 8052, 8059	Nursing Homes	72.60%
8062, 8063, 8069	Hospitals	72.60%
8211, 8243, 8249, 8299	Schools	72.60%
8221, 8222	Colleges/Universities	72.60%
9223	Prisons	18.44%

Table E.1.6. CHP Market Potential by Market Segments in North Carolina: Existing and New Facilities 2008-2030

Market	50-500 kW (MW)	500kW-1 MW (MW)	1-5 MW (MW)	5-20 MW (MW)	>20 MW (MW)	Total (MW)
Traditional High Load Factor Market						
Existing Facilities	394	260	785	789	399	2,627
New Facilities	116	79	229	298	207	929
Total	510	340	1,013	1,087	606	3,556
Traditional Low Load Factor Market						
Existing Facilities	45	2	0	0	0	47
New Facilities	33	0	0	0	0	33
Total	78	2	0	0	0	80
Cooling CHP High Load Factor Market						
Existing Facilities	154	44	100	53	32	383
New Facilities	129	35	77	38	24	303
Total	283	80	177	91	56	686
Cooling CHP Low Load Factor Market						
Existing Facilities	929	524	393	29	0	907
New Facilities	934	340	260	19	0	755
Total	1,864	865	652	48	0	1,662
Total Market including Incremental Cooling Load						
Existing Facilities	1,522	831	1,277	871	431	4,932
New Facilities	1,212	455	566	355	230	2,818
Total	2,734	1,286	1,843	1,226	661	7,751

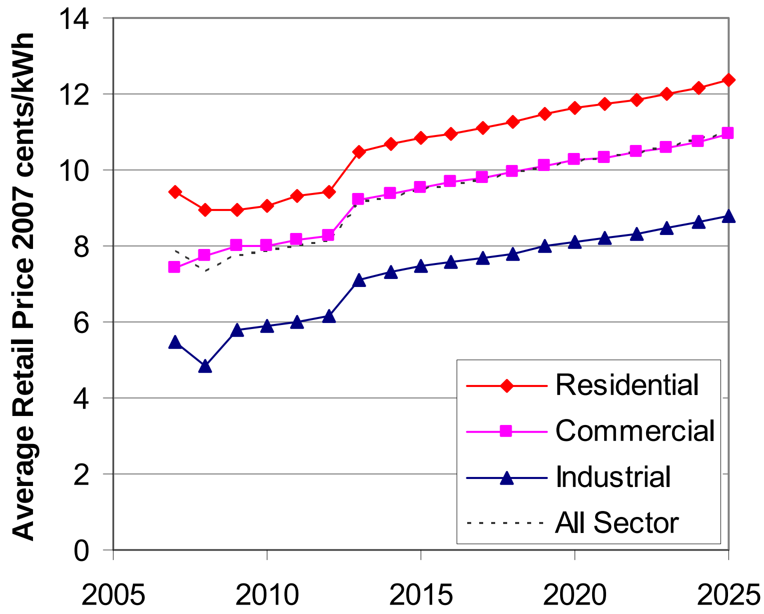
E.2. Energy Price Projections

The expected future relationship between purchased natural gas and electricity prices, called the *spark spread* in this context, is one major determinant of the ability of a facility with electric and thermal energy requirements to cost-effectively utilize CHP. For this screening analysis, a fairly simple methodology was used.

E.2.1. Electric Price Estimation

The retail electric price forecasts were provided by ACEEE based on a proprietary electric supply model and retail price markups from the EIA *2009 Annual Energy Outlook* electric generation price forecast for the Southeast Electric Reliability Council (SERC.). **Figure E.2.1** shows the annual forecast track for major customer groups. The avoidable portion of the retail rate due to baseload CHP operation is assumed to be 90% of the industrial rate. This assumption accounts for unavoidable charges like customer charges, standby rates, and demand charges. Low load factor CHP is assumed to be 17% higher than the baseload rate; avoided electric air conditioning is assumed to be 60% higher. The smallest size category in the analysis, 50-500 kW, is assumed to be 20% higher across the board. These prices are shown in **Table E-2.1**.

Figure E.2.1. Retail Electric Price Forecast



Source: ACEEE

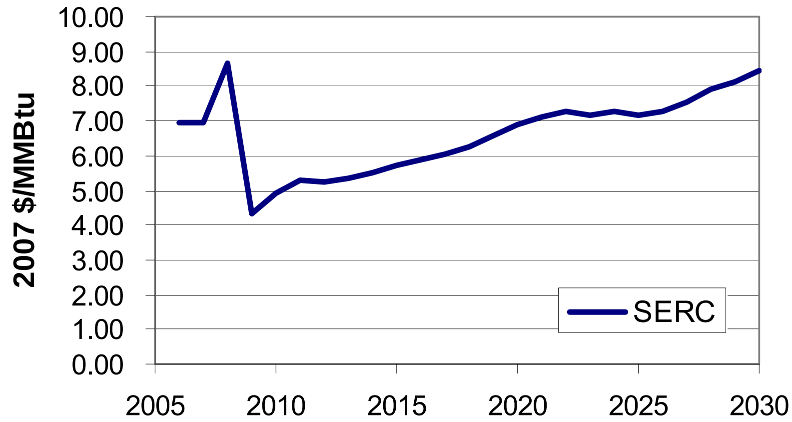
Table E.2.1. Avoided CHP Electric Rates by Size and Load Factor (2007$)

