NUDGE the Meter

Behavioral Policy Approaches to Lower Residential Energy Consumption in Colorado

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EXECUTIVE SUMMARY

Residential energy consumption continues to grow in Colorado, largely due to its accelerating population. Excessive energy consumption in Colorado is detrimental due to negative externalities such as pollution, electric grid instability, and energy insecurity that create additional costs for society. In response, Colorado law requires investor-owned utilities, such as Xcel Energy, to develop programs to reduce energy use in Colorado. Current energy-saving efforts are heavily rebate-based and largely target financial motivations of consumers. However, price signals do not significantly affect consumer energy decisions due to a large number of market barriers. Therefore, energy-saving efforts only addressing financial consumer motivations neglects other factors that affect consumer decisions, such as psychological and sociological motivations.

This policy memorandum analyzes three behavioral policy options to determine if decreasing the role of rebates, while increasing the role of behavioral programs could create a larger reduction in energy use and larger net-benefits for Colorado. The three behavioral programs include: (1) installing smart meters and in-home displays; (2) providing electricity feedback reports, and (3) adopting the Green Button Initiative. By performing a cost-benefit analysis, this research suggests that behavioral programs could provide a $17.0 million net benefit to Colorado in energy-saving benefits. Most importantly, this memorandum argues that behavioral policy programs can be just as successful, if not more so, than programs focused on rebates and equipment upgrades. Xcel Energy and Colorado can maximize energy reductions and eliminate unnecessary energy waste by creating a more balanced demand-side management portfolio, targeting financial, psychological, and sociological motivations of consumers.

1. INTRODUCTION

Residential energy consumption continues to grow in Colorado, largely due to its accelerating population. The consequences of unchecked energy consumption include air pollution, electric grid failures, energy insecurity, and global climate change. In addition, studies indicate that Colorado residents are wasting energy at an alarming public cost. To address rising energy demand and energy waste, Colorado law requires investor-owned utilities to implement energy reduction strategies, defined as demand-side management programs, to achieve electricity savings of 5% of the utility's 2006 peak demand by 2018.[1] Since the adoption of this law in 2007, energy efficiency policies have remained a top priority for Colorado. Energy efficiency offers an emissions-free and low-cost energy resource that should be fully utilized before large capital investments are initiated to address swelling energy demands. In addition, energy efficiency is a politically feasible policy tool to address rising energy demand and climate change.

Xcel Energy's current demand-side management programs are heavily rebate-based and may be failing to achieve optimal efficiency gains by only focusing on one aspect of consumer motivation—financial incentives. Rather, behavioral policy options targeting psychological and sociological motivations for reducing energy use may be equally or more effective than financial solutions. Often nicknamed, the 'nudge' or 'libertarian paternalism,' the behavioral policy approach has gained considerable attention as an intriguing, multi-disciplinary method to achieve intended policy outcomes at a low cost. Proponents of this policy approach argue that behavioral policy options respect an individual's freedom of choice, but still guide individuals toward intended policy outcomes using less authoritative and intrusive means (Pollitt and Shaorshadze, 2011). Aligning with the disciplines of psychology and sociology, behavioral policies exploit cognitive biases and irrational behavior that are common amongst consumers. Additionally, the rise of behavioral science within public policy demonstrates a rise in the popularity of other disciplines of social science affecting policy rather than

[1] Colorado Revised Statutes, Section 40-3.2-101,104-5; 'Strategies' include any program that reduces energy consumption including promoting energy efficient technology, conservation programs, and informational campaigns.

basing policy solely on price-based incentives (Thaler, 2012). By targeting psychological and sociological motivations for consumer behavior, government interventions can target a policy problem from alternate vantage points, and in some circumstances, achieve greater societal benefits.

Most importantly, empirical evidence suggests that behavioral policies are producing astounding behavioral changes, sometimes more than traditional price-based incentives. For example, individuals are much less likely to opt out of something rather than opt in. Knowing this, many policies are using default options to encourage behavior such as organ donations, participating in green energy credits, or saving for retirement (Pollitt and Shaorshadze, 2011; Thaler, 2012). Other cognitive cues are also becoming increasingly relevant. Examples include frequent prompts, strategically placed information, and commitments. As an example, the United States spends over $300 billion on health complications resulting from individuals forgetting to take medications (NEHI, 2009). Attempting to solve this problem, a U.S. company created GlowCaps, a pill bottle with a cap that lights up when it is time for an individual to take their medication. If the user has not opened the cap within two hours of needing the medication, the wireless-capable cap will call the individual's phone, send a text message, or make a noise. A clinical study found that GlowCaps increased adherence rates of medication by 27% and suggested that a strategically designed pill bottle cap can become an effective tool to reduce health care costs (Center for Connected Health, 2011).

Proponents of the behavioral approach argue that many behavioral interventions can incentivize energy efficient behavior in ways that are more effective than traditional, price-based solutions. Therefore, this policy memorandum will examine alternatives to Xcel Energy's current demand-side management portfolio, specifically focusing on its residential programs. Each proposed alternative alters Xcel Energy's demand-side management portfolio by eliminating some rebate programs that have shown minimal success and substituting behavioral-based programs. The goal of this analysis is to determine if demand-side management portfolios that decrease the role of rebates, while increasing the reliance on behavioral programs create a greater reduction in energy use and larger net-benefit for society.

2. PROBLEM DEFINITION

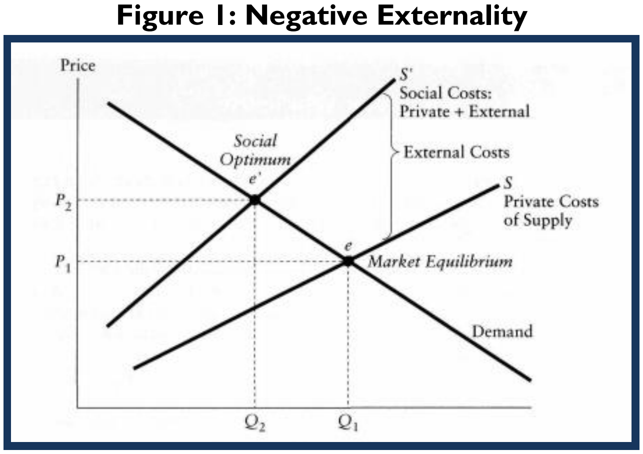
The policy problem is twofold: (1) Residential electricity consumption continues to grow in Colorado; and (2) Current energy efficiency programs primarily target financial motivations of consumers, leaving the benefits of behavioral-based policy programs largely untapped.

Excessive electricity consumption is detrimental to society due to market inefficiencies that result in higher costs for both individuals and society. This chapter addresses the market failures within the residential energy sector by discussing negative externalities, market barriers, and the presence of an energy efficiency gap. Negative externalities within the energy industry provide an initial justification for government intervention within the energy market.

2.1 Market Failures within the Residential Energy Sector

Negative externalities create additional costs that are not included within the market price, but rather, are borne by a third party, which in this case is society. As negative externalities persist, goods are over-consumed to the detriment of society. Figure 1 illustrates this concept by demonstrating how free markets over-produce commodities that produce negative externalities. If electricity were priced higher, the socially optimal level of consumption would be lower than current levels. However, the price of electricity does not include negative externalities. As such, excessive consumption and energy waste is created.

Figure 1: Negative Externality



Source: Harris and Roach, 2009, p. 41

Electricity generation produces three primary negative externalities: (1) pollution; (2) electric grid instability; and (3) energy insecurity. The following sections discuss the negative consequences resulting from each externality.

1. *Pollution and Climate Change:* The Intergovernmental Panel on Climate Change (IPCC) warns that global warming is undeniable and primarily is caused by human interference through the emissions of greenhouse gases. The electricity generation is the largest producer of greenhouse gas emissions in the United States, accounting for 32% of total emissions (EPA, 2012). The McKinsey Institute (2009) estimated that the United States could abate 1.1 gigatons of greenhouse gases annually or approximately 20% of U.S. greenhouse gas emissions from 2011 levels by reducing energy consumption. Further, the Alliance Commission on National Energy Efficiency Policy (2013) estimated that if the United States doubled its energy efficiency by 2030, carbon dioxide emissions would decline by 22% from 2005 levels.

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> **The cost of electricity may be artificially low, thereby encouraging greater energy consumption than is optimal for society.**

2. *Electric Grid Instability:* Due to rising electricity demands, the United States, including Colorado, risks widespread electricity disruptions and outages resulting from over-loaded electric grid infrastructures. Ironically, while the electric grid and technological innovation act as a driving force of the economy, the resulting growth in standards of living, income, and wealth have increasingly stressed the power system. Since 1982, growth in peak electricity demand has exceeded transmission growth by almost 25% every year (U.S. Department of Energy, 2009, p.6). Further, Mills (2013) notes that electricity demand within the United States is expected to rise 16% during the next two decades, which will require the United States to generate additional electricity equal to the power system of Germany. Large-spread electric grid failures could bring catastrophic consequences and disrupt all facets of the economy. In fact, some analysts argue that the information age has created a new electricity paradigm where demand for reliable and consistent electricity is equal or greater than demand for more electricity. Deemed the “always on era,” the current generation demands a reliable electric grid as an

essential function of the economy and consumer lifestyles (Mills, 2013). The U.S. Department of Energy (2009) estimated that outages due to power quality issues cost U.S. businesses over $100 billion each year, and Simonoff, et al. (2005) found that annual incidents of electric power outages have increased 8% from 1990 to 2004.[2] New pressures such as increasing extreme weather events and a greater risk of cyber attacks further necessitate the need to optimize electric grid stability and reliability (Ebinger and Banks, 2013). In sum, the risks associated with an electric grid failure and the increasing demands for reliable electricity are not included within electricity prices. As a result, the costs associated with power outages are borne by society.

3. *Energy Insecurity and Foreign Policy Constraints:* The International Energy Agency (2013) defines energy security as the "uninterrupted availability of energy sources at an affordable price." Currently, 80% of energy consumed is produced by oil, natural gas, or coal; each is vulnerable to supply disruptions. Because supply risks associated with each energy source are not included within the price, the cost of electricity may be artificially low, thereby encouraging greater electricity consumption than is optimal for society (Gillingham, Newell, and Palmer, 2009). While the electricity sector is less prone to disruptions than the transportation sector due to a greater flexibility in fuel source, a larger domestic supply, and spare production and storage capacity; non-renewable energy resources generate the majority of electricity and are vulnerable to price instability and depleting supplies (Congressional Budget Office, 2012). If the United States doubled its energy efficiency by 2030, net energy imports could be reduced to 7% of U.S. energy consumption, compared to 19% imported currently (Alliance Commission on National Energy Efficiency Policy, 2013). Reducing overall electricity use and continuing to diversify supply are important goals to reduce energy insecurity and ensure energy prices remain stable.

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[2] A study completed by the Center for Risk and Economic Analysis of Terrorism Events, University of Southern California. Authors analyzed U.S. electric power outages from January 1990 – August 2004 using data collected by the North American Electric Reliability Council (NERC).

2.2 Electricity Rate Increases are not Affecting Energy Demand

In addition to negative externalities, market barriers within the energy sector distort consumer decisions. Moreover, energy companies are regulated monopolies. As a result, energy prices are not exclusively market driven and are often artificially low due to subsidies and public utility commissions' authority to set prices. Additionally, Borenstein (2009) found that consumers do not choose energy consumption levels based on the observed price per billing period, even when utilities used tiered-rates. By analyzing utility pricing data, Borenstein found that the elasticity for energy consumption is low, in the range of -0.1 to -0.2. This result indicates that electricity price signals do not significantly affect consumer behavior. Ito (2013) found similar evidence by concluding that electricity consumers are inattentive to complex pricing structures, resulting in an ineffective tiered-rate pricing systems. Ito suggests that both complex, monthly utility bills and the inability of consumers to monitor the compounding effect of their electricity use during the billing cycle create this result. Thus, conventional public policies impacting price have been found ineffective in lowering energy use among electricity consumers. Even if electricity prices were set "correctly" though appropriate public policies, a lack of information, poor understanding of future prices, and a low-elasticity for energy consumption would continue to perpetuate excessive energy use. Studies demonstrate that consumers often behave irrationally when making energy consumption and energy efficiency purchase decisions due to a multitude of market barriers that create disincentives toward making socially optimal energy use decisions.

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This policy memorandum will discuss three market barriers in further detail: (1) information barriers, (2) complexity barriers, and (3) the salience effect. These market barriers are often the biggest impediments to efficient residential energy consumption (Gillingham, Newell, and Palmer, 2009; Linares and Labandeira, 2010).

2.3.1 Consumers do not have access to information

In a free-market economy, consumers require perfect information to make economically rational decisions. While this condition is often never fully achieved, the energy market suffers from multiple information barriers. Due to the low price of electricity, consumers have weak incentives to spend time analyzing their electricity spending or energy-intensive habits. Electricity costs typically represent approximately 1% to 3% of total rental or mortgage costs, and thus, do not provide strong incentives for consumers to save on energy costs relative to other expenditures (International Energy Agency, 2007). Also, many consumers do not have the technology in their household to monitor energy use in real time. Instead, consumers passively wait for their monthly electricity bill. This is referred to as a transaction cost related to the time necessary to gather information or install energy tracking tools, such as smart energy meters (International Energy Agency, 2007; Gillingham, Newell, and Palmer, 2009). As a result, consumers do not realize the full potential of energy efficient decisions and are steered away from the most optimal, cost-effective decisions.

2.3.2 Consumers do not understand the information

Even if sufficient information is provided, consumers still make irrational decisions because the information is difficult to understand. Often electricity consumers fail to take the time to comprehend information regarding their energy use due to both the complexity and the minimal implications to the consumer's decisions (Linares and Labandeira, 2010). To illustrate this point, energy is a cheap commodity for residential consumers, but the industry is highly technical. Due to the cheap prices and low impact on a consumer's budget, the consumer may opt to use more energy than is optimal and face a slight or unknown increase to his or her electricity bill. Thus, the consumer behaves irrationally for two reasons: (1) the consumer does not understand the rational choice; and (2) the consumer does not face a significant budgetary consequence if the consumer makes an irrational decision that does not align with a cost-minimizing choice (Linares and Labandeira, 2010). To address this information barrier, economists advocate for higher upfront costs or increased education to help consumers understand the ramifications of their actions from an energy-saving and financial perspective.

2.3.3 Consumers are focused on upfront costs of energy efficiency investments

Consumers disproportionally respond to factors that are either psychologically vivid or observable in the present; this is referred to as the "salience effect" (IEA, 2007). When considering energy efficiency investments, consumers become overly focused on upfront costs, when, in reality, the long-term benefits of energy efficient purchases typically outweigh the upfront costs. However, consumers are often deterred by upfront costs, which creates a barrier toward making a cost-effective purchase (Gillingham, Palmer, and Newell, 2009). Consumers also are deterred by the irreversibility of energy efficiency investments. Jaffe and Stavins (1994) found that consumers placed a much higher discount rate on energy efficiency purchases, meaning consumers valued the present more than their future benefits. This psychological barrier also prevents cost-effective energy efficient technologies from becoming widely adopted by mass consumers.

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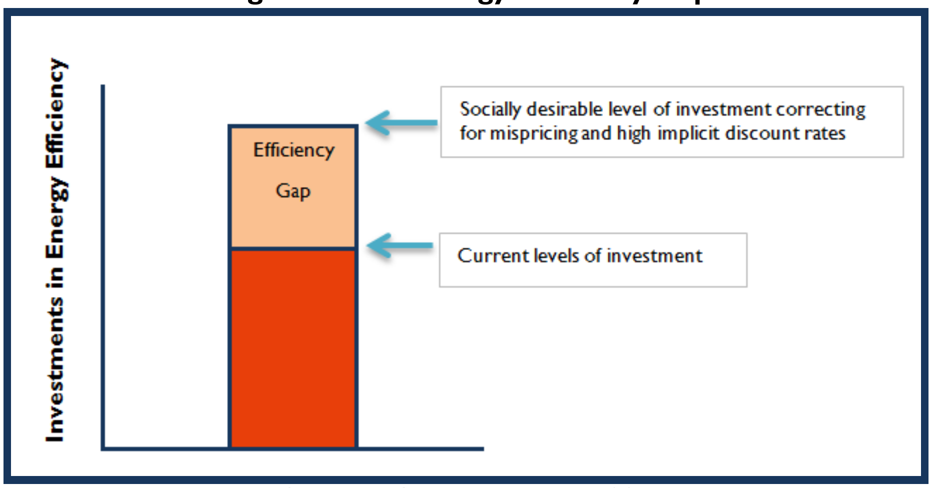
> **Consumers become overly focused on upfront costs…**

2.3 The Resulting Energy Efficiency Gap

The resulting effect of the market failures and barriers in the electricity sector is the existence of energy waste. The "energy efficiency gap," as it is popularly named, indicates that market-driven energy use is consumed beyond a socially efficient level. Allcott and Mullainathan (2010) illustrate this energy paradox stating, "Historically, energy efficiency has been a leading example of the difficulties in inducing people to change behaviors and adopt new technologies, even when it appears to be in their own financial interest." (p. 1). To provide a stimulus for policy intervention targeted toward the energy efficiency gap, many studies have attempted to monetize the gap and potential energy savings available. A nationwide study, funded collaboratively by public, private, and non-profit interests, proposed that by 2020, the United States has the potential to yield energy savings of $1.2 trillion and reduce end-use energy consumption by 23% of projected demand (McKinsey, 2009).[3] Figure 2 below illustrates the gaps between current levels of energy efficiency and socially beneficial levels of energy efficiency. Golove and Eto (1996) suggest that the energy efficiency gap occurs for two primary reasons: (1) Market barriers prevent energy efficiency investments; and (2) Energy is mispriced.

Figure 2: The Energy Efficiency Gap



Source: Golove and Eto, 1996

Pimentel et al. (2003), found that by adopting energy conservation behaviors and technologies, the U.S. could save approximately 33% of U.S. energy consumption, equating to $438 billion. Further, energy efficiency offers a low-cost measure to absorb additional electricity demand (Pimental, et.al., 2003). When comparing energy efficiency to other forms of electricity generation, Laitner et al. (2012) found that energy efficiency investments cost between 3 to 5 cents per saved kilowatt hour (kWh), while the next low-cost alternative, wind energy, costs between 8 to 11 cents per produced kWh. To illustrate the low cost of energy efficiency, Figure 3 on the next page shows the costs per kWh of electricity generation by resource.

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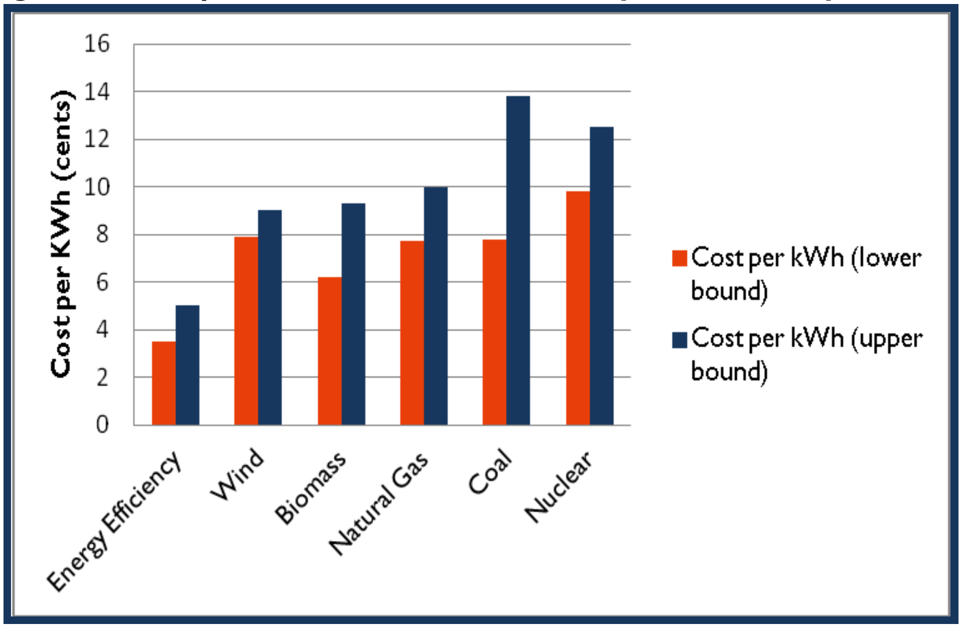
[3] While this study is often cited as the impetus to many public energy efficiency programs, other researchers and policy analysts caution its attempt at predicting such a precise estimate. Researchers from the Massachusetts Institute of Technology Economics Department, Allcott and Greenstone (2012), claim that the magnitude of the energy efficiency gap is difficult to quantify and may be over-stated.

