Assessing the viability of the bundled energy efficiency/electricity supply business model

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Executive Summary

The restructuring of the U.S. electricity economy has enabled the emergence of a unique form of energy efficiency provision, the bundled energy efficiency/electricity supply contract. A growing number of electricity retailers are offering a supply contract that incorporates the cost of energy efficiency services into the supply cost quoted. In so doing, the bundled energy efficiency/electricity supply contract represents a solution to two major barriers to energy efficiency; lack of capital, and unwillingness to use debt-financing. Electricity retailers providing energy efficiency services offer a number of different financing options. However, the bundled energy efficiency/electricity supply contract model, a type of managed energy services agreement (MESA), has been adopted by several of the largest electricity retailers and has the greatest potential to grow efficiency implementation.

The competitive electricity market is well on its way to adopting the bundled energy efficiency/electricity supply contract model. Electricity retailers providing energy efficiency services (through a variety of financing mechanisms) account for approximately half of all residential and commercial sales in the competitive electricity market. As of July 2013, energy efficiency services in the form of energy efficient products (e.g. programmable thermostats) and project services (e.g. lighting retrofit services) are provided by 13 of the 80 electricity retailers (16.3%) serving the residential market provided energy efficiency services; however, the 13 electricity retailers accounted for 47.2% of total residential market share.[1] Energy efficiency services are provided by 17 of the 94 electricity retailers (18.1%) serving the commercial market; however, the 17 electricity retailers accounted for 53.7% of total commercial market share. Of particular note, the largest electricity retailer for the commercial market and the second largest electricity retailer of the residential market have both specifically adopted bundled energy/electricity supply contracts models in the past 2 years.

Having reviewed the current market for electricity retailers providing energy efficiency services, we focus on the strategic implications of the bundled energy efficiency/electricity supply contract model. In so doing, we identify mutually beneficial opportunities for coordination between electricity retailers, energy services companies (ESCOs), and third party financers in providing bundled energy efficiency/electricity supply contracts.

Finally, we focus on quantifying the potential value of energy efficiency to electricity retailers and their customers due to the impacts of energy efficiency implementation. By providing energy efficiency services to its customers, an electricity supplier can reduce the costs it pays to power plants to supply its customers; customers can share in these costs savings. An energy efficiency valuation analysis was completed to determine the comparative impact of energy efficiency on electricity costs savings based on differences in United States wholesale electricity market (ERCOT vs. PJM), electricity procurement strategy, and operational characteristics of energy efficiency technologies.

[1] Information used to calculate market size comes from the 2011 U.S. Energy Information Administration 861 dataset. The 2011 dataset was the most recent, publicly-available information at the time of writing.

The results of the analysis reveal the quantitative basis for the popularity of fixed cost electricity supply products that including lighting retrofits. There is a nearly perfect correlation between a customer's load factor and the customer's electricity cost savings (fixed pricing) for lighting retrofits; in contrast, a customer's load factor and the average real-time electricity price have inconsistent impacts on a customer's electricity cost savings under real-time pricing products. Paradoxically, despite the difficulty in predicting the cost savings outcomes with real-time electricity pricing products, the electricity cost saving potential is greatest under real-time electricity products (in ERCOT). Beyond these insights, the marked divergence in potential energy efficiency savings between the ERCOT and PJM wholesale electricity markets reveals the implications of fundamental differences in wholesale market design.

The energy efficiency modeling results suggest that in order for electricity retailers to maximize the value of bundled energy efficiency/electricity supply contracts, they will need to tailor contract design based on wholesale electricity market. All told, the complexity of maximizing the value from energy efficiency, the early stage of the business model's development, and the hundreds of billions of dollars in annual electricity costs paid by consumers, ensure future market development and innovation.

Contents

Chapter 1 – Introduction

The United States and the world at large require solutions that can reduce dependence on foreign sources of energy, stimulate economic growth, and dramatically reduce climate- warming fossil fuel use. Investments targeted at increasing energy efficiency in the built environment offer a financially attractive and environmentally prudent strategy to meet these seemingly divergent goals of the 21st century (Lovins, 2011).

Beginning with the 1973 Oil crisis, energy efficiency has grown in importance as a strategy to cost-effectively reduce negative environmental impacts associated with energy use and reduce energy costs for consumers. Investments in energy efficiency reduce growth in energy demand and allow utilities to delay costly investments in transmission and distribution upgrades and new power plants (Regulatory Assistance Project, 2011). Investments in energy efficiency often times represent the lowest investment to ensure system reliability (National Association of Regulatory Utility Commissioners, 2007).

Energy Efficiency Potential

Despite a 41% reduction in energy consumption per real dollar of GDP since 1980, significant untapped profitable potential energy efficiency investment remains. By 2020 the United States could reduce annual energy consumption by 23% from a business-as-usual (BAU) projection through approximately $520 billion investment in NPV-positive non-transportation energy efficiency measures, yielding approximately $1.2 trillion in energy savings (McKinsey and Co., 2009). The existence of such a substantial energy efficiency investment potential is the product of several fundamental attributes of energy efficiency (upfront capital investment, fragmentation, low mind-share, and difficulty measuring) and a series of structural, behavioural, and availability barriers. New solutions are needed to bridge the gap between current investment in energy efficiency and the NPV-positive potential identified.

Recent Regulatory Changes – Revenue Decoupling

Recent changes to the regulatory framework that governs the U.S. electricity grid and electricity economy have created the potential for innovation in energy efficiency investing. While utility investments in energy efficiency serve to defer capital costs, they also have the effect of depressing revenues, which limits incentives for energy efficiency investment (Regulatory Assistance Project, 2011). To date, a minority of states[2] have adopted a policy of decoupling a utility's electricity sales from revenues, thereby allowing utilities to recoup lost revenues due to improved efficiency among their customers (Morgan, 2013).

[2] As of January 2012, Oregon, California, Idaho, Arizona, Wisconsin, Michigan, Ohio, New York, Vermont, Massachusetts, Connecticut, Maryland, and Washington D.C. had adopted electric decoupling policies. Electric decoupling policies were pending in Washington, New Mexico, Minnesota, New Hampshire, and Delaware.

Recent Regulatory Changes – Electricity Restructuring

In addition to the introduction of revenue decoupling, some U.S. electricity markets began restructuring in the early 1990s, mandating that vertically-integrated utilities sell off their power plants to third parties, while utilities retained control over the transmission and distribution system. Electricity market restructuring has facilitated the emergence of new market actors, electricity retailers, entities that purchase electricity and sell it competitively through the utility's transmission and distribution system. In 13 states and the District of Columbia,[3] consumers can choose to purchase their electricity supply from electricity retailers (O'Connor, 2012). Electricity retailers not only compete to undercut the incumbent utility's electricity supply charge but also differentiate themselves based on providing value-added electricity supply products, e.g. multi-year fixed price contracts, 100% green electricity contracts. Owing to the low costs and added services provided, the electricity retailers' market has experienced significant growth; electricity retailers' sales grew 53% between 2008 and 2011 and now account for 18% of total U.S. electricity sales (O'Connor, 2012).

New Energy Efficiency Business Models

In the restructured electricity market, electricity retailers do not have the same incentive limitations on stimulating energy efficiency implementation as do vertically-integrated utilities in traditional monopolistic markets without revenue decoupling. A growing number of electricity retailers, including some of the most successful, have begun to see providing energy efficiency services as a competitive imperative. By facilitating energy efficiency retrofit services along with their core business of electricity supply, electricity retailers can offer products that attract and retain customers by facilitating a more cost-effective use of electricity. Electricity retailers have adopted different mechanisms to pass on the capital costs of energy efficiency upgrades to their customers, with the most innovative charging a cost premium on the electricity supply cost to recoup investment. Customers that elect to pursue energy efficiency retrofits use less electricity, thereby reducing the costs paid for transmission and distribution service immediately; the cost premium per kWh provided by the electricity retailers may negate electricity supply cost savings over the life of the contract. However, after the electricity supply contract is completed, the consumer keeps the energy efficiency equipment and benefits from cost savings in both the electricity supply and transmission and distribution.

The Future of Competitive Retail Electricity Suppliers and Energy Efficiency

There is significant potential for growth in the number of electricity retailers that provide this type of offering, particularly if professional partnerships can be created between electricity retailers,

[3] Connecticut, Delaware, Washington D.C., Illinois, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Texas offer full competitive choice to electricity customers. In 4 other states, (California, Montana, Michigan, and Oregon), a small percentage of the state's electricity customers can purchase electricity from ELECTRICITY MARKETERS.

energy efficient hardware/software providers and financers. Competition between electricity retailers to provide energy efficiency could help to bridge the energy efficiency gap.

1.1 Problem definition

Despite hundreds of billions of dollars in potential profits over the next decade, investments in energy efficiency are impeded by a series of structural barriers, including a lack of willing investors. Efforts to address existing barriers and entice investors are needed in order to bridge the energy efficiency 'gap'.

Electricity market restructuring has redefined incentive structures within the electricity system. The emerging business model in which electricity retailers bundle energy efficiency services along with electricity supply may present value to all stakeholders in the electricity system. In order for this business model to make a significant impact on energy efficiency provision, private and public stakeholders will need to contend with a series of major issues related to contract design, division of energy efficiency savings, measurement and verification of energy savings, and energy efficiency financing mechanism.

1.2 Research question

To what extent, and in which ways, does the emerging business model that bundles energy efficiency retrofits with electricity supply, constitute an improvement in energy efficiency provision?

Answering the research question requires an analysis of major trends in electricity supply and electricity consumption, market design and segmentation, and energy efficiency modeling. Specifically, we seek to answer the following research sub-questions:

1.2.1 Research sub-questions

1. *What existing barriers to energy efficiency does the bundled energy efficiency/electricity supply business model address, and how?*

2. *What are the potential consequences of intra-annual and inter-annual volatility in the ERCOT and PJM electricity on an electricity retailer's cost of procurement for its customers?*

3. *How does the competitive nature of the energy efficiency/electricity supply business model produce opportunities to capture unrealized value for all stakeholders involved?*

4. *What are the potential economic gains due to energy efficiency implementation for both electricity retailers and customers?*

1.2.2 System boundaries

While electricity retailers are currently operating in 17 states and the District of Columbia, energy efficiency modeling was confined to the Texas (ERCOT) and Pennsylvania (PJM) competitive electricity markets. Fundamental differences in market structure between ERCOT and PJM motivated the choice to choose these two markets for comparing the potential value of energy efficiency.

The energy efficiency hardware upgrades studied are limited to those with short payback times: lighting and HVAC optimization (building management systems, programmable thermostats, etc.). The competitive nature of the electricity retailer market – contracts between electricity retailers and electricity consumers generally last between 3 months and 3 years (Public Utility Commission of Texas, 2013) – precludes an on-bill financing mechanism provided by *electricity retailers* for energy efficiency investments with long (>5 years) payback times.

Research focuses on *electricity retailers* that market *electricity* and energy efficient hardware/software that uses electricity; gas and oil efficiency measures are not considered.

1.3 Thesis Overview

The thesis takes the following organization:

Chapter 2 provides an explanation of all data sources and the methodologies used to analyze data. Focus is given to the design of the energy efficiency calculator used to approximate the value of energy efficiency implementation to electricity retailers and customers.

We continue by providing a review of the relevant literature on the state of the energy efficiency provision economy. Original analysis is integrated to fill in perceived gaps in the existing literature. Taken as a whole, Chapter 3 provides the foundation on which to judge the impact and greater strategic significance of the bundled energy efficiency/electricity supply business model in the context of the existing energy efficiency provision economy.

Chapter 4 describes the *supply side.* First, we detail the emergence of electricity market restructuring and the growth and segmentation of electricity retailers market share. Next, we examine the inter-annual and intra-annual behavior of two wholesale electricity markets (ERCOT and PJM) in the service of explaining the significant opportunities and risks available to customers that are capable of customizing electricity supply contracts.

Having established general trends in the supply side of the energy economy, we use Chapter 5 to describe the *demand side*. In particular, general trends in electricity consumption patterns are established as of means of contextualizing later analysis of the cost/risk continuum. Finally, we discuss the implications of energy efficient technologies that produce a permanent demand reduction (e.g. lighting) versus those the produce a variable demand reduction (e.g. HVAC optimization) on measurement and verification of energy efficiency savings. In so doing, we provide context to modeling used to analyze the relative cost savings available to electricity retailers and its customers due to energy efficiency implementation.

Chapter 6 is divided into two major parts: bundled energy efficiency/electricity supply market design and market analysis. First, we propose the competitive significance of differences in market design, as well as the major strategic issues with which electricity retailers and customers must contend. Next, we present electricity retailers' energy efficiency adoption rates, and compare these results to a similar study conducted 12 years ago. Finally, we examine commercially-available bundled energy efficiency/electricity supply products from Constellation NewEnergy, Reliant Energy, and Green Mountain Energy in the service of explaining differences in product design and implicit valuation of energy efficiency.

Chapter 7 summarizes the relevance of the lessons learned in chapters 4 through 6 on the competitive marketplace for energy efficiency/electricity supply product through a Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis format.

Chapter 8 provides the results of the energy efficiency modeling scenarios. By modeling the distribution of energy efficiency cost saving benefits to electricity retailers and their customers, based on differences in technology installed, electricity procurement strategy, customer consumption behavior, and electricity market, we establish the challenges electricity retailers face in designing bundled energy efficiency/electricity supply contracts. Sensitivity and correlation analyses reveal the comparative impact of independent variables on electricity retailers and customer energy efficiency cost saving benefits.

Chapter 9 concludes with a summation of the lessons learned throughout the thesis.

Chapter 2 – Methodology

The foregoing chapter briefly explains the methodology used to collect and analyze data in the service of answering the main research question and sub-questions.

2.1 Data Collection

Before data collection could begin, I reviewed background reading on the theoretical case for electricity restructuring and the electricity retailer business model. After establishing the theoretical foundations, the research transitioned into the data collection phase. The major data sources used in this research are summarized below:

1. ***Publicly available electricity retailer electricity supply contracts for residential customers.***[4] We consider electricity supply contracts that incorporate energy efficiency and those that do not, to compare the added premium electricity retailers' assign to their bundled energy efficiency/electricity supply products.
2. ***Publicly available wholesale electricity market data.*** Energy efficiency modeling was conducted for both the ERCOT and PJM markets. Wholesale electricity market data (both real-time and day-ahead markets) are publicly available and published daily in all wholesale markets. The energy efficiency modeling performed later used real-time electricity pricing (2009-2012) for the Houston load zone in ERCOT and the MetEd (Metropolitan Edison) load zone in PJM. The ERCOT real-time electricity market quotes prices every 15 minutes while the PJM real-time market quotes prices every hour.[5]
3. ***Publicly available backcasted customer load data*** *from the wholesale market operator Energy Reliability Council of Texas (ERCOT)*. The ERCOT backcasted load data is of primary importance as it, alone, was used to model the value of energy efficiency on electricity retailers and customers. The ERCOT market maintains a backcasted dataset through a partnership with Texas' transmission and distribution utilities (TDUs) as part of a market settlement initiative. The Texas TDUs submit electricity consumption data in 15 minute intervals ('backcasted customer load data') for a representative sample of residential, commercial, and industrial customers. The sample is ~0.04% of total residential customers and ~0.75% of total non-residential customers. For full information on the customer load samples used by each T&D utility in their submissions to ERCOT, see the **Profile Data Evaluation Report** at http://www.ercot.com/mktinfo/loadprofile/. All information pertinent to ERCOT's load profiling methodology can be accessed in the ERCOT Load Profiling Guide.[6] ERCOT takes the sample of

[4] Electricity supply contracts for commercial and industrial customers are not publicly available, as the price of each contract is quoted on a case-by-case basis.
[5] All wholesale electricity market data can be downloaded at http://www.gdfsuezenergyresources.com/index.php?id=712
[6] The current load profiling guide (sections 1-19 and appendices A-E) is available for download at http://www.ercot.com/mktrules/guides/loadprofiling/current

backcasted customer load data and differentiates the data based on weather zone, (i.e. location), customer type, (i.e. residential, business), and electricity consumption behavior (i.e. load factor). Business sample load data was differentiated based on load factor. MEDLF (medium load factor) was defined as a load factor between 0.4 and 0.6. HILF (high load factor) was defined as a load factor that exceeded 0.66. LOLF (low load factor) was defined as a load factor below 0.4. Residential customers are differentiated based on their winter ratio. Winter ratio is defined as the proportion of usage in winter months to usage in the fall base and spring base months. Residential meter load data samples either fall into the high winter ratio (HIWR) or low winter ratio (LOWR) categories. Five samples of meter data were used are used in the energy efficiency modeling (Chapter 8). These meter data samples all came from the Houston weather zone and are defined as follows: BUSHILF (business high load factor), BUSMEDLF (business medium load factor), BUSLOLF (business low load factor), RESHIWR (residential high winter ratio), and RESLOWR (residential low winter ratio).[7]

4. **Publicly available backcasted customer load data** from the vertically integrated utility Pacific Gas & Electric. Pacific Gas & Electric (PG&E) provides aggregated load profiles for all tariffs they serve;[8] the data is updated on a daily basis. The load profiles are based on a statistical sample of customer classes and rate schedules. PG&E does not provide significant documentation of the statistical sampling methodology used.
5. ***Interviews with individuals throughout the competitive electricity supply chain*** (retailers, brokers, consultants, energy service companies).
6. ***Desk research*** on electricity and energy efficiency markets.

2.2 Data Analysis

Electricity Consumption and Real-Time Electricity Price Trends

In order to understand the cost implications of differences between the ERCOT load zones (and their particular pricing behavior) and the PJM load zones (and their particular pricing behavior), we modeled annual energy costs for the same five ERCOT customer examples for both the ERCOT and PJM pricing data. Note that this data analysis technique is inexact insofar as backcasted load data is likely to be different in the PJM market when compared to the ERCOT market. However, we have decided to tolerate this inexactness because the general intra-annual trends in electricity consumption are generally observable in regions with air-conditioning load in the summer (Lazar & Baldwin, 2011). Both PJM and ERCOT have summer air-conditioning load. In addition, by using the same electricity consumption data for two different sets of electricity price data, we can directly observe the

[7] All ERCOT backcasted load data can be downloaded at http://www.ercot.com/mktinfo/loadprofile/alp/
[8] All PG&E backcasted meter data can be downloaded at http://www.pge.com/nots/rates/tariffs/energy_use_prices.shtml

implications of differences in pricing trends without having to parse the impact of differences in electricity consumption behavior.

Value of Energy Efficiency

We model the value of energy efficiency in two ways. All data analysis was completed in Microsoft Excel 2010.

First, we examine the relationship between system-wide electricity load with wholesale market prices in both ERCOT and PJM. To determine whether there is a positive correlation between Load Factor and Spot Market price, we plot Load Factor on the x-axis for each hour of the year and Real-Time market price on the y-axis. Real-Time market price is determined every 15 minutes, so this analysis averages each 4, 15-minute price period into 1 hour blocks.

Second, we analyze the impact of energy efficiency on an electricity retailer's procurement costs and customer's annual energy costs savings (under fixed pricing and real-time pricing scenarios) and percentage change in load factor. The design of this energy efficiency modeling calculator is described at great length in Chapter 8.

Chapter 3 – Literature Review/Background

3.1 Introduction

Before examining the economic, legal, and strategic issues that define the opportunities and risks associated with the bundled energy efficiency/electricity supply business model, we must first provide context to the subject matter under consideration. Members of the academic, business, and governmental communities specialize in different issues that pertain to the business model at hand. The purpose of this thesis is to produce scholarship unique to the bundled energy efficiency/electricity supply business model by combining the previous work of others within the energy efficiency community with original data collection, analysis, and strategic thinking.[9]

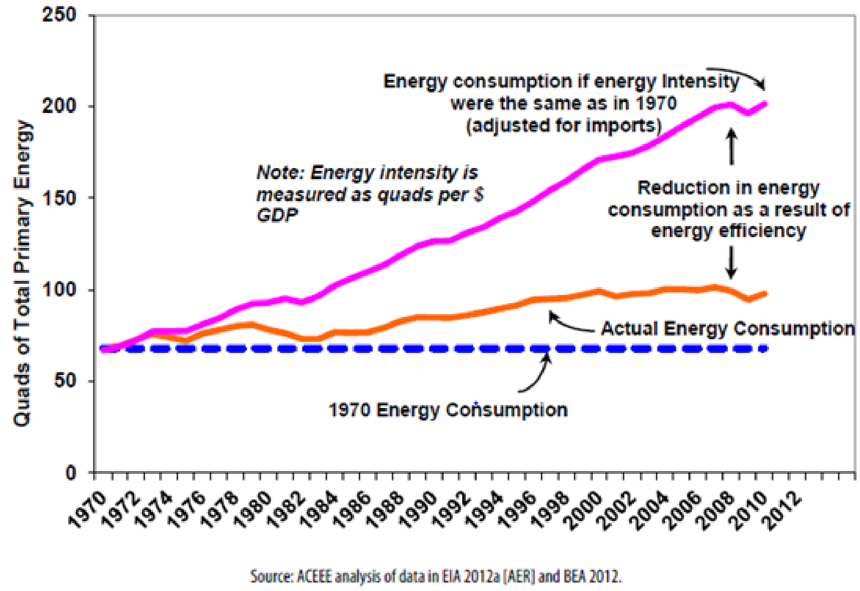
The foregoing chapter first describes: the historical development of energy efficiency implementation; the roles of major public and private sector stakeholders involved in the energy efficiency economy; the most common energy efficient technologies pursued; and the current level of industry revenues and customer bill savings realized. Next, we consider the existing potential for growth in energy efficiency implementation and the various barriers that are responsible for the existence of the unrealized potential. In recognition that bridging the energy efficiency implementation 'gap' will require a rapid increase in investment, we focus on energy efficiency financing mechanisms and their prospects for future growth. Establishing an understanding of the issues and trends in the energy efficiency economy serves as a required foundation on which to base the more substantive analysis of electricity purchasing and energy efficiency implementation from the perspective of the supply side (Chapter 4) and the demand side (Chapter 5).

3.2 Energy Efficiency Implementation Today

The existing U.S. energy efficiency industry has grown in size and scope over the past 40 years, since the 1973 oil crisis brought energy efficiency to national attention (Alliance to Save Energy, 2013). Over the past 40 years, the U.S. economy has benefited from a dramatic reduction in energy use per unit of GDP; U.S. energy user per GDP has roughly doubled over the past 40 years, adjusting for imports (see Figure 1).

[9] The foregoing chapter cannot be characterized as a literature review in the strictest sense as it utilizes original analysis to give greater context to existing research and bridge perceived gaps in the existing research.

Figure 1. U.S. Energy Use Per Unit GDP (1970-2010)



Source: (Vaidyanathan, et al., 2013)

The total economic value due to this dramatic rise in energy productivity is difficult to approximate; in 2004, the American Council for an Energy-Efficiency Economy estimated that energy cost savings due to previous energy productivity gains exceed $700 billion (Peretz, 2009).

3.2.1 Energy Efficiency Market - Stakeholders

In the United States, energy efficiency savings are delivered through a combination of public and private stakeholders. Major stakeholders' roles are summarized below:

3.2.1.1 Public Stakeholders

Federal Government

The United States Federal government has historically played an important role in promoting the efficient use of energy; all three branches of the Federal government have contributed.[10] Of particular importance, the Federal government has established the Department of Energy (established 1977), the Federal Energy Regulatory Commission (established 1977), and the Environmental Protection Agency (established 1970).

The Department of Energy

The Department of Energy (DOE) supports energy efficiency and the clean energy economy more broadly through investments in emerging technologies in both renewable energy and energy efficiency.

[10] For a full explication of the history of energy efficiency in the United States since 1973, consult the Alliance to Save Energy's "The History of Energy Efficiency" (2013).

By supporting new technologies, the DOE helps to seed technological development at an early stage, supporting innovation for private and public sector application.

Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC), among its many regulatory duties, is tasked with monitoring wholesale electricity markets, investigating manipulation in electricity markets, and enforcing fair competitive practices through civil penalties. Manipulation of wholesale markets has not only defrauded consumers of billions of dollars; severe market manipulation during the California Energy Crisis of 2000-2001 led to blackouts, despite adequate generating capacity (Joskow, 2001). FERC enforcement of market manipulation continues today. On July 30, 2013, JP Morgan agreed to pay $410 million in connection with market manipulation in California and Midwest electricity markets (Wingfield & Kopecki, 2013).

U.S. Environmental Protection Agency

Beyond its duties in litigating violations of existing environmental statutes, the U.S. Environmental Protection Agency has contributed directly to the energy efficiency industry through its pursuit of the ENERGY STAR program. The ENERGY STAR program allows consumers and business owners to identify energy efficient products (and their long-term financial and environmental benefits) through a rigorous qualification and labeling system. Environmental benefits due to the ENERGY STAR program were estimated at 1,883 $MMTCO_2e$ from the program initiation in 1992 through the end of 2012 (U.S. Environmental Protection Agency, 2013).

State Government

State government and state-run organizations have been integral to the development of energy efficiency within states and equally importantly, in pressuring the Federal government to pursue energy efficiency. Of particular note, the first appliance standards in the nation were pursued on the state level; California first adopted appliance efficiency standards in 1974 (Alliance to Save Energy, 2013).

Some states have elected to administer energy efficiency rebate, incentive, and financing programs through state-run energy research agencies in lieu of individual utility programs. Several noteworthy state energy agencies rank high on the total energy efficiency funding list; in 2011, the New York State Energy Research Development Agency (NYSERDA) sponsored the second largest energy efficiency rebate, incentive, and financing program (measured by budget) in the nation (U.S. Energy Information Administration, 2012). In addition, state energy agencies are also integral to seeding clean energy technological development.

3.2.1.2 Private Stakeholders

Transmission and Distribution Utilities

Transmission and distribution utilities (as well as vertically integrated utilities[11]) have played a key role in promoting energy efficiency in the U.S. economy. In the 1980's the modern utility model began to emerge through the pursuit of integrated-resource planning, whereby utilities were directed by Public Utility Commissions to pursue the lowest cost options to maintain reliable electricity delivery (State & Local Energy Efficiency Action Network, 2011). Often, utilities can meet the electricity needs of their customer more economically through investments in the demand side (energy efficiency and demand response), deferring more costly upgrades to supply-side infrastructure (generation, transmission and distribution).

In order to facilitate the adoption of least-cost measure on the demand side, utilities began to offer rebate and incentive programs on energy efficient products (Alliance to Save Energy, 2013). In order to fund energy efficiency rebate, incentive, and financing programs, utilities collect system benefits charges (SBC); an SBC is a nominal charge collected by all ratepayers to be used to finance demand side management and renewable energy programs. In 2011, utilities (and state energy agencies utilizing SBC funding) offered more than $2.3 billion in *electric* energy efficiency rebates, incentives, and low or no-cost financing to electricity ratepayers (U.S. Energy Information Administration, 2012). The historical development of utility DSM funding is presented later in this chapter.

Energy Service Companies (ESCOs)

Energy Service Companies (ESCOs) perform an invaluable service in the energy efficiency economy through the provision of energy efficiency project implementation and financing services. Larsen et al. (2012) define an ESCO as:

> A Company that provides energy-efficiency and other value-added services and for which performance contracting is a core part of its energy-efficiency services business. In a performance contract, the ESCO guarantees energy and/or dollar savings for the project and ESCO compensation is therefore linked in some fashion to the performance of the project.

ESCO services and ownership come in a variety of configurations, but the plurality of ESCOs are also building equipment manufacturers, like Johnson Controls (Larsen, et al., 2012).

[11] Vertically integrated utilities have retained ownership of generation assets. They are distributed throughout the Southeastern, Southwestern, and Northwestern U.S.

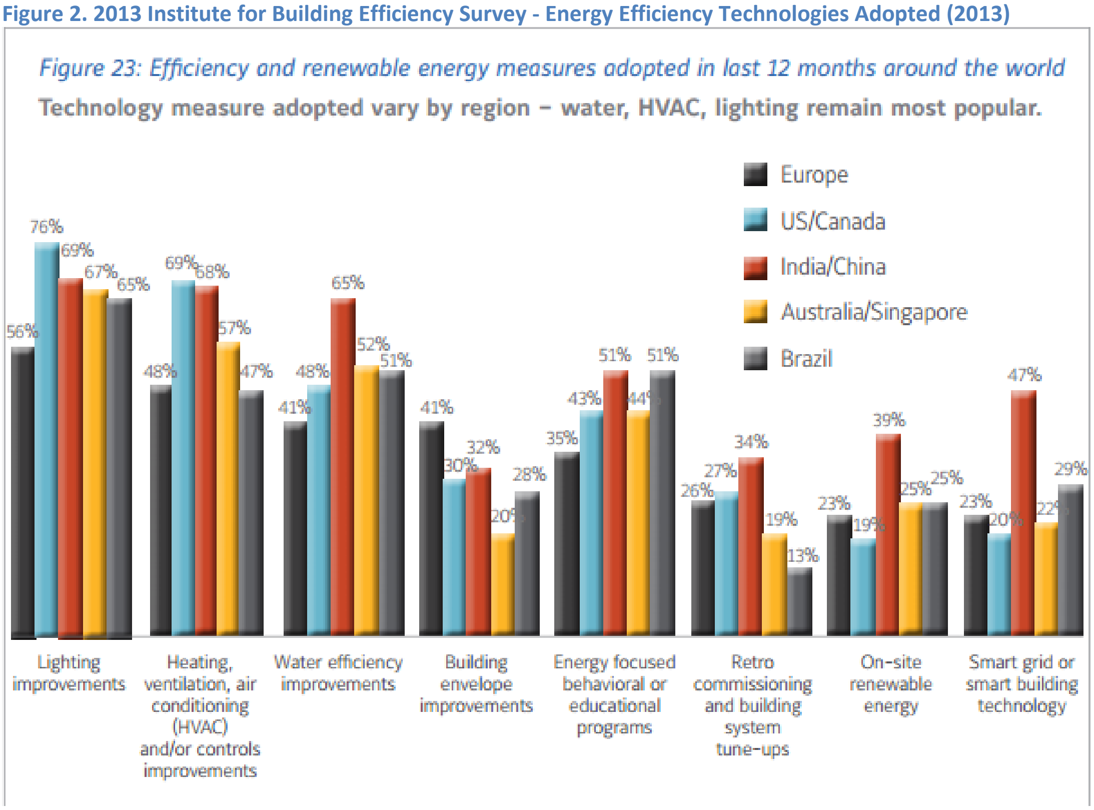
Third Party Financers

Third party financers will play an increasingly important role in growing the energy efficiency industry over the coming years. Financers raise capital and collaborate with ESCOs, utilities, and other energy efficiency providers to deploy energy efficiency projects. Energy efficiency financing mechanisms utilizing third-party financers is discussed at greater length later in this literature review.

3.2.2 Energy Efficiency Market – Technologies and Payback Times Pursued

Energy efficiency in buildings can be improved through the adoption of behavioral and technological changes. For the purposes of this research, energy saving benefits due to behavioral changes will not be considered; strictly speaking, energy saving benefits due to behavioral changes is defined as energy conservation, rather than energy efficiency. Technological changes that improve energy efficiency allow consumers to maintain the same energy service while reducing energy use. The most popular energy efficiency measures pursued throughout the economy are lighting and HVAC/building controls due to their comparatively low payback periods (The Rockefeller Foundation; DB Climate Change Advisors, 2012) (Institute for Building Efficiency, 2012) (McKinsey and Co., 2009). Broadly speaking, energy efficiency measures targeting an improvement in the building envelope (improved insulation, high efficiency windows) have longer payback times, limiting market adoption. A global survey of more than 3,000 executive decision-makers by the Johnson Controls Institute for Building Efficiency reveals that lighting and HVAC/building controls retrofits are between 1.5 and 3 times more popular than building envelope improvements, depending on location (see Figure 2 for full details).

Figure 2. 2013 Institute for Building Efficiency Survey - Energy Efficiency Technologies Adopted (2013)



Source: (Institute for Building Efficiency, 2013)

The results of the 2013 IBE survey, i.e. a concentration on lighting and HVAC/building controls energy efficiency upgrades, are consistent with previous years' results.

The most common energy efficiency technologies pursued (lighting and HVAC/building controls) are popular because of their short payback times. A Lawrence Berkeley National Laboratory meta-analysis of ESCO-initiation energy efficiency projects found that the median simple payback time was 3.2 years (Larsen et. al, 2012). In contrast, energy efficiency projects in the institutional sector had a median simple payback of 10.2 years.

The general trend observed in Larsen et. al (2012) is corroborated by the Institute for Building Efficiency's 2010 EEI Indicator study. Approximately 50% of respondents, regardless of sector, required a payback of 3 years or less to pursue an energy efficiency project. Respondents all indicated a desire for a quick payback; the average maximum payback for an energy efficiency project varied slightly among Industrial customers (2.7 years), commercial customer (2.9 years), and institutional customers (4.3 years) (Supple, 2010).

3.2.3 Energy Efficiency Market - Current Market Size

The variety of ways in which the energy efficiency market can be quantified deserves discussion. The existing energy efficiency market has been measured in a variety of ways: ESCO revenue, energy efficiency rebate and incentive funding, value of energy cost savings due to energy efficiency implementation, etc. For the purposes of this thesis, we limit our discussion of the energy efficiency market to the built environment. We briefly review industry estimates of revenues generated through the sale of building energy efficiency products and services before estimating the value of cost savings due to utility and state-energy agency sponsored rebate, incentive, and financing programs. Such programs, along with those that support demand response, can be categorized as demand-side management (DSM) programs.

3.2.3.1 Value of Revenues Generated

Energy efficiency markets support original equipment manufacturers and ESCOs' businesses insofar as energy efficiency implementation requires energy efficiency hardware/software and installation services.

The North American energy efficient building market (narrowly defined as ESCO revenues and the revenues from the sale of energy efficiency HVAC and lighting systems), was approximately $17 billion in 2011 (Bloom & Wheelock, 2011), with the residential sector comprising approximately $10 billion in 2012 (Gibson & Adamson, 2012). The market is expected to grow at a compound annual rate of 7% over the next 5 years (Bloom & Wheelock, 2011).

ESCO revenue was estimated at $7.1 billion in 2011, representing major growth from $4.1 billion in 2008 (Larsen, et al., 2012). ESCO revenues are concentrated in the institutional market with 69% of revenue coming from the M.U.S.H (Municipalities, Universities, Schools, and Hospitals) sector and 15% of revenue coming from the government sector.

3.2.3.2 Value of Energy and Demand Costs Savings

Building energy efficiency implementation provides benefits to ratepayers in the form of savings on electricity bills. Estimating the value of these savings requires careful specification because energy savings due to efficiency can be accounted in different ways. For the purposes of this analysis, we reviewed the most current United States Energy Information Administration (U.S. EIA) 861 dataset to estimate total energy and demand saved in 2011 due to utility and state energy agency-sponsored DSM programs.

The U.S. EIA collects data on energy and peak demand savings due to energy efficiency in two broad categories: actual annual effects and annualized incremental effects. Actual annual effects are defined as the effects (energy (MWh) reduction and peak demand (MW) reduction) caused by all participants in a utility's DSM program in a given year. Importantly, annual effects account for new and existing participants in existing programs (those implemented in prior years that are in place during the given year) and all participants in new programs (those implemented during the survey year). Annualized Incremental effects are defined as the energy (MWh) and peak demand (MW) savings caused by new participants in existing DSM programs and all participants in new DSM programs during a given year (U.S. Energy Information Administration, 2012). Since many utility DSM programs last for several years, actual annual energy and peak demand reduction effects usually larger annualize incremental energy effects.

For unabridged definitions of all U.S. EIA metrics analyzed below, consult Appendix 1.

The historical development of utility and state energy agency-sponsored *electric* energy efficiency incentive programs, and resulting energy and peak demand impacts is summarized in Table 1 below.

Table 1. Utility and state energy agency-sponsored energy efficiency programs - effects and costs (2004-2011)

	Annualized Incremental Effects (GWh)	Actual Annual Effects (GWh)	Annualized Incremental Peak Effects (GW)	Actual Annual Peak Effects (GW)	Energy Efficiency Incentive Payments (Million $)	Utility Direct Costs (Million $)	Utility Indirect Costs (Million $)
2004	4,532	52,663	1.7	14.3	$310	$601	$132
2005	5,879	59,000	1.7	15.4	$635	$547	$128
2006	5,394	63,076	1.3	16.0	$651	$621	$129
2007	7,680	67,278	2.0	17.8	$846	$837	$160
2008	10,433	86,010	6.3	19.7	$1,080	$1,266	$190
2009	5,030	62,226	1.8	8.7	$1,134	$1,127	$394
2010	13,560	86,926	4.7	20.8	$1,615	$1,287	$274
2011	21,421	120,659	4.0	26.3	$2,369	$1,633	$329

Apart from the year 2009, which is an outlier, the actual and incremental annualized energy effects due to energy efficiency implementation have experienced steady growth. The growth in energy efficiency savings is correlated with spending (incentives, direct and indirect program costs) on energy efficiency DSM programs.

In 2011, utility and state energy agency-sponsored energy efficiency activity was segmented as follows:

Table 2. Utility and state energy agency-sponsored energy efficiency program - effects and costs by sector (2011)

	Residential	Commercial	Industrial	Other
Energy Efficiency Incremental Effects (GWh)	9,989	8,166	3,261	6
Energy Efficiency Annual Effects (GWh)	46,790	50,732	23,061	76
Direct Cost EE (Million $)	$668	$722	$198	$45
Indirect Cost EE (Million $)	$190	$97	$41	$1
Incentive Payments EE (Million $)	$1,044	$1,033	$288	$4
Total Costs EE (Million $)	$1,902	$1,852	$527	$50
Average Cost of EE Procurement (total costs EE $/incremental kWh saved)	$0.19	$0.19	$0.19	$0.19
Average Cost of EE Procurement (total costs EE $/annual kWh saved)	$0.04	$0.04	$0.04	$0.04

In 2010, utility and state energy agency-sponsored energy efficiency activity was segmented as follows:

Table 3. Utility and state energy agency-sponsored energy efficiency program - effects and costs by sector (2010)

	Residential	Commercial	Industrial	Other
Energy Efficiency Incremental Effects (GWh)	6,479	5,319	1,758	5
Energy Efficiency Annual Effects (GWh)	32,112	37,480	17,245	89
Direct Cost EE (Million $)	$573	$469	$245	$0
Indirect Cost EE (Million $)	$160	$90	$23	$0
Incentive Payments EE (Million $)	$774	$705	$135	$0
Total Costs EE (Million $)	$1,508	$1,265	$403	$0
Average Cost of EE Procurement (total costs EE $/incremental kWh saved)	$0.23	$0.24	$0.23	$0.00
Average Cost of EE Procurement (total costs EE $/annual kWh saved)	$0.05	$0.03	$0.02	$0.00

Analysis of utility and state energy agency-sponsored energy efficiency programs in 2010 and 2011 reveal two major trends. First, utility spending is disproportionately concentrated in the residential and commercial sectors. More importantly, the analysis reveals the cost-effectiveness of utility investments in energy efficiency. There is approximately an order of magnitude difference between the average cost per kWh reduced of annual energy efficiency effects versus annualized incremental effects. The major differences observed between the costs of annual energy efficiency effects versus annualized incremental energy efficiency effects comes from the fact that many DSM programs last for multiple years. Without a knowledge of the starting and ending date of each DSM program, it is not possible to comment on the cost-effectiveness of utility energy efficiency spending on a program-by-program basis. However, the data analysis does confirm basic facts about energy efficiency investment: energy efficiency is a comparatively expensive short term investment and a comparatively inexpensive long-term investment. Energy efficiency procurement costs for incremental annualized energy effects are higher than the average retail cost of electricity (see Table 5 below), but the energy efficiency procurement costs for annual energy effects are significantly lower than the average retail cost of electricity.

To quantify the value of energy efficiency cost savings in comparison to total expenses, were first tallied total U.S. electricity sales (see Table 4).

Table 4. U.S. Electricity Sales and Costs By Sector (2011)

	Residential	Commercial	Industrial
Total Sales (TWh)	1,477	1,566	1,160
Total Revenue (Million $)	166,714	135,926	67,606
Avg. Cost ($/kWh)	$0.113	$0.087	$0.058

In 2011, total U.S. electricity sales of 4,203 TWh cost ~$317 billion.

Average Cost – All U.S. Electricity Sales (includes electricity purchases from power marketers and T&D utilities)

Table 5. Average Annual U.S. Electricity Costs By Sector (2004-2011)

	Residential	Commercial	Industrial
2004	$0.088	$0.075	$0.049
2005	$0.094	$0.080	$0.053
2006	$0.103	$0.087	$0.058
2007	$0.106	$0.087	$0.059
2008	$0.112	$0.092	$0.064
2009	$0.114	$0.091	$0.062
2010	$0.113	$0.088	$0.060
2011	$0.113	$0.087	$0.058

In order to estimate the approximate total value of electricity cost savings due to utility energy efficiency programs in 2011, we multiplied the average residential, commercial, and industrial electricity prices by the annual electricity savings due to utility energy efficiency programs.[12] For the purposes of

[12] This methodology is a rough approximation, given that it does not distinguish based on regional electricity price differences or individual utility electricity costs.

this estimation, energy efficiency savings (category: other) were grouped with industrial energy efficiency savings.

The breakdown of approximate total value of electricity cost savings (in Million $) in 2011 is as follows:

Table 6. Electricity Cost Savings Due to Utility and State Energy Agency-Sponsored Energy Efficiency Programs (2011)

	Residential	Commercial	Industrial/Other
Electricity Cost Savings (Million $)	$5,287	$4,414	$1,342

In 2011, the approximate total value of electricity cost savings due to utility energy efficiency programs was $11 billion. In 2010, the approximate value was $8 billion. Energy efficiency cost savings equaled approximately 2.5% of total U.S. electricity cost in 2011.

Value of Permanent Peak Demand Savings

Reducing electricity usage during system peak has economic value to transmission and distribution utilities and society at large. Energy efficiency directly displaces peaking power plants. The value of permanent demand reduction depends on the location in which the permanent demand reduction takes place. Permanent demand reduction is most valuable in areas in which the supply/demand balance is strained due to high demand and/or constrained transmission and distribution networks and/or generation infrastructure shortfalls. While a full accounting of the value of permanent demand reduction is beyond the scope of this paper, we can estimate the total approximate value of permanent demand reduction based on the value earned by permanent demand reduction in the ISO-NE and PJM markets; in these markets, permanent demand reduction due to energy efficiency can be sold as a resource in the forward capacity market.[13]

The value of permanently reducing demand through energy efficiency, while not accessible through market revenues throughout the United States, has an indirect economic benefit for consumers insofar as permanently reducing peak load reduces investments in generation and/or transmission and distribution infrastructure. The costs of these infrastructural investments are ultimately passed on to electricity customers.

Permanent demand reduction due to energy efficiency has historically had a value of $30-50/kW per year in the ISO-NE and PJM forward capacity markets (see Appendix 2 for year-by-year results). As such, the approximate total value of the 26.3 GW of annual permanent demand reduction in 2011 to the electricity grid is between ~$0.8-$1.3 billion.

[13] For more information on forward capacity markets, see "Energy Efficiency in the Forward Capacity Market: Evaluating the Business Case for Building Energy Efficiency as a Resource for the Electric Grid" (Fetter et. al 2012). ACEEE Summer Study of Energy Efficiency in Buildings.

3.3 Energy Efficiency Potential

Despite the growth in utility and state energy agency-sponsored energy efficiency spending and energy efficiency impact over the past 8 years, there is a wide consensus that the energy efficiency industry remains a small fraction of its potential size (McKinsey and Co., 2009; The Rockefeller Foundation; DB Climate Change Advisors, 2012; Electric Power Research Institute, 2009; Faruqui & Mitarotonda, 2011). Estimates on the potential for the growth of energy efficiency implementation in the United States differ from study to study, but are consistent in identifying a large potential for improvement over the status quo.

Differences in Energy Efficiency Potential

The most optimistic energy efficiency study identifies potential energy efficiency savings of 9.1 quadrillion BTUs as compared to a Business As Usual (BAU) scenario in 2020, a reduction of 23% below current annual electricity consumption; an energy efficiency potential of 1,080 TWh for the year 2020 (McKinsey and Co., 2009). End-use efficiency potential distribution among the major sectors is as follows: residential (35%), industrial (40%), commercial (25%) (McKinsey and Co., 2009). Achieving this technical potential assumes a dramatic shift in energy efficiency implementation, a scenario in which major barriers to energy efficiency potential are solved by innovative strategies, business models, and legislation.

A more conservative study focuses on the realistically achievable energy efficiency potential through implementation of current best practices and existing programs. The more conservative study, sponsored by the Electric Power Research Institute, identified 2020 maximum achievable energy potential of 372 TWh and a realistic energy efficiency potential of 141 TWh (Electric Power Research Institute, 2009).

Differences in Implementation Costs

The more optimistic energy efficiency study identifies potential energy efficiency savings of $1.2 trillion based on an investment of $520 billion (not including program costs) through 2020.[14] The study does not specify the 2020 cost of this implementation, but if we assume a straight line investment, required investment in 2020 is $52 billion.

The more conservative EPRI study identifies the cost of implementation for the maximum achievable potential to be $16-$41 billion in 2020, and costs to achieve the realistic potential of $8-$20 billion in 2020.

On a per TWh basis, McKinsey's analysis is in line with the most optimistic EPRI energy efficiency cost projections. A $52 billion investment in 2020 yielding savings of 1,080 TWh, yields an investment rate of $48 million per TWh saved. This investment equates to $0.048 per annualized incremental kWh saved. Recall that the 2010 and 2011 cost of incremental energy efficiency procurement ranged from $0.19-

[14] McKinsey and Co. (2009) analysis assumes a 7% discount rate. At a 40% discount rate, energy efficiency potential reduces to 5.2 quadrillion BTUs, still large enough to more an offset projected increases in annual energy consumption.

$0.24/kWh saved due to DSM energy efficiency programs. EPRI's maximum achievable potential cost projections range from $43-$110 million per TWh saved ($0.043-$0.110/annualized incremental kWh), while EPRI's realistic achievable potential cost projections range from $56-$141 million per TWh saved ($0.056-$0.141/annualized incremental kWh).

Both the McKinsey and EPRI studies project an improvement in the cost-effectiveness of energy efficiency investment over the coming decade.

The major differences observed in energy efficiency potential between the McKinsey and EPRI study[15] stem from the fact that McKinsey's analysis does not differentiate between realistic, maximum achievable, and economic energy efficiency potentials, includes more energy efficiency technologies, and assumes a higher discount rate (7% versus 5%) (McKinsey and Co., 2009).

3.4 Barriers to Energy Efficiency

Four fundamental attributes to energy efficiency have thus far limited its uptake; energy efficiency requires large upfront investment, is fragmented throughout the economy, is not of primary strategic importance to most businesses, and is more difficult to measure than many other outputs (McKinsey and Co., 2009). Beyond these attributes, there are a series of structural, behavioral, and strategic barriers that limit the uptake of energy efficiency.

The most important barriers to energy efficiency implementation relevant to the bundled energy efficiency/electricity supply business model are summarized below. Barriers exist in all aspects of the energy infrastructure; but their relative importance in dissuading energy efficiency varies.

Financial Barriers

McKinsey's (2009) analysis reveals the need for ~$52 billion in average annual spending from 2010-2020 to meet the energy efficiency potential. To reach this level, the current investment rate in the United States will need to more than triple.[16] Achieving the needed growth in energy efficiency investment will require more investment from both the public and private sectors. Investment from the public sector is ultimately limited by political considerations; transmission and distribution utilities, which funded ~$2.4 billion in incentives for electric energy efficiency programs in 2011, raise these funds from ratepayers. Increasing public sector investment at the level required to bridge the investment gap would in the short run increase costs to ratepayers significantly.[17] Due to the limitation of public financing, private sources of energy efficiency financing will need to dramatically increase.

[15] For a more detailed discussion of the methodological differences between McKinsey and Co. and EPRI's energy efficiency potential study, see McKinsey's "EPRI and McKinsey Report on Energy Efficiency: A Comparison" (2009).
[16] The current level of energy efficiency investment in the United States is not precisely known. Bloom et. al (2013) produced research estimating North American energy efficiency in 2012 to be $17.5 billion. It is reasonable to assume that the majority of this investment comes from within the United States, but the exact extent of U.S. investment is not articulated.
[17] It is beyond the scope of this thesis to make a financial estimate of increased costs to ratepayers due to increased energy efficiency investment by utilities or the potential return on investment to ratepayers funding large-scale efficiency implementation.

Financial Barrier 1: Lack of Capital

More than tripling the current rate of energy efficiency investment will require significant capital outlay. In the current economic landscape, many consumers and firms are either unable or unwilling to make investments in energy efficiency improvements. For those firms and consumers willing to take on a debt obligation to finance efficiency improvements, investors are needed. For those firms and consumers who are unwilling to take on additional debt to fund energy efficiency projects[18], internal capital budgets are needed to fund efficiency improvements.

Financial Barrier 2: Desired ROI Not Achieved

Despite the significant profitable potential of energy efficiency financing, the existing financial, structural and strategic barriers (summarized below) and the relative novelty of private energy efficiency financing, may mean that investors will demand a higher rate of returns than other investment vehicles in order to develop solutions to overcome existing barriers (Peretz, 2009).

Many consumers and companies will only undertake investments in energy efficiency if the payback time is short. Recall that the average maximum desired payback times ranged from a low of 2.7 years (industrial customers) to a high of 4.1 years (institutional customers) in the 2010 Institute for Building Efficiency survey while median payback times for ESCO projects in the LBNL meta-analysis ranged from 3.2 years for private sector customers to 10.2 years for institutional customers. Many important energy efficiency measures such as whole building retrofits require longer payback times than many customers will tolerate, despite having attractive internal rates of return. This barrier holds back the adoption of building envelope improvements (McKinsey and Co., 2009)

Financial Barrier 3: Transaction Costs

In the aggregate, energy efficiency investment presents a compelling economic opportunity. However, the investment potential is spread across more than 100 million locations and billions of devices (McKinsey and Co., 2009). In order to get more interest and participation from the finance industry, solutions addressing the need for aggregation are needed and reduce private interest rates charged (Peretz, 2009).

Financial Barrier 4: Perceived Lack of Collateral

Utilities and third-parties investing in energy efficiency projects need assurances that they can recoup their investment in the case that the borrower is unable to meet her debt obligation. Many residential and commercial customers have existing mortgages for which lenders have primary liens. Many mortgage lenders do not permit secondary liens on energy efficiency equipment installed in mortgaged

[18] More attention is paid to the issues surrounding on-balance sheet vs. off-balance sheet investment vehicles later in this literature review.

properties (Kim, et al., 2012). Finding acceptable solutions to this problem is key to furthering energy efficiency debt financing on existing mortgaged properties.[19]

Structural Barriers

Structural barriers, such as principal-agent split incentives and ownership transfer, limit the uptake of energy efficiency measures in the large rental market, as well as the uptake of long-term, whole building energy efficiency measures in all buildings.

Structural Barrier 1: Principal-Agent Split Incentives

In the rental market, the major differences in time horizons between tenants (who might stay in the property for a few years) and owners (who may own the building for many tens of years), limit the implementation of energy efficiency measures (Kim, et al., 2012). In a situation in which the owner pays for capital improvements and the tenant pays for operating energy expenses, many profitable energy efficiency investments will not be pursued by tenants (who are unlikely to remain in the property long enough to pay back the investment) or owners (who do not pay for energy expenses).[20] The principal-agent problem impacts energy efficiency measure with a payback beyond a few years.

Beyond the oft-cited example of tenant and building owner, the restructuring of the utility industry[21] has created a scenario in which no single portion of the electricity system (generation, transmission, distribution, consumption) can capture the full benefits of an energy efficiency investment (Peretz, 2009). This is a particularly interesting issue in the context of the relationship between transmission and distribution utilities offering energy efficiency rebates and incentives and ELECTRICITY RETAILERS offering additional on-balance sheet or off-balance sheet financing options to customers. Transmission and distribution utilities benefit from improved efficiency through the deferral of investments in upgraded transmission and distribution infrastructure, but having been forced to sell off generation assets, no longer benefit from energy efficiency in terms of reducing investment in generation infrastructure.

[19] One possible solution to the lack of a secondary lien on energy efficiency equipment is to give the lender the ability to disable the equipment remotely in the case of non-payment (Peretz, 2009). This solution may appear draconian; acceptance of this type of arrangement is uncertain.
[20] The Energy Services Agreement (ESA) financing mechanism, which is described in greater detail later in this chapter, creates an important solution for the split incentives existing in many tenant-owner relationships whereby energy efficiency improvement costs are passed on from owners to tenants.
[21] A more complete explanation of the restructuring of the utility industry comes at the end of this literature review.

Structural Barrier 2: Ownership Transfer Issue

Beyond the rental market, efficiency potential is lost due to owners being unwilling to pursue longer-term energy efficiency retrofits because of a fear that they will not own the property long enough to pay back the initial investment. Full building retrofits that target improvements in the building envelope often represent compelling internal rates of return, but pay back over a longer period of time than lighting and HVAC optimization measures.

When ownership transfers from one entity to another, recouping the cost of energy efficiency investments made in that property is critical to incentivize longer-term energy efficiency investments. Solutions to this ownership transfer issue have been proposed. The most popular solution ties the monthly energy efficiency investment (in the case of financing) to the electricity meter, thereby ensuring that the owner or occupant will pay for the improved efficiency, even if ownership changes over time.

Strategic Barriers

Beyond financial and structural barriers, energy efficiency implementation would be aided by improved standardization of project evaluation, measurement, and verification of savings.

Strategic Barrier 1: Measurement and Verification Issues/Uncertainty of Savings

Measurement and verification of energy efficiency savings is a critical requirement for many projects, particularly because many energy efficiency financing mechanisms depend on the value of energy efficiency savings as a form of repayment for services rendered. Depending on project size and repayment method, different forms of measurement and verification may be appropriate. While the International Performance Measurement and Verification Protocol (IPMVP) lays out four internationally recognized measurement and verification techniques, there is an observed lack of standardization of M&V in the energy efficiency industry (Peretz, 2009). In particular, accounting for changes in energy consumption that are not related to the underlying energy efficiency project can be problematic (Kim, et al., 2012).

3.4.1 Prevalence of Barriers to Energy Efficiency

Estimating the relative contribution of different barriers to the energy efficiency "gap" is difficult, but through surveys and other analyses, researchers have presented estimates. The Institute for Building Efficiency and the International Facility Management Association has annually surveyed thousands of decision-makers on their organizations' energy efficiency attitudes and practices. Beginning in 2009, the survey asked respondents to name the "top barrier to capturing energy efficiency savings for your company or organization. The results of these surveys are presented in Table 7 below.

Table 7. Summary of Energy Efficiency Barriers – Institute for Building Efficiency Surveys (2009-2013)

Year	Number of Respondents	Most Popular Barriers to Energy Efficiency
2009	2,567	Capital Availability (37%), Payback/ROI (31%), Buy-in from senior leaders (9%), Dedicated attention (5%), Landlord/tenant split incentive (5%)
2010	2,882	Lack of capital budget (29%), Uncertainty of Savings/ROI (18%), Insufficient payback/ROI (18%), Technical expertise (12%), Buy-in from senior leaders (6%), Inability to finance – credit/collateral (6%)
2011*	3,868	Capital Availability (38%), Financial Criteria/ROI (21%), Certainty of savings (10%), Awareness (7%), Technical expertise (6%)
2012*	3,478	Capital Availability (37%), Financial Criteria/ROI (21%), Certainty of savings (12%), Awareness (7%), Technical expertise (6%)
2013*	2,998	Capital Availability (31%), Financial Criteria/ROI (20%), Certainty of savings (17%), Awareness (7%), Technical expertise (7%)

Sources: (International Facility Management Association, 2009; Institute for Building Efficiency, 2010; Institute for Building Efficiency, 2011; Institute for Building Efficiency, 2012; Institute for Building Efficiency, 2013)

* The data presented in the years 2011-2013 is for the U.S. and Canada only. 2009-2010 data was available on a global scale.

Consistently, capital availability, financial criteria/desired return on investment, and the certainty of energy efficiency savings rank as the most important barriers to energy efficiency implementation. The existence of these barriers emphasize the need for new financing mechanisms, more cost-effective energy efficient technologies, and standardized measurement and verification protocols to fulfill the energy efficiency 'gap'.

3.5 Energy Efficiency Financing

Financing strategies have the potential to address some of the most important barriers responsible for the 'gap' in energy efficiency implementation. The purpose of this section is to briefly review the current market for energy efficiency financing and the financing mechanisms available.

3.5.1 Energy Efficiency Financing - Market Size

To date, the majority of energy efficiency financing has been delivered by Energy Service Companies (ESCOs) providing energy efficiency retrofit projects. Many transmission and distribution utilities also offer low or no-cost energy efficiency financing to their customers. As of 2012, approximately 15% of the global commercial building energy efficiency retrofit market was paid via financial instruments (Bloom, et al., 2013). Market segmentation on energy efficiency financing in the United States was not available at the time of writing.

3.5.2 Energy Efficiency Financing – Financing Mechanisms

Bridging the energy efficiency 'gap' will require acceleration in investments from both the public and private sectors. There are a group of well-established and newly emerging financing mechanisms to meet the specific needs of different customer types (institutional, commercial, residential, etc.) with different economic goals and restrictions. The purpose of this section is to briefly outline the most popular established and emerging financing models in the context of the bundled energy efficiency/electricity supply business model. Readers interested in gaining a more in depth knowledge of all financing models would be well served to consult Kim et. al (2012) and (2013).

3.5.2.1 Energy Savings Performance Contracting (ESPC)

The Energy Savings Performance contract (ESPC) is a widely-deployed energy efficiency implementation structure, which is particularly popular in the institutional and M.U.S.H markets. Typically, the participating ESCO provides 'turnkey' services, i.e. the ESCO serves as project originator, developer, and arranger of financing (Kim, et al., 2012). In an ESPC, the ESCO installs energy efficient retrofits; customers either self-fund the energy efficiency improvements or use debt or lease financing to cover upfront costs. Financing under the ESPC model is considered 'on-balance' sheet. The customer pays back the cost of the installed measures in regular payments. Projects are designed such that a customer's energy related expenses (energy cost + cost of equipment) will not increase from previous levels; the monthly energy cost savings is equal to or greater than the cost of the equipment repayment. Analysis of a group of ESCO deals reveals that the ESCO seeks to capture approximately 90% of the energy savings on a six-year deal, and 75-80% of the savings on an 8-year deal (Peretz, 2009).

The value of energy efficiency savings is split between ESCO and customer in an ESPC. In many ESPCs, the ESCO guarantees a level of energy savings. In the case that this level of energy savings is not met, the ESCO is compelled to pay the customer the difference. The 'guaranteed savings' model is useful for customers that want to minimize risk, but actually acts to reduce the types of energy efficiency projects undertaken by an ESCO. If all savings in excess of the guaranteed level are retained by the customer, then the ESCO does not have a financial incentive to pursue more aggressive energy efficiency projects.

Estimates of the annual ESPC market range from $4-$7 billion (Bloom, et al., 2013) (The Rockefeller Foundation; DB Climate Change Advisors, 2012) (Larsen, et al., 2012). Contracts typically range from $1-$50 million (Bloom, et al., 2013).

Performance contracts are particularly popular among public and institutional sector projects; meta-analysis of ESCO projects reveals that 73% of public and institutional sector and 40-45% of private sector projects utilized a performance contract. (Larsen, et al., 2012)

3.5.2.2 Property Assessed Clean Energy (PACE) Financing

While ESPC remains a popular option, consumers and businesses have an array of other financing options to suit their needs. PACE financing has the potential to overcome the ownership transfer and upfront capital availability barriers by moving the cost of energy efficiency upgrades onto a property's annual property tax (Kim, et al., 2012). In a PACE financing deal, local governments or improvement district authorities provide property owners with upfront capital that is repaid through property tax assessments levied on the property. Property tax assessments are secured by a lien that takes precedence over the mortgage lien on the property; an important hurdle to clear for lenders interested in financing energy efficiency projects.

Since residential PACE is currently stalled due to regulations, the PACE market currently confined to the commercial sector. The North American PACE market is approximately $200 million in size, with typical projects ranging from $3,000-$100,000 (Bloom, et al., 2013).

3.5.2.3 Utility Energy Efficiency Programs

Currently, utilities serve as a major source of energy efficiency financing. Utilities leverage ratepayer funds to offer rebate, incentive, and financing programs for energy efficiency retrofits.

3.5.2.3.1 Rebates/Incentives

Transmission and distribution utilities offer rebates and incentives to their customers for energy efficient products.

Rebates are the simplest form of utility spending on energy efficiency. Simply put, rebates offer a fixed price per energy efficient product. Customers need only produce evidence that qualifying energy efficiency equipment has been purchased and installed to qualify for the rebate.

Incentives are different than rebates in that incentives are usually paid based on actual energy (kWh or therms) and/or demand (kW) savings. In order to qualify for most incentives, customers need to document and prove the quantity of energy and demand savings achieved through installation of qualifying energy efficient equipment. Incentives are particularly popular for commercial and industrial customers. While the value is more difficult to access, energy efficient incentives give project implementers the incentive to maximize energy savings.

3.5.2.3.2 On-Bill Financing

For customers and businesses interested in pursuing larger energy efficiency projects or for those who cannot afford to pursue energy efficiency upgrades, even with available rebates and incentives, utility-sourced financing is available.