CHP Size Range	Load Factor	2009-2013	2014-2018	2019-2023	2024-2029
50-500 kW	Baseload	$0.0668	$0.0817	$0.0887	$0.0943
	Low Load Factor	$0.0782	$0.0956	$0.1037	$0.1103
	Avoided AC	$0.1336	$0.1635	$0.1773	$0.1885
Greater than 500 kW	Baseload	$0.0557	$0.0681	$0.0739	$0.0786
	Low Load Factor	$0.0651	$0.0797	$0.0865	$0.0919
	Avoided AC	$0.1113	$0.1362	$0.1478	$0.1571

E.2.2. Natural Gas Price Estimation

Future natural gas prices were estimated from the EIA 2009 AEO SERC region gas price for electric power generation as shown in **Figure E.2.2**. This price is assumed to reflect the city-gate price for natural gas. The delivery mark-up for CHP was based on an analysis of Piedmont Natural Gas Company's North Carolina *Large General Transportation Service Rate* (113.) The incremental transportation cost for a process boiler customer adding a 5 MW CHP system is $1.20/MMBtu. It was assumed that this current price will increase with inflation—that is, will be constant in real dollars. This mark-up was used for all CHP systems and sizes.

Figure E.2.2. Natural Gas Price Forecast, SERC Electric Power Generation Price



Source: EIA, AEO2009 Stimulus Case

E.3. CHP Technology Cost and Performance

The CHP system itself is the engine that drives the economic savings. The cost and performance characteristics of CHP systems determine the economics of meeting the site's electric and thermal loads. A representative sample of commercially and emerging CHP systems was selected to profile performance and cost characteristics in CHP applications. The selected systems range in capacity from approximately 100–40,000 kW. The technologies include gas-fired reciprocating engines, gas turbines, microturbines and fuel cells. The appropriate technologies were allowed to compete for market share in the penetration model. In the smaller market sizes, reciprocating engines competed with microturbines and fuel cells. In intermediate sizes (1 to 20 MW), reciprocating engines competed with gas turbines.

Cost and performance estimates for the CHP systems were based on work being undertaken for the EPA.[67] The foundation for these updates is based on work previously conducted for NYSERDA,[68] on peer-reviewed technology characterizations that Energy and Environmental Analysis (EEA) developed for the National Renewable Energy Laboratory (NREL 2003) and on follow-on work conducted by DE Solutions for Oak Ridge National Laboratory (ORNL 2004). Additional emissions characteristics and cost and performance estimates for emissions control technologies were based on ongoing work EEA is conducting for EPRI (EPRI 2005). Data is presented for a range of sizes that include basic electrical performance characteristics, CHP performance characteristics (power to heat ratio), equipment cost estimates, maintenance cost estimates, emission profiles with and without after-treatment control, and emissions control cost estimates. The technology characteristics are presented for three years: 2009, 2014, 2019. The 2009-2013 market penetration estimates are based on current 2009 commercially available and emerging technologies. The cost and performance estimates for 2014 and 2019 reflect current technology development paths and currently planned government and industry funding. These projections were based on estimates included in the three references mentioned above. NOx emissions estimates in lb/MWh are presented for each technology both with and without aftertreatment control (AT). For this analysis, aftertreatment costs were included. The installed costs are base on national averages. The cost and performance data are show in Tables E-3.1 through E.3.4.

[67] EPA CHP Partnership Program, Technology Characterizations, December 2007.
[68] *Combined Heat and Power Potential for New York State*, Energy Nexus Group (later became part of EEA), for NYSERDA, May 2002.

Table E.3.1. Reciprocating Engine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2009	2014	2019
100 kW-Rich Burn with 3 way catalyst	Installed Costs, $/kW	2,210	1,925	1,568
	Heat Rate, Btu/kWh	12,000	10,830	10,500
	Electric Efficiency, %	28.4	31.5	32.5
	Thermal Output, Btu/kWh	6100	5093	4874
	Overall Efficiency, %	79.3	78.5	78.9
	Power to Heat	0.56	0.67	0.70
	O&M Costs, $/kWh	0.02	0.016	0.012
	NO_x Emissions, lbs/MWh (w/ AT)	0.15	0.15	0.15
	NO_x Emissions, lbs/MWh (w/AT) CHP Credit	0.05	0.06	0.06
	After-treatment Cost, $/kW	incl.	incl.	incl.