Figure 3: Costs per Kilowatt Hour of Electricity Generation by Resource



Source: Laitner, et.al, 2012

When viewed as a low-cost energy resource, energy efficiency becomes an attractive policy option in lieu of expensive infrastructure investments needed to generate additional electricity. Proponents encourage that investments in energy efficiency investments should be optimized before capital investments are initiated. In sum, public policies can help close the energy efficiency gap by correcting the multitude of market barriers and failures to achieve the positive gains associated with energy efficiency behaviors and investments that are attainable through existing technologies and resources.

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3. METHODS

3.1 Population Examined

This policy memorandum examines the Public Service Co. of Colorado's (Xcel Energy) demand-side management portfolio. Colorado's Energy Efficiency Resource Standard only applies to investor-owned utilities, of which there are two in Colorado. Xcel Energy is the largest retailer of electricity in Colorado, and its electricity sales are almost 16 times greater than Black Hills, Colorado's only other investor-owned utility. Table 1 below lists the top five retailers of electricity in Colorado (EIA, 2012a). Not only is Xcel Energy Colorado's largest utility serving approximately 1.3 million customers, Xcel Energy has a robust demand-side management program, spending over $85 million dollars per year (SWEEP, 2011).

Table 1: Top Five Retailers of Electricity in Colorado, 2010[4]

	Entity	**Type of Provider**	**Residential Sales (MWh)**	**Percent of Total Residential Sales**
1	Public Service Co of Colorado	Investor-Owned	9,086,992	50%
2	City of Colorado Springs	Public	1,476,921	8%
3	Intermountain Rural Electric Association	Cooperative	1,366,799	8%
4	Black Hills	Investor-Owned	628,551	3%
5	City of Fort Collins	Public	494,038	3%

Source: EIA Colorado Electricity Profile, 2010 data (Released January 2012)

To narrow the scope, this policy memorandum will only examine electricity consumption within the residential households and demand-side management programs targeted at the residential sector. Nationally, residential end-use accounts for 35% of the potential end-use efficiency gains (McKinsey, 2009). Colorado ranks 34th in the United States for total energy per capita, and 16th in the 2013 State Energy Efficiency Scorecard (EIA, 2012a; ACEEE, 2013b).[5] Additionally, behavioral policy solutions are most effective when targeting residential consumers because the barriers to rational energy use are

[4] Smaller electricity retailers make up the remaining 28% of total residential sales.

[5] For the measurement of total energy per capita, a rank of 50th means the lowest energy use per capita, while a rank of one means the highest energy use per capita. For the 2013 Energy Efficiency Scorecard, a rank of one means the most energy efficiency state, while a rank of 50 means the lowest energy efficient state.

large behavioral in this sector. In contrast, profit and financial incentives are primary motivators for the commercial and industrial sector (Armel, 2008).

3.2 Analytical Framework

To quantitatively examine policy options, this policy memorandum will perform a cost-benefit analysis using a methodology applied by many utilities when examining demand-side management programs: the total resource cost test. However, this policy memorandum will administer a variation of the total resource cost test by factoring in social benefits, such as avoided CO_2 emissions and other non-energy benefits and costs. The cost-benefit analysis methodology isolates four main stakeholders (1) Participants, (2) Ratepayers; (3) the Utility Company; and (4) Society.[6]

Xcel Energy calculates ex-post cost-benefit analyses on each of its demand-side management programs using a modified total resource cost test. The Colorado Public Utility Commission requires demand-side management programs to achieve a total resource cost ratio greater than one, meaning that benefits have exceeded the costs of implementing the program. Additionally, Xcel Energy examines the net benefits of its residential programs over a weighted average lifetime of all products and programs (Xcel Energy, 2012). The framework in this memorandum differs from Xcel Energy's cost-benefit analysis in the following ways: (1) The cost-benefit analysis is dis-aggregated by isolating only residential, demand-side management programs focusing on energy efficiency; (2) Social benefits are included by monetizing avoided carbon dioxide (CO_2) emissions in addition to a non-energy benefits adder of 10%; and (3) The cost-benefit analysis uses a discount rate of 5% to estimate future net benefits. Arimura et al. (2012) analyzed the cost-effectiveness of demand-side management expenditures and recommended using alternative discount rates of 3%, 5%, and 7% to account for energy savings that may accrue over a longer time period. For the focal point of analysis, Arimura et al. recommended using a discount rate of 5% because it is the average rate and a discount rate often used in governmental policy analyses. A sensitivity analysis will be conducted to analyze changes in the discount rate by varying discount rates

[6] In this policy memorandum, society refers to the residents of Colorado and the State of Colorado.

from 3%, 5%, and 7%. The Colorado Public Utilities Commission mandates the use of a non-energy benefits adder, and other states such as Washington, Oregon, and Utah also include a 10% non-energy adder. This adder accounts for externalities and non-quantifiable benefits such as avoided water use and other public health benefits (Daykin, Aiona, and Hedman, 2012).

To monetize avoided CO_2 emissions, a shadow price was assigned per ton of avoided CO_2. Nemet, Holloway, and Meier (2010) analyzed over 22 previous studies from developed countries and found a range of \$2/tonCO_2 to \$128/tonCO_2 to monetize the benefits of avoided CO_2. Under Executive Order 12866, federal agencies are required to perform a cost-benefit analysis for proposed regulations and include a social cost of CO_2 to monetize damages attributed to increases in carbon emissions. Annually, a federal interagency working group publishes values of the cost per ton of CO_2 avoided. The cost is intended to include changes to agricultural productivity, human health, property values, and ecosystem services (United States Government, 2013, p. 2). This analysis will utilize the values mandated by the federal government to monetize avoided CO_2 emissions, which suggests a shadow price of \$40 per ton of avoided CO_2.

Finally, this policy memorandum assumes that reduced energy demand will equate to reduced electricity generated by coal, and thereby reduced CO_2 emissions. An additional assumption is that Xcel Energy would not incur sunk costs related to unused capital due to two reasons: (1) Inefficient coal plants are eligible to be retired; and (2) Reduced energy demand will stabilize Colorado's energy use as its population grows. However, evidence suggests that these assumptions may be correct. The March 2014 economic forecast published by the Colorado Legislative Council found that coal production in Colorado is declining, likely due to electricity utilities switching from coal-fired generation to natural gas generation. In 2013, coal production in Colorado decreased 16% from 2012 production levels (Colorado Legislative Council, 2014). Also, Fleischman et al. (2013) found that many Colorado coal-fired plants and coal-plants around the country are eligible to retire. As natural gas and renewable resources have become cheaper to produce, coal has become a less desirable resource. In addition, many utilities are hesitant to build new coal-fired power plants due to the potential for impending federal pollution controls.

3.3 Data

The data used in this analysis come from multiple sources such as: government sources, scholarly journals, utility companies, and the non-profit sector. The primary data sources are directly from Xcel Energy in the form of annual reports, demand-side management plans, and ex post cost-benefit analyses on each of Xcel's demand-side management programs in 2012. The data for the status quo cost-benefit analysis was obtained from Xcel staff within its Demand-Side Management Program and Renewables department.

A number of weaknesses and limitations surround the data and evidence collected. First, due to constraints such as time and lack of funding, this policy memorandum relies on outside data. As such, this study focuses on a thorough analysis of outside, reputable data, rather than the accuracy of the data and initial data collection methods. Secondly, both costs and benefits were difficult to quantify and relied on multiple assumptions. For example, the cost-benefit analysis uses data from comparable case studies and estimated projections for electricity use per household. Further, not all of the case studies discussed were completely analogous to Colorado, and thus, the accuracy of this analysis is limited to comparisons of different populations. As such, utilization and success rates of many policy options are adopted from published case studies. Additionally, monetizing the environmental impacts of CO_2 emissions relied on estimation. Similarly, external benefits associated with environmental improvements such as impacts to health, happiness, and comfort levels were difficult to quantify and monetize and were included in the cost-benefit analysis as a 10% benefits adder. Finally, analyzing the rebound effects of energy efficiency programs within the cost-benefit analysis was beyond the scope of expertise for this analysis.

3.4 Criteria for Success

This policy analysis measures residential energy end-use consumption. Success will be defined quantitatively, by estimating the absolute reduction in end-use electricity consumption measured in kWh saved and by estimating total net benefits. Therefore, this analysis relies heavily on a cost-benefit analysis to determine which demand-side management program achieves the greatest reduction in energy consumption, while also achieving the greatest net benefit to Colorado.

4. ISSUE ANALYSIS

The following section examines the energy efficiency debate occurring in Colorado. First, this section discusses the historical role of energy efficiency policy within the United States providing past context to the rise of energy efficiency as a viable policy option to address rising energy demand. Second, this section provides evidence of Colorado's intersecting demands that generate compounding pressures on natural resources such as population growth, energy demand, and energy generation. Third, this section introduces the role of each stakeholder in the policy debate.

4.1 The Historical Rise of Energy Efficiency Policy in the United States

The role of energy efficiency has evolved over time, but remains an essential component of United States energy policy. Advances in energy efficiency have allowed the United States to absorb additional energy demands associated with population growth and economic expansion. Since the 1970s, the U.S. economy has tripled in economic output, and as a result, energy demand continued to rise. However, over three-quarters of the additional demands were absorbed through advances in energy efficiency rather than through additional energy supply (Laitner, et al., 2012). Many economists and policy analysts predict that energy efficiency will continue to play a growing role in coping with additional economic and population growth in the next century.

4.1.1 Early History

Rapidly developing countries in the 19th century, such as the United States and Great Britain, relied on coal as their primary fuel source. At that time, knowledge about future coal reserves as well as other sources of energy was limited. The British government grew concerned about dwindling coal reserves and the potential for industrial decline. In response, British economist, William Stanley Jevons wrote the 1865 renowned article, "The Coal Question: An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal Mines." Jevons argued that due to the declining coal reserves, the British industrial sector was heading toward a stationary economic state within the next century. Jevons predicted that technology and additional energy resources would do little to stop the impending collapse of coal-driven enterprises (Foster, Clark, and York, 2010). While Jevons was incorrect in his predictions of the collapse of coal, his book highlighted a need to examine the way natural resources are depleted. In addition, Jevons debated the role of energy efficiency and created the theory now known as the "Jevons Paradox." In arguing the demise of coal, Jevons claimed that an increase in energy efficiency would not solve the problem of the finite limit to coal. In fact, the premise of the Jevons Paradox is that an increase in energy efficiency will lead to an increase in energy demand. However, Jevons' reasoning can be attributed to the historical time period. In the mid- to late-1800s, coal was the primary fuel source for steam engines and the production of iron. As coal utilization became more efficient, Jevons concluded that additional capacity would be generated to increase production, and therefore, the demand for coal would grow (Foster, Clark, and York, 2010). As a result, Jevons viewed energy efficiency not as a solution, but rather as an instigating factor to greater energy use and a faster depletion of coal reserves.

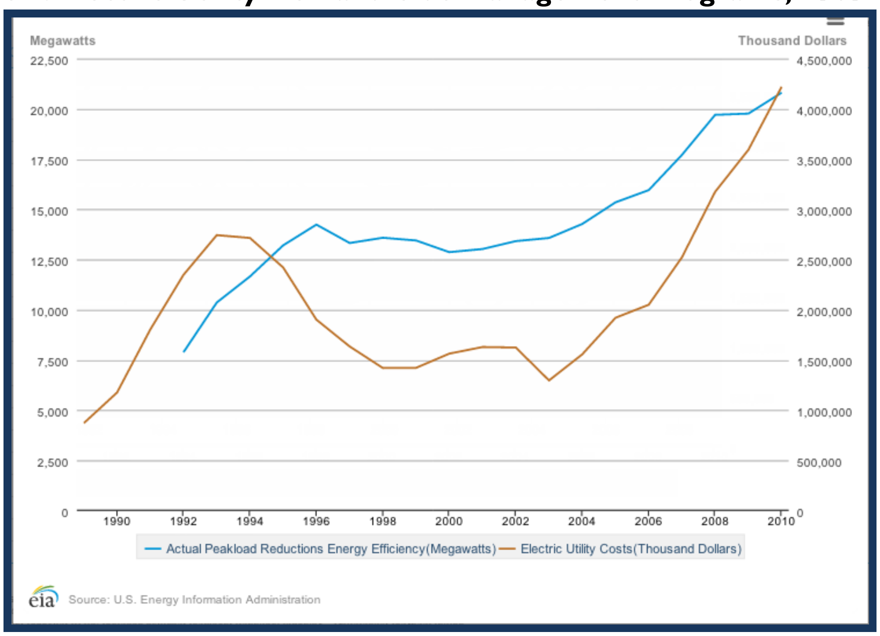
4.1.2 1970's Energy Crisis

As petroleum and alternate fuel supplies became adequate substitutes for coal, concerns regarding an imminent energy crisis were suspended, and energy efficiency became a concept of the past. It was not until the 1970s oil crisis that the concept of energy efficiency and resource scarcity was revived, and the United States' notion of cheap, abundant energy was shattered. As a result, the United States renewed its focus on energy policy and energy efficiency to cope with the depletion of oil, which at the time seemed imminent (Ross, 2013). The oil crisis spurred bi-partisan energy policy focusing on conservation and a diversified energy supply from renewable resources. Consumers responded by reducing energy consumption levels. As a result, a significant change occurred within United States' energy consumption patterns. Since 1973, the United States observed almost a 50% reduction in energy intensity or energy consumption per unit of GDP, and CO_2 emissions decelerated from a growth rate of 4.5% to a growth rate of 0.4% (Ross, 2013). Many economists and historians believe that without the oil crisis, United States energy consumption levels would have accelerated and exacerbated current environmental problems. While the 1970s oil crisis brought energy policies to the forefront, United States energy consumption levels remain higher than most developed countries on a per capita basis.

4.1.3 1990's Resurgence and Current Role of Energy Efficiency

Energy efficiency programs experienced a secondary surge in the 1990s. The 1978 Public Utilities Regulatory Policies Act required state Public Utility Commissions to consider energy efficiency programs when setting electricity prices. Since 1978, utilities have increased spending on demand-side management programs focused on the promotion of energy efficiency and energy conservation (Arimura, et,al, 2012). Figure 4 below shows the electric utility spending on demand-side management programs and the associated reductions in energy attributed to these programs from 1989-2010.

Figure 4: Electric Utility Demand-Side Management Programs, 1989-2010[7]



Source: EIA, Annual Energy Review 2012- Table 8.13

Figure 4 shows spending on energy efficiency programs by utilities hit a peak in the mid-1990s. As state Public Utilities Commissions began discussions to restructure the energy industry and allow for increased competition within the energy production industry, spending on energy efficiency programs began to decline as utility companies reduced costs in fear of competitive pressures (Arimura, et.al, 2012). More recently, the United States has experienced a resurgence in energy efficiency spending as energy efficiency programs have been considered a cost-effective solution to diversifying energy supplies and reducing CO_2 emissions (Laitner, et al., 2012). Colorado and 24 other states have enacted Energy

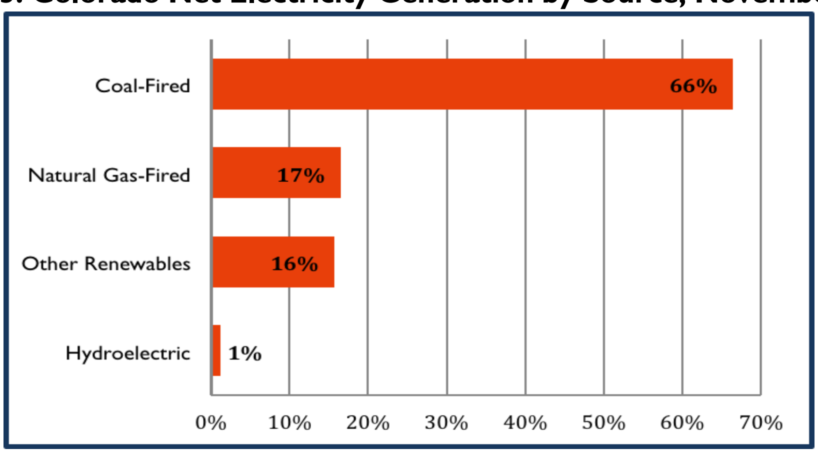
[7] This chart includes all forms of utility demand-side management including residential, commercial and industrial programs. It is assumed that the overall trend would be similar if isolating only residential demand-side management programs.

Efficiency Resource Standards (EERS). EERS targets establish a goal of energy savings that must be met through customer energy efficiency programs. In fact, the American Council for an Energy-Efficient Economy (ACEEE) (2013a) estimated that if each state abided by its EERS target, approximately 6.3% of 2011 total electricity sales nationwide could be saved.

4.2 Colorado Energy Portfolio and Natural Resource Pressures

As shown in Figure 5, Colorado's energy portfolio is primarily coal-based, comprising 66% of Colorado's electricity generation. Natural gas comprises 17% and renewable resources comprise 16% (EIA, 2013a). Both natural gas-fired and coal-fired electricity generation are non-renewable energy sources and release harmful pollutants and greenhouse gas emissions that degrade air quality and contribute to global climate change (Solomon, et. al, 2007).

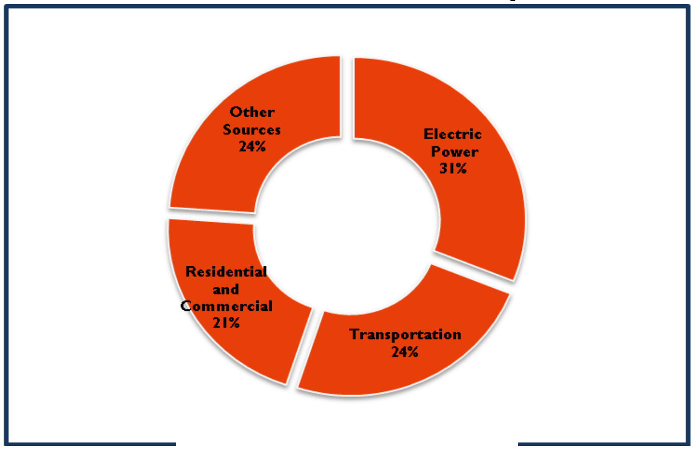
Figure 5: Colorado Net Electricity Generation by Source, November 2013



Source: EIA, Electric Power Monthly, November 2013

Figure 6 on the next page shows the primary sources of Colorado's greenhouse gas emissions, of which electricity generation is the main source of emissions. Colorado's large amount of emission attributed to electricity generation directly relates to its reliance on coal-fired power plants. As a result, Colorado's greenhouse gas emissions are higher than the national average (Clean Energy Action, 2014).

Figure 6: Colorado Greenhouse Gas Emissions by Emission Sector, 2010[8]



Source: Arnold, et al., 2013

Coal holds the highest carbon content of any energy resource, and as a result, releases large amounts of carbon dioxide into the atmosphere as well as other air pollutants such as sulfur dioxide, nitrogen oxides, particulate matter, and mercury. The impacts of these air pollutants include ozone, smog, and acid rain, all of which negatively affect public health and degrade Colorado's environment. Additionally, coal-fired power generation utilizes large quantities of water, exacerbating the threat of looming water shortages in Colorado (EPA, 2013b).

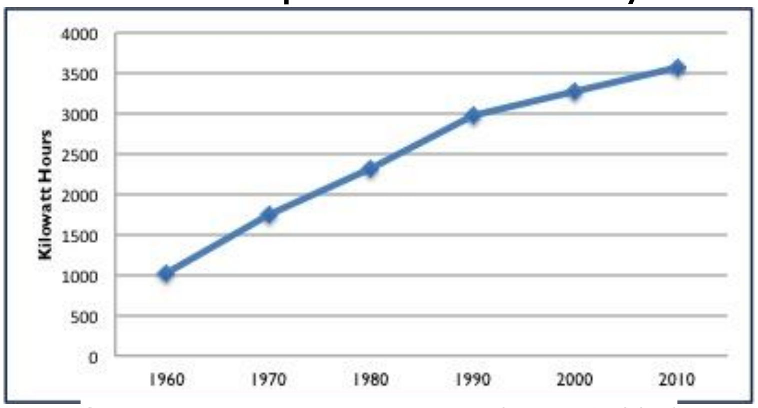
Colorado's growing population creates additional problems related to increasing energy demand and energy instability. Compared to other states, Colorado experienced the largest absolute increase in energy-related carbon dioxide emissions from 2000 to 2010, increasing emissions by 13.9%. Energy Information Administration (EIA) analysts believe that population growth is likely causing the observed absolute increase in carbon dioxide emissions. Residential sector emissions also rose 15% during this time period, further indicating that population growth may be to blame (EIA, 2013b).