On-bill financing programs allow consumers to pay back the cost of energy efficiency measures over time through a separate line item on their utility bill. Monthly energy efficiency equipment repayments are calculated such that total monthly expenses (utility cost plus energy efficiency equipment repayments) do not rise above pre-retrofit levels. Utilities can offer this arrangement so long as the value of energy cost savings is larger than the cost of the retrofit, adjusted for the time value of money.

Today, on-bill financing programs are widely available to consumers through utility sponsors. At least 20 states offer on-bill financing programs with specific enabling legislation in Illinois, Hawaii, Oregon, California, Kentucky, Georgia, South Carolina, Michigan and New York (Catherine J. Bell, 2011). [22] The size of loans and interest rate charged differ based on utility and customer type. Loans range from as

[22] Users interested in staying up-to-date with on-bill financing and other clean energy legislation would be well served to visit the Advanced Energy Legislation Tracker at http://www.aeltracker.org/

small as $5,000 for residential customers and as large as $1 million for institutional customers (Copithorne & Fine, 2011).

On-bill financing programs have performed well in terms of participants paying back the cost of equipment installed. The on-bill financing model has been successful in producing a high rate of repayment; default rates have been below 1 percent with the exception of Southern California Edison's on-bill financing pilot which had a 6.8% default rate (Bell, et al., 2011). The high level of repayment is due in part to the generally high level of payment for utility bills and to the ability of many utilities to shut off electricity service in cases of non-payment (Copithorne & Fine, 2011). Paying back the cost of energy efficiency financing on the electricity bill allows customers to see the positive economic effects of their investment immediately, and on a month-to-month basis (Kim, et al., 2012).

Remaining Issues

The issue of electricity disconnection for lack of payment for energy efficiency remains a critical and contentious issue for the continued growth of utility on-bill financing, on-bill repayment, and competitive retail electricity supplier bundled energy efficiency/electricity supply contracts. In addition, there are administrative barriers to on-bill financing, particularly those that leverage third-party ESCO services. For instance, the billing system used by many utilities is not easily re-configurable to accommodate third party services (Peretz, 2009).

3.5.2.3.3 On-Bill Repayment

On-Bill Repayment (OBR) programs promise to expand the size and scope of successful utility-funded on-bill financing programs through the use of *private* capital.

Like on-bill financing programs, on-bill repayment programs bundle energy efficiency improvement on to a customer's monthly utility bill. OBR obligations can be structured as an electricity rate tariff such that the cost of repayment stays with the meter, regardless of ownership. This innovation can facilitate longer-term energy efficiency projects and lower interest rates (Copithorne & Fine, 2011).

OBR programs are currently being considered in major U.S. electricity markets (California, New York, Illinois).

3.5.2.4 Energy Service Agreements (ESA)

Energy Service Agreements (ESA) represent a relatively new financing mechanism in the energy efficiency industry, which has the potential to dramatically increase energy efficiency participation by firms that are unwilling to take on on-balance sheet debt (Hinkle & Kenny, 2010). In an ESA, a project developer arranges for financing and project implementation (usually by an ESCO). The customer pays the project developer service payments based on the energy saved. Service payments are based on a percentage of energy savings achieved, either a percentage of the customer's utility rate or as a fixed cost per kWh saved (Kim, et al., 2012). The service payment structure incentivizes project developers to maximize energy savings because they increase their return with increasing energy savings levels. ESAs may be treated as operating leases or capital leases and are considered off-balance sheet (Kim, et al., 2012).

As of 2012, it was estimated that there were between 100-125 annual ESA deals, with $500 million in deals in the investment pipeline (The Rockefeller Foundation; DB Climate Change Advisors, 2012).

3.5.2.5 Managed Energy Service Agreements (MESA)

The MESA is a slightly different version of an ESA, wherein a project developer owns the energy efficiency equipment and serves as the only point of contact between the customer and the electric utility/electricity supplier. In a MESA, the customer makes a single payment to the project developer (to cover the cost of capital installed and energy costs); the project developer, in turn, assumes payment of a customer's electricity bills to the utility/and or electricity supplier (Kim, et al., 2012). Customers can either pay the MESA their baseline energy cost or the project developer can guarantee a percentage reduction in energy bills to the customer (Hinkle & Kenny, 2010). Like an ESA, a MESA is considered off-balance sheet.

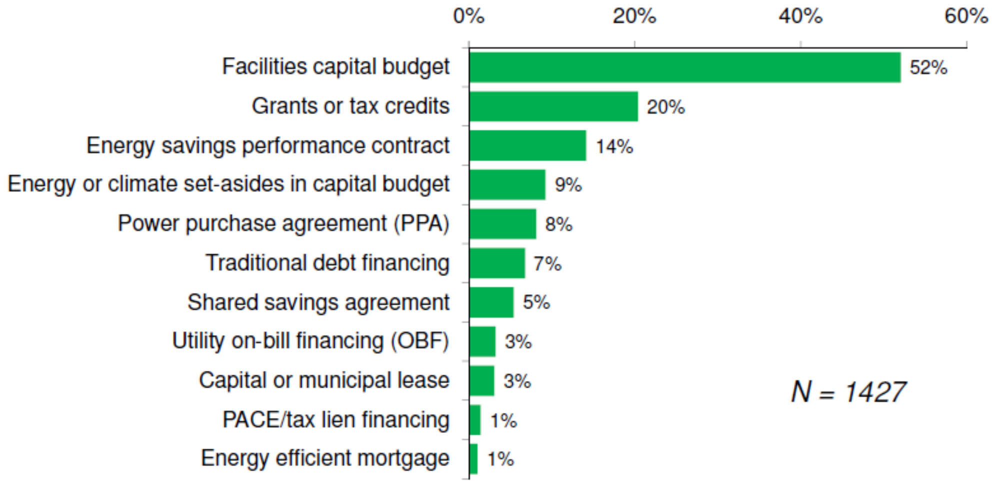
With a MESA structure, the customer has the project developer as a single point of contact and makes a single payment for all of its utility expenses. In contrast, under an ESA structure, the customer pays the ESA provider a service payment based on the realized savings and then pays each of its utility bills. As with an ESA, MESAs involve the sale of energy savings as a service and are considered to be off-balance sheet arrangements at this time. The MESA is a particularly attractive model for competitive retail electricity suppliers (ELECTRICITY RETAILERS) offering energy efficiency services because it reduced administrative complexity for potential customers. Participating customers in a mechanism in which the cost of energy efficiency retrofits are paid back through the supply cost paid to the ELECTRICITY RETAILERS benefit from simplicity and off-balance sheet funding.

3.5.3 Energy Efficiency Financing Distribution – Survey Data

The Institute for Building Efficiency and the International Facility Management Association has annually surveyed thousands of decision-makers on their organizations' energy efficiency attitudes and practices. A majority of respondents considering investments in energy efficiency in 2010[23] (61%) expected to use a facilities or energy capital budget. The full results of expected financing options for energy efficiency are presented in Figure 3 below.

[23] Results of other years' surveys were not available in publicly available executive summaries

Figure 3. Distribution of Energy Efficiency Financing Options - Institute for Building Efficiency Survey (2010)



Source: (Supple, 2010)

The Institute for Building Efficiency's (IBE) annual survey reveals that for organizations considering energy efficiency investments, pursuing those investments with in-house budgets is largely preferable. Keeping investments in-house obviates the need to take on debt obligations and in so doing, maximizes the potential returns to an energy efficiency investment. The avowed preference for pursuing energy efficiency investments with in-house funding is consistent with the observation that a lack of capital remains the largest and most consistent barrier to energy efficiency projects in IBE's annual survey results (recall Section 3.4.1).

3.6 Conclusion

Although it has grown considerably over the past decade, the existing energy efficiency market remains a small fraction of its potential size due to a series of structural, strategic, and financial barriers. Profitable energy efficiency investments are being avoided because of a lack of upfront capital and unwillingness among many firms and individuals to adopt debt-financing. The most common projects to be implemented have the shortest payback times due to both market preference and an inability to recoup energy efficiency investments in the case that ownership or tenancy changes. As a result, many longer-term energy efficiency investments with compelling rates of return are avoided. Changes to regulations the form of making energy efficiency investment repayments part of a utility's electric tariff, thereby ensuring repayment regardless of ownership, have the potential to stimulate the energy efficient market; particularly in the under-utilized market for energy efficiency measures with longer payback times (e.g. building envelope improvements). Innovative financing mechanisms such as the energy services agreement (ESA) and managed energy services agreement (MESA) convert energy efficiency investment repayments from on-balance sheet debt to off-balance sheet operating expenses, thereby addressing a major barrier to energy efficiency adoption. While the dramatic increase in public sector funding for energy efficiency rebates, incentives, and financing has been integral to the recent growth of the energy efficiency economy, private investment is needed to profitably quadruple the current size of the energy efficiency economy. The aforementioned innovations in regulation and financing mechanisms have the potential to attract significant private capital to energy efficiency investment.

Chapter 4 – The Supply Side

4.1 Introduction

The challenges and potential benefits of a bundled energy efficiency /electricity supply product are best understood in the context of the historical development of the competitive electricity supply market. The foregoing chapter first provides a macro-level perspective on the size and segmentation of the competitive retail electricity market from 1999-2011.[24] Having established the historical growth of the competitive electricity supply market and the segmentation of the market amongst electricity retailers, the chapter segues to an explication of general trends in wholesale electricity market behavior.

The opportunities presented by the bundled energy efficiency/electricity supply business model are largely the product of the unique business model of electricity suppliers. Electricity suppliers, unlike vertically integrated utilities, must compete for ratepayers' business. In response to the competitive forces of the competitive electricity market, electricity retailers have delivered a wide variety of electricity product types to suit different customer needs. Whereas vertically-integrated utilities generally offer different tariffs, i.e. the different electricity rates, based on a ratepayer's peak electricity demand – with limited potential for personalization – electricity retailers personalize electricity supply products according to each customer's needs.[25]

Understanding the pricing behavior of wholesale electricity markets and the electricity supply products available to consumers serves a necessary foundation to modeling the cost and risk implications of different electricity products available to customers in restructured electricity markets and the relative value of energy based on differences in customer type, technology implemented, electricity procurement strategy, and electricity market.

The chapter continues by explicating the costs incurred by ratepayers taking electricity supply from electricity retailers and describes the major electricity product types available in the context of value and risk to customer.

4.2 Electricity Restructuring

The economic and political rationale for restructuring the electricity industry has spawned considerable academic research. Unsurprisingly, restructuring an industry that accounts for hundreds of billions of dollars in annual revenue ensures continuous contentious debate. For the purposes of this thesis, the debates concerning whether electricity restructuring has led to a reduction in electricity prices for

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[24] The United States Energy Information Administration (EIA) compiles annual data on electricity sales volumes, prices, and number of customers for the residential, commercial, and industrial sectors.

[25] Contract personalization is particularly relevant to the commercial and industrial markets where electricity suppliers can quote a price based on a customer's specific electricity-consumption habits (load factor, peak load) and risk tolerance (percent of load purchased in the day-ahead and real-time markets). In practice, customers purchasing electricity from a vertically integrated utility are quoted a price based on the average cost to serve customers within a designated group of the entire utility customer portfolio. Not only do customers not have the ability to benefit from personalized attention to their specific consumption habits, but they have no ability to tailor their electricity contract according to their desired procurement strategy.

consumers and an increase in electricity reliability will not be considered. This is not to suggest that the debate is not worthy of study, simply that it falls outside of the scope of this thesis.[26]

Instead of devoting research resources to join the debate on the micro and macroeconomic merits of electricity restructuring as they pertain to electricity pricing trends, the purpose of this section is to familiarize readers with the rationale for electricity restructuring, the history of electricity restructuring, and today's electricity restructuring landscape.

The Rationale for Electricity Restructuring

Before explaining the rationale for electricity restructuring, it serves to briefly describe the existing electricity business structure that has changed over the past 20 plus years. Historically, the electricity system has been managed as a vertically-integrated, monopolistic (publicly-regulated) business. A single entity, known as the "utility" owned and operated all parts of the electricity system: generation (power plants), transmission (high frequency power lines you may see when travelling through sparsely populated areas), and distribution (the poles and wires that bring electricity from high frequency power lines to homes and businesses). All parts of the electricity system were considered natural monopolies (Alliance to Save Energy, 2013). Consumers paid a regulated rate that allowed utilities to recover their costs and retain a reasonable profit. The regulated price system remains today for the electricity transmission and distribution industries.

With technological advances in electricity generation and transmission infrastructure, and a perceived deficit in investment in new generation and transmission equipment by vertically integrated incumbent utilities leading to antiquated infrastructure, advocates for electricity restructuring proposed an end to the natural monopoly (ISO New England, 2013). States that restructured their electricity markets compelled the vertically-integrated utilities to sell off generation assets, while maintaining their ownership and operation of the transmission and distribution system. Instead of utility-owned generation facilities, independently-owned generation facilities now provide power to wholesale electricity markets throughout much of the geographic United States (Cooke, 2011). Electricity retailers emerged as market participants that broker electricity exchanges between power plants and consumers/businesses. Some ELECTRICITY RETAILERS also own generation units, but these generation units can sell electricity to any bidder on the open market, not just their associated electricity retailers.

Advocates for competitive choice in the electricity industry believed that competition would produce additional investment and lower prices for consumers. As an added benefit, with electricity generation unbundled from the transmission and distribution utilities, poor investments in electricity generation would impact an independent electricity producer's shareholders. Historically, the costs of poor investment decisions in generation assets were passed on to ratepayers who were compelled to pay. (Compete Coalition, 2010)

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[26] For more information on this important debate, see Kwoka (2006), Joskow (2000), Littlechild (2000), Wolack (2007) and Domagalski & O'Connor (2013).

The History of Electricity Restructuring

Electricity restructuring started in earnest in 1992 with the passage of the Federal Energy Policy Act, it facilitated the establishment of independent service operators (ISOs) and regional transmission organizations (RTOs) in the later 1990s to oversee the integration of existing utility transmission systems into an integrated system where electricity could be bought, sold, and delivered over long distances (PJM Interconnection, 2013). In 1996, the Federal Energy Regulatory Commission (FERC) issued Orders 888 and 889 which formally opened access to the nation's electricity grid for independent power producers (New York Independent Service Operator, 2013). Following the opening of the transmission grid, independent power producers and competitive power marketers emerged to provide electricity supply to retail customers.

In the transition period from vertical integration to competitive choice, many public utility commission imposed rate freezes for a number of years to ensure benefits to consumers in the transitional years (Kwoka, 2006). Customers not choosing to purchase electricity from an electricity retailer still receive electricity still receive electricity service from their transmission and distribution utility. The transmission and distribution utility remains the Provider-of-Last-Resort, i.e. they must supply their customers if they do not choose an electricity retailer, in the case that a competitive retailer declares bankruptcy (Compete Coalition, 2010).

Today's Electricity Restructuring Landscape

Today, electricity consumers have full access to competitive electricity supply in 13 states and Washington D.C.; limited access is permitted in 4 other states. Electricity restructuring has reached into the majority of the U.S. electricity market; the Southeast, Southwest, and Northwestern states retain traditional vertical integration (Compete Coalition, 2010).

4.3 The Competitive Retail Electricity Market

As of 2011,[27] there were 13 U.S. states and Washington D.C. that offer full competitive choice to all residential, commercial, and industrial customers (Compete Coalition 2012). Four other states (California, Michigan, Montana, and Oregon), offer competitive choice to a subset of electricity in-state electricity customers.

The 13 U.S. states and Washington D.C. with competitive choice[28] comprised approximately half of the entire U.S. electricity market in 2011 (53% residential customers, 52.2% commercial customers, 48.4% industrial customers).

[27] The EIA-861 dataset from which the market segmentation research is drawn is released annually in September. As of the writing of this thesis, the 2012 dataset has yet to be released. While the electricity volumes, revenues, number of customers, and number of competitive electricity retailers serving those customers has changed over the past year, there remain 13 U.S. states and Washington D.C. with full competitive electricity choice as of this writing.

[28] As Table 8 reveals, the percentage of customers within a state with competitive choice is not 100% for all states.

Note that Table 8 below reflects the total volume of competitive purchases (GWh) in addition to the percentage of customers *eligible* for competitive electricity choice who purchase electricity from electricity retailers (i.e. 'customer switching rate'). The data also displays the percentage of competitive electricity sales to the total sales of electricity (competitive and non-competitive purchases. Differences between *eligible percentage* and *total percentage* are the product of states in which not all electricity is sold competitively.

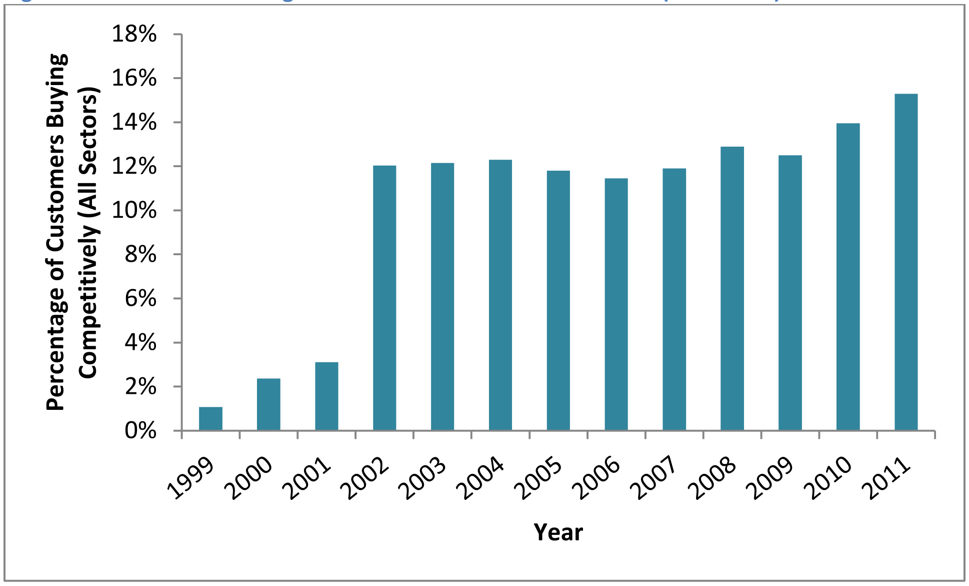
Table 8. Competitive Electricity Choice - Market Segmentation and Switching Statistics (2011)

2011 GWh KEMA Reported Competitive Sales as Percent of 2011 Eligible Load & as Percent of EIA Reported Total Statewide C&I or Residential Load						
Jurisdiction	Non-Residential Competitive Load			Residential Competitive Load		
	GWh	Eligible %	Total %	GWh	Eligible %	Total %
California	21,939	17.80%	13.40%	101	0.10%	0.10%
Connecticut	13,363	85.20%	78.90%	5,583	45.60%	43.00%
Delaware	4,068	75.00%	62.00%	115	3.80%	2.50%
DC	8,318	83.90%	87.50%	127	6.30%	6.20%
Illinois	71,406	80.00%	75.20%	2,211	5.40%	4.70%
Maine	4,541	68.60%	64.50%	24	0.60%	0.50%
Maryland	28,514	81.70%	78.50%	5,056	20.70%	18.50%
Massachusetts	23,094	76.20%	64.50%	2,199	12.70%	10.50%
Michigan	7,999	100.00%	11.50%	0	0%	0%
Montana	2,453	100.00%	27.60%	1	0%	0%
New Hampshire	3,380	57.20%	52.80%	9	0.20%	0.20%
New Jersey	33,325	79.40%	70.40%	3,680	12.30%	12.50%
New York	54,795	68.20%	59.30%	8,800	22.50%	17.20%
Ohio	52,746	58.60%	52.30%	14,872	33.10%	27.90%
Oregon	959	5.30%	3.50%	0	0%	0%
Pennsylvania	75,232	81.80%	80.00%	12,265	23.30%	22.40%
Rhode Island	2,204	48.00%	47.90%	32	1.00%	1.00%
Texas	142,442	100.00%	64.30%	78,810	100.00%	55.10%
TOTAL	**550,778**	**68.20%**	**52.80%**	**133,885**	**31.30%**	**22.10%**

Source: (O'Connor, 2012)

Within the competitive states, customer switching from utilities to competitive retailers has experienced two periods of rapid growth (2001-2002) and (2009-present); see Figure 4 below for the development of the U.S. competitive market. Figure 1 represents the ratio of electricity customers (residential, commercial, and industrial) purchasing electricity competitively to all electricity customers in the United States.

Figure 4. Customer Switching in All Sectors of Restructured States (1999-2011)



Source: (U.S. Energy Information Administration, 2012)

Within the competitive states, the percentage of customers choosing to purchase electricity from a competitive retail electricity supplier (electricity retailers) instead of the utility, varies substantially.

The residential, commercial, and industrial market sizing results reveals that Texas, Ohio, and Pennsylvania are the three largest markets for competitive electricity purchasing. It was this data that motivated our interest in modeling the value of energy efficiency in the Texas and Pennsylvania competitive markets.

4.3.2 Competitive Retail Electricity Market Size – Retailer Comparison

Just as the total volume of electricity sales is concentrated in a few major states (Texas, Pennsylvania, and Ohio), the total volume of electricity sales is concentrated in a relatively small number of competitive electricity retailers.

In 2011, the last year with complete publicly available data, there were 80 competitive suppliers that supplied electricity for residential customers that were still in business in July 2013.[29] The residential market is skewed towards a relatively small percentage of the electricity retailer community; 69.3% of the competitive residential market was supplied by 13 competitive retailers. The top 2 retailers (TXU Energy – 21.1% and Reliant Energy Retail Services – 15.2%) supplied the residential market in Texas only (see Table 9 below).

[29] We queried the websites of all competitive retail electricity suppliers (ELECTRICITY MARKETERS) extant in the 2011 U.S. EIA 861 dataset to determine whether they were in business. Some ELECTRICITY MARKETERS have gone out of business while others have been acquired by other ELECTRICITY MARKETERS.

Table 9. Top electricity retailers (by Market Share) serving the U.S. residential competitive electricity market

Competitive Retailers	U.S. Residential Market Share (MWh)
TXU Energy Retail Co LP	21.1%
Reliant Energy Retail Services	15.2%
First Energy Solutions Corp.	10.6%
Dominion Retail Inc	5.2%
NextEra Energy Power Marketing	2.6%
Direct Energy, LP	2.6%
Green Mountain Energy Company	2.1%
CPL Retail Energy, LP	1.9%
Consolidated Edison Sol Inc	1.9%
First Choice Power	1.8%
GEXA Corp.	1.6%
Washington Gas Energy Services	1.3%
Cirro Group, Inc.	1.3%

Source: (U.S. Energy Information Administration, 2012)

There were 94 electricity retailers supplying electricity to commercial customers in 2011 that remain in business in July 2013; the top 15 account for more than 77% of total electricity sales to the commercial sector. As with the residential market, there is significant concentration of total market share in the top of the market (see below):

Table 10 below):

Table 10. Top Retailers (by Market Share) serving the U.S. commercial competitive electricity market

Competitive Retailers	U.S. Commercial Market Share (MWh)
Constellation NewEnergy, Inc	12.7%
Direct Energy Business	11.2%
First Energy Solutions Corp.	8.2%
Noble Americas Energy Solutions LLC	8.1%
Suez Energy Resources North Am	7.0%
Exelon Energy Company	5.6%
Amerada Hess Corporation	4.1%
Consolidated Edison Sol Inc	3.9%
Integrys Energy Services, Inc.	2.7%
GEXA Corp.	2.7%
Washington Gas Energy Services	2.5%
Hudson Energy Services	2.3%
Liberty Power Corp.	2.2%
TXU Energy Retail Co LP	2.1%
Champion Energy Services	2.1%

Source: (U.S. Energy Information Administration, 2012)

There were 54 electricity retailers supplying electricity to industrial customers in 2011; like the residential and commercial sectors, there is significant concentration of total market share among a small group of electricity retailers. The top electricity retailers are presented in Table 11 below.

Table 11. Top Retailers (by Market Share) serving the U.S. industrial competitive electricity market

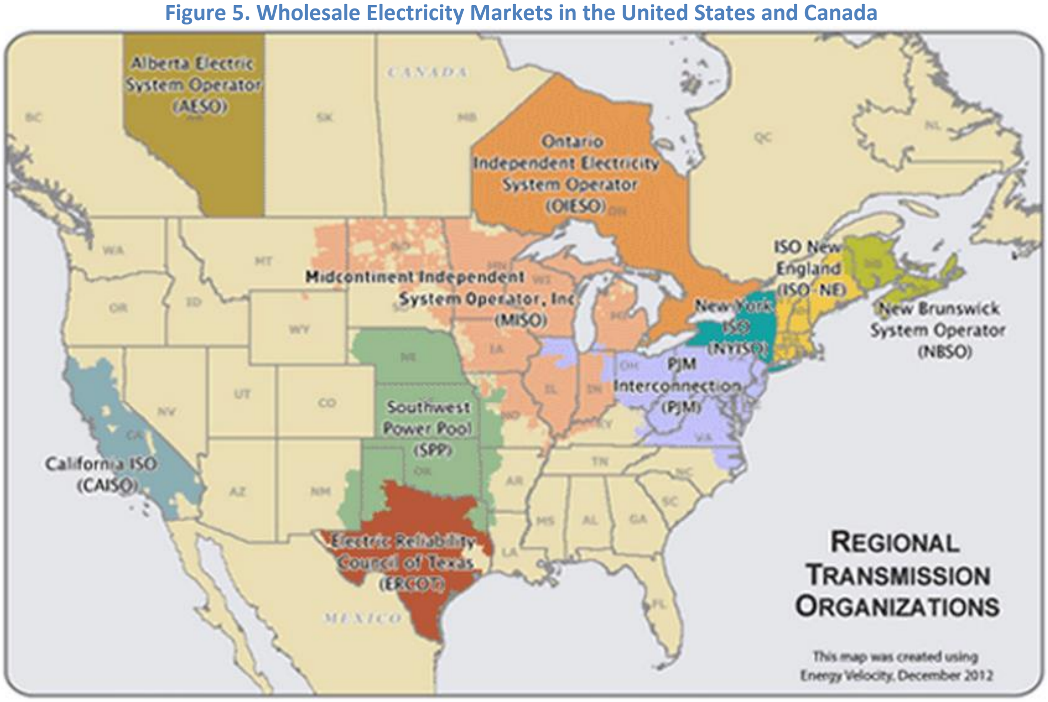
Competitive Retailers	U.S. Industrial Market Share (MWh)
First Energy Solutions Corp.	13%
Reliant Energy Retail Services	12%
Constellation NewEnergy, Inc	10%
TXU Energy Retail Co LP	8%
Amerada Hess Corporation	8%
Suez Energy Resources North Am	7%
EDF Industrial Power Services (TX), LLC	5%
Noble Americas Energy Solutions LLC	5%
TransCanada Energy Sales Ltd. - WSPP	4%
PPL EnergyPlus LLC	4%

Source: (U.S. Energy Information Administration, 2012)

4.4 Wholesale Electricity Markets

The restructuring of the U.S. electricity economy produces a group of interconnected wholesale electricity markets managed so as to provide equal access to the transmission system. The current landscape of regional transmission organization (sometimes also called “independent service operators” or ISOs) is displayed in Figure 5 below.

Figure 5. Wholesale Electricity Markets in the United States and Canada



Source: (Federal Energy Regulatory Commission, 2013)

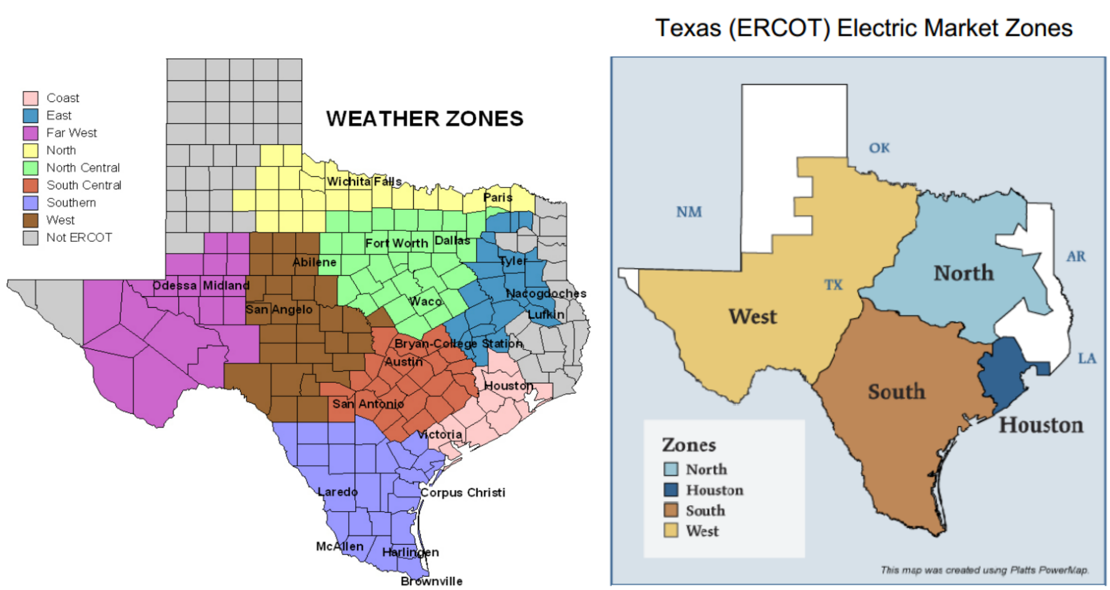
We review the market designs of two fundamentally different wholesale electricity markets, ERCOT (Electric Reliability Council of Texas) and PJM (Pennsylvania Jersey Maryland Interconnection), as a means of providing a theoretical foundation for the differences in which wholesale electricity markets compensate market participants and the implications of these differences on electric reliability.

4.4.1 The ERCOT Wholesale Market

ERCOT measures hourly load data in 8 weather zones: Coast, East, Far West, North, North Central, South Central, Southern, and West. ERCOT quotes pricing data at it least granular level for 4 load zones: Houston, North, West, and South (see

Figure 6 below).

Figure 6. ERCOT Weather and Load Zone Maps



Source: (Federal Energy Regulatory Agency, 2007) (Electric Reliability Council of Texas, 2006)

In order to perform a high-level analysis on trends between electricity demand (MW) and real-time electricity price ($/MWh), we associated each of the 8 weather zones with one of the 4 load zones. While the boundaries of the weather and load zones do not correspond perfectly, for the purposes of this analysis we associated each weather zone in its entirety to a load zone. The relationship of weather zones and load zones is defined as follows:

Table 12. ERCOT Weather and Load Zones

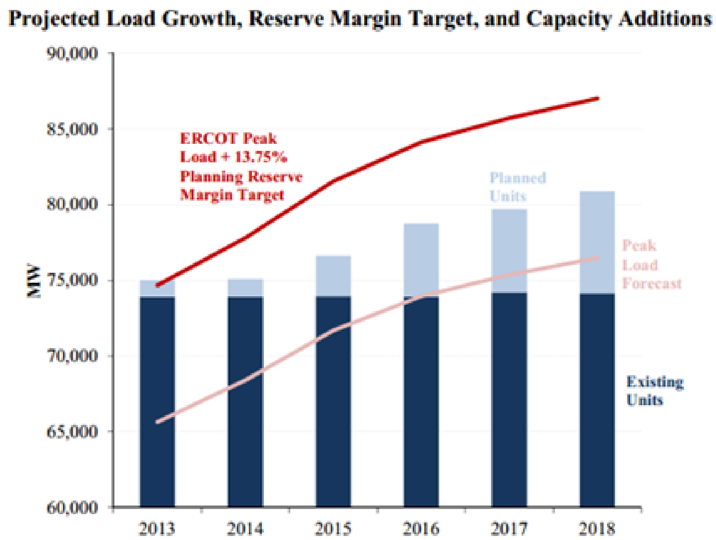
Load Zone	Associated Weather Zones
North	East, North Central
Houston	Coast
South	Southern, South Central
West	North, West, Far West

4.4.1.1 The ERCOT Wholesale Market – Market Design

Before considering the implications of the load factor analysis results calculated in Table 38 below, it serves to briefly discuss two major characteristics which differentiate the ERCOT wholesale market from other wholesale markets throughout the United States:

The ERCOT market is an 'energy-only' market. In energy-only electricity markets, power plants are paid only for the electricity they provide to the grid (The Brattle Group, 2012). In other wholesale electricity markets, power plants are also paid according to the electricity capacity they can provide during periods of peak grid demand, providing an additional source of revenue for power plants. The existence of a forward capacity market provides a degree of revenue certainty to power plant investors. Without the stable revenue available through a capacity market, investment in power plants in the ERCOT market is less certain. As a means of encouraging investment in ERCOT's 'energy-only' market, ERCOT has instituted a series of increasing price caps for wholesale electricity prices over the next 2 years. Up until June 1st, 2013, the price cap, i.e. the highest possible clearing price for real-time electricity in any given 15-minute period is set at $3,000/MWh. Over the next 2 years, ERCOT's price cap will be raised from $4,500/MWh on June 1st, 2013 to $9,000/MWh on June 1st, 2015 (Direct Energy Business, 2012). The rationale behind increasing the price cap is to stimulate investment in power plants needed to meet peak demand; ERCOT, unlike other wholesale markets is facing potential shortfalls in its required reserve margin (see Figure 7 below).

Figure 7. Resource Adequacy Projections - ERCOT Market



Source: (The Brattle Group, 2012)

The existence of these high wholesale price caps in addition to the energy only nature of the ERCOT market, produces a degree of pricing volatility not observed in other wholesale markets. As of the first half of 2013, there is a lively debate on whether the introduction of a capacity market would provide net benefits to the ERCOT market, but analysis of this issue is outside the scope of this thesis.

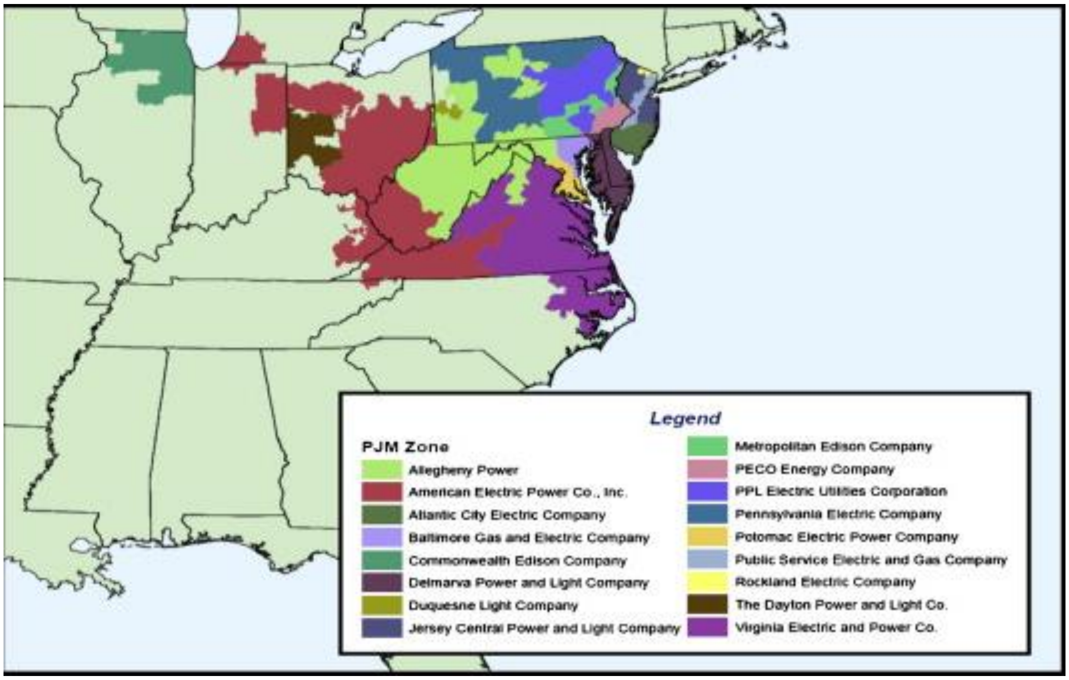
The ERCOT market has a high percentage of intermittent wind generation. In 2011, ~6.9% of all electricity generated in the state of Texas came from wind power (AWEA 2013). This wind resource is comparatively large in the context of other U.S. wholesale electricity markets; only ~0.9% of all electricity generated in Pennsylvania came from wind in 2011 (AWEA 2013). The intermittent nature of wind generation adds an additional source of volatility to the electricity supply/demand balance, impacting the behavior of the ERCOT wholesale electricity market. Modeling the impact of wind generation on wholesale electricity price volatility falls outside of the scope of this analysis.

4.4.2 The PJM Interconnection Wholesale Market

The PJM Interconnection administers the wholesale electricity market in all or part of 13 states (see Figure 8 below). For the purposes of this analysis (and its focus on markets that allow competitive choice), we have limited the analysis to PJM load zones that are entirely contained within the state of Pennsylvania.

1. Pennsylvania Electric Company (PENELEC)
2. Metropolitan Edison Company (METED)
3. PPL Electric Utilities (PPL)
4. PECO Energy (PECO)
5. Duquesne Light (DUQ)

Figure 8. Map of PJM Interconnection With Load Zones



Source: (PJM Interconnection, 2013)

4.4.2.1 The PJM Interconnection Wholesale Market – Market Design

Unlike ERCOT, The PJM Interconnection wholesale grid operator sponsors a forward capacity market. The market is divided into 19 load zones, covering all or part of 13 U.S. states.

4.5 Pricing Trends in Wholesale Electricity Markets

In order to further develop the reader's understanding of the volatility inherent in indexed electricity products, it serves to describe the overall behavior and quantify the intra-annual and inter-annual volatility of the ERCOT and PJM real-time electricity markets. In so doing, we establish the basis on which to quantitatively model the volatility-risk continuum.

Real-time electricity pricing data – data availability

The wholesale electricity grid operators publish day-ahead and real-time electricity pricing data, available for public use. The electricity pricing data used in this analysis came from the wholesale electricity grid operators ERCOT and PJM. In order to limit the scope of this analysis, the pricing data analyzed was taken from 2 load zones in ERCOT (South and Coast) and 2 load zones in PJM (MetEd and Penelec). ERCOT's load zones South and Coast are contained entirely within the state of Texas while MetEd and Penelec load zones are contained entirely within the state of Pennsylvania. The decision to choose these particular wholesale electricity markets was made both because each market has robust competitive choice (and a high number of ratepayers participating) and because fundamental differences in market structure produce significant differences in pricing behavior.

Real-time pricing data was downloaded in February 2013; the years 2008-2012 were used in the foregoing analysis.

Real-time electricity pricing data – data analysis

Based on the wholesale electricity pricing data available through ERCOT and PJM, we can model intra-annual and inter-annual variability. Intra-annual variability in in ERCOT and PJM wholesale markets is based on seasonal differences in weather; system demand is highest when electricity is used to air condition spaces than they do in the winter months when air-conditioning is not needed. Unlike Europe, electric space heating is not popular in the United States. Averaged intra-annual electricity pricing data (from 2009-2012) for Load Zone Houston customer type is displayed in Table 11 below. The table displays the average real-time electricity price ($/MWh) in each hour of the day for each month of the year for the years 2009-2012.

The average intra-annual variability in real-time electricity prices in Load Zone Houston differs by a factor of 15 between the highest value: $254/MWh (August, H.B. 16) and the lowest value: $17/MWh (March, April, May, October, multiple hours).

Figure 9. Average real-time electricity price distribution (LZ_HOUSTON 2009-2012)

2009-2012 average	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
H.B. 0	22	23	42	35	32	30	27	27	27	30	21	24
H.B. 1	23	22	18	20	23	24	24	24	21	19	18	23
H.B. 2	23	22	17	18	18	20	22	22	19	17	18	23
H.B. 3	24	25	17	17	17	19	21	21	18	17	18	23
H.B. 4	31	29	18	18	18	19	21	20	19	18	19	25
H.B. 5	34	54	21	20	21	20	22	21	20	20	22	32
H.B. 6	56	66	29	25	20	20	22	22	24	26	25	30
H.B. 7	50	67	29	24	21	22	23	23	23	28	25	33
H.B. 8	37	50	24	28	23	25	26	25	23	24	28	32
H.B. 9	36	48	26	30	25	28	29	28	26	29	30	33
H.B. 10	38	57	29	30	27	31	32	32	28	33	29	33
H.B. 11	33	44	32	31	29	38	36	36	34	28	29	30
H.B. 12	29	27	25	27	31	42	36	40	31	28	25	27
H.B. 13	27	27	27	34	37	67	49	82	45	31	30	26
H.B. 14	26	25	30	35	43	84	61	186	58	38	27	25
H.B. 15	24	24	28	42	53	113	66	239	68	43	27	24
H.B. 16	25	24	47	47	52	89	65	254	75	48	25	25
H.B. 17	31	27	36	31	42	68	51	108	54	36	41	46
H.B. 18	46	51	45	28	36	41	42	53	32	28	49	47
H.B. 19	35	37	35	25	30	35	37	41	29	33	36	34
H.B. 20	33	34	42	33	29	33	35	38	36	29	26	31
H.B. 21	29	30	28	27	30	32	34	35	27	26	24	29
H.B. 22	32	32	37	28	34	37	34	32	27	35	31	30
H.B. 23	27	25	26	25	25	28	29	31	27	26	24	27

Inter-annual variability is calculated by computing the percentage difference in each year's average 15-minute consumption data for each hour and each month to the average calculated in Figure 9 above. As an example, Figure 10 below displays the percentage difference from the 2009-2012 average for the year 2009.

Figure 10. Deviation of real-time electricity price distribution from 2009-2012 average (LZ_HOUSTON 2009)

2009 deviation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
H.B. 0	3%	24%	261%	205%	221%	8%	8%	-3%	111%	7%	1%	57%
H.B. 1	-13%	-24%	-8%	-15%	34%	-2%	-7%	-12%	-14%	3%	-12%	34%
H.B. 2	-14%	-26%	-14%	-22%	0%	-6%	-10%	-13%	-15%	4%	-17%	37%
H.B. 3	-11%	-35%	-13%	-25%	-4%	-12%	-13%	-14%	-13%	4%	-20%	32%
H.B. 4	-21%	-32%	-14%	-22%	-5%	-14%	-13%	-14%	-13%	2%	-13%	38%
H.B. 5	38%	-57%	-13%	-16%	-14%	-14%	-12%	-13%	-13%	2%	5%	20%
H.B. 6	-27%	-68%	-42%	-24%	-6%	-14%	-14%	-14%	-15%	-9%	-10%	25%
H.B. 7	48%	-5%	-23%	-7%	-12%	-15%	-14%	-16%	-12%	11%	-9%	66%
H.B. 8	-11%	-49%	-9%	-26%	-4%	-13%	-15%	-18%	-16%	13%	-13%	55%
H.B. 9	-7%	-44%	-7%	6%	-3%	-8%	-11%	-15%	-16%	12%	15%	37%
H.B. 10	-12%	-48%	-8%	8%	1%	-6%	-11%	-17%	1%	3%	18%	43%
H.B. 11	0%	-33%	-9%	-20%	1%	24%	-7%	-18%	-14%	19%	14%	38%
H.B. 12	-14%	-20%	-6%	-20%	-8%	7%	-12%	-25%	-8%	10%	-9%	21%
H.B. 13	-5%	-8%	-6%	-24%	11%	59%	-1%	-36%	-17%	4%	-1%	18%
H.B. 14	-7%	-8%	-17%	-27%	-12%	22%	-28%	-77%	-32%	26%	12%	11%
H.B. 15	-10%	-8%	-15%	-38%	-18%	43%	-2%	-80%	-54%	-17%	14%	6%
H.B. 16	-10%	-9%	-47%	-34%	8%	83%	-3%	-78%	-57%	-12%	2%	14%
H.B. 17	-11%	-13%	3%	-17%	11%	99%	13%	-58%	65%	-8%	-17%	10%
H.B. 18	-1%	-31%	-44%	-16%	-3%	24%	6%	-32%	-16%	0%	-1%	36%
H.B. 19	6%	-8%	30%	-16%	-3%	8%	0%	-23%	-17%	22%	-4%	41%
H.B. 20	-5%	-17%	42%	-20%	3%	-1%	-9%	-18%	22%	16%	-7%	39%
H.B. 21	-4%	-18%	-9%	3%	-11%	-3%	-9%	-18%	-6%	3%	-9%	32%
H.B. 22	13%	18%	25%	-9%	46%	7%	-2%	-10%	-17%	-22%	-5%	28%
H.B. 23	-2%	-1%	33%	2%	-2%	4%	1%	29%	11%	-6%	18%	43%

Real-time electricity prices in Load Zone Houston are characterized by high levels of intra-annual and inter-annual volatility. Table 13 summarizes the largest annual deviations from the 2009-2012 average for Load Zone Houston.

Table 13. Summary data - deviation of electricity consumption from 2009-2012 average (LZ_HOUSTON)

Year	Most Positive Deviation	Date and Time of Most Positive Deviation	Most Negative Deviation	Date and Time of Most Negative Deviation
2009	261%	March, H.B. 0	-80%	August, H.B. 15
2010	239%	October, H.B. 0	-48%	May, H.B. 14
2011	204%	August, H.B. 15	-47%	March, H.B. 0
2012	108%	March, H.B. 16	-77%	August, H.B. 14

Analysis of PJM pricing data reveals real-time pricing volatility, but on a smaller scale than that observed in the ERCOT market.

The average intra-annual variability in real-time electricity prices in Load Zone MetEd (Metropolitan Edison) differs by a factor of 4 between the highest value: \$95/MWh (July, H.B. 16) and the lowest value: \$21/MWh (June, H.B. 3). See Figure 11 below for full pricing details.

Figure 11. Average real-time electricity price distribution (METED 2009-2012)

2009-2012 average	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
H.B. 0	46	35	29	28	28	30	34	30	27	27	29	35
H.B. 1	46	36	29	27	26	27	32	29	26	27	29	34
H.B. 2	44	34	28	25	23	23	29	26	24	26	28	33
H.B. 3	45	33	27	25	22	21	25	24	23	26	28	32
H.B. 4	43	34	29	26	22	22	25	25	24	26	29	32
H.B. 5	45	37	31	29	26	23	27	27	28	28	31	33
H.B. 6	58	53	42	36	27	25	28	29	36	41	44	43
H.B. 7	66	52	48	37	33	33	32	29	31	40	43	47
H.B. 8	64	47	43	38	37	36	41	33	33	39	40	44
H.B. 9	59	48	44	41	40	40	52	39	38	41	41	48
H.B. 10	60	47	44	43	46	49	61	48	43	43	43	49
H.B. 11	58	45	42	44	46	50	67	51	46	41	39	45
H.B. 12	54	41	40	44	50	50	71	55	48	39	38	41
H.B. 13	51	39	38	46	53	56	85	60	51	38	35	40
H.B. 14	48	38	35	42	53	60	81	66	53	37	33	36
H.B. 15	45	36	34	41	60	68	88	71	57	35	33	37
H.B. 16	51	37	34	41	65	70	95	66	61	36	41	46
H.B. 17	80	50	36	41	59	61	92	63	52	36	67	74
H.B. 18	76	59	44	36	48	50	69	50	42	51	51	56
H.B. 19	64	56	50	42	42	45	57	45	57	50	43	51
H.B. 20	62	50	47	53	50	44	62	56	54	40	42	54
H.B. 21	57	46	39	43	47	47	60	45	36	35	38	47
H.B. 22	46	37	32	32	34	34	40	35	31	30	31	38
H.B. 23	43	35	30	29	31	31	37	32	27	28	29	34

Table 14. Summary data - deviation of average real-time electricity price distribution from 2009-2012 average (METED)

Year	Most Positive Deviation	Date and Time of Most Positive Deviation	Most Negative Deviation	Date and Time of Most Negative Deviation
2009	39%	January, H.B. 9	-53%	July, H.B. 13
2010	62%	September, H.B. 16	-36%	January, H.B. 17
2011	57%	June, H.B. 15	-25%	December, H.B. 12-13
2012	34%	November, H.B. 17	-54%	May, H.B. 6

The magnitude of inter-annual variability in load zone MetEd is smaller (by a factor of 4) than the magnitude of the inter-annual variability in load zone Houston. However, the dates and times on which the deviations occur are similar to the load zone Houston data insofar as their timing is inconsistent from year-to-year.

4.6 Elements of Electricity Supply Contract

The foregoing section describes the elements that comprise and electricity *supply* contract.[30] The elements of the supply contract listed below, unless otherwise stated, are separate and distinct from the charges invoiced to customers for expenses incurred for *transmission and distribution* services.

Residential Customers

Residential customers are most often quoted a single rate (cost for each kWh of electricity consumed). All additional *supply-related* costs, which are charged as distinct items for most commercial and industrial customers, are bundled into the residential supply cost.

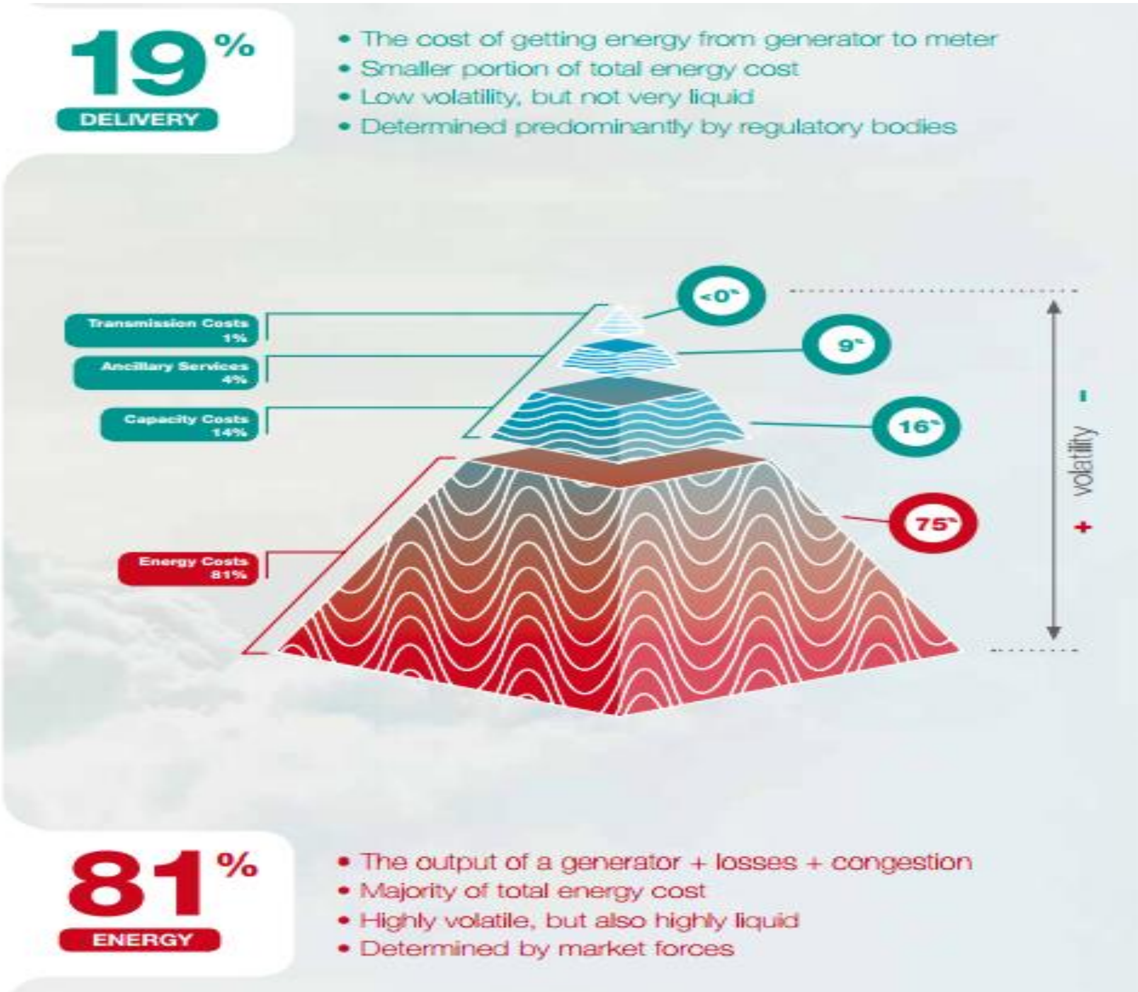
Commercial and Industrial Customers

Commercial and industrial (C&I) customers, different than residential customers, often times see multiple line items on the electricity supply side of the bill. The major electricity supply charges are explained in greater detail below. However, before this explanation, it serves to view the scope and volatility of the different electricity supply components visually (see

Figure 12 below):

Figure 12. Electricity Supply Cost Matrix

[30] The elements specified in electricity supply contracts differ for residential versus commercial and industrial customers. The differences between residential and commercial contracts are specified.



Source: (GDF Suez Energy Resources, 2013)

Not only do energy costs represent the vast majority of electricity supply costs, they are also the most volatile component of the electricity supply bill.[31] It bears mentioning that the figures cited in Figure 1 above are averages and differ by wholesale electricity market and year. Nevertheless, the general trend of energy costs being the largest and most volatile portion of the electricity supply bill is consistent throughout all wholesale electricity markets.[32] Further details on electricity supply costs for C&I customers are presented here (Shuttenburg, 2013):

Energy costs. Energy costs consist of the locational marginal price charged by the Independent Service Operator (ISO). Wholesale energy costs are highly variable depending on the supply-demand balance and fuel commodity prices. The supply-demand balance is sensitive to weather (hot weather increases electricity demand) and power plant availability (unplanned power plant outages reduce supply). Energy cost variability differs considerably between each U.S. wholesale electricity market.

[31] Volatility is expressed in the wholesale electricity market. In practice, a high percentage of electricity is transacted bilaterally, at fixed costs.
[32] However, the price volatility and average price of each wholesale market differs significantly, and will be discussed at further length later in this chapter.

Ancillary services and other ISO costs. In order to ensure a reliable electricity system, wholesale electricity grid operators must procure a variety of ancillary services from power plants and demand side resources. Some ancillary services like frequency regulation (maintaining electrical frequency system-wide to maintain reliable electrical transmission) are procured on a second-by-second basis, while others, e.g. spinning and non-spinning reserves (ensuring adequate electricity generation supply in case of unexpected failures) are procured in 10 to 30 minute cycles, as needed. The ELECTRICITY RETAILERS has the task of apportioning ancillary services charged by the ISO to its customers (Fusco, 2013).

Capacity costs. Capacity costs are charged by the wholesale electricity grid operator to ensure that there is sufficient electricity generating capacity to ensure security of supply during times of peak grid demand, generally the hottest summer afternoons. It is important to note, ERCOT, the wholesale electricity grid operator that oversees the Texas wholesale market, does not have a capacity market; power plants are paid only for the energy (kWh) they deliver to the market rather than also receiving revenue for the capacity (kW) they can deliver if needed (ERCOT 2013). The ERCOT market is what is known as an "energy-only" market. ERCOT is unique in all wholesale markets in being an energy-only market.[33] Despite being an energy-only market, customers in ERCOT are still charged a capacity "tag" based on their average electricity demand during the top hour of ERCOT-wide system peak demand in June, July, August, and September (Fusco, 2013). PJM, the wholesale electricity market that includes the state of Pennsylvania, has a capacity market. The percentage of a customer's bill comprised of capacity costs differs widely based on wholesale market; in ERCOT and PJM capacity costs generally impact less than 5% of a customer's total electricity bill.[34]

Transmission costs. Transmission costs are charged by the local transmission and distribution (T&D) utility based on a customer's electricity demand at system peak on the highest demand hour for the highest 5 demand days between June 1st and September 30th. Just as capacity costs are used to ensure sufficient electricity generating capacity, transmission costs are used to ensure that there is sufficient transmission capacity to meet peak electricity demand.

Line loss costs. Transmitting electricity from the point of generation to the point of use involves efficiency losses. The existence of line losses ensures that the locational marginal price (LMP) of electricity is higher at the point of use than at the point of generation, since line losses have the effect of reducing supply. If line losses are incorporated into the LMP, they are presented as a separate line item on a customer's bill.

Renewable Portfolio Standard (RPS) costs. RPS costs, a fraction of a cent per kWh, are charged to all ratepayers as a means of meeting renewable portfolio standard costs. All entities serving electrical load (e.g. electricity retailers) are required to source an increasing percentage of electricity from renewable sources, or pay a charge to support renewable energy generation.

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[33] The volatility and energy cost implications of ERCOT's energy only market are highly relevant to the potential value of energy efficiency in a bundled energy efficiency/electricity supply contract and is discussed in greater detail later in the chapter.

[34] For more information on the relative impact of capacity costs on customers' bills in different wholesale markets, consult the Joule Assets Peak Power Index at http://jouleassets.com/wp/about-joule-assets/peak-power-index/

4.7 The Electricity Product Purchasing Process

Electricity retailers procure electricity for their portfolio of customers through a combination of bilateral agreements with power plants, forward contracts, and purchases in the wholesale market (day-ahead and real-time). The exact distribution of an electricity retailer's purchases between these electricity procurement options depends on the particular electricity retailer, the wholesale market served, customer preferences and prevailing wholesale market conditions. What is most important to understand in the context of this chapter, however, is the ways in which a customer's electricity demand, i.e. volume of electricity consumption, and load factor, i.e. the ratio of average to maximum load, impact the fixed price quoted to customers.

Electricity Consumption Volume

The basic dynamics of supply and demand dictate that customers with higher electricity consumption volume (industrial customers usually being the largest), can procure the lowest rates from electricity retailers. Residential customers, with their comparatively low electricity consumption volumes, generally pay the highest electricity rate per unit of electricity.

Electricity Procurement Data

Intra-annual and diurnal variations in real-time wholesale electricity prices serve as a proxy for the differences between base load and peaking power prices for cost comparison between different customer types.

The Mechanics of Electricity Product Purchasing for Residential and Commercial Customers

Commercial Customers

Paradoxically, purchasing retail electricity as a commercial (or industrial) customer provides the opportunity for the most attractive and least attractive electricity supply contracts. Unlike with residential customers, electricity retailers do not publicly publish electricity supply contracts for commercial (and industrial) customers. Thus commercial customers do not have the opportunity to objectively compare offers in the same way as residential customers. Retailers do not publish supply contracts for commercial customers because they are customized based on a customer's risk tolerance (i.e. how much electricity will be purchased in the day-ahead and/or real-time market) and the customer's load shape (i.e. its electricity consumption pattern through the year). Electricity retailers customize contracts based on the anticipated cost of serving a particular customer's electricity consumption based on that customer's risk tolerance (Domagalski, 2013). Without familiarity of the dynamics of electricity procurement, the commercial customer is immediately put at a disadvantage in electricity supply contract negotiations. In order to ameliorate the existence of asymmetries in expertise between electricity retailers and customer, electricity supply brokers have emerged as an important market player to facilitate commerce while representing customers' interests (Shuttenburg, 2013). Electricity supply brokers can facilitate competitive bidding between retailers for a commercial or industrial customer's business.[35] Most brokers are paid a small, fixed fee by the electricity retailer that ultimately serves the broker's customer. The fee paid is contractually determined such that any retailer ultimately getting business from the broker will pay the same price. This incentive structure creates an alignment of interests between the customer and the broker, i.e. the broker does not have a specific interest in any particular electricity retailer's electricity supply, only the customer's satisfaction with the final outcome. Brokers serve the important role of reducing a customer's transaction costs of searching for an optimal electricity supply contract.

Commercial customers interested in pursuing bundled energy efficiency/electricity supply products must face added complexity in the procurement process due to the introduction of energy efficiency implementation as a variable in electricity supply contract pricing. Due to the fact that bundled energy efficiency/electricity supply contracts like Constellation NewEnergy's Efficiency Made Easy℠ are relatively new, there has yet to be a proliferation of supply brokers specializing in electricity procurement with embedded efficiency measures. If and when the bundled energy efficiency/electricity supply product gains greater market share, customers will need additional expertise in contract negotiation based on the value gained by the retailer through permanently changing their customers' load shapes.

Residential Customers

Unlike the commercial market, residential customers have the ability of easily comparing offers between electricity retailers on comparison retail electricity shopping websites. While the existence of these shopping websites ensures that electricity retailers must compete for residential customers by providing the lowest possible electricity supply option, residential customers lose the value of contract customization. By providing a single price for residential customers, retailers' are providing a price based on the *average cost* of serving *all* residential customers in their portfolio, rather than the *actual cost* of serving a *single* residential customer.[36] The substantial administrative challenge of personalizing residential electricity supply contracts for potentially millions of accounts makes the existence of a single price understandable.

Pricing of Bundled Energy Efficiency/Electricity Supply Products

Primarily, electricity retailers compete for customers' business based on providing the lowest-possible electricity supply cost. Retail competition has also led to value-added electricity supply contracts,

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[35] As an example, EnergyChoices (http://www.energychoices.com/content.php?id=1030) sponsors competitive supply auctions.

[36] Residential customers can reduce supply costs to the level of commercial customers in their ability to command electricity supply prices based on the actual cost of providing service if they are willing and able to participate in Community Choice Aggregation (CCA). CCA bundled thousands of residential customers into a single electricity procurement bid, giving residential customers the same scale, i.e. electricity consumption, and negotiating power as large commercial or industrial customers.

including those with 100% renewable energy and energy efficiency measures, giving consumers greater choice in customizing their electricity purchasing experience. The ability of a customer to command the lowest possible price for a basic or value-added electricity supply contract depends on the customer type and customer's level of expertise with the retail electricity market.