CHP System	Characteristic/Year Available	2009	2014	2019
800 kW-Lean Burn	Installed Costs, $/kW	1,640	1,443	1,246
	Heat Rate, Btu/kWh	9,760	9,750	9,225
	Electric Efficiency, %	35.0	35.0	37.0
	Thermal Output, Btu/kWh	4299	4300	3800
	Overall Efficiency, %	79.0	79.1	78.2
	Power to Heat	0.79	0.79	0.90
	O&M Costs, $/kWh	0.016	0.013	0.011
	NO_x Emissions, gm/bhp (w/o AT)	0.7	0.4	0.25
	NO_x Emissions, lbs/MWh (w/o AT)	2.17	1.24	0.775
	NO_x Emissions, lbs/MWh (w/AT)	0.11	0.12	0.08
	NO_x Emissions, lbs/MWh (w/AT) CHP Credit	0.05	0.05	0.04
	After-treatment Cost, $/kW	300	190	140
3000 kW-Lean Burn	Installed Costs, $/kW	1,130	1,100	1,041
	Heat Rate, Btu/kWh	9,492	8,750	8,325
	Electric Efficiency, %	35.9	39.0	41.0
	Thermal Output, Btu/kWh	3510	3189	2900
	Overall Efficiency, %	72.9	75.4	75.8
	Power to Heat	0.97	1.07	1.18
	O&M Costs, $/kWh	0.014	0.012	0.01
	NO_x Emissions, gm/bhp (w/o AT)	0.7	0.4	0.25
	NO_x Emissions, lbs/MWh (w/o AT)	2.17	1.24	0.775
	NO_x Emissions, lbs/MWh (w/AT)	0.11	0.12	0.08
	NO_x Emissions, lbs/MWh (w/AT) CHP Credit	0.05	0.06	0.04
	After-treatment Cost, $/kW	200	130	100

CHP System	Characteristic/Year Available	2009	2014	2019
5000 kW-Lean Burn	Installed Costs, $/kW	1,130	1,099	1,038
	Heat Rate, Btu/kWh	8,758	8,325	7,935
	Electric Efficiency, %	39	41	43
	Thermal Output, Btu/kWh	3046	2797	2605
	Overall Efficiency, %	73.7	74.6	75.8
	Power to Heat	1.12	1.22	1.31
	O&M Costs, $/kWh	0.011	0.01	0.009
	NO_x Emissions, gm/bhp (w/o AT)	0.5	0.4	0.25
	NO_x Emissions, lbs/MWh (w/o AT)	1.55	1.24	0.775
	NO_x Emissions, lbs/MWh (w/AT)	0.11	0.12	0.08
	NO_x Emissions, lbs/MWh (w/AT) CHP Credit	0.06	0.07	0.04
	After-treatment Cost, $/kW	150	115	80

Table E.3.2. Microturbine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2009	2014	2019
65 kW	Installed Costs, $/kW	2,739	2,037	1,743
	Heat Rate, Btu/kWh	13,542	12,500	11,375
	Electric Efficiency, %	25.2	27.3	30
	Thermal Output, Btu/kWh	6277	5350	4500
	Overall Efficiency, %	71.5	70.1	69.6
	Power to Heat	0.54	0.64	0.76
	O&M Costs, $/kWh	0.022	0.016	0.012
	NO_x Emissions, lbs/MWh (w/o AT)	0.17	0.14	0.13
	NO_x Emissions, lbs/MWh (w/o AT) CHP Credit	0.06	0.05	0.06
	After-treatment Cost, $/kW			
250 KW-use multiple units	Installed Costs, $/kW	2,684	2,147	1,610
	Heat Rate, Btu/kWh	12,290	11,750	10,825
	Electric Efficiency, %	27.8	29	31.5
	Thermal Output, Btu/kWh	4800	4300	3700
	Overall Efficiency, %	66.8	65.6	65.7
	Power to Heat	0.71	0.79	0.92
	O&M Costs, $/kWh	0.015	0.013	0.012
	NO_x Emissions, lbs/MWh (w/o AT)	0.14	0.13	0.13
	NO_x Emissions, lbs/MWh (w/o AT) CHP Credit	0.06	0.06	0.06
	After-treatment Cost, $/kW			