In addition, evidence suggests that Colorado's electricity consumption growth is growing, along with its population. Colorado's population has been growing at an approximate average rate of 1.5% per year, while electricity sales have grown at an average rate of 2.6% per year from 1997 to 2008

[8] Other sources include coal mining and abandoned mines, gas production, industrial processes, waste management, and agriculture.

(Colorado Energy Office, 2009). Figure 7 depicts Colorado's residential per capita electricity use from 1960 to 2010. Since 1960, Colorado per capita electricity use has grown 255% (EIA, 2014).

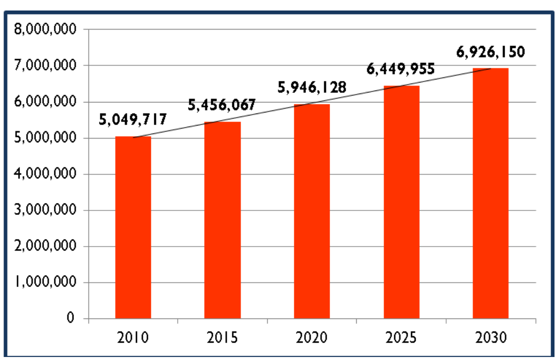
Figure 7: Colorado Per Capita Residential Electricity Consumption



Source: Data compiled by author from EIA, 2014

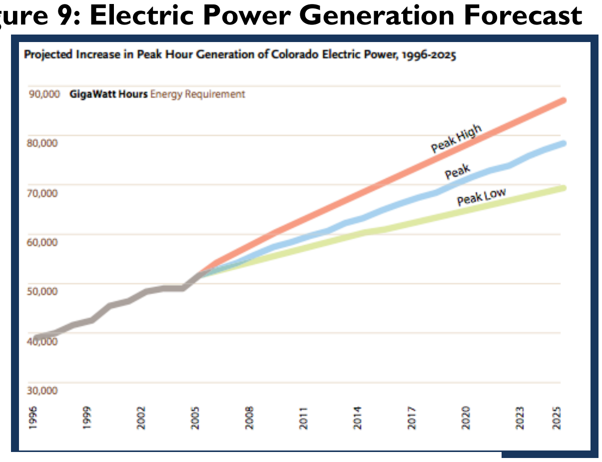
Figure 8 and 9 depict projections for population growth and likely scenarios of future electricity demands. However, Xcel Energy projects residential electricity sales to grow at a lower rate of 0.3% through 2028 due to four assumptions: (1) slowing growth in cooling usage; (2) increasing federal energy efficiency standards; and (3) increasing customer-owned solar generation; and (4) projected success from Xcel Energy's demand-side management programs.

Figure 8: Colorado Population Forecast



Source: Colorado Department of Local Affairs

Figure 9: Electric Power Generation Forecast



Source: Colorado Energy Office, 2009.

The Colorado Energy Office summarizes the challenge of balancing population growth and energy demand by stating, "The challenge Colorado faces is to make cost-effective and environmentally responsible decisions, while improving the historically high level of electric reliability in the state." (p. 17). Without strategic decisions and actions, Colorado may face natural resource and environmental pressures in the future as it seeks to balance its population growth and rising energy demand.

4.3 Stakeholder Interests

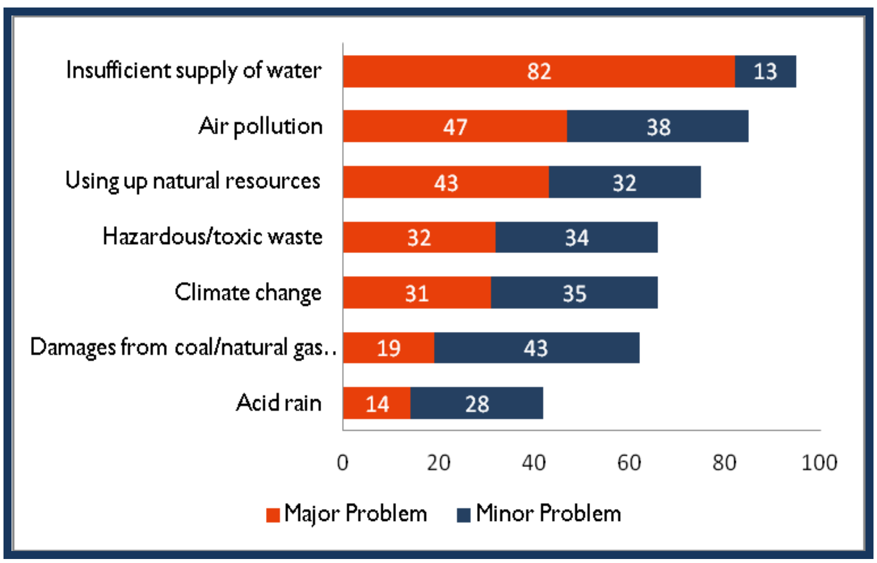
The stakeholders considered include: (1) Colorado residents; (2) Colorado investor-owned utilities (specifically Xcel Energy); (3) the State of Colorado; and (4) Ratepayers. This section will examine each stakeholder in further detail.

4.3.1 Colorado Residents

Energy efficiency will likely fill a critical gap as Colorado proceeds with the costly, time-intensive transition of converting power generation from fossil fuels to renewable sources. Ideally, this will slow the growth in energy-related demand as unnecessary energy use is eliminated. Additionally, studies have identified room for improvement within energy conservation and efficiency in Colorado. The Southwest Energy Efficiency Project (SWEEP) (2002) estimated that Colorado could save 2,500 megawatts of new power capacity and save 14 billion gallons of water a year by implementing policies that promote high efficiency scenarios through 2020. In a follow-up study focusing on Colorado's energy efficiency potential, SWEEP (2012) found that Colorado could realize a net benefit of $4.8 billion dollars by adopting energy efficient actions. The high efficiency scenario assumes Colorado commits to increase its investment in energy efficient programs and retire outdated coal-fired power plants. The positive benefits include avoided costs by eliminating the need for additional energy generation, while also providing consumer benefits of lower utility bills.

Additionally, Colorado's citizens support the transition from fossil fuels to renewable energy and energy efficiency. Surveys completed by Colorado residents in 1999, 2003, 2012, and 2013 demonstrate that Coloradoans view environmental responsibility as a top priority. In 2012 and 2013 surveys of Colorado voters by Colorado College, 68% of Colorado voters identified themselves as conservationists, and 78% believed that land and water can be protected, while still supporting a strong economy. Further, 71% of Coloradoans supported the Clean Air Act and also supported updating standards to target smog, dust, and emissions from power plants, factories, and cars. A 2003 University of Colorado Denver survey investigated Coloradoans' perceptions regarding the environment, renewable energy, and electricity. Through the survey, Appelbaum and Cuciti (2003) analyzed 602 telephone surveys completed by Colorado voters. One of the questions asked respondents to classify environmental concerns as either a major problem, moderate problem, or not currently a problem in Colorado. The results are displayed in Figure 10 and show that Coloradoans are most concerned with water pollution, air pollution, and resource depletion, which is consistent with surveys analyzed by Colorado College. Thus, a vast majority of Coloradoans supports actions that promote environmental sustainability, especially within the energy industry.

Figure 10: Colorado Voter Environmental Concerns



Source: Appelbaum and Cuciti, 2003, p.6

The survey also found that Colorado homeowners continue to prefer renewable energy sources to fossil fuels and support a transition from Colorado's coal dependence. According to the survey results, a majority of the respondents would be willing to pay an additional $10 per month to transition from fossil fuels to renewable energy in Colorado. Finally, the survey found that Coloradoans prefer energy efficiency to new energy generation. When asked how utilities should handle projected increases in demand, 72% of Coloradoans believed utilities should help customers use energy more efficiently. As such, the surveys suggest that Colorado voters favor the use of energy efficiency as a mechanism to transition to renewable energy and a low-carbon future.

4.3.2 Colorado Investor-Owned Utilities

Colorado's Energy Efficiency Resource Standards have been in effect since 2007. These standards require investor-owned utilities to implement demand-side management programs with a goal of reducing peak electricity demand by 5% of 2006 levels by 2018 (DSIRE, 2012). To address the disincentives for utilities to promote energy efficiency due to administrative costs and foregone revenue, the Colorado Public Utilities Commission approved rewards for utilities in the form of a disincentive offset and a performance incentive.[9] With the disincentive offset, Xcel energy can receive a $5 million pre-tax award if it achieves 100% of its electricity saving goals. If Xcel only achieved between 80% and 99% of its target, the utility would only receive $3.2 million (pre-tax). The performance incentive equates to a percentage of net benefits above the electricity savings goal. This percentage increases as Xcel Energy achieves greater electricity savings, but is capped at 15% for achieved savings of 150% of the savings goal. However, the combined total of the performance incentive and disincentive offset cannot exceed $30 million. The awards are collected via ratepayers, and the utility can begin collecting the performance incentive and disincentive offset from ratepayers beginning on July 1 of the following year (COPUC, 2011). In 2012, Xcel energy achieved 121% of its electricity reduction goal meaning the utility received the full disincentive offset of $5 million and received $17,688,263 as a performance incentive for total incentive of $22,688,263. Further, Xcel energy charges a Demand Side Management Cost Adjustment (DCMCA) tariff to its ratepayers to recover costs associated with implementing its demand-side management portfolio.[10] Currently, Xcel energy charges $0.00265 to $0.0028 per kilowatt-hour for its demand-side management cost adjustment for general residential customers. Many other states have a similar regulatory framework supporting ratepayer-funded energy efficiency. The Institute for Electric Efficiency (2012) found that ratepayer funded energy efficiency budgets for utilities in the United

[9] The disincentive offset is a flat-rate reward if Xcel Energy meets its energy savings goal. The performance incentive is based on a percentage of benefits. The reward structure seeks to partially decouple revenues from energy sales.
[10] The Public Utility Commission approved the Demand Side Management Cost Adjustment in 2008 in its Decision No. C08-0560.

States grew 25% from 2010 to 2011, reaching $6.8 billion. The Institute predicts that energy efficiency budgets could reach $12 billion by 2020 as utilities continue to invest in energy efficiency and as state regulatory agencies continue to support utilities and energy efficiency.

4.3.3 The State of Colorado and the Colorado Public Utility Commission

The Public Utilities Commission (PUC) regulates public utilities in Colorado. The independent commission is established in the Colorado Constitution and is a division within the Colorado Department of Regulatory Agencies. The Commission consists of three commissioners, all of which are appointed by the Governor and confirmed by the Colorado State Senate. The PUC regulates rates, services, infrastructure, and the authority to operate. In addition, the PUC has statutory authority to initiate enforcement actions to ensure that utilities comply with statute, Commission decisions, and rules and safety standards. When setting and analyzing rates, the PUC states that its goal is to "maintain electricity rates as low as possible for residential and business consumers consistent with minimum standards of service, safety, economic viability, and the environment." (DORA, 2014). The PUC and the Colorado General Assembly support the pursuit of aggressive energy efficiency actions through the adoption of its Energy Efficiency Resource Standard and the creation of a robust regulatory framework that incentivizes utilities to adopt cost-effective demand-side management programs.

Studies indicate that states that have adopted energy efficiency policies have realized substantial, positive benefits. Disaggregating the effects of energy efficiency to determine the impacts on a statewide level, Tonn and Peretz (2007) examined the benefits of state-level energy efficiency programs and found that these programs provide numerous state-level benefits including job creation, higher state tax revenues, increased property values, healthier environments, and increased investment in energy efficiency technologies. Examples of state-level energy efficiency programs include appliance standards, building energy codes, tax incentives, and utility-run programs. Specifically, New York created the New York Energy $mart Program, which targets multiple market barriers by funding energy education, rebates and financing, and technical assistance program to guide residential, commercial, and industrial sectors toward energy efficient purchases (Tonn and Peretz, 2007). Tonn and Peretz further identified that most state-level energy efficiency programs are cost-effective and exhibit benefit-cost ratios of 3:1, which could be higher if macro effects, such as job creation and increases to state gross domestic product, were included within the analysis. Further, rate adjustments and incentives awarded for successful demand-side management programs are included in the price of electricity paid by ratepayers. Therefore, Colorado and the PUC do not incur any additional costs to support the demand-side management programs.

4.3.4 Ratepayers

Xcel Energy's demand-side management programs are ratepayer-funded, meaning ratepayers pay the demand-side management cost-adjustment fee and the incentives through increased electricity prices, regardless of whether the ratepayer participates in a demand-side management program. This is the most common funding structure for energy efficiency policies. In 2009, thirty-five states had ratepayer-funded energy efficiency programs (Barbose, et al., 2009). At first glance, it would appear that ratepayers not involved in demand-side management programs would be opposed to paying this fee. However, numerous secondary benefits associated with demand-side management programs are indirectly passed onto all ratepayers. These benefits include avoided pollution emissions, avoided costs of operations and maintenance, and avoided supply costs associated with the generation of additional energy resources.[11] Thus, the Colorado PUC views demand-side management programs as an "investment that defers higher costs of new generating equipment" (COPUC, 2011, p. 7). However, the Colorado Energy Consumers (CEC), an unincorporated association of corporations within Xcel energy's Colorado territory, opposes the current regulatory structure, calling into question the practice of passing on the costs of demand-side management programs to ratepayers. The CEC believes that the performance mechanism is too high and a "gratuitous transfer from customers to shareholders" (COPUC, 2011, p. 19). The CEC further recommends that a performance mechanism should be awarded to Xcel energy, but current award levels are too high and perhaps arbitrary.

[11] These benefits can be monetized and are included within the net benefits calculated in the cost-benefit analyses beginning on page 43.

Other critics of ratepayer-funded energy efficiency programs and public policies promoting energy efficiency claim that a market-based approach focusing on private investment would lead to a socially desired level of energy efficiency. For example, the government could let private energy companies set energy prices without the involvement of the Public Utility Commission. With the ability to set prices equivalent to market conditions, critics argue that a socially beneficial outcome will occur once the market can operate without intervention. Thus, critics believe that government intervention through the promotion of demand-side management programs distorts the energy market and places unnecessary burdens onto ratepayers (Eto, Goldman, and Kito, 1996). The recent movement to deregulate and restructure electricity utilities may challenge ratepayer funded energy efficiency programs. If deregulation increases competition for utility providers, utilities may no longer be the most appropriate administrator of energy efficiency programs. Rather, state agencies or nonprofits may be tasked with administering energy efficiency programs in the future (Blumstein, Goldman, & Barbose, 2005). However, an in-depth discussion of utility restructuring and deregulation is beyond the scope of this policy memorandum.

5. SOLUTIONS

Traditional policy tools to address excessive energy consumption are primarily associated with price-based interventions, such as tiered-rates or rebates. However, a growing body of research indicates that behavioral policy interventions could create astounding gains in energy efficiency that are equally as effective as price-based interventions and typically, less costly. Allcott and Mullainathan (2010) discuss behavioral interventions in the context of energy efficiency by highlighting the following behavioral strategies: (1) psychological cues; (2) commitment Devices; (3) default options; and (4) social norms. Allcott and Mullainathan tie potential behavioral responses to the above strategies, which have been compiled in Table 2.

Table 2: Behavioral Strategies to Induce Energy Efficient Behaviors

Behavioral Strategy	Concept	Response
Psychological Cues	Framing and psychological cues can affect the demand for a product (p. 2)	Can electricity bills be designed more effectively? (p. 2)
Commitment Devices	Humans tend to procrastinate and delay actions or investments into the future (p. 2)	"How many households are aware of ways to save energy but plan to take care of it tomorrow? Can we induce people to commit financially to reducing energy consumption and stick to it?" (p. 2)
Default Options	People rarely switch from an option that requires no action (p. 2)	Can this be applied to energy-related decisions? i.e. Such as a default option for energy efficiency settings on products (p. 2)
Social Norms	People conform to others' behavior and are motivated by social comparisons. (p. 3)	Can social comparisons induce energy efficient behavior?

Source: Information compiled by author from Allcott and Mullainathan, 2010

Further, Ehrhardt-Martinez (2011) explains that behavioral programs motivate consumers to reduce energy use through three categories of action: "(1) Simple changes in routine habits; (2) Low-cost energy stocktaking behaviors (i.e. replacing incandescent bulbs with CFLs, weather stripping, etc); and (3) Consumer investments in new energy-efficient appliances, devices, and materials" (p. 1). In addition, Ehrhardt-Martinez emphasizes that "technology adoption doesn't occur in a social vacuum," and thus, behavioral policies become a critical component when attempting to incentivize the adoption of energy efficient habits, purchases, or investments (p. 4).

Therefore, behavioral policies should be included in demand-side management portfolios for two primary reasons: (1) Behavioral policies produce effective results, often at a lower cost than rebates and equipment upgrades; and (2) Behavioral policies address psychological and sociological motivations rather than relying exclusively on financial incentives. However, many energy efficiency behavioral policy interventions have yet to be empirically tested in multiple markets to determine their ability to be scaled and implemented to large and diverse populations. Fueled by academic researchers and utilities across the country, an effort is underway to test the effectiveness of behavioral policy interventions within the electricity and energy industry. The policy alternatives discussed in this chapter provide examples of programs that align with this emerging trend. However, the policy alternatives are not intended to replace the status quo portfolio in entirety because rebate programs can be successful mechanisms to lower energy use, but should not be the sole focus of demand-side management portfolios.

5.1 Alternative 1 – Status Quo

The status quo option examines Xcel Energy's current residential demand-side management portfolio and provides a baseline to measure the success of additional policy options. The residential program includes customers living in single-family homes, apartments, and condominiums that receive electricity service from Xcel Energy. In 2012, the most recent ex-post evaluation of the program, Xcel energy spent $18,814,441 on residential electric demand-side management programs and served 1,005,493 customers (Xcel Energy, 2012).[12] This program relies heavily on rebate-based programs. Based on actual program expenditures, the residential portfolio consists of 79% rebate and equipment-based programs, 12% behavioral/market transformation programs, and 9% education programs.[13]

[12] Some customers may be double-counted. For example, if one customer participates in more than one program, that individual appears in the total count twice.
[13] Author's calculations using data from 2012 Colorado Demand-Side Management Annual Status Report

5.1.1 Pros of the Status Quo Approach

The current program is cost-effective and continues to meet the energy saving goals set by the Colorado PUC. In addition, Xcel's residential demand-side management programs achieved a total resource cost ratio of 4:1, meaning benefits exceeded costs by over 400 percent (Xcel, 2012). Further, energy efficiency strategies based on cash rebates and equipment upgrades have been utilized and effective since the 1970s and continue to be the dominant programs within utility demand-side management programs across the United States. Because Xcel Energy continues to exceed its energy savings targets, the utilities' current portfolio fulfills the obligations of the Colorado Energy Resource Standard and can be viewed as a net benefit to society.