4.8 Electricity Supply Product Options

Electricity retailers provide a wide array of electricity supply product choices, representing the needs and risk tolerance of their customers. The following section does not present all possible electricity product types, but describes the most popular categories.

Electricity Product Category 1. Fixed Price

Low Risk/Low Volatility

Customers choosing fixed price contracts have the greatest budget certainty of any electricity product type. Fixed price contracts offer customers a fixed price per kWh used, usually in 500-1,000 kWh blocks for residential customers, e.g. customer A will be charged $0.10/kWh for up to 1,000 kWh used in a month. Fixed price contracts often quote lower unit cost ($/kWh) the larger a customer's monthly electricity consumption.

- For residential customers, all non-energy related costs are incorporated into the cost per kWh quoted in a fixed price contract.
- For commercial and industrial customers, a fixed price contract simply means that all electricity costs (energy, ancillary services, transmission, line losses) are fixed, i.e. do not fluctuate with the monthly, day-ahead, or real-time electricity markets.

Electricity Product Category 2. Index Contract

Highest Risk/Highest Volatility

Index electricity products are those in which the cost per kWh used is based on some external "index". The most common indexes on which electricity products are based are the price of natural gas (monthly) and the price of wholesale electricity (day-ahead or real-time market). Index products are unique in that they subject the customer to the highest level of risk, but because of this, represent the lowest cost premiums charged by electricity retailers. In this, indexed products are most useful for customers with high level of control and flexibility in operations, and those with a strong understanding of the natural gas and electricity markets.

Electricity Product Category 3. Hybrid (Fixed + Index)

Medium Risk/Medium Volatility

Hybrid electricity products, which come in a plethora of combinations, combine some form of fixed price contract and some form of indexed price contract. As an example, a customer might enter into a contract that provides a fixed price for a “block” of 1MW for all hours of the month. The price of any electricity consumption above this 1 MWh per hour might be based, for instance, on the monthly natural gas price (for example, a “heat rate index”) or on the hourly real-time electricity price. The important strategic advantage of hybrid contracts comes from mixing a no-risk electricity position (fixed price portion) with the potential to reduce costs if market conditions dictate (index portion). The index portion of the hybrid electricity product exposes the customer to the risk of volatility and potentially high prices. However, the index portion also can allow a customer to reduce overall electricity costs if the natural gas and/or real-time electricity markets experience price declines.

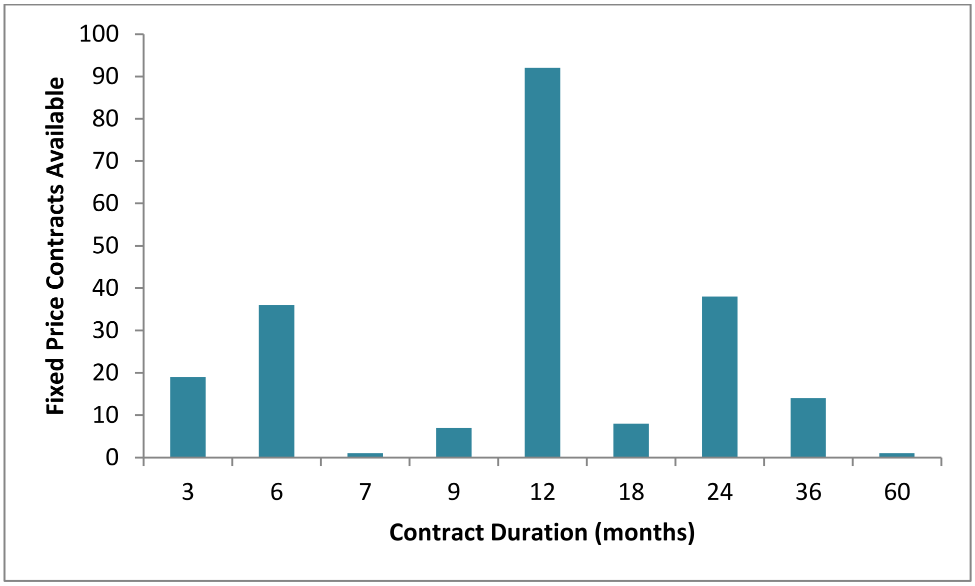
Electricity Supply Product Distribution - Residential Market Data

While we have not been able to locate data on the distribution of residential customers between electricity product types, there are alternative means to approximate the market’s composition. The Texas retail electricity market is worthy of study both because of its substantial size and level of maturity. The Public Utility Commission of Texas sponsors a website (PowertoChoose.org) that allows residential customers to compare different electricity product offerings by searching by zip code, transmission, and distribution utility. By querying this database, we can document the composition of electricity products available to residential customers. For the purposes of this inquiry, we have chosen to focus on the electricity product choices available to customers of a single transmission and distribution (T&D) utility in the Houston, Texas area: CenterPoint Energy. Electricity products available to residential customers (as well as commercial and industrial customers) are defined by contract length, renewable energy content and pricing mechanism.

Fixed Price Products

As of May 2013, there were 216 unique fixed price electricity products offered by 48 electricity retailers in the CenterPoint area, ranging in length from 3 months to 5 years (see Figure 13 below):

Figure 13. Distribution of Fixed Price Contact Duration (CenterPoint Energy service area)

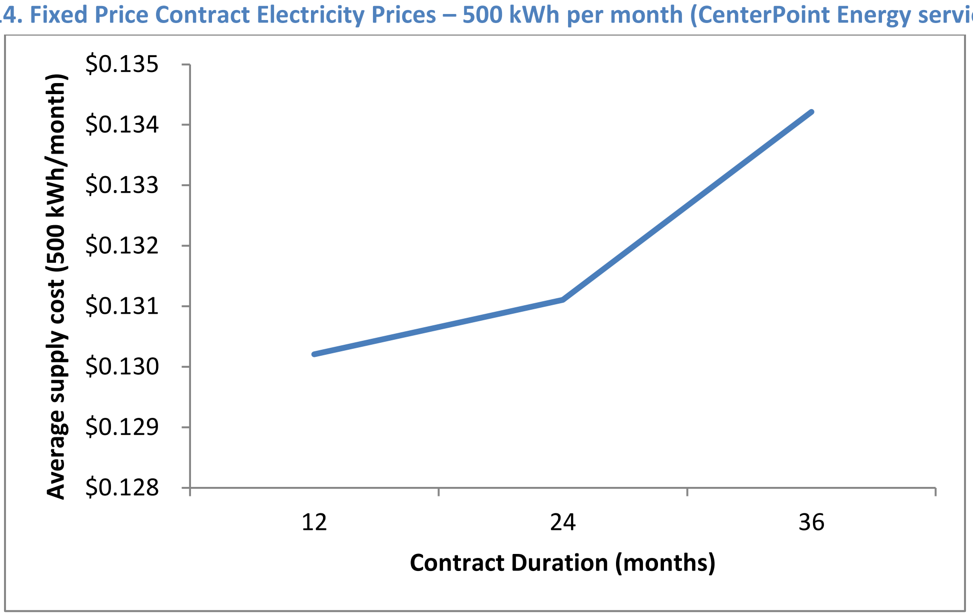


Source: Texas Public Utility Commission, 2013

The majority of fixed price contracts available to Texas residential customers are for 12 months and less, likely reflecting customer preferences for short duration contracts.

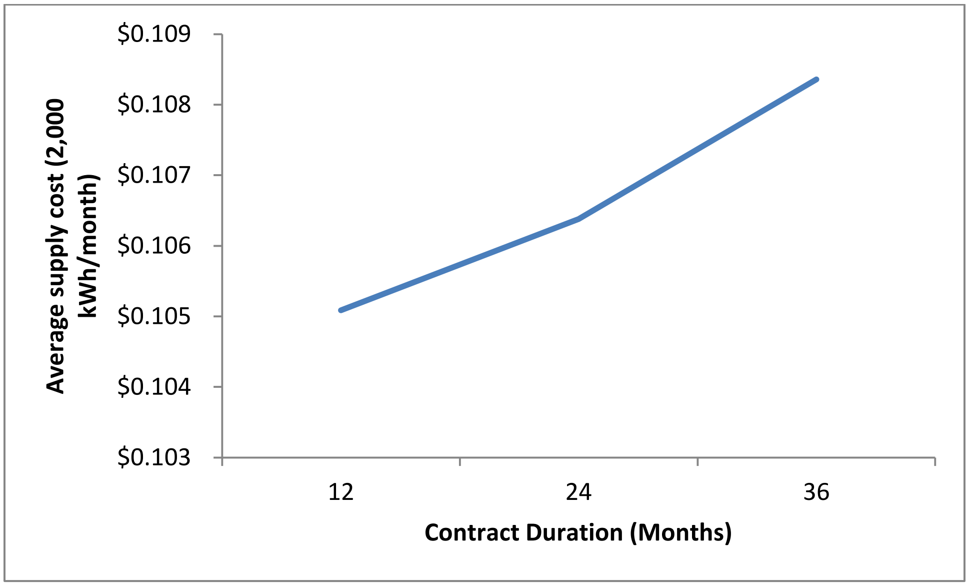
Additionally, it serves mentioning that on average, the longer the duration of a fixed price contract, the higher the cost per kWh charged. Figure 14 and Figure 15 below represent the average electricity supply costs for all fixed price electricity contracts with durations of 12, 24, and 36 month.

Figure 14. Fixed Price Contract Electricity Prices – 500 kWh per month (CenterPoint Energy service area)



Source: Texas Public Utility Commission, 2013

Figure 15. Fixed Price Contract Electricity Prices - 2,000 kWh per month (CenterPoint Energy service area)



Source: Texas Public Utility Commission, 2013

The trend of electricity supply costs increasing with the length of contract duration is clearly observable for both fixed price contracts of 500 (slope = $0.00017/month) and 2,000 kWh (slope = $0.00014/month) a month. However, the most pronounced observable trend uncovered by analyzing the fixed price electricity contract data is the impact of increasing electricity volume on decreasing electricity cost. As an example, the average supply cost of a 36 month contract for a customer using 500 kWh per month is 23.8% greater than the average cost of a 36 month contract for a customer using 2,000 kWh per month.

In comparison to the 216 unique fixed price electricity products available to CenterPoint Energy customers, there were 43 hybrid electricity and 4 indexed products available. In the case of variable products, the variable portion of the bill is still based on a fixed per kWh charge; the fixed cost per kWh charge changes each month based on the cost on the monthly NYMEX natural gas future contract.

Electricity Supply Product Distribution - Commercial and Industrial Market Data

Determining the distribution of electricity among commercial and industrial ratepayers is not possible insofar as competitive retailers do not publish this data nor are there comparison shopping websites available from public utility commissions. However, conversations with representatives of ELECTRICITY RETAILERS and electricity brokers reveal general trends in the commercial and industrial marketplace. Overall, the larger the commercial or industrial electricity customer, the more likely that customer is to purchase electricity using a hybrid or indexed electricity supply contract (Domagalski, 2013;Miller, 2013). However, this can only be presented as a general trend, as many large customers still prefer the budget certainty of fixed price contracts.

4.9 Volatility – Risk Continuum

When choosing from among the array of electricity products available, customers must weigh costs, budget certainty, and risk tolerance. Customers choose electricity products for a host of reasons, but the most important decision a customer will make in a purchase decision is the amount of risk and uncertainty that is tolerable.

- For the customer who is completely risk adverse and wants as much budget certainty as possible, fixed price products purchased for long time periods are advisable. As an electricity retailer must take all of the risk of meeting their customers contracted electricity consumption through the electricity retailer's procurement strategy (bilateral contracts, forward contracts, day-ahead and real-time market), the electricity retailer will charge the highest premium for fixed price contracts.

- For the customer who has a medium risk tolerance and some control over and flexibility in operations, a hybrid electricity product, in which some percentage of electricity consumption is purchased based on an index (natural gas, day-ahead or real-time electricity, etc.) is appropriate. An electricity retailer does not need to take the risk of meeting its customer's electricity purchase requirements on the portion of the customer's bill that sources electricity in the day-ahead or real-time market. Instead, the customer's electricity consumption is said to be "passed through", whereby the electricity retailers will purchase electricity on behalf of their customer in the day-ahead or real-time market, charging a small fee per kWh purchased.

- For the customer who has a high risk tolerance, significant control over and flexibility in operations, an indexed electricity product is advisable.

4.10 Conclusion

The fundamental differences between the pricing behavior of the ERCOT and PJM real-time markets provide a basis on which to understand the pricing uncertainty created by volatility. Purchasing electricity in the real-time market reduces premium charged by electricity retailers and in so doing, can lower prices for customers. However, the volatility of the real-time procurement strategy produces significant risk to the customer in the form of: difficulty in predicting average cost of procurement outcomes based on a customer's known consumption habits.

Competitive Electricity Supplier Market Segmentation

Analysis of the EIA-861 dataset reveals a competitive electricity market that is highly skewed towards a few states with large market share (Texas, Pennsylvania, and Ohio) and a relatively small number of competitive electricity suppliers (Constellation NewEnergy, Reliant Energy, TXU Energy, Direct Energy, First Energy Solutions) with a large market share. There is a huge potential for growth of customer switching to competitive electricity suppliers in most states that offer competitive choice. Recall that the 13 states and Washington D.C. with full competitive choice comprised approximately half of all electricity (MWh) sold in the United States in 2011, but customer switching rates within all competitive states combined remain relatively low: 19.2% of residential sales (MWh), 38.6% of commercial sales (MWh), and 27.3% of industrial sales (MWh). The market gap, i.e. the electricity customers in competitive states who are not taking electricity service from competitive electricity suppliers, provides a significant opportunity for business growth for competitive suppliers. Market consolidation among a few high-market share competitive suppliers provides economies of scale for customers interested in purchasing the lowest cost-possible electricity, but also gives opportunities to small-market share competitive suppliers to increase business by providing value-added energy efficiency products that larger incumbent suppliers may not yet be providing.

Chapter 5 – The Demand Side

5.1 Introduction

The foregoing chapter introduces a general understanding of trends in facility electricity consumption and the impact of energy efficiency technologies on electricity consumption. Through an analysis of public available backcasted meter data, the size and scope of inter-annual and intra-annual consumption volatility is established. Having previously presented general trends in wholesale electricity market pricing behavior, we present a quantitative explanation of the volatility-price continuum.

Finally, we discuss the implications of energy efficient technologies that produce a permanent demand reduction (e.g. lighting) versus those the produce a variable demand reduction (e.g. HVAC optimization) on measurement and verification of energy efficiency savings. In so doing, we provide context to modeling used to analyze the relative cost savings available to electricity retailers and its customers due to energy efficiency implementation.

5.2 Methods of Categorizing Electricity Consumption

Load Factor

A customer's load factor also is vital in determining its supply cost due to the impact of load factor on a electricity retailer's procurement requirements and risk mitigation strategies. In order to understand the relationship between a customer's load factor and the electricity retailer's average cost of procurement for that customer, one needs to understand the costs and operational characteristics of different types of power plants.

Customers with high load factors, i.e. those whose electricity demand is highly consistent throughout the day and year, can be served largely by the cheapest base load power plants (which run at constant output throughout the year). Customers with lower, more variable load factors can only have a portion of their load served by base load power plants, where the remainder of their load must be served by a combination of higher priced peaking power plants.

Coefficient of Variation

It is important to examine the inter-annual volatility in load factor for our dataset. We can compare the inter-annual volatility in load factor by computing the ***coefficient of variation***, i.e. the ratio of the standard deviation to the mean:

$$c_v = \frac{\sigma}{\mu}$$

Table 15. Load Factor during Lighting Occupancy Period - Statistical Analysis (2012)

	Coefficient of Variation	Load Factor
BUSHILF	0.00292	0.79
BUSMEDLF	0.03381	0.67
BUSLOLF	0.03399	0.63
RESHIWR	0.05174	0.41
RESLOWR	0.04808	0.37

Inter-annual volatility in load factor increases as average load factor values decrease (R-value is -0.91). Owing to the fact that we only use 5 examples of customer load data in our energy efficiency valuation analysis, it serves to test whether the general trends in electricity consumption observed in the ERCOT load examples are consistent with other load data. Pacific Gas & Electric offers backcasted load data for all of its customer types. Analysis of 6 different electricity consumption data samples[37] reveals a strong relationship between load factor and coefficient of variation, confirming the general trend observed in the ERCOT load data.

Table 16. PG&E Backcasted Load Data Correlation (R-squared) Between Load Factor and Coefficient of Variation (2008-2012)

Year	r-squared
2008	0.870
2009	0.872
2010	0.934
2011	0.802
2012	0.869

Source: PG&E 2013

For full descriptive statistics of the PG&E load data (standard deviation, mean, coefficient of variation, and load factor) see Appendix 3.

Electricity consumption data – data availability

Due in large part to data privacy and business competitiveness concerns, electricity consumption 'meter' data is largely unavailable to the public. Despite this difficulty in research, there are substantial meter data resources available in aggregate form. ERCOT, the wholesale electricity grid operator that manages the restructured Texas market, and Pacific Gas & Electric, one of the largest investor owned utilities in the country, both provide 'backcasted' meter data for different customer types based on an anonymous, representative sample of actual customer data. The ERCOT data I use to model the cost impact of

[37] Meter data samples were for the A1, A6, A10, E1, E19P, and E20P tariffs.

different electricity products is based on a representative sample of 250 customers per customer type. The ERCOT data presents electricity (kWh) used in 15 minute increments. The customer types modeled were business high load factor (BUSHILF), business medium load factor (BUSMEDLF), business low load factor (BUSLOLF), residential high winter ratio (RESHIWR), and residential low winter ratio (RESLOWR).[38]

Electricity consumption data – data analysis

Based on the electricity consumption data available through ERCOT, we can model intra-annual and inter-annual variability. Intra-annual variability in the United States, particularly in the ERCOT market, is based on seasonal differences in weather; customers consume significantly more electricity in the summer months when electricity is used to air condition spaces than they do in the winter months when air-conditioning is not needed. Unlike Europe, electric space heating is not popular in the United States. Averaged intra-annual electricity consumption data (from 2009-2012) for the BUSMEDLF (business medium load factor) customer type is displayed in Table 17 below. The table displays the average electricity (kWh) consumption in each hour of the day for each month of the year for the years 2009-2012.

Table 17. Average 15-minute electricity consumption (BUSMEDLF_COAST) for years 2009-2012

2009-2012 average	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
H.B. 0	3.86	3.78	4.06	4.29	4.71	5.42	5.57	5.79	5.18	4.51	3.93	3.91
H.B. 1	3.73	3.66	3.82	4.06	4.48	5.14	5.28	5.51	4.87	4.18	3.80	3.79
H.B. 2	3.74	3.68	3.75	3.98	4.41	5.08	5.21	5.44	4.78	4.10	3.76	3.79
H.B. 3	3.74	3.67	3.72	3.92	4.31	4.93	5.06	5.25	4.65	4.03	3.74	3.78
H.B. 4	3.81	3.75	3.74	3.92	4.31	4.91	5.03	5.18	4.58	4.02	3.78	3.81
H.B. 5	4.13	4.10	4.08	4.24	4.65	5.29	5.39	5.59	4.93	4.35	4.00	4.04
H.B. 6	4.52	4.49	4.47	4.66	5.04	5.62	5.76	5.95	5.22	4.68	4.25	4.39
H.B. 7	4.95	4.93	4.87	5.05	5.56	6.28	6.35	6.63	5.80	5.20	4.59	4.81
H.B. 8	5.23	5.34	5.36	5.78	6.36	7.29	7.36	7.76	6.66	5.79	5.13	5.15
H.B. 9	5.55	5.71	5.81	6.34	7.01	8.04	8.06	8.57	7.37	6.40	5.61	5.50
H.B. 10	5.75	5.92	6.16	6.76	7.50	8.57	8.57	9.09	7.86	6.92	5.95	5.69
H.B. 11	5.87	6.07	6.38	7.07	7.84	8.92	8.89	9.54	8.28	7.27	6.20	5.83
H.B. 12	5.95	6.16	6.55	7.28	8.06	9.16	9.11	9.83	8.54	7.55	6.39	5.90
H.B. 13	5.99	6.19	6.67	7.42	8.23	9.32	9.26	10.03	8.72	7.75	6.50	5.96
H.B. 14	6.04	6.22	6.79	7.54	8.36	9.41	9.33	10.15	8.81	7.90	6.59	6.00
H.B. 15	6.06	6.21	6.87	7.58	8.41	9.44	9.35	10.14	8.81	8.00	6.60	5.99
H.B. 16	5.98	6.14	6.81	7.50	8.32	9.28	9.19	9.98	8.66	7.88	6.47	5.91
H.B. 17	6.12	6.13	6.59	7.21	7.97	8.93	8.87	9.69	8.37	7.57	6.51	6.20
H.B. 18	6.29	6.30	6.32	6.74	7.47	8.36	8.31	9.04	7.83	7.16	6.50	6.25
H.B. 19	6.06	6.16	6.36	6.68	7.29	8.12	8.06	8.64	7.76	7.23	6.32	6.02
H.B. 20	5.83	5.94	6.26	6.80	7.37	8.08	8.09	8.75	7.66	6.92	6.08	5.84
H.B. 21	5.35	5.43	5.69	6.20	6.78	7.58	7.62	8.00	6.95	6.25	5.54	5.41
H.B. 22	4.78	4.78	5.04	5.48	5.99	6.77	6.83	7.06	6.16	5.52	4.92	4.86
H.B. 23	4.14	4.13	4.26	4.78	5.23	6.01	6.10	6.35	5.54	4.88	4.33	4.24

Source: ERCOT 2013

Intra-annual variability is clearly visible in Table 17 above. The highest average 15 minute electricity consumption values occur in August between H.B. (hours beginning) 13 and H.B. 17. This finding is consistent with the hypothesis that summer air-conditioning load drives demand in the ERCOT market.

[38] Recall that more complete definitions of each customer type can be found in Chapter 2 – Methodology.

Electricity consumption averages range from ~4 kWh per 15 minute period during the highest ('peak') demand hours to ~1 kWh per 15 minute period during the lowest ('baseline') demand hours.

Intra-annual variability is most easily quantified by the quotient of a facility's average electricity demand and its maximum electricity demand, i.e. "load factor".

Inter-annual variability is calculated by computing the percentage difference in each year's average 15-minute consumption data for each hour and each month to the average calculated in Table 17 above. As an example, Table 18 below displays the percentage difference between electricity consumption in 2009 and the 2009-2012 average displayed in Table 17 above.

Table 18. Deviation of electricity consumption from 2009-2012 average (BUSMEDLF_COAST 2009)

2009 deviation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
H.B. 0	-2%	-2%	0%	-3%	0%	-1%	3%	-3%	-3%	2%	-2%	1%
H.B. 1	-2%	-3%	0%	-3%	0%	-1%	3%	-3%	-3%	3%	-1%	1%
H.B. 2	-2%	-3%	0%	-3%	-1%	-1%	3%	-3%	-3%	3%	-1%	1%
H.B. 3	-2%	-3%	0%	-3%	0%	-1%	3%	-3%	-3%	3%	-1%	2%
H.B. 4	-2%	-4%	0%	-3%	0%	-1%	3%	-3%	-2%	3%	-1%	2%
H.B. 5	-2%	-4%	0%	-2%	-1%	-1%	3%	-4%	-2%	4%	-2%	2%
H.B. 6	-2%	-4%	0%	-2%	-1%	-1%	3%	-4%	-2%	4%	-3%	2%
H.B. 7	-2%	-4%	0%	-2%	-1%	-1%	4%	-4%	-2%	4%	-3%	2%
H.B. 8	-2%	-3%	-1%	-3%	-1%	-1%	4%	-4%	-3%	4%	-3%	1%
H.B. 9	-1%	-2%	-1%	-3%	-1%	0%	4%	-4%	-3%	2%	-3%	0%
H.B. 10	0%	-1%	-1%	-4%	-1%	0%	4%	-4%	-3%	1%	-3%	-1%
H.B. 11	0%	0%	-1%	-4%	-1%	0%	4%	-3%	-4%	0%	-3%	-2%
H.B. 12	1%	1%	-1%	-4%	-2%	0%	5%	-3%	-4%	-1%	-3%	-3%
H.B. 13	1%	2%	-1%	-4%	-2%	1%	5%	-4%	-4%	-1%	-3%	-3%
H.B. 14	1%	3%	-1%	-4%	-2%	1%	5%	-4%	-5%	-2%	-4%	-3%
H.B. 15	1%	3%	-1%	-4%	-2%	1%	5%	-4%	-5%	-2%	-4%	-4%
H.B. 16	1%	3%	-1%	-4%	-2%	1%	5%	-4%	-5%	-2%	-4%	-3%
H.B. 17	0%	2%	-1%	-4%	-2%	1%	5%	-5%	-5%	-1%	-4%	-2%
H.B. 18	0%	1%	-2%	-4%	-2%	1%	5%	-4%	-5%	-1%	-3%	-1%
H.B. 19	0%	1%	-2%	-4%	-2%	1%	4%	-4%	-4%	0%	-3%	-1%
H.B. 20	-1%	0%	-1%	-3%	-1%	0%	4%	-4%	-4%	0%	-3%	-1%
H.B. 21	-1%	0%	-1%	-3%	-1%	0%	4%	-4%	-4%	1%	-2%	0%
H.B. 22	-2%	-1%	-1%	-3%	-1%	0%	4%	-4%	-3%	1%	-2%	0%
H.B. 23	-2%	-1%	-1%	-4%	-1%	0%	4%	-4%	-4%	1%	-2%	0%

Source: ERCOT 2013

Electricity consumption in 2009 was largely consistent with the 2009-2012. Higher observed electricity consumption values in the month of July (3-5% over the 4 year average) may be the product of higher-than-average air temperatures. The same analysis was run for each year, with the highest and lowest values summarized in Table 19 below.

Table 19. Summary data - deviation of electricity consumption from 2009-2012 average (BUSMEDLF_COAST)

Year	Most Positive Deviation	Date and Time of Most Positive Deviation	Most Negative Deviation	Date and Time of Most Negative Deviation
2009	5%	July, H.B. 13 – H.B. 17	-5%	September, H.B. 14 – H.B. 18
2010	3%	January, H.B. 0 – H.B. 7	-7%	March, H.B. 12 – H.B. 13
2011	8%	August, H.B. 14 – H.B. 18	-2%	October, H.B. 6 – H.B. 9
2012	6%	March, H.B. 12 – H.B. 14	-5%	July, H.B. 12 – H.B. 18

The same intra-annual and inter-annual analyses were conducted for four other customer types within the ERCOT market:

1. BUSHILF – business high load factor
2. BUSLOLF – business low load factor
3. RESHIWR – residential high winter ratio
4. RESLOWR – residential low winter ratio

Analysis of a range of customer representatives with different load factors reveals differences in intra-annual or inter-annual electricity consumption trends that may have implications for the price/volatility continuum in competitive electricity procurement and the potential value of energy efficiency. The results of intra-annual and inter-annual analysis are presented in Table 20, Table 21, Table 22, and

Table 23 below.

Table 20. Summary data - deviation of electricity consumption from 2009-2012 average (BUSHILF_COAST)

Year	Most Positive Deviation	Date and Time of Most Positive Deviation	Most Negative Deviation	Date and Time of Most Negative Deviation
2009	3%	October, H.B. 7	-3%	April, H.B. 11 – H.B. 23
2010	2%	October, H.B. 13 – H.B. 16	-5%	March, H.B. 11 – H.B. 16
2011	5%	April, H.B. 12	-2%	January, H.B. 13 – H.B. 15
2012	4%	March, H.B. 9 – H.B. 23	-3%s	July, H.B. 11 – H.B. 17

Table 21. Summary data - deviation of electricity consumption from 2009-2012 average (BUSLOLF_COAST)

Year	Most Positive Deviation	Date and Time of Most Positive Deviation	Most Negative Deviation	Date and Time of Most Negative Deviation
2009	6%	July, H.B. 15	-10%	February, H.B. 3 – H.B. 5
2010	12%	February, H.B. 3-4	-7%	July, H.B. 15 – H.B. 16
2011	14%	September, H.B. 15 – H.B. 18	-3%	December, H.B. 7
2012	8%	March, H.B. 13 - H.B. 17	-11%	January, H.B. 3 – H.B. 4

Table 22. Summary data - deviation of electricity consumption from 2009-2012 average (RESHIWR_COAST)

Year	Most Positive Deviation	Date and Time of Most Positive Deviation	Most Negative Deviation	Date and Time of Most Negative Deviation
2009	20%	December, H.B. 3 – H.B. 4	-31%	February, H.B. 4
2010	35%	February, H.B. 4	-14%	April, H.B. 14 – H.B. 16
2011	23%	February, H.B. 3 – H.B. 4	-9%	March, H.B. 4

2012	-27%	January, H.B. 4	12%	April, H.B. 15 – H.B. 16

Table 23. Summary data - deviation of electricity consumption from 2009-2012 average (RESLOWR_COAST)

Year	Most Positive Deviation	Date and Time of Most Positive Deviation	Most Negative Deviation	Date and Time of Most Negative Deviation
2009	8%	July, H.B. 15 – H.B. 17	-14%	April, H.B. 15
2010	9%	January, H.B. 9	-19%	March, H.B. 15
2011	16%	April, H.B. 14 – H.B. 16	-7%	December, H.B. 15
2012	19%	March, H.B. 15	-10%	July, H.B. 14 – H.B. 15

Intra-annual variability is consistently greater within the two residential customer consumption datasets than is the case for the three business customers. The greater the inter-annual volatility, the more difficult it is to predict electricity costs, regardless of electricity procurement strategy.

The example electricity consumption data we use in our analysis is by definition, a representative sample. As such, the electricity consumption data averages the varying volatility of all customers within the sample; some customers will exhibit more volatile consumption behavior and some will exhibit less volatile consumption behavior. Individual customers' electricity consumption patterns will vary, but the basic trends remain legitimate.

5.3 Modeling the Volatility-Risk Continuum

Having previously established the major trends in in real-time electricity price data (in Chapter 4) and the major trends in intra-annual and inter-annual customer electricity consumption, we turn now to modeling the cost implications of different electricity procurement strategies for the sample customer types explicated above.

Backcasted load data is available for a number of different customer types. In order to demonstrate the volatility of real-time electricity costs, we modeled energy only costs for five different backcasted customer types for the years 2009-2012 based on the assumption that each customer would purchase 100% of electricity in the real-time electricity market. This method produced a total cost per customer and an average procurement cost by which to compare cost implications of different electricity consumption patterns.

Table 8. WZ_COAST Load Factor (from backcasted load data)

Customer Profile	2009	2010	2011	2012

BUS_HILF	0.748	0.749	0.742	0.748
BUS_MEDLF	0.540	0.542	0.511	0.504
BUS_LOLF	0.409	0.412	0.405	0.378
RES_HIWR	0.376	0.296	0.316	0.391
RES_LOWR	0.318	0.320	0.297	0.310

Table 24. Average Procurement Cost based on Load Zone Houston Prices (Real-Time Electricity Pricing Product)

Load Zone	Customer Type	2009	2010	2011	2012
Houston	BUSHILF	\$0.033	\$0.037	\$0.046	\$0.026
Houston	BUSMEDLF	\$0.035	\$0.039	\$0.051	\$0.027
Houston	BULOLF	\$0.036	\$0.041	\$0.057	\$0.028
Houston	RESHIWR	\$0.036	\$0.040	\$0.052	\$0.026
Houston	RESLOWR	\$0.037	\$0.041	\$0.051	\$0.025

Table 24 reveals an inconsistent negative correlation between load factor and average procurement cost, i.e. the higher the load factor, the lower the average procurement cost. However, the correlation between load factor and average procurement cost differs substantially from year to year. R-squared values vary from a low of 0.00 (2012) to a high of 0.98 (2009).

In addition to the observation that average procurement cost is negatively correlation with load factor (in 2009, 2010 and 2011), analysis reveals that there is significant inter-annual variability in the intra-annual variance in average procurement costs (based on different customer consumption patterns). Average procurement costs vary as little as 9.12% (2010) and as much as 22.86% (2011). The observed volatility in intra-annual variance makes it difficult to predict costs to serve a particular customer. Notice that there is substantial inter-annual variability in minimum and maximum average procurement costs.

Table 25. Variance in Average Procurement Cost Based on Load Zone Houston Price (Real-Time Electricity Pricing Product)

	2009	2010	2011	2012
MIN	\$0.033	\$0.037	\$0.046	\$0.025
MAX	\$0.037	\$0.041	\$0.057	\$0.028
Variance	12.80%	9.12%	22.86%	10.17%

In order to understand the differences between the ERCOT load zones (and their particular pricing behavior) and the PJM load zones (and their particular pricing behavior), we modeled annual energy costs for the five customer examples based on electricity prices in PJM's MetEd load zone. Note that this data analysis technique is inexact insofar as the electricity consumption data used comes from the ERCOT market. However, we have decided to tolerate this inexactness because the general intra-annual trends in electricity consumption are generally observable in regions with air-conditioning load in the summer (Lazar & Baldwin, 2011). Both PJM and ERCOT have summer air-conditioning load. In addition, by using the same electricity consumption data for two different sets of electricity price data, we can directly observe the implications of differences in pricing trends without having to parse the impact of differences in electricity consumption behavior.

Table 26. Average Procurement Cost based on Load Zone MetEd Prices (Real-Time Electricity Pricing Product)

Load Zone	Customer Type	2009	2010	2011	2012
MetEd	BUSHILF	$0.066	$0.032	$0.048	$0.049
MetEd	BUSMEDLF	$0.066	$0.032	$0.048	$0.049
MetEd	BULOLF	$0.066	$0.032	$0.048	$0.049
MetEd	RESHIWR	$0.066	$0.032	$0.048	$0.048
MetEd	RESLOWR	$0.068	$0.031	$0.048	$0.049

An analysis of Table 26 reveals an inconsistent relationship between load factor and average procurement cost in the MetEd load zone. R-squared values vary from a low of 0.05 (2012) to a high of 0.27 (2009).

Table 27. Variance in Average Procurement Cost based on Load Zone MetEd Prices (Real-Time Electricity Pricing Product)

	2009	2010	2011	2012
MIN	$0.066	$0.031	$0.048	$0.048
MAX	$0.068	$0.032	$0.048	$0.049
Variance	3.80%	2.75%	0.64%	1.43%

The substantial year-over-year volatility in total energy only costs observed in Table 24 and Table 26 above are caused by volatility in average annual real-time electricity prices (see Table 28 below). Average real-time electricity prices were calculated for Load zones Houston and South in the ERCOT market and Load zones Penelec and MetEd in the PJM market.

Table 28. Average Real-Time Electricity Costs of Several Load Zones in ERCOT and PJM - $/MWh (2008-2012)

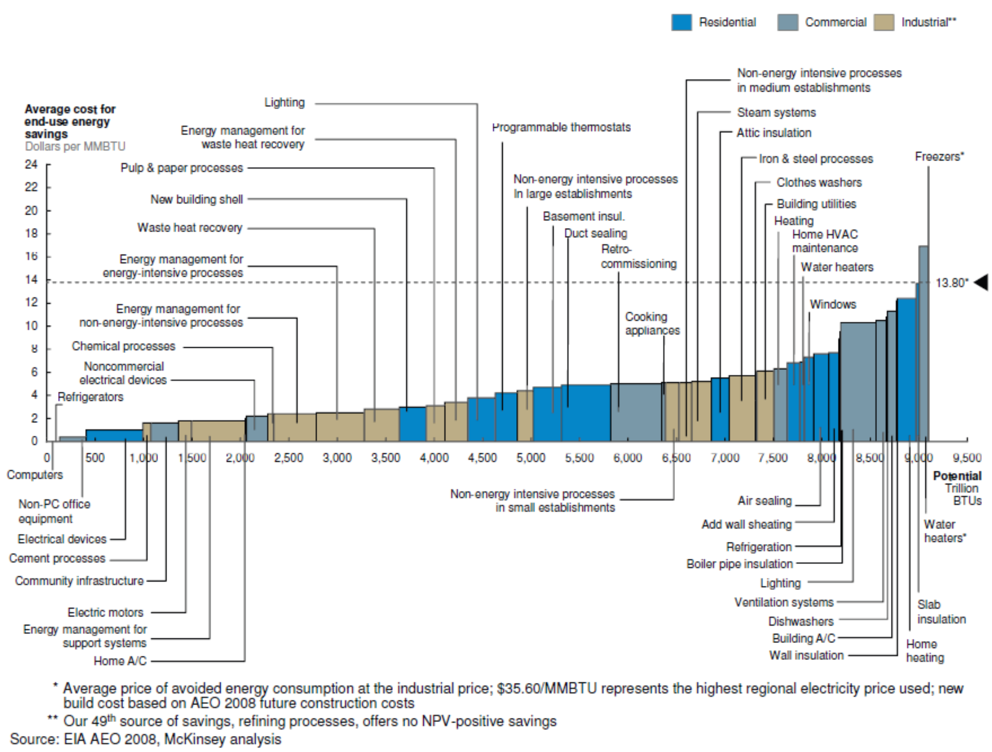
Wholesale Market	Load Zone	2009	2010	2011	2012
ERCOT	Houston	$31.64	$36.34	$43.58	$25.22
PJM	MetEd	$64.57	$32.19	$47.84	$48.86

5.4 Energy Efficient Technologies

Before modeling the value of energy efficiency implementation to ELECTRICITY RETAILERS and its customers, we must establish the impacts of different types of energy efficient technologies available for installation. In an effort to limit the scope of this analysis, the energy efficient technologies explicated in this section (and used later in the energy efficiency modeling analysis) are restricted to two categories: lighting and HVAC optimization. The decision to limit the analysis to these two energy efficient technology categories was made for several reasons:

The limited time duration of electricity supply contracts (many lasting for only 12 months, the vast majority lasting for 3 years or less), limits the technologies implemented to those with a simple payback (including applicable rebates and incentives) of 3 years or less. Several lighting and HVAC optimization technologies fit into this category. The global consultancy McKinsey and Co. produced a marginal abatement cost curve for a series of energy efficient technologies (differentiated by the residential, commercial, and industrial sectors). The results of McKinsey's analysis (see Figure 16 below) provide justification for the choice to focus on lighting and HVAC optimization technologies as cost-effective technologies for significant potential for market growth. The third and fourth most cost-effective technology groups for residential customers listed in the McKinsey chart are lighting and programmable thermostats (a form of HVAC optimization). Also note that the third most cost-efficient technology category for commercial customers is retro-commissioning (HVAC optimization is a form of retro-commissioning).

Figure 16. U.S. Energy Efficiency Supply Curve 2020



Source: (McKinsey and Co., 2009)

Lighting and HVAC optimization technologies are fundamentally different in terms of their impact on a customer's load profile. Lighting retrofits provide a constant demand reduction whereas HVAC optimization technologies provide a variable demand reduction (depending on weather, building envelope characteristics and customer comfort choices). The fundamental difference between a fixed (e.g. lighting) versus variable (e.g. HVAC optimization) demand reduction has implications on the magnitude of electricity cost savings for customers, the value of electricity costs savings for customers and electricity retailers under different electricity product types, and the requirements used to measure and verify electricity and demand savings. As such, choosing to model these two technology types gives breadth to the analysis and its implications for electricity product choices.

The following section provides a summary of several energy efficient technologies based on their respective energy savings potential and measurement and verification issues.

5.4.1 Lighting – Considerations for Energy Efficiency Implementation

Energy efficient lighting retrofits are a cost-effective, widely implemented, easily understandable option to improve a building's energy efficiency. Replacing existing lighting fixtures with energy efficient lighting fixtures provides a range of benefits:

1. **Permanent reduction in electricity demand.** If a facility is using lighting during its peak usage, i.e. the time when its monthly transmission and distribution (T&D) demand charge is set, energy efficient lighting will reduce the demand charge.
2. **Annual electricity savings.** Energy efficient lighting provides electricity and associated cost savings throughout the year.
3. **Operational benefits,** which may include reduced maintenance costs due to longer life, better light quality, faster start times, etc.

Measuring the permanent demand reduction and annual electricity savings from a lighting retrofit is relatively straightforward. Calculating the energy savings value is based on the following variables:

1. Lighting Schedule
2. Rated capacity (W) of existing lighting equipment
3. Rated capacity (W) of new lighting equipment

The following example demonstrates the simplicity with which lighting retrofit savings can be calculated:

An existing 32-watt T8 linear fluorescent lamp may be replaced by a 28-watt T8 linear fluorescent lamp, yielding 12.5% permanently reduced demand and annual electricity savings equal to 12.5% of total lighting electricity consumption (assuming that the lighting schedule remains the same).

There are real economic savings associated with the operational benefits of lighting retrofits, but they fall outside of the scope of this analysis.

5.4.2 HVAC Optimization – Considerations for Energy Efficiency Implementation

Due to their high electricity demand, particularly during times of peak wholesale electricity prices, HVAC systems are attractive targets for improved energy efficiency. Electricity consumption due to heating, ventilating, and cooling (HVAC) facilities represents a substantial portion of annual electricity usage; the 2003 CBECs survey revealed that space heating (38%), cooling (7%), and ventilation (7%) account for over half of annual electricity consumption for commercial buildings (CBECS 2013). Additionally, HVAC usage is particularly important in resource adequacy issues, as air conditioning usage puts major strain on grid reliability during warm summer afternoons. HVAC systems are particularly relevant to this analysis because air-conditioning usage during times of peak grid demand are in part responsible for the high wholesale peaking power prices observed in the ERCOT and PJM markets.

Options for improving the energy efficiency of a building's HVAC system either target:

1. ***The efficiency of the equipment itself***, e.g. replacing an air conditioning unit with a new air conditioner that can provide the same level of air conditioning with less electricity demand.

2. ***The efficiency with which the equipment is used***. Instead of replacing major HVAC hardware equipment, there are a variety of options that residential, commercial, and industrial customers can choose to optimize the operations of their HVAC system. In the case of residential customers, programmable thermostats (many today are WiFi enabled, allowing for remote control), allow customers to optimize their energy use by allowing the indoor air temperature to increase while they are out of the house. The programmable thermostat does not improve the efficiency of the HVAC equipment per se, but improves the efficiency of the HVAC system insofar as it maintains the same level of energy service during occupied hours, while reducing energy use and costs during non-occupied hours.

For commercial and industrial customers, HVAC optimization is often associated with retro commissioning, i.e. the process by which an existing facility is made more efficient through the more efficient use of existing equipment. Often times, facilities are designed with excess HVAC capacity, creating an operations schedule that over cools a facility and wastes money in the process (McKinsey 2009). HVAC optimization hardware options control HVAC equipment through a variety of building management system software, which optimizes use of the system as a whole. Retro commissioning provides a large, low-cost solution for commercial customers (recall McKinsey's costs curve).

Measurement and Verification Considerations

Calculating the electricity and cost savings due to HVAC optimization requires a great level of complexity than for doing so with lighting equipment. Peak demand and annual electricity use due to HVAC systems is dependent on three major factors:

1. Occupancy
2. Outdoor air temperature
3. Tenant comfort requirements
4. Building insulation level

Providing measurement and verification services for HVAC optimization requires an energy analyst to mathematically model a facility's predicted electricity demand without HVAC optimization, i.e. create a consumption baseline. In practice, this modeling can be accomplished by modeling the historical relationship between air temperature, humidity, and facility electricity consumption. By comparing a facility's post retrofit electricity consumption with its electricity baseline, an energy analyst can provide electricity savings estimates due to HVAC optimization. Note that this technique is simplified insofar as it assumes no change in building occupancy or tenant comfort requirements.

5.4.2.1 HVAC Optimization Residential Example – Nest Learning Thermostat

The Nest Learning Thermostat (NLT) has gained significant attention within the utility community and a number of high-profile partnerships with electricity retailers and utilities since its launch in 2011. Nest has partnered with major retailers active in the ERCOT competitive market, including Reliant and Green Mountain Energy (Reliant Energy 2013; Green Mountain 2013).

Figure 17. Nest Learning Thermostat

Source: (Nest 2013)

The NLT was designed to reduce the barriers to successfully[39] using programmable thermostats, by adjusting indoor air temperature (i.e. HVAC system) based on a consumer's observed patterns of occupancy and desired comfort level.[40] The NLT has the largest energy saving potential when consumers are not at home, when indoor air temperatures can rise without disrupting occupant comfort (Nest 2013).

Due to the recent release of the NLT and the different ways in which it can be used to save energy, there is a paucity of academic scholarship modeling demand (kW) and electricity (kWh) savings value. Based on its own simulations, Nest claims that average savings[41] range from 19.5-36.1% (Nest, 2013b).

5.4.2.2 HVAC Optimization Commercial Example – REGEN Energy SWARM Energy Management

REGEN Energy's SWARM Energy Management system is an integrated hardware/software product used to improve the utilization efficiency of a facility's existing HVAC system (REGEN Energy, 2013). In many facilities, significant demand and electricity savings can be achieved without disrupting occupant comfort by reducing the number of air conditioning or heating units utilized at a given time. REGEN's technology can achieve these efficiency gains because many facilities have excess air conditioning capacity to meet their needs.

Figure 18. SWARM Energy Management System

Source: (REGEN Energy 2013)

The SWARM Energy Management product is a small hardware controller affixed to rooftop air conditioning units. REGEN's energy management software optimizes the scheduling REGEN Energy provides a variety of case studies to detail the operational benefits of their SWARM Energy Management product.

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[39] See http://eetd.lbl.gov/news/article/11200/measuring-the-usability-of-programmable-thermostats for more information on the relative difficulty with which consumers use programmable thermostats.

[40] For more information on how the Nest Learning Thermostat saves consumers' energy, please consult nest.com

[41] See 'White Paper – Nest Learning Thermostat Efficiency Simulation: Update Using Data from First Three Months' (2013) for more information on the simulation modeling methodology.

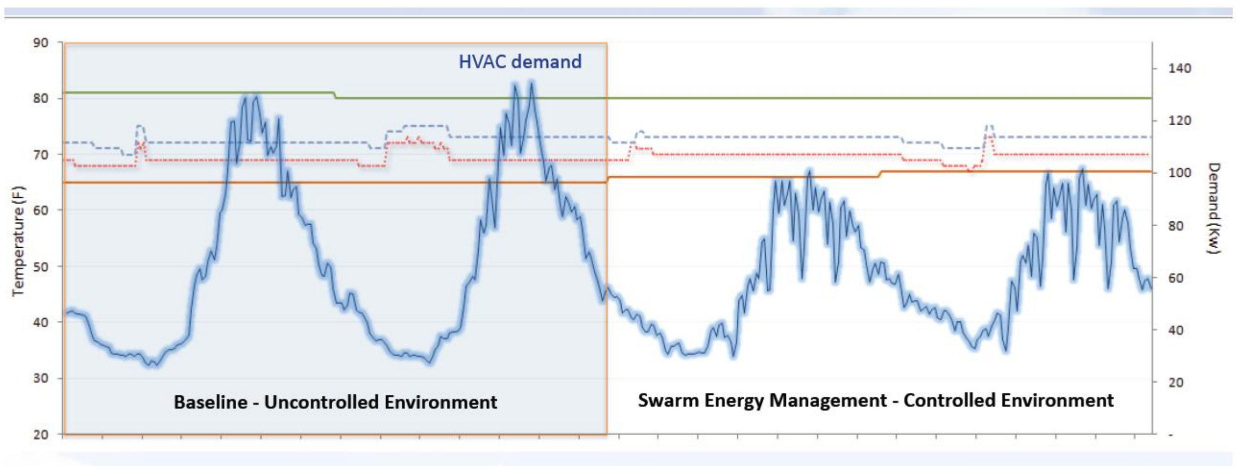
Table 29. REGEN Energy - SWARM Energy Management Case Study Results

	Average Monthly Peak reduction per site	Average monthly demand reduction per site	Average electricity saved per site
Big Box Retailer Case Study	31 kW	14%	47,201 kWh
Movie Theater Case Study	26 kW	15%	53,012 kWh

Source: (REGEN Energy, 2013)

The SWARM Energy Management product's impact on a customer's load profile is presented in Figure 19 below. Notice that the magnitude of 'controlled' demand savings is correlated with the magnitude with 'uncontrolled' demand, consistent with our basic understanding of the energy efficiency benefits of HVAC optimization.

Figure 19. Impact of SWARM Energy Management on Customer Profile



Source: (REGEN Energy, 2013)

5.5 Conclusion

Compared to wholesale electricity pricing behavior, variability in electricity consumption behavior is relatively small. However, the multiplicative effects of wholesale electricity price volatility and electricity consumption volatility can produce uncertain electricity procurement cost results (as evidenced by the inter-annual variability in average procurement cost). Modeling results indicate that average procurement costs can more than double from year-to-year. Energy efficiency implementation adds another level of complexity in modeling the expected cost of serving a particular customer in a particular wholesale market. All told, the results serve as quantitative evidence for the observed preference for fixed-price electricity supply products.

Chapter 6 – The Market for Bundled Energy Efficiency/Electricity Supply Products

6.1 Introduction

The foregoing chapter presents the current market for bundled energy efficiency/electricity supply in three parts. First, we review differences in business models used to offer bundled energy efficiency/electricity supply products. In so doing, we identify four major strategic decision areas that define the difficulties and opportunities available to an electricity retailer pursuing a bundled energy efficiency/electricity supply business model. Through the use of online research we present the current scope of energy efficiency provision in the competitive electricity retailer market. Electricity retailers accounting for approximately half of total residential and commercial market share provide some form of energy efficiency project services. Finally, we highlight several commercially-available bundled energy efficiency/electricity supply products. By reviewing their design, the rationale for providing these products, and their current market penetration, we reveal significant differences in the manner in which electricity suppliers' account for the economic impact of reduced electricity sales due to energy efficiency implementation.

6.2 Bundled Energy Efficiency/Electricity Supply Products – Market Organization

Providing the market with bundled energy efficiency/electricity supply products is a complex process. Electricity retailers offering bundled energy efficiency/electricity supply products must contend with a series of strategic decisions in four major areas: energy efficiency provision, financing, equipment security, and with measurement and verification. The following chapter introduces the potential choices available to electricity retailers in the four strategic decision areas and the major considerations that may motivate the decision-making process.

The following section draws on existing research in the fields of energy efficiency provision and energy efficiency finance. While the research is intended to represent the major issues involved in providing bundled energy efficiency/electricity supply products, the undeveloped nature of the bundled energy efficiency/electricity supply market and the paucity of academic research on this market, creates the possibility that there may be elements missing from the analysis.

6.2.1 Market Organization – Energy Efficiency Provision

Before any other strategic decisions can be made, Electricity retailers must contend with the scope and implementation of energy efficiency services that will be provided to customers. Electricity retailers that offer competitive electricity supply differ in complexity from fully-integrated energy companies (that provide competitive supply, electricity generation, energy efficiency services) to competitive power marketers (that only provide competitive electricity supply). Competitive retailers that have decided to pursue energy efficiency services can either provide these services through *in-house expertise* (AEP Energy, 2013) or *through a partnership with an energy services company* (e.g. GDF Suez partners with American Energy Solutions) (GDF Suez Energy Resources, 2013).

6.2.2 Market Organization – Financing

Electricity retailers providing energy efficiency services to customers at no upfront cost must contend with sourcing, financing, and designing a cost recovery mechanism to meet their strategic goals while providing attractive terms to their customers.

Financing Source

The electricity retailer industry is diverse in terms of revenue and business complexity, creating an environment in which some electricity retailers have the ability to self-finance projects and some must source third-party capital.

Cost Recovery Mechanism

Electricity retailers choosing to offer energy efficiency services, either in-house or through a partnership with an ESCO, differ in the mechanisms through which they provide financing for energy efficiency services to their customers. While there are several mechanisms through which energy efficiency can be financed, the most major decision point for a retailer providing financing is whether or not to provide on-balance sheet on-bill financing or off-balance sheet “supply cost” financing.

On-bill financing takes the form of monthly line-item repayments of the capital cost of the installed energy efficient measure, at an agreed upon interest rate (Kim, et al., 2012). On-bill financing is an established financing strategy and is widely available to customers through their transmission and distribution utilities; at least 20 states have transmission and distribution utilities that have implemented or in the process of implementing on-bill financing programs. On-bill financing programs are noteworthy in their low default rates, with most below 1 percent (Catherine J. Bell, 2011). Despite the value delivered through on-bill financing programs, they have limited applicability insofar as they still require a participating customer to take on a debt repayment obligation; some companies are hesitant to take on debt repayment obligation due to accounting considerations.

Supply-cost financing provides an innovative form of financing in which the cost of the capital measure is amortized over the life of the electricity contract through a cost premium on the supply cost paid by the customer. In this financing mechanism, there is no monthly debt repayment obligation; the cost of the measure is repaid through operational costs (electricity supply) rather than capital costs. This type of financing is becoming more popular recently in both the commercial sector (Constellation NewEnergy’s Efficiency Made Easy™ product) and residential sector (Reliant Energy’s Learn & Conserve 24 with Nest™).

6.2.3 Market Organization – Equipment Security

Electricity retailers who deploy capital on energy efficiency upgrades do so with the intention of recovering the expense of that capital outlay. The competitive nature of the electricity supply industry in deregulated markets creates an environment in which customers can easily switch between electricity retailers. Given that customer retention is uncertain, electricity retailers offering bundled energy efficiency/electricity supply products must account for the potential of customer attrition in designing the contracts governing their products.

The legal and strategic issues pertaining to three options for equipment security (equipment liens, early termination fees, and electricity service disconnection) are summarized below.

Equipment Liens

Securing energy efficiency equipment through liens has the benefit of simplicity, but has limited applicability, particularly in cases when existing mortgages exist on the property in question. Many loan originators prohibit commercial and industrial building owners from accepting liens on energy efficient equipment because this equipment is “considered part of the assets securing the original mortgage note” (Kapur, et al., 2011). In the residential sector, even if a lien on installed equipment existed, it may be and impractical option insofar as the expense of retrieving the equipment from a home may exceed the cost of the equipment itself.

If equipment liens prove too problematic to implement, electricity retailers also have the option to institute early termination fees on electricity supply contracts.

Early Termination Fees offer electricity retailers a modicum of security in the case that customers elect to choose electricity supply service from a competitor before the existing contract is completed.

Recall that Reliant Energy and Green Mountain Energy both offer a bundled energy efficiency/electricity supply product that utilizes the Nest™ thermostat. Each of these contracts has an early termination fee clause which helps to cover the electricity retailer’s investment in the energy efficient Nest thermostat in the case that the customer elects to leave the contract early.

Both Reliant Energy and Green Mountain energy charge a $295 early termination fee for its bundled efficiency/electricity supply contract (Reliant Energy, 2013) (Green Mountain Energy, 2013). The Nest™ thermostat is listed at $249, so the $295 early termination fee is more than sufficient in recovering the cost of purchasing the equipment. In signing an electricity supply contract a residential customer agrees that if he or she cancels “the contract before the end of your contract term, you agree to pay the penalty or fee for early cancellation indicated in the EFL…” (Green Mountain Energy, 2013)

Disconnection of Service

In many utility-sourced on-bill financing programs, failure to pay back the cost of energy efficiency can result in disconnection of electricity service. While this practice may be an effective deterrent against non-payment, it faces ongoing legal challenges. Achieving a successful system of disconnection for an electricity retailer’s customer, coordination between the electricity retailer and the existing transmission and distribution utility is needed.

6.2.4 Measurement and Verification

Electricity retailers design electricity products based on the expected costs it will face in meeting its customers' electricity consumption habits over the length of the contract and based on the customer's risk tolerance and associated procurement choices. Accounting for the impact of energy efficiency measures on the cost to serve a customer, and accurately representing this value to customers, adds additional complexity (and potentially expense) to developing electricity supply contracts. Electricity retailers hoping to entice customers to sign up for bundled energy efficiency/electricity supply contracts under the assumption that doing so will be economically prudent for the customer, must not allow measurement and verification costs to crowd out economic savings due to energy efficiency.

The rationale for providing measurement and verification is, at its core, about "risk management – balancing costs and value of information/risk of not knowing the savings value" (Schiller, 2010). The value of providing measurement and verification services is particularly uncertain in cases in which the capital repayment schedule is not dependent on actual energy efficiency savings. For the purposes of accounting for the value of energy efficiency in a bundled energy efficiency/electricity supply contract, electricity retailers are likely to follow a series of steps:

1. Isolating energy and demand impacts of energy efficiency versus other important factors (changes in occupancy, weather variations, installation of new equipment). Factors influencing energy consumption such as changes in occupancy, weather variations, and installation of new equipment must be established contractually.
2. Establishing a baseline energy consumption profile for the customer based on data from past years.
3. Specifying the algorithm by which the baseline will be altered to accommodate for changes in weather, occupancy, etc.
4. Specifying the expected impact of the energy efficiency measures on the customer's baseline energy consumption profile.
5. Specifying the IPMVP measurement and verification option chosen to calculate energy efficiency savings.
6. Monthly reporting of expected energy consumption (pre-retrofit baseline) versus actual energy consumption (post-retrofit).

The major challenge an electricity retailer faces in providing measurement and verification services to its customers stem from the additional costs and administrative complexity associated with providing these services. Given that the bundled energy efficiency/electricity supply product is in the early stages of market adoption, significant questions remain as to the nature and extent of measurement and verification services provided to customers.

Remaining Issues

- Can an electricity retailer monitor a customer's operational activity so that you it knows that the customer is operating her facility or home based on the operational assumptions that were developed for the specific bundled energy efficiency/electricity supply product?
    - One possible solution would be to conduct random sampling of meter data to see if there are unexpected aberrations from a customer's expected load profile.

Alternatives to measurement and verification

In the absence of measurement and verification – which some electricity retailers may determine to be too costly to provide – electricity retailers may adopt alternative strategies to ensuring that customers are assured of the energy efficiency benefits of the project implemented. Without a detailed accounting of the impact of energy efficiency on the customers load profile, electricity retailers may elect to provide its customer with a guaranteed monthly cost. Such a structure benefits from simplicity, but contains threats to both the electricity retailers and customer:

- For the electricity retailer, a guaranteed monthly cost model opens the possibility that the electricity retailer will lose revenue in the case that: it overestimates the impact of energy efficiency measures on the customer's load shape; seasonal weather variations produce increases in electricity consumption beyond expectations and the customer's operational schedule may also change.
- For the customer, agreeing to a guaranteed monthly cost model provides cost certainty, but also surrenders the real hour-to-hour value of energy efficiency on their electricity consumption profile.

6.3 Energy Efficiency Services in the Competitive Electricity Market

Having established the market size and segmentation of the competitive retailer electricity market, we focused our attention on the extent to which competitive retailers provide energy efficiency services.

Methodology

Primary data collection in assessing the provision of energy efficiency services was accomplished through analysis of available content on each electricity retailer's website. Due to resource limitations and difficulty in successfully contacting representatives of competitive retailers, only selected follow up interviews were conducted.

Borrowing from the methodology outlined by Kushler and Witte (2001), the website research identified language that mentioned energy efficiency in two broad categories: a) informational material on best practices and energy saving tips for energy efficiency; b) energy efficiency services, e.g. lighting and HVAC retrofits available to participating customers.

6.3.1 Energy Efficiency Services - Market Data

The primary interest of our research was on bundled energy efficiency/electricity supply products for the residential and commercial sectors, and as such, our analysis of retailers was confined to these two sectors.[42]

Residential Data

Recall that in 2011, there were 80 electricity retailers supplying electricity to the residential sector that still remain in business today. Of these 80 electricity retailers, internet research revealed the following energy efficiency practices:

	Total Number of Electricity Retailers	Percentage of Total Electricity Retailers	Market Share (MWh sold)
Provides Energy Efficiency Services	13	16.3%	47.2%
Provides Energy Efficiency Tips Only	30	37.5%	16.0%
Provides Neither Energy Efficiency Services or Tips	37	46.2%	36.8%

The most common energy efficient device for residential customers was the programmable thermostat. The two largest electricity retailers for residential customers (TXU Energy and Reliant Energy), representing more than 36% of the entire U.S. residential competitive market, provide both energy efficiency tips and energy efficiency services (programmable thermostats).

Commercial Data

Recall that in 2011, there were 94 electricity retailers supplying electricity to the commercial sector that still remain in business today. Of these 94 electricity retailers, internet research revealed the following energy efficiency practices:

	Total Number of Electricity Retailers	Percentage of Total Electricity Retailers	Market Share (MWh sold)
Provides Energy Efficiency Services	17	16.3%	53.7%
Provides Energy Efficiency Tips Only	23	37.5%	7.2%
Provides Neither Energy Efficiency Services or Tips	54	46.2%	39.1%

[42] However, many of the largest competitive retailers (by market size) in the residential and commercial sectors also provide electricity to industrial customers. Recall Table 9, below):
Table 10 and Table 11 for information on the largest competitive retailers (by market size) for the residential, commercial, and industrial sectors.

6 of the largest 8 competitive retailers (by market size) offer energy efficiency services in the form of energy efficient equipment retrofits, including the two largest retailers: Constellation NewEnergy (12.7% market share) and Direct Energy Business (11.2%).

6.4 Comparison with Previous Results

The internet research on electricity retailers' provision of energy efficiency services provides valuable insights into the dynamics of the bundled energy efficiency/electricity supply market. The results are particularly interesting in the context of previous research into the same topic, undertaken in the early years of competitive choice by Kushler and Witte (2001).[43] Kushler and Witte (2001) found that out of 89 operating competitive retailers in 2001, 29% provided actual energy efficiency measures, while an additional 7% provided energy efficiency info. Follow up interviews with selected retailers, presented slightly different data: 14% of retailers provided energy efficiency information while 16% provided actual energy efficiency measures.