Table E.3.3. Fuel Cell Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2009	2014	2019
200/400 kW PAFC (assumes all high grade and 50% low grade thermal utilized)	Installed Costs, $/kW	6,310	4,782	3,587
	Heat Rate, Btu/kWh	9,475	9,475	9,000
	Electric Efficiency, %	36	36	37.9
	Thermal Output, Btu/kWh	2923	2923	2800
	Overall Efficiency, %	66.9	66.9	69
	Power to Heat	1.17	1.17	1.22
	O&M Costs, $/kWh	0.038	0.017	0.015
	NO_x Emissions, lbs/MWh (w/o AT)	0.04	0.035	0.035
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.
300 kW MCFC	Installed Costs, $/kW	5,580	4,699	3,671
	Heat Rate, Btu/kWh	8,022	7,700	7,300
	Electric Efficiency, %	42.5	44.3	46.7
	Thermal Output, Btu/kWh	1600	1500	1300
	Overall Efficiency, %	62.5	63.8	64.5
	Power to Heat	2.13	2.27	2.62
	O&M Costs, $/kWh	0.035	0.02	0.015
	NO_x Emissions, lbs/MWh (w/o AT)	0.01	0.01	0.01
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.
1500 kW MCFC	Installed Costs, $/kW	5,250	4,523	3,554
	Heat Rate, Btu/kWh	8,022	7,500	6,820
	Electric Efficiency, %	42.5	45.5	50
	Thermal Output, Btu/kWh	1583	1400	1100
	Overall Efficiency, %	62.3	64.2	66.2
	Power to Heat	2.15	2.44	3.1
	O&M Costs, $/kWh	0.032	0.019	0.015
	NO_x Emissions, lbs/MWh (w/o AT)	0.01	0.01	0.01
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.

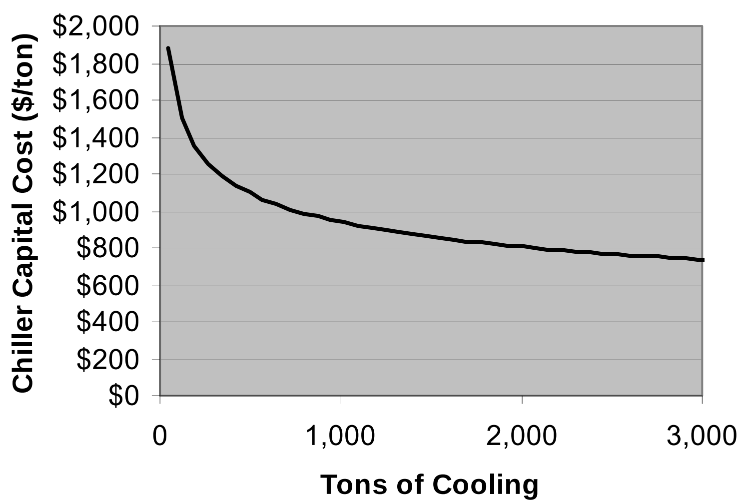
Table E.3.4. Gas Turbine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2009	2014	2019
3000 KW GT	Installed Costs, $/kW	1,690	1,560	1,300
	Heat Rate, Btu/kWh	13,100	12,650	11,500
	Electric Efficiency, %	26	27	29.7
	Thermal Output, Btu/kWh	5018	4750	4062
	Overall Efficiency, %	64.4	64.5	65
	Power to Heat	0.68	0.72	0.84
	O&M Costs, $/kWh	0.0074	0.0065	0.006
	NO_x Emissions, ppm (w/o AT)	15	9	5
	NO_x Emissions, lbs/MWh (w/o AT)	0.68	0.38	0.2
	NO_x Emission, lb/MWh (w/AT)	0.07	0.07	0.07
	After-treatment Cost, $/kW	210	175	150

CHP System	Characteristic/Year Available	2009	2014	2019
10 MW GT	Installed Costs, $/kW	1,298	1,278	1,200
	Heat Rate, Btu/kWh	11,765	10,800	9,950
	Electric Efficiency, %	29	31.6	34.3
	Thermal Output, Btu/kWh	4674	4062	3630
	Overall Efficiency, %	68.7	69.2	70.8
	Power to Heat	0.73	0.84	0.94
	O&M Costs, $/kWh	0.007	0.006	0.005
	NO_x Emissions, ppm (w/o AT)	15	9	5
	NO_x Emissions, lbs/MWh (w/o AT)	0.68	0.38	0.2
	NO_x Emission, lb/MWh (w/AT)	0.07	0.07	0.07
	After-treatment Cost, $/kW	140	125	100
40 MW GT	Installed Costs, $/kW	972	944	916
	Heat Rate, Btu/kWh	9,220	8,865	8,595
	Electric Efficiency, %	37	38.5	39.7
	Thermal Output, Btu/kWh	3189	3019	2892
	Overall Efficiency, %	71.6	72.5	73.3
	Power to Heat	1.07	1.13	1.18
	O&M Costs, $/kWh	0.004	0.004	0.004
	NO_x Emissions, ppm (w/o AT)	15	5	3
	NO_x Emissions, lbs/MWh (w/o AT)	0.55	0.2	0.1
	NO_x Emission, lb/MWh (w/AT)	0.06	0.06	0.06
	After-treatment Cost, $/kW	90	75	40

In the cooling markets, an additional cost was added to reflect the costs of adding chiller capacity to the CHP system. These costs depend on the sizing of the absorption chiller which in turn depends on the amount of usable waste heat that the CHP system produces. Figure E.3.1 shows this cost approximation.