5.1.2 Cons of the Status Quo Approach

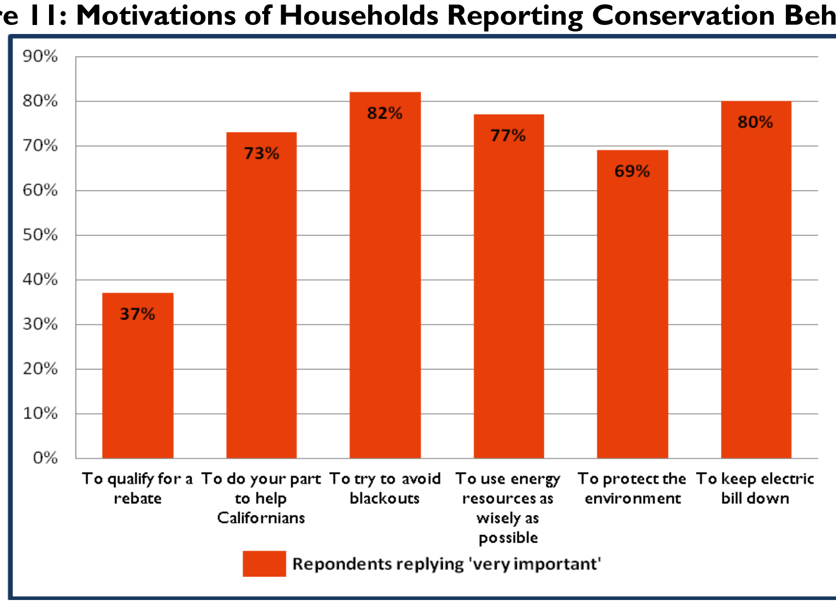
While Xcel Energy's current portfolio is achieving policy and energy saving goals, studies suggest that a portfolio addressing multiple market barriers through a multi-disciplinary approach could achieve greater results and a greater net benefit for society. To a large extent, the current portfolio only targets one market barrier within the energy industry, a lack of financial capital. Xcel Energy addresses this market barrier by providing price-based incentives in the form of rebates and equipment upgrades. However, other market barriers not addressed are informational or psychologically based. Jessoe, Rapson, and Smith (2013) state, "In the residential electricity choice setting non-monetary incentives such as moral license or pressure to conform to social norms can dominate financial incentives" (p.2). In addition, Jessoe, Rapson, and Smith note that altruism and environmental concerns can be effective motivators for residential consumers to adopt energy efficiency behaviors and technology. Therefore, a portfolio only focusing on one barrier impacting electricity use may be shortsighted and neglect other factors that affect consumer decisions. As a result, Xcel Energy's demand-side management portfolio may be achieving policy goals inefficiently by solely focusing on price-based incentives.

While many of Xcel Energy's residential demand-side management programs achieve cost-effective results, some rebate programs do not. For example, in 2012, the water heater rebate program achieved a benefit-cost ratio of 0.6:1, meaning costs exceeded the benefits for that program (Xcel

Energy, 2012). Also, a market potential study commissioned for Xcel Energy concluded that its traditional portfolio of rebates and equipment-based measures will become less cost-effective and will produce lower energy savings between 2015 and 2020 (Xcel Energy, 2013b). More stringent building code standards are achieving impressive results in energy efficiency, but concurrently are making equipment-based demand-side management programs less effective (Xcel Energy, 2013b). In essence, two policies are attempting to achieve the same outcomes, and in turn, ratepayers are facing increasing rates, but less effective savings.

As the market increasingly absorbs energy efficiency products, some rebate programs may become less cost-effective and more prone to free riders. As consumers purchase energy efficient products at increasing rates, free riders begin to take advantage of rebates even though these individuals would have purchased the equipment regardless of the rebate incentive (Xcel Energy, 2013b). As an example, in a study analyzing household conservation responses to the 2000-2001 energy crisis in California, Lutzenhiser, et al. (2003) found that consumers were motivated by concerns other than price increases, such as altruism and civic concerns (Figure 11). In fact, only 37% of the study respondents viewed qualifying for a rebate as a 'very important' motivator to adopt energy conservation behaviors.

Figure 11: Motivations of Households Reporting Conservation Behaviors



Source: Lutzenhiser, et al., 2003

Due to such findings, Xcel Energy's Strategic Issues Docket filed with the Colorado PUC in 2013 asked for the approval of non-traditional energy efficiency programs, such as behavioral change programs, and Xcel Energy's 2014 DSM Plan states that the company will continue to place a greater emphasis on education and market transformative programs (Xcel Energy, 2013c).[14] Xcel Energy informed the Colorado PUC that the utility intends to reach 500,000 customers through behavioral demand-side management programs by 2020 (Xcel Energy, 2013a). Therefore, the following alternatives discussed in the next subsections evaluate this transition towards a new demand-side management paradigm, which places a greater emphasis on behavioral policies.

5.2 Alternative 2 – Installation of Smart Meters and In-Home Displays

This policy alternative provides energy consumption feedback through smart meters and in-home displays installed in single-family homes.[15] Also, this demand-side management approach eliminates information barriers of electricity use by allowing residential consumers to view their electricity use in real-time rather than waiting for their monthly bill. Smart meters add a 'salience effect', in which electricity use is now highly visible, and consumers can actively monitor their electricity use or proactively change their behavior to lower their electricity consumption and subsequently, their monthly utility bills.

Xcel Energy conducted a small-scale In-Home Smart Devices (IHSD) pilot in 2012. Smart meters were installed in Colorado homes in the cities of Boulder, Centennial, and Westminster. The energy use data of participants and a control group were analyzed. A consulting firm conducted a third-party analysis of the pilot, and the researchers calculated energy savings of approximately 3% from the energy use of the control group; however, these results were not statistically significant. The researchers did claim that adding 2013 summer data or using a different econometric methodology could produce statistically significant results (EnerNOC, 2013). Xcel plans to end the pilot in 2013 with

[14] Docket No. 13A-0686EG

[15] Smart meters are electric metering devices that record and communicate electricity energy consumption at real-time intervals to the utility and customer. These devices are also referred to as advanced metering devices.

a final analysis completed in 2014. Xcel did not offer any reasoning for discontinuing the pilot, but may reverse their decision after reviewing the final analysis and program design.

5.2.1 Pros of the Installation of Smart Meters and In-Home Displays

Jessoe and Rapson (2013) provide three primary reasons why providing real-time electricity use information may guide consumers to more efficient outcomes: (1) A lack of information within the electricity industry creates a market barrier; (2) The quantity of electricity consumption is invisible to residential consumers; and (3) Electricity consumption occurs in the background of daily lives (p. 1-2). This policy approach provides real-time feedback to consumers, which allows consumers to understand how their electricity consumption translates into expenditures (Jessoe and Rapson, 2013). Smart meters are also beneficial to utility companies as they provide more detailed and timely information. This allows utilities to manage electricity demand more efficiently, to determine times and causes of peak loads, and to provide detailed guidance to customers on how to best manage their electricity use. Further, smart meters allow utilities to modernize the electric grid, potentially delaying large costs to expand and upgrade existing electric grid infrastructure (Depuru, et al., 2011).

Several pilot studies have found that smart meters increase the elasticity of demand for electricity and produce energy savings amongst residential consumers. Jessoe and Rapson (2013) compared the effects of changing electricity prices amongst residential electricity consumers by dividing participants into a price-only group and a group that was also exposed to a price change, but were equipped with in-home energy use displays. Jessoe and Rapson found that consumers exposed to only price effects reduced their electricity use by 0% to 7%, while those with in-home displays reduced their electricity use by 8% to 22%. Jessoe and Rapson also saw that consumers with in-home displays exhibited conservation behaviors even when prices were not increased, indicating that in-home displays could lead to long-term conservation behaviors. In another pilot program, The Energy Center of Wisconsin provided in-home displays and conducted a billing analysis on 153 homes and a control group of 95 homes that did not receive in-home displays (Mendyk, Kihm, and Pigg, 2010). The results indicated that the homes with successfully installed in-home displays reduced energy consumption by approximately 1.5%, but could likely fall between -1.4 to 4.3% with a 90% confidence interval. However, the researchers did indicate that success rates directly correlated to consumer attitudes towards to the device. For example, those who frequently viewed the in-home display reported energy savings between 3% to 5%. Also, the study found that in-home displays were more effective on high consumptive energy users (Mendyk, Kihm, and Pigg, 2010). In 2009, Cape Light Compact completed an in-home display pilot in which participants received an in-home display as well as access to an internet-based dashboard displaying energy use, savings, and CO_2 emissions for one year. The results indicated energy savings of approximately 9.3% and also indicated the participants who received displays would be willing to pay $8 per month to continue the service (PA Consulting Group, 2010). An interesting variation between the Wisconsin program and the Cape Light Compact program is that the Cape Light program offered in-home training for the devices, while the Wisconsin program did not. The variation may explain the different results, but this claim is not substantiated. However, the results discussed above are similar to pilot programs across the country. An analysis of 12 in-home display pilot programs indicated that energy reductions averaged 5%, with a range of 0% to 18% (PA Consulting Group, 2010). Thus, while the energy savings vary, the installation of smart meters and in-home displays could provide significant benefits to both consumers and utilities.

5.2.2 Cons of the Installation of Smart Meters and In-Home Displays

While studies indicate that smart meters lead to energy saving benefits, the installation of smart meters may create multiple challenges in the form of substantial upfront costs and security and privacy concerns. Purchasing and installing smart grid infrastructure can also require large financial investments by a utility or ratepayer. In order to transmit real-time data, utility companies need to house servers at their facilities and store large quantities of data. While the cost of communication networks may not be a burden on utilities currently, utilities may incur future costs related to data capacity and security installments as the adoption of smart meters continues (Depuru, 2011). The Edison Institute (2011) estimated that installing smart meters in one million households would cost between $198 and $272 million (or between $198 and $272 per household), depending on what each utility has previously invested in smart grid infrastructure (Faruqui, et al., 2011). Further, the Sacramento Municipal Utility District estimated that the payback period for smart meters was between 8 to 10 years, but is only 3 to 6 years when factoring federal subsidies.[16] Thus, costs associated with smart meters continue to delay and deter the widespread adoption among utilities and consumers and the digital upgrade of the electric grid.

As smart grids share more information with both the consumer and utility, smart grids simultaneously create greater risks for privacy invasion. Essentially, as electric meters are connected to a computerized infrastructure, the electric grid becomes increasingly vulnerable to cyber attacks. If hackers were able to manipulate the information sent from smart meters to utilities, instances of consumer fraud or theft could alter electricity bills and usage (McDaniel and Smith, 2009). In addition, some consumers remain wary of smart meters due to privacy concerns. For example two main questions arise:

1. If programs monitor their energy use, could this lead to criminal targeting of homes if energy patterns indicate the individuals are not home? (McDaniel and McLaughlin, 2009)
2. If programs have access to residential energy use (i.e. Google PowerMeter service), are privacy policies strict enough to prevent a company from using the information for commercial or marketing purposes? (Khurana, et al., 2010).

Smart meter technology is relatively new. As such, many privacy and security risks remain a concern for consumers, utilities, and government regulators.

5.3 Alternative 3 – Electricity Feedback Reports

A second policy alternative provides electricity customers with customized electricity feedback reports. This demand-side management approach addresses information barriers, but also addresses social norms amongst households. Diamond and Moezzi (2004) discuss the importance of sociological

[16] The Federal Government provided $3.4 billion in matching funds in the American Reinvestment and Recovery Act for Smart Grid Investment Grants. Two utilities in Colorado received grants: City of Fort Collins Utilities and Black Hills Electric Utility Co. of which 79,000 and 42,000 smart meters were installed respectively (U.S. Department of Energy).

ties on electricity use in the United States. Electricity is often consumed beyond a level of necessity, and is consumed in excess for status, pleasure, and convenience. These underlying social values may explain why the household floor area per capita has increased by a factor of three between 1950 and 2000, while the number of individuals per household has decreased during the same time period (Diamond and Moezzi, 2004, p. 3). Therefore, electricity feedback reports exploit sociocultural norms by providing both personalized information of a consumer's electricity consumption and comparisons to neighbors or similar households.

Since 2011, Xcel Energy has completed an energy feedback pilot within its demand-side management programs. During the initial pilot in 2011-2012, energy reports were mailed periodically to 40,000 participants or e-mailed monthly to 10,000 participants. Energy savings exceeded expectations, primarily due to higher than expected success with e-mailed reports (Xcel Energy, 2013c). In 2013, the pilot expanded to include an additional 50,000 participants who received both print and e-mail feedback reports. The reports analyzed electricity use and provided action steps for reducing electricity consumption. Xcel Energy reported savings between 1% and 2% of electricity use from the initial pilot, and expects savings to reach 1.9% as the pilot continues. Xcel Energy has chosen to continue this pilot in 2014 with the addition of online platforms to view reports and other data (Xcel Energy, 2013c).

5.3.1 Pros of Electricity Feedback Reports

Social norms can be a powerful influence on behavior. Understanding this, energy feedback reports that provide customized electricity use information in an understandable context and neighbor comparisons have been successful tools to lower residential electricity consumption. Allcott (2011) identified three reasons why energy feedback reports including social comparisons can affect household electricity consumption: (1) Individuals derive utility from conserving more than their neighbors; (2) Households perceive energy conservation as a benefit to society or the notion of "doing your part" for the greater good; and (3) Feedback reports facilitate social learning by comparing a neighbor's electricity use to their own. To study how electricity feedback reports affect residential electricity consumption, Allcott analyzed the effect of social comparisons within electricity use and energy efficiency behaviors in residential households in Minnesota. Approximately 39,000 residential households received electricity feedback reports that had two main components: a Social Comparison Module and an Action Steps Module. The Social Comparison Module compared electricity usage to neighbors and provided emoticons to judge the household's electricity consumption. The Action Steps Module provided suggestions to reduce monthly electricity consumption. Allcott found that participants that received monthly feedback reports reduced their electricity use by 2%. OPower, one of the largest companies contracted to provide feedback reports, reported average electricity savings of approximately 1.5% to 3.5% based on findings from its utility partners (Opower, 2014). In another study researching feedback report programs in Sacramento and Puget Sound, Ayres, Raseman, and Shih (2009) found average reductions in electricity consumption of 2.1% and 1.2%, respectively for each city. The findings suggest that feedback reports and peer comparisons can be effective in multiple geographic settings and demographics. In addition to the effectiveness of peer comparisons and feedback reports, the reports are a relatively low-cost demand-side management program. OPower estimates the cost-effectiveness of energy feedback reports to be approximately three cents per kilowatt-hour saved (OPower, 2014).

5.3.2 Cons of Electricity Feedback Reports

Studies indicate that feedback reports must be received frequently in order to prompt continued reductions in electricity consumption. In the experiment conducted by Allcott (2011), a group of participants received feedback reports quarterly. This group of participants exhibited electricity reduction behaviors that progressively decayed as the time between reports lengthened. This result indicates that electricity feedback reports are ineffective unless frequent reminders are provided to motivate sustained reductions in electricity consumption.

In addition to decayed results, feedback reports that include peer comparisons can also create a "boomerang effect," in which customers increase their energy consumption after viewing their peer comparisons (Allcott, 2011; Ayres, Raseman, and Shih, 2009). This is most likely to occur for participants who already are low consumers of electricity, and thus, the participants have actually over-estimated their consumption in comparison to their peers. Thus, when these individuals see that they are using less energy than their peers, they become less vigilant to conserve energy and may increase their electricity consumption. Therefore, this effect indicates that feedback letters may be more effective for high electricity consumers and may not be an effective tool to deploy to all customers.

5.4 Alternative 4 – Green Button Initiative

The final alternative proposes the Green Button initiative, a program started in 2011 and advocated by the federal government. The program also is an industry-led effort to provide online, secure access to household electricity data. The Green Button program allows users to download and analyze their own energy data. The data is downloaded into an XML-format, and consumers can provide their data to a third party analysis at an individual or utility-level discretion (Green Button, 2014). Additionally, consumers can provide this information to repairmen or building owners, renters, or prospective buyers. Also, the data standard can be utilized by both utilities that have deployed smart meters and those that have not, making the program flexible for all utilities and ratepayers. The underlying premise of the program is to provide a standard platform to allow electricity consumers to access their consumption data and better understand their electricity consumption patterns. A standard platform creates a common experience from utility to utility. The name Green Button stems from a common 'green button' on utility websites that consumers can click to retrieve their energy data. The Green Button program has been implemented by 35 utilities, and many other utilities have committed to implement the program (Green Button, 2014).

5.4.1 Pros of the Green Button Initiative:

A fundamental benefit of the Green Button program is standardization. Han (2012) states that this standard allows software developers to focus on web and mobile phone apps, tools, and programs that easily analyze the data rather than trying to develop adapters for inconsistent or varied data sets. Further, Han notes that standardization also provides certainty for investors, and thus, incentivizes research and development focused on energy efficiency data tools. Apple has experienced a similar success through the standardization of its iOS platform. By charging a low price to access its standardized platform, the number of apps available on the Apple App store grew rapidly (Cooper, Han, Wood, 2012). Using an example related to energy use, Han states, "With a standardized utility data format, thermostat makers, such as Nest, have an incentive to build in capability to adapt to real-time utility data" (p.4). If this were to occur, consumers would be able to program thermostats to automatically turn off heat or air conditioning during peak times of energy use. Thus, this program incentivizes the widespread adoption of energy data as an everyday component of consumer households and electricity use.

Additionally, the program has both the backing of the White House's Office of Science and Technology and private sector industry through the agreement of utilities across the country. Thus, the program not only has political acceptance, but also has acceptance from business and investment communities. As the program offers certainty and standardization, the correct signals are sent to the business community to spur investment and ultimately, stimulate the widespread adoption of energy data within households (Han, 2012). Cooper, Han, and Wood (2012) add that the unique goal of Green Button is that it creates "an innovation cycle between utilities, technology developers, and customers," and the result creates a tipping point for energy data (p.4). Thus, this synergistic relationship is a critical step towards reshaping consumer attitudes toward energy consumption and energy data.

5.4.2 Cons of the Green Button Initiative:

While the Green Button program's potential appears promising, the program has had a slow adoption rate thus far. This is detrimental, as many of the benefits of standardization and certainty are not realized until certain thresholds of adoption are realized. For example, San Diego Gas & Electric was an early adopter of the Green Button program; however, the utility noted that a key challenge of the program is teaching consumers how to download and use their data (Cooper, Han, and Wood, 2012). In addition to San Diego Gas and Electric's struggle, Cooper, Han, and Wood identified three key challenges for the Green Button Program:

1. Currently, consumers must download their energy data themselves, then supply it to a third-party program for analysis. Rather, this step should be eliminated, and the data should automatically be sent to a third party with the consumer's consent;
2. To eliminate the data-sharing step from consumers, standard protocols need to be developed for data sharing with third parties. These policies need to be both transparent and easy for consumers to provide their consent; and
3. Marketing the third-party energy data apps to consumers remains a challenge. Consumers need to be aware of energy app downloads through effective marketing campaigns.

Therefore, while the program has facilitated an impressive partnership between utilities and technology developers, Cooper, Han, and Wood (2012) note, "the crucial link becomes the customer" (p. 8). Until the program becomes more widely accepted by consumers, concerns arise regarding the long-term success of the Green Button program.

5.5 Conclusion

While each behavioral alternative involves the provision of energy information to the consumer, each alternative addresses unique market barriers, and each alternative offers a different behavioral policy strategy. To summarize the four policy alternatives discussed in this section, Table 3 compares each alternative and includes specific considerations for Xcel Energy when examining each policy option. The next section of this policy memorandum utilizes the methodology of cost-benefit analysis to examine which policy alternative would best fit within Xcel Energy's demand-side management portfolio for its Colorado market. By comparing the net benefits of each program, the cost-benefit analysis provides insight into which program would provide the greatest net benefit to society, the greatest potential to reduce electricity consumption, and the greatest potential to promote the adoption of energy efficiency behaviors.

Table 3: Comparison of Policy Options

	Alternative 1: Status Quo	Alternative 2: Installation of Smart Meters and In-Home Displays	Alternative 3: Electricity Feedback Reports	Alternative 4: Green Button Initiative
Market Barrier Addressed:	Financial	Imperfect Information	Imperfect Information	Lack of business incentives/ Imperfect information
Behavioral Policy Approach:	None	Real-time information	Social norms	Default option
Pros:	• Increases the market diffusion rate of energy efficiency equipment • Lowers the cost of energy efficiency purchases • Proven methodology since the 1970s and has been accepted by consumers	• Upgrades and modernizes the current electric grid • Allows for utilities to implement real-time pricing • Evidence of long-term effects	• Low cost per kilowatt-hour saved • Social comparisons can increase the utility of reducing electricity consumption • Facilitates social learning	• Provides standardization and certainty • Spurs investment in energy data tools • Creates a functioning relationship between stakeholders
Cons:	• Outdated methodology • Some rebates are no longer cost-effective	• High costs • Potential data storage and design concerns • Security and privacy concerns	• Decayed effects between reports • 'Boomerang Effect' • Security and privacy concerns	• Low Adoption Rates • Marketing third-party applications • Security and privacy concerns
Considerations for Xcel Energy:	Is there sufficient reasoning to alter the current portfolio?	Are the benefits of smart meters worth the high capital costs? Will consumers use this feature?	Will this be an effective tool for all customers? Will consumers use this feature?	Do the indirect benefits associated with increased business investment outweigh the costs to implement the standard data platform? Will consumers use this feature?