Table 30. Comparison of Electricity Retailers Offering Energy Efficiency Services (2001 vs. 2013)

Year	Survey Method	Number of Retailers	Percentage of Retailers Offering Energy Efficiency Tips Only	Percentage of Retailers Offering Energy Efficiency Products and Services
2001	Internet search	89	7%	29%
2001	Phone interviews	89	14%	16%
2013	Internet search	80 (serving residential)	16.3%	37.5%
2013	Internet Search	94 (serving commercial)	18.1%	24.5%

Source: (Kushler & Witte, 2001) and own analysis

Table 30 provides comparison between Kushler and Witte's survey results and our own. The 2011 results for actual energy efficiency services provided are similar to Kushler and Witte's telephone-based results. Compared to 2001, there has been a marked increase in the percentage of electricity retailers offering energy efficiency tips, but growth in the percentage offering energy efficiency products and services is unchanged. However, these results need to be interpreted in the context of the fact that the retailers offering energy efficiency products and services are serving a disproportionate size of the market; retailers offering energy efficiency services accounted for 47.2% of sales to the residential market and 53.7% of the sales to the commercial market.

6.5 Examples of Select Bundled Energy Efficiency/Electricity Supply Products

Several high-profile, high-market share competitive electricity suppliers offer bundled energy efficiency/electricity supply products to commercial and residential customers. The following section describes the design of 1 bundled energy efficiency/electricity supply product for commercial and

[43] Kushler and Witte (2001) did not differentiate their survey results based on market sector, e.g. residential, commercial, and industrial.

industrial customers and 2 similar bundled energy efficiency/electricity products for residential customers.

6.5.1 Constellation New Energy – Efficiency Made Easy

Product Overview

Constellation NewEnergy offers a unique bundled energy efficiency/electricity supply product to commercial and industrial customers known as Efficiency Made Easy™. Customers electing to purchase electricity through Efficiency Made Easy™ are quoted a fixed electricity supply price for a contract term (presented as 3 years on the Constellation website). The cost of energy efficiency services provided is embedded in the fixed electricity supply price. In doing so, Constellation takes the cost of energy efficiency services off-balance sheet, i.e. the customer does not need to carry any debt in its accounting. We have named the mechanism of paying back capital costs through 'supply-cost financing'.

Overview

Constellation began offering the program in early 2011 to large and medium commercial customers in every state with a competitive electricity market. As of December 2012, the majority of retrofit projects undertaken were lighting retrofits; Constellation first pursued lighting retrofits because of familiarity with the energy savings potential of lighting technologies and to speed up market entry time. (Ulloa, 2012)

Rationale for Offering the Program

Providing energy efficiency services helps to establish a closer relationship with customers. The goal is to become a "customer's energy provider for life" by helping the customer meeting both their energy and business needs. Customer retention and acquisition were cited as motivations for offering this product. (Ulloa, 2012)

Contracts and Funding

Constellation self-funds the energy efficiency projects it pursues in the Efficiency Made Easy℠ product. In the case that a customer wants to switch to another electricity supplier before the end of the contract, the customer must reimburse Constellation for the funds associated with the energy efficiency project and any other traditional termination provisions related to the underlying commodity contract. (Ulloa, 2012)

Marketing and Channel Partnerships

Constellation conducts a rigorous pre-qualification process (operational and credit history) on strategic energy efficiency providers (e.g. lighting contractors) it uses to implement Efficiency Made Easy℠. Constellation benefits from contractors marketing its Efficiency Made Easy℠ offering, but does not ask for exclusivity in marketing its offering. Constellation's marketing plan consists in part of video testimonials of customers that have participated in the Efficiency Made Easy℠ program. (Ulloa, 2012)

Measurement and Verification

Constellation does not guarantee any savings nor do they provide any traditional M&V for EME projects however they do perform a thorough audit of electricity consumption (note: natural gas and water & sewer savings projects are also considered) patterns and potential future changes in customer electricity consumption (occupancy and facility use) before quoting a supply price. The supply contract is designed in such a way as to designate an expected range of energy savings (+ or -10% of the audited assumptions). If energy savings fall within this range, no action is taken. In the case that energy savings are lower than anticipated (i.e. the customer uses more than energy than anticipated), Constellation will true up the customer for any overpayment of the energy efficiency project. If the case that energy savings are higher than anticipated (i.e. the customer uses less than anticipated), the customer is required to compensate Constellation for any underpayment of the energy efficiency project. (Ulloa, 2012)

Impact

Constellation has reported CO_2 emissions savings due to Efficiency Made Easy projects on at least two occasions in 2013. The results of these disclosures reveal the following savings:

Table 31. Energy Efficiency Impacts - Efficiency Made Easy – February-June 2013

Date	**CO_2 emissions abated (metric tons)**	**CO_2 emissions abated (lbs)**	**Total MWh saved**[44]
February 20, 2013	30,779	67,855,319	43,624
June 24, 2013	75,427	166,289,142	106,906
Difference	***44,648***	***98,433,823***	***63,282***

Sources: (Fox, 2013; Constellation NewEnergy, 2013)

All projects (those already completed before February 20th, and those completed between February 20th and June 24th) count towards total annual energy effects,[45] i.e. total MWh saved. If we assume that Constellation's customers save energy at the same rate established in this 4 month sample for a full 12 months,[46] Constellation's customers would save a total of 189,847 MWh per year in annual energy effects.

If we assume that all Constellation projects are for commercial and industrial customers and compare Constellation's EME annual energy savings to those transmission and distribution utilities that sponsor energy efficiency rebate, incentive, and financing programs, Constellation would rank as the 64th largest utility provider of annual energy effects (MWh) in 2011. In 2011, there were 424 utilities, coops, municipal utilities, and state energy agencies that reported annual energy efficiency savings for

[44] Constellation states that it used the U.S. Environmental Protection Agency's conversion factor for non-baseload power plants (7.055×10^{-4} metric tons of CO_2/kWh) to convert from MWh saved to CO_2 emissions abated.
[45] Recall the U.S. EIA definition for annual energy effects as the effects (energy (MWh) reduction and peak demand (MW) reduction) caused by all participants in a utility's DSM program in a given year.
[46] In reality, this may be an underestimation; as more projects are built, more MWh are saved. Depending on what measures are installed, MWh savings at a given facility may be higher during the summer months (in the case of HVAC retrofits) or they may be fairly consistent throughout the year (in the case of lighting retrofits).

commercial and industrial customers to the EIA-861 dataset. The average annual effects for commercial and industrial customers were 174,039 MWh (U.S. Energy Information Administration, 2012). The distribution of energy efficiency savings between utilities is skewed. The top 4 utilities (Southern California Edison, Pacific Gas & Electric, Northern States Power Co – Minnesota, NYSERDA) accounted for more than 39% of total annual U.S. energy efficiency effects (MWh saved) in 2011. If Constellation's energy efficiency benefits were added to the list, they would account for 0.25% of the U.S. total energy efficiency savings for commercial and industrial customers.

According to the EIA, Constellation sold 59,847,551 MWh to commercial and industrial customers in 2011. As a percentage, the projected annual energy efficiency savings for Constellation's EME customers (189,847 MWh per year) corresponds to 0.3% of total commercial and industrial sales.[47]

In comparison, the average ratio of energy efficiency savings (MWh) to total sales (MWh) for commercial and industrial customers was 3.0% for the 401 utilities, coops, municipals that sold electricity to commercial and industrial customers in 2011.[48] The three utilities with the largest annual energy efficiency savings among their customers (based on total MWh saved due to energy efficiency programs) had energy efficiency to sales ratio of 20.8% (Southern California Edison Co.), 14.0% (Pacific Gas & Electric Co.), and 20.2% (Northern States Power Co – Minnesota).

6.5.2 Green Mountain Energy – Pollution Free Efficiency with Nest™

On April 22, 2013, Green Mountain Energy announced the launch of a unique electricity product for residential customers interested in combining 100% renewable energy electricity supply with energy efficiency services, Pollution Free Efficiency with Nest™ (PRWeb, 2013).

Product Overview

Green Mountain Energy provides it Pollution Free Efficiency with Nest™ electricity product to residential electricity customers in the competitive states it serves, including Texas (Green Mountain Energy, 2013). Pollution Free Efficiency with Nest™ provides a 2 year contract at a fixed rate of 12.9 cents per kWh (assuming 2,000 kWh monthly usage) for customers in the CenterPoint (Houston) transmission and distribution service area (Green Mountain Energy, 2013). The full details of the electricity product are presented in Table 32 below.

For the purposes of better understanding the value and cost implications of bundled energy efficiency/electricity supply products, we can compare Green Mountain's Pollution Free Efficiency with Nest™ product with Green Mountain's basic electricity product (Pollution Free Reliable Rate) that does not include the Nest™ thermostat (Green Mountain Energy, 2013). Pricing information was collected on May 28th, 2013.

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[47] To be fair this percentage could be smaller insofar as Constellation's commercial and industrial sales may have risen from 2011 to the present.
[48] There were 23 state energy agencies and other energy efficiency providers counted in the EIA-861 dataset that did not serve customer load, (e.g. NYSERDA, Focus on Energy).

Table 32. Comparison of Green Mountain Energy's Electricity Products for Residential Customers in CenterPoint (Houston) transmission and distribution service area

Product Name	Rate Type	Cost (per kWh)	Term	Cancellation Fee	Monthly kWh usage	Renewable Content
Green Mountain Pollution Free Efficiency with Nest™	Fixed	12.9 cents	24 months	$295	2,000	100%
Pollution Free Reliable Rate	Fixed	12.2 cents	12 months	$200	2,000	100%

Cost Comparison Implications

Comparing the two Green Mountain electricity supply products reveals a total cost premium of 5.7% for the Pollution Free Efficiency with Nest™ electricity product ($0.007/kWh higher), and a $95 greater cancellation fee. In reality, the supply cost premium is higher, in that the 12.9 cents charged by Green Mountain includes 3.5 cents of “passed-through” transmission and distribution charges from CenterPoint energy. Therefore, the *supply cost* increases from 8.7 cents to 9.4 cents per kWh, a *supply cost* premium of 8.0%.

Nest has advertised its product as capable of annual cost savings of 20% (Business Wire, 2012), so a 5.7% cost premium suggests that Green Mountain Energy may lose revenue by providing its Pollution Free Efficiency with Nest™ electricity product alongside its Pollution Free Reliable Rate product, provided the customers save more than 8% of annual electricity consumption.

Rationale for Providing Program

According to president James Steffes, Green Mountain Energy is pleased to offer a product that enables “consumers the opportunity to conserve all they can and use renewable energy to cover the rest.” (PRWeb, 2013). Green Mountain Energy is known in the competitive marketplace for its provision of renewable energy supply; providing energy efficiency services to residential customers is a logical step in serving its environmentally-minded customers.

6.5.3 Reliant Energy – Learn and Conserve 24 Plan with Nest™

Reliant Energy, the second largest provider of competitive retail electricity service to residential customers in Texas and the United States, has also partnered with Nest™ to provide energy efficiency services. On June 25th, 2012, Reliant Energy announced the Learn and Conserve 24 Plan with Nest Learning Thermostat™, a new bundled energy efficiency/electricity product for residential customers (Business Wire, 2012).

Figure 20. Reliant Learn and Conserve 24 with Nest™ Promotional Billboard

Source: (Tweed, 2013)

Product Overview

Like the Green Mountain electricity product, Reliant's Learn & Conserve with Nest™ electricity product provides a Nest™ thermostat free of charge along with a 2-year fixed electricity rate (Reliant Energy, 2013). The full details of the electricity product, alongside Reliant's basic 1-year fixed price product (Reliant Energy, 2013) are presented in Table 33. Pricing information was collected on May 28th, 2013.

Table 33. Comparison of Reliant Energy's Electricity Products for Residential Customers in CenterPoint (Houston) transmission and distribution service area

Product Name	Rate Type	Cost (per kWh)	Term	Cancellation Fee	Monthly kWh usage	Renewable Content
Learn and Conserve Plan with Nest	Fixed	12.5 cents	24 months	$295	2,000	3%
Reliant Basic Power Plan 12	Fixed	10.5 cents	12 months	$150	2,000	3%

Cost Comparison Implications

Assuming that a customer choosing to purchase electricity through the Reliant Basic Power Plan 12 would renew service at the same price of 2 years, the Learn and Conserve Plan with Nest contains a 19% total cost premium ($0.02/kWh) over Reliant's basic electricity rate. The *supply cost premium* is significantly larger, because 3.5 cents of the 12.5 cents of the total cost is for CenterPoint transmission and delivery services – therefore; an increase of 10.5 to 12.5 cents per kWh is, from Reliant's perspective, an increase of 7 to 9 cents: a *supply cost premium* of 28.6%.

In addition, Reliant further limits its potential revenue losses due to efficiency by charging a cancellation fee of $295 for customers choosing the Learn and Conserve plan, nearly double the basic plan cancellation fee.

Rationale for Offering the Program

Along with customer retention and customer acquisition, the bundled energy efficiency/electricity supply product offering is important in helping Reliant to "build a brand". Beyond improving the marketing efforts of the company, the bundled product is evidence that Reliant is "working in your [the customers'] best interest", leading to a transformation of the commodity buying experience. Reliant indicated that providing value-added products such as the Nest thermostat would likely increase customer loyalty. Reliant's decision to provide an electricity product with a free Nest thermostat was made based on customer input. (McConomy, 2013)

Measurement and Verification

Customers choosing to purchase electricity through Reliant's Learn and Conserve with Nest electricity product are provided weekly summary emails with electricity usage. Electricity usage is disaggregated based on each appliance's energy usage and each day. Disaggregation is based on averages calculated from data of similar homes. Installation of the Nest thermostat allows customers to participate in Demand Response programs, as well as saving electricity costs due to better management of HVAC system.

6.6 Conclusion

In order for the market for bundled energy efficiency/electricity supply products to mature, significant strategic questions related to the provision, financing, and accounting of energy efficiency services need to be addressed.

Several important questions remain:

- In the case that electricity retailers cannot or are unwilling to finance energy efficiency projects, how can third-party financers be incentivized to provide financing? What are the most practical means of securing energy efficiency investments in order to recoup investment in the case of customer default?
- Can electricity retailers produce a measurement and verification model such that customers can easily understand the value of energy efficiency without the electricity retailer incurring costs sufficient to undermine the overall electricity cost savings provided to the customer?
- Given the asymmetries in knowledge associated with the value of energy efficiency on an electricity retailer's operations and electricity procurement strategies in restructured electricity markets, can customers be assured that they are receiving a fair share of the value their energy efficiency projects produce for the electricity retailer?

Extent of Energy Efficiency Services Provided By Competitive Electricity Suppliers

Previous research has been conducted on the extent of energy efficiency service provision by competitive retail suppliers (Kushler & Witte, 2001). Research conducted in 2013 on the state of the competitive retail market in 2011 revealed a similar percentage of competitive retailers supplying energy efficiency services in 2011 (16% in Kushler and Witte's (2001) interview-based analysis versus 16.3% residential and 18.1% commercial in our website-based analysis). There was a significant increase in the number of retailers also providing energy efficient tips to help their customers save (14% in Kushler and Witte's (2001) interview-based analysis versus 37.5% residential and 28.7% commercial in our website-based analysis).

The lack of growth in the percentage of retailers offering energy efficiency services beyond energy efficiency tips speaks to the difficulties associated with retailers offering value-added services beyond their core competencies as power marketers. For more discussion and data on the motivations for retailers choosing not to provide energy efficiency services, see Kushler and Witte's survey results (2001).

Financing Structure of Bundled Energy Efficiency/Electricity Supply Products

The structure used to finance bundled energy efficiency/electricity products is a key determinant to the business model's future growth in both the residential and commercial markets. There are important differences in the size and scope of residential versus commercial energy efficiency projects that impact the importance of energy efficiency financing structures used.

Residential Customers

The bundled energy efficiency/electricity supply business model is currently limited in scope by the relatively short length (1-3 years) of most electricity supply contracts. Energy efficiency measures with payback times within 1-3 years are limited to the lighting and HVAC optimization (programmable thermostat) categories. With many transmission and distribution already offering free or reduced price lighting upgrades and on-bill financing programs, the largest opportunity for electricity retailers in the residential market may be in using off-balances sheet 'supply-cost'; financing for HVAC optimization products like the Nest thermostat

Recall that as many as 20 states have established or in the process of establishing on-bill financing programs through the local transmission and distribution utility.

Commercial Customers

While the basic strategic differences between on-bill financing and supply-cost financing, i.e. on-balance sheet versus off-balance sheet financing, remains consistent between the residential and commercial sectors, the value of off-balance sheet financing may be greater for the commercial industry because the size of project investment required is significantly larger than that in the residential sector. With lack of capital availability being the most important financing barrier to energy efficiency implementation and many firms uncomfortable or unable to take on on-balance sheet debt, off-balance sheet ‘supply-cost’ financing provides an invaluable solution.

Future Trends and Issues

Constellation’s Efficiency Made Easy™ product is in its first full year of deployment, and as such, has had a limited uptake in the market. With the vast majority of projects to date consisting of lighting retrofit projects, there is significant room for growth in providing other energy efficient technologies to customers. However, as the energy efficient technologies offered through the supply-cost financing model migrate from lighting to include HVAC optimization technologies, customers will likely expect more robust measurement and verification justification for pricing electricity products; more complex measurement and verification will likely add significant cost to the product. Reducing measurement and verification costs and clearly presenting this information to customers interested in installing energy efficient equipment through a supply-cost financing model will be vital to the continued growth of this offering.

The recent growth in electricity retailers partnering with technology providers, like Nest, is noteworthy for its potential to transform the retail residential electricity purchasing experience. The proliferation of WiFi connectivity (estimated at 61% of U.S. homes) and underutilized programmable thermostats (according to Nest only 10% are being used), creates a major opportunity for energy efficiency gains in the residential sector creates a major opportunity for energy efficiency gains in the residential sector (Miller, 2013). The nexus of WiFi connectivity and internet-enable programmable thermostats is progressing from telemetry, i.e. real-time monitoring of household electricity consumption, to control, i.e. capability of remotely controlling HVAC and other household devices. Alongside the evolution of WiFi connectivity, the composition of the energy efficiency industry is also adapting; e. hardware providers are entering the energy management business and ELECTRICITY RETAILERS are entering the hardware business (Miller, 2013). Electricity retailers that can bring hardware expertise in-house are in a position to optimize the operation of energy efficient equipment they deploy in their customers’ facilities. Retailers that determine electricity supply pricing based on expected savings for a customer, i.e. ‘supply-cost’ financing, are naturally conservative in deploying technologies with which they have limited familiarity. Bringing hardware expertise in-house can facilitate more competitive pricing for customers as retailers’ compete to provide the lowest cost ‘supply cost’ financing.

Chapter 7 – SWOT Analysis

7.1 Introduction

By focusing on the Strengths, Weaknesses, Opportunities, and Threats (SWOT) for each relevant stakeholder, we intend to describe, but not quantify[49], the strategic landscape of the bundled energy efficiency/electricity supply produce business model. The four major stakeholders relevant to this business model, i.e. those that are most closely involved and/or effected, are defined as competitive retail electricity suppliers, energy efficiency services companies, electricity customers, and third-party financers.

Compiling a SWOT analysis serves as a requisite step in establishing the issues on which the future prospects of the business model depends, and providing context for the quantification of economic benefits to the electricity retailers and electricity customers (See Chapter 8).

7.2 SWOT Analysis

The bundled energy efficiency/electricity supply product can involve as few as two stakeholders (an electricity retailer and customer in the case that the electricity retailer provides both financing and energy efficiency services) and as many as four stakeholders (an electricity retailer, customer, energy efficiency provider, third-party financer) in the case that the electricity retailer cannot provide energy efficiency services or financing.

The following section intends to describe the strategic strengths, weaknesses, opportunities, and threats of each stakeholder taking part in the bundled energy efficiency/electricity supply business model.

Table 34. SWOT Analysis – Electricity retailers

Strengths	***Electricity supply contract customization.*** Electricity retailers are experts at designing electricity supply contracts to meet customer's cost and risk tolerances. By designing customized electricity contracts for customers, electricity retailers provide additional value that vertically integrated utilities have traditionally not offered. ***Knowledge of customer electricity consumption patterns****.* Electricity retailers are a natural conduit for energy efficiency services insofar as they are experts in understanding the relative cost of serving different types of electricity consumption patterns ("load shapes").
Weaknesses	***Limitations on contract length.*** The nature of the competitive retail electricity market limits the length of contracts to 5 years or less. While commercial and industrial market data is unavailable, residential market data from Texas reveals that the median contract length is 12 months (Texas Public Utility Commission, 2013). The limited time horizon of bundled energy efficiency/electricity supply contracts limits

[49] Quantifying the value of energy efficiency implementation for competitive retail suppliers and electricity customers in a bundled energy efficiency services/electricity supply model is a major focus of this thesis. The design and results of this analysis are presented at length in chapter 8.

	the energy efficiency projects eligible under this model. ***Contract design standardization.*** Electricity retailers may find it difficult to standardize contract design for energy efficiency measures that do not produce a consistent permanent demand reduction. Difficulty in standardization may raise costs of implementation. ***Measurement and verification*** - The need to true-up the customer in the case that energy efficiency savings are less than anticipated limits the types of technologies that an electricity retailer may be willing to deploy, or the value of energy savings passed on to the customer.
Opportunities	***Customer retention***. Because many energy efficiency measures take more than a year to pay back, entering into a bundled energy efficiency/electricity supply product requires customers to sign contracts for longer than 1 year. By retaining existing customers for longer contract times, electricity retailers benefit from a more certain income stream. It is beyond the scope of this thesis to attempt to quantify the magnitude of the economic benefit of an electricity retailer maintaining longer contracts with customers, but we posit that there is a positive economic benefit. By providing energy efficiency services, an electricity retailer is forming a closer relationship with its customer. The electricity retailer goes from only an electricity supplier to an electricity services supplier. If the electricity retailer is performing or facilitating retrofits at a customer's facility, the customer has a real face-to-face relationship with the electricity retailer. ***Customer acquisition***. The retail electricity supply business is one defined by customer switching between electricity retailers. Providing energy efficiency services gives electricity retailers an additional selling point to attract customers to purchase electricity supply. Like the value of customer retention, the value gained from customer acquisition is real, but quantifying its value falls outside the scope of this research. ***Reduced procurement costs due to a customer's changing load shape***. Depending on the electricity market and the ELECTRICITY RETAILERS' underlying procurement strategy, energy efficiency implementation can reduce the procurement costs required to serve a customer's load. It is uncertain how much of the cost savings due to energy efficiency an electricity retailer will retain in a bundled energy efficiency/electricity supply product. Modeling the value of energy efficiency implementation on an electricity retailer procurement costs and a customer's supply cost is a main focus and the major quantitative analysis of this thesis. ***Increased sales and marketing at no additional cost.*** In the case that electricity retailers choose to provide energy efficiency services through the use of third-party energy efficiency providers, electricity retailers gain a direct sales and marketing team at no additional cost. Third-party energy efficiency providers will be willing to market an electricity retailer's electricity supply services because doing so opens a new opportunity to expand their core business, i.e. sell energy efficiency services to customers.
Threats	**Low customer uptake** of bundled energy efficiency/electricity supply contracts due to the perception of higher supply costs. If electricity retailers are unsuccessful in correctly explaining the "all-in cost" rationale for bundled energy efficiency/electricity supply cost contracts, they may not attract customers due to the higher supply costs associated with bundled energy efficiency/electricity supply contracts.

Table 35. SWOT Analysis - Energy Service Companies (ESCOs)

Strengths	***Energy efficiency project administration.*** Energy efficiency providers are experts at designing, implementing, and measuring the impact of energy efficiency retrofit projects.
Weaknesses	None.
Opportunities	***Increased sales through access to financing.*** Energy efficiency providers that participate in providing energy efficiency services for bundled energy efficiency/electricity supply products are accessing the potential for increased sales of their products. Energy efficiency providers are likely to be aided in their sales and marketing efforts given that their equipment can be installed without upfront *capital* expense if a customer chooses a bundled energy efficiency/electricity supply product.
Threats	***Limited scope of energy efficiency services eligible*. ** The limited scope of energy efficiency services currently eligible for the bundled energy efficiency/electricity supply product (given contract length and payback time restrictions), may detract from energy efficiency providers' attention on deep retrofit projects.

Table 36. SWOT Analysis - Retail Electricity Customers

Strengths	***None.***
Weaknesses	***Lack of understanding regarding benefits of energy efficiency, electricity markets and electricity supply pricing.*** The average retail electricity customer may not easily grasp the value that implementing energy efficiency in their homes may have on their electricity retailers' cost of providing electricity service. The nuances of electricity supply pricing (risk premiums, different procurement strategies, etc.) are likely poorly understood by the public at large. Without detailed knowledge of the potential value that their energy efficiency brings to the electricity retailer and issues relating to electricity procurement in wholesale markets, customers are vulnerable of ceding a large percentage of the value of energy efficiency to electricity retailers.
Opportunities	***Changing load shape through energy efficiency***. Implementation provides the potential for a reduction in procurement costs and an increase in load factor, thereby ensuring the customer has the opportunity to access more competitive electricity supply contracts in future negotiations. ***Reduced or eliminated capital requirements for energy efficiency implementation***. Retail electricity customers that are currently dissuaded from pursuing energy efficiency projects due to capital and/or debt constraints can access energy efficiency projects through off-balance sheet solutions such as in the case of 'supply-cost' financing. ***Demanding greater transparency in electricity product pricing.*** If customers are made aware (likely by a third party broker) that their energy efficiency may produce value to electricity retailer (in the form of reduced procurement costs), they may be able to negotiate more competitive contracts. The complexity of attributing the value of energy efficiency to the electricity retailer and customer, and the lack of publicly available information on these issues, may delay this potential opportunity for retail electricity customers.

Threats	***Poor performance of energy efficient equipment.*** If installed energy efficient equipment performs poorly and contractual guarantees are not secured, customers may pay higher *total* electricity prices. ***Electricity market declines during the length of the contract.*** If wholesale electricity market prices decline during the duration of the contract, electricity customers may forgo cost savings available through shorter-term contracts. In some cases, the potential cost savings due to reduction in wholesale electricity prices may outweigh the cost savings benefits due to energy efficiency implementation. ***Energy efficiency implementation, under specific circumstances, may actually reduce load factor.*** If energy efficiency retrofits negatively affect a customer's load profile, i.e. if a customer's load factor decreases due to energy efficiency implementation, the customer may face higher future supply contract prices. While energy efficiency implementation generally increases load factor, there are circumstances under which the opposite is true – significant research is conducted regarding the impact of energy efficiency on changing a customer's load factor in Chapter 8 of this thesis.

Table 37. SWOT Analysis – Third Party Financers

Strengths	***Investment and risk management.*** Third party financers' main strength is in designing investment vehicles that can achieve financial returns such that additional investments can be undertaken. Specifically, investors are naturally predisposed to quantifying and managing potential risk and returns when undertaking investment opportunities.
Weaknesses	**Lack of experience with energy efficiency financing.** The market for energy efficiency financing is currently undersized in part due to much of the financial community's lack of familiarity with energy efficiency projects and financial mechanisms to capture this value.
Opportunities	***Filling investment market gap for small and mid-market ELECTRICITY RETAILERS***. Financing energy efficiency projects for competitive retail electricity suppliers who do not have capital to self-finance energy efficiency projects.
Threats	***Transaction costs may be prohibitive*** in the case that bundled energy efficiency/electricity supply contracts cannot be standardized. The complexity of offering different types of energy efficiency measures to different types of customers creates a significant challenge for the electricity retailer in representing the value proposition of each individual customer's bundled energy efficiency/electricity supply contract.

Chapter 8 – Value of Energy Efficiency – Modeling Results

8.1 Introduction

In order to understand the relative benefits of bundling energy efficiency with electricity supply for electricity retailers and their customers, quantitative analysis is needed. The following section seeks to answer the following research question:

What is the approximate division of electricity savings between an electricity retailer (which procures, manages risk, and resells electricity) and its customer (which purchases electricity) under real-time and fixed-cost contracts?

There are a series of sub-questions that must be addressed in order to answer the two questions:

Does reducing customer demand have an impact on wholesale electricity prices at the market-wide level real-time electricity price, i.e. could lowering customer demand lead to lower marginal real-time electricity prices?

Which independent variables (percentage permanent demand reduction, initial size (kW) of equipment load, equipment operational period) have the largest and smallest impact on the dependent variables analyzed?

Are independent variables (average real-time electricity cost, customer load factor) correlated with dependent variables?

8.2 Conceptual Framework for Evaluating the Value of Energy Efficiency

Addressing the chapter's main research questions (and designing a quantitative test therein) requires a conceptual understanding of the comparative value of energy efficiency to the customer and electricity retailer. It is the purpose of this section to provide a framework through which this chapter's energy efficiency modeling results can be contextualized.

The value of energy efficiency implementation for the customer and electricity retailer is inextricably tied to the economics governing electricity purchasing in competitive markets. In short, the cost per unit of electricity quoted by an electricity retailer is dependent on the amount the electricity retailer expects to pay to secure sufficient supply to meet its customer's electricity needs, while also taking a margin. Substantial study can be given to the procurement strategies of electricity retailers. In this section we outline the basic dynamics governing the differences in fixed price contracts between different customer types, instead of explicating the cost/risk continuum in great detail. The majority of electricity contracts for residential and commercial customers provided by electricity retailers are fixed price contracts.

<u>Electricity Retailer Benefits</u>

Benefit 1. Energy efficiency implementation will reduce the average procurement cost, giving the electricity retailer an opportunity to increase its margins. The value for the electricity retailer in providing energy efficiency stems from a reduced procurement cost per kWh to serve its customer's load. Energy efficiency implementation has the potential to reduce the average procurement cost per kWh regardless of the electricity retailer's procurement strategy or the type of contract offered to a customer. The electricity retailer would maximize the possible savings achieved through changing its customer's average procurement cost if it bought 100% of its customers' electricity in the real-time market while quoting a fixed price to its customer, assuming that percentage cost savings due to energy efficiency are higher if electricity is purchased in the real-time market than if electricity is purchased in bilateral, fixed price contracts. A scenario in which an electricity retailer quotes a fixed price to its customers and purchases all of its customer's electricity in the real-time market is a highly unlikely scenario. In order to hedge against volatility in the real-time electricity market, the electricity retailer would likely have to quote a fixed cost price that was higher than the fixed cost price it would be capable of offering based on a procurement strategy that including a percentage of bilateral, fixed price contracts.

The value of energy efficiency to the electricity retailer under a fixed price contract is likely to be highest in terms of reducing procurement costs for customers with low load factors, i.e. those customers with the highest existing procurement costs. Customers with low load factors generally exhibit more volatility in their electricity consumption behavior; as such, electricity retailers are likely to find it more difficult to procure electricity for customers with low load factors using only bilateral contracts.

The minimum procurement cost savings to an electricity retailer are equal to the percentage savings experienced by the customer under a fixed price contract. Even in cases in which an electricity retailer offers a fully fixed-price contract and procure all electricity to serve that customer, the electricity retailer can still benefit from taking a margin of the procurement cost savings available through changes in its bilateral procurement needs.

Customer Benefits

Benefit 1. Reduction in electricity demand leads to cost savings for the life of the energy efficient equipment so long as the electricity retailer does not increase the cost per unit of supply beyond the percentage decrease in electricity consumption.

Benefit 2. Energy efficiency implementation may increase a customer's load factor, allowing it to secure more competitive prices in future electricity supply contracts. An increase in load factor may allow customers to negotiate more attractive contracts in the future because their load is comparatively less expensive to serve on an average $/kWh basis.

8.3 The Macroeconomic Value of Energy Efficiency in the ERCOT and PJM Markets

Before modeling the impact of energy efficiency measures on a single facility or a portfolio of customers, we need to first understand the impact of energy efficiency at the macro level. By modeling the relationship between load factor and real-time (wholesale) electricity price, we can ascertain whether there is a predictable market value (in the form of reduced real-time prices) for permanently reducing system demand. The central question considered in this section is:

What is the impact of reducing electricity demand on the wholesale price of electricity in the real-time market?

A strong correlation between electricity demand and wholesale price of electricity in the real-time market would provide justification to the argument that by permanently reducing demand of its customers, electricity retailers can reduce marginal real-time procurement costs ($/MWh) for its entire portfolio of customers; not only those with energy efficiency products.

8.3.1 The ERCOT Wholesale Market - Load Factor Analysis

To determine whether there is a correlation between load factor and real-time electricity price, we plot Load Factor on the x-axis for each hour of the year and Real-Time market price on the y-axis. Real-Time market price is determined every 15 minutes, so this analysis averages each 4, 15-minute price period into 1 hour blocks.

The results of the ERCOT load factor analysis are presented in Table 38 and Table 39 below.

Figure 21. Correlation of Load Factor vs. Real-Time Price - Load Zone Houston 2012

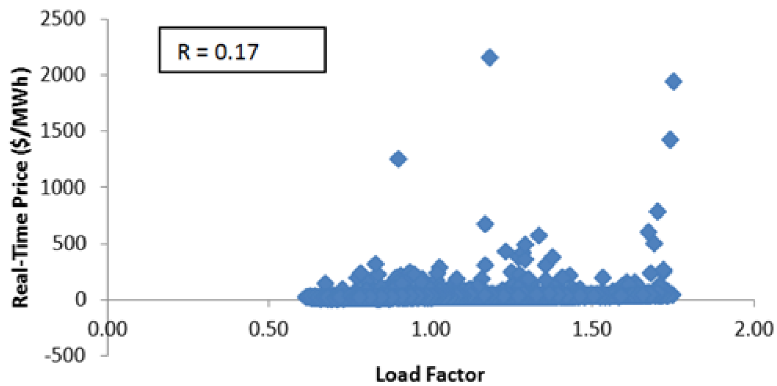


Table 38. Correlation Coefficient between Real-Time Prices and Load Factor – ERCOT Load Zones (2008-2012)

Year	LZ_HOUSTON	LZ_WEST	LZ_SOUTH	LZ_NORTH
2012	0.17	0.29	-0.16	-0.15
2011	0.22	0.25	-0.19	-0.18
2010	0.26	0.37	-0.24	-0.25
2009	0.16	0.25	-0.14	-0.15
2008	0.31	0.31	-0.27	-0.29

Table 39. Correlation Coefficient between Real-Time Prices and Load Factor – ERCOT Load Zones (2008-2012)

Year	LZ_HOUSTON	LZ_WEST	LZ_SOUTH	LZ_NORTH
2012	0.03	0.08	0.03	0.02
2011	0.05	0.06	0.04	0.03
2010	0.07	0.14	0.06	0.06
2009	0.03	0.06	0.02	0.02
2008	0.10	0.10	0.07	0.08

8.3.1.1 The ERCOT Wholesale Market – Discussion of Load Factor Analysis Results

In a simple, closed (no imports or exports) electricity system, we would expect a high level of correlation between system demand and wholesale electricity prices in the real-time market. The results of the ERCOT load factor analysis reveal a low correlation between system demand and wholesale price for each of the 4 load zones analyzed; the maximum r-squared value was 0.1. The results of the load factor analysis reveal that an electricity retailer cannot reliably predict that reducing their customer portfolio's energy demand through energy efficiency implementation will lead to reduced real-time electricity prices. It is important to note that this observation should not be interpreted as disqualifying the value of energy efficiency to electricity retailers. However, it does signify that there is no reliable predictor of gaining from reduced wholesale electricity prices by reducing its customer portfolio's energy demand in the ERCOT market.

8.3.2 The PJM Interconnection Wholesale Market – Load Factor Analysis

The results of the PJM load factor analysis for Pennsylvania load zones revealed a significantly stronger correlation between load factor and real-time electricity price, than did the ERCOT results. Nevertheless, correlation (r-squared) observed in the 5 load zones from the period 2008-2012 never exceeded 0.46, suggesting that other factors besides system demand were important in influencing real-time market prices. The full results of the analysis are displayed in Table 40 and Table 41 below.

Table 40. Correlation Coefficient between Real-Time Prices and Load Factor - PJM Load Zones (2008-2012)

Year	PENELEC	METED	PPL	PECO	DUQ
2012	0.47	0.49	0.47	0.50	0.47
2011	0.25	0.24	0.25	0.21	0.21
2010	0.57	0.63	0.56	0.64	0.47
2009	0.67	0.63	0.68	0.56	0.45
2008	0.59	0.62	0.57	0.64	0.53

Table 41. Correlation (R-squared) between Real-Time Prices and Load Factor - PJM Load Zones (2008-2012)

Year	PENELEC	METED	PPL	PECO	DUQ
2012	0.22	0.24	0.22	0.25	0.22
2011	0.06	0.06	0.06	0.04	0.04
2010	0.32	0.40	0.31	0.41	0.22
2009	0.45	0.40	0.46	0.31	0.20
2008	0.35	0.38	0.32	0.41	0.28

8.3.2.1 The PJM Interconnection Wholesale Market – Discussion of Load Factor Analysis Results

The PJM load factor analysis reveals a moderate correlation between system load factor and real-time electricity prices. However, the analysis cannot be interpreted as evidence for the existence of electricity retailers or customer cost savings simply through reducing real-time time prices through reduced demand (due to efficiency).

8.4 Energy Efficiency Modeling Design

Designing an energy efficiency model capable of estimating the financial energy efficiency benefits to electricity retailers and its customers necessitated an approach that struck a balance between complexity, proximity to reality, and the time constraints faced by the principal researcher.

The foregoing analysis is simplified insofar as it only contends with energy costs (rather than other supply costs identified for commercial and industrial customers such as capacity and ancillary services costs). Modeling the cost implications of different electricity procurement strategies based on energy only costs is useful insofar as energy costs constitute the vast majority of total supply costs and are the most volatile cost item of all supply costs.

The decision to model the impact of energy efficiency on electricity supply-only costs was made because it is this impact that impacts the electricity retailer. Customers benefit from energy efficiency through reduced costs paid for transmission and distribution (T&D) service; however, this value was not modeled in this analysis.

An energy efficiency cost calculator ("the calculator") was developed in Microsoft Excel 2010 in order to approximate the financial value of energy efficiency of different energy efficient measures to electricity retailers and customers. The calculator leveraged example ERCOT customer meter data (recall previous explanation) from 2009-2012, as well as real-time pricing data from the ERCOT and PJM markets form 2009-2012. Unlike ERCOT, there was no backcasted load data from PJM available. Therefore, we utilized ERCOT load data to model pricing in PJM to evaluate the difference between the cost savings implications of the different wholesale electricity markets.

Based on the example ERCOT customer meter data and pricing data, the following dependent variables can be evaluated for a variety of different scenarios:

1. ***Annual costs.*** Annual costs are defined as the total energy only cost (does not include ancillary services, capacity and transmission charges, RPS charges, etc.)
2. ***Average procurement cost per kWh***. The average procurement cost per kWh is defined as the quotient of annual costs ($) and annual electricity consumption (kWh). Under a fixed price contract, the average procurement cost per kWh will be equal to the fixed price. However, under a real-time contract, the average procurement cost per kWh varies based on a customer's load factor.
3. ***Customer load factor.*** A customer's load factor is defined by the quotient of average demand (kW) and maximum demand (kW). The customer load factor variable allows for easy comparison between customers based on their respective electricity consumption patterns.

In order to evaluate the impact of energy efficiency on the aforementioned dependent variables, the calculator was designed to incorporate the following independent variables:

1. ***Percentage demand of energy efficient technology (lighting or HVAC) of customer peak demand.*** Evaluating the value of energy efficiency requires an understanding of the total contribution of the equipment being replaced/retrofitted to the customer's overall energy demand.
2. ***Percentage permanent demand reduction due to energy efficiency implementation.*** By defining the magnitude of energy efficiency improvement for the energy efficient technology selected, we can model the implications of energy efficiency during the time periods defined by the independent variables 3 through 5 listed below
3. ***Starting and ending hour of the day.*** This variable was used to define the period of energy efficiency savings.
4. ***Starting and ending day of the week.*** This variable was used to define the period of energy efficiency savings.
5. ***Starting and ending month of the year.*** This variable was used to define the period of energy efficiency savings.
6. ***Customer electricity consumption.*** ERCOT backcasted load data provided electricity consumption (kWh) data for each 15-minute period between 2009-2012.
7. ***Electricity prices.*** Real-time electricity price data from ERCOT and PJM was used to calculate electricity costs for each 15-minute consumption period for customers on a real-time electricity product. In cases of fixed price electricity products, prices were chosen from publicly available data from the Texas Public Utility website.

By multiplying both the pre- and post-retrofit electricity consumption (kWh) by the electricity price in each 15-minute period, we can calculate the value of the three dependent variables (annual costs, average procurement cost per kWh, and customer load factor) in both pre- and post-retrofit environments.

There were two separate calculators built, one that modeled energy efficient modeling implementation and one that modeled energy efficiency HVAC optimization implementation. Building two separate calculators was required because of the fact that lighting energy efficiency provides a constant demand reduction whereas HVAC optimization energy efficiency provides variable energy savings based on the changing output of the HVAC equipment throughout the intra-annual and diurnal variations in outdoor air temperatures. The details of the differences in calculator design are described in further detail below.

It is important to note that the energy efficiency calculator does not calculate the interaction between HVAC and lighting savings, i.e. reduced lighting output can reduce HVAC requirements.

8.4.1 Energy Efficiency Calculator 1 – Lighting Retrofit

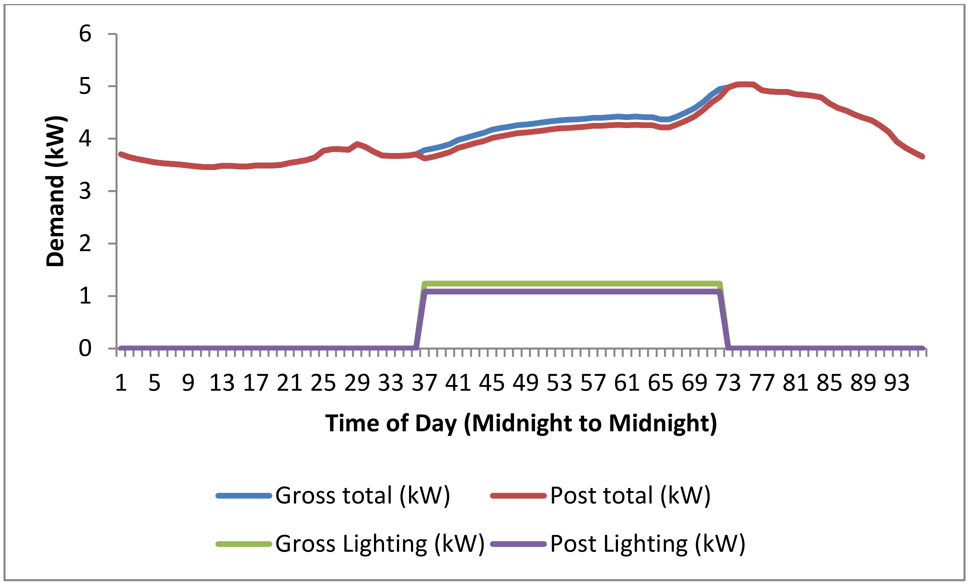
In order to calculate the value of energy efficiency for a lighting retrofit, the lighting calculator was designed as follows:

1. Define the customer's max load through (=MAX) Excel formula
2. Define the amount of lighting used in the facility before the retrofit by defining the % of max load that is comprised of lighting. Note that using this technique assumes no change in lighting level throughout the hours of operation. While this is a simplification, it is a justifiable simplification given that the main goal of this analysis is to compare fundamentally different types of efficiency measures (lighting vs. HVAC). Variables 1 and 2 are used to calculate the pre-retrofit lighting demand.
3. Define the % permanent demand reduction due to lighting retrofit. This product of % permanent demand reduction due to lighting retrofit and the % of max load that is comprised of lighting are defined as the lighting retrofit savings. Note that this lighting retrofit savings is constant throughout the year.

To further clarify the impact of lighting on a customer's load shape, maximum customer load for 2012.

Figure 22 displays the impact of 12.5% permanent demand reduction on the BUSMEDLF customer example for January 2, 2012. The example assumes that lighting comprises 10% of maximum customer load for 2012.

Figure 22. Example of Impact of Lighting Retrofit (January 2, 2012 - BUSMEDLF)



8.4.2 Electricity Efficiency Calculator 2 – HVAC Retrofit

In order to calculate the value of energy efficiency for an HVAC retrofit, the HVAC calculator was designed as follows:

1. Define the customer's max electricity demand by using the (=MAX) Excel function
2. Define the amount of HVAC used in the facility before the retrofit by defining the % of max load that is comprised of HVAC.
3. Define the % demand reduction due to HVAC energy efficiency implementation.

Calculating the impact of energy efficiency savings due to the HVAC retrofit was a more complex process than was the case with modeling lighting efficiency. The following logic is provided to clarify the process by which this calculation was made.

Post-retrofit kWh for each 15-minute period was calculated as follows:

IF the 15 minute electricity consumption period fell into the curtailment period (defined by hours of the day, days of the week, and months of the year),

THEN, Post-retrofit kWh = Pre-retrofit kWh – (Pre-retrofit kWh multiplied by % HVAC at peak)*(Pre-retrofit kWh/Peak annual kWh)*(1- % demand reduction due to HVAC efficiency improvement),

IF NOT, i.e. if the 15 minute electricity consumption period does not fall into the curtailment period, then the post-retrofit kWh is equal to the pre-retrofit kWh.

To further explain this concept, the following example helps clarify how HVAC demand was modeled.

<u>Inputs</u>

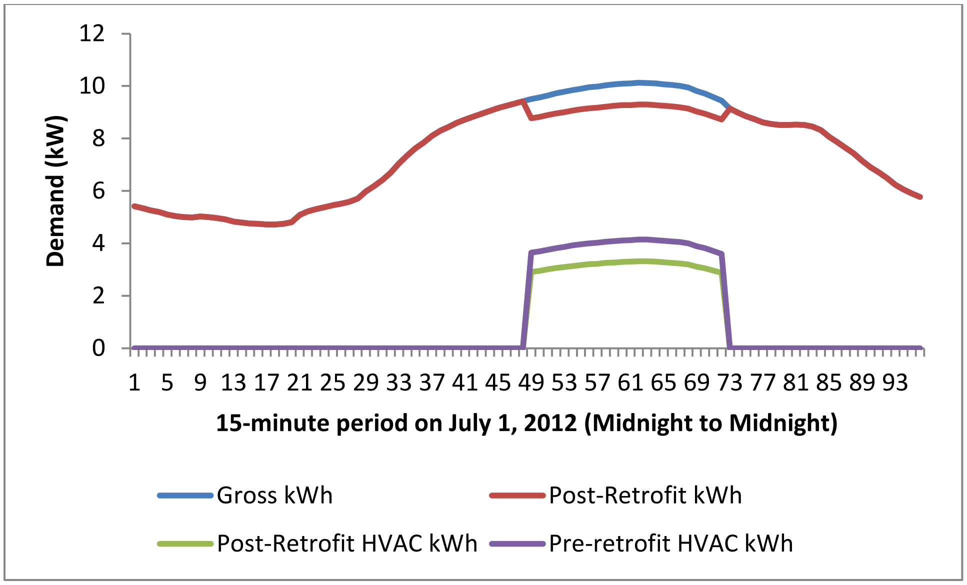
Starting Day	Ending Day	Starting Hour	Ending Hour	Starting Month	Ending Month	% of Max Demand Due to HVAC	% HVAC demand reduction
Monday	Friday	11 am	5 pm	May	September	50%	20%

The magnitude of HVAC savings is directly proportional to the total HVAC demand. In periods of low HVAC demand, HVAC demand savings due to efficiency are low. In periods of high HVAC demand, HVAC demand savings due to efficiency are high.

To further explain the calculator, an HVAC optimization efficiency scenario (20% permanent demand reduction, HVAC comprises 50% of Max demand for the year) is modeled in

Figure 23 below.

Figure 23. Example of Energy Efficiency Savings Due to HVAC Optimization (BUSMEDLF)



8.5 Energy Efficiency Modeling Scenarios

The following section briefly outlines the different energy efficiency implementation scenarios used in the various energy efficiency calculators. Each of the energy efficiency modeling scenarios described below calculate pre- and post-retrofit: annual costs, average procurement cost per kWh, and customer load factor, for 5 customer profiles from ERCOT's COAST load zone (Business High, Medium, and Low Load Factor, and Residential High and Low winter ratio). For scenarios in which real-time electricity prices are used, real-time prices are used for both ERCOT's Houston load zone and PJM's MetEd load zone.

The energy efficiency modeling scenarios were designed to quantify the relative value of energy efficiency to the ELECTRICITY RETAILERS and customer.

The electricity retailer benefits are defined as follows:

1. **Electricity Retailer Margin.** Electricity Retailer Margin is defined as the difference between annual percentage cost savings (fixed price contract) and annual percentage costs savings (real-time contract). Recall that this formulation describes the retailer's maximum possible increase in margin.

The customer benefits are defined as follows:

1. **Annual Percentage Cost Savings (assuming Real-Time Contract)**
2. **Annual Percentage Cost Savings (assuming Fixed Price Contract)**
3. **Percentage change in load factor**

8.5.1 Energy Efficiency Modeling Scenarios – Lighting calculator

Understanding the relative value of lighting retrofits requires an analysis of the most import factors influencing the impact of percentage permanent demand reduction (Scenario L1), size of lighting load (Scenario L2), and lighting schedule (Scenario L3). In order to make comparisons between Scenarios L1, L2 and L3, the same baseline energy efficiency implementation scenario was used for all three scenarios. Each individual scenario (L1 through L3) varied a single independent variable + or – 5% to see the comparative impacts on electricity retailer and customer benefits. The baseline energy efficiency scenario assumes a lighting schedule of 9 am – 5 pm, from Monday to Friday, in all weeks of the year, a permanent demand reduction of 12.5% (corresponding to the replacement of 32 watt fluorescent lamps with 28 watt lamps), and a lighting load that represents 10% of maximum annual demand.

All results are presented in figures and tables below. For ease of comparison the title of the figures and table names follow the following format: Scenario name, Electricity Retailer or Customer Benefit Tested. For example, the figure displaying results for the sensitivity analysis performed for electricity retailer margin under scenario L1 is named “Figure XX. Scenario L1 – Sensitivity Analysis. Electricity Retailer Margin.”

Lighting Calculator – Scenario L1 – Permanent Demand Reduction

For all calculations completed under Lighting Scenario 6.1.1, the following input parameters apply:

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	Permanent demand reduction	% of max load consisting of lighting
1	9	17	2	6	1	12	7.5%	10%
2	9	17	2	6	1	12	12.5%	10%
3	9	17	2	6	1	12	17.5%	10%

Lighting Calculator – Scenario L2 – Initial Size of Lighting Load

For all calculations completed under Scenario L2, the following lighting input parameters apply:

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	Permanent demand reduction	% of max load consisting of lighting
1	9	17	2	6	1	12	12.50%	5%
2	9	17	2	6	1	12	12.50%	10%
3	9	17	2	6	1	12	12.50%	15%

Lighting Calculator – Scenario L3 – Lighting Schedule

For all calculations completed under Scenario L3, the following lighting input parameters apply:

Scenario	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	% of max load consisting of lighting	Permanent demand reduction	% of Total Annual Hours
1	11	18	2	6	1	12	10%	12.5%	17.60%
2	9	18	2	6	1	12	10%	12.5%	22.60%
3	8	19	2	6	1	12	10%	12.5%	27.60%

8.5.2 Energy Efficiency Modeling Scenarios – HVAC calculator

Following the methodology used to model the value of lighting energy efficiency, a baseline energy efficiency implementation scenario for HVAC was established to compare the sensitivity of electricity retailer and customer benefits to changes in the same three independent variables tested in the lighting scenarios. The HVAC energy efficiency implementation scenario assumes a PDR of 20%, 50% HVAC demand as a percentage of peak demand, and an HVAC schedule from 12-5pm, Monday-Friday, May-September.

Importantly, the sensitivity analyses completed in Scenario H1, H2, and H3, vary the independent variable + or – 2.7% (whereas Scenarios L1, L2, and L3 varied independent variables + or -5%). The decision to vary the independent variables + or – 2.7% was made based on the desire to create realistic differences in HVAC schedule (see Scenario H3 below). Varying HVAC schedule + or – 5% from the baseline energy efficiency implementation scenario would have produced HVAC schedules so long and so short as to be unrealistic.

HVAC Calculator – Scenario H1 – Permanent Demand Reduction

For all calculations completed under HVAC Scenario 6.2.1, the following input parameters apply:

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	% of Max Demand Due to HVAC	% Permanent Demand Reduction
1	12	17	2	6	5	9	50%	17.3%
2	12	17	2	6	5	9	50%	20.0%
3	12	17	2	6	5	9	50%	22.7%

HVAC Calculator – Scenario H2 – Initial Size of HVAC Load

For all calculations completed under Scenario H2, the following input parameters apply:

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	Permanent Demand Reduction	% of Max Demand Due to HVAC

1	12	17	2	6	5	9	20%	47.3%
4	12	17	2	6	5	9	20%	50.0%
7	12	17	2	6	5	9	20%	52.7%

HVAC Calculator – Scenario H3 – HVAC Schedule

For all calculations completed under HVAC Scenario 6.2.2, the following input parameters apply:

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	% of Total Annual Hours	Permanent Demand Reduction	% of Max Demand Due to HVAC
1	14	16	2	6	5	9	1.9%	20%	50%
2	12	17	2	6	5	9	4.6%	20%	50%
3	11	19	2	6	5	9	7.3%	20%	50%

8.5.3 Lighting and HVAC Scenarios

The lighting and HVAC scenarios were formulated to mimic the lighting only and HVAC only energy efficiency implementation scenarios. In that, we mean that the input values chosen to model changes in permanent demand reduction, initial size of load, and operational schedule were equal to those modeled in the lighting only and HVAC only energy efficiency implementation scenarios. See Appendix 6 for the input parameters for the Lighting and HVAC scenarios (Scenarios LH1-LH3).

8.6 Energy Efficiency Modeling Results

The foregoing section presents the results of the three energy efficiency modeling scenarios. Only the most relevant results are summarized. The results for each of the scenarios are presented using a Radar Plot so as to graphically display the comparative results of up to 10 examples (i.e. 5 customer samples paying ERCOT electricity prices and 5 customer samples paying PJM electricity prices).

Under circumstances in which the shape of the Radar Chart remains the same over several different input values of the independent variable, i.e. there is a linear relationship between the independent variable (e.g. customer load factor) and dependent variable (e.g. Electricity Retailer Margin), we only need to model correlation based on a single scenario. As such, we chose to present only the results of the sensitivity analysis for each of the independent variables surveyed, so long as the relationship between independent and dependent variables was linear. Under circumstances in which there is not a linear relationship between the independent and dependent variables, we show the results of all simulations as only showing the results of the sensitivity analysis would be misleading.

At the beginning of the Lighting and HVAC modeling results section, the Radar Plot of the baseline energy efficiency scenario is displayed. In cases in which there is a linear relationship between independent variable (permanent demand reduction, maximum load due to energy efficient devices, and operational schedule) and dependent variables (electricity retailer margin, annual percentage cost savings (fixed price), annual percentage cost savings (real-time price), percentage change in load factor) only sensitivity analysis graphs are displayed because the baseline energy efficiency scenario is the same for all three groups of simulations.

For full results, consult Appendix 4 (Lighting efficiency scenarios), Appendix 5 (Lighting and HVAC efficiency scenarios) and Appendix 6 (Lighting and HVAC efficiency scenarios).

Correlation Analysis

Electricity retailers undertaking bundled energy efficiency/electricity supply contracts need a mechanism of accounting for inter-annual variability in customer electricity consumption patterns and inter-annual variability in wholesale electricity prices. The correlation analysis completed queries the relationship between the customer load factor (during the operational period of the energy efficient device) and the average real-time price (during the operational period of the energy efficient device) and all dependent variables. We refer to these independent variables as customer load factor and average real-time price. There is a fundamental difference between the ways in which we can model the relationship between customer load factor and dependent variables, and the relationship between average real-time price and dependent variables insofar as the customer load factor is different for all 5 customer types modeled whereas the average real-time price is the same for all 5 customer types modeled. As such, we can only model the correlation between average real-time price and dependent variables for each customer type over the 4 years evaluated, whereas we can model the correlation between customer load factor and dependent variables for each customer type over the 4 years evaluated *and* the correlation between the 5 customers load factors and dependent variable within a single year (2009-2012).

The correlation analysis sections below classify the relationship between the independent variables and dependent variables based on two measures: correlation coefficient (R-value) and coefficient of determination (r-squared). The correlation coefficient is classified as *positive*, *negative* or *inconsistent* (values can range from -1 to 1). The correlation coefficient (R-value) is described as *inconsistent* in cases in which some R-values calculated are negative and some are positive, e.g. the relationship between customer load factor and electricity retailer margin for the years 2009-2012 may be different enough such that the R-value for 2009 is positive, but the R-value for 2012 is negative. The correlation of determination (r-squared) is calculated by multiplying the R-value by the R-value (values can range from 0 to 1). The correlation of determination describes the proportion of total variation in the dependent variable explained by the independent variable (Steel, 1960). The correlation of determination is described as *low* (0-0.33), *moderate* (0.33-0.66), or *high* (0.67-1). In cases in which the R-values fall within more than one classification (e.g. *low* and *moderate*), all classifications are noted.

8.6.1 Energy Efficiency Modeling Results – Lighting Calculator

Scenario L1 – Electricity Retailer Benefits

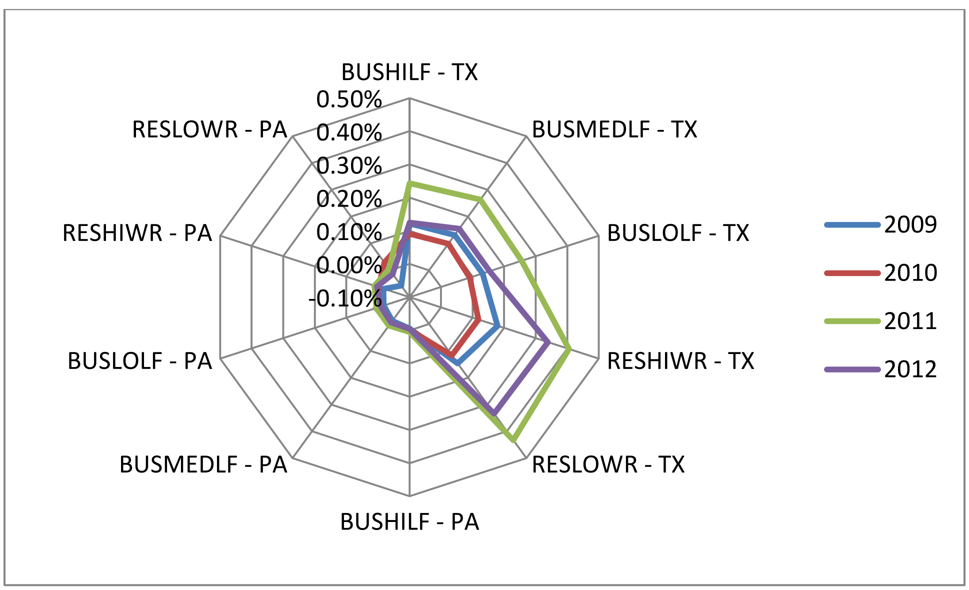
The relative impact of changing the permanent demand reduction (PDR) due lighting efficiency implementation on the ***Electricity retailer benefits*** is summarized below:

Benefit 1 – Electricity Retailer Margin

The electricity retailer margin accruing from the baseline energy efficiency implementation scenario for lighting retrofits (on which Scenario L1, L2, and L3 analyses depend) is represented in

Figure 24 below.

Figure 24. Scenario L1 – Electricity Retailer Margin. 12.5% PDR, 10% Lighting as Max Load

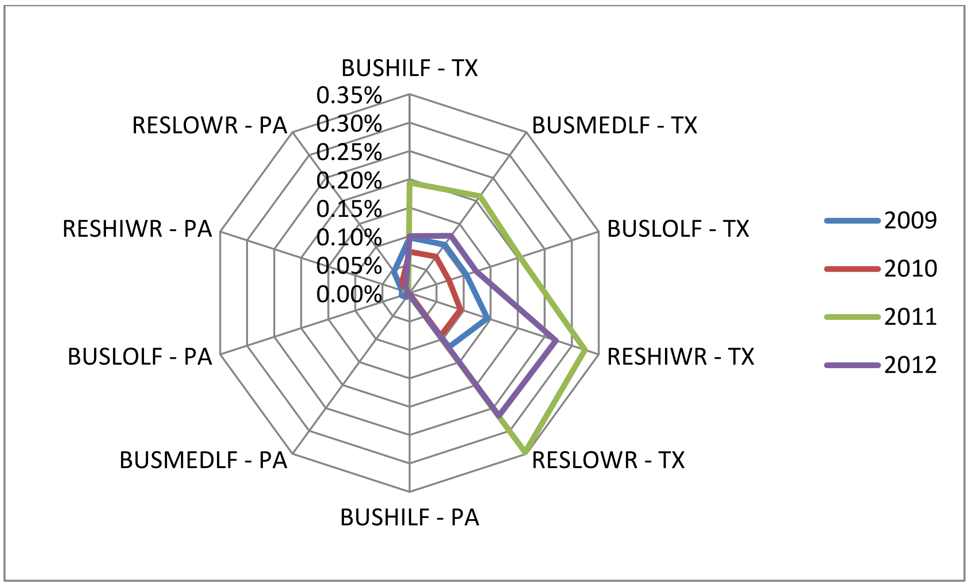


In the ERCOT market, the largest increase in *electricity retailer margin* results from efficiency implementation in the three customer examples (RESLOWR, RESHIWR, and BUSLOLF) with the three smallest load factors. The two largest *electricity retailer margin* increases come in the years 2011 and 2012. *Electricity retailer margin* is essentially unchanged for all load examples in the PJM market examples.