Figure E.3.1. Absorption Chiller Capital Costs



E.4. Market Penetration Analysis

ICF International has developed a CHP market penetration model that estimates cumulative CHP market penetration in 5-year increments. This model evaluates CHP market penetration for natural gas fired systems in commercial, institutional, and industrial applications. For this analysis, only applications that could use the CHP generated electricity on-site were considered. Therefore, the forecast results reflect the opportunity for electrically sized systems fired by natural gas. The potential markets for CHP using opportunity fuels or for large export projects is not included.

For this analysis, the forecast periods are 2013, 2018, 2023, and 2028. These results are interpolated to the output years 2010, 2015, 2020, and 2025. The target market is comprised of the facilities that make up the technical market potential as defined in previously in this section. Thee economic competition module in the market penetration model compares CHP technologies to purchased fuel and power in 5 different sizes and 4 different CHP application types. The calculated payback determines the potential pool of customers that would consider accepting the CHP investment as economic. Additional, non economic screening factors are applied that limit the pool of customers that can accept CHP in any given market/size. Based on this calculated economic potential, a market diffusion model is used to determine the cumulative market penetration for each 5-year time period. The cumulative market penetration, economic potential and technical potential are defined as follows:

- *Technical potential* represents the total capacity potential from existing and new facilities that are likely to have the appropriate physical electric and thermal load characteristics that would support a CHP system with high levels of thermal utilization during business operating hours.

- *Economic potential*, as shown in the table, reflects the share of the technical potential capacity (and associated number of customers) that would consider the CHP investment economically acceptable according to a procedure that is described in more detail below.

- *Cumulative market penetration* represents an estimate of CHP capacity that will actually enter the market between 2009 and 2025. This value discounts the economic potential to reflect non-economic screening factors and the rate that CHP is likely to actually enter the market.

In addition to segmenting the market by size, as shown in the table, the analysis is conducted in four separate CHP market applications (high load and low load factor traditional CHP and high and low load factor CHP with cooling.) These markets are considered individually because both the annual load factor and the installation and operation of thermally activated cooling has an impact on the system economics.

Economic potential is determined by an evaluation of the competitiveness of CHP versus purchased fuel and electricity. The projected future fuel and electricity prices and the cost and performance of CHP technologies determine the economic competitiveness of CHP in each market. CHP technology and performance assumptions appropriate to each size category and region were selected to represent the competition in that size range (Table E.4.1). Additional assumptions were made for the competitive analysis. Technologies below 1 MW in electrical capacity are assumed to have an economic life of 10 years. Larger systems are assumed to have an economic life of 15 years. Capital related amortization costs were based on a 10% discount rate. Based on their operating characteristics (each category and each size bin within the category have specific assumptions about the annual hours of CHP operation (80-90% for the high load factor cases with appropriate adjustments for low load factor facilities), the share of recoverable thermal energy that gets utilized (80%-90%), and the share of useful thermal energy that is used for cooling compared to traditional heating. The economic figure-of-merit chosen to reflect this competition in the market penetration model is simple payback.[69] While not the most sophisticated measure of a project's performance, it is nevertheless widely understood by all classes of customers.

Table E.4.1. Technology Competition Assumed within Each Size Category

CHP Market Size	Equivalent Full Load Hours of Use	Thermal Utilization	Competing CHP Technologies
50-500 kW	HiLF = 7,008 LoLF = 4,500	H only Markets 80% H / 0% C H/C Markets 40% H / 40% C	100 kW ICE 65 kW MT 200 kW PAFC
500-1,000 kW	HiLF = 7,008 LoLF = 4,500	H only Markets 80% H / 0% C H/C Markets 40% H / 40% C	800 kW ICE 250 kW MT x 3 300 kW MCFC x 2
1-5 MW	HiLF = 7,008 LoLF = 4,500	H only Markets 80% H / 0% C H/C Markets 40% H / 40% C	3000 kW ICE 3000 kW GT 1500 kW MCFC
5-20 MW	HiLF = 7,446 LoLF = 4,500	H only Markets 90% H / 0% C H/C Markets 45% H / 45% C	5 MW ICE 10 MW GT
>20 MW	HiLF = 8059 LoLF = 4,500	H only Markets 100% H / 0% C H/C Markets 50% H / 50% C	40 MW GT