6. COST-BENEFIT ANALYSIS

6.1 Alternative 1 – Status Quo

Data for the cost-benefit analysis of the status quo alternative largely was provided by Xcel Energy. However, the cost-benefit analysis differs from Xcel Energy's net benefit calculation for three reasons: (1) avoided carbon emissions were factored into the net benefits; and (2) the net benefits were discounted at a rate of 5%, and (3) the figures were converted to 2014 dollars. Table 4 shows the discounted net benefits of Xcel Energy's 2012 residential programs. In total, the residential program had a net benefit of $64.5 million dollars.

Table 4: Status Quo Cost-Benefit Analysis

Residential Demand-Side Management Program	Lifespan	Number of Participants	Total KwH Saved (Annually)	Total Costs	Total Benefits	Net Benefits	Discounted Net Benefits
Home Lighting and Recycling	6.65	522,500	121,391,719	$15.0M	$82.3M	$67.2M	$48.5M
Evaporative Cooling Rebates	15.0	4,298	3,117,462	$2.7M	$22.6M	$20.0M	$9.6M
School Education Kits	7.44	30,000	5,424,632	$2.0M	$4.3M	$2.3M	$1.6M
Refrigerator Recycling	8.6	4,250	3,844,802	$902,000	$3.5M	$2.5M	$1.6M
High Efficiency Air Conditioning	7.78	2,010	2,246,467	$5.2M	$7.1M	$1.9M	$1.3M
ENERGY STAR New Homes	18.8	2,580	1,652,222	$1.2M	$3.2M	$2.0M	$825,000
Showerhead	6.00	2,631	599,379	$45,000	$428,000	$383,000	$286,000
Insulation Rebate	19.5	3,120	510,390	$521,000	$2.1M	$1.6M	$626,000
Home Performance with ENERGY STARY	12.48	200	348,286	$234,000	$604,000	$370,000	$202,000
Water Heater Rebate	13.00	200	68,292	$103,000	$94,000	($9,000)	(4,900)
TOTAL NET BENEFIT							**$64.5M**

**Figures are rounded and adjusted to 2014 dollars*

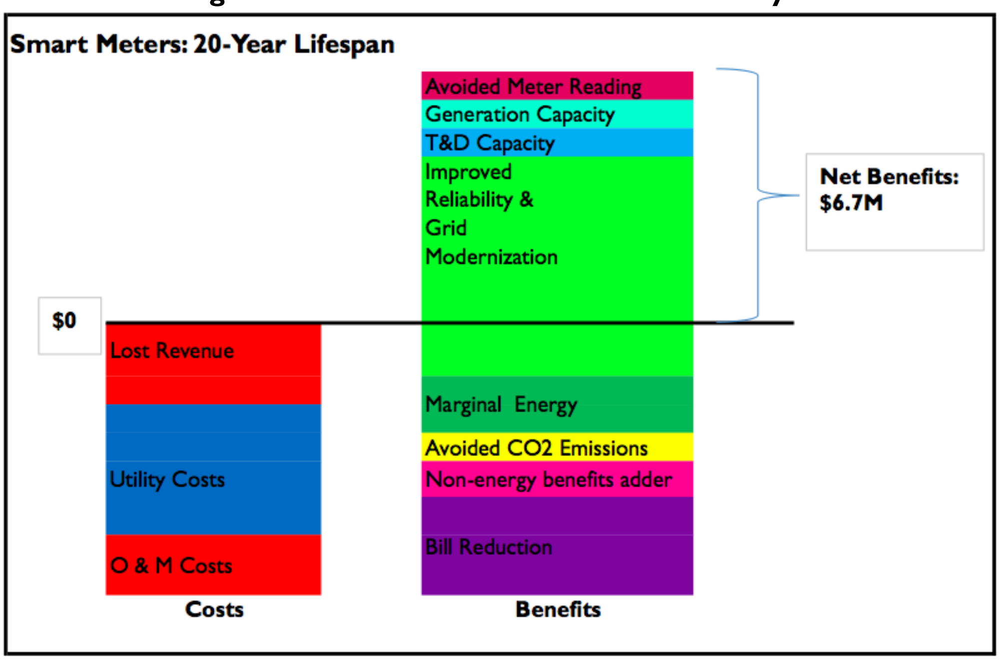
6.2 Alternative 2 – Installation of Smart Meters and In-Home Displays

The smart meter cost-benefit analysis uses data from three primary sources: (1) Xcel Energy's smart meter pilot conducted in 2012; (2) The Edison Foundation's smart meter cost-benefit analysis study; and (3) the Perfect Power Institute's smart meter cost-benefit analysis study. These sources provided key inputs to calculate shadow prices for indirect benefits such as grid modernization benefits, avoided meter reading costs, and marginal energy benefits used for each policy alternative. Per participant costs were calculated using the costs from Xcel Energy's pilot program and then extrapolated to the number of participants analyzed for this policy alternative and converted to 2014 dollars. The program had a total net benefit of $6.7 million over an estimated lifespan of 20 years.

Table 5: Smart Meter Cost-Benefit Analysis

Alternative	Lifespan	Number of Particpants	Total KwH Saved (Annually)	Total Costs	Total Benefits	Net Benefits	Discounted Net Benefits
Smart Meters	20 years	2,000	508,320	$5.6M	$18.3 M	$12.7M	$6.7M

Figure 12: Smart Meters Cost-Benefit Analysis



Sensitivity Analysis

The net benefits of smart meters primarily are driven by grid modernization and reliability benefits. If these benefits were eliminated from the analysis, the net present value of the alternative would be negative. However, grid modernization benefits are an important variable in this analysis as digitizing the grid will avoid future costs related to an aging electric grid.

Table 6: Smart Meter Sensitivity Analysis

Change	Total Costs	Total Benefits	Net Benefits	Discounted Net Benefits
Eliminating Grid Modernization Benefits	$5.6M	$3.4M	($2.2M)	($2.6M)

**Parentheses denote negative values*

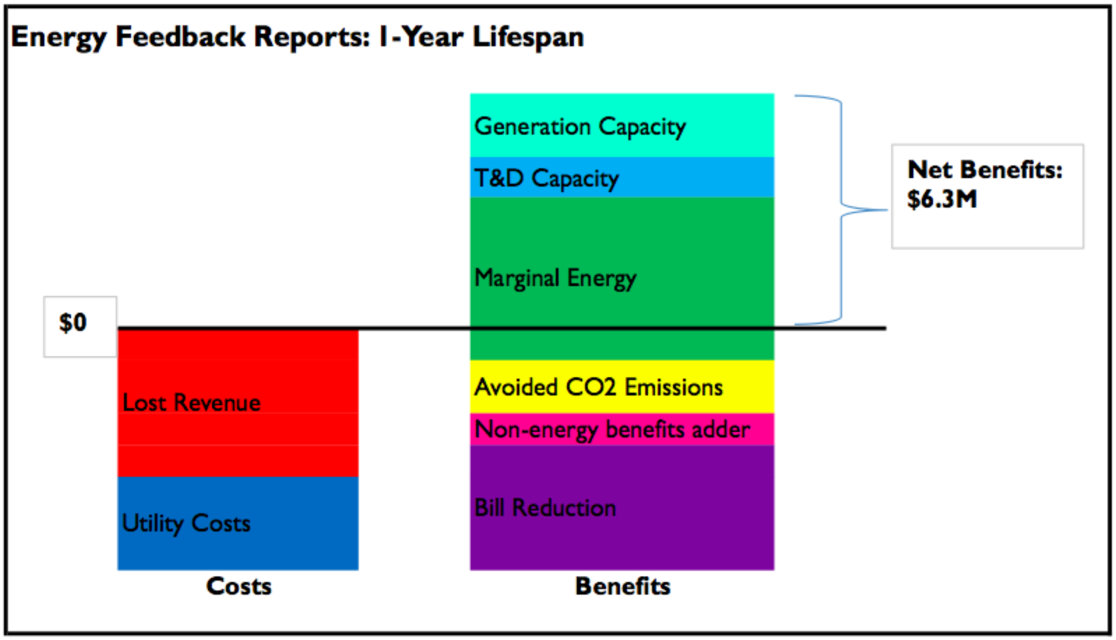
6.3 Alternative 3 – Energy Feedback Reports

The primary data sources used for this analysis were Xcel Energy's pilot program and the Edison Foundation's cost-benefit analysis. This alternative estimated that approximately 250,000 individuals would receive energy feedback reports, which equates to a 443 percent increase to the 2012 Energy Feedback Report Pilot program. Per participant costs were calculated using the costs from Xcel Energy's pilot program and then extrapolated to the number of participants analyzed for this policy alternative and converted to 2014 dollars. Additionally, energy feedback reports are estimated to have a lifespan of one year because the feedback reports must continually be sent rather than accruing benefits after the initial installation, such as in the case of smart meters. The program had a total net benefit of $6.3 million over an estimated lifespan of one year.

Table 7: Energy Feedback Reports Cost-Benefit Analysis

Alternative	Lifespan	Number of Particpants	Total KwH Saved (Annually)	Total Costs	Total Benefits	Net Benefits	Discounted Net Benefits
Energy Feedback Reports	1 year	250,000	61,422,000	$10.5M	$16.8M	$6.3	$6.3M

Figure 13: Energy Feedback Reports Cost-Benefit Analysis



Sensitivity Analysis

As discussed earlier, feedback letters have been shown to be more effective with high-energy users. Table 8 shows how the cost-benefit analysis results would change with above-average energy users. Total discounted net benefits would increase by approximately $4.0 million.

Table 8: Energy Feedback Reports Sensitivity Analysis

Change	Total Costs	Total Benefits	Net Benefits	Discounted Net Benefits
Feedback letters sent to high energy users*	$13.5	$23.7	$10.3M	$10.3M

**Average energy use per month was increased from 706 kWh per month to 1,000 kWh per month.*

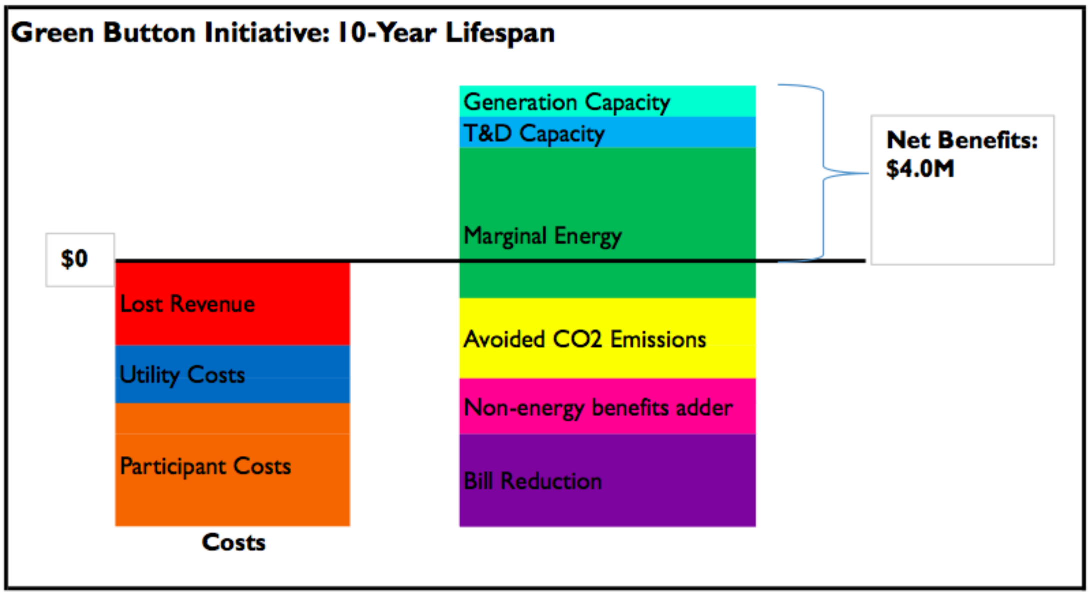
6.4 Alternative 4 – Green Button Initiative

Alternative 4 primarily uses sources from two utilities in California who have already implemented this program: Pacific Gas & Electric and San Diego Gas and Electric. While utility would fund the upfront infrastructure costs, participation in third party programs or apps is voluntary for ratepayers. Using the participation rates of San Diego Gas and Electric, it was assumed that approximately 33,000 households or one percent of Xcel Energy's residential customers would participate in this program. Additionally, this program was estimated to have a ten-year lifespan due to the estimated lifetime of the initial infrastructure investment. This program has the lowest net benefit of the three behavioral options.

Table 9: Green Button Initiative Cost-Benefit Analysis

Alternative	Lifespan	Number of Particpants	Total KwH Saved (Annually)	Total Costs	Total Benefits	Net Benefits	Discounted Net Benefits
Green Button Initiative	10 year	33,000	9,785,160	$20.1M	$25.3M	$5.2M	$4.0M

Figure 14: Green Button Initiative Cost-Benefit Analysis



Because this program involves one-time costs, the net benefits primarily are driven by the participation rates. Table 10 shows how the net benefits can increase dramatically if more of Xcel Energy's ratepayers took advantage of this program. Due to the reliance on high participation rates, Xcel Energy risks incurring sunk costs if participation rates amongst ratepayers are low.

Table 10: Green Button Initiative Sensitivity Analysis

Change	Total Costs	Total Benefits	Net Benefits	Discounted Net Benefits
Higher participation rates (500,000)	$297.0M	$383.9M	$86.9M	$68.3M
Higher particpation rates (50,000)	$30.2M	$38.4M	$8.2M	$6.3M

A sensitivity analysis was conducted for all three alternatives to examine the net benefit effects to varied discount rates. The results are displayed in Table 11. As expected, a lower discount rate equates to higher net benefits and a higher discount rate equates to lower net benefits.

Table 11: Discount Rate Sensitivity Analysis

Discount Rate	NET BENEFITS: Smart Meters	NET BENEFITS: Energy Feedback Reports	NET BENEFITS: Green Button Initiative
3.5%	$8.1M	$6.3M	$4.3M
5.0% *(Discount rate used in analysis)*	$6.7M	$6.3M	$4.0M
7.0%	$5.2M	$6.3M	$3.6M

**The discount rate does not effect the calculations for Energy Feedback Reports because the program has a one-year lifespan.*

A sensitivity analysis was conducted for all three alternatives to examine the net benefit effects to varied time periods. The results are displayed in Table 12. Energy Feedback Reports realize the greatest net benefit during each time period. The smart meters program has the longest payback period due to its initial high capital costs.

Table 12: Time Period Sensitivity Analysis

Time Period	NET BENEFITS: Smart Meters	NET BENEFITS: Energy Feedback Reports	NET BENEFITS: Green Button Initiative
Year One	($2.7M)	$6.3M	($160,000)
Year Five	($450,000)	$30.8M	$1.6M
Year Ten	$2.2M	$59.1M	$4.0M

**Parentheses denote negative values*
***The net benefits were discounted at 5.0%*

To assess the costs per household, a sensitivity analysis was conducted to demonstrate the cost and benefits incurred by the consumer. As shown in Table 13, each alternative offers a positive net benefit to the consumer, primarily because the program costs are absorbed by the utility. Consumers receive direct benefits in the form of a reduced electricity bill. However, the annual net benefits are relatively small, and therefore, consumers may not be incentivized enough to participate in the programs.

Table 13: Annual Household Net Benefits

	Smart Meters	Energy Feedback Reports	Green Button Initiative
Household Costs	($12.50)	$0.00	($20.00)
Household Benefits (Bill Reduction)	$30.00	$29.00	$34.00
Net Benefit Per Household	$17.50	$29.00	$14.00

In sum, Table 14 includes the three behavioral programs within Xcel Energy's status quo portfolio. Only the Home Lighting and Recycling and Evaporative Cooling Rebates offer greater net benefits than the behavioral programs. This indicates that behavioral programs should be included within Xcel Energy's demand-side management portfolio, alongside successful rebate programs. By including the behavioral policy options analyzed in this policy memorandum, Xcel Energy could realize a combined increase of $17.0 million in additional net benefits.

Table 14: Summary Table

Residential Demand-Side Management Program	Lifespan	Number of Participants	Total KwH Saved (Annually)	Total Costs	Total Benefits	Net Benefits	Discounted Net Benefits
Home Lighting and Recycling	6.65	522,500	121,391,719	$15.0M	$82.3M	$67.2M	$48.5M
Evaporative Cooling Rebates	15.0	4,298	3,117,462	$2.7M	$22.6M	$20.0M	$9.6M
Smart Meters	**20.0**	**2,000**	**508,320**	**$5.6M**	**$18.3 M**	**$12.7M**	**$6.7M**
Energy Feedback Reports	**1.0**	**250,000**	**61,422,000**	**$10.5M**	**$16.8M**	**$6.3**	**$6.3M**
Green Button Initiative	**10.0**	**33,000**	**9,785,160**	**$20.1M**	**$25.3M**	**$5.2M**	**$4.0M**
School Education Kits	7.44	30,000	5,424,632	$2.0M	$4.3M	$2.3M	$1.6M
Refrigerator Recycling	8.6	4,250	3,844,802	$902,000	$3.5M	$2.5M	$1.6M
High Efficiency Air Conditioning	7.78	2,010	2,246,467	$5.2M	$7.1M	$1.9M	$1.3M
ENERGY STAR New Homes	18.8	2,580	1,652,222	$1.2M	$3.2M	$2.0M	$825,000
Showerhead	6.00	2,631	599,379	$45,000	$428,000	$383,000	$286,000
Insulation Rebate	19.5	3,120	510,390	$521,000	$2.1M	$1.6M	$626,000
Home Performance with ENERGY STARY	12.48	200	348,286	$234,000	$604,000	$370,000	$202,000
Water Heater Rebate	13.00	200	68,292	$103,000	$94,000	($9,000)	(4,900)
TOTAL NET BENEFIT							**$81.5M**

7. STRATEGIC RECOMMENDATION

My first recommendation to Xcel Energy is to increase its use of energy feedback reports. This alternative had the highest annual reduction of energy use and the highest net benefits that can be realized immediately. However, ratepayers should be viewed as heterogeneous consumers, and the energy feedback reports should be strategically targeted towards Xcel Energy's highest energy users to maximize both private and social benefits. In addition to continuing energy feedback reports, I recommend that Xcel Energy begin to upgrade its electric infrastructure and equip ratepayers with smart meters and in-home displays. Due to the high capital costs, Xcel should consider cost-sharing mechanisms either with ratepayers or through federal grant opportunities. Additionally, Xcel Energy should continue to seek efficiencies to lower the high capital costs of smart meters. By delaying the modernization of its electric grid infrastructure, Xcel Energy risks future electric grid failures and high repair costs as its infrastructure ages. Finally, Xcel Energy should consider implementing the Green Button Initiative to allow ratepayer's electricity data to be automatically transferred to third parties at their discretion. Because this program is very new, Xcel should monitor the implementation strategies of other utilities, such as those in California, to determine best management practices in regards to issues such as privacy, data storage, and information technology.

Most importantly, this policy memorandum indicates that behavioral policy programs can be just as beneficial, if not more so, than programs focused on rebates and equipment upgrades. Foremost, this policy memorandum argues that demand-side management portfolios should target a wide variety of consumer motivations that can incentivize energy conservation behaviors and energy efficiency investments. By strategically targeting the financial, psychological, and sociological motivations of consumers, Xcel Energy and the Colorado can maximize energy reductions and eliminate unnecessary energy waste. As a result, Colorado can realize net benefits and can manage its growing energy demand and population growth without having to implement costly capital construction projects to provide additional sources of energy supply.

8. WEAKNESSES AND LIMITATIONS

A critical weakness of this policy memorandum is the main assumption that energy efficiency should be a priority for public and ratepayer spending. The status quo option assumes that Xcel Energy's demand-side management portfolio should continue in its current form. However, this policy memorandum did not address whether energy efficiency programs should be pursued at all. While eliminating energy efficiency programs would not comply with Colorado statute, this could be a valid discussion that is beyond the scope of this policy memorandum.