The *electricity retailer margin* sensitivity analysis (

Figure 25) follows the same shape as the *electricity retailer margin* baseline energy efficiency implementation scenario, indicating a linear relationship between permanent demand reduction and *electricity retailer margin*.

Figure 25. Scenario L1 – Electricity Retailer Margin – Sensitivity Analysis



The sensitivity analysis displays the change in *electricity retailer margin* based on increasing permanent demand reduction 5% and reducing it by 5% from the baseline efficiency scenario.

Correlation Analysis

Independent Variable 1: Customer Load Factor

ERCOT – There is a *negative* correlation (R-value) between customer load factor and *electricity retailer margin*, i.e. *electricity retailer margin* increases as customer load factor decreases. The coefficient of determination (r-squared) is *high* - ranging from 0.69 in 2009 to 0.86 in 2011.

PJM –There is an *inconsistent* correlation (R-value) between customer load factor and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* to *moderate* – ranging from 0.01 in 2009 to 0.54 in 2009.

Independent Variable 2: Average Real-Time Price

ERCOT – There is a *positive* correlation (R-value) between average real-time price and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* to *moderate* – ranging from 0.03 for the RESHIWR customer type to 0.49 for the BUSHILF customer type.

PJM – There is a *negative* correlation (R-value) between average real-time price and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* to *high* – ranging from 0.08 for the BUSHILF customer type to 0.92 for the RESLOWR customer type.

Context: Electricity retailers in ERCOT selling fixed price electricity products have the most to gain, i.e. the highest possible margins, for customers with the lowest load factors. This opportunity comes with risk, as retailers which procure a high percentage of a residential customer's electricity in the real-time market face the risk of unexpectedly high peaking prices. The inter-annual differences observed in

Figure 24 above speak to the uncertainty the electricity retailer faces if it wants to calculate potential margin increases when purchasing a high percentage of electricity in the real-time market. Whereas in ERCOT electricity retailer margin is consistently and strongly correlated with customer load factor, there is an inconsistent correlation between electricity retailer margin and customer load factor in PJM. The results of the correlation between average real-time price and electricity retailer margin for both ERCOT and PJM highlight the uncertain nature of predicting CRES margin based on average real-time prices.

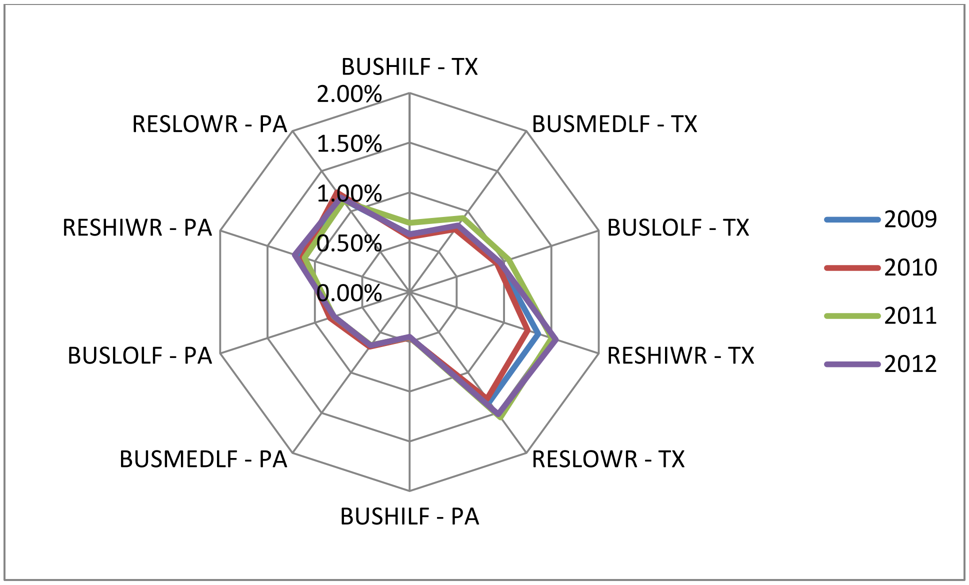
8.6.1.2 Scenario L1 – Customer Benefits

The relative impact of changing the permanent demand reduction due lighting efficiency implementation on the ***customer's benefits*** is summarized below:

<u>Customer Benefit 1 – Annual Percentage Cost Savings (Real Time Pricing)</u>

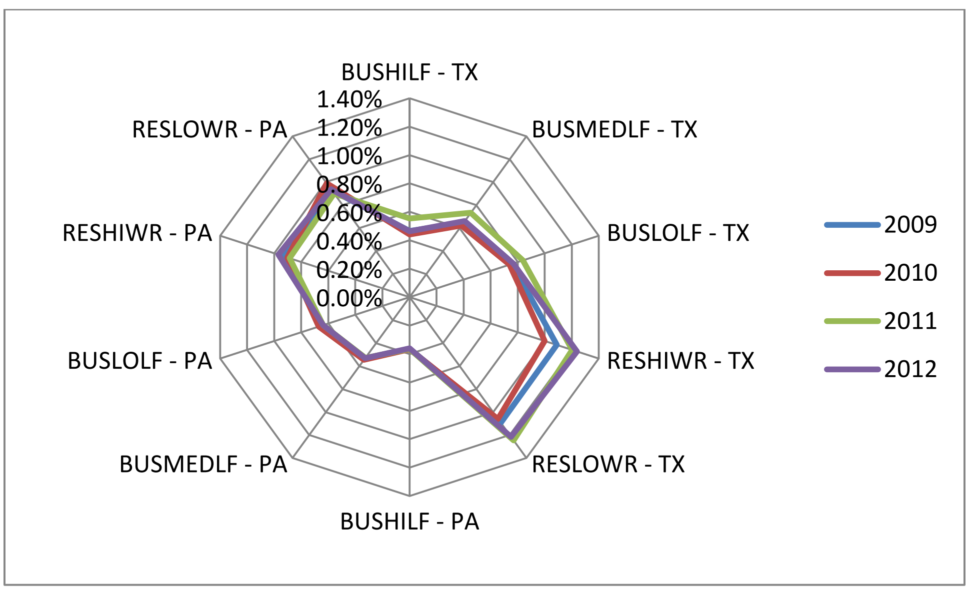
The annual costs savings achieved by customers that buy their electricity in the real-time market is highly dependent on the customer load factor, see Figure 26 below.

Figure 26. Scenario L1 – Annual Percentage Cost Savings (Real Time Pricing) – 12.5% PDR, 10% Lighting as Max Load



Annual percentage costs savings are approximately 50% higher for residential customers (RESHIWR and RESLOWR) in ERCOT as compared to PJM. Interestingly, the cost saving differential is less for BUSLOLF then BUSMEDLF, despite the fact that BUSLOLF has a lower load factor than BUSMEDLF.

Figure 27. Scenario L1 – Annual Percentage Cost Savings (Real Time Pricing) – Sensitivity Analysis



The shape of the sensitivity analysis graph is the same as that of the baseline energy efficiency implementation scenario, indicating a linear relationship between changes in PDR and annual percentage costs savings (real-time pricing).

Correlation Analysis

Independent Variable 1: Customer Load Factor

ERCOT – There is a *negative* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *high* – ranging from 0.99 in 2010 to 1.00 in 2009.

PJM – There is a *negative* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *high* – ranging from 0.98 in 2010 to 0.99 in 2009.

Independent Variable 2: Average Real-Time Price

ERCOT – There is an *inconsistent* correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low* to *high* – ranging from 0.01 for RESLOWR customer type to 0.52 for BUSHILF customer type.

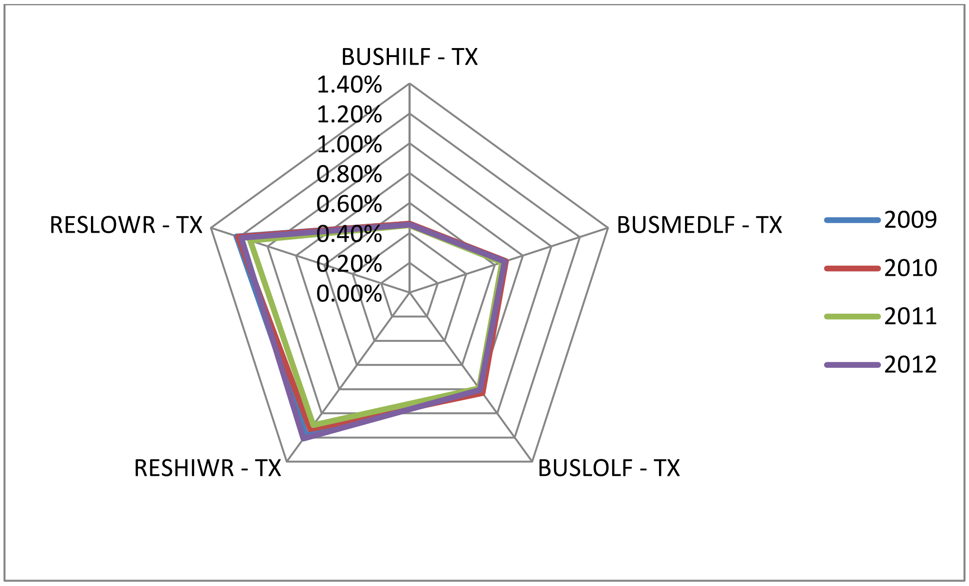
PJM – There is an *inconsistent* correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low* to *moderate* – ranging from 0.06 for RESHIWR customer type to 0.61 for RESLOWR customer type.

Customer Benefit 2 – Annual Percentage Cost Savings (Fixed Cost Pricing)

Annual percentage cost savings for customers buying electricity at a fixed price are displayed in

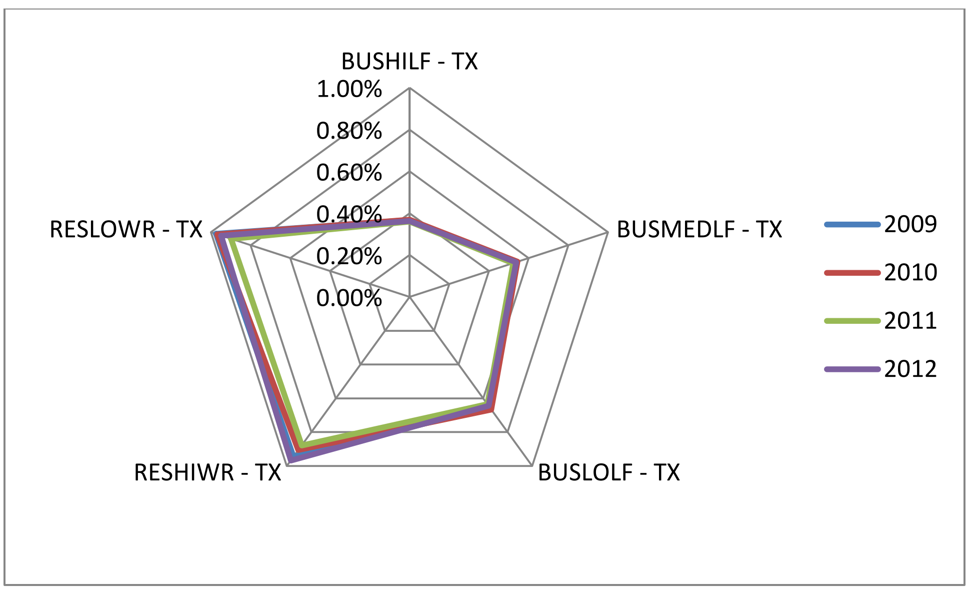
Figure 28 below. Inter-annual results show greater consistency than the annual percentage costs savings (real-time pricing).

Figure 28. Scenario L1 – Annual Percentage Cost Savings (Fixed Pricing) – 12.5% PDR, 10% Lighting as Max Load



The annual percentage cost sensitivity analysis follows the same shape as the baseline energy efficiency implementation scenario, indicating a linear relationship between changes in permanent demand reduction and annual percentage costs savings (fixed-cost pricing).

Figure 29.Scenario L1 - Annual Percentage Cost Savings (Fixed Pricing) – Sensitivity Analysis



Note that annual percentage cost savings (real-time pricing) are consistently 10-30% larger than annual percentage cost savings (fixed pricing) for ERCOT (see Table 42).

Difference between annual percentage cost savings (real-time pricing) versus annual percentage savings (fixed-price)

Table 42. Difference between annual percentage cost savings (real-time pricing) versus annual percentage savings (fixed-price) - ERCOT

	2009	2010	2011	2012
BUSHILF - TX	20.90%	16.42%	35.06%	21.55%
BUSMEDLF - TX	16.26%	12.72%	28.74%	18.80%
BUSLOLF - TX	13.86%	9.86%	24.35%	16.07%
RESHIWR - TX	13.21%	9.45%	26.98%	21.88%
RESLOWR - TX	10.78%	8.80%	27.82%	21.98%

However, the annual percentage cost savings (real-time pricing) are not consistently higher than annual percentage cost savings (fixed pricing) for PJM (see Table 43).

Table 43. Difference between annual percentage cost savings (real-time pricing) versus annual percentage savings (fixed-price) - PJM

	2009	2010	2011	2012
BUSHILF – PJM	1.12%	0.41%	-1.05%	0.96%
BUSMEDLF – PJM	1.74%	-0.19%	-0.87%	0.95%
BUSLOLF – PJM	2.31%	-0.75%	-0.62%	1.11%
RESHIWR – PJM	1.51%	0.23%	-0.97%	-0.23%
RESLOWR – PJM	4.97%	-2.28%	-0.41%	1.19%

Correlation Analysis

The fixed price used to calculate annual percentage cost savings (fixed pricing) was the same for both ERCOT and PJM. Therefore the results of this correlation analysis can be applied to both the ERCOT and PJM examples.

Independent Variable 1: Customer Load Factor

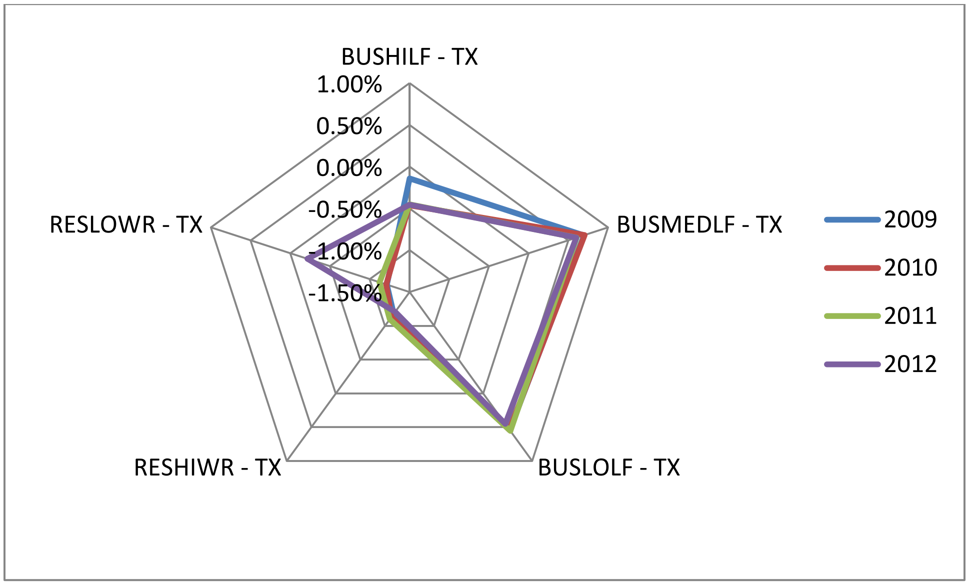
There is a *negative* correlation (R-value) between *customer load factor* and *annual percentage savings (fixed price).* The coefficient of determination (r-squared) is *high* – values are 0.99 for 2009-2012.

We do not evaluate the correlation between average real-time price and annual percentage fixed cost savings because real-time prices are not charge to customers taking electricity service on a fixed price contract.

Customer Benefit 3 – Percent Change in Load Factor

Interestingly, customer load factor actually decreases for the two residential customers (see Figure 30 below), despite the fact that these two customers experienced the greatest costs savings. What this suggests is that lighting efficiency implementation may save residential customers in the near term, but will not improve their future supply contract bargaining position by increasing their load factor.

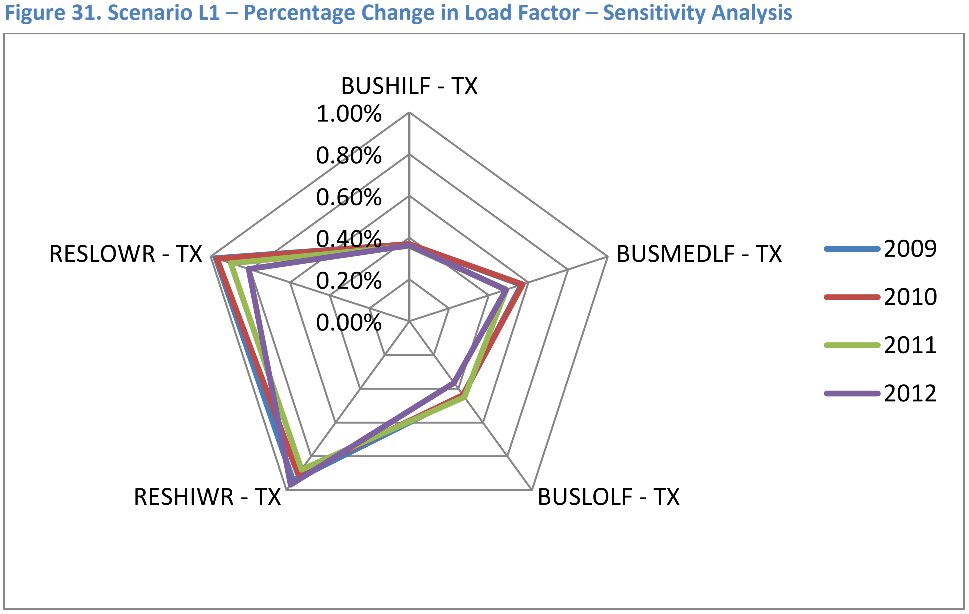
Figure 30. Scenario L1 – Percentage Change in Load Factor - 12.5% PDR, 10% Lighting as Max Load



The changing load factor sensitivity analysis reveals that the two residential customers' change in load factor is the most sensitive of the 5 customer groups to changes in PDR. The percentage change in load factor becomes more negative, the greater the PDR applied to the lighting retrofit.

The 2012 change in load factor results for the RESLOWR-TX sample is an outlier in the results

Figure 31. Scenario L1 – Percentage Change in Load Factor – Sensitivity Analysis



Notice that the shape of this Radar Chart is not the same as the shape of the 12.5% PDR, 10% Max Lighting Load in Figure 31 above. The difference in shape is the product of the non-linearity of the changes in load factor in the BUSHILF and RESLOWR meter data examples. These two meter data samples have the highest (BUSHILF) and lowest (RESLOWR) load factors of the 5 meter data samples modeled.

__Correlation Analysis__

Independent Variable 1: Customer Load Factor

The customer load consumption profiles used were the same for both ERCOT and PJM. Therefore the results of this correlation analysis can be applied to both the ERCOT and PJM examples.

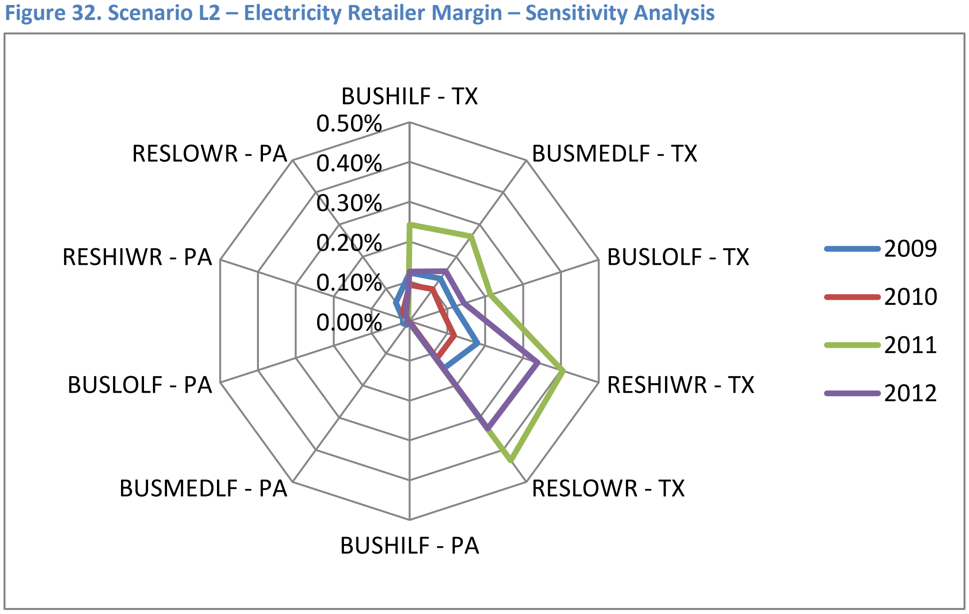
There is a *positive* correlation (R-value) between *customer load factor* and *percentage change in load factor.* The coefficient of determination (r-squared) is *low* to *moderate* – ranging from 0.22 in 2012 to 0.61 in 2009.

We do not evaluate the correlation between percentage change in load factor and annual percentage fixed cost savings because real-time prices in and of themselves are independent of load factor.

8.6.1.3 Scenario L2 – Electricity Retailer Benefits

The relative impact of changing the composition of load made up of lighting on the ***Electricity Retailers' benefits*** is summarized below:

Figure 32. Scenario L2 – Electricity Retailer Margin – Sensitivity Analysis



This sensitivity analysis models a + or -5% change in Pre-Retrofit Size of Lighting as a % of Total Peak Load from the baseline energy efficiency implementation scenario. Compared to a + or -5% change in

PDR, changing the Pre-Retrofit Size of Lighting as a % of Total Peak is slightly more impacting in the ERCOT examples (Maximum 0.09% greater in RESLOWR in 2011, minimum of 0.01% greater in BUSLOLF in 2009). Compared to a + or -5% change in PDR, changing the Pre-Retrofit Size of Lighting as a % of Total Peak is almost exactly the same as the PJM examples, with values ranging from 0.01% larger to 0.00%. (See Table 44 below).

Table 44. Percentage Difference in Sensitivity between Scenario L1 and L2 (Electricity Retailers Margin)

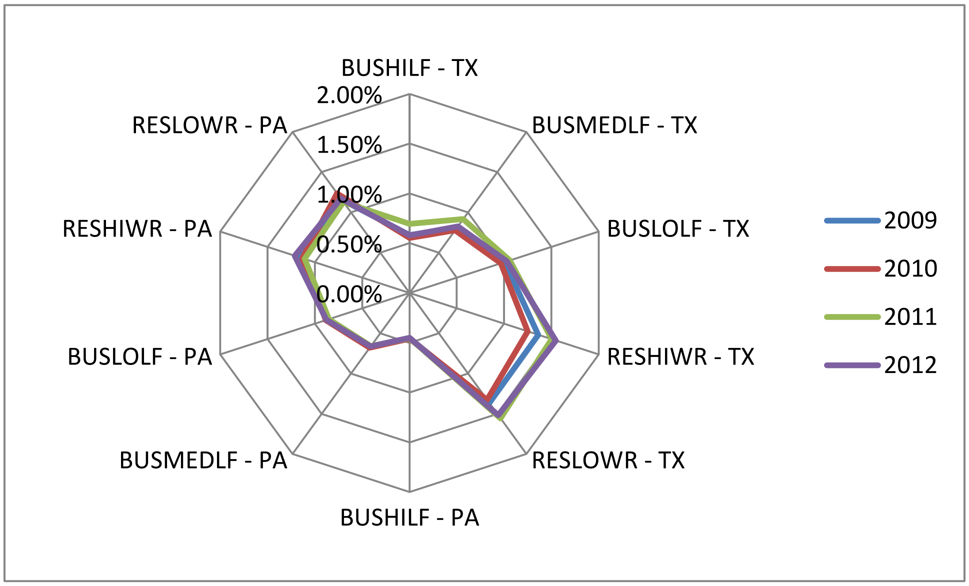
	2009	2010	2011	2012
BUSHILF - TX	-0.10%	-0.07%	-0.19%	-0.10%
BUSMEDLF - TX	-0.11%	-0.08%	-0.21%	-0.12%
BUSLOLF - TX	-0.10%	-0.07%	-0.20%	-0.12%
RESHIWR - TX	-0.14%	-0.09%	-0.32%	-0.27%
RESLOWR - TX	-0.12%	-0.09%	-0.35%	-0.27%
BUSHILF - PA	0.00%	0.00%	0.00%	0.00%
BUSMEDLF - PA	-0.01%	0.00%	0.00%	-0.01%
BUSLOLF - PA	-0.01%	-0.01%	0.00%	-0.01%
RESHIWR - PA	-0.01%	0.00%	-0.01%	0.00%
RESLOWR - PA	-0.05%	-0.02%	0.00%	-0.01%

Note that we do not perform a correlation analysis for Scenario L2 because the baseline efficiency scenario is the same, i.e. the correlation would produce the same results.

8.6.1.4 Scenario L2 – Customer Benefits

The relative impact of changing the composition of load made up of lighting on the ***customer's benefits*** is summarized below:

Figure 33. Scenario L2. Annual Percentage Cost Savings (Real Time Pricing) – Sensitivity Analysis

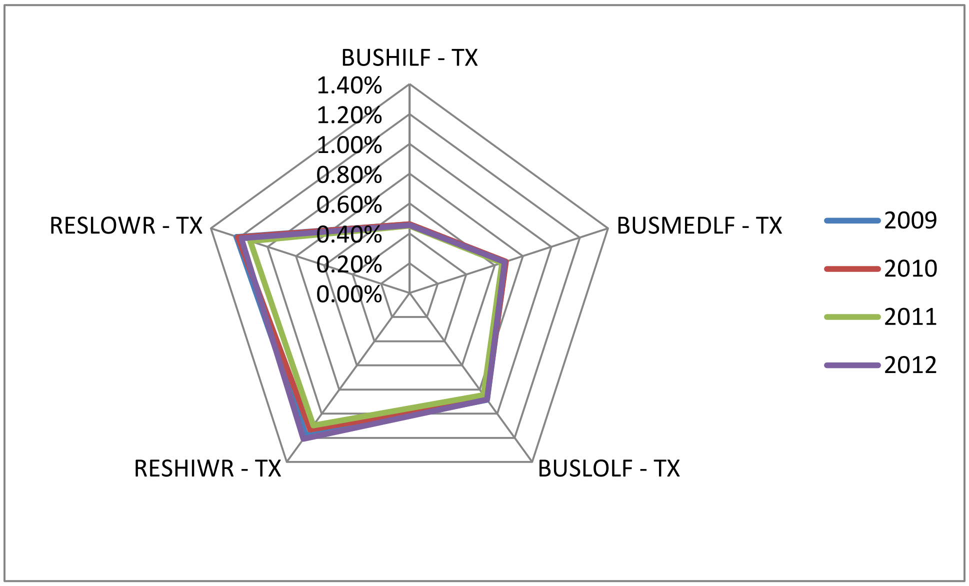


Changing the magnitude of lighting composition has a greater impact (~20%) on annual percentage costs savings (real time pricing) than does changing PDR. The difference in sensitivity is represented in Table 45 below which shows the percentage difference between L1 and L2.

Table 45. Percentage Difference in Sensitivity between Scenario L1 and L2 – Annual Percentage RT Cost Savings

	2009	2010	2011	2012
BUSHILF - TX	20%	20%	20%	20%
BUSMEDLF - TX	20%	20%	20%	20%
BUSLOLF - TX	25%	23%	21%	25%
RESHIWR - TX	20%	20%	20%	20%
RESLOWR - TX	20%	20%	20%	20%
BUSHILF - PA	20%	20%	20%	20%
BUSMEDLF - PA	20%	20%	20%	20%
BUSLOLF - PA	27%	24%	25%	27%
RESHIWR - PA	20%	20%	20%	20%
RESLOWR - PA	20%	20%	20%	20%

Figure 34. Scenario L2. Annual Percentage Cost Savings (Fixed Pricing) – Sensitivity Analysis

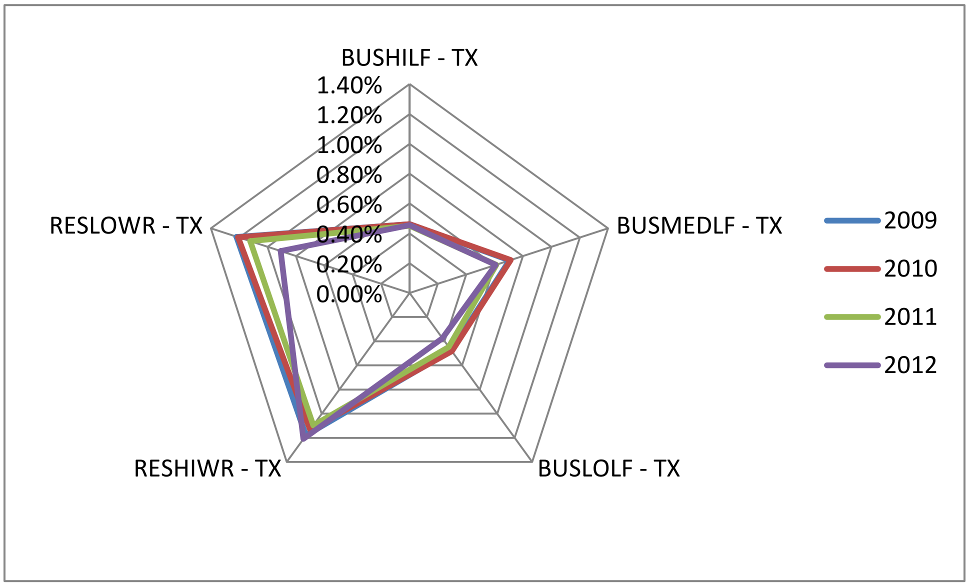


Similarly, changing the size of lighting load has a greater impact (~20%) on annual percentage costs savings (fixed price) than does changing PDR. The difference in sensitivity is represented in Table 46 below which shows the percentage difference between Scenario A and Scenario B.

Table 46. Percentage Difference in Sensitivity between Scenario L1 and L2 – Annual Percentage Fixed Cost Savings

	2009	2010	2011	2012
BUSHILF	20%	20%	20%	20%
BUSMEDLF	20%	20%	20%	20%
BUSLOLF	26%	24%	25%	27%
RESHIWR	20%	20%	20%	20%
RESLOWR	20%	20%	20%	20%

Figure 35. Scenario L2. Percentage Change in Load Factor – Sensitivity Analysis



Changing the size of lighting load has a greater impact (~20%) on percentage change in load factor than does changing PDR. The difference in sensitivity is represented in Table 47 below which shows the percentage difference between Scenario L1 and L2.

Table 47. Percentage Difference in Sensitivity between Scenario L1 and L2 – Change in Load Factor

	2009	2010	2011	2012
BUSHILF	20%	20%	20%	20%
BUSMEDLF	20%	20%	20%	20%
BUSLOLF	8%	10%	0%	3%
RESHIWR	20%	20%	20%	20%
RESLOWR	20%	20%	20%	11%

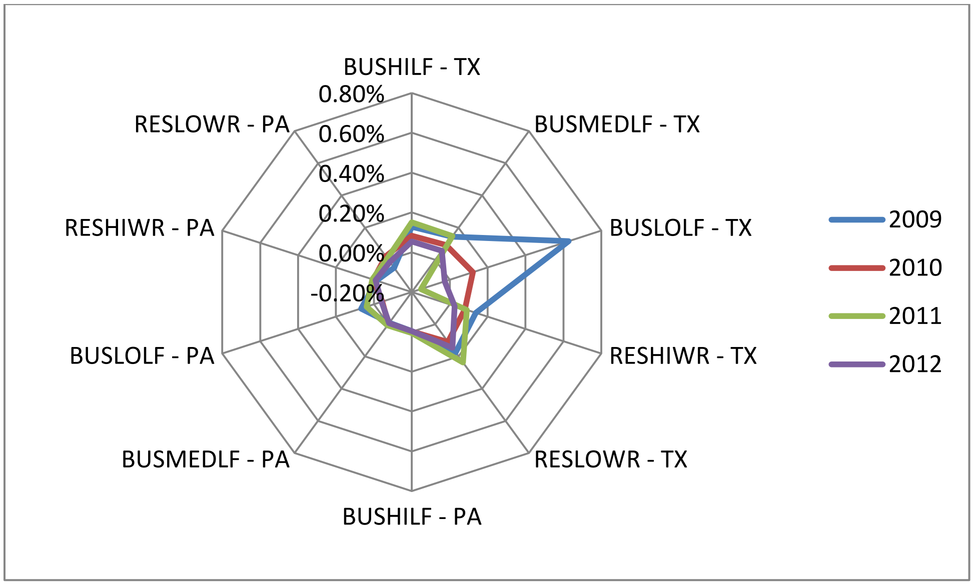
Note that we do not perform a correlation analysis for Scenario L2 because the baseline efficiency scenario is the same, i.e. the correlation would produce the same results.

8.6.1.5 Scenario L3 – Electricity Retailer Benefits

The relative impact of changing the composition of load made up of lighting on the ***Electricity Retailer's benefits*** is summarized below:

Radar Plots of the three scenarios are all shown to demonstrate the variability of results based on changes in operational period. There is non-linear relationship between operational period and electricity retailer margin, evidenced by the different shapes of the electricity retailer margin graphs below.[50]

Figure 36. Scenario L3 – Change in Occupancy Period - 12.5% PDR, 10% Lighting as Max Load, 17.6% Occupancy



[50] Notice that the shape of the Radar Plot for the "baseline scenario" is different than the Radar Plot "baseline scenario" shown in Scenario L1. The Radar Plot in the "baseline scenario" in Scenario L3 is different because it calculates Electricity Retailer Margin based on an occupancy period of all weekdays of the year, hour starting 9 and hour ending 18; Scenario L3 calculated Electricity Retailer Margin based on an operational period of all weekdays of the year, hour starting 9 and hour ending 17. The decision to change the occupancy period slightly for Scenario L3 was made to comply with the decision to use a + or -5% sensitivity analysis. Changing the hours to calculate a + or -5% sensitivity analysis was possible with an H.B. 9-18, but not with an H.B. 9-17.

Figure 37. Scenario L3 – Change in Occupancy Period - 12.5% PDR, 10% Lighting as Max Load, 22.6% Occupancy

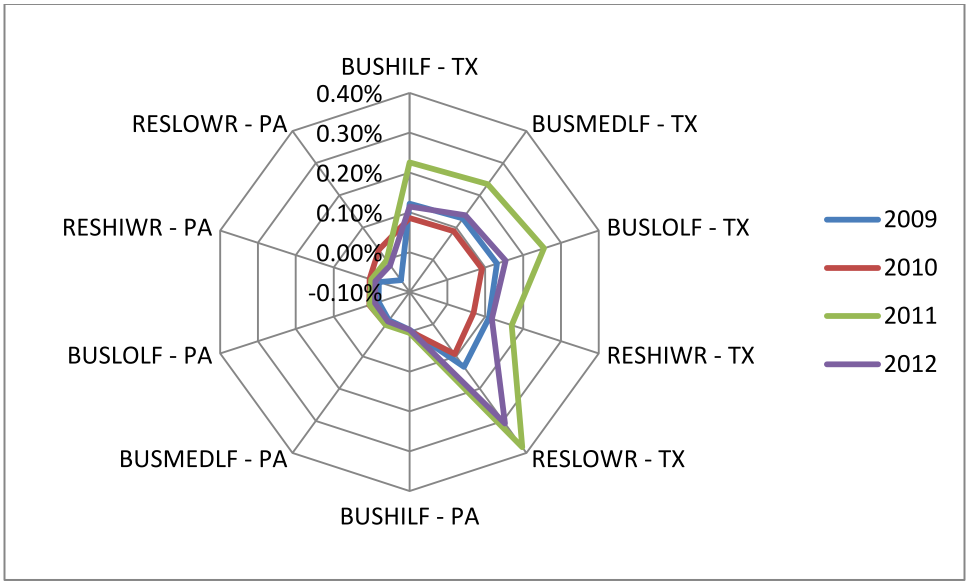
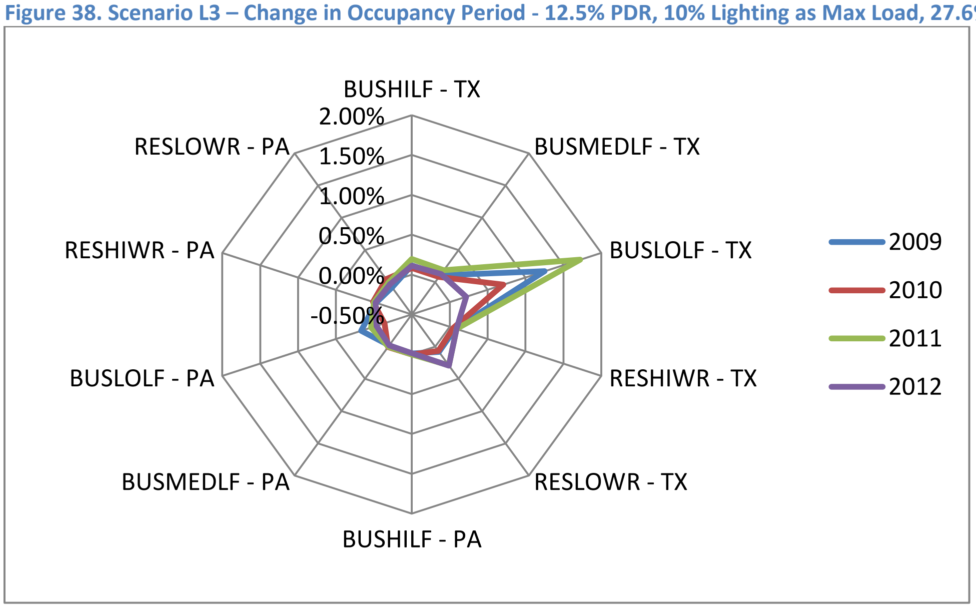
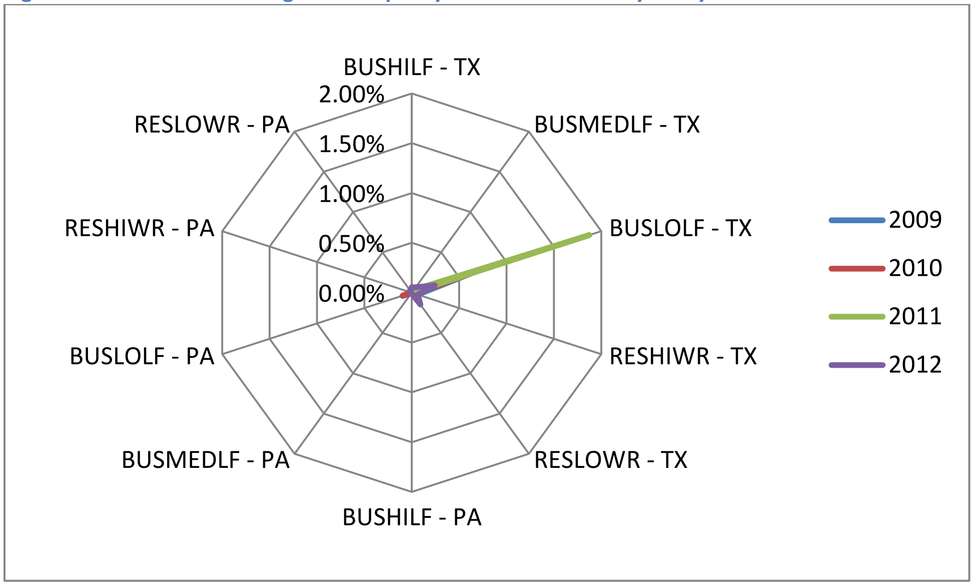


Figure 38. Scenario L3 – Change in Occupancy Period - 12.5% PDR, 10% Lighting as Max Load, 27.6% Occupancy



The relationship between operational period and Electricity retailer margin is non-linear, as evidenced by the irregularity in the shape of the 3 Radar plots above and the sensitivity analysis chart below. Interestingly, the sensitivity of changing the lighting schedule is highly sensitive for only the BUSLOLF – TX customer during the year 2011 (see Figure 39). This is a mystery.

Figure 39. Scenario L3. Change in Occupancy Period – Sensitivity Analysis



<u>Correlation Analysis</u>

Independent Variable 1: Customer Load Factor

ERCOT (17.6% occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* – ranging from 0.00 in 2009 to 0.11 in 2012.

PJM (17.6% occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* – ranging from 0.00 in 2011 to 0.17 in 2009.

ERCOT (27.6% occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* – ranging from 0.00 in 2011 to 0.29 in 2012.

PJM (27.6% occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* to *moderate* – ranging from 0.07 in 2011 to 0.60 in 2012.

Independent Variable 2: Average Real-Time Price

ERCOT (17.6% occupancy) – There is an *inconsistent* correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low to high*– ranging from 0.07 for the BUSLOLF customer type to 0.77 for the BUSHILF customer type.

PJM (17.6% occupancy) – There is an *inconsistent* correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* to *high* – ranging from 0.01 for the BUSHILF customer type to 0.88 for the RESLOWR customer type.

ERCOT (27.6% occupancy) – There is an *positive* correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* – ranging from 0.02 for the RESHIWR customer type and 0.76 for the BUSLOLF customer type.

PJM (27.6% occupancy) – There is an *inconsistent* correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* to *high* – ranging from 0.30 for the BUSLOLF customer type to 0.95for the BUSHILF customer type.

<u>Context</u>*:* The sensitivity analysis Radar Plot needs to be put into proper context. Changes in *electricity retailer margin* due to changes in occupancy are not consistent, i.e. a 5% increase and a 5% decrease in occupancy period will not yield an equal change in electricity retailer margin, due to the fact that the composition of real-time prices (average real-time price, standard deviation, etc.) will change irregularly from pricing period to pricing period.

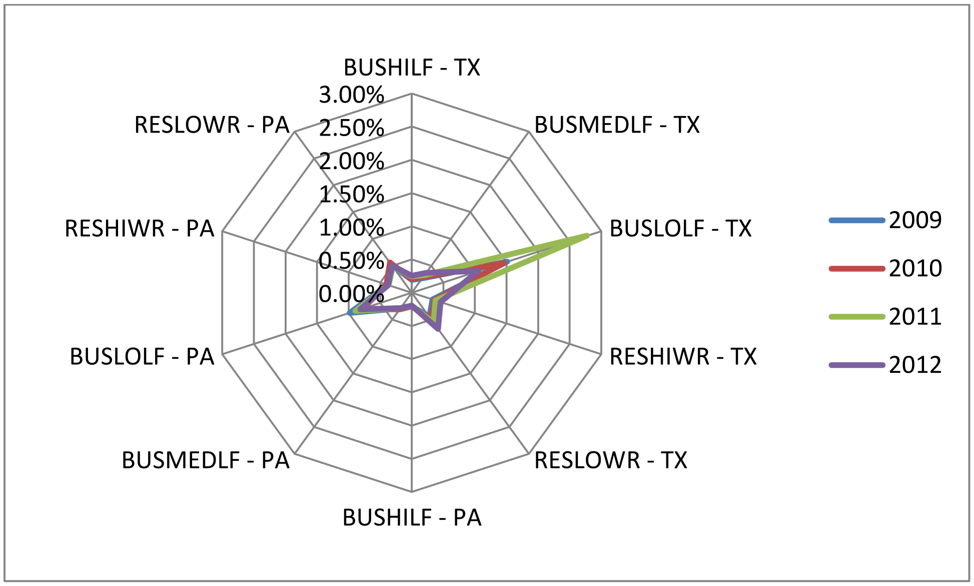
Making predictions as to changes in electricity retailer margin is very difficult when the operational period of the energy efficiency equipment is not known. The inconsistent results found in the correlation analysis reveal the difficulty of predicting electricity retailer margin even in cases in which the electricity supplier could predict the average real-time price and customer load factor.

8.6.1.6 Scenario L3 – Customer Benefits

The relative impact of changing the composition of load made up of lighting on the ***customer's benefits*** is summarized below:

Following the non-linear results of the electricity retailer benefits, the sensitivity of annual percentage cost savings (real-time pricing) to changes in lighting schedule demonstrated comparatively large variability between customer type (as compared to Scenario L1 and L2). Full results of the sensitivity analyses can be found in Figure 40 below.

Figure 40. Scenario L3. Annual Percentage Cost Savings (Real Time Pricing) – Sensitivity Analysis



Changes in lighting schedule (Scenario L3) produced substantially less variability in annual percentage costs saving or change in load factor than either changes in PDR (Scenario L1) or changes in size of lighting load (Scenario L2). See Figure 41 and Figure 42 for full details.

Figure 41. Scenario L3. Annual Percentage Cost Savings (Fixed Pricing) – Sensitivity Analysis

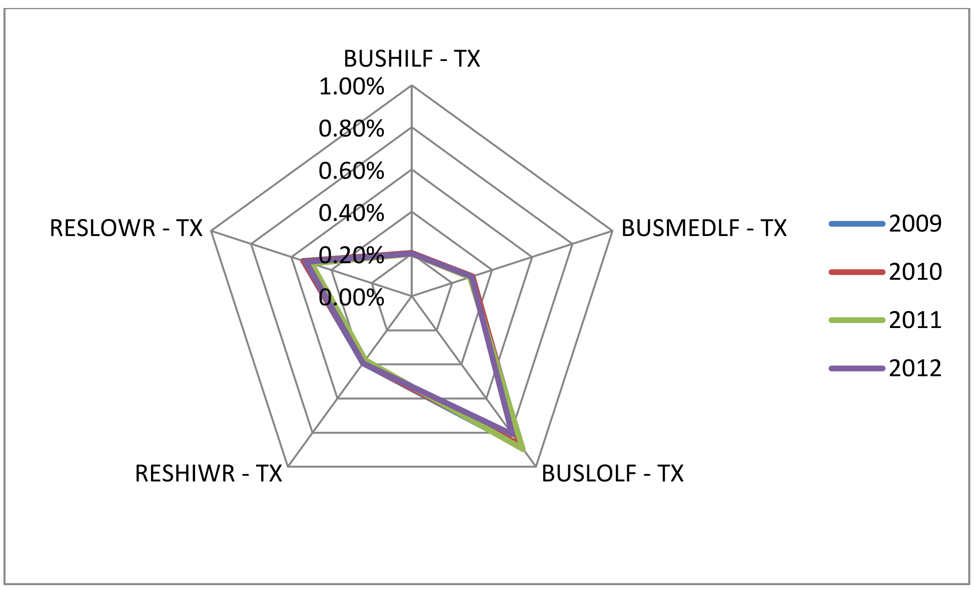
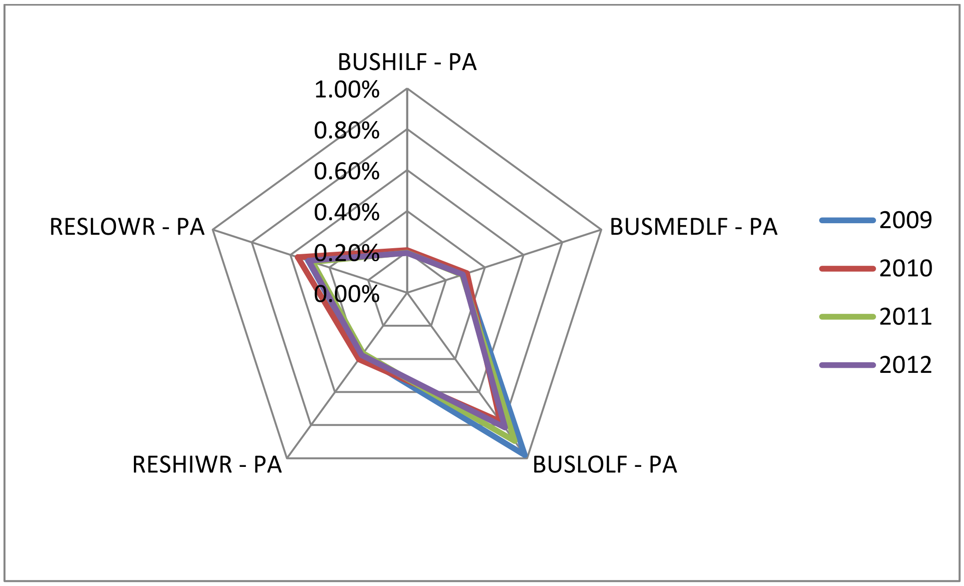


Figure 42. Scenario L3. Percentage Change in Load Factor – Sensitivity Analysis



These changes are not linear due to the average cost differences between different occupancy periods.

Correlation Analysis

Independent Variable 1: Customer Load Factor

Impact on Percentage Change in Load Factor

(17.6% occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *percentage change in load factor.* The coefficient of determination (r-squared) is *low*– ranging from 0.02 in 2010 to 0.03 in 2011.

(27.6% occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *percentage change in load factor.* The coefficient of determination (r-squared) is *low*– ranging from 0.00 in 2012 to 0.07 in 2011.

Context: The percentage change in load factor due to energy efficiency implementation (lighting) has no discernible relationship with a customer's existing load factor during the operational period.

Impact on Annual Percentage Cost Savings (Real-Time Pricing)

ERCOT (17.6% occupancy) – There is an *negative* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *moderate* – ranging from 0.59 in 2009 to 0.71 in 2010.

PJM (17.6% occupancy) – There is an *negative* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *high* – ranging from 0.70 in 2010 to 0.91 in 2009.

ERCOT (27.6% occupancy) – There is a *negative* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low to high* – ranging from 0.03 in 2011 to 0.74 in 2012.

PJM (27.6% occupancy) – There is a *negative* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *moderate to high* – ranging from 0.43 in 2011 to 0.82 in 2012.

Context: The annual percentage cost savings (real-time pricing) due to energy efficiency implementation (lighting) has a consistently negative correlation with customer load factor; however, the magnitude of this correlation differs dramatically.

Independent Variable 2: Average Real-Time Cost

ERCOT (17.6% occupancy) – There is an *inconsistent* correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low to high* – ranging from 0.02 for the RESHIWR customer type to 0.73 of the BUSHILF customer type.

PJM (17.6% occupancy) – There is an *inconsistent* correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low* to *moderate*– ranging from 0.06 for the BUSHILF customer type to 0.48 for the RESLOWR customer type.

ERCOT (27.6% occupancy) – There is an *inconsistent* correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low* to *high* – ranging from 0.03 for the RESLOWR customer type to 0.76 for the RESHIWR customer type.

PJM (27.6% occupancy) – There is an *inconsistent* correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low* to *moderate*– ranging from 0.20 for the BUSHILF customer type to 0.66 for the BUSLOLF customer type.

Context: The *average real-time cost* has no discernible relationship with a customer's annual percentage costs savings (real-time pricing).

8.6.2 Energy Efficiency Modeling Scenarios – HVAC calculator

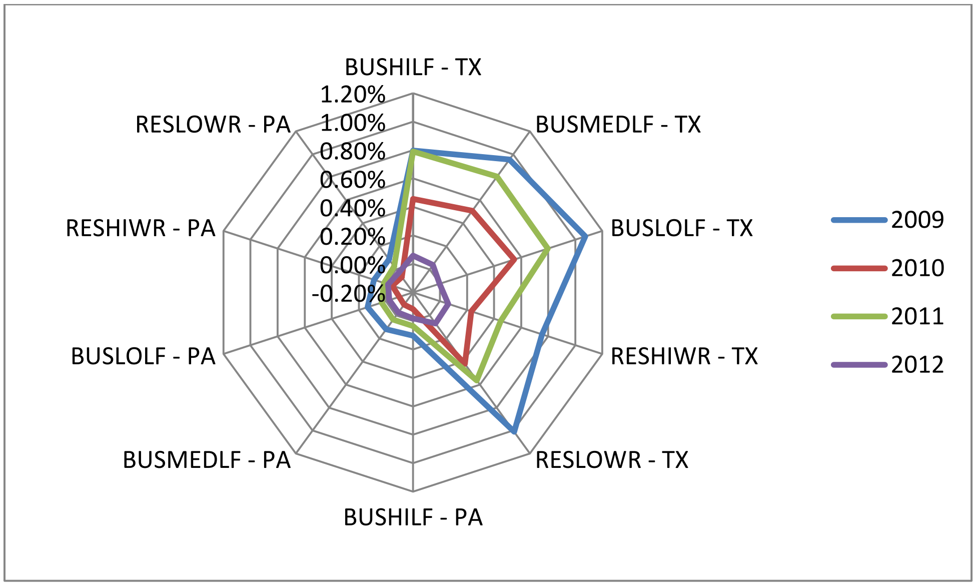
Following the methodology used to model the value of lighting energy efficiency, a baseline energy efficiency implementation scenario for HVAC was established to compare the sensitivity of Electricity retailer and customer benefits to changes in the same three independent variables tested in the lighting scenarios. The HVAC energy efficiency implementation scenario assumes a PDR of 20%, 50% HVAC demand as a percentage of peak demand, and an HVAC schedule from 12-5pm, Monday-Friday, May-September.

Importantly, the sensitivity analyses completed in Scenario H1, H2, and H3, vary the independent variable + or – 2.7% (whereas Scenarios L1, L2, and L3 varied independent variables + or -5%). The decision to vary the independent variables + or – 2.7% was made based on the desire to create realistic differences in HVAC schedule (see Scenario H3 below). Varying HVAC schedule + or – 5% from the baseline energy efficiency implementation scenario would have produced HVAC schedules so long and so short as to be unrealistic.

8.6.2.1 Scenario H1 – Electricity Retailer Benefits

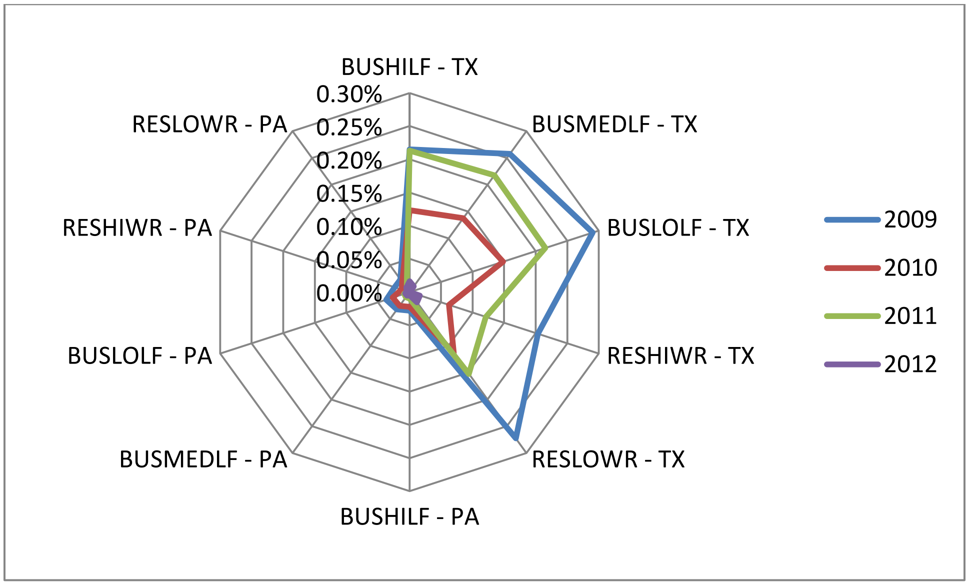
Electricity Retailer Benefit 1. Electricity Retailer Margin

Figure 43. Scenario H1 – Baseline Efficiency Implementation Scenario – Electricity Retailer Margin



Positive electricity retailer margin values for PJM are in years 2009 and 2011 and negative in 2010 and 2012. 2009 and 2011 have the highest average real-time price and 2010 and 2012 have the lowest average real-time prices during the efficiency implementation period. There is a highly robust (1.9% to 7.3% occupancy – see below) and positive correlation between average real-time price and electricity retailer margin. However, the electricity retailer margin is very low – highest is 0.17% for BUSLOLF in 2009.

Figure 44. Scenario H1 – 20% Permanent Demand Reduction – Electricity Retailer Margin – Sensitivity Analysis (2009-2012)



This sensitivity analysis Radar Chart follows the same shape as the baseline HVAC energy efficiency implementation scenario, indicating a linear relationship between changes in PDR and changes in electricity retailer margin. In this scenario, electricity retailer margin increases as the PDR increases, but the magnitude of this change (sensitivity analysis) differs significantly between years.

Correlation Analysis

Independent Variable 1: Customer Load Factor

ERCOT – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* to *high* – ranging from 0.00 in 209 to 0.67 in 2011.

PJM – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin*. The coefficient of determination (r-squared) is *low* to *moderate*– ranging from 0.20 for the BUSHILF customer type to 0.66 for the BUSLOLF customer type.

Context: The *customer load factor* has no discernible relationship with the *electricity retailer margin*.

Independent Variable 2: Average Real-Time Price

ERCOT – There is a *positive* correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low* to *high* – ranging from 0.35 for the RESLOWR customer type to 0.81 for the BUSHILF customer type.

PJM – There is a *positive* correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *high* – ranging from 0.90 for the RESLOWR customer type to 0.96 for the BUSLOLF customer type.
Context: There is a strong relationship between *average real-time price* and electricity retailer, particularly in the PJM market.

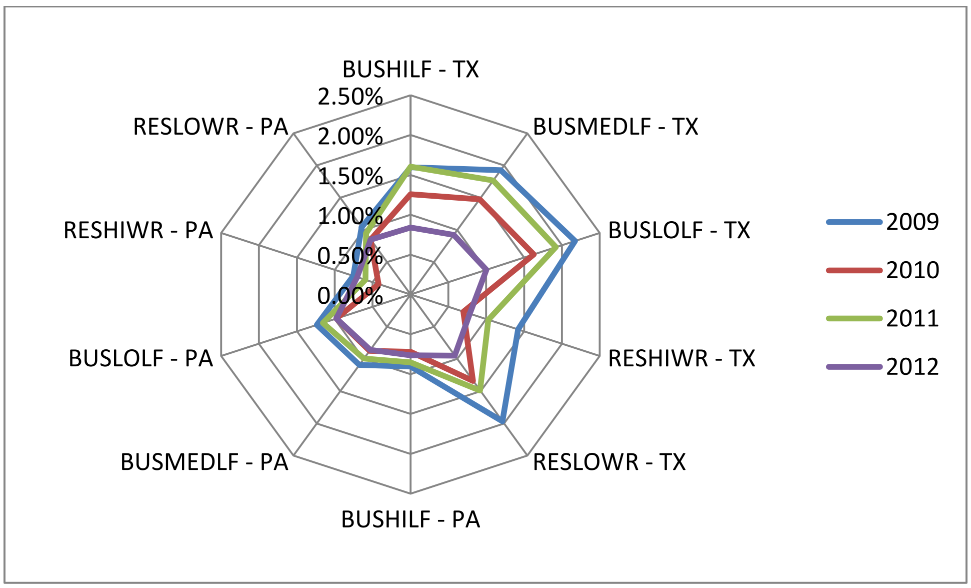
8.6.2.2 Scenario H1 – Customer Benefits

The relative impact of changing the composition of load made up of lighting on the ***customer's benefits*** is summarized below:

Mirroring the major observation in Scenario H1 – Electricity Retailer Margin, the magnitude of annual percentage costs savings (real time pricing) appears to be more dependent on annual differences that affect all customer types rather than differences between customer types. See for full details:

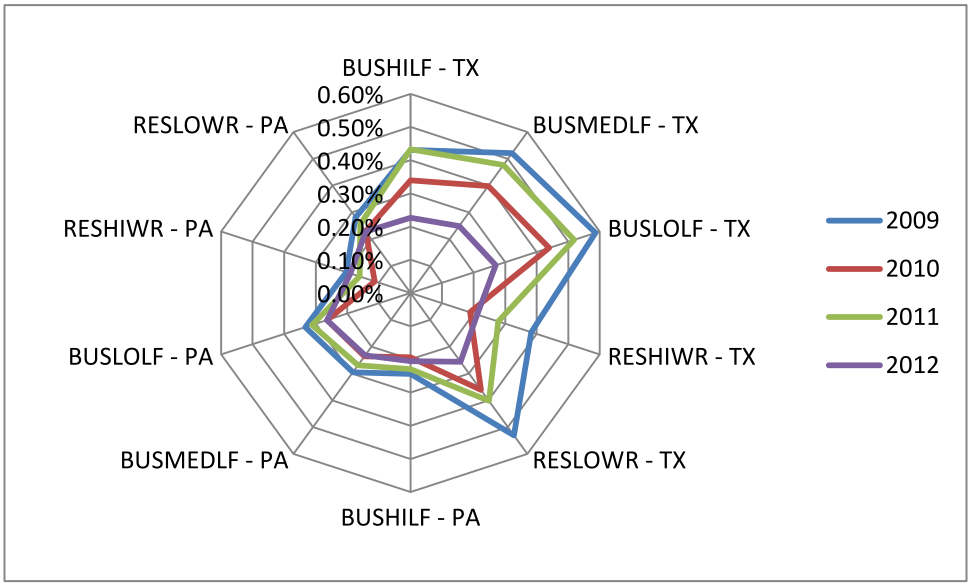
Figure 45 for full details:

Figure 45. Scenario H1 — Baseline Energy Efficiency Implementation Scenario - Annual Percentage Cost Savings (Real Time Pricing)



The sensitivity analysis follows the same pattern, suggesting a linear relationship between changes in PDR and annual percentage cost savings (real time pricing).