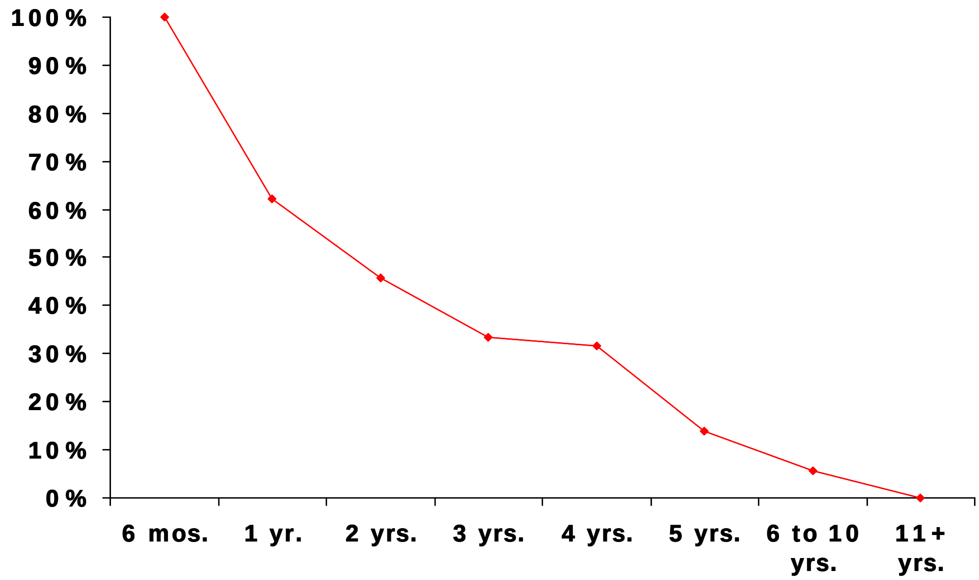
Abbreviations

Load Factor:	HiLF = High load factor, LoLF = Low load factor
Thermal	H = heating (boiler replacement) C = cooling (electric AC replacement)
Technology	ICE = Internal combustion engine MT = Microturbine PAFC = phosphroic acid fuel cell MCFC = molten carbonate fuel cell GT = gas turbine

Rather than use a single payback value, such as 3-years or 5-years as the determinant of economic potential, we have based the market acceptance rate on a survey of commercial and industrial facility operators concerning the payback required for them to consider installing CHP. Figure E.4.1 shows the percentage of survey respondents that would accept CHP investments at different payback levels (CEC 2005b). As can be seen from the figure, more than 30% of customers would reject a project that promised to return their initial investment in just one year. A little more than half would reject a project with a payback of 2 years. This type of payback translates into a project with an ROI of between 49-100%. Potential explanations for rejecting a project with such high returns is that the average customer does not believe that the results are real and is protecting himself from this perceived risk by requiring very high projected returns before a project would be accepted, or that the facility is very capital limited and is rationing its capital raising capability for higher priority projects (market expansion, product improvement, etc.).

[69] Simple payback is the number of years that it takes for the annual operating savings to repay the initial capital investment.

Figure E.4.1. Customer Payback Acceptance Curve



Source: *Primen's 2003 Distributed Energy Market Survey*

For each market segment, the economic potential represents the technical potential multiplied by the share of customers that would accept the payback calculated in the economic competition module.

The rate of market penetration is based on *Bass diffusion curves* with allowance for growth in the maximum market. This function determines cumulative market penetration for each 5-year period. Smaller size systems are assumed to take a longer time to reach maximum market penetration than larger systems. Cumulative market penetration using a Bass diffusion curve takes a typical S-shaped curve. In the generalized form used in this analysis, growth in the number of ultimate adopters is allowed. The curves shape is determined by an initial market penetration estimate, growth rate of the technical market potential, and two factors described as *internal market influence* and *external market influence*.

The cumulative market penetration factors reflect the economic potential multiplied by the non-economic screening factor (maximum market potential) and by the Bass model market cumulative market penetration estimate.

Once the market penetration is determined, the competing technology shares within a size/utility bin are based on a *logit function* calculated on the comparison of the system paybacks. The greatest market share goes to the lowest cost technology, but more expensive technologies receive some market share depending on how close they are to the technology with the lowest payback. (This technology allocation feature is part of the ICF CHP model that is not specifically used for this analysis.)

Three cases were run for this analysis:

1. Base Case—no program incentives (Table E.4.2)
2. $500/kW Incentive—$500/kW capital cost reduction for CHP projects less than 20 MW (Table E.4.3)
3. $1,000/kW incentive—$1,000/kW capital cost reduction for CHP projects less than 20 MW (Table E.4.4)