A similar weakness is the assumption that energy efficiency will lower energy use. Some studies indicate that energy efficiency may stimulate economic growth, and therefore, may contribute to increased energy use. For example, as households realize lower energy bills resulting from an energy efficient investment or behavior, the household may use its additional income to purchase additional energy-using goods. This is also referred to as the rebound effect. Economists disagree regarding the size of the rebound effect and whether it negates energy efficiency enhancements or energy conservation behaviors. While also an intriguing discussion, an in-depth analysis of the rebound effect is beyond the scope of this policy memorandum.

As discussed in the Methods section of this policy memorandum, data sources were a limiting factor in this analysis. As primary data were not collected for this study, the cost-benefit analysis relied on success rates, shadow prices, and infrastructure costs from third-party studies or pilot programs. Therefore, the confidence of the cost-benefit analyses is limited, and Xcel Energy could realize different costs and benefits if the programs were implemented as suggested. For example, the success rates of the Green Button Initiative were from two utilities in California; the constituents of California may differ greatly from individuals living in Colorado. Similarly, participation rates and success rates could vary widely from the rates used in the cost-benefit analysis and could be influenced by outside factors, such as the economy or weather.

9. REFERENCES

Alliance Commission on National Energy Efficiency Policy. (2013). Energy 2030: Recommendations to double U.S. energy productivity by 2030. *Alliance to Save Energy*. Retrieved from: https://www.ase.org/sites/ase.org/files/report_summary.pdf.

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics, 95*(9), 1082-1095.

Allcott, H. & Greenstone, M. (2012). Is there an energy efficiency gap? *Journal of Economic Perspectives, 26*(1), 3-28.

Allcott, H., & Mullainathan, S. (2010). Behavior and energy policy. *Science, 327*(5970), 1204-1205.

American Council for an Energy-Efficiency Economy (ACEEE). (2013a). State energy efficiency resource standard (EERS) activity. Retrieved from: http://aceee.org/files/pdf/policy-brief/eers-07-2013.pdf

American Council for an Energy-Efficiency Economy (ACEEE). (2013b). The state energy efficiency scorecard. Retrieved from: http://www.aceee.org/state-policy/scorecard.

Appelbaum, L & Cuciti, P. (2003). Electricity generation, renewable energy, and environmental considerations: Results of a Colorado Survey. *U.C. Denver: The Wells Fargo Public Opinion Research Program.*

Arimura, Toshi; Li, Shanjun; Newewll, Richard; & Palmer, Karen. (2012). Cost-effectiveness of electricity energy efficiency programs. *The Energy Journal, 33*(2), 63-99.

Armel, C. (2008). Behavior and energy. *Behavior, Energy, and Climate Change Conference.* Opening Plenary. Sacramento, CA, November 2008.

Arnold, S., Dileo, J., & Takushi, T. (2013). Colorado greenhouse gas inventory- 2013 update including projections to 2020 and 2030. Colorado Department of Public Health and Environment.

Ayres, I., Raseman, S., Shih, A., & National Bureau of Economic Research. (2009). Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage. Cambridge, Mass: National Bureau of Economic Research.

Barbose, G., Goldman, C. & Schlegal, J. (2009) The shifting landscape of ratepayer-funded energy efficiency in the U.S. *The Electricity Journal, 22*(8), 29-44.

Blumstein, C., Goldman, C., & Barbose, G. (2005). Who should administer energy-efficiency programs? *Energy Policy, 33*(8), 1053-1067.

Borenstein, S. (2009). To what electricity price do consumers respond? Residential demand elasticity under increasing-block pricing. *University of California, Berkeley.*

California Standard Practice Manual. (October 2001). Economic analysis of demand-side programs and projects. Available at: http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF

Center for Connected Health. (2010). Wireless medication adherence study conducted at the partners center for connected health shows promising initial findings. Retrieved from: http://www.connected-health.org/media-center/press-releases/wireless-medication-adherence-study-conducted-at-the-partners-center-for-connected-health-shows-promising-initial-findings.aspx

Clean Energy Action. (2014). Xcel's coal plants. Retrieved from: http://cleanenergyaction.org/learn-more/colorado-coal-plants/.

Colorado College. (2013). State of the rockies: Conservation in the west poll-Colorado report. Retrieved from: http://www.coloradocollege.edu/other/stateoftherockies/documents/11_12-documents/conservation-in-the-west-poll/coloradoreport.pdf

Colorado College. (2012). State of the rockies: Conservation in the west poll-Colorado report. Retrieved from: http://www.coloradocollege.edu/other/stateoftherockies/documents/11_12-documents/conservation-in-the-west-poll/coloradoreport.pdf

Colorado Department of Local Affairs (DOLA). (2014). Population forecasts years 2000-2040. Retrieved from: http://www.colorado.gov/cs/Satellite?c=Page&childpagename=DOLA-Main%2FCBONLayout&cid=1251593346834&pagename=CBONWrapper. Retrieved on March 1, 2014.

Colorado Department of Regulatory Agencies (DORA). (2014). About regulated electric utility service. Retrieved from: http://cdn.colorado.gov/cs/Satellite/DORA-PUC/CBON/DORA/1251632683058.

Colorado Energy Office. (2009). Connecting Colorado's renewable resources to the markets in a carbon-constrained electricity sector.

Colorado Legislative Council. (2014). Focus Colorado: Economic and revenue report. Retrieved from: http://www.colorado.gov/cs/Satellite/CGA-LegislativeCouncil/CLC/1251651104206.

Colorado Public Utilities Commission (COPUC). (2011). Decision No. C11-0442, DOCKET NO. 10A-554EG.

Congressional Budget Office. (2012). Energy Security in the United States. Retrieved from: www.cbo.gov/publication/43012.

Cooper, A., Han, L., &Wood, L. (2012). Green Button: One year later. *Innovation Energy Efficiency: An Institute of the Edison Foundation.* IEE Issue Brief.

Database of State Incentives for Renewables and Efficiency (DSIRE). (2012). Colorado incentives/policy for renewables and efficiency: Energy efficiency resource standard. Retrieved from: http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=CO46R&re=0&ee=0.

Daykin, E., Aiona, J., & Hedman, B. (2012). Picking a standard: Implications of differing TRC requirements. *The Cadmus Group.* Available at: http://www.cadmusgroup.com/wp-content/uploads/2012/11/Picking-a-Standard.pdf

Depuru, S., Wang, L., & Devabhaktuni, V. (2011). Smart meters for power grid: Challenges, issues, advantages and status. *Renewable and Sustainable Energy Reviews, 15*(6), 2736-2742.

Diamond, R. & Moezzi, M. (2004). Changing trends: A brief history of the US household consumption of energy, water, food, beverages, and tobacco. 2004 ACEEE Summer Study on Energy Efficiency in Buildings.

Ebinger, C & Banks, J. (2013). The electricity revolution. *The Brookings Institute.* Retrieved from: http://www.brookings.edu/research/reports/2013/11/06-electricity-revolution-ebinger-banks

Ehrhardt-Martinez, K. (2011) Changing habits, lifestyles, and choices: The behaviors that drive feedback-induced energy savings. In Proceedings of the 2011 ECEEE Summer Study on Energy Efficiency in Buildings, Toulon, France, 6–11 June 2011; ECEEE: Stockholm, Sweden, 2011.

Energy Information Administration. (EIA). (2012a). Colorado electricity profile 2010. Retrieved from: http://www.eia.gov/electricity/state/colorado/pdf/colorado.pdf.

Energy Information Administration (EIA). (2012b). Annual energy review. Retrieved from: http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0813

Energy Information Administration (EIA). (2013). Household energy usage in Colorado. Retrieved from: http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/co.pdf

Energy Information Administration (EIA). (2013b). State-level energy-related carbon dioxide emissions, 2000-2010. Retrieved from: http://www.eia.gov/environment/emissions/state/analysis/pdf/stateanalysis.pdf.

Energy Information Administration (EIA). (2014). State energy data system (SEDS).

EnerNOC Utility Solutions Consulting. (2013). Preliminary impact evaluation of Xcel Energy's in-home smart device pilot based on summer 2012. Retrieved from: https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM/CO-2012-In-Home-Smart-Device-Pilot-Impact-Evaluation.pdf

Environmental Protection Agency (EPA). (2012). Overview of greenhouse gases: Carbon dioxide emissions. Retrieved from: http://www.epa.gov/climatechange/ghgemissions/sources.html.

Environmental Protection Agency (EPA). (2013b). Air emissions. Retrieved from: http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html.

Environmental Protection Agency (EPA). (2014). Greenhouse gas equivalencies calculator. Retrieved from: http://www.epa.gov/cleanenergy/energy-resources/calculator.html. Retrieved on February, 1, 2014.

Eto, J., Goldman, C., & Kito, S. (1996). Ratepayer-funded energy-efficiency programs in a restructured electricity industry: Issues, options, and unanswered questions. *Lawrence Berkeley National Laboratory.* Sponsored by U.S. Department of Energy.

Faruqui, A.; Mitrotonda, D.; Wood, L.; Cooper, A.; & Schwartz, J. (2011). The costs and benefits of smart meters for residential customers. The Edison Foundation: Institute for Electric Efficiency Whitepaper

Fleischman L, Cleetus R, Deyette J, Clemmer S and Frenkel S. (2013). Ripe for retirement: an economic analysis of the U.S. coal fleet *The Electricity Journal 26*(10): 51-63.

Foster, J.B., Clark, B., & York, R. (2010). Capitalism and the curse of energy efficiency: The return of the jevons paradox. *Monthly Review,62*(6), 1-12.

Giberson, Dr. Michael. (2011) Worried about too much demand elasticity in electric power markets. *The Energy Collective.* http://theenergycollective.com/michaelgiberson/62698/worried-about-too-much-demand-elasticity-electric-power-markets.

Gillingham, K., Newell, R., & Palmer, K. (2009). Energy efficiency economics and policy. *Resources for the Future.* (RFF DP 09-13). Available at: http://ssrn.com/abstract=1372872.

Gillingham, K., Palmer, K. (2013): Bridging the energy efficiency gap: Insights for policy from economic theory and empirical analysis. Discussion Papers dp-13-02, *Resources for the Future.*

Golove, W & J. Eto. (1996). "Market Barriers to Energy Efficiency: a Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency." Lawrence Berkeley National Laboratory (LBNL).

Green Button. (2014). About. Retrieved from: http://www.greenbuttondata.org/greenabout.html.

Han, L. (2012). Green Button Program: An analysis of business opportunities. *Erb Institute for Global Sustainable Enterprise.*

Harris, J. M., and B. Roach. (2009). *The Economics of Global Climate Change*. Global Development and Environment Institute, Tufts University.

Herring, H. (2006). Energy efficiency—a critical view. *Energy,31*(1), 10-20.

Institute for Electric Efficiency. (2011). The costs and benefits of smart meters for residential customers. *The Edison Foundation-* IEE White Paper.

Institute for Electric Efficiency. (2012). State electric efficiency regulatory frameworks. *The Edison Foundation.*

Institute for Energy Research (IER). (2013). Colorado: An energy and economic analysis. Retrieved from: http://www.instituteforenergyresearch.org/2013/09/10/colorado-an-energy-and-economic-analysis/.

International Energy Agency (IEA). (2013). Topic: Energy security. Retrieved from: www.iea.org/topics/energysecurity.

International Energy Agency (IEA). (2007). Mind the gap. http://www.iea.org/publications/freepublications/publication/mind_the_gap.pdf

Ito, K. (forthcoming). Nonlinear pricing in energy and environmental markets. *American Economic Review.*

Jaffe, A. & R. Stavins. (1994). Energy-efficiency investments and public policy." *The Energy Journal 15* (2): 43-65.

Jessoe, K., Rapson, D. (2013). Knowledge is (less) power: Experimental evidence from residential energy use. Working Paper 18344, *National Bureau of Economic Research.*

Jessoe, K., Rapson, D., & Smith, E. J. B. (2013). Are residential electricity consumers utility maximizers? Evidence from a natural experiment. Forthcoming *Journal of Economic Behavior and Organization.*

Khurana, H., Hadley, M., Ning Lu, & Frincke, D. A. (2010). Smart-grid security issues. *IEEE Security&Privacy Magazine,7*(1), 81-85.

Laitner, J., Nadal, S., Elliott, N., Sachs, H., & Khan, A. (2012). The long-term energy efficiency potential: What the evidence suggests. *American Council for an Energy-Efficiency Economy.* Research Report E121.

Linares, P., & Labandeira, X. (2010). Energy efficiency: Economics and policy. *Journal of Economic Surveys, 24*(3), 573-592.

Lutzenhiser, L; Kunkle, R.; Woods, J.; & Lutzenhiser, S. (2003). Conservation behavior by residential consumers during and after the 2000-2001 California energy crisis. Appendix A in Public Interest Energy Strategies Report. (100-03-012F). California Energy Commission.

McDaniel, P., & McLaughlin, S. (2009). Security and privacy challenges in the smart grid. *IEEE Security & Privacy Magazine, 7*(3), 75-77.

McKinsey and Co. (2009) Unlocking energy efficiency in the United States economy.

Mendyk, A., Kihm, S., & Pigg, S. (2010). A reflection of ourselves…How households interact with in-home feedback devices: Results from a treatment/control experiment. *Energy Center of Wisconsin.* Retrieved from: http://www.ecw.org/ecwresults/aceee/powercostmonitor.pdf

Mills, M. (2013). Information technology has created a new electric paradigm. *Forbes Magazine.* Available at: http://www.forbes.com/sites/markpmills/2013/01/08/information-technology-has-created-a-new-electric-demand-paradigm/

Nemet, G. F., Holloway, T., & Meier, P. (2010). Implications of incorporating air-quality co-benefits into climate change policymaking. *Environmental Research Letters, 5*(1), 014007-014007.

New England Healthcare Institute (NEHI). (2009). NEHI research shows patient medication nonadherence costs health care system $290 billion annually. Retrieved from: http://www.nehi.net/news/press releases/110/nehi_research_shows_patient_medication_nonadherence_costs_health_care_system_290_billion

OPower. (2014). Results. Accessed on January 29, 2014. Retrieved from: http://opower.com/utilities/results/.

PA Consulting Group. (2010). Cape Light Compact: Residential smart energy monitoring pilot final report. Prepared for Cape Light Compact.

Pacific Gas and Electric Company. (2013). Smart grid annual report- 2013. Order Instituting Rulemaking 08-12-009. California Public Utilities Commission. Retrieved from: http://www.smartgridinformation.info/pdf/5252_doc_1.pdf.

Perfect Power Institute. (2013). Investing in grid modernization: The business case for empowering consumers, communities, and utilities. Retrieved from: http://www.perfectpowerinstitute.org/sites/default/files/PPI%20Grid%20Modernization%20Report%20031813.pdf

Pimentel, D., Jackson, A., Lee, M., Eaton, A., Pleasant, A., Barron, J., Schiavoni, C. (2003). US energy conservation and efficiency: Benefits and costs. *Environment, Development and Sustainability, 6*(3), 279-305.

Pollitt, M. & Shaorshadze, I. (2011) The role of behavioral economics in climate and energy policy. *University of Cambridge Electricity Policy Research Group.*

Ross, M. 2013. How the 1973 oil shock saved the planet. *Foreign Affairs.* Retrieved from: http://www.foreignaffairs.com/articles/140173/michael-l-ross/how-the-1973-oil-embargo-saved-the-planet

Sacramento Municipal Utility District. (2014). Common questions about smart meters. Accessed January 29, 2014. Retrieved from: https://www.smud.org/en/residential/customer-service/smart-meters/common-questions.htm.

San Diego Gas and Electric. (2013). [Press Release]: SDG&E introduces three new green button apps to help customers save energy. Retrieved from: http://www.sdge.com/newsroom/press-releases/2013-05-01/sdge-introduces-three-new-green-button-apps-help-customers-save.

Simonoff, J.; Restrepo, C.; Zimmerman, R.; Remington, W.; Lave, L.; Schuler, R.; and Dooskin, N. (2005). Electricity case: Statistical analysis of electric power outages" (2005). *Create Homeland Security Center, Center for Risk and Economic Analysis of Terrorism Event, University of Southern California.*

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller. (2007). "IPCC: Summary for Policymakers." *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK.

Southwest Energy Efficiency Project (SWEEP). (2002). The new mother lode: The potential for more efficient electricity use in the southwest.

Southwest Energy Efficiency Project (SWEEP). (2011). Colorado energy fact sheet.

Southwest Energy Efficiency Project (SWEEP). (2012). The $20 billion bonanza: Best practice electric utility energy efficiency programs and their benefits for the southwest. Retrieved from:

Stocker, T., Qin, Plattner, Tignor, Allen, Boschung, Nauels, Xia, Bex & Midgley. (2013). IPCC, 2013: Summary for policymakers. In: Climate change 2013: The physical science basis. *Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK.

Thaler, R. (2012). Watching behavior before writing the rules. *The NY Times.* Retrieved from: http://www.nytimes.com/2012/07/08/business/behavioral-science-can-help-guide-policy-economic-view.html?pagewanted=all.

The White House, Office of Press Secretary (2013). President Obama's blueprint for a clean and secure energy future. Retrieved from: http://www.whitehouse.gov/the-press-office/2013/03/15/fact-sheet-president-obama-s-blueprint-clean-and-secure-energy-future.

Tonn, B., & Peretz, J. (2007). State-level benefits of energy efficiency. *Energy Policy, 35*(7), 3665-3674.

United States Government- Interagency Working Group on Social Cost of Carbon. (2013). Technical support document: Technical update of the social cost of carbon for regulatory impact analysis- under Executive Order 12866.

U.S. Department of Energy. (2009). The smart grid: An introduction. Retrieved from: http://energy.gov/oe/downloads/smart-grid-introduction-0

U.S. Global Change Research Program (USGCRP). (2009). Global climate change impacts in the United States: Second national climate assessment. Retrieved from: http://www.globalchange.gov/resources/reports.

Xcel Energy. (2012). 2012 Colorado demand-side management annual status report. Available at http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM-2012-Annual-Status-Report.pdf

Xcel Energy (2013a). Docket No. 13A-0686EG: 2013 DSM strategic issues application.

Xcel Energy (2013b). Docket No. 13A-0686EG: Direct testimony of Debra Sundin.

Xcel Energy. (2013c). 2014 demand-side management plan: Electric and natural gas.

Xcel Energy. (2013d) 2014 renewable energy standard plan. Exhibit No. RLK-1. (Vol. 1).