Figure 46. Scenario H1 — Annual Percentage Cost Savings (Real Time Pricing) – Sensitivity Analysis



Independent Variable 1: Customer Load Factor

ERCOT – There is a *positive* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low* to *moderate* – ranging from 0.01 in 2009 to 0.23 in 2010.

PJM – There is a *positive* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low* – ranging from 0.00 in 2012 to 0.06 in 2011.

Context: There is a no discernible relationship between *customer load factor* and *annual percentage cost savings (real-time pricing)* in either the ERCOT or PJM markets.

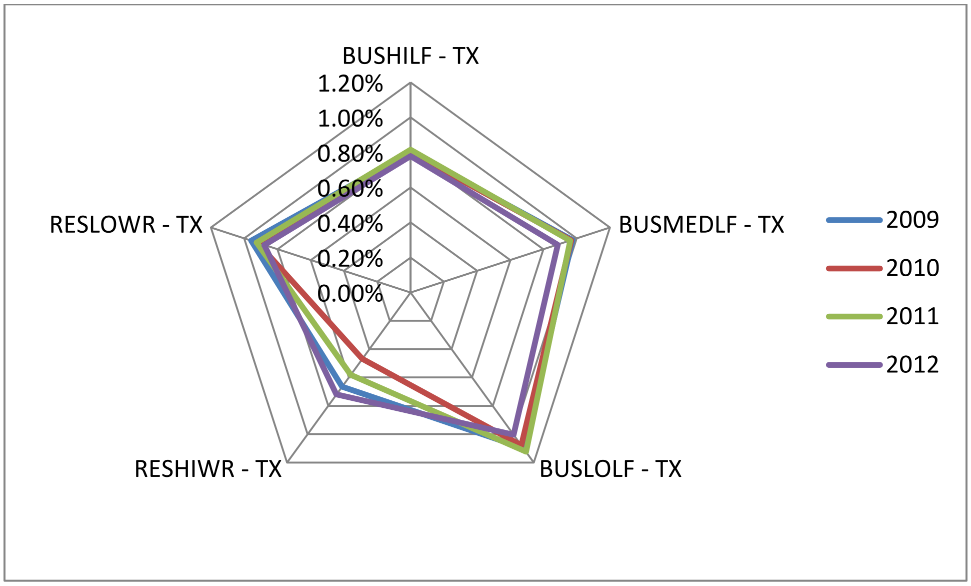
Independent Variable 2: Average Real-Time Price

ERCOT – There is a *positive* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low to high* – ranging from 0.04 for the RESHIWR customer type to 0.81 for the BUSHILF customer type.

PJM – There is a *positive* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *high* – ranging from 0.71 for the BUSLOLF customer type to 0.85 for the BUSHILF customer type.

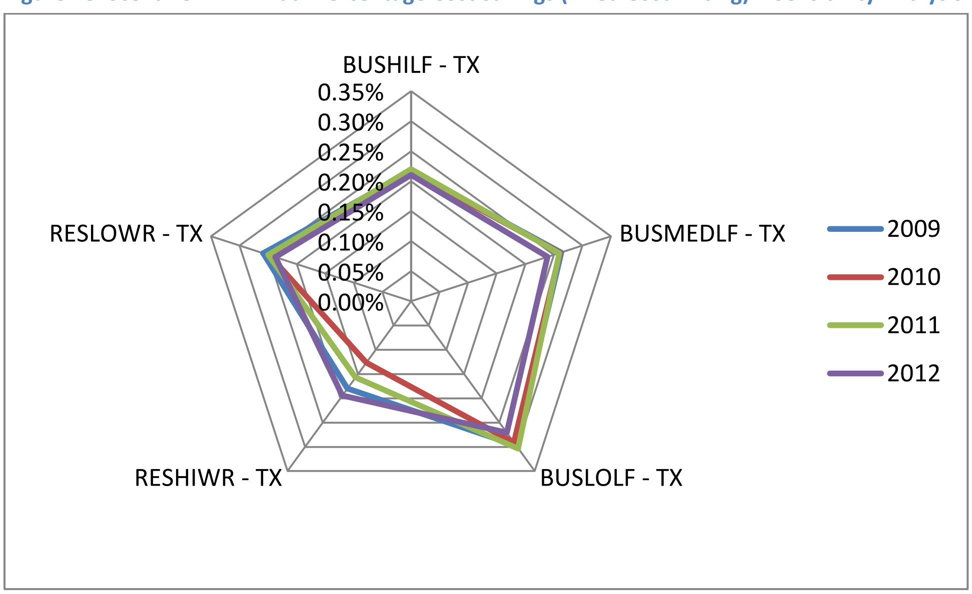
Context: There is a positively correlated relationship between *customer load factor* and *annual percentage cost savings (real-time pricing)* in both the ERCOT and PJM markets. The positive correlation is higher and more consistent in the PJM market.

Figure 47. Scenario H1 – Baseline Energy Efficiency Implementation Scenario – Annual Percentage Cost Savings (Fixed Cost Pricing)



Interestingly, there is little variability between years or customer types in terms of annual percentage cost savings (fixed cost pricing).

Figure 48. Scenario H1. Annual Percentage Cost Savings (Fixed Cost Pricing) – Sensitivity Analysis



Independent Variable 1: Customer Load Factor

PJM – There is an *inconsistent* correlation (R-value) between *customer load factor* and *annual percentage cost savings (fixed-cost pricing).* The coefficient of determination (r-squared) is *low* – ranging from 0.00 in 2012 to 0.06 in 2010.

Context: There is no discernible relationship between *customer load factor* and *annual percentage cost savings (fixed-cost pricing)*.

Implementing HVAC optimization energy efficiency yields substantial reduction in load factor for residential customers and substantial increases for BUSMEDLF and BUSLOLF. The level of changes to load factor observed in Figure 49 are substantially larger than changes in load factor due to lighting efficiency implementation (Scenario L1, L2, and L3).

Figure 49. Scenario H1. Baseline Energy Efficiency Implementation Scenario – Percentage Change in Load Factor

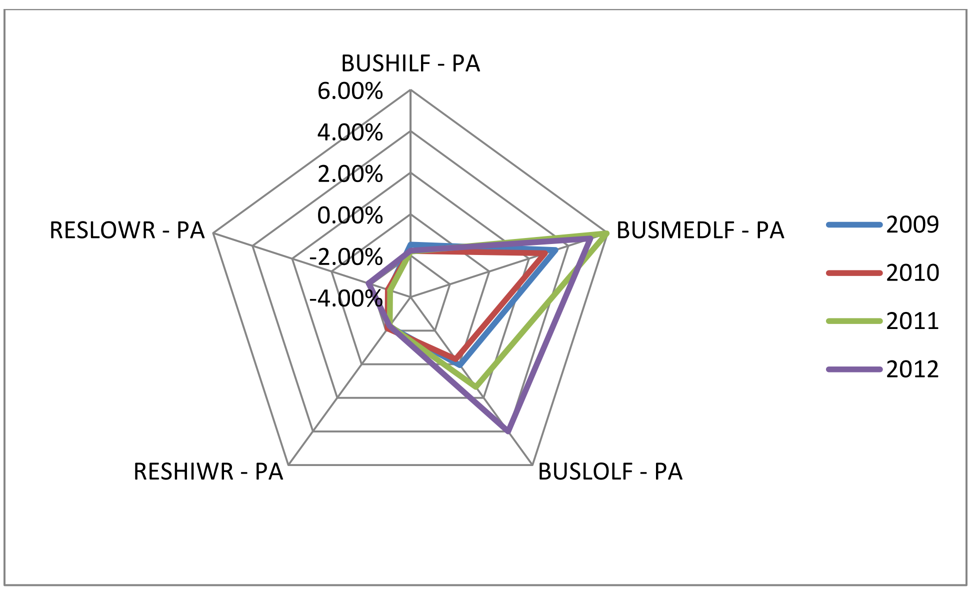
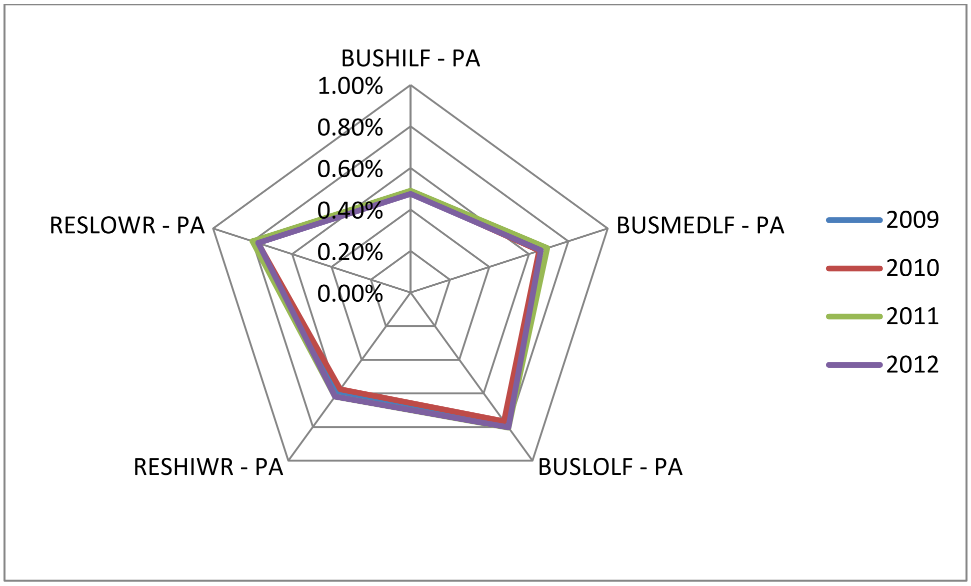


Figure 50. Scenario H1. Baseline Energy Efficiency Implementation Scenario – Percentage Change in Load Factor - Sensitivity Analysis



Independent Variable 1: Customer Load Factor

PJM – There is a *positive* correlation (R-value) between *customer load factor* and *percentage change in load factor.* The coefficient of determination (r-squared) is *low to moderate* – ranging from 0.07 in 2012 to 0.35 in 2009.

Context: The relationship between *customer load factor* and *percentage change in load factor* is not strong enough, i.e. the correlation is weak, to be able to accurately predict the impact of a customer's load factor on that customer's percentage change in load factor.

8.6.2.3 Scenario H2 – Electricity Retailer Benefits

Changes in the initial size of HVAC load produce substantially less of an effect on electricity retailers margin than do changes in permanent demand reduction (see

Table 48 below)

Figure 51. Scenario H2 – Electricity Retailer Margin – Sensitivity Analysis

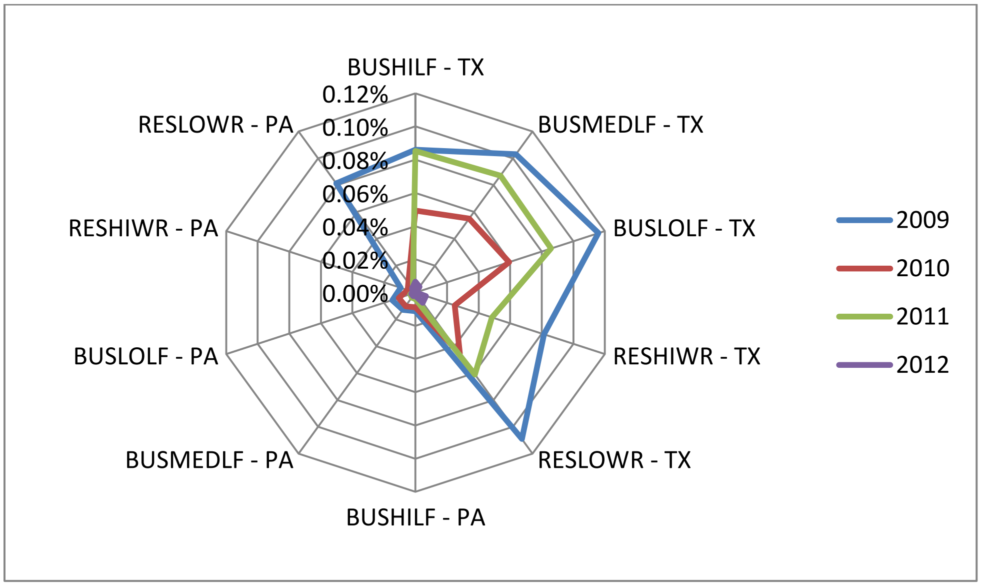


Table 48. Percentage Difference in Sensitivity between Scenario H2 and H1 – Electricity Retailer Margin

	2009	2010	2011	2012
BUSHILF - TX	-150%	-150%	-150%	-150%
BUSMEDLF - TX	-150%	-150%	-150%	-150%
BUSLOLF - TX	-150%	-150%	-150%	-150%
RESHIWR - TX	-150%	-150%	-150%	-150%
RESLOWR - TX	-150%	-150%	-150%	-150%
BUSHILF - PA	-150%	-150%	-150%	-150%
BUSMEDLF - PA	-150%	-150%	-150%	-150%
BUSLOLF - PA	-150%	-150%	-150%	-150%
RESHIWR - PA	-150%	-150%	-150%	-150%
RESLOWR - PA	71%	-150%	-150%	-150%

Scenario A (Changing % of PDR) has 150% more impact on electricity retailer margin than Scenario B (Changing % of Max HVAC)

8.6.2.4 Scenario H2 – Customer Benefits

<u>Correlation Analysis</u>

The relative impact of changing the composition of load made up of lighting on the ***customer's benefits*** is summarized below:

Figure 52. Scenario H2. Percentage Annual Cost Savings (RT Pricing) – Sensitivity Analysis

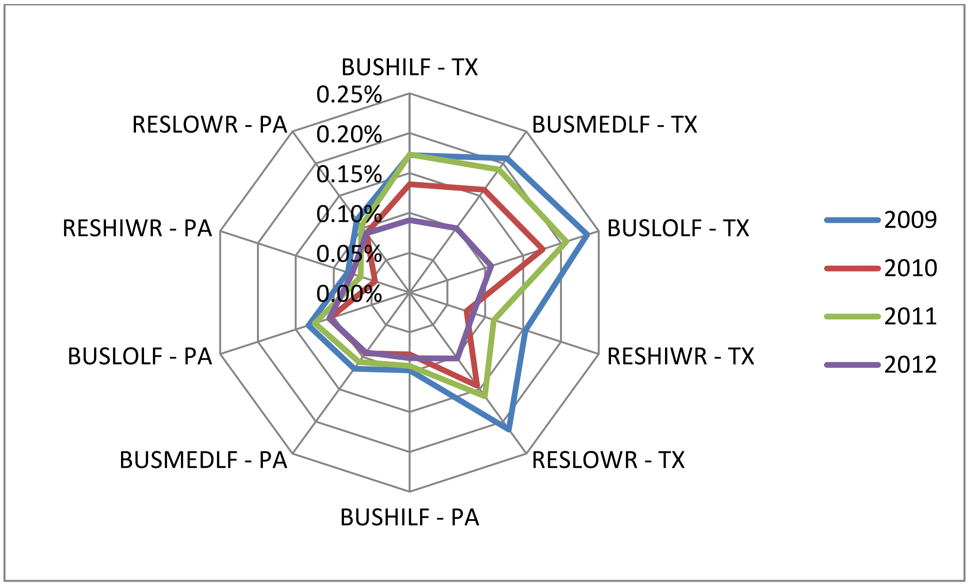


Table 49. Percentage Difference in Sensitivity Between Scenario H2 and H1 – Percentage Annual Cost Savings (RT Pricing)

	2009	2010	2011	2012
BUSHILF - TX	-150%	-218%	-149%	-375%
BUSMEDLF - TX	-107%	-170%	-126%	-332%
BUSLOLF - TX	-84%	-145%	-108%	-299%
RESHIWR - TX	-181%	-471%	-287%	-411%
RESLOWR - TX	-103%	-198%	-168%	-321%
BUSHILF - PA	-341%	-456%	-369%	-424%
BUSMEDLF - PA	-265%	-358%	-301%	-363%
BUSLOLF - PA	-223%	-307%	-246%	-308%
RESHIWR - PA	-430%	-848%	-570%	-467%
RESLOWR - PA	-282%	-369%	-320%	-370%

Scenario A (Changing % of PDR) has between 78% and 328% greater impact on annual percentage savings (fixed cost pricing) than Scenario B (Changing % of Max HVAC)

Figure 53. Scenario H2. – Percentage Annual Cost Savings – Sensitivity Analysis

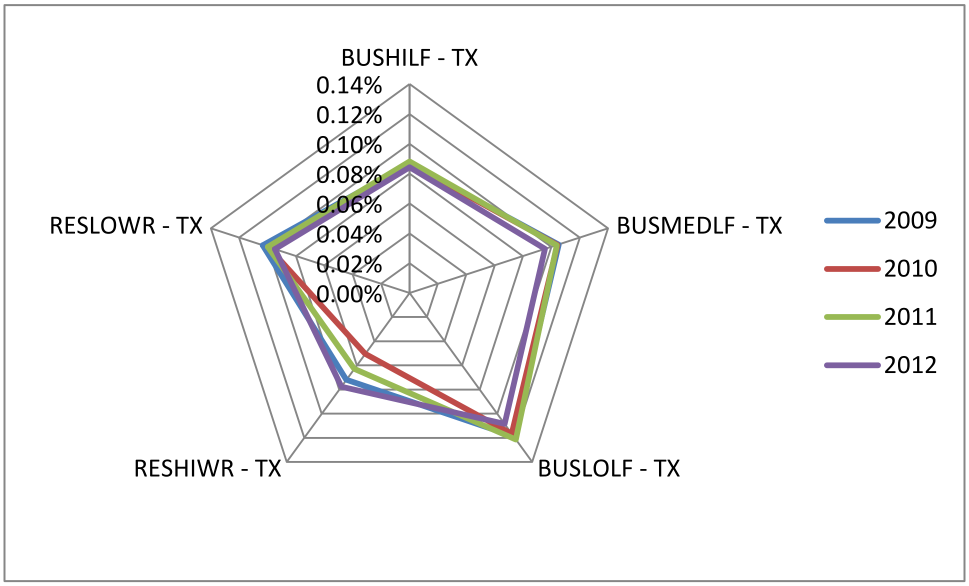


Table 50. Percentage Difference in Sensitivity Between Scenario H2 and H1 – Percentage Annual Cost Savings (Fixed Cost Pricing)

	2009	2010	2011	2012
BUSHILF	-150%	-150%	-145%	-157%
BUSMEDLF	-106%	-107%	-108%	-126%
BUSLOLF	-82%	-85%	-78%	-99%
RESHIWR	-201%	-328%	-244%	-178%
RESLOWR	-109%	-118%	-116%	-128%

Scenario A (Changing % of PDR) has between 84% and 471% greater impact on annual percentage savings (real time pricing) than Scenario B (Changing % of Max HVAC)

We did not present results for the impact of changing maximum load due to HVAC (independent variable) on the percentage change in load factor (dependent variable) because varying the independent variable had no impact on the dependent variable. This is a mystery

8.6.2.5 Scenario H3 – Electricity Retailer's Benefits

The relative impact of changing the HVAC schedule on the ***Electricity Retailer's benefits*** is summarized below:

Figure 54. Scenario H3 – Changing Occupancy Period – Electricity Retailer's Margin – 1.9% Occupancy

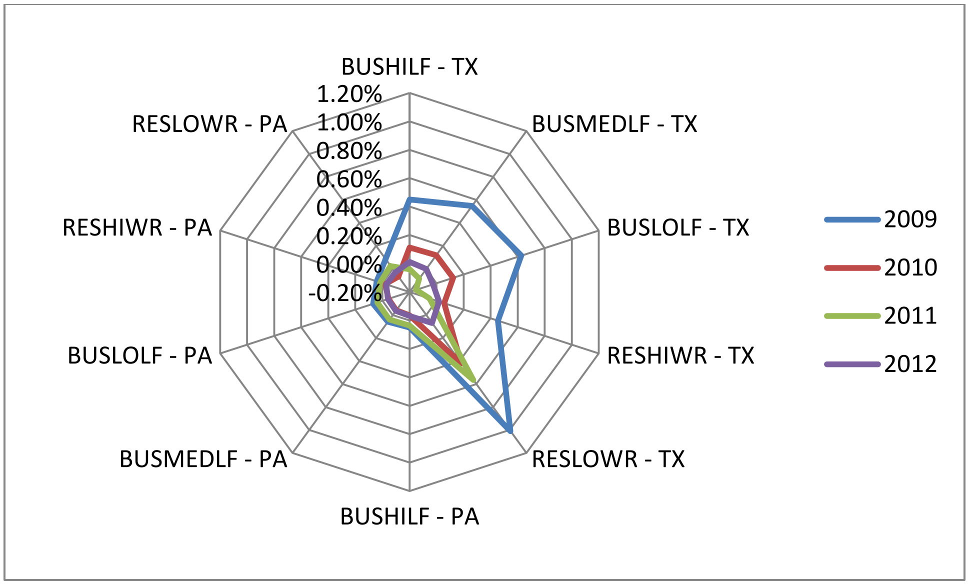


Figure 55. Scenario H3 – Changing Occupancy Period – Electricity Retailer Margin – 4.6% Occupancy

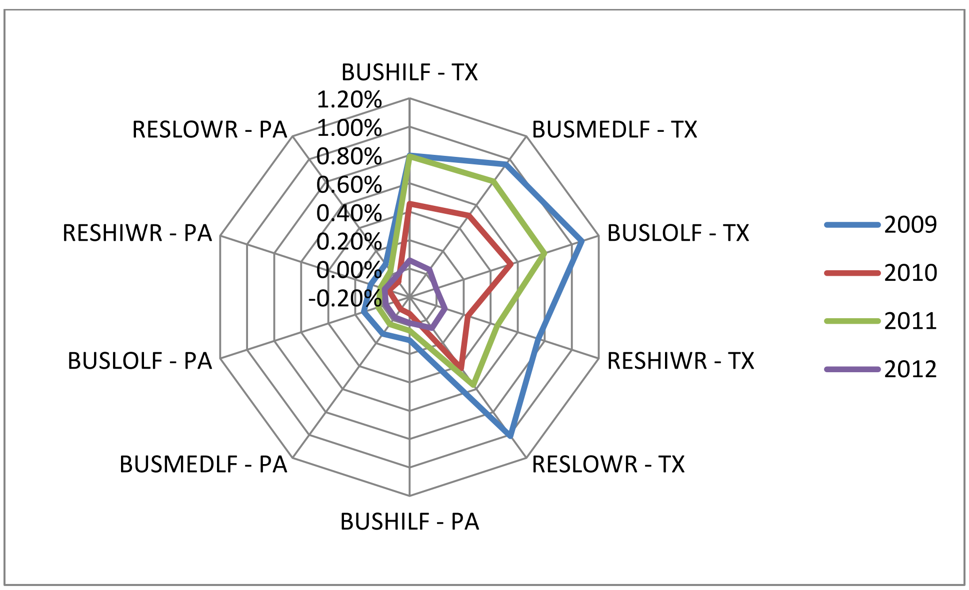


Figure 56. Scenario H3 – Changing Occupancy Period – Electricity Retailer Margin – 7.3% Occupancy

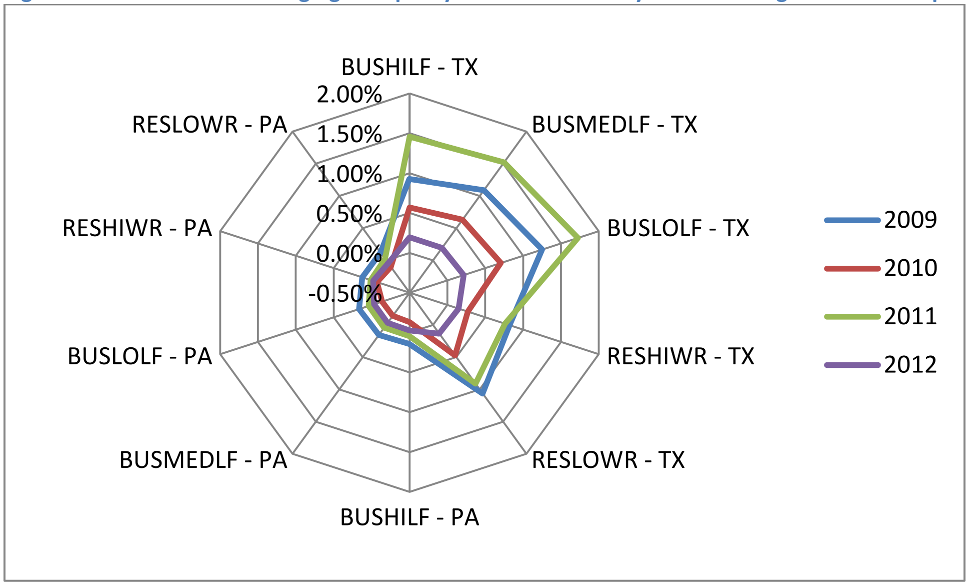
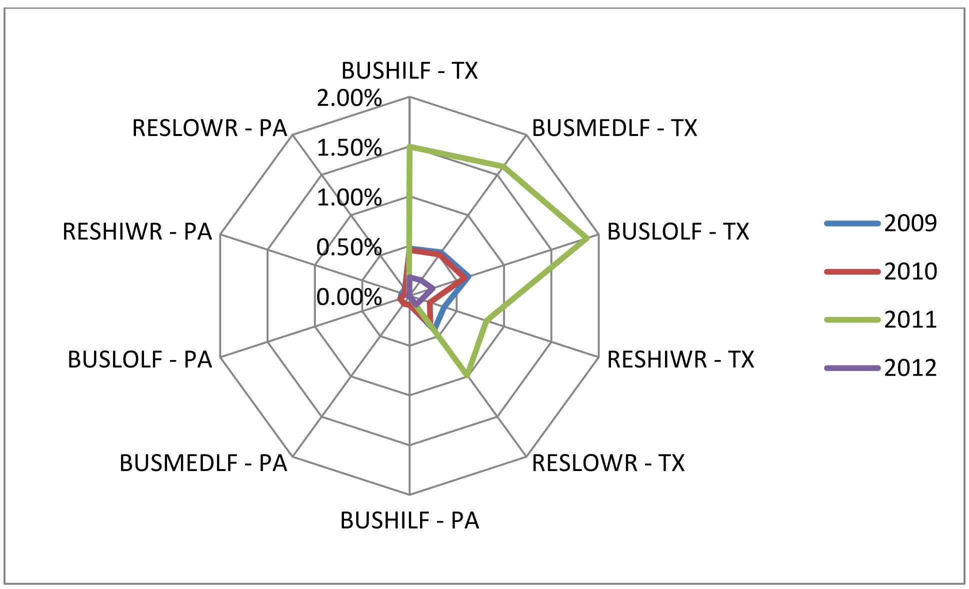


Figure 57. Scenario H3 – Sensitivity Analysis – Change in HVAC Schedule – Electricity Retailer Margin



The relationship between changes in HVAC schedule and electricity retailer margin is not linear because the average price per kWh is different for the three HVAC schedules chosen (H.B. 14-16, H.B. 12-17, H.B. 11-19). For results of each of the three HVAC schedules chosen see Appendix 5.

Changes in HVAC schedule consistently have a larger impact (40-70% greater) on electricity retailer margin than does changing PDR (see Table 51 below).

Table 51. Percentage Difference in Sensitivity Analyses Between Scenario H3 and H1 – Electricity Retailer Margin

	2009	2010	2011	2012
BUSHILF - TX	55%	73%	86%	91%
BUSMEDLF - TX	52%	73%	86%	94%
BUSLOLF - TX	54%	75%	89%	100%
RESHIWR - TX	44%	71%	85%	87%
RESLOWR - TX	36%	68%	85%	83%
BUSHILF - PA	69%	76%	-15%	-29%
BUSMEDLF - PA	66%	74%	-319%	-49%
BUSLOLF - PA	63%	72%	-2613%	2%
RESHIWR - PA	71%	75%	29%	52%
RESLOWR - PA	71%	75%	23%	-3585%

Correlation Analysis

Independent Variable 1: Customer Load Factor

ERCOT (1.9% Occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low to high* – ranging from 0.01 in 2009 to 0.80 in 2011.

ERCOT (7.3% Occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low to high* – ranging from 0.01 in 2009 to 0.80 in 2011.

PJM (1.9% Occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low to high* – ranging from 0.04 in 2010 to 0.72 in 2011.

PJM (7.3% Occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low to high* – ranging from 0.08 in 2012 to 0.90 in 2011.

Context: There is no discernible relationship between *customer load factor* and *electricity retailer margin*.

Independent Variable 2: Average Real-Time Price

ERCOT (1.9% Occupancy) – There is a positive correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low to high* – ranging from 0.61 for the BUSHILF customer type to 0.92 for the RESLOWR customer type.

ERCOT (7.3% Occupancy) – There is a positive correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *low to moderate* – ranging from 0.17 for the RESLOWR customer type to 0.61 for the BUSHILF customer type.

PJM (1.9% Occupancy) – There is a positive correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *high* – ranging from 0.76 for the RESHIWR customer type to 0.96 for the RESLOWR customer type.

PJM (7.3% Occupancy) – There is a positive correlation (R-value) between *average real-time price* and *electricity retailer margin.* The coefficient of determination (r-squared) is *high* – ranging from 0.94 for the RESLOWR customer type to 0.97 for the BUSLOLF customer type.

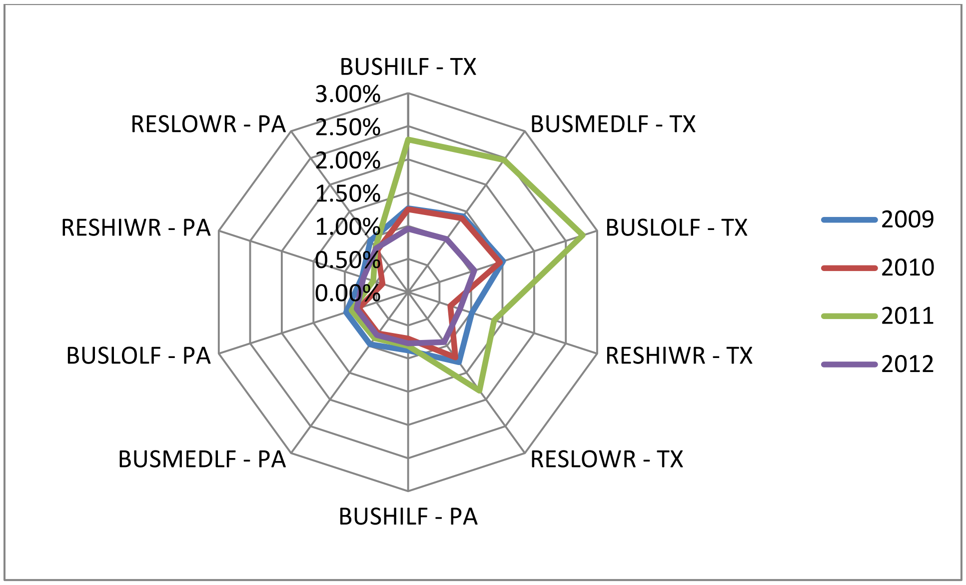
Context: There is a highly positive correlation between *average real-time price* and *electricity retailer margin* for the PJM examples. The correlation is still positive, but less consistent, and less strong for the ERCOT examples.

8.6.2.6 Scenario H3 – Customer Benefits

The relative impact of changing the composition of load made up of HVAC schedule on the ***customer's benefits*** is summarized below:

Changes in HVAC schedule have a comparatively big impact on annual percentage costs savings (real time pricing and fixed cost pricing) when compared to changes in PDR (see Table 52 and Table 53 below).

Figure 58. Scenario H3. Annual Percentage Cost Savings (RT Pricing) – Sensitivity Analysis



Changes in HVAC schedule have the biggest impact on annual percentage cost savings (real-time pricing) than any of the other independent variables (see Table 52 below).

Table 52. Percentage Difference in Sensitivity Analyses Between Scenario H3 and H1 – Percentage Annual Cost Savings (RT Pricing)

	2009	2010	2011	2012
BUSHILF - TX	66%	66%	81%	55%
BUSMEDLF - TX	69%	69%	83%	56%
BUSLOLF - TX	71%	70%	84%	59%
RESHIWR - TX	57%	36%	68%	48%
RESLOWR - TX	67%	65%	77%	54%
BUSHILF - PA	51%	38%	47%	44%
BUSMEDLF - PA	55%	44%	50%	46%
BUSLOLF - PA	56%	45%	52%	47%
RESHIWR - PA	41%	-7%	21%	39%
RESLOWR - PA	55%	45%	48%	47%

Figure 59. Scenario H3 – Annual Percentage Cost Saving (Fixed Cost Pricing) – Sensitivity Analysis

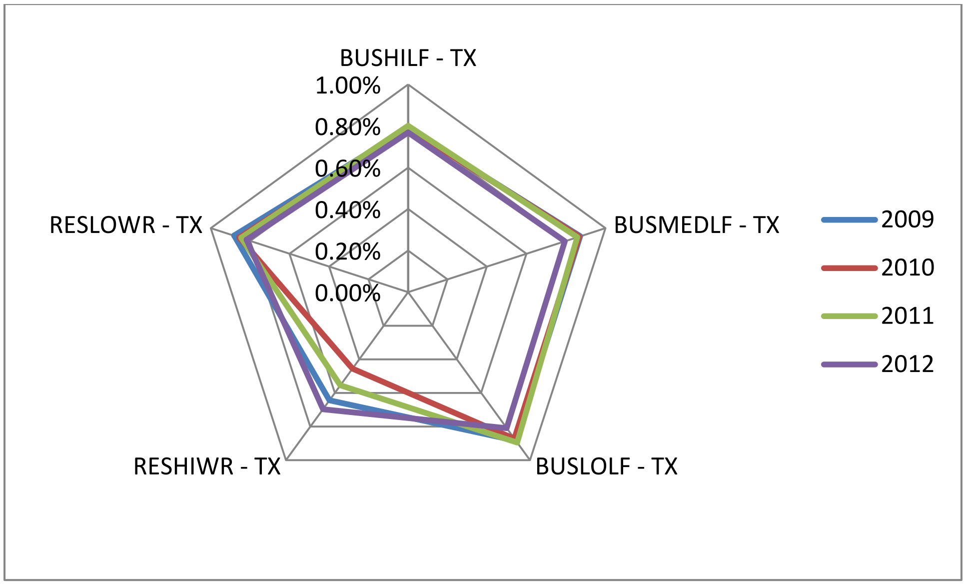


Table 53. Percentage Difference in Sensitivity Analyses Between Scenario H3 and H1 – Annual Percentage Cost Savings (Fixed Cost Pricing)

	2009	2010	2011	2012
BUSHILF	67%	73%	73%	72%
BUSMEDLF	91%	92%	95%	93%
BUSLOLF	79%	81%	82%	2%
RESHIWR	78%	77%	78%	72%
RESLOWR	76%	82%	83%	49%

Changes in HVAC schedule have the biggest impact on percentage change in load factor than any of the other independent variables (see Table 54 below).

Figure 60. Scenario H3 – Percentage Change in Load Factor – Sensitivity Analysis

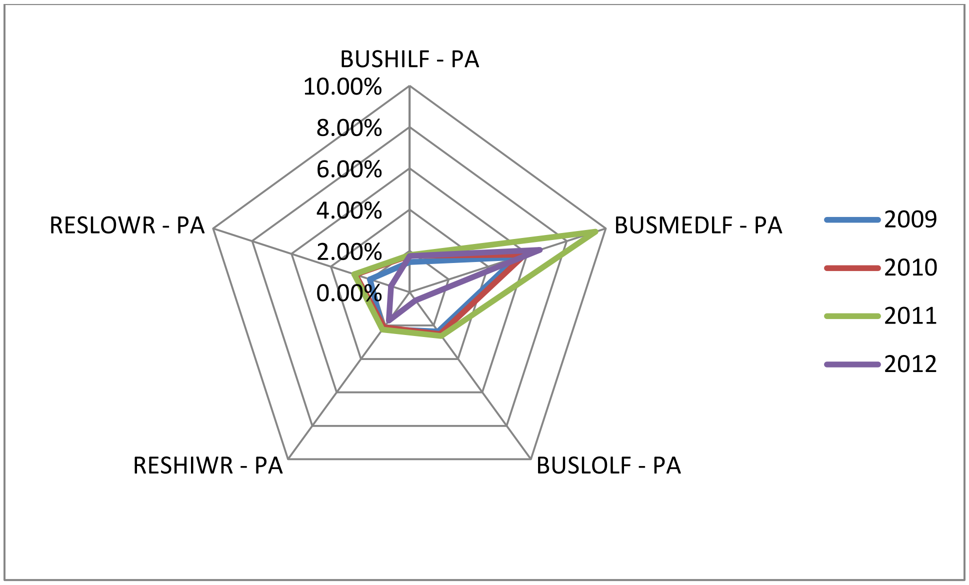


Table 54. Percentage Difference in Sensitivity Analyses Between Scenario H3 and H1 – Change in Load Factor

	2009	2010	2011	2012
BUSHILF	67%	73%	73%	72%
BUSMEDLF	91%	92%	95%	93%
BUSLOLF	79%	81%	82%	2%
RESHIWR	78%	77%	78%	72%
RESLOWR	76%	82%	83%	49%

<u>Correlation Analysis</u>

Independent Variable 1: Customer Load Factor

(1.9% Occupancy) – There is a positive correlation (R-value) between *customer load factor* and *percentage change in load factor.* The coefficient of determination (r-squared) is *low to moderate* – ranging from 0.07 in 2012 to 0.35 in 2009.

(7.3% Occupancy) – There is an *inconsistent* correlation (R-value) between *customer load factor* and *percentage change in load factor.* The coefficient of determination (r-squared) is *low* – ranging from 0.0 in 2012 to 0.28 in 2011.

Context: There is no discernible relationship between *customer load factor* and *electricity retailer margin*.

Independent Variable 2: Average Real-Time Price

ERCOT (1.9% Occupancy) – There is a positive correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *moderate to high* – ranging from 0.51 for the RESHIWR customer type to 0.80 for the BUSMEDLF customer type.

ERCOT (7.3% Occupancy) – There is a positive correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *low to high* – ranging from 0.20 for the RESHIWR customer type and 0.93 for the BUSHILF customer type.

PJM (1.9% Occupancy) – There is a positive correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *moderate to high* – ranging from 0.58 for the BUSLOLF customer type to 0.82 for the RESHIWR customer type.

PJM (7.3% Occupancy) – There is a positive correlation (R-value) between *average real-time price* and *annual percentage cost savings (real-time pricing).* The coefficient of determination (r-squared) is *high* – ranging from 0.71 for the BUSLOLF customer type and 0.86 for the BUSHILF customer type.

Context: There is a moderately to highly strong relationship between average-real time price and annual percentage cost savings (real-time pricing) for the PJM market. Increases in average real-time price lead to increases in annual percentage cost savings (real-time pricing). For the ERCOT market, there is a low to moderately strong relationship between average real-time price and annual percentage cost savings (real-time pricing).

8.6.3 Energy Efficiency Modeling Scenarios – Lighting + HVAC Calculator

We modeled the impact of simultaneously installing both lighting and HVAC energy efficiency upgrades. Time constraints precluded analysis of these results. For full results of each of the scenarios, consult Appendix 6.

8.7 Conclusion

Modeling the differences between electricity retailers and customer benefits associated with lighting and HVAC optimization energy efficiency measures presents the complexity of accounting for energy efficiency savings in the bundled energy efficiency/electricity supply business model. The value of energy efficiency to the electricity retailers and its customers varies substantially depending on the customer's load factor, the energy efficiency technology chosen, electricity procurement strategy, and wholesale electricity market. It is the purpose of this discussion section to: a) highlight the most important findings from the quantitative analysis b) contextualize these findings within the greater narrative of this thesis, and c) suggest remaining unanswered questions for further analysis.

Main Conclusions – Lighting Efficiency

<u>*Customers*</u>

1. Annual percentage cost savings potential (for both real-time pricing and fixed-price contracts) is highest among residential customers that also have the lowest load factors. Load factor decreases for RESLOWR and RESHIWR customer types. Annual cost savings are approximately 20% more cost sensitive to the size of lighting load than the magnitude (%) of permanent demand reduction. Changes in lighting schedule introduce an added level of volatility in terms of changing average real-time price for different lighting schedules.
2. Annual percentage real-time cost savings are between 9-35% greater than annual percentage fixed price savings (ERCOT). In a volatile market like ERCOT, there are significantly more savings available to a customer choosing an electricity contract that's priced based on real-time prices rather than fixed prices, but choosing an electricity contract based on real-time prices increases the risk of increased total costs due to changes in the market's pricing behavior. The factors that influence the size of energy efficiency savings for customer and electricity supplier are, in descending order, operational period, and maximum load due to lighting, permanent demand reduction.
3. Annual percentage real-time cost savings are between 1% smaller and 5% greater than annual percentage fixed price savings (PJM). Customers in PJM do not have a compelling case to choose real-time pricing contracts if that choice is motivated by a belief that they will save a higher percentage of their annual costs if they implement energy efficiency. The potential benefits and risks of purchasing real-time electricity in the PJM market are relatively low when compared to ERCOT.

4. Under circumstances of real-time electricity contracts, the annual percentage cost savings (real-time pricing) due to energy efficiency implementation (lighting) has a consistently negative correlation with customer load factor; however, the magnitude of this correlation differs dramatically.
5. Under circumstances of fixed-price electricity contracts, there is a *negative* correlation (R-value) between *customer load factor* and *annual percentage savings (fixed price).* The coefficient of determination (r-squared) is *high* – values are 0.99 for 2009-2012.

<u>Electricity Retailers</u>

1. Under circumstances of real-time electricity contracts, electricity suppliers in ERCOT can reliably predict a negative correlation between customer load factor and electricity supplier margin. The same does not hold true for electricity suppliers in PJM.

Context of Findings – Lighting Efficiency

1. While residential customer samples may save the most under lighting efficiency, they will not be able to negotiate more competitive supply contracts in the future as their load factor actually decreases.
2. The results of the analysis reveal the quantitative basis for the popularity of fixed cost electricity supply products. In particular, the nearly perfect correlation between *customer load factor* and *annual percentage cost savings (fixed pricing)* during lighting efficiency stands in stark contrast to the inconsistent impacts of *average real-time price* and *customer load factor* under real-time pricing supply products and those that utilize HVAC.

Unanswered Questions – Lighting Efficiency

1. Why does load factor decrease the most among the lowest existing load factor customers (RESHIWR, RESLOWR) while these customers achieve the highest annual percentage cost savings?
2. Why is the BUSLOLF customer sample such an outlier when it comes to the lighting schedule sensitivity analysis?

Main Conclusions – HVAC Efficiency

Customers

1. The factors that influence the size of energy efficiency savings for customer and electricity supplier are, in descending order, operational period, permanent demand reduction, max load due to HVAC.
2. The only reliable correlation between independent and dependent variables came in the PJM market
3. There is a *positive* correlation (R-value) between *customer load factor* and *annual percentage cost savings (real-time pricing)* in PJM. The coefficient of determination (r-squared) is *high* – ranging from 0.71 for the BUSLOLF customer type to 0.85 for the BUSHILF customer type.

Electricity Retailers

1. There is a *positive* correlation between *average real-time price* in PJM and *electricity retailer margin* throughout the three HVAC operational schedules modeled.
2. Individual customer's load factors are significantly less important in determining *electricity retailer margin* than was the case with lighting efficiency.
3. Changes in HVAC schedule introduce an added level of volatility in terms of changing average real-time price for different HVAC schedules.

Context of Findings – HVAC Efficiency

1. Residential customers implementing HVAC optimization efficiency will not be able to negotiate more competitive supply contracts in the future as their load factor actually decreases with efficiency implementation.

Unanswered Questions – HVAC Efficiency

1. Why does the customer load factor have a smaller impact on *electricity retailer's margin* in HVAC than lighting?
2. HVAC energy efficiency implementation increases the load factor for BUSLOLF and BUSMEDLF, but decreases the load factor for RESLOWR and RESHIWR substantially. The load factor of BUSLOLF is closer to RESLOWR and RESHIWR than BUSMEDLF; nevertheless the change in load factor results is dramatically different. There may be something particular about the RESHIWR, RESLOWR meter data samples that set them apart from the 3 business data samples. It is

possible that we need to find a more exact metric by which to define and compare load profiles than our current reliance on load factor.

Caveats to Modeling

The energy efficiency modeling conducting in this chapter reveals valuable insights, but it is important to state the limitations of both the model and its results.

1. The energy efficiency model is an approximation of the energy costs of the electricity supply part of a customer's electricity bill. The cost savings associated with reduced demand charges were not modeled.
2. The HVAC efficiency calculator calculates energy based on a fixed % savings for each 15-minute period. This is an approximation, not entirely accurate form of modeling.

Remaining Questions/Issues

1. The energy efficiency implementation baseline scenarios were chosen to approximate reality, but actual efficiency implementation will differ depending on the particular customer and electricity market. As such, the value of this exercise is likely confined to the results of the sensitivity analysis rather than the magnitude of electricity retailers and customer benefits. The modeling results demonstrate the dynamics which make valuing energy efficiency implementation such a complex task.
2. It is unclear how big a change in load factor is required for a retailer to quote a different supply price. It may be easier for large C&I customers to have a different price based on load shape (all C&I contracts are based on customized solicitations in which an electricity retailer considers a facility's operations (annual kWh, load factor)). Residential customers might have a harder time in getting a new price for a changed load factor as all residential contract prices are posted (appear to be non-negotiable). However, savvy residential customers could make the argument for a lower supply cost based on their improved load factor.

Chapter 9 – Conclusions

The past decade has witnessed a significant increase in the attention given to and value generated by energy efficiency implementation. Despite recent growth in public and private sector energy efficiency investment, a series of structural, strategic, and financial barriers have limited total investment to a small fraction of its profitable potential. The recent emergence of the bundled energy efficiency/electricity supply business model offers a unique opportunity for electricity retailers to drive substantial growth in energy efficiency provision.

The foregoing chapter answers the four research sub-questions we posed in the introduction, before proposing a general conclusion to the main research question.

1. *What existing barriers to energy efficiency does the bundled energy efficiency/electricity supply business model address, and how?*

The bundled energy efficiency/electricity supply contract, through its provision of energy efficiency upgrades at no upfront capital cost, addresses the biggest barrier to energy efficiency provision: capital availability.[51] In an economic climate in which financing energy efficiency projects through on-balance sheet debt obligations ranks among the least favorable mechanisms for energy efficiency provision,[52] the bundled energy efficiency/electricity supply contract provides a form of off-balance sheet financing that sources energy efficiency repayments through operating costs.

This form of bundled energy efficiency/electricity supply contract is currently being utilized by the largest electricity retailer for the U.S. commercial market (Constellation NewEnergy) and the second largest electricity for the U.S. residential market (Reliant Energy).

2. *What are the potential consequences of intra-annual and inter-annual volatility in the ERCOT and PJM electricity on an electricity retailer's cost of procurement for its customers?*

Successful electricity retailers mitigate the risks associated with intra-annual and inter-annual volatility in the ERCOT and PJM markets through the use of procurement strategies which mix forwards contracts, bilateral contracts, and wholesale market purchases. Electricity retailers pursuing a strategy of purchasing a high percentage of electricity for its portfolio in the real-time market take on two major risks: future price increases for the entire portfolio and difficulty in predicting the distribution of electricity procurement costs throughout its portfolio.

Evaluation of the pricing behavior of the PJM and ERCOT real-time electricity markets revealed large inter-annual volatility in average procurement costs for all customer types. In PJM, average procurement costs declined more than 50% from 2009 to 2010 and increased by more than 50% between 2010 and 2011. In PJM, the variance of average electricity procurement costs per customer

[51] As evidenced by the Institute for Building Efficiency's 2009-2013 annual energy efficiency survey results

[52] Recall the 2010 IBE annual survey on energy efficiency for respondents preferred mechanisms for financing energy efficiency projects; in-house capital budgets rank highest on this list.

varied by as little as 0.64% in 2011 and as much as 3.80% in 2009. In ERCOT, the variance of average electricity procurement costs per customer varied by as little as 9.12% in 2010 and as much as 22.86% in 2011. Taken together, an electricity retailer adopting a strategy of more electricity purchasing in the real-time market is risking portfolio procurement cost certainty. Analysis of the results does reveal fundamental differences in the volatility of the PJM and ERCOT markets; the existence of these differences requires market-specific risk mitigation techniques.

3. *How does the competitive nature of the electricity retail industry produce opportunities to capture unrealized value for all stakeholders involved in deploying a bundled energy efficiency/electricity supply contract?*

In stark contrast to the traditional vertically integrated utility model, the competitive nature of the electricity supply industry – in which electricity retailers compete for market share through the provision of personalized, value-added electricity supply products – ensures innovation. Recently, the bundled energy efficiency/electricity supply business model has emerged as a strategy used by electricity retailers to further relationships with existing customers by serving their best interests as an electricity consumer; and acquire new customers that can save on long term electricity costs through the provision of energy efficiency. Above and beyond any electricity supply procurement cost savings due to energy efficiency, the value of customer retention and customer acquisition provide an economic imperative for electricity retailers to evolve from brokers between power plants and consumers to integrated providers of energy (efficiency) services. Beyond the relationship between electricity retailer and customer, energy services companies (ESCOs) and third party financers also can participate in mutually beneficial provision of the bundled energy efficiency/electricity supply business models. ESCOs providing energy efficiency services to electricity retailers' customers can increase sales due to the fact that the provision of their services requires no upfront investment from participating customers. Third party financers, who are sorely needed to grow the energy efficiency market to its full potential, can enter the energy efficiency financing market by supporting the capital costs associated with the bundled energy efficiency/electricity supply business model.

4. *What are the potential economic gains due to energy efficiency implementation for both electricity retailers and customers?*

The results of the energy efficiency valuation analysis reveal the quantitative basis for the popularity of fixed cost electricity supply products insofar as the economic gains due to energy efficiency are most easy to predict when they accrue to electricity retailers sourcing bilateral, fixed-price contracts and electricity customers purchasing fixed-price electricity supply. In particular, the nearly perfect correlation between *customer load factor* and *annual percentage cost savings (fixed pricing)* for lighting-only energy efficiency projects stands in stark contrast to the inconsistent impacts of *average real-time price* and *customer load factor* under real-time pricing supply products. Despite the admitted difficulty in predicting the cost saving benefits of energy efficiency, there are higher cost savings opportunities available to customers and electricity retailers that pursue energy efficiency implementation alongside real-time electricity market procurement. As such, there is an economic imperative for new or repurposed electricity procurement strategies that leverage the value of energy efficiency , while mitigating the risk of real-time electricity market volatility.

Having provided conclusions it serves to conclude this analysis by answering the main research question:

To what extent, and in which ways, does the emerging business model that bundles energy efficiency retrofits with electricity supply, constitute an improvement in energy efficiency provision?

The bundled energy efficiency/electricity supply business model constitutes a major improvement in energy efficiency provision in that it address two major financial barriers while leveraging the competitive imperatives of restructured electricity markets; customer acquisition and retention are valued above electricity sales volumes. Beyond the economic benefit of improved customer retention and customer acquisition, the bundled energy efficiency/electricity supply business model can provide total cost savings to the electricity retailer and electricity customer.

The market for bundled energy efficiency/electricity supply products is likely to grow in scope and complexity over the coming years as electricity retailers seek to compete for a market that constitutes approximately half of the total U.S. electricity market. As more electricity retailers offer similar energy efficiency/electricity supply products, competitive forces will identify the value of energy efficiency to electricity retailers and their customers in different wholesale markets.

There is significant room for growth in customer switching in many of the states with competitive electricity choice (all other states except for Texas). The bundled energy efficiency/electricity supply business model, if properly executed, can spur the continued growth in customer switching from incumbent utilities to electricity retailers.

Suggestions for Further Research

Over the course of the research process, a series of compelling questions and related issues emerged that could not be answered or addressed. It is the purpose of this section to present these remaining questions and related issues in the hopes that other researchers might adopt them, thereby enriching the analysis completed through this these.

Market Structure Changes

Recall that the competitive nature of the electricity supply market limits the length of supply contracts to a maximum of 3-5 years, and the existence of this market outcome negates the potential installation of energy efficiency measures with longer payback times. Future research could be conducted on the legal feasibility of tying a repayment obligation to a building's meter in cases of energy efficiency financing sourced by electricity retailers. Work has already gone into designing on-bill repayment programs that maintain energy efficiency financing obligations with the utility meter.

There is also the potential for collaboration in energy efficiency provisions between electricity retailers and transmission and distribution (T&D) utilities. Whereas many T&D utilities administer energy efficiency rebate, incentive, and financing programs for their customers, this funding is sourced from all ratepayers through the system benefits charge (SBC). Given that T&D utilities may benefit financially from energy efficiency investments made by third party electricity retailers. It is conceivable that a T&D utility could repurpose some of the funding it uses to administer its own energy efficiency rebate, incentive, and financing programs to incentivize electricity retailers that provide energy efficiency services to a T&D utility's customers. Such a payment would be made to any electricity retailers offering energy efficiency services to a T&D utility's customers; thereby creating an additional incentive for electricity retailers to provide energy efficiency services. Conversations with progressive T&D utilities could initiate the research process.

Electricity Retailer Procurement Strategies

More accurate modeling of the potential value of energy efficiency provision to an electricity retailer requires a more nuanced understanding of electricity retailers' electricity procurement strategies. In particular, differences in market design and historical pricing behavior may compel electricity retailers to pursue different electricity procurement strategies to serve their customer's portfolio. The Federal Energy Regulatory Commission (FERC), in an effort to monitor market manipulation, collects details (for the past three months) of each transaction (names of seller and buyer, product duration, duration of transaction, point of receipt and delivery of the grid, quantity, price , and total charges.[53]

[53] CRES are compelled to provide this data to FERC. Data is available for download at http://www.ferc.gov/docs-filing/eqr/data/database.asp

The Value of Energy Efficiency

Finally, the trends observed in the energy efficiency modeling results we calculated could be further contextualizing by expanding the energy efficiency modeling analysis to a larger sub-set of customers. Pacific Gas & Electric provides average backcasted data of all of its meter samples.

Time restrictions in this project did not allow for a comprehensive review of the value of energy efficiency in all U.S. wholesale markets. The energy efficiency modeling analysis could be expanded to cover NYISO, ISO-NE, and MISO.

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Appendices

Appendix 1. Definitions of Surveyed Data in U.S. EIA 861 Dataset

Annualized Incremental Effects: The annual effects in energy use (measured in megawatt hours) and peak load (measured in megawatts) caused by new participants in existing DSM programs and all participants in new DSM programs during a given year. Reported incremental effects should be annualized to indicate the program effects that would have occurred had these participants been initiated into the program on January 1 of the given year. Incremental effects are not simply the Annual Effects of a given year minus the Annual Effects of the prior year, since these net effects would fail to account for program attrition, degradation, demolition, and participant dropouts.

Actual Annual Effects: The total effects in energy use (measured in megawatt hours) and peak load (measured in megawatts) caused by all participants in the DSM programs that are in effect during a given year. It includes new and existing participants in existing programs (those implemented in prior years that are in place during the given year) and all participants in new programs (those implemented during the given year). The effects of new participants in existing programs and all participants in new programs should be based on their start-up dates (i.e., if participants enter a program in July, only the effects from July to December should be reported). If start-up dates are unknown and cannot be reasonably estimated, the effects can be annualized (i.e., assume the participants were initiated into the program on January 1 of the given year). The Annual Effects should consider the useful life of efficiency measures, by accounting for building demolition, equipment degradation and attrition.

Energy Efficiency: Refers to programs that are aimed at reducing the energy used by specific end-use devices and systems, typically without affecting the services provided. These programs reduce overall electricity consumption, often without explicit consideration for the timing of program-induced savings. Such savings are generally achieved by substituting technically more advanced equipment to produce the same level of end-use services using less electricity. Examples include high-efficiency appliances, efficient lighting programs, high efficiency heating, ventilating and air conditioning (HVAC) systems or control modifications, efficient building design, advanced electric motor drives, and heat recovery systems.

> **Energy Effects:** The changes in aggregate electricity use (measured in megawatt hours) for customers that participate in a utility DSM program. Energy Effects should represent changes at the consumer meter (i.e. exclude transmission and distribution effects) and reflect only activities that are undertaken specifically in response to utility-administered programs, including those activities implemented by third parties under contract to the utility. To the extent possible, Energy Effects should exclude non-program related effects such as changes in energy usage attributable to nonparticipants, government-mandated energy-efficiency standards that legislate improvements in building and appliance energy usage, changes in consumer behavior that result in greater energy use after initiation in a DSM program, the natural operations of the marketplace, and weather and business-cycle adjustments.

Actual Peak Load Reduction: The actual reduction in annual peak load (measured in megawatts) achieved by consumers that participate in a utility DSM program. It reflects the real changes in the demand for electricity resulting from a utility DSM program that is in effect at the same time the utility experiences its annual peak load, as opposed to the installed peak load reduction capability (i.e., Potential Peak Load Reduction). It should account for the regular cycling of energy efficient units during the period of annual peak load.

Incentive Payment Energy Efficiency: Payment by the utility to the customer (in thousand dollars) for energy efficiency incentives. Examples of incentives are zero or low-interest loans, rebates, and direct installation of low cost measures, such as water heater wraps or duct work.

Direct Costs, excluding incentive payments - Energy Efficiency: The cost for implementing energy efficiency programs (in thousand dollars) incurred by the utility.

Incentive Payment Energy Efficiency: Payment by the utility to the customer (in thousand dollars) for energy efficiency incentives. Examples of incentives are zero or low-interest loans, rebates, and direct installation of low cost measures, such as water heater wraps or duct work.

Indirect Cost: A utility cost that may not be meaningfully identified with any particular DSM program category. Indirect costs could be attributable to one of several accounting cost categories (i.e., Administrative, Marketing, Monitoring & Evaluation, Utility-Earned Incentives, Other). Accounting costs that are known DSM program costs should not be reported under Indirect Utility Cost, rather those costs should be reported as Direct Utility Costs under the appropriate DSM program category.

Total Cost: The sum of the total Direct and Indirect Utility Costs for the year. Utility costs should reflect the total cash expenditures for the year, reported in nominal dollars, that flowed out to support DSM programs. They should be reported in the year they are incurred, regardless of when the actual effects occur.