Table E.4.2. Market Penetration Results for Base Case

CHP Measurement	2010	2015	2020	2025
Cumulative Market Penetration (MW)				
Industrial	5	33	78	113
Commercial/Institutional	1	6	14	20
Total	6	39	92	134
Avoided Cooling	0	0	1	1
Scenario Grand Total	6	39	93	135
Annual Electric Energy (Million kWh)				
Industrial	43	261	613	883
Commercial/Institutional	8	45	103	146
Total	51	307	716	1029
Avoided Cooling	0	1	3	4
Scenario Grand Total	51	308	719	1,033
Incremental Onsite Fuel (billion Btu/year)				
Industrial	225	1357	3177	4577
Commercial/Institutional	47	264	596	841
Total	271	1,622	3,772	5,418
Cumulative Investment (million 2007$)	$6	$43	$104	$152
Cumulative Incentive Payments (Million 2007$)	$0	$0	$0	$0
Annual Electric Energy (Million 2007 $)				
Industrial	2	17	35	54
Commercial/Institutional	0	3	6	9
Total	3	20	41	63
Avoided Cooling	0	0	0	0
Scenario Grand Total	3	20	41	64
Incremental Onsite Fuel (million 2007 $)				
Industrial	1	10	25	39
Commercial/Institutional	0	2	5	7
Total	2	11	30	46

Table E.4.3. Market Penetration Results for $500/kW Incentive Case

CHP Measurement	2010	2015	2020	2025
Cumulative Market Penetration (MW)				
Industrial	5	76	211	296
Commercial/Institutional	1	10	27	42
Total	6	85	238	337
Avoided Cooling	0	0	1	2
Scenario Grand Total	6	86	239	339
Annual Electric Energy (Million kWh)				
Industrial	43	571	1573	2200
Commercial/Institutional	8	70	188	282
Total	51	641	1761	2482
Avoided Cooling	0	1	4	6
Scenario Grand Total	51	642	1,765	2,488
Incremental Onsite Fuel (billion Btu/year)				
Industrial	225	3043	8386	11699
Commercial/Institutional	47	400	1080	1631
Total	271	3,443	9,466	13,330
Cumulative Investment (million 2007$)	$6	$76	$204	$281
Cumulative Incentive Payments (Million 2007$)	$0	$27	$87	$129
Annual Electric Energy (Million 2007 $)				
Industrial	2	39	91	136
Commercial/Institutional	0	5	11	17
Total	3	43	101	153
Avoided Cooling	0	0	0	0
Scenario Grand Total	3	44	101	153
Incremental Onsite Fuel (million 2007 $)				
Industrial	1	22	66	100
Commercial/Institutional	0	3	9	14
Total	2	25	74	114

Table E.4.4. Market Penetration Results for $1,000/kW Incentive Case

CHP Measurement	2010	2015	2020	2025
Cumulative Market Penetration (MW)				
Industrial	35	266	655	895
Commercial/Institutional	2	29	83	125
Total	38	295	738	1020
Avoided Cooling	0	1	4	7
Scenario Grand Total	38	296	742	1,027
Annual Electric Energy (Million kWh)				
Industrial	267	1960	4786	6543
Commercial/Institutional	17	199	567	847
Total	284	2159	5353	7390
Avoided Cooling	0	5	14	22
Scenario Grand Total	284	2,164	5,367	7,413
Incremental Onsite Fuel (billion Btu/year)				
Industrial	1421	10519	25589	34722
Commercial/Institutional	94	1184	3409	5111
Total	1,515	11,703	28,998	39,833
Cumulative Investment (million 2007$)	$13	$102	$242	$316
Cumulative Incentive Payments (Million 2007$)	$31	$263	$674	$939
Annual Electric Energy (Million 2007 $)				
Industrial	15	130	278	404
Commercial/Institutional	1	14	32	52
Total	16	143	309	455
Avoided Cooling	0	1	1	2
Scenario Grand Total	16	144	310	457
Incremental Onsite Fuel (million 2007 $)				
Industrial	9	75	200	297
Commercial/Institutional	1	9	27	44
Total	10	84	227	341

In the Base Case, 135 MW of additional natural gas-fired CHP capacity plus avoided electric cooling capacity is projected by 2025. This CHP is predominantly high load factor industrial CHP larger than 5 MW. Adding a $500/kW capital cost reduction incentive more than doubles this market penetration to 339 MW with an incentive cost of $1 million. Doubling of the incentive to $1,000/kW increases the 2025 market penetration to 1,027 MW with an incentive cost of $939 million.

APPENDIX F: THE DEEPER MODEL AND MACRO MODEL

The Dynamic Energy Efficiency Policy Evaluation Routine—or the DEEPER Model—is a 15-sector quasi-dynamic input-output impact model of the U.S. economy.[70] Although an updated model with a new name, the model has a 15-year history of use and development. See, for example, Laitner, Bernow, and DeCicco (1998) and Laitner (2007) for a review of past modeling efforts. The model is generally used to evaluate the macroeconomic impacts of a variety of energy efficiency (including renewable energy) and climate policies at both the state and national level. The national model now evaluates policies for the period 2008 through 2050. Although, the DEEPER Model for the North Carolina specific analysis covers the period between 2009 through 2025. As it is now designed, the model solves for the set of energy prices that achieves a desired and exogenously determined level of greenhouse gas emissions (below some previously defined reference case). Although the model does include non-CO_2 emissions and other emissions reduction opportunities, it currently focuses on energy-related CO_2 emissions and on the prices, policies, and programs necessary to achieve the desired emissions reductions. DEEPER is an Excel-based analytical tool that consists generally of six sets of key modules or groups of worksheets. These six sets of modules now include:

Global data: The information in this module consists of the economic time series data and key model coefficients and parameters necessary to generate the final model results. The time series data includes the projected reference case energy quantities such as trillion Btus and kilowatt-hours, as well as the key energy prices associated with their use. It also includes the projected gross domestic product, wages and salary earnings, and levels of employment as well as information on key technology cost and performance characteristics. The sources of economic information include data from the Energy Information Administration, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and Economy.com. The cost and performance characterization of key technologies is derived from available studies completed by ACEEE and others, as well as data from the Energy Information Administration's (EIA) National Energy Modeling System (NEMS). One of the more critical assumptions in this study is that alternative patterns of electricity consumption will change and/or defer the mix of investments in conventional power plants. Although we can independently generate these impacts within DEEPER, we can also substitute assumptions from the ICF Integrated Planning Model (IPM) and similar models as they may have different characterizations of avoided costs or alternative patterns of power plant investment and spending.

Macroeconomic model: This set of modules contains the "production recipe" for the region's economy for a given "base year"—in this case, 2006, which is the latest year for which a complete set of economic accounts are available for the regional economy. The I-O data, currently purchased from the Minnesota IMPLAN Group (IMPLAN 2007), is essentially a set of input-output accounts that specify how different sectors of the economy buy (purchase inputs) from and sell (deliver outputs) to each other. In this case, the model is now designed to evaluate impacts for 15 different sectors, including: Agriculture, Oil and Gas Extraction, Coal Mining, Other Mining, Electric Utilities, Natural Gas Distribution, Construction, Manufacturing, Wholesale Trade, Transportation and Other Public Utilities (including water and sewage), Retail Trade, Services, Finance, Government, and Households.

Investment, Expenditures and Energy Savings: Based on the scenarios mapped into the model, this worksheet translates the energy policies into a dynamic array of physical energy impacts, investment flows, and energy expenditures over the desired period of analysis. It estimates the needed investment path for an alternative mix of energy efficiency and other technologies (including efficiency gains on both the end-use and the supply side). It also provides an estimate of the avoided investments needed by the electric generation sector. These quantities and expenditures feed directly

[70] There is nothing particularly special about this number of sectors. The problem is to provide sufficient detail to show key negative and positive impacts while maintaining a manageable sized model. If we choose to reflect a different mix of sectors and stay within the 15 x 15 matrix, that can be done easily. If we wish to expand the number of sectors, that would take some minor programming changes or adjustments to reflect the larger matrix.

into the final demand module of the model which then provides the accounting that is needed to generate the set of annual changes in final demand (see the related module description below).

Price dynamics: There are two critical drivers that impact energy prices within DEEPER. The first is a set of carbon charges that are added to retail prices of energy depending on the level of desired level of emission reductions and also depending on the available set of alternatives to achieve those reductions. The second is the price of energy as it might be affected by changed consumption patterns. In this case DEEPER employs an independent algorithm to generate energy price impacts as they reflect changed demand. Hence, the reduced demand for natural gas in the end-use sectors, for example, might offset increased demand by utility generators. If the net change is a decrease in total natural gas consumption, the wellhead prices might be lowered. Depending on the magnitude of the carbon charge, the change in retail prices might either be higher or lower than the set of reference case prices. This, in turn, will impact the demand for energy as it is reflected in the appropriate modules. In effect, then, DEEPER scenarios rely on both a change in prices and quantities to reflect changes in overall investments and expenditures.

Final demand: Once the changes in spending and investments have been established and adjusted to reflect changes in prices within the other modules of DEEPER, the net spending changes in each year of the model are converted into sector-specific changes in final demand. This, in turn, drives the input-output model according to the following predictive model:

$$X = (I-A)^{-1} * Y$$

where:

X = total industry output by sector
I = an identity matrix consisting of a series of 0's and 1's in a row and column format for each sector (with the 1's organized along the diagonal of the matrix)
A = the production or accounting matrix also consisting of a set of production coefficients for each row and column within the matrix
Y = final demand, which is a column of net changes in final demand by sector

This set of relationships can also be interpreted as

$$\Delta X = (I-A)^{-1} * \Delta Y$$

which reads: a change in total sector output equals $(I-A)^{-1}$ times a change in final demand for each sector. Employment quantities are adjusted annually according to exogenous assumptions about labor productivity in each of the sectors (based on Bureau of Labor Statistics forecasts).

Results: For each year of the analytical time horizon, the model copies each set of results into this module in a way that can also be exported to a separate report.