Alternative 2: SMART METERS

BENEFITS				
Inputs	**Statistic**		**Source/ Calculation**	
Number of Households	2000	A	Author Estimate	
Status Quo Energy Use-kWh per month per household	706	B	Energy Information Administraion; (Data from form EIA-861)	
Status Quo Energy Use- kWh per year per household	8472	C	B * 12 months	
Status Quo Energy Use- kW-yr per year per household	0.967	D	C/8760 (1kWh/8760 = 1kW-yr)	
Total Status Quo Energy Use kWh	16944000	E	A * C	
Total Status Quo Energy Use kW-yr	1934	F	A * D	
Success Rate	3.00%	G	Xcel Energy pilot program: (EnerNOC, 2013)	
Gross kWh avoided	508320.00	H	G * E	
Gross kW-yr avoided	58.03	I	G * F	
Gross MWh avoided	508.32	J	G/1000 (1 kWh/1000 = 1 MWh)	
Average electricity price-Residential (cents/kWh)	0.1165	K	Energy Information Administraton; (Data from form EIA-861)	
Discount rate	5%	L	Arimura et al., 2012	
Inflation	2.9%	M	Colorado Legislative Council December 2013 Economic Forecast	
Metric tons of CO2 per kWh	0.00070555	N	EPA Greenhouse Gas Equivalencies Calculator	
Kilowatt hours saved to CO2 tons	358.65	O	N * H	
Cost per ton of CO2 avoided	40.00	P	United States Government, 2013	
Improved reliability and grid modernization (cents/kWh save	0.0201	Q	Perfect Power Institute, 2013, p. 14	
Measurements	**Formula**		**Source**	**Escalator**
Avoided metering reading costs	$5 * A		Institute for Electric Efficiency, 2011 (The Costs and Benefits of Smart Meters for Residential Customer	2.90%
Generation Capacity	$50 per kW-year * I		Institute for Electric Efficiency, 2011 (The Costs and Benefits of Smart Meters for Residential Customer	2.36%
Transmission & Distribution Capacity	$30 per kW-year * I		Xcel Energy 2012 CO DSM Annual Report	2.36%
Marginal Energy	J * average cost to produce electricity		Xcel Energy 2012 CO DSM Annual Report	See Marginal Energy Inputs
Improved Reliability and Grid Modernization	Q * H		Perfect Power Institute, 2013	2.90%
Avoided Emissions CO2	P * O		EPA Greenhouse Gas Equivalencies Calculator	2.90%
Non-Energy Benefits Adder (10.2%)	10.2 % of utility benefits		Xcel Energy 2012 CO DSM Annual Report	None
Bill Reduction -Electric	K * H			2.90%
Participant Rebates and Incentives	$0			
COSTS				
Inputs				
Utility Project Cost per particpant				
Program, Planning, and Design per participant	$ 0.91	R	Xcel Energy 2012 CO DSM Annual Report: $925/1,011 participants	
Administration and Program Delivery	$ 519.82	S	Xcel Energy 2012 CO DSM Annual Report: $525540/1,011 participants	
Administration, Promotion, and Consumer Ed.	$ 22.36	T	Xcel Energy 2012 CO DSM Annual Report: $22,601/1,011 participants	
Particpant Rebates and Incentives	$ -	U	Xcel Energy 2012 CO DSM Annual Report: $0/1,011 participants	
Equipment and Installation	$ 1,083.49	V	Xcel Energy 2012 CO DSM Annual Report: $1095410/1,011 participants	
Measurement and Verficiation	$ 7.88	W	Xcel Energy 2012 CO DSM Annual Report: $7969/1,011 participants	
Total Per Participant 2012 Dollars	**$ 1,634.47**			
Cumulative Rate of Inflation 2012-2014	2.3%		US Governmnet Consumer-Price Index Data; Inflation through February 2014	
Total Per Particpant 2014 Dollars	**$ 1,672.06**			
Operation and Maintenance Costs	$ 12.50	X		
Measurements	**Formula**		**Source**	**Escalator**
Utility Project Cost				
Program, Planning, and Design per participant	R * A			
Administration and Program Delivery	S * A			
Administration, Promotion, and Consumer Ed.	T * A			
Particpant Rebates and Incentives	U * A			
Equipment and Installation	V * A			
Measurement and Verficiation	W * A			
Utility Revenue Reduction				
Revenue Reduction	K * H			2.90%
Particpant Costs				
Incremental Capital Costs	$0			2.90%
Incremental O&M Costs	X * A			2.90%

Amy Laughlin
Nudge the Meter

Alternative 2: SMART METERS

NPV Cost-Benefit Summary Analysis

	1	2	3	4	5	6	7	8	9	10
BENEFITS										
Utility Benefits										
Avoided Meter Reading Costs	$ 10,000.00	$ 10,290.00	$ 10,588.41	$ 10,895.47	$ 11,211.44	$ 11,536.57	$ 11,871.14	$ 12,215.40	$ 12,569.64	$ 12,934.16
Generation Capacity	$ 2,901.37	$ 2,969.84	$ 3,039.93	$ 3,111.67	$ 3,185.11	$ 3,260.28	$ 3,337.22	$ 3,415.98	$ 3,496.59	$ 3,579.11
Transmission & Distribution Capacity	$ 1,740.82	$ 1,781.91	$ 1,823.96	$ 1,867.00	$ 1,911.06	$ 1,956.17	$ 2,002.33	$ 2,049.59	$ 2,097.96	$ 2,147.47
Marginal Energy	$ 30,641.53	$ 33,020.47	$ 34,685.22	$ 35,363.82	$ 36,675.29	$ 38,121.46	$ 39,435.47	$ 40,843.51	$ 42,566.72	$ 44,429.71
Improved Reliability and Grid Modernization	$ 508,320.02	$ 523,061.30	$ 538,230.08	$ 553,838.75	$ 569,900.07	$ 586,427.18	$ 603,433.56	$ 620,933.14	$ 638,940.20	$ 657,469.46
Avoided Emissions CO2	$ 14,345.81	$ 14,761.84	$ 15,189.93	$ 15,630.44	$ 16,083.72	$ 16,550.15	$ 17,030.10	$ 17,523.97	$ 18,032.17	$ 18,555.10
Subtotal	$ 567,949.55	$ 585,885.35	$ 603,557.52	$ 620,707.16	$ 638,966.70	$ 657,851.80	$ 677,109.82	$ 696,981.59	$ 717,703.28	$ 739,115.02
Non-Energy Benefits Adder (10.2%)	$ 57,930.85	$ 59,760.31	$ 61,562.87	$ 63,312.13	$ 65,174.60	$ 67,100.88	$ 69,065.20	$ 71,092.12	$ 73,205.73	$ 75,389.73
Subtotal	$ 625,880.40	$ 645,645.66	$ 665,120.39	$ 684,019.29	$ 704,141.30	$ 724,952.68	$ 746,175.02	$ 768,073.71	$ 790,909.02	$ 814,504.76
Particpant Benefits										
Bill Reduction -Electric	$ 59,219.28	$ 60,936.64	$ 62,703.80	$ 64,522.21	$ 66,393.36	$ 68,318.76	$ 70,300.01	$ 72,338.71	$ 74,436.53	$ 76,595.19
Participant Rebates and Incentives	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Subtotal	$ 59,219.28	$ 60,936.64	$ 62,703.80	$ 64,522.21	$ 66,393.36	$ 68,318.76	$ 70,300.01	$ 72,338.71	$ 74,436.53	$ 76,595.19
TOTAL BENEFITS	$ 685,099.68	$ 706,582.30	$ 727,824.19	$ 748,541.50	$ 770,534.66	$ 793,271.45	$ 816,475.03	$ 840,412.42	$ 865,345.55	$ 891,099.95
COSTS										
Utility Project Costs										
Program Planning & Design	$ 1,871.96	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Administration & Program Delivery	$ 1,063,555.73	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Advertising/Promotion/Customer	$ 45,738.52	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Particpant Rebates and Incentives	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Equipment and Installation	$ 2,216,823.80	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Measurement and Verficiation	$ 16,127.18	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ 3,344,117.18	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Utility Revenue Reduction										
Revenue Reduction	$ 59,219.28	$ 60,936.64	$ 62,703.80	$ 64,522.21	$ 66,393.36	$ 68,318.76	$ 70,300.01	$ 72,338.71	$ 74,436.53	$ 76,595.19
Subtotal	$ 59,219.28	$ 60,936.64	$ 62,703.80	$ 64,522.21	$ 66,393.36	$ 68,318.76	$ 70,300.01	$ 72,338.71	$ 74,436.53	$ 76,595.19
Particpant Costs										
Incremental Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Incremental O&M Costs	$ 25,000.00	$ 25,725.00	$ 26,471.03	$ 27,238.68	$ 28,028.61	$ 28,841.44	$ 29,677.84	$ 30,538.50	$ 31,424.11	$ 32,335.41
Subtotal	$ 25,000.00	$ 25,725.00	$ 26,471.03	$ 27,238.68	$ 28,028.61	$ 28,841.44	$ 29,677.84	$ 30,538.50	$ 31,424.11	$ 32,335.41
TOTAL COSTS	$ 3,428,336.46	$ 86,661.64	$ 89,174.83	$ 91,760.90	$ 94,421.96	$ 97,160.20	$ 99,977.85	$ 102,877.20	$ 105,860.64	$ 108,930.60
NET BENEFIT	$ (2,743,236.78)	$ 619,920.66	$ 638,649.36	$ 656,780.61	$ 676,112.69	$ 696,111.25	$ 716,497.18	$ 737,535.21	$ 759,484.91	$ 782,169.35
BENEFIT/COST RATIO	0.20	$ 8.15	$ 8.16	$ 8.16	$ 8.16	$ 8.16	$ 8.17	$ 8.17	$ 8.17	$ 8.18
Discount Rate 5%	*1.00*	*1.05*	*1.10*	*1.16*	*1.22*	*1.28*	*1.34*	*1.41*	*1.48*	*1.55*
DISCOUNTED NET BENEFIT	$ (2,743,236.78)	$ 590,400.63	$ 579,273.80	$ 567,351.78	$ 556,239.59	$ 545,421.38	$ 534,661.23	$ 524,152.51	$ 514,049.28	$ 504,193.33

	11	12	13	14	15	16	17	18	19	20	TOTAL LIFETIME
BENEFITS											
Utility Benefits											
Avoided Meter Reading Costs	$ 13,309.26	$ 13,695.22	$ 14,092.38	$ 14,501.06	$ 14,921.59	$ 15,354.32	$ 15,799.60	$ 16,257.78	$ 16,729.26	$ 17,214.41	$ 265,987.14
Generation Capacity	$ 3,663.58	$ 3,750.04	$ 3,838.54	$ 3,929.13	$ 4,021.86	$ 4,116.78	$ 4,213.93	$ 4,313.38	$ 4,415.18	$ 4,519.37	$ 73,078.91
Transmission & Distribution Capacity	$ 2,198.15	$ 2,250.03	$ 2,303.13	$ 2,357.48	$ 2,413.12	$ 2,470.07	$ 2,528.36	$ 2,588.03	$ 2,649.11	$ 2,711.62	$ 43,847.34
Marginal Energy	$ 46,246.95	$ 47,398.30	$ 47,245.80	$ 47,769.37	$ 49,152.00	$ 50,671.88	$ 52,329.00	$ 53,541.35	$ 54,756.23	$ 56,344.16	$ 881,238.23
Improved Reliability and Grid Modernization	$ 676,536.08	$ 696,155.63	$ 716,344.14	$ 737,118.12	$ 758,494.54	$ 780,490.89	$ 803,125.12	$ 826,415.75	$ 850,381.81	$ 875,042.88	$ 13,520,658.72
Avoided Emissions CO2	$ 19,093.20	$ 19,646.90	$ 20,216.66	$ 20,802.95	$ 21,406.23	$ 22,027.01	$ 22,665.80	$ 23,323.10	$ 23,999.47	$ 24,695.46	$ 381,580.02
Subtotal	$ 761,047.22	$ 782,896.12	$ 804,040.66	$ 826,478.11	$ 850,409.35	$ 875,130.94	$ 900,661.81	$ 926,439.39	$ 952,931.06	$ 980,527.91	$ 15,166,390.36
Non-Energy Benefits Adder (10.2%)	$ 77,626.82	$ 79,855.40	$ 82,012.15	$ 84,300.77	$ 86,741.75	$ 89,263.36	$ 91,867.50	$ 94,496.82	$ 97,198.97	$ 100,013.85	$ 1,546,971.82
Subtotal	$ 838,674.04	$ 862,751.52	$ 886,052.81	$ 910,778.88	$ 937,151.10	$ 964,394.30	$ 992,529.31	$ 1,020,936.21	$ 1,050,130.02	$ 1,080,541.76	$ 16,713,362.17
Particpant Benefits											
Bill Reduction -Electric	$ 78,816.45	$ 81,102.13	$ 83,454.09	$ 85,874.26	$ 88,364.61	$ 90,927.18	$ 93,564.07	$ 96,277.43	$ 99,069.48	$ 101,942.49	$ 1,575,156.68
Participant Rebates and Incentives	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Subtotal	$ 78,816.45	$ 81,102.13	$ 83,454.09	$ 85,874.26	$ 88,364.61	$ 90,927.18	$ 93,564.07	$ 96,277.43	$ 99,069.48	$ 101,942.49	$ 1,575,156.68
TOTAL BENEFITS	$ 917,490.49	$ 943,853.65	$ 969,506.89	$ 996,653.14	$ 1,025,515.71	$ 1,055,321.48	$ 1,086,093.39	$ 1,117,213.64	$ 1,149,199.50	$ 1,182,484.25	$ 18,288,518.85
COSTS											
Utility Project Costs											
Program Planning & Design	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Administration & Program Delivery	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Advertising/Promotion/Customer	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Particpant Rebates and Incentives	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Equipment and Installation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Measurement and Verficiation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,344,117.18
Utility Revenue Reduction											
Revenue Reduction	$ 78,816.45	$ 81,102.13	$ 83,454.09	$ 85,874.26	$ 88,364.61	$ 90,927.18	$ 93,564.07	$ 96,277.43	$ 99,069.48	$ 101,942.49	$ 1,575,156.68
Subtotal	$ 78,816.45	$ 81,102.13	$ 83,454.09	$ 85,874.26	$ 88,364.61	$ 90,927.18	$ 93,564.07	$ 96,277.43	$ 99,069.48	$ 101,942.49	$ 1,575,156.68
Particpant Costs											
Incremental Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Incremental O&M Costs	$ 33,273.14	$ 34,238.06	$ 35,230.96	$ 36,252.66	$ 37,303.99	$ 38,385.80	$ 39,498.99	$ 40,644.46	$ 41,823.15	$ 43,036.02	$ 276,945.08
Subtotal	$ 33,273.14	$ 34,238.06	$ 35,230.96	$ 36,252.66	$ 37,303.99	$ 38,385.80	$ 39,498.99	$ 40,644.46	$ 41,823.15	$ 43,036.02	$ 276,945.08
TOTAL COSTS	$ 112,089.59	$ 115,340.19	$ 118,685.05	$ 122,126.92	$ 125,668.60	$ 129,312.99	$ 133,063.06	$ 136,921.89	$ 140,892.63	$ 144,978.51	$ 5,584,241.70
											20-Year Net Benefit
NET BENEFIT	$ 805,400.90	$ 828,513.46	$ 850,821.84	$ 874,526.22	$ 899,847.12	$ 926,008.49	$ 953,030.32	$ 980,291.75	$ 1,008,306.87	$ 1,037,505.73	$ 12,704,277.15
BENEFIT/COST RATIO	$ 8.19	$ 8.18	$ 8.17	$ 8.16	$ 8.16	$ 8.16	$ 8.16	$ 8.16	$ 8.16	$ 8.16	$ 3.28
Discount Rate 5%	*1.63*	*1.71*	*1.80*	*1.89*	*1.98*	*2.08*	*2.18*	*2.29*	*2.41*	*2.53*	**20-Year Discounted Net Benefit**
DISCOUNTED NET BENEFIT	$ 494,446.29	$ 484,414.66	$ 473,769.44	$ 463,779.93	$ 454,483.94	$ 445,425.92	$ 436,594.17	$ 427,698.04	$ 418,972.33	$ 410,576.25	$ 6,682,667.71

1-year	$ (2,743,236.78)
5-year	$ (449,970.99)
10-year	$ 2,172,506.74
15-year	$ 4,543,400.99
20-year	$ 6,682,667.71

Alternative 3: ENERGY FEEDBACK REPORTS				
BENEFITS				
Inputs	**Statistic**		**Source/ Calculation**	
Number of Households	250,000	A	Author Estimate	
Status Quo Energy Use-kWh per month per household	706	B	Energy Information Administraion; (Data from form EIA-861)	
Status Quo Energy Use- kWh per year per household	8472	C	B * 12 months	
Status Quo Energy Use- kW-yr per year per household	0.967	D	C/8760 (1kWh/8760 = 1kW-yr)	
Total Status Quo Energy Use kWh	2118000000	E	A * C	
Total Status Quo Energy Use kW-yr	241781	F	A * D	
Success Rate	2.90%	G	Xcel Energy 2014 Demand-Side Management Plan	
Gross kWh avoided	61422000.00	H	G * E	
Gross kW-yr avoided	7011.64	I	G * F	
Gross MWh avoided	61422.00	J	G/1000 (1 kWh/1000 = 1 MWh)	
Average electricity price-Residential (cents/kWh)	0.1165	K	Energy Information Administraion; (Data from form EIA-861)	
Discount rate	5%	L	Arimura et al., 2012	
Inflation	2.9%	M	Colorado Legislative Council December 2013 Economic Forecast	
Metric tons of CO2 per kWh	0.00070555	N	EPA Greenhouse Gas Equivalencies Calculator	
Kilowatt hours saved to CO2 tons	43336.29	O	O * H	
Cost per ton of CO2 avoided	40.00	P	United States Government, 2013	
Measurements	**Formula**		**Source**	**Escalator**
Generation Capacity	$50 per kW-year * I		Institute for Electric Efficiency, 2011 (The Costs and Benefits of Smart Meters for Residential Custo	2.36%
Transmission & Distribution Capacity	$30 per kW-year * I		Xcel Energy 2012 CO DSM Annual Report	2.36%
Marginal Energy	* average cost to produce electricity		Xcel Energy 2012 CO DSM Annual Report	See Marginal Energy Input
Avoided Emissions CO2	P * O		EPA Greenhouse Gas Equivalencies Calculator	2.90%
Non-Energy Benefits Adder (10.2%)	10.2 % of utility benefits		Xcel Energy 2012 CO DSM Annual Report	None
Bill Reduction -Electric	K * H			2.90%
Participant Rebates and Incentives	$0			2.90%
COSTS				
Inputs				
Utility Project Cost per particpant				
Program, Planning, and Design per participant	$ 0.37	Q	Xcel Energy 2012 CO DSM Annual Report: $17003/46082 participants	
Administration and Program Delivery	$ 12.72	R	Xcel Energy 2012 CO DSM Annual Report: $586,176/46082 participants	
Administration, Promotion, and Consumer Ed.	$ -	S	Xcel Energy 2012 CO DSM Annual Report: $0/46082 participants	
Particpant Rebates and Incentives	$ -	T	Xcel Energy 2012 CO DSM Annual Report: $0/46082 participants	
Equipment and Installation	$ -	U	Xcel Energy 2012 CO DSM Annual Report: $0/46082 participants	
Measurement and Verficiation	$ -	V	Xcel Energy 2012 CO DSM Annual Report: $0/46082 participants	
Total Per Participant 2012 dollars	**$ 13.09**			
Cumulative Rate of Inflation 2012-2014	2.3%		US Governmnet Consumer-Price Index Data; Inflation through February 2014	
Total Per Participant 2014 dollars	$ 13.39			
Measurements	**Formula**		**Source**	**Escalator**
Utility Project Cost				
Program, Planning, and Design per participant	Q *A			2.90%
Administration and Program Delivery	R * A			2.90%
Administration, Promotion, and Consumer Ed.	S * A			2.90%
Particpant Rebates and Incentives	T * A			2.90%
Equipment and Installation	U * A			2.90%
Measurement and Verficiation	V * A			2.90%
Utility Revenue Reduction				
Revenue Reduction	K * H			2.90%
Particpant Costs				
Incremental Capital Costs	$0			2.90%
Incremental O&M Costs	$0			2.90%

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Alternative 3: ENERGY FEEDBACK REPORTS