Appendix 2. Historical Pricing Behavior – United States Forward Capacity Markets

Table 55. Historical prices paid for energy efficiency permanent demand reduction resources in ISO-NE's Forward Capacity Market (FCM)

	Clearing Price ($/kW-year)							
Zone	**2010-2011**	**2011-2012**	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**	**2016-2017**	**Average**
Connecticut	$54	$43	$35	$35	$39	$41	$38	$41
NEMA-Boston	$54	$43	$35	$35	$39	$41	$180	$61
Maine	$54	$43	$35	$35	$39	$41	$38	$41
New Hampshire	$54	$43	$35	$35	$39	$41	$38	$41
Vermont	$54	$43	$35	$35	$39	$41	$38	$41
South East Mass.	$54	$43	$35	$35	$39	$41	$38	$41
Western Mass.	$54	$43	$35	$35	$39	$41	$38	$41
Rhode Island	$54	$43	$35	$35	$39	$41	$38	$41

Source: (ISO-NE, 2013)

Table 56. Historical prices paid for energy efficiency permanent demand reduction resources in PJM's Reliability Pricing Model (RPM)

	Clearing Price ($/kW-year)										
Zone	**2007-2008**	**2008-2009**	**2009-2010**	**2010-2011**	**2011-2012**	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**	**2016-2017**	**Average**
AE	$72	$55	$72	$64	$40	$54	$49	$49	$61	$43	$56
AEP *	$15	$41	$38	$64	$40	$6	$46	$46	$49	$22	$37
APS	$15	$41	$72	$64	$40	$6	$46	$46	$49	$22	$40
ATSI	$0	$0	$0	$0	$0	$0	$46	$46	$125	$38	$26
BGE	$69	$78	$89	$64	$40	$50	$49	$49	$61	$43	$59
COMED	$15	$41	$38	$64	$40	$6	$46	$46	$49	$22	$37
DAYTON	$15	$41	$38	$64	$40	$6	$46	$46	$49	$22	$37
DEOK **	$0	$0	$0	$0	$0	$0	$46	$46	$49	$22	$16
DLCO	$0	$0	$0	$0	$0	$0	$46	$46	$49	$22	$16
DOM *	$15	$41	$38	$64	$40	$6	$46	$46	$49	$22	$37
DPL	$72	$55	$72	$65	$40	$6	$52	$52	$61	$43	$52
EKPC**	$0	$0	$0	$0	$0	$0	$0	$0	$0	$22	$2
DUQ	$15	$41	$38	$64	$40	$65	$0	$49	$0	$0	$31
JCPL	$72	$55	$72	$64	$40	$54	$49	$49	$61	$43	$56
METED	$15	$41	$72	$64	$40	$50	$49	$49	$61	$43	$48
PECO	$72	$55	$72	$64	$40	$54	$49	$49	$61	$43	$56
PENLC	$15	$41	$72	$64	$40	$50	$49	$49	$61	$43	$48
PEPCO	$69	$78	$89	$64	$40	$50	$49	$49	$61	$43	$59
PL	$15	$41	$72	$64	$40	$50	$49	$66	$61	$43	$50
PS	$72	$55	$72	$64	$40	$62	$66	$49	$61	$80	$62
RECO	$72	$55	$72	$64	$40	$54	$49	$0	$61	$43	$51

Source: (PJM Interconnection, 2013)

Appendix 3. Pacific Gas & Electric Example Load Data – Descriptive Statistics

PG&E backcasted load data – data analysis

Year	Metric	A1	A10	A6	E1	E19P	E20P
2008	STDEV	0.69	8.52	1.78	0.23	59.60	176.50
2008	MEAN	2.04	27.55	7.06	0.76	352.98	1163.00
2008	CV	0.34	0.31	0.25	0.30	0.17	0.15
2008	MAX	5.23	58.23	15.63	1.88	601.84	1729.20
2008	Load Factor	0.39	0.47	0.45	0.40	0.59	0.67
2009	STDEV	0.71	8.76	1.66	0.24	59.09	191.31
2009	MEAN	2.12	28.35	7.71	0.77	361.45	1212.89
2009	CV	0.34	0.31	0.22	0.31	0.16	0.16
2009	MAX	4.69	54.64	14.01	1.88	529.60	1729.20
2009	Load Factor	0.45	0.52	0.55	0.41	0.68	0.70
2010	STDEV	0.65	8.07	1.63	0.21	55.95	162.95
2010	MEAN	2.02	26.66	6.45	0.74	350.52	1162.92
2010	CV	0.32	0.30	0.25	0.29	0.16	0.14
2010	MAX	4.72	56.63	13.17	1.82	530.84	1633.65
2010	Load Factor	0.43	0.47	0.49	0.41	0.66	0.71
2011	STDEV	0.65	8.25	1.43	0.22	49.67	170.02
2011	MEAN	2.02	27.51	6.05	0.76	332.03	1147.45
2011	CV	0.32	0.30	0.24	0.29	0.15	0.15
2011	MAX	4.54	53.71	11.65	1.69	552.35	1599.56
2011	Load Factor	0.45	0.51	0.52	0.45	0.60	0.72
2012	STDEV	0.64	7.83	1.45	0.23	47.71	159.06
2012	MEAN	1.97	26.36	6.68	0.77	333.32	1132.20
2012	CV	0.32	0.30	0.22	0.30	0.14	0.14
2012	MAX	4.43	50.27	12.96	1.75	474.34	1531.91
2012	Load Factor	0.44	0.52	0.52	0.44	0.70	0.74

Source: (Pacific Gas & Electric, 2013)

Scenario L1 – Electricity Retailer Benefits

Correlation between Load Factor and Electricity Retailer Margin (ERCOT)

	2009	2010	2011	2012
R	-0.83	-0.83	-0.93	-0.90
r-squared	0.69	0.69	0.86	0.81

Correlation between Load Factor and Electricity Retailer Margin (PJM)

	2009	2010	2011	2012
R	0.74	-0.59	-0.39	0.11
r-squared	0.54	0.35	0.15	0.01

Correlation between Average Real Time Price and Electricity Retailer Margin (ERCOT

	R	r-squared
BUSHILF	0.70	0.49
BUSMEDLF	0.60	0.35
BUSLOLF	0.57	0.32
RESHIWR	0.17	0.03
RESLOWR	0.23	0.05

Correlation between Average Real Time Price and Electricity Retailer Margin (PJM)

	R	r-squared
BUSHILF	-0.28	0.08
BUSMEDLF	-0.67	0.45
BUSLOLF	-0.84	0.71
RESHIWR	-0.55	0.30
RESLOWR	-0.96	0.92

Scenario L1 – Customer Benefits

Correlation between Load Factor and Annual Percentage Real-Time Cost Savings (ERCOT)

	2009	2010	2011	2012
R	-1.00	-0.99	-1.00	-1.00
r-squared	1.00	0.99	0.99	0.99

Correlation between Load Factor and Annual Percentage Real-Time Cost Savings (PJM)

	2009	2010	2011	2012
R	-1.00	-0.99	-1.00	-1.00
r-squared	0.99	0.98	0.99	0.99

Correlation between Average Real Time Price and Annual Percentage Real Time Cost Savings (ERCOT)

	r	r-squared
BUSHILF	0.72	0.52
BUSMEDLF	0.60	0.36
BUSLOLF	0.64	0.41
RESHIWR	-0.15	0.02
RESLOWR	0.09	0.01

Correlation between Average Real Time Price and Annual Percentage Real Time Cost Savings (PJM)

	r	r-squared
BUSHILF	-0.38	0.15
BUSMEDLF	-0.59	0.35
BUSLOLF	-0.78	0.61
RESHIWR	0.25	0.06
RESLOWR	-0.66	0.44

Correlation between Load Factor and Annual Percentage Fixed Cost Savings

	2009	2010	2011	2012
R	-1.00	-0.99	-1.00	-1.00
r-squared	0.99	0.99	0.99	0.99

Correlation between Load Factor and Percentage Change in Load Factor

	2009	2010	2011	2012
R	0.78	0.67	0.66	0.47
r-squared	0.61	0.45	0.43	0.22

Scenario L3 – Electricity Retailer Benefits

ERCOT – 17.6% Occupancy

Correlation Between Load Factor and Electricity Retailer Margin (ERCOT)

	2009	2010	2011	2012
R	0.02	-0.12	-0.18	-0.33
r-squared	0.00	0.01	0.03	0.11

PJM – 17.6% Occupancy

Correlation Between Load Factor and Electricity Retailer Margin (PJM)

	2009	2010	2011	2012
R	0.41	-0.34	0.06	0.20
r-squared	0.17	0.12	0.00	0.04

ERCOT – 22.6% Occupancy

Correlation Between Load Factor and Electricity Retailer Margin (ERCOT)

	2009	2010	2011	2012
R	0.07	0.36	-0.34	-0.65
r-squared	0.01	0.13	0.11	0.42

PJM – 22.6% Occupancy

Correlation Between Load Factor and Electricity Retailer Margin (PJM)

	2009	2010	2011	2012
R	0.82	-0.69	0.69	0.89
r-squared	0.67	0.48	0.48	0.79

ERCOT – 27.6% Occupancy

Correlation Between Load Factor and Electricity Retailer Margin (ERCOT)

	2009	2010	2011	2012
R	0.13	0.15	0.15	-0.54
r-squared	0.02	0.02	0.02	0.29

PJM – 27.6% Occupancy

Correlation Between Load Factor and Electricity Retailer Margin (PJM)

	2009	2010	2011	2012
r	0.34	-0.28	0.27	0.77
r-squared	0.11	0.08	0.07	0.60

17.6% OCCUPANCY

Correlation Between Average Real Time Price and Electricity Retailer Margin (ERCOT)

	R	r-squared
BUSHILF	0.88	0.77
BUSMEDLF	0.80	0.64
BUSLOLF	-0.26	0.07
RESHIWR	0.47	0.22
RESLOWR	0.71	0.51

Correlation Between Average Real Time Price and Electricity Retailer Margin (PJM)

	r	r-squared
BUSHILF	-0.09	0.01
BUSMEDLF	-0.49	0.24
BUSLOLF	0.81	0.66
RESHIWR	-0.68	0.47
RESLOWR	-0.94	0.88

22.6% OCCUPANCY

Correlation Between Average Real Time Price and Electricity Retailer Margin (ERCOT)

	R	r-squared
BUSHILF	0.86	0.75
BUSMEDLF	0.79	0.62
BUSLOLF	0.76	0.58
RESHIWR	0.67	0.45
RESLOWR	0.47	0.22

Correlation Between Average Real Time Price and Electricity Retailer Margin (PJM)

	R	r-squared
BUSHILF	-0.35	0.12
BUSMEDLF	-0.78	0.61
BUSLOLF	-0.86	0.74
RESHIWR	-0.91	0.82
RESLOWR	-0.98	0.97

27.6% OCCUPANCY

Correlation Between Average Real Time Price and Electricity Retailer Margin (ERCOT)

	R	r-squared
BUSHILF	0.82	0.68
BUSMEDLF	0.68	0.46
BUSLOLF	0.87	0.76
RESHIWR	0.15	0.02
RESLOWR	0.22	0.05

Correlation Between Average Real Time Price and Electricity Retailer Margin (PJM)

	r	r-squared
BUSHILF	-0.54	0.30
BUSMEDLF	-0.78	0.61
BUSLOLF	0.97	0.95
RESHIWR	-0.86	0.74
RESLOWR	-0.97	0.95

Scenario L3 – Customer Benefits

17.6% occupancy

Correlation Between Load Factor and Percentage Change in Load Factor (ERCOT)

	2009	2010	2011	2012
R	-0.13	0.14	0.18	-0.15
r-squared	0.02	0.02	0.03	0.02

22.6% occupancy

Correlation Between Load Factor and Percentage Change in Load Factor (ERCOT)

	2009	2010	2011	2012
R	-0.10	0.24	0.27	-0.39
r-squared	0.01	0.06	0.07	0.15

27.6% occupancy

Correlation Between Load Factor and Percentage Change in Load Factor (ERCOT)

	2009	2010	2011	2012
R	-0.08	0.17	0.26	-0.06
r-squared	0.01	0.03	0.07	0.00

17.6% Occupancy

Correlation Between Load Factor and RT Cost Savings (ERCOT)

	2009	2010	2011	2012
R	-0.77	-0.84	-0.78	-0.84
r-squared	0.59	0.71	0.61	0.71

Correlation Between Load Factor and Real Time Cost Savings (PJM)

	2009	2010	2011	2012
R	-0.96	-0.84	-0.95	-0.90
r-squared	0.91	0.70	0.90	0.80

22.6% Occupancy

Correlation Between Load Factor and RT Cost Savings (ERCOT)

	2009	2010	2011	2012
R	-0.95	-0.87	-0.86	-0.92
r-squared	0.90	0.75	0.73	0.85

Correlation Between Load Factor and Real Time Cost Savings (PJM)

	2009	2010	2011	2012
R	-0.96	-0.88	-0.93	-0.96
r-squared	0.93	0.77	0.87	0.92

27.6% Occupancy

Correlation Between Load Factor and Real Time Cost Savings (ERCOT)

	2009	2010	2011	2012
R	-0.34	-0.46	-0.17	-0.86
r-squared	0.12	0.21	0.03	0.74

Correlation Between Load Factor and Real Time Cost Savings (PJM)

	2009	2010	2011	2012
R	-0.70	-0.83	-0.66	-0.91
r-squared	0.49	0.69	0.43	0.82

22.6% Occupancy

Correlation between Average Real-Time Price and Real-Time Cost Savings (ERCOT)

	R	r-squared
BUSHILF – TX	0.879	0.773
BUSMEDLF – TX	0.784	0.615
BUSLOLF - TX	0.827	0.684
RESHIWR - TX	0.275	0.076
RESLOWR - TX	0.272	0.074

22.6% Occupancy

Correlation between Average Real Time Price and Real-Time Cost Savings (PJM)

	r	r-squared
BUSHILF – PJM	-0.363	0.132
BUSMEDLF – PJM	-0.526	0.277
BUSLOLF – PJM	-0.823	0.677
RESHIWR – PJM	-0.391	0.153
RESLOWR – PJM	-0.643	0.413

17.6% occupancy

Correlation between Average Real Time Price and Real-Time Cost Savings (ERCOT)

	R	r-squared
BUSHILF - TX	0.854	0.729
BUSMEDLF - TX	0.678	0.46
BUSLOLF - TX	-0.181	0.033
RESHIWR - TX	0.134	0.018
RESLOWR - TX	0.379	0.143

17.6% occupancy

Correlation between Average Real Time Price and Real-Time Cost Savings (PJM)

	R	r-squared
BUSHILF - PJM	-0.245	0.06
BUSMEDLF - PJM	-0.599	0.359
BUSLOLF - PJM	0.641	0.411
RESHIWR - PJM	-0.443	0.196
RESLOWR - PJM	-0.69	0.476

27.6% Occupancy

Correlation between Average Real Time Price and Real-Time Cost Savings (ERCOT)

	R	r-squared
BUSHILF - TX	0.849	0.72
BUSMEDLF - TX	0.623	0.388
BUSLOLF - TX	0.871	0.758
RESHIWR - TX	-0.832	0.692
RESLOWR - TX	-0.182	0.033

27.6% Occupancy

Correlation between Average Real Time Price and Real-Time Cost Savings (PJM)

	R	r-squared
BUSHILF - PJM	-0.452	0.204
BUSMEDLF - PJM	-0.574	0.33
BUSLOLF - PJM	0.815	0.665
RESHIWR - PJM	-0.511	0.261
RESLOWR - PJM	-0.662	0.438

Scenario H1 – Electricity Retailer Benefits

Correlation between Load Factor and Electricity Retailer Margin (ERCOT)

	2009	2010	2011	2012
r	-0.05	0.51	0.82	-0.16
r-squared	0.00	0.26	0.67	0.03

Correlation between Load Factor and Electricity Retailer Margin (PJM)

	2009	2010	2011	2012
R	0.59	-0.60	0.77	0.35
r-squared	0.35	0.36	0.59	0.12

Correlation between Average Real Time Price and Electricity Retailer Margin (ERCOT)

	r	r-squared
BUSHILF	0.90	0.81
BUSMEDLF	0.83	0.69
BUSLOLF	0.77	0.59
RESHIWR	0.60	0.36
RESLOWR	0.59	0.35

Correlation between Average Real Time Price and Electricity Retailer Margin (PJM)

	R	r-squared
BUSHILF	0.97	0.94
BUSMEDLF	0.98	0.96
BUSLOLF	0.98	0.96
RESHIWR	0.97	0.94
RESLOWR	0.95	0.90

Scenario H1 – Customer Benefits

Correlation Between Load Factor and Real Time Cost Savings (ERCOT)

	2009	2010	2011	2012
r	0.09	0.48	0.40	0.25
r-squared	0.01	0.23	0.16	0.07

Correlation Between Load Factor and Real Time Savings (PJM)

	2009	2010	2011	2012
R	0.25	0.20	0.24	0.01
r-squared	0.06	0.04	0.06	0.00

Correlation Between Average Real Time Price and Real Time Cost Savings (ERCOT)

	r	r-squared
BUSHILF	0.90	0.81
BUSMEDLF	0.83	0.69
BUSLOLF	0.80	0.64
RESHIWR	0.39	0.15
RESLOWR	0.60	0.36

Correlation Between Average Real Time Price and Real Time Cost Savings (PJM)

	r	r-squared
BUSHILF	0.92	0.85
BUSMEDLF	0.86	0.74
BUSLOLF	0.84	0.71
RESHIWR	0.89	0.79
RESLOWR	0.88	0.77

Correlation Between Load Factor and Fixed Cost Savings

	2009	2010	2011	2012
R	0.20	0.24	0.21	-0.01
r-squared	0.04	0.06	0.05	0.00

Correlation Between Load Factor and Change Load Factor

	2009	2010	2011	2012
R	0.59	0.48	0.40	0.25
r-squared	0.35	0.23	0.16	0.07

Scenario H3 – Electricity Retailer Benefits

1.9% Occupancy

Correlation between Load Factor and Electricity Retailer Margin (ERCOT)

	2009	2010	2011	2012
r	-0.08	0.66	0.9	-0.31
r-squared	0.01	0.43	0.8	0.1

Correlation between Load Factor and Electricity Retailer Margin (PJM)

	2009	2010	2011	2012
R	0.65	-0.75	0.83	0.37
r-squared	0.43	0.56	0.69	0.14

4.6% Occupancy

Correlation between Load Factor and Electricity Retailer Margin (PJM)

	2009	2010	2011	2012
r	-0.41	0.19	0.85	-0.34
r-squared	0.17	0.04	0.72	0.12

7.3% Occupancy

Correlation between Load Factor and Electricity Retailer Margin (PJM)

	2009	2010	2011	2012
R	0.7	-0.82	0.95	0.28
r-squared	0.49	0.67	0.9	0.08

1.9% OCCUPANCY

Correlation between Average Real-Time Price and Electricity Retailer Margin (ERCOT)

	r	r-squared
BUSHILF – TX	0.78	0.61
BUSMEDLF – TX	0.86	0.74
BUSLOLF – TX	0.91	0.82
RESHIWR – TX	0.91	0.82
RESLOWR – TX	0.96	0.92

Correlation between Average Real-Time Price and Electricity Retailer Margin (PJM)

	r	r-squared
BUSHILF - PJM	0.88	0.77
BUSMEDLF - PJM	0.89	0.79
BUSLOLF - PJM	0.90	0.81
RESHIWR - PJM	0.87	0.76
RESLOWR - PJM	0.98	0.96

4.6% OCCUPANCY

Correlation between Average Real-Time Price and Electricity Retailer Margin (ERCOT)

	r	r-squared
BUSHILF – TX	0.89	0.80
BUSMEDLF – TX	0.83	0.69
BUSLOLF – TX	0.77	0.59
RESHIWR – TX	0.60	0.36
RESLOWR – TX	0.59	0.35

Correlation between Average Real-Time Price and Electricity Retailer Margin (PJM)

	r	r-squared
BUSHILF - PJM	0.97	0.95
BUSMEDLF - PJM	0.97	0.95
BUSLOLF - PJM	0.98	0.96
RESHIWR - PJM	0.97	0.95
RESLOWR - PJM	0.95	0.91

7.3% OCCUPANCY

Correlation between Average Real-Time Price and Electricity Retailer Margin (ERCOT)

	r	r-squared
BUSHILF - TX	0.78	0.61
BUSMEDLF - TX	0.69	0.47
BUSLOLF - TX	0.61	0.37
RESHIWR - TX	0.45	0.20
RESLOWR - TX	0.41	0.17

Correlation between Average Real-Time Price and Electricity Retailer Margin (PJM)

	r	r-squared
BUSHILF - PJM	0.97	0.95
BUSMEDLF - PJM	0.98	0.96
BUSLOLF - PJM	0.98	0.97
RESHIWR - PJM	0.98	0.96
RESLOWR - PJM	0.97	0.94

Scenario H3 – Customer Benefits

Correlation between Real-Time Cost Savings and Average Real Time Price (ERCOT) – 4.6% Occupancy

	r	r-squared
BUSHILF – TX	0.9	0.82
BUSMEDLF - TX	0.83	0.69
BUSLOLF – TX	0.8	0.64
RESHIWR – TX	0.39	0.16
RESLOWR – TX	0.6	0.36

Correlation between Real-Time Cost Savings and Average Real Time Price (ERCOT) – 1.9% Occupancy

	R	r-squared
BUSHILF - TX	0.89	0.79
BUSMEDLF - TX	0.89	0.8
BUSLOLF - TX	0.89	0.79
RESHIWR - TX	0.72	0.51
RESLOWR - TX	0.86	0.75

Correlation between Real-Time Cost Savings and Average Real Time Price (ERCOT) – 7.3% occupancy

	R	r-squared
BUSHILF - TX	0.97	0.93

BUSMEDLF - TX	0.93	0.86
BUSLOLF - TX	0.93	0.86
RESHIWR - TX	0.45	0.2
RESLOWR - TX	0.66	0.44

Correlation between Real-Time Cost Savings and Average Real Time Price (PJM) – 4.6% Occupancy

	r	r-squared
BUSHILF - PJM	0.92	0.85
BUSMEDLF - PJM	0.86	0.74
BUSLOLF - PJM	0.84	0.71
RESHIWR - PJM	0.89	0.79
RESLOWR - PJM	0.88	0.78

Correlation between Real-Time Cost Savings and Average Real Time Price (PJM) – 1.9% Occupancy

	r	r-squared
BUSHILF - PJM	0.82	0.67
BUSMEDLF - PJM	0.77	0.6
BUSLOLF - PJM	0.76	0.58
RESHIWR - PJM	0.9	0.82
RESLOWR - PJM	0.79	0.62

Correlation between Real-Time Cost Savings and Average Real Time Price (PJM) – 7.3% Occupancy

	r	r-squared
BUSHILF - PJM	0.93	0.86
BUSMEDLF - PJM	0.86	0.75
BUSLOLF - PJM	0.84	0.71
RESHIWR - PJM	0.88	0.77
RESLOWR - PJM	0.9	0.81

Appendix 6. Combined HVAC and Lighting Efficiency Simulations

For all calculations completed under Scenario LH1, the following input parameters apply:

Lighting Inputs

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	Permanent demand reduction	% of max load consisting of lighting
1	9	17	2	6	1	12	7.5%	10%
2	9	17	2	6	1	12	12.5%	10%
3	9	17	2	6	1	12	17.5%	10%

HVAC Inputs

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	% of Max Demand Due to HVAC	% Permanent Demand Reduction
1	12	17	2	6	5	9	50%	17.3%
2	12	17	2	6	5	9	50%	20.0%
3	12	17	2	6	5	9	50%	22.7%

For all calculations completed under Scenario LH2, the following lighting input parameters apply:

Lighting Inputs

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	Permanent demand reduction	% of max load consisting of lighting
1	9	17	2	6	1	12	12.50%	5%
2	9	17	2	6	1	12	12.50%	10%
3	9	17	2	6	1	12	12.50%	15%

HVAC Inputs

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	Permanent Demand Reduction	% of Max Demand Due to HVAC
1	12	17	2	6	5	9	20%	47.3%
2	12	17	2	6	5	9	20%	50.0%
3	12	17	2	6	5	9	20%	52.7%

For all calculations completed under Scenario H2, the following input parameters apply:

Lighting Inputs

Scenario	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	% of max load consisting of lighting	Permanent demand reduction	% of Total Annual Hours
1	11	18	2	6	1	12	10%	12.5%	17.60%
2	9	18	2	6	1	12	10%	12.5%	22.60%
3	8	19	2	6	1	12	10%	12.5%	27.60%

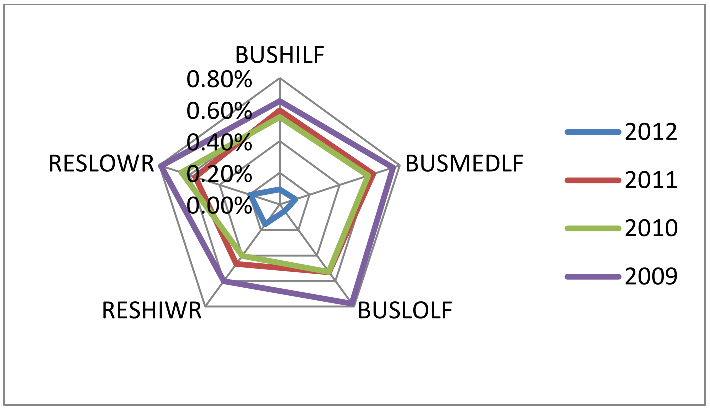
HVAC Inputs

Simulation	Starting Hour	Ending Hour	Starting Weekday	Ending Weekday	Starting Month	Ending Month	% of Total Annual Hours	Permanent Demand Reduction	% of Max Demand Due to HVAC
1	14	16	2	6	5	9	1.9%	20%	50%
2	12	17	2	6	5	9	4.6%	20%	50%
3	11	19	2	6	5	9	7.3%	20%	50%

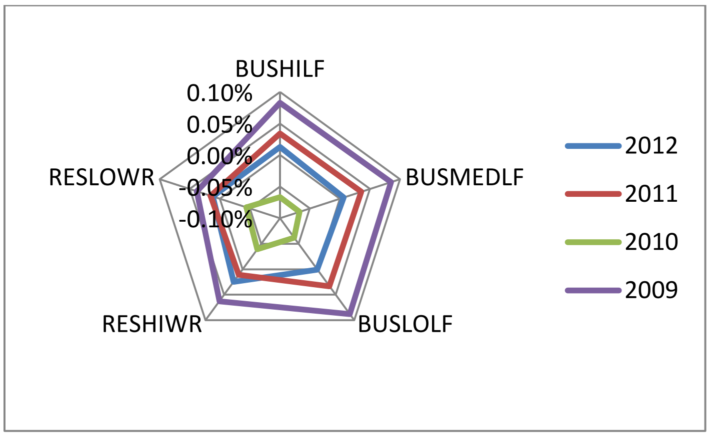
Scenario LH1.1 - Permanent Demand Reduction

ELECTRICITY RETAILERS BENEFITS

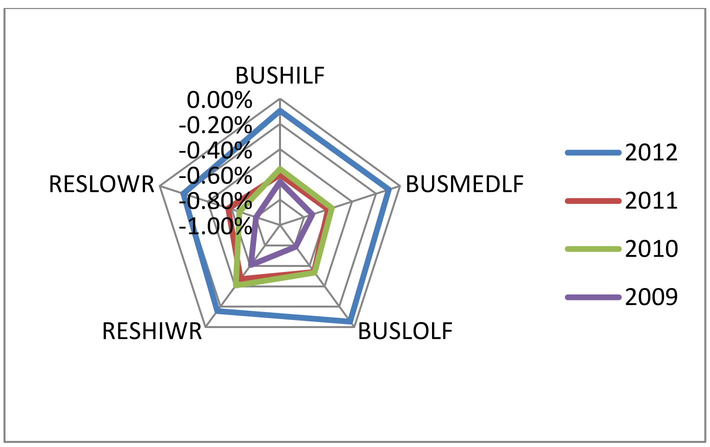
Electricity Retailer Margin – Houston



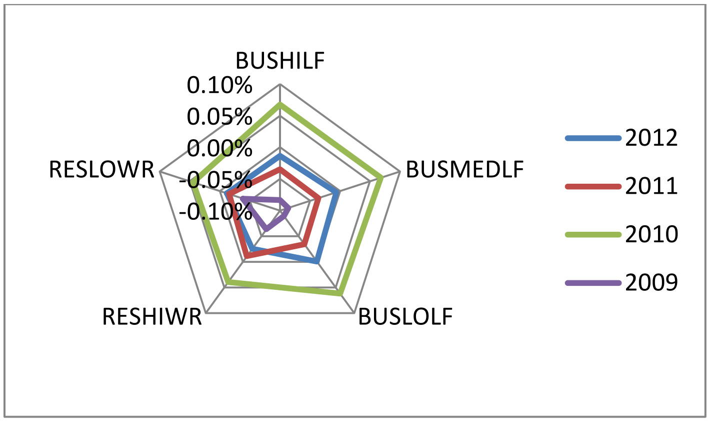
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

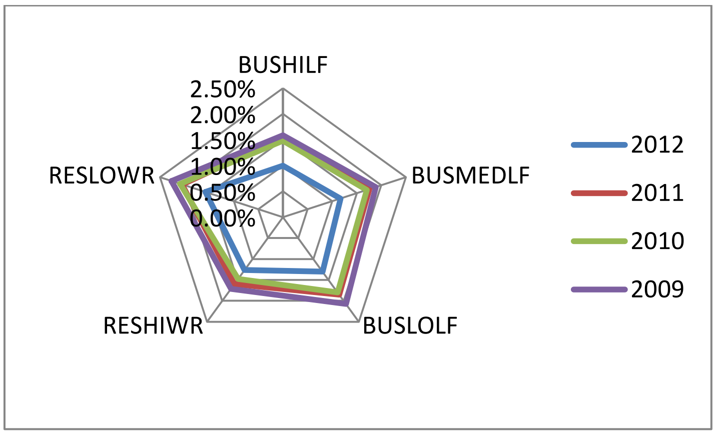


% Change Real-Time Procurement Costs - Metropolitan Edison

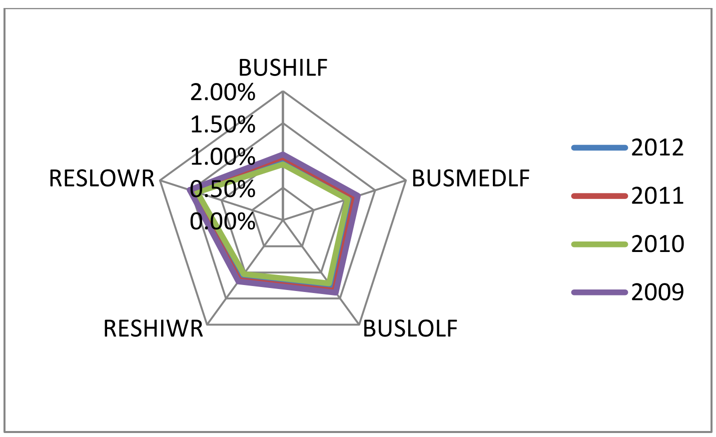


<u>CUSTOMER BENEFITS</u>

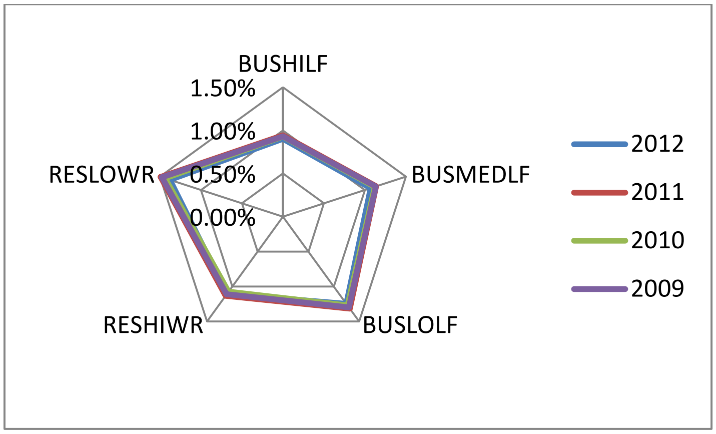
Real-Time Cost Savings – Houston



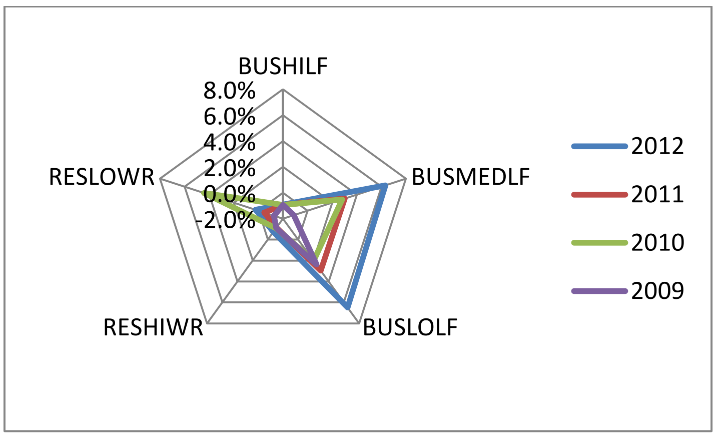
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



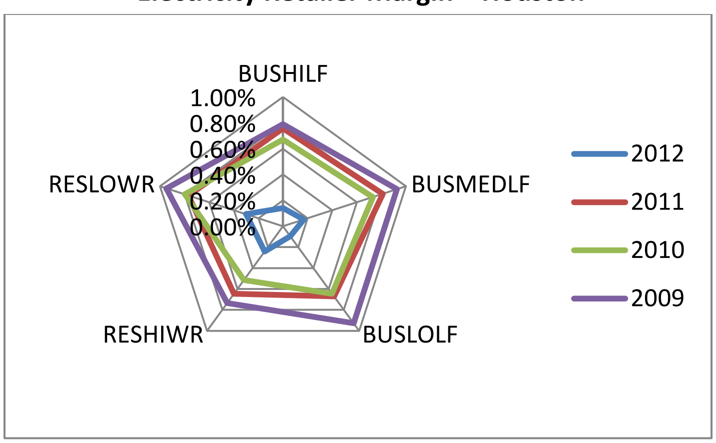
% Change in Load Factor



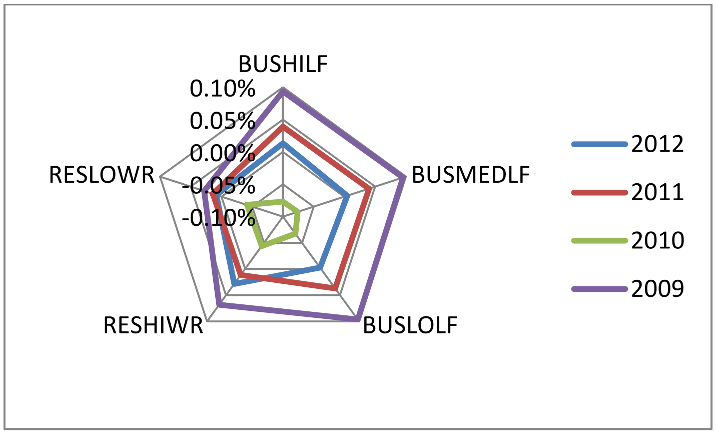
Scenario LH1.2 - Permanent Demand Reduction

ELECTRICITY RETAILERS BENEFITS

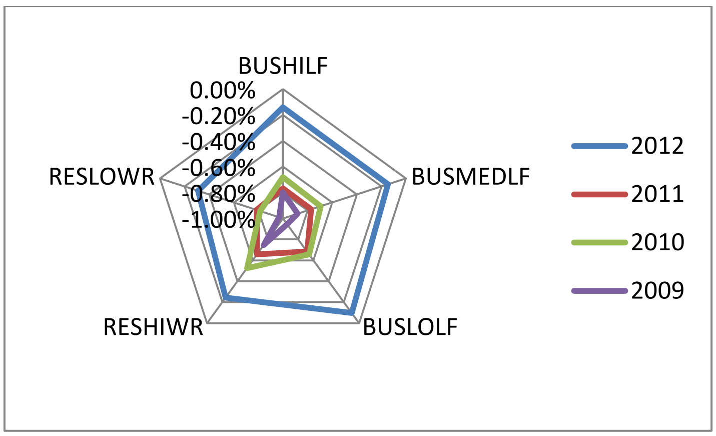
Electricity Retailer Margin – Houston



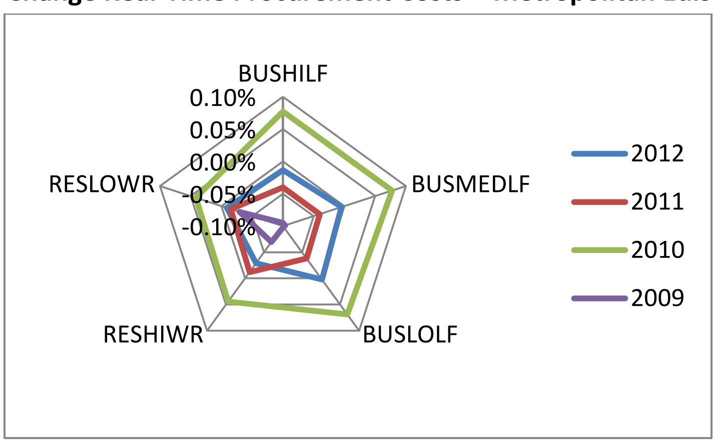
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

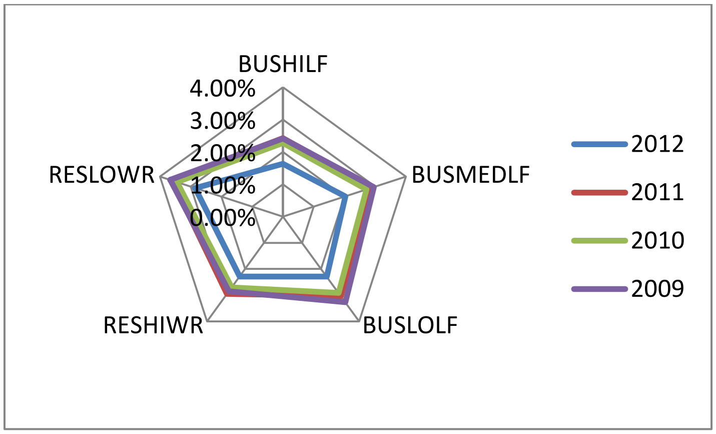


% Change Real-Time Procurement Costs - Metropolitan Edison

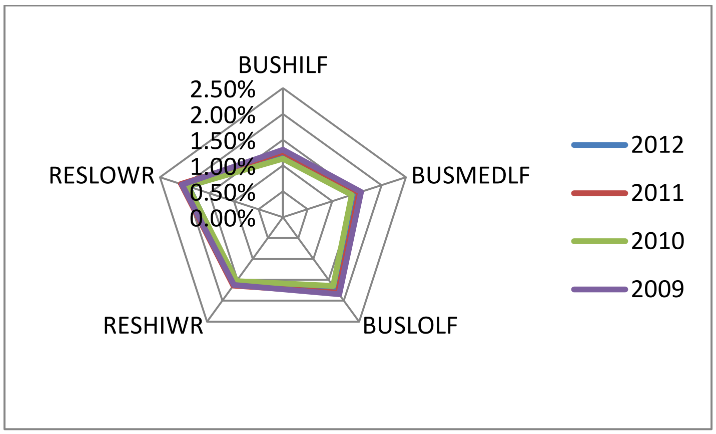


CUSTOMER BENEFITS

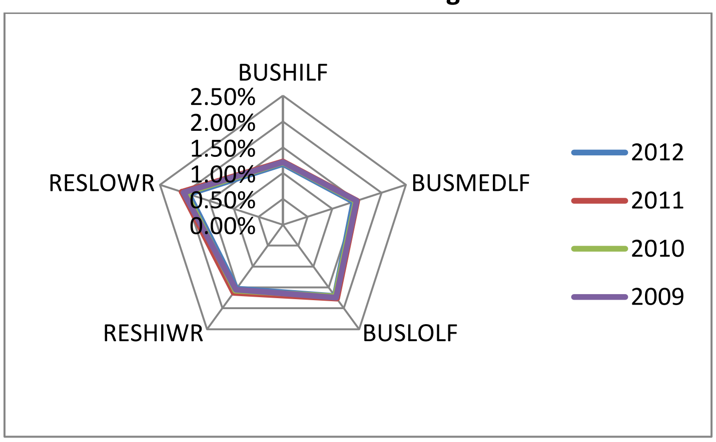
Real-Time Cost Savings – Houston



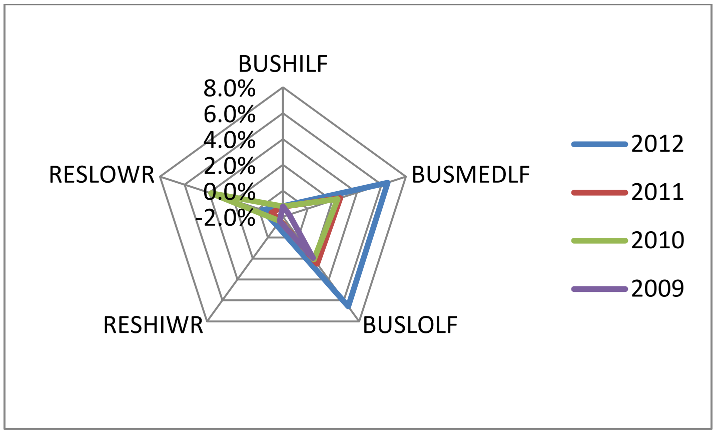
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



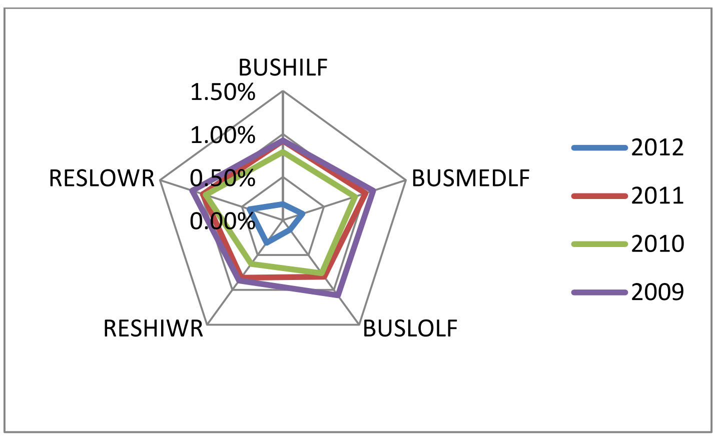
% Change in Load Factor



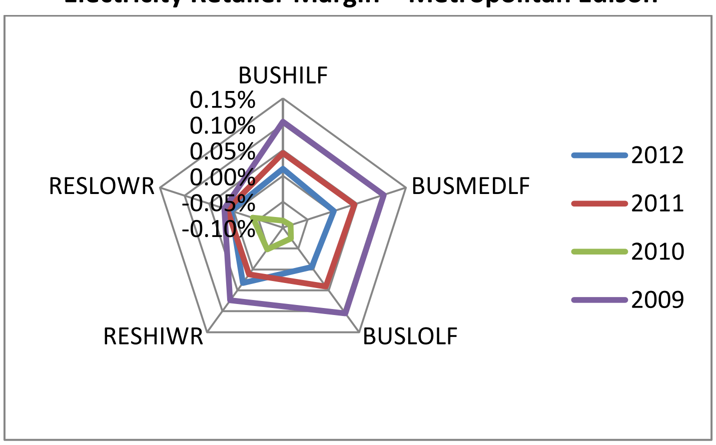
Scenario LH1.3 - Permanent Demand Reduction

ELECTRICITY RETAILERS BENEFITS

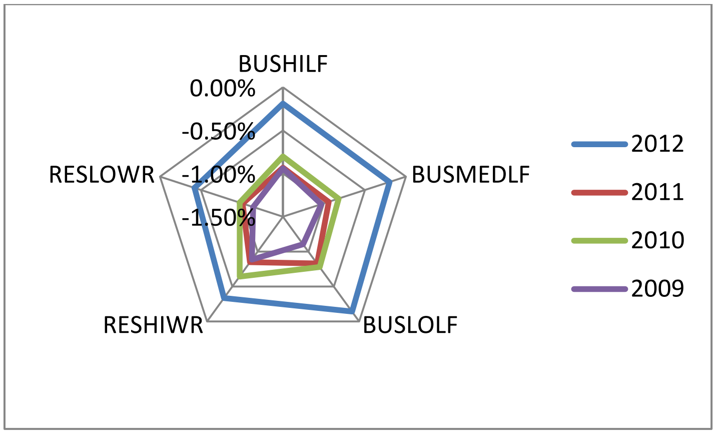
Electricity Retailer Margin – Houston



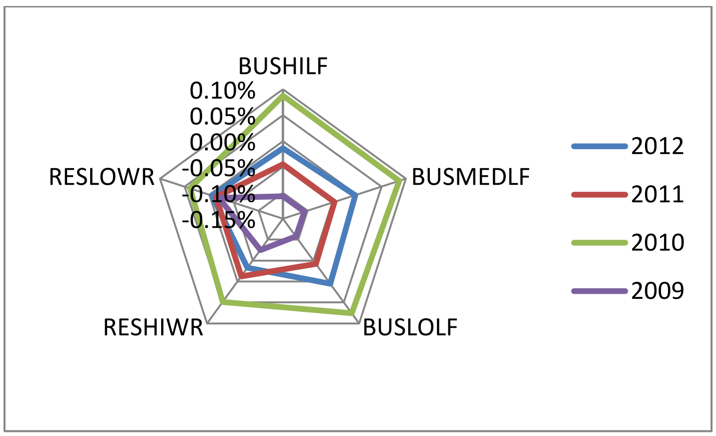
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

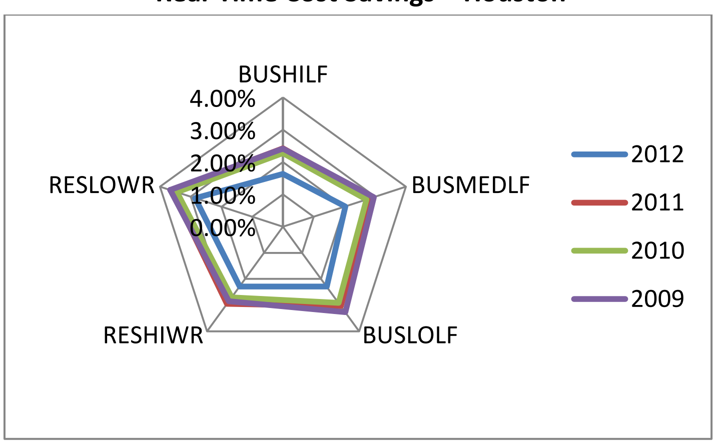


% Change Real-Time Procurement Costs - Metropolitan Edison

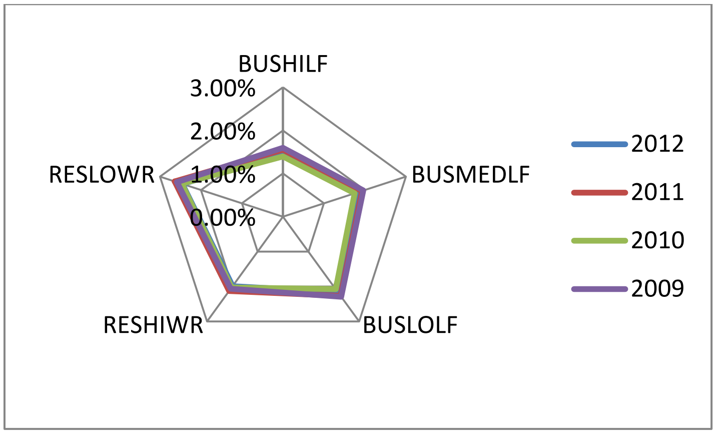


CUSTOMER BENEFITS

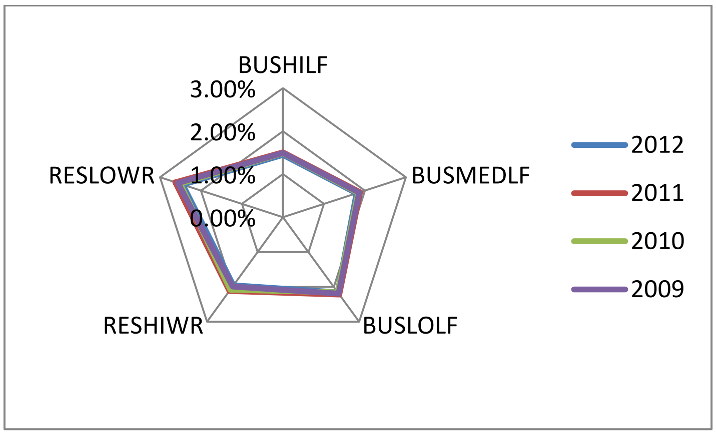
Real-Time Cost Savings – Houston



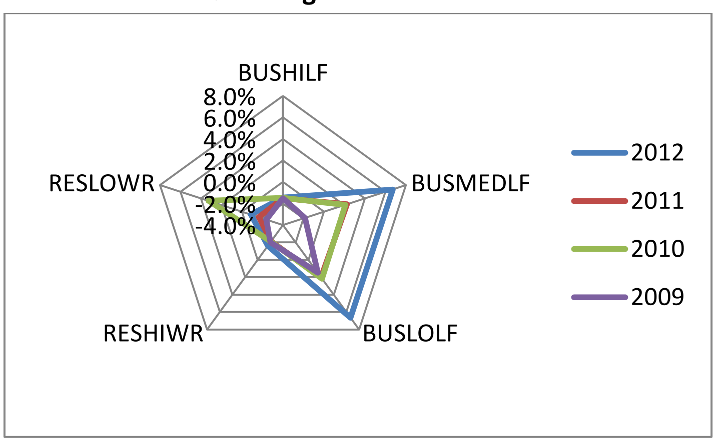
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



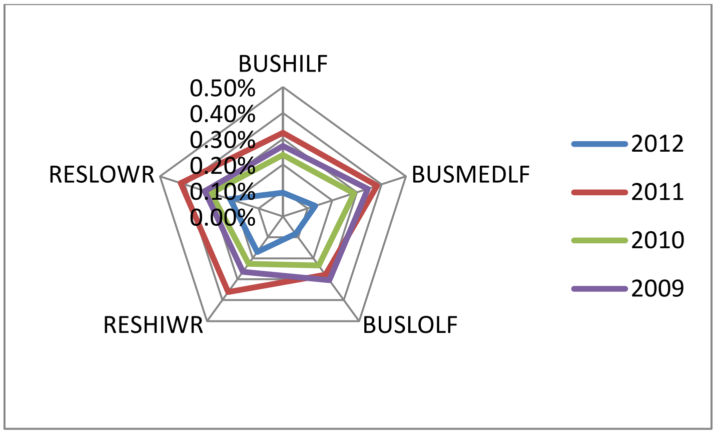
% Change in Load Factor



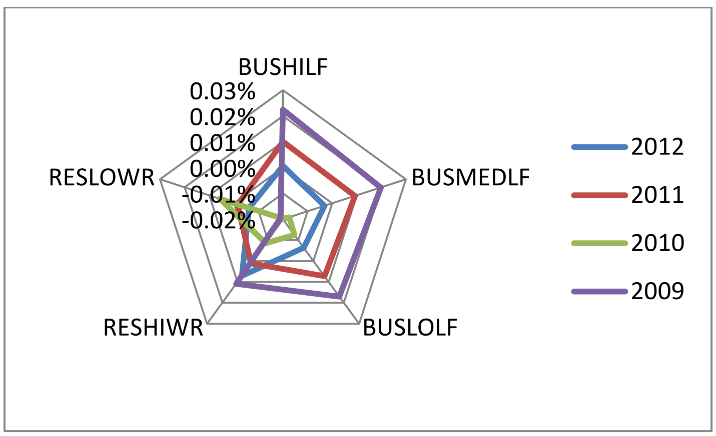
Scenario LH1 - Permanent Demand Reduction – Sensitivity Analysis

ELECTRICITY RETAILERS BENEFITS

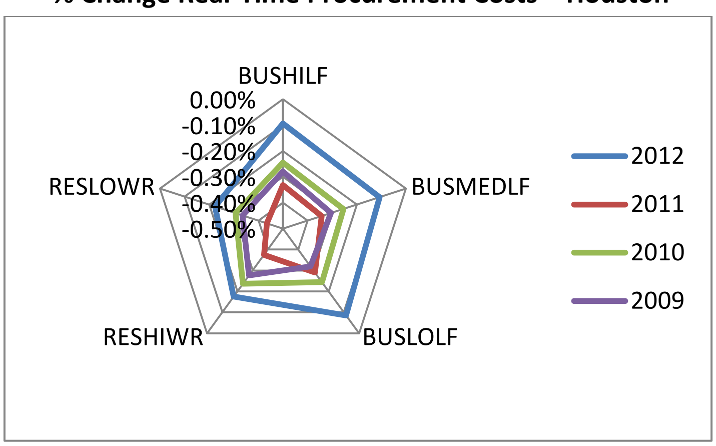
Electricity Retailer Margin – Houston



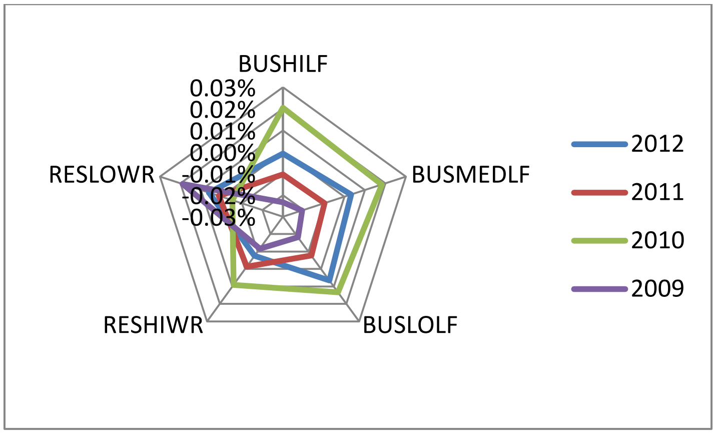
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

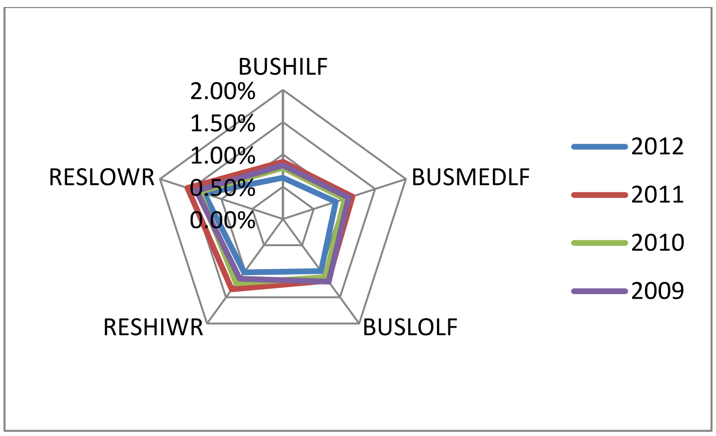


% Change Real-Time Procurement Costs - Metropolitan Edison

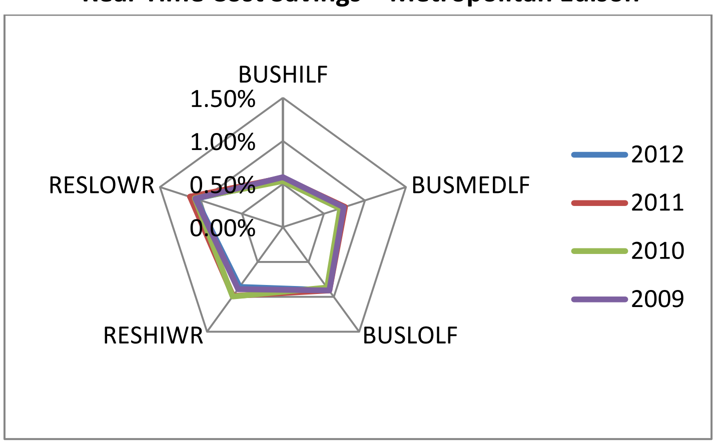


<u>CUSTOMER BENEFITS</u>

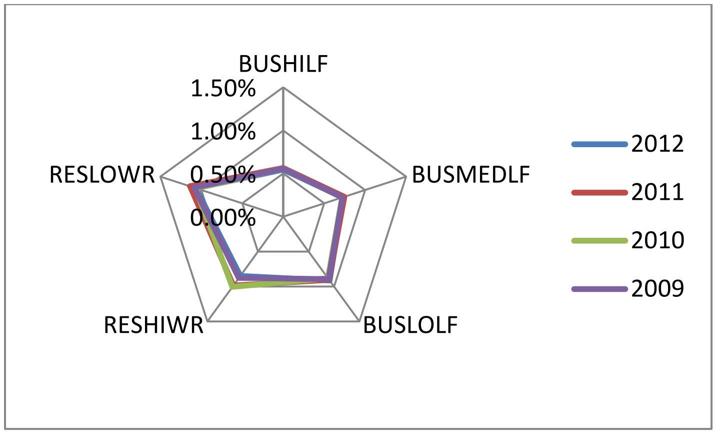
Real-Time Cost Savings – Houston



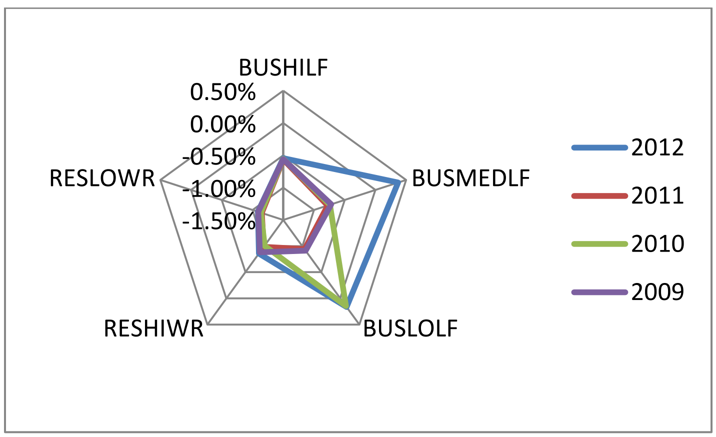
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



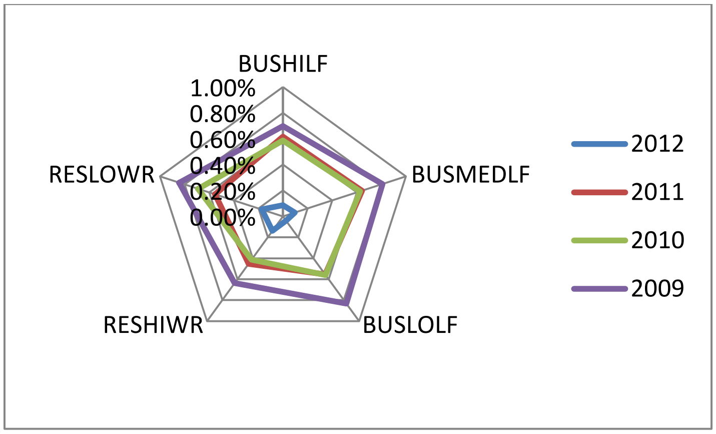
% Change in Load Factor



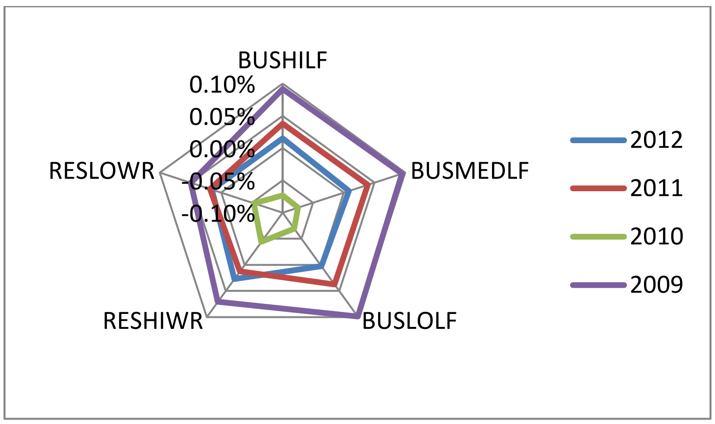
Scenario LH2.1 – Maximum Load Due to Energy Efficient Equipment

ELECTRICITY RETAILERS BENEFITS

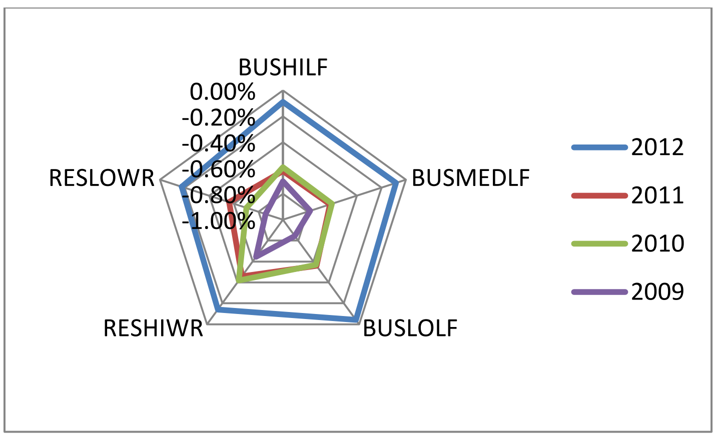
Electricity Retailer Margin – Houston



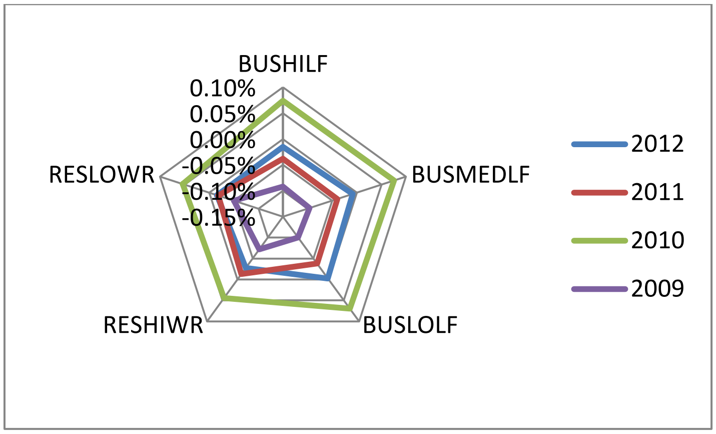
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