NPV Cost-Benefit Summary Analysis

	1	2	3	4	5	6	7	8	9	10
BENEFITS										
Utility Benefits										
Generation Capacity	$ 3,071,100.00	$ 3,143,577.96	$ 3,217,766.40	$ 3,293,705.69	$ 3,371,437.14	$ 3,451,003.06	$ 3,532,446.73	$ 3,615,812.47	$ 3,701,145.65	$ 3,788,492.68
Transmission & Distribution Capacity	$ 210,349.32	$ 215,313.56	$ 220,394.96	$ 225,596.28	$ 230,920.35	$ 236,370.07	$ 241,948.41	$ 247,658.39	$ 253,503.13	$ 259,485.80
Marginal Energy	$ 3,702,518.16	$ 3,989,973.12	$ 4,191,130.17	$ 4,273,128.54	$ 4,431,597.30	$ 4,606,342.89	$ 4,765,118.76	$ 4,935,257.70	$ 5,143,478.28	$ 5,368,589.91
Avoided Emissions CO2	$ 1,733,451.68	$ 1,783,721.78	$ 1,835,449.71	$ 1,888,677.76	$ 1,943,449.41	$ 1,999,809.44	$ 2,057,803.92	$ 2,117,480.23	$ 2,178,887.16	$ 2,242,074.89
Subtotal	$ 8,717,419.16	$ 9,132,586.42	$ 9,464,741.24	$ 9,681,108.26	$ 9,977,404.20	$10,293,525.46	$10,597,317.81	$10,916,208.79	$11,277,014.21	$11,658,643.28
Non-Energy Benefits Adder (10.2%)	$ 889,176.75	$ 931,523.82	$ 965,403.61	$ 987,473.04	$ 1,017,695.23	$ 1,049,939.60	$ 1,080,926.42	$ 1,113,453.30	$ 1,150,255.45	$ 1,189,181.61
Subtotal	$ 9,606,595.91	$10,064,110.24	$10,430,144.85	$10,668,581.31	$10,995,099.43	$11,343,465.06	$11,678,244.23	$12,029,662.09	$12,427,269.66	$12,847,824.90
Particpant Benefits										
Bill Reduction -Electric	$ 7,155,663.00	$ 7,363,177.23	$ 7,576,709.37	$ 7,796,433.94	$ 8,022,530.52	$ 8,255,183.91	$ 8,494,584.24	$ 8,740,927.18	$ 8,994,414.07	$ 9,255,252.08
Participant Rebates and Incentives	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ 7,155,663.00	$ 7,363,177.23	$ 7,576,709.37	$ 7,796,433.94	$ 8,022,530.52	$ 8,255,183.91	$ 8,494,584.24	$ 8,740,927.18	$ 8,994,414.07	$ 9,255,252.08
TOTAL BENEFITS	$ 16,762,258.91	$17,427,287.46	$18,006,854.22	$18,465,015.24	$19,017,629.96	$19,598,648.97	$20,172,828.47	$20,770,589.27	$21,421,683.73	$22,103,076.98
COSTS										
Utility Project Costs										
Program Planning & Design	$ 94,364.77	$ 97,101.35	$ 99,917.29	$ 102,814.89	$ 105,796.52	$ 108,864.62	$ 112,021.69	$ 115,270.32	$ 118,613.16	$ 122,052.94
Administration & Program Delivery	$ 3,253,211.93	$ 3,347,555.07	$ 3,444,634.17	$ 3,544,528.56	$ 3,647,319.89	$ 3,753,092.17	$ 3,861,931.84	$ 3,973,927.86	$ 4,089,171.77	$ 4,207,757.75
Advertising/Promotion/Customer	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Particpant Rebates and Incentives	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Equipment and Installation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Measurement and Verficiation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ 3,347,576.69	$ 3,444,656.42	$ 3,544,551.46	$ 3,647,343.45	$ 3,753,116.41	$ 3,861,956.78	$ 3,973,953.53	$ 4,089,198.18	$ 4,207,784.93	$ 4,329,810.69
Utility Revenue Reduction										
Revenue Reduction	$ 7,155,663.00	$ 7,363,177.23	$ 7,576,709.37	$ 7,796,433.94	$ 8,022,530.52	$ 8,255,183.91	$ 8,494,584.24	$ 8,740,927.18	$ 8,994,414.07	$ 9,255,252.08
Subtotal	$ 7,155,663.00	$ 7,363,177.23	$ 7,576,709.37	$ 7,796,433.94	$ 8,022,530.52	$ 8,255,183.91	$ 8,494,584.24	$ 8,740,927.18	$ 8,994,414.07	$ 9,255,252.08
Particpant Costs										
Incremental Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Incremental O&M Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL COSTS	$ 10,503,239.69	$10,807,833.65	$11,121,260.82	$11,443,777.39	$11,775,646.93	$12,117,140.69	$12,468,537.77	$12,830,125.37	$13,202,199.00	$13,585,062.77
NET BENEFIT	$ 6,259,019.22	$ 6,619,453.82	$ 6,885,593.39	$ 7,021,237.86	$ 7,241,983.03	$ 7,481,508.28	$ 7,704,290.70	$ 7,940,463.91	$ 8,219,484.73	$ 8,518,014.20
BENEFIT/COST RATIO	$ 1.60	$ 1.61	$ 1.62	$ 1.61	$ 1.61	$ 1.62	$ 1.62	$ 1.62	$ 1.62	$ 1.63
Discount Rate 5%	*1.00*	*1.05*	*1.10*	*1.16*	*1.22*	*1.28*	*1.34*	*1.41*	*1.48*	*1.55*
DISCOUNTED NET BENEFIT	$ 6,259,019.22	$ 6,304,241.73	$ 6,245,436.19	$ 6,065,209.25	$ 5,957,997.36	$ 5,861,957.50	$ 5,749,060.34	$ 5,643,139.45	$ 5,563,270.80	$ 5,490,787.90

	11	12	13	14	15	16	17	18	19	20	TOTAL LIFETIME
BENEFITS											
Utility Benefits											
Generation Capacity	$ 3,877,901.11	$ 3,969,419.58	$ 4,063,097.88	$ 4,158,986.99	$ 4,257,139.08	$ 4,357,607.57	$ 4,460,447.10	$ 4,565,713.66	$ 4,673,464.50	$ 4,783,758.26	$ 77,354,023.50
Transmission & Distribution Capacity	$ 265,609.67	$ 271,878.05	$ 278,294.38	$ 284,862.12	$ 291,584.87	$ 298,466.27	$ 305,510.08	$ 312,720.11	$ 320,100.31	$ 327,654.68	$ 5,298,220.79
Marginal Energy	$ 5,588,173.56	$ 5,727,294.39	$ 5,708,867.79	$ 5,772,132.45	$ 5,939,200.29	$ 6,122,852.07	$ 6,323,087.79	$ 6,469,579.26	$ 6,616,377.84	$ 6,808,252.80	$ 106,482,953.07
Avoided Emissions CO2	$ 2,307,095.06	$ 2,374,000.81	$ 2,442,846.84	$ 2,513,689.40	$ 2,586,586.39	$ 2,661,597.39	$ 2,738,783.72	$ 2,818,208.45	$ 2,899,936.49	$ 2,984,034.65	$ 46,107,585.18
Subtotal	$12,038,779.39	$12,342,592.84	$12,493,106.88	$12,729,670.96	$13,074,510.63	$13,440,523.30	$13,827,828.69	$14,166,221.47	$14,509,879.14	$14,903,700.38	$ 235,242,782.54
Non-Energy Benefits Adder (10.2%)	$ 1,227,955.50	$ 1,258,944.47	$ 1,274,296.90	$ 1,298,426.44	$ 1,333,600.08	$ 1,370,933.38	$ 1,410,438.53	$ 1,444,954.59	$ 1,480,007.67	$ 1,520,177.44	$ 23,994,763.82
Subtotal	$13,266,734.89	$13,601,537.30	$13,767,403.79	$14,028,097.40	$14,408,110.71	$14,811,456.68	$15,238,267.21	$15,611,176.07	$15,989,886.81	$16,423,877.82	$ 259,237,546.36
Particpant Benefits											
Bill Reduction -Electric	$ 9,523,654.39	$ 9,799,840.37	$10,084,035.74	$10,376,472.78	$10,677,390.49	$10,987,034.81	$11,305,658.82	$11,633,522.92	$11,970,895.09	$12,318,051.05	$ 190,331,431.99
Participant Rebates and Incentives	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ 9,523,654.39	$ 9,799,840.37	$10,084,035.74	$10,376,472.78	$10,677,390.49	$10,987,034.81	$11,305,658.82	$11,633,522.92	$11,970,895.09	$12,318,051.05	$ 190,331,431.99
TOTAL BENEFITS	$22,790,389.28	$23,401,377.67	$23,851,439.52	$24,404,570.17	$25,085,501.20	$25,798,491.49	$26,543,926.03	$27,244,698.99	$27,960,781.90	$28,741,928.87	$ 449,568,978.34
COSTS											
Utility Project Costs											
Program Planning & Design	$ 125,592.48	$ 129,234.66	$ 132,982.46	$ 136,838.96	$ 140,807.28	$ 144,890.70	$ 149,092.53	$ 153,416.21	$ 157,865.28	$ 162,443.37	$ 2,509,981.46
Administration & Program Delivery	$ 4,329,782.73	$ 4,455,346.42	$ 4,584,551.47	$ 4,717,503.46	$ 4,854,311.06	$ 4,995,086.08	$ 5,139,943.58	$ 5,289,001.95	$ 5,442,383.00	$ 5,600,212.11	$ 86,531,252.88
Advertising/Promotion/Customer	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Particpant Rebates and Incentives	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Equipment and Installation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Measurement and Verficiation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ 4,455,375.20	$ 4,584,581.08	$ 4,717,533.93	$ 4,854,342.42	$ 4,995,118.35	$ 5,139,976.78	$ 5,289,036.11	$ 5,442,418.15	$ 5,600,248.28	$ 5,762,655.48	$ 89,041,234.34
Utility Revenue Reduction											
Revenue Reduction	$ 9,523,654.39	$ 9,799,840.37	$10,084,035.74	$10,376,472.78	$10,677,390.49	$10,987,034.81	$11,305,658.82	$11,633,522.92	$11,970,895.09	$12,318,051.05	$ 190,331,431.99
Subtotal	$ 9,523,654.39	$ 9,799,840.37	$10,084,035.74	$10,376,472.78	$10,677,390.49	$10,987,034.81	$11,305,658.82	$11,633,522.92	$11,970,895.09	$12,318,051.05	$ 190,331,431.99
Particpant Costs											
Incremental Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Incremental O&M Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL COSTS	$13,979,029.59	$14,384,421.45	$14,801,569.67	$15,230,815.19	$15,672,508.83	$16,127,011.59	$16,594,694.93	$17,075,941.08	$17,571,143.37	$18,080,706.53	$ 279,372,666.32
											20-Year Net Benefit
NET BENEFIT	$ 8,811,359.69	$ 9,016,956.22	$ 9,049,869.85	$ 9,173,754.98	$ 9,412,992.37	$ 9,671,479.90	$ 9,949,231.11	$10,168,757.91	$10,389,638.53	$10,661,222.34	$ 170,196,312.02
BENEFIT/COST RATIO	$ 1.63	$ 1.63	$ 1.61	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.59	$ 1.59	$ 1.61
Discount Rate 5%	*1.63*	*1.71*	*1.80*	*1.89*	*1.98*	*2.08*	*2.18*	*2.29*	*2.41*	*2.53*	**20-Year Discounted Net Benefit**
DISCOUNTED NET BENEFIT	$ 5,409,410.50	$ 5,272,027.55	$ 5,039,306.16	$ 4,865,038.13	$ 4,754,200.79	$ 4,652,147.19	$ 4,557,857.40	$ 4,436,595.39	$ 4,317,109.40	$ 4,219,007.70	$ 106,662,819.97

1-year	$ 6,259,019.22
5-year	$ 30,831,903.74
10-year	$ 59,140,119.74
15-year	$ 84,480,102.87
20-year	$ 106,662,819.97

Alternative 4: GREEN BUTTON INITIATIVE					
BENEFITS					
Inputs	**Statistic**		**Source/ Calculation**		
Number of Households	33,000	A	San Diego Gas & Electric Participation Estimate (1% of Xcel Energy's Residential Customers)		
Status Quo Energy Use-kWh per month per household	706	B	Energy Information Administraion; (Data from form EIA-861)		
Status Quo Energy Use- kWh per year per household	8472	C	B * 12 months		
Status Quo Energy Use- kW-yr per year per household	0.967	D	C/8760 (1kWh/8760 = 1kW-yr)		
Total Status Quo Energy Use kWh	279576000	E	A * C		
Total Status Quo Energy Use kW-yr	31915	F	A * D		
Success Rate	3.50%	G	Opower, 2014		
Gross kWh avoided	9785160.00	H	G * E		
Gross kW-yr avoided	1117.03	I	G * F	$	296.52
Gross MWh avoided	9785.16	J	G/1000 (1 kWh/1000 = 1 MWh)	$	33.98
Average electricity price-Residential (cents/kWh)	0.1146	K	Energy Information Administraion; (Data from form EIA-861)		
Discount rate	5%	L	Arimura et al., 2012		
Inflation	2.9%	M	Colorado Legislative Council December 2013 Economic Forecast		
Metric tons of CO2 per kWh	0.00070555	N	EPA Greenhouse Gas Equivalencies Calculator		
Kilowatt hours saved to CO2 tons	6903.92	O	N * H		
Cost per ton of CO2 avoided	40.00	P	United States Government, 2013		
Measurements	**Formula**		**Source**	**Escalator**	
Generation Capacity	$50 per kW-year * I		Institute for Electric Efficiency, 2011 (The Costs and Benefits of Smart Meters for Residential Custor	2.36%	
Transmission & Distribution Capacity	$30 per kW-year * I		Xcel Energy 2012 CO DSM Annual Report	2.36%	
Marginal Energy	J * average cost to produce electricity		Xcel Energy 2012 CO DSM Annual Report	See Marginal Energy Inputs	
Avoided Emissions CO2	P * O		EPA Greenhouse Gas Equivalencies Calculator	2.90%	
Non-Energy Benefits Adder (10.2%)	10.2 % of utility benefits		Xcel Energy 2012 CO DSM Annual Report	None	
Bill Reduction -Electric	K * H			2.90%	
Participant Rebates and Incentives	$0			2.90%	
COSTS					
Inputs	**Statistic**		**Source/ Calculation**	**Notes**	
Participant cost for 3rd part apps per year	$20	Q	San Diego Gas & Electric (cost for application service by EnergyAi)		
Utility Project Cost 2013 Dollars	$540,000	R	Pacific Gas and Electric, Smart Grid Annual Report 2013, p.20		
Utility Project Cost 2014 Dollars (Adjusted for 2013 inflati	$ 555,660.00	**S**	R * M		
Measurements	**Formula**		**Source**	**Escalator**	
Utility Project Cost	S		Pacific Gas and Electric, Smart Grid Annual Report 2013, p.20	None	
Utility Revenue Reduction					
Revenue Reduction	K * H			2.90%	
Particpant Costs					
Incremental Capital Costs	Q * A		San Diego Gas & Electric (cost for application service by EnergyAi)	2.90%	
Incremental O&M Costs	$0			2.90%	

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Alternative 4: GREEN BUTTON INITIATIVE

NPV Cost-Benefit Summary Analysis

	1	2	3	4	5	6	7	8	9	10	TOTAL LIFETIME
BENEFITS											
Utility Benefits											
Generation Capacity	$ 55,851.37	$ 57,169.46	$ 58,518.66	$ 59,899.70	$ 61,313.33	$ 62,760.33	$ 64,241.47	$ 65,757.57	$ 67,309.45	$ 68,897.95	$ 621,719.31
Transmission & Distribution Capacity	$ 33,510.82	$ 34,301.68	$ 35,111.20	$ 35,939.82	$ 36,788.00	$ 37,656.20	$ 38,544.88	$ 39,454.54	$ 40,385.67	$ 41,338.77	$ 373,031.59
Marginal Energy	$ 589,849.44	$ 635,643.99	$ 667,690.39	$ 680,753.58	$ 705,999.29	$ 733,838.07	$ 759,132.71	$ 786,237.61	$ 819,409.30	$ 855,271.91	$ 7,233,826.31
Avoided Emissions CO2	$ 276,156.79	$ 284,165.33	$ 292,406.13	$ 300,885.90	$ 309,611.60	$ 318,590.33	$ 327,829.45	$ 337,336.51	$ 347,119.26	$ 357,185.72	$ 3,151,287.02
Subtotal	$ 955,368.42	$ 1,011,280.47	$ 1,053,726.38	$ 1,077,479.01	$ 1,113,712.23	$ 1,152,844.93	$ 1,189,748.52	$ 1,228,786.23	$ 1,274,223.68	$ 1,322,694.36	$ 11,379,864.23
Non-Energy Benefits Adder (10.2%)	$ 97,447.58	$ 103,150.61	$ 107,480.09	$ 109,902.86	$ 113,598.65	$ 117,590.18	$ 121,354.35	$ 125,336.20	$ 129,970.82	$ 134,914.82	$ 1,160,746.15
Subtotal	$ 1,052,816.00	$ 1,114,431.07	$ 1,161,206.47	$ 1,187,381.87	$ 1,227,310.87	$ 1,270,435.12	$ 1,311,102.87	$ 1,354,122.42	$ 1,404,194.50	$ 1,457,609.18	$ 12,540,610.38
Particpant Benefits											
Bill Reduction -Electric	$ 1,121,379.34	$ 1,153,899.34	$ 1,187,362.42	$ 1,221,795.93	$ 1,257,228.01	$ 1,293,687.62	$ 1,331,204.56	$ 1,369,809.50	$ 1,409,533.97	$ 1,450,410.46	$ 12,796,311.13
Participant Rebates and Incentives	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal	$ 1,121,379.34	$ 1,153,899.34	$ 1,187,362.42	$ 1,221,795.93	$ 1,257,228.01	$ 1,293,687.62	$ 1,331,204.56	$ 1,369,809.50	$ 1,409,533.97	$ 1,450,410.46	$ 12,796,311.13
TOTAL BENEFITS	$ 2,174,195.34	$ 2,268,330.41	$ 2,348,568.89	$ 2,409,177.80	$ 2,484,538.88	$ 2,564,122.74	$ 2,642,307.43	$ 2,723,931.92	$ 2,813,728.47	$ 2,908,019.64	$ 25,336,921.51
COSTS											
Utility Project Costs	$ 555,660.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$555,660
Subtotal	$ 555,660.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$555,660
Utility Revenue Reduction											
Revenue Reduction	$ 1,121,379.34	$ 1,153,899.34	$ 1,187,362.42	$ 1,221,795.93	$ 1,257,228.01	$ 1,293,687.62	$ 1,331,204.56	$ 1,369,809.50	$ 1,409,533.97	$ 1,450,410.46	$ 12,796,311.13
Subtotal	$ 1,121,379.34	$ 1,153,899.34	$ 1,187,362.42	$ 1,221,795.93	$ 1,257,228.01	$ 1,293,687.62	$ 1,331,204.56	$ 1,369,809.50	$ 1,409,533.97	$ 1,450,410.46	$ 12,796,311.13
Particpant Costs											
Incremental Capital Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Incremental O&M Costs	$ 660,000.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 6,772,260.00
Subtotal	$ 660,000.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 679,140.00	$ 6,772,260.00
TOTAL COSTS	$ 2,337,039.34	$ 1,833,039.34	$ 1,866,502.42	$ 1,900,935.93	$ 1,936,368.01	$ 1,972,827.62	$ 2,010,344.56	$ 2,048,949.50	$ 2,088,673.97	$ 2,129,550.46	$ 20,124,231.13
											10-Year Net Benefit
NET BENEFIT	$ (162,844.00)	$ 435,291.07	$ 482,066.47	$ 508,241.87	$ 548,170.87	$ 591,295.12	$ 631,962.87	$ 674,982.42	$ 725,054.50	$ 778,469.18	$ 5,212,690.38
BENEFIT/COST RATIO	0.93	1.24	1.26	1.27	1.28	1.30	1.31	1.33	1.35	1.37	$ 1.26
Discount Rate 5%	*1.00*	*1.05*	*1.10*	*1.16*	*1.22*	*1.28*	*1.34*	*1.41*	*1.48*	*1.55*	**10-Year Discounted Net Benefit**
DISCOUNTED NET BENEFIT	$ (162,844.00)	$ 414,562.93	$ 437,248.50	$ 439,038.43	$ 450,981.53	$ 463,295.20	$ 471,580.42	$ 479,697.41	$ 490,745.43	$ 501,808.18	$ 3,986,114.02

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Marginal Energy Inputs

	Combustion Turbine Marginal Energy $/MWh	Combined-Cycle Plan Marginal Energy $/MWh	Average Cost	% Change
2012	$66.65	$39.44	**$ 53.05**	
2013	$71.03	$42.28	**$ 56.66**	7%
2014	$75.43	$45.13	**$ 60.28**	6%
2015	$81.09	$48.83	**$ 64.96**	8%
2016	$85.08	$51.39	**$ 68.24**	5%
2017	$86.76	$52.38	**$ 69.57**	2%
2018	$89.93	$54.37	**$ 72.15**	4%
2019	$93.42	$56.57	**$ 75.00**	4%
2020	$96.60	$58.56	**$ 77.58**	3%
2021	$100.00	$60.70	**$ 80.35**	4%
2022	$104.14	$63.34	**$ 83.74**	4%
2023	$108.61	$66.20	**$ 87.41**	4%
2024	$112.98	$68.98	**$ 90.98**	4%
2025	$115.79	$70.70	**$ 93.25**	2%
2026	$115.56	$70.33	**$ 92.95**	0%
2027	$116.91	$71.04	**$ 93.98**	1%
2028	$120.27	$73.12	**$ 96.70**	3%
2029	$123.96	$75.41	**$ 99.69**	3%
2030	$127.97	$77.92	**$ 102.95**	3%
2031	$130.95	$79.71	**$ 105.33**	2%
2032	$133.93	$81.51	**$ 107.72**	2%

Source: Xcel Energy 2012 CO DSM Annual Report, p.101