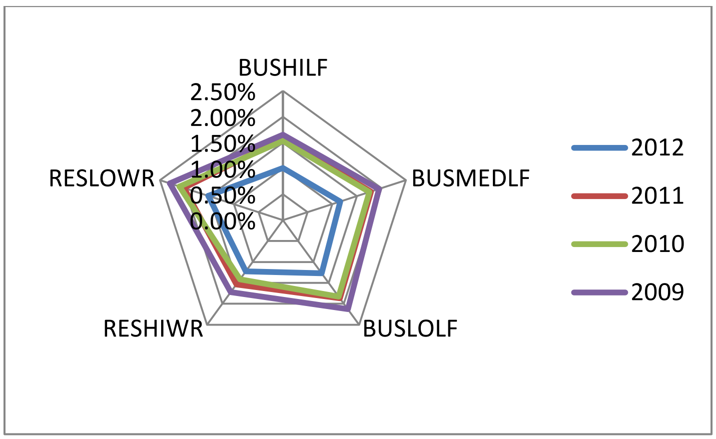


% Change Real-Time Procurement Costs - Metropolitan Edison

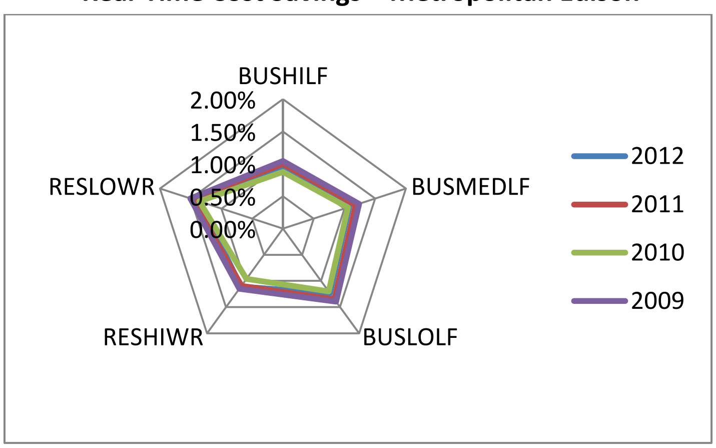


<u>CUSTOMER BENEFITS</u>

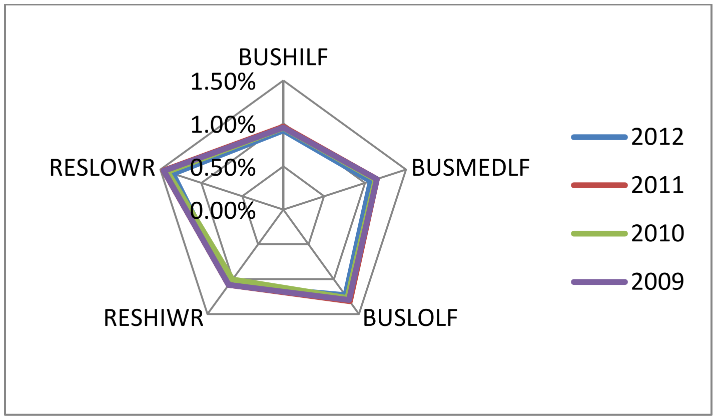
Real-Time Cost Savings – Houston



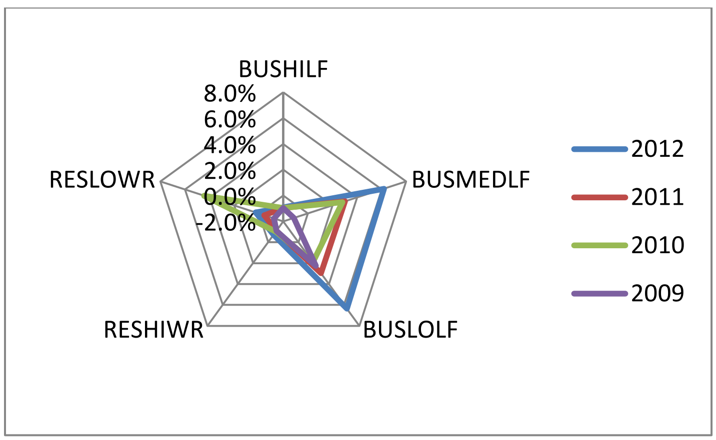
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



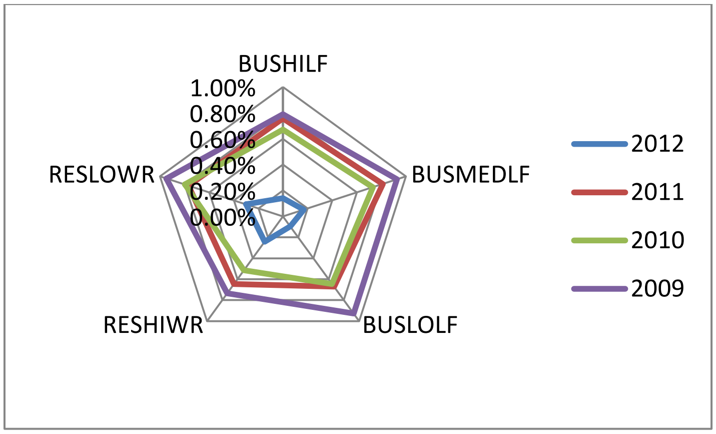
% Change in Load Factor



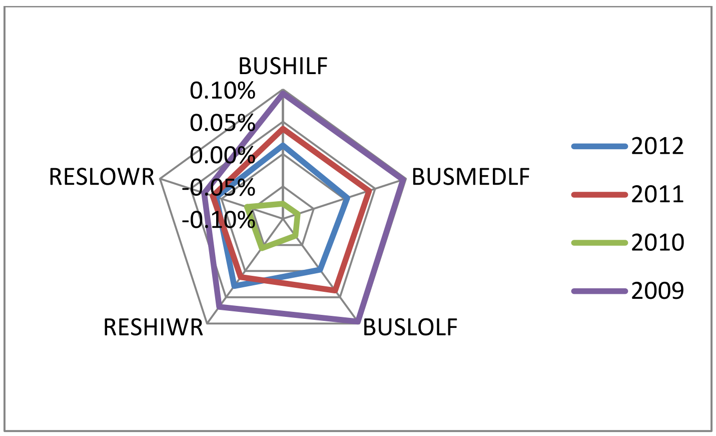
Scenario LH2.2 – Maximum Load Due to Energy Efficient Equipment

ELECTRICITY RETAILERS BENEFITS

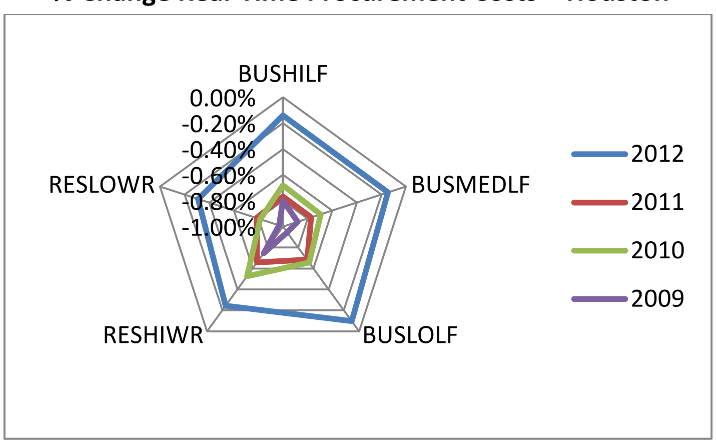
Electricity Retailer Margin – Houston



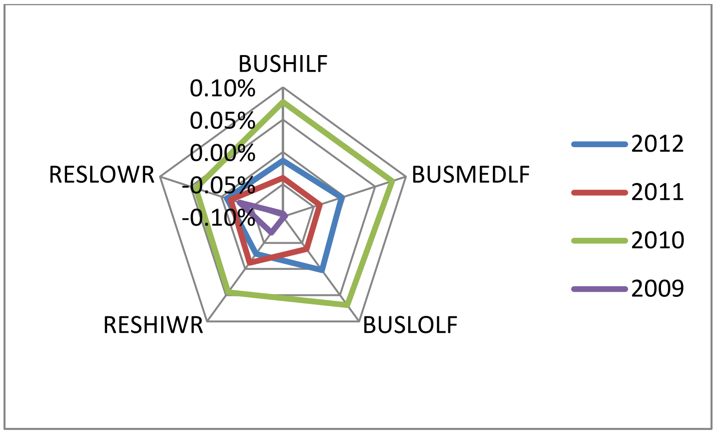
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

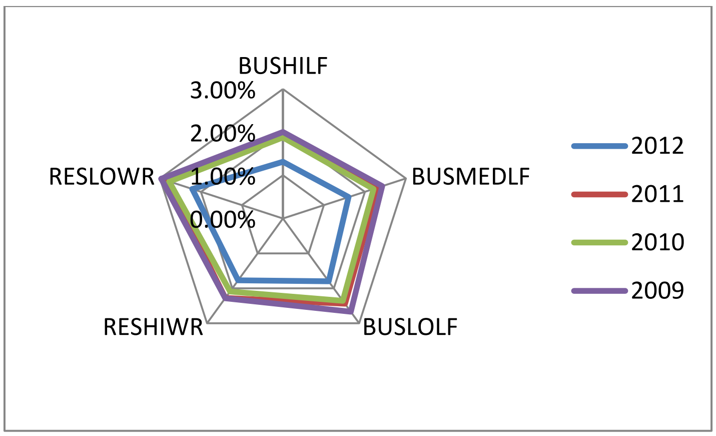


% Change Real-Time Procurement Costs - Metropolitan Edison

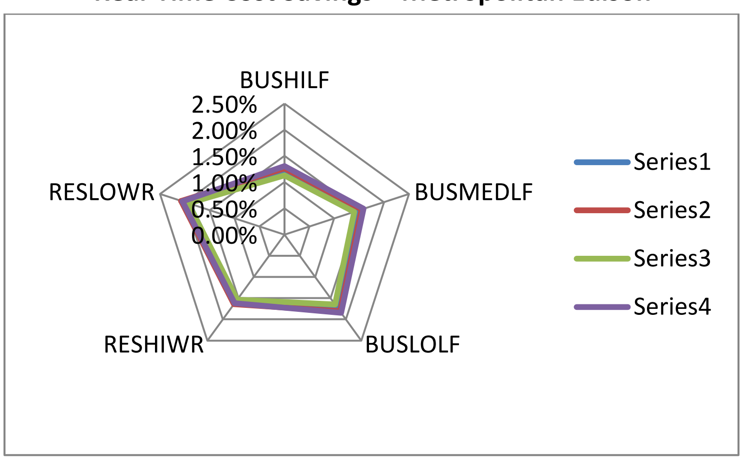


<u>CUSTOMER BENEFITS</u>

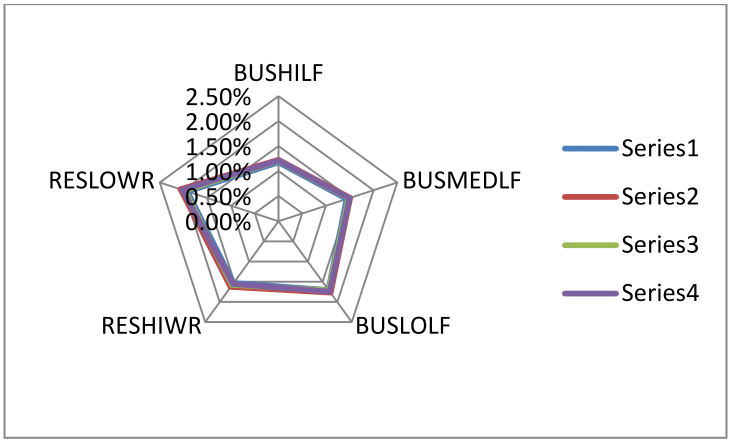
Real-Time Cost Savings – Houston



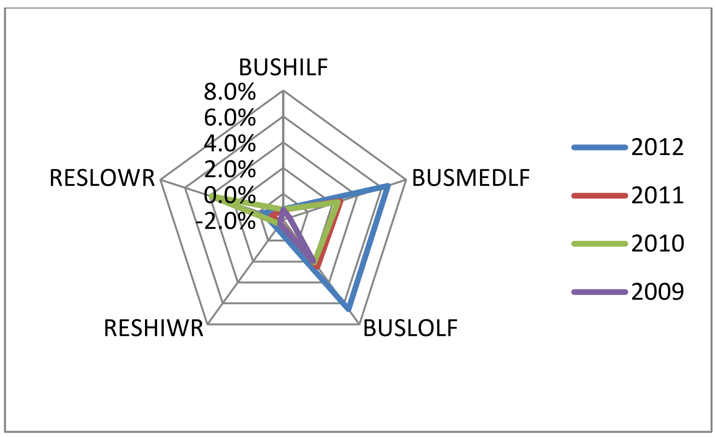
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



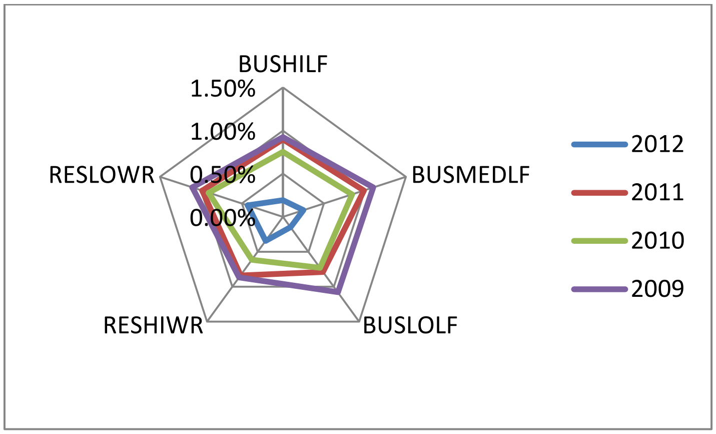
% Change in Load Factor



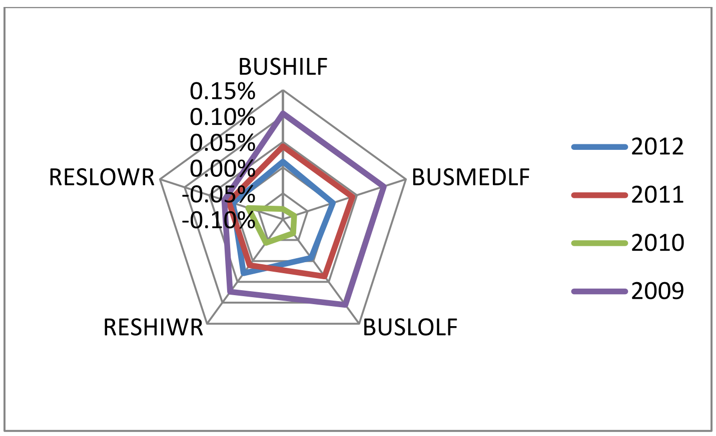
Scenario LH2.3 – Maximum Load Due to Energy Efficient Equipment

ELECTRICITY RETAILERS BENEFITS

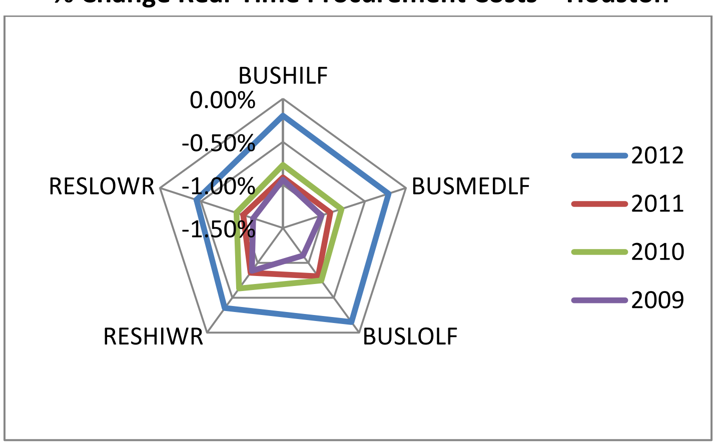
Electricity Retailer Margin – Houston



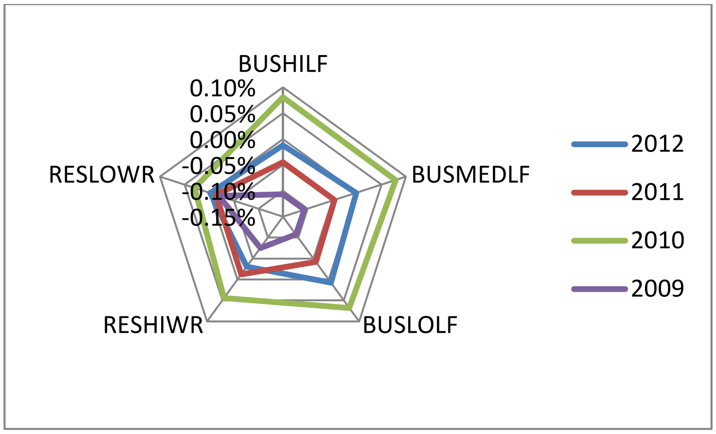
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

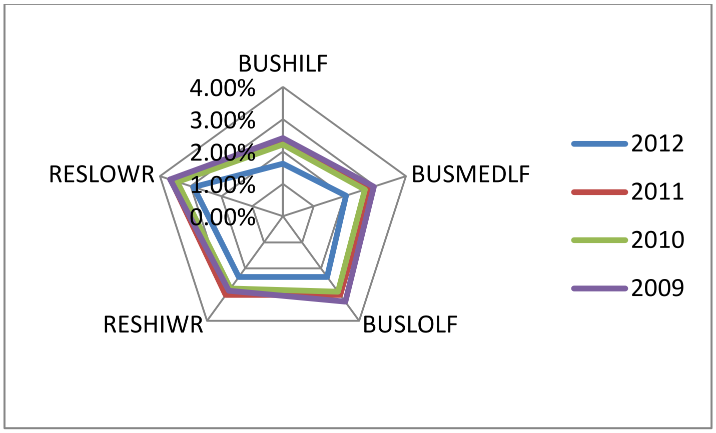


% Change Real-Time Procurement Costs - Metropolitan Edison

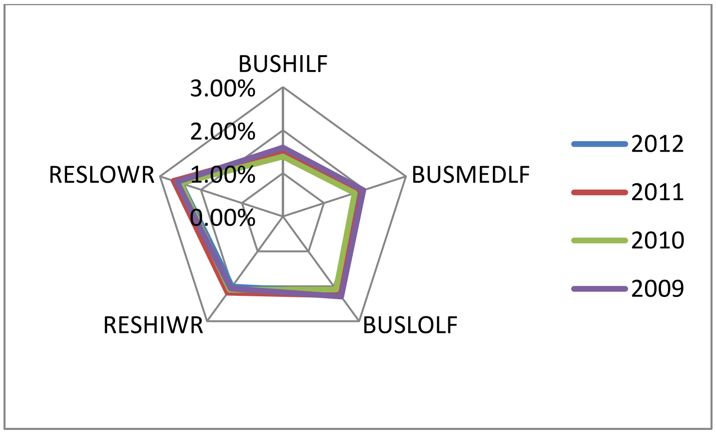


CUSTOMER BENEFITS

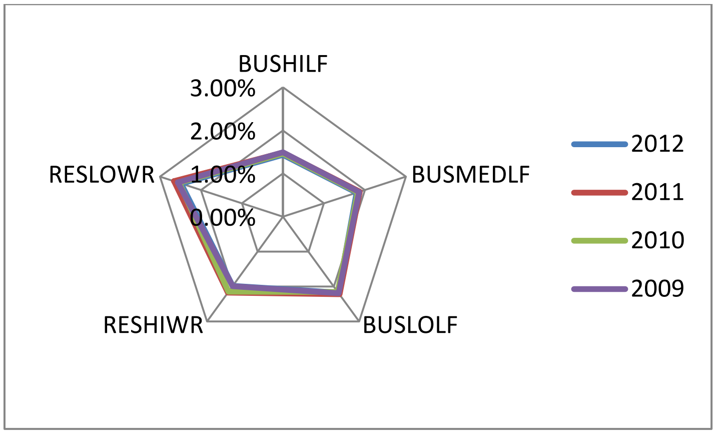
Real-Time Cost Savings – Houston



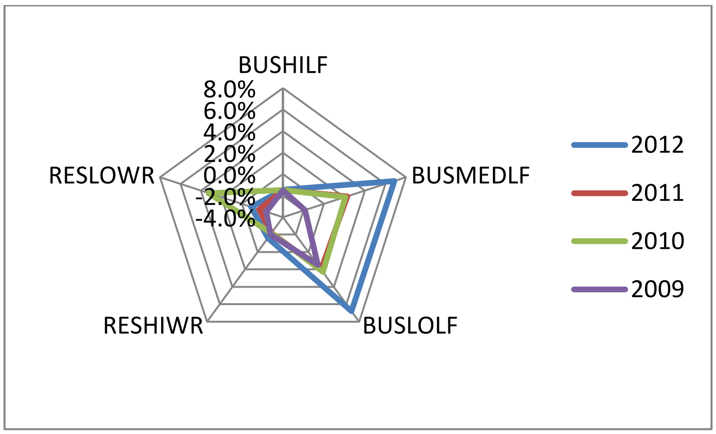
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



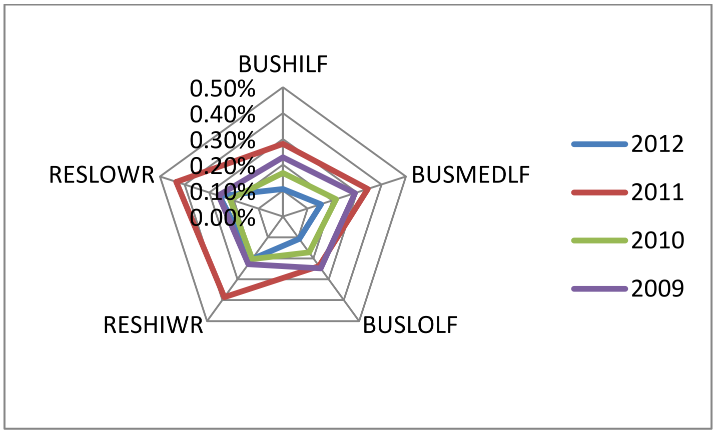
% Change in Load Factor



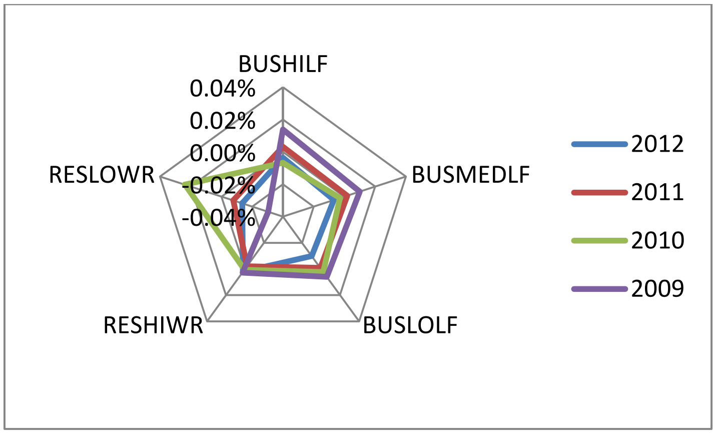
Scenario LH2 – Maximum Load Due to Energy Efficient Equipment – Sensitivity Analysis

ELECTRICITY RETAILERS BENEFITS

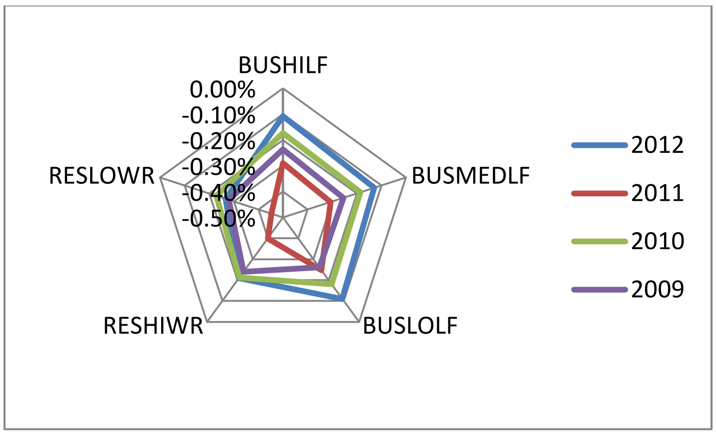
Electricity Retailer Margin – Houston



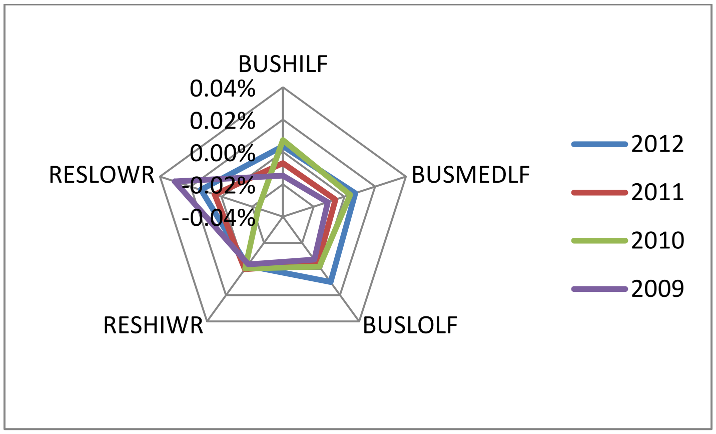
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

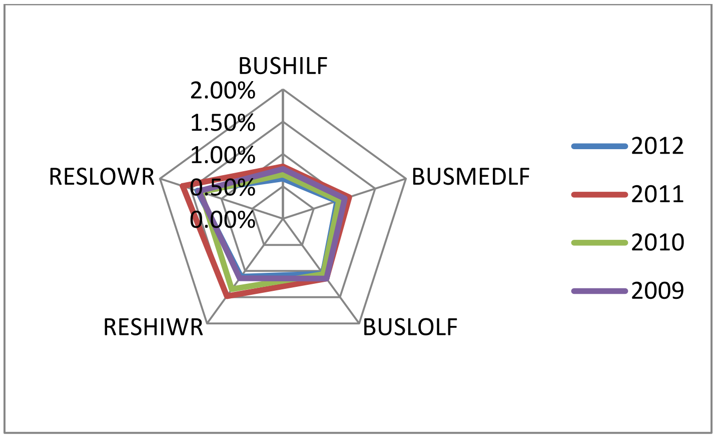


% Change Real-Time Procurement Costs - Metropolitan Edison

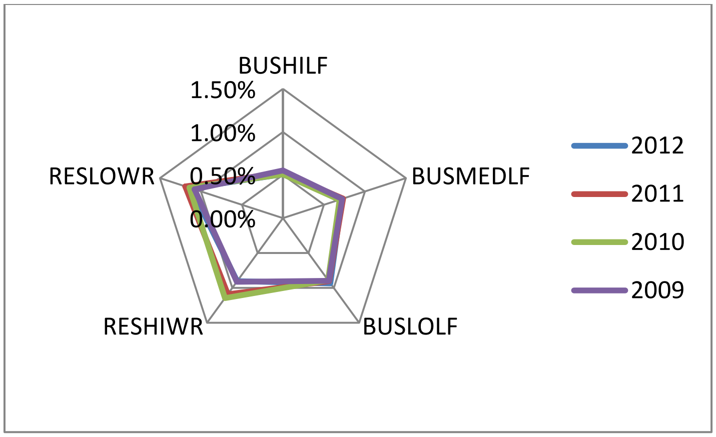


<u>CUSTOMER BENEFITS</u>

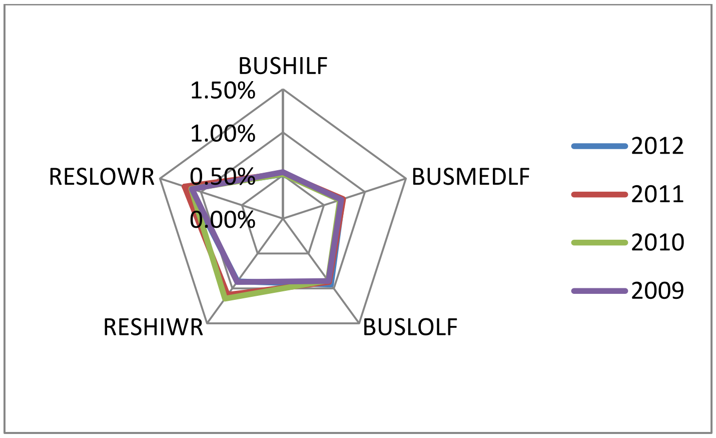
Real-Time Cost Savings – Houston



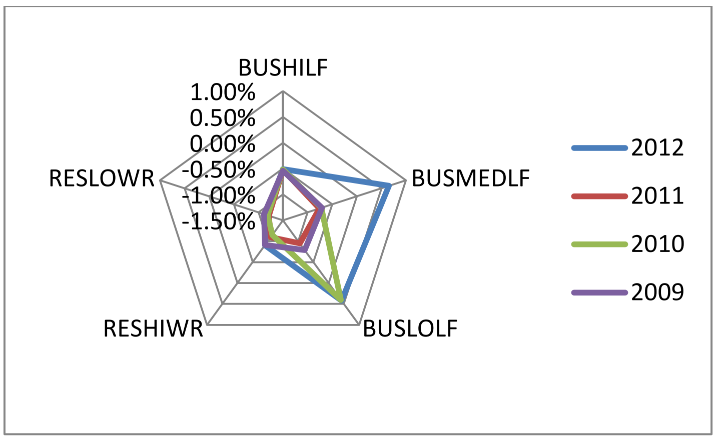
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



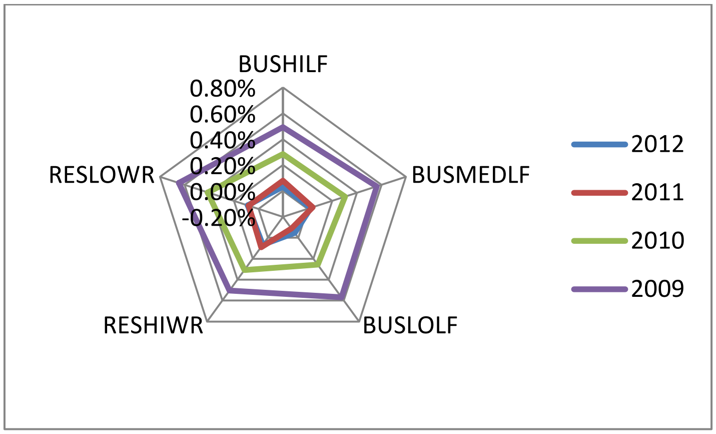
% Change in Load Factor



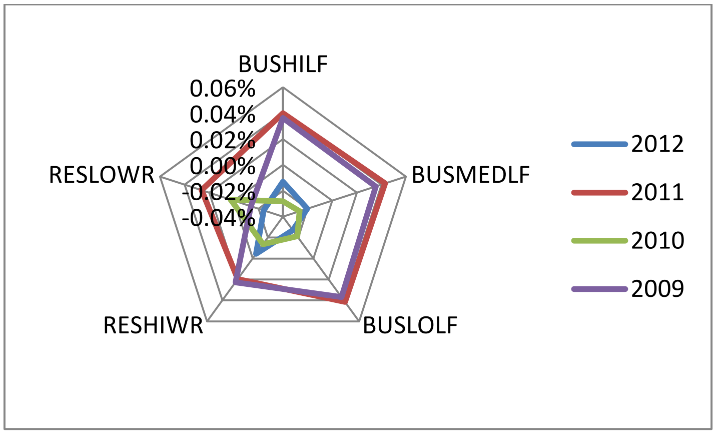
Scenario LH3.1 – Occupancy Schedule

ELECTRICITY RETAILERS BENEFITS

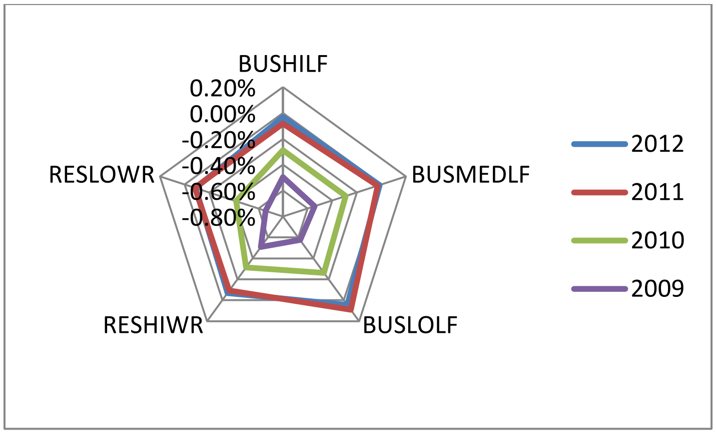
Electricity Retailer Margin – Houston



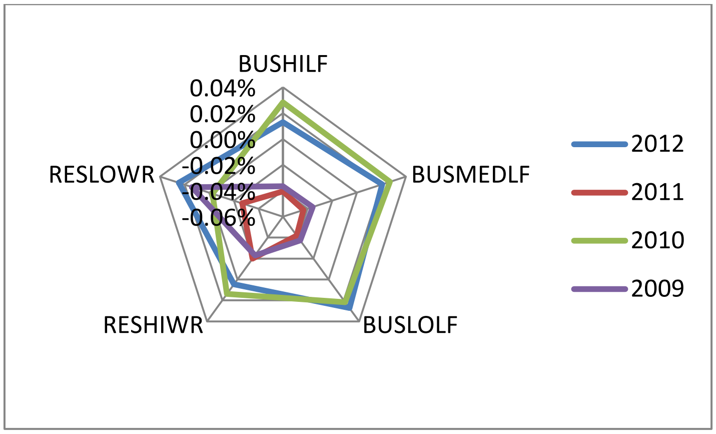
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

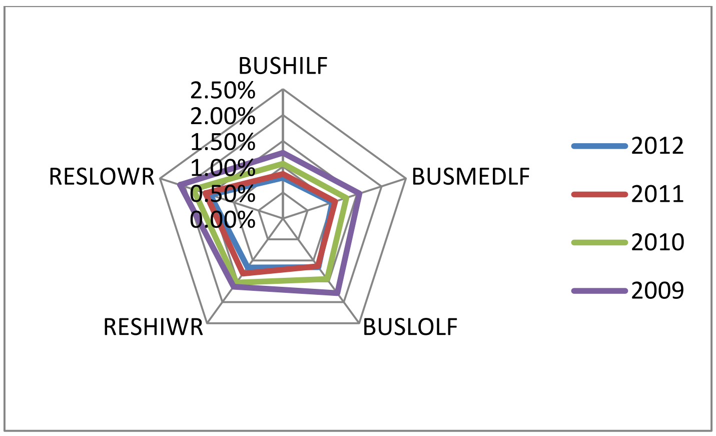


% Change Real-Time Procurement Costs - Metropolitan Edison

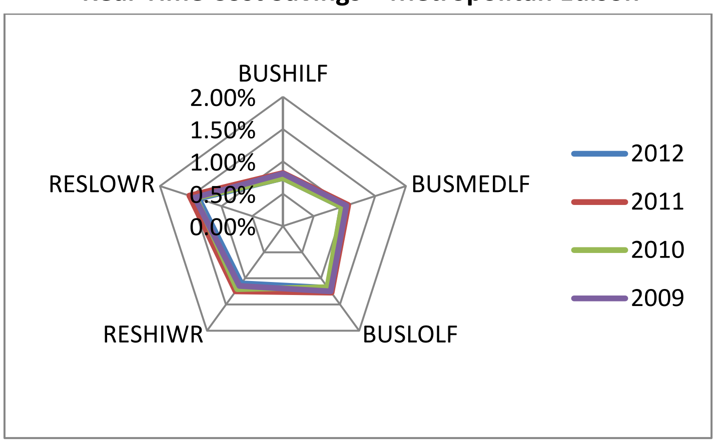


<u>CUSTOMER BENEFITS</u>

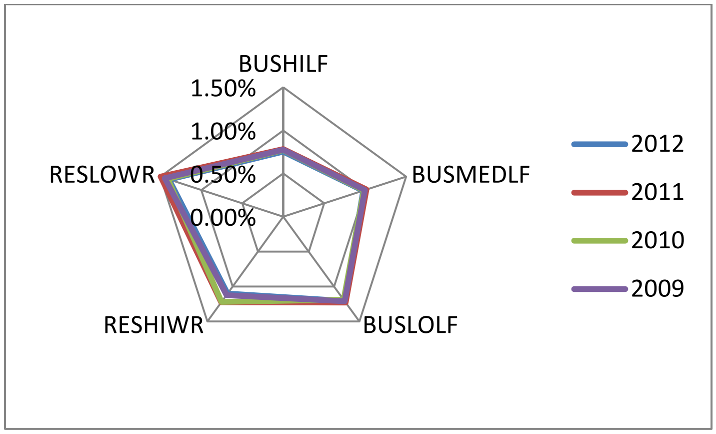
Real-Time Cost Savings – Houston



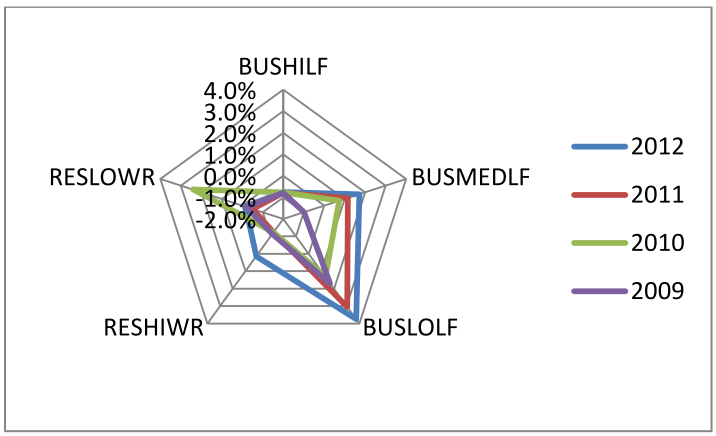
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



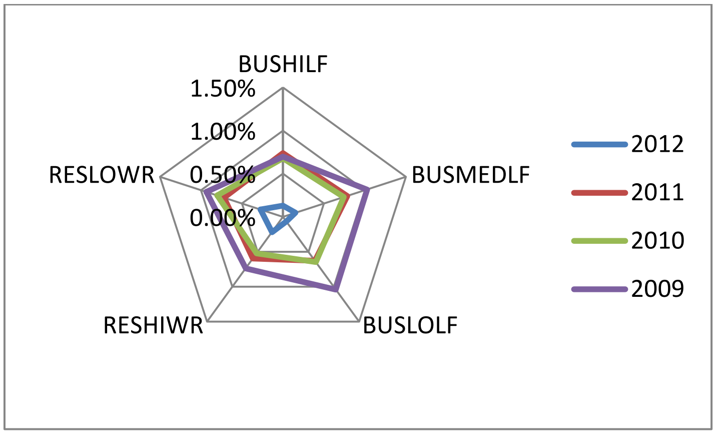
% Change in Load Factor



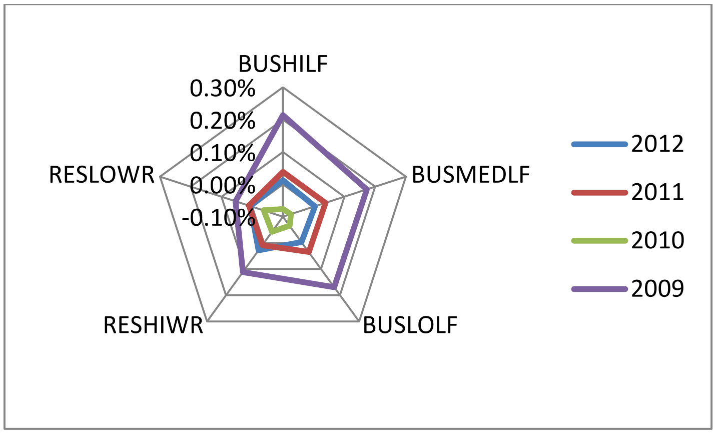
Scenario LH3.2 – Occupancy Schedule

ELECTRICITY RETAILERS BENEFITS

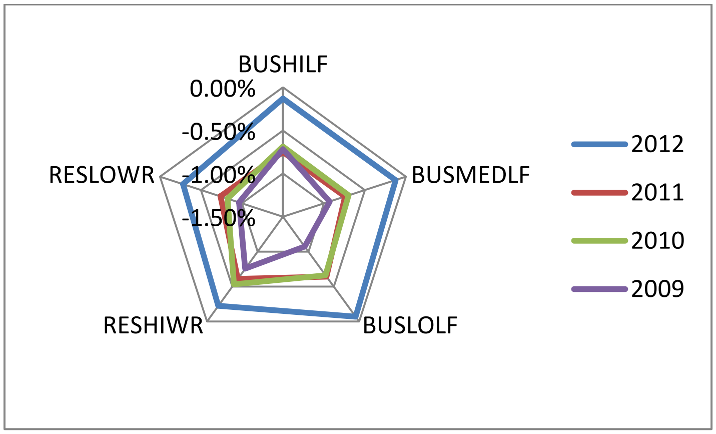
Electricity Retailer Margin – Houston



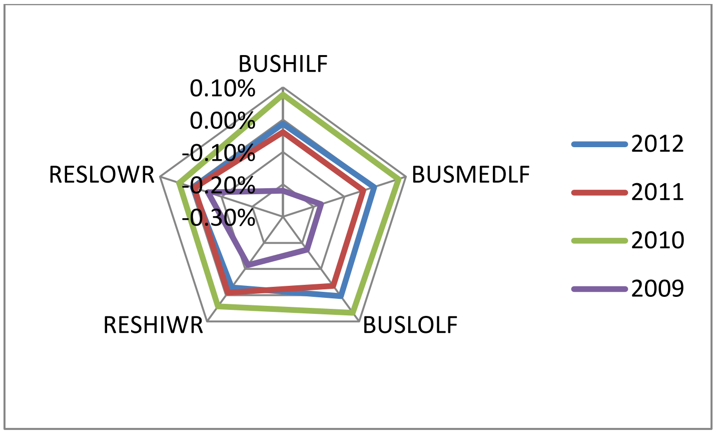
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

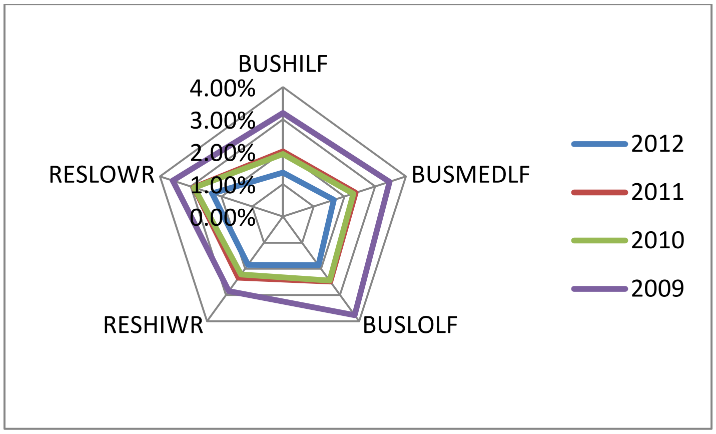


% Change Real-Time Procurement Costs - Metropolitan Edison

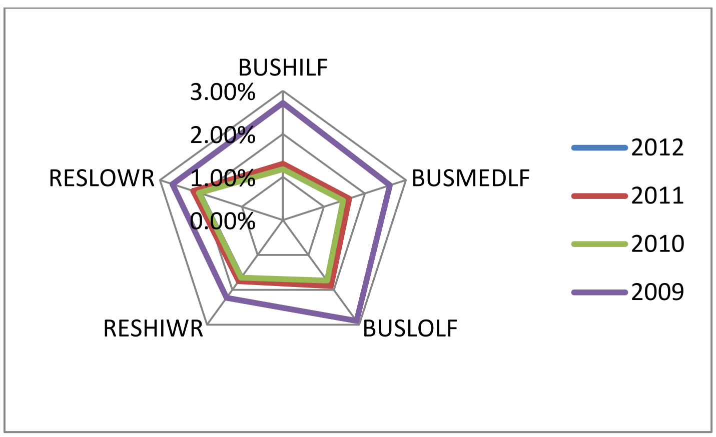


CUSTOMER BENEFITS

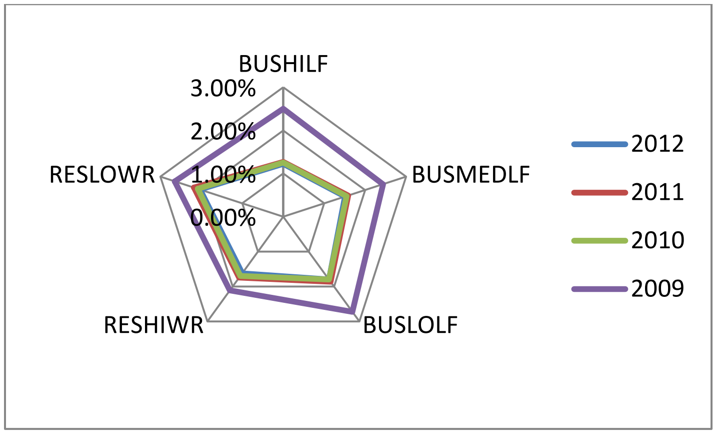
Real-Time Cost Savings – Houston



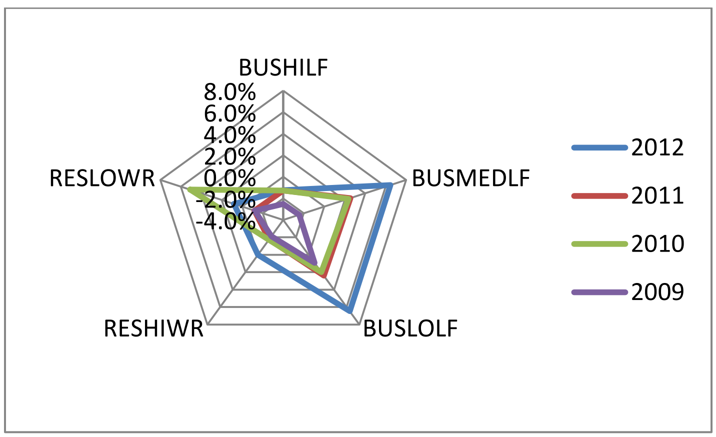
Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



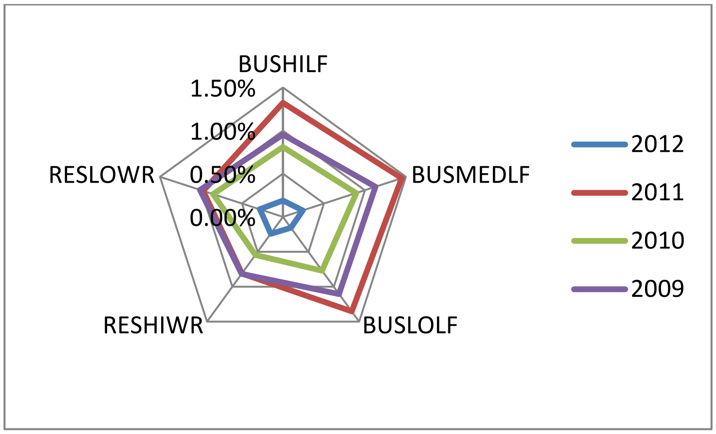
% Change in Load Factor



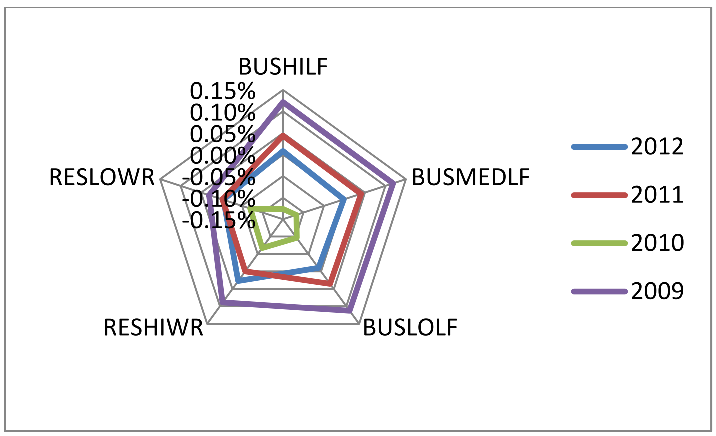
Scenario LH3.3 – Occupancy Schedule

ELECTRICITY RETAILERS BENEFITS

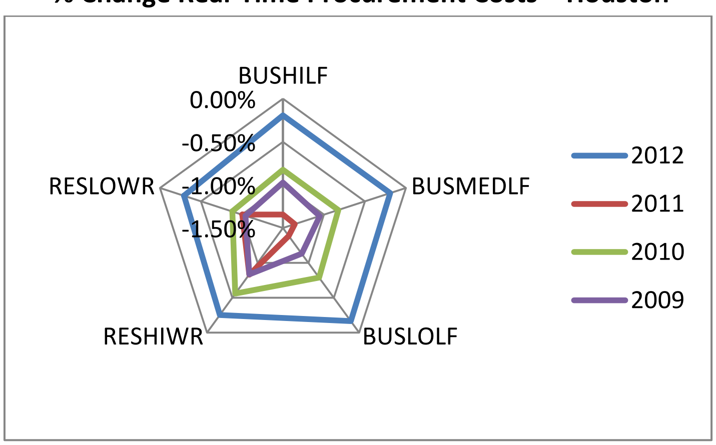
Electricity Retailer Margin– Houston



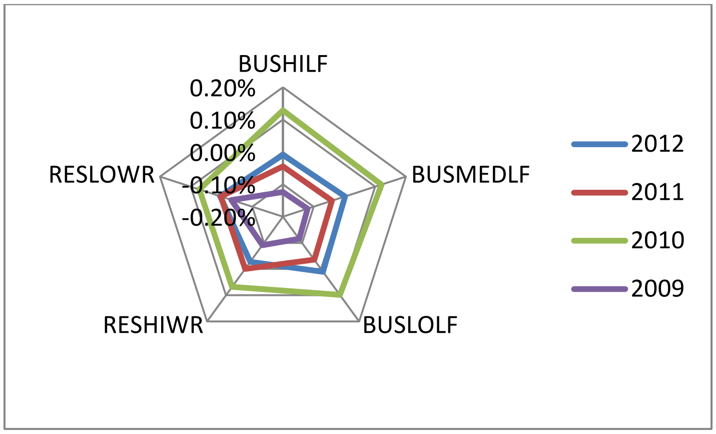
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

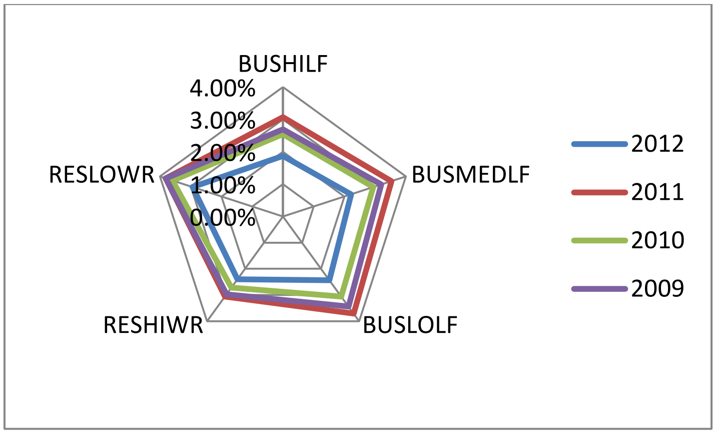


% Change Real-Time Procurement Costs - Metropolitan Edison

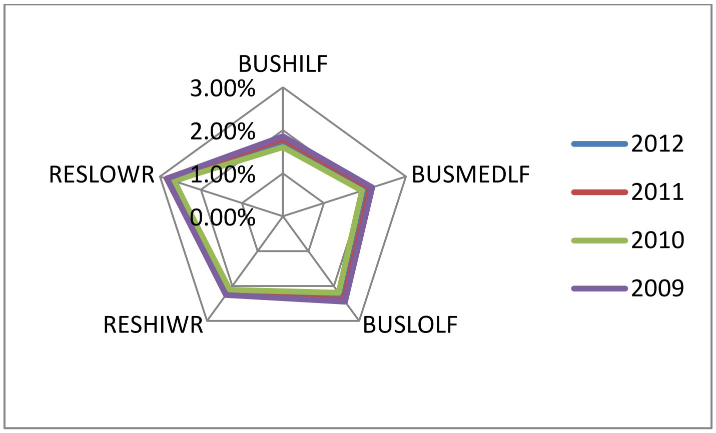


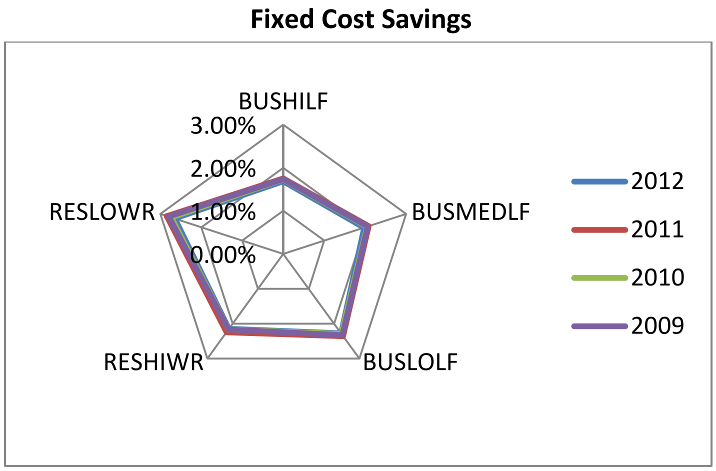
<u>CUSTOMER BENEFITS</u>

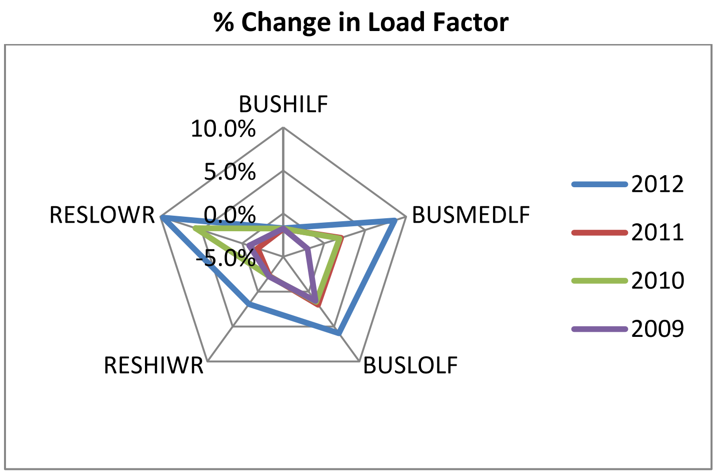
Real-Time Cost Savings – Houston



Real-Time Cost Savings – Metropolitan Edison



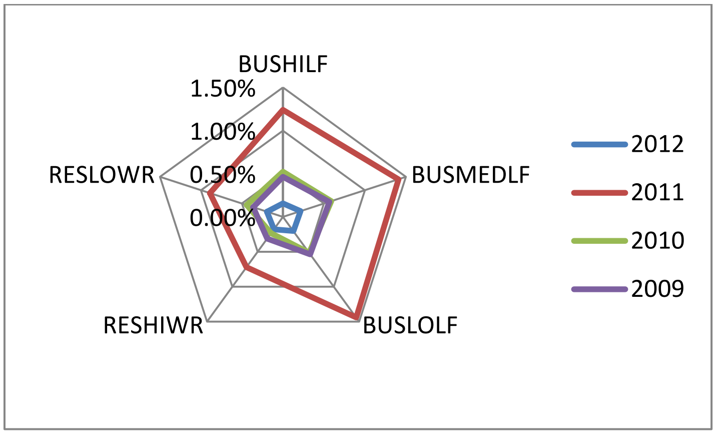

Fixed Cost Savings
BUSHILF
3.00%
2.00%
1.00%
0.00%
BUSMEDLF
BUSLOLF
RESHIWR
RESLOWR
2012
2011
2010
2009


% Change in Load Factor
BUSHILF
10.0%
5.0%
0.0%
-5.0%
BUSMEDLF
BUSLOLF
RESHIWR
RESLOWR
2012
2011
2010
2009

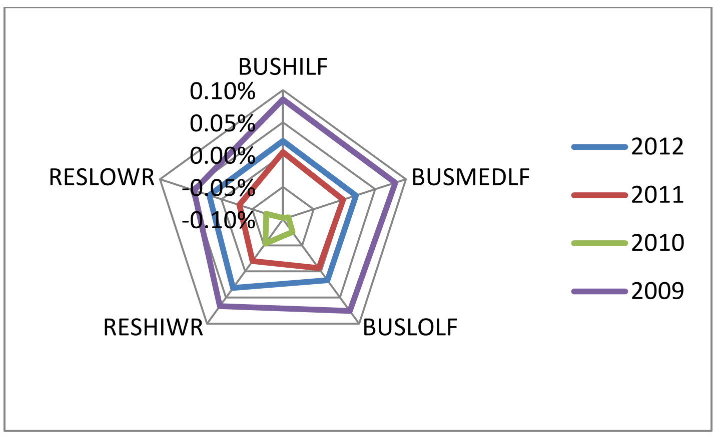
Scenario LH3 – Occupancy Schedule – Sensitivity Analysis

ELECTRICITY RETAILERS BENEFITS

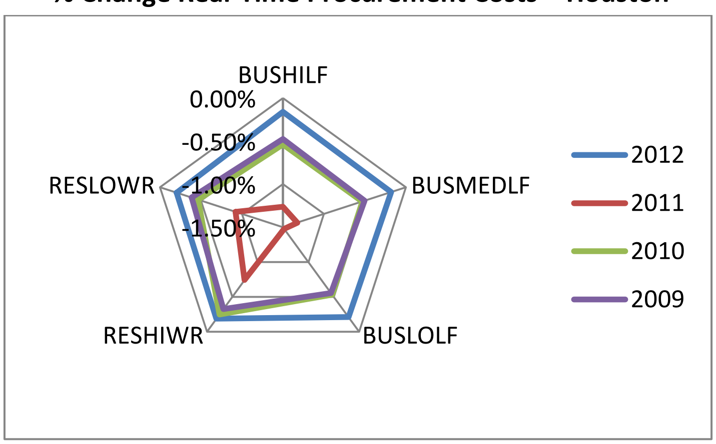
Electricity Retailer Margin – Houston



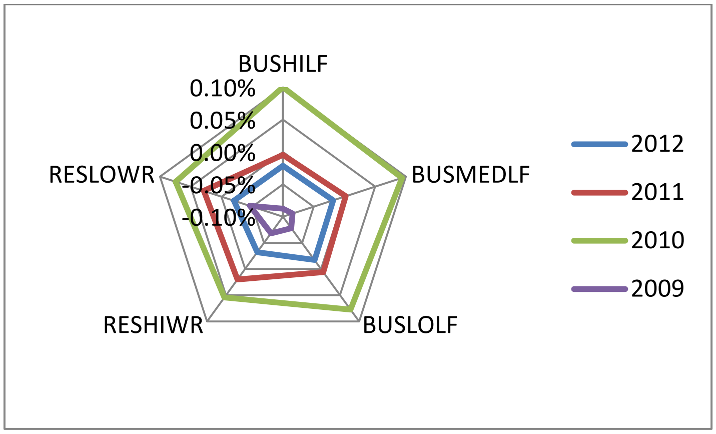
Electricity Retailer Margin – Metropolitan Edison



% Change Real-Time Procurement Costs – Houston

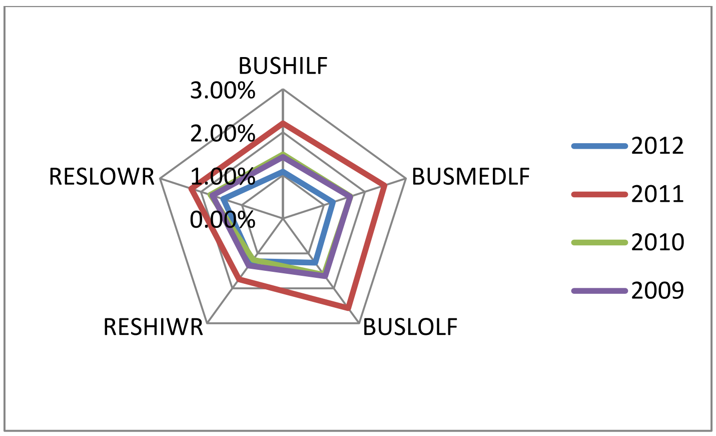


% Change Real-Time Procurement Costs - Metropolitan Edison

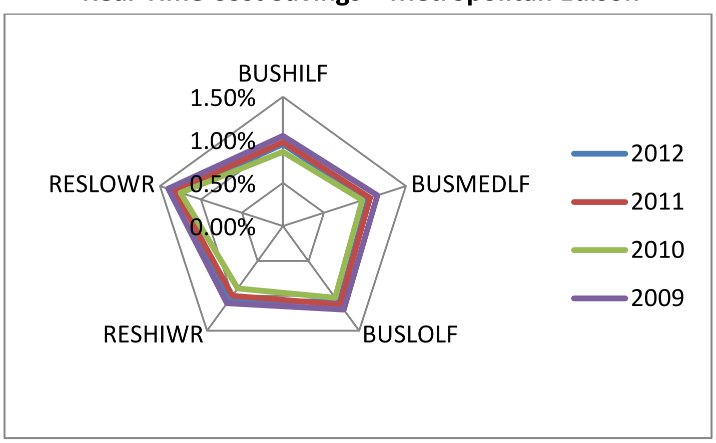


<u>CUSTOMER BENEFITS</u>

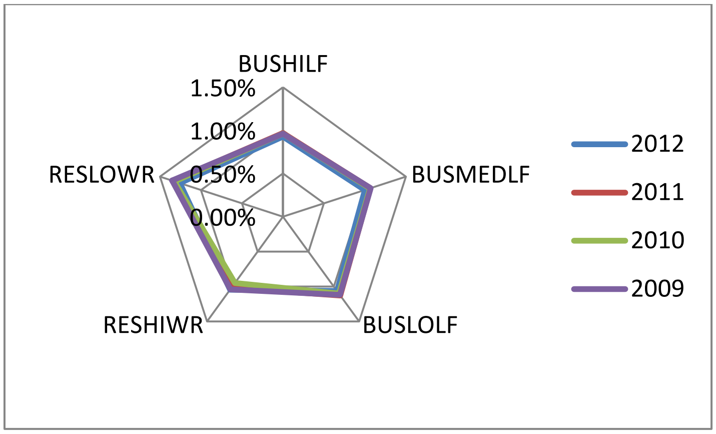
Real-Time Cost Savings – Houston



Real-Time Cost Savings – Metropolitan Edison



Fixed Cost Savings



% Change in Load Factor