Greater Cincinnati Energy Alliance

THE ENERGY EFFICIENCY MARKET IN THE GREATER CINCINNATI REGION:

ENERGY SAVINGS POTENTIAL AND STRATEGIES TO IMPROVE PERFORMANCE OF RESIDENTIAL AND NONPROFIT BUILDINGS

ACEEE American Council for an Energy-Efficient Economy

BETTER BUILDINGS U.S. DEPARTMENT OF ENERGY

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Economics Center

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THE ENERGY EFFICIENCY MARKET IN THE GREATER CINCINNATI REGION: ENERGY SAVINGS POTENTIAL AND STRATEGIES TO IMPROVE PERFORMANCE OF RESIDENTIAL AND NONPROFIT BUILDINGS

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- Working collaboratively with businesses, public interest groups, and other organizations
- Organizing conferences and workshops
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- Educating consumers and businesses

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

University of Cincinnati Economics Center

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Thank you to those who contributed their time to in-person meetings and phone calls and/or who commented on drafts of the report. A list of these people and their organizations is included in Appendix A—Stakeholder Engagement. We hope that none have been overlooked. By naming these individuals and their organizations we do not mean to imply endorsement of the report; instead our intention is to acknowledge their contributions and to thank them.

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EXECUTIVE SUMMARY

This report analyzes the opportunity presented to the Cincinnati region by the Greater Cincinnati Energy Alliance, a local nonprofit organization committed to improving energy efficiency in existing buildings, through its grant work under the Department of Energy Better Buildings Neighborhood Program. The mission of the Energy Alliance is “to facilitate investment in energy efficiency for homeowners, nonprofit organizations, and commercial building owners through outreach and education, project management, and financing solutions” (Energy Alliance 2011). Energy efficiency is important for the regional economy as a whole, but the immediate focus of the Energy Alliance, and this report, is on single-family residential and nonprofit buildings. The four counties currently served by the Energy Alliance are Hamilton in Ohio plus Boone, Kenton, and Campbell in Kentucky. As a result we restrict our analysis in this report to these four counties.

We estimate that thanks to existing utility energy efficiency programs, total electricity consumption in the Cincinnati region will decline at an average annual rate of 0.2% between 2008 and 2030, based on a 0.7% annual decrease in the residential sector and a 0.4% annual increase in the commercial sector (including nonprofits). However, over this same time period we project a 53 to 55% increase in market electricity prices in the residential and commercial sectors due to costs associated with supply-side investments, such as additional generating capacity and transmission- and distribution-related infrastructure. Natural gas consumption presents a different picture. We estimate that total natural gas consumption in the four-county Cincinnati region will grow at an average annual rate of 0.17% between 2008 and 2030, and 0.20% and 0.02% in the residential and commercial sectors, respectively. Gas price increases over the time period are expected to range from 20 to 25% for the market serving the residential and commercial sectors.

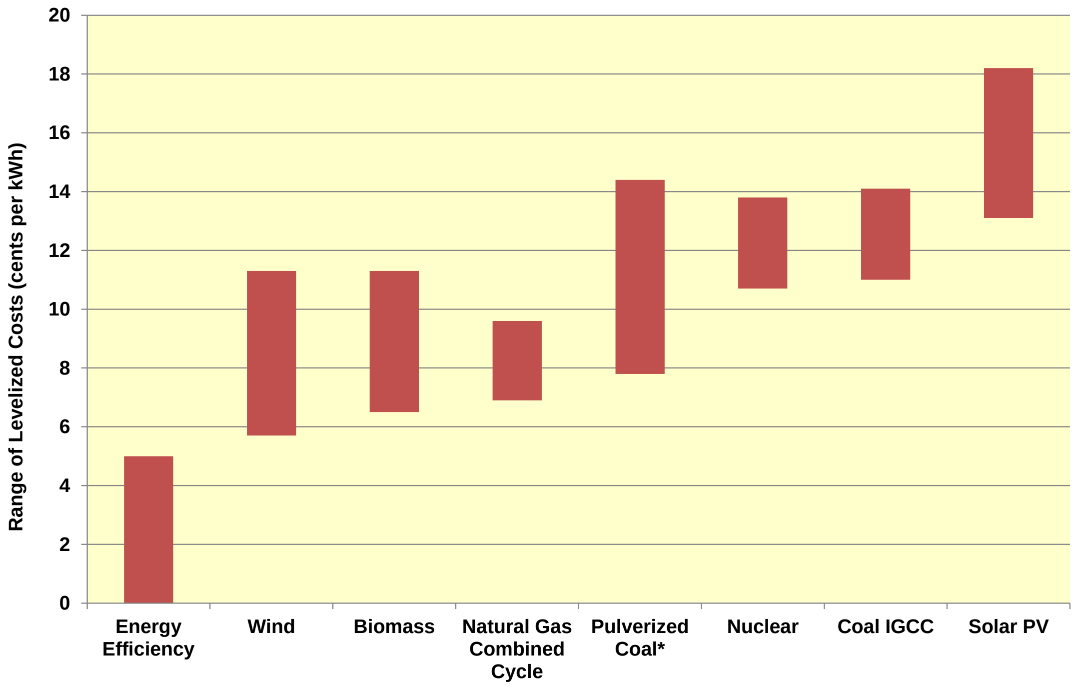
Energy efficiency is a less expensive way to meet energy needs than any supply-side resource. Figure ES-1 shows the cost advantage of energy efficiency from the perspective of electric utilities compared to fuels for generating electricity. The relationship holds for natural gas as well. From an investment perspective, energy efficiency provides relatively high returns with low risk; the returns on typical energy efficiency investments are roughly equivalent to small company stocks while the risks are similar to U.S. Treasury Bills. As a result, additional energy efficiency programs such as those run by the Energy Alliance can decrease the energy costs of households and nonprofits as well as provide additional economic benefits to the region.

Energy Alliance Program Potential

The Energy Alliance currently provides financial incentives to program participants who implement energy efficiency measures. It is also beginning to introduce low-interest loan programs that will allow participants to finance the entirety of their energy efficiency investment. The Energy Alliance’s current offering for residential participants, GC-HELP, is a revolving loan fund that provides financing for all eligible energy-related home improvements at a 6.99% interest rate for up to ten years. It is planning to launch a similar product for the commercial sector to be aimed initially at nonprofit organizations.

The market for the Energy Alliance’s residential programs is about 140,000 households. This includes all owner-occupied, single-family, detached homes in the four counties that are likely to achieve 20% or greater energy savings through sealing and insulation measures alone, and whose occupants have a household income at or above 200% of the poverty level. Households below 200% of the poverty level are served by other existing programs.

Figure ES-1. Electricity Resource Utility Cost Ranges



Notes: All data from Lazard (2009). High-end range of advanced pulverized coal includes 90% carbon capture and compression.

For the nonprofit program, we estimate a total market size of 1,350 buildings occupied by nonprofits within the counties served by the Energy Alliance. As larger buildings are the primary target of the program, we estimate the total number of nonprofit buildings of 25,000 square feet or greater as around 470 buildings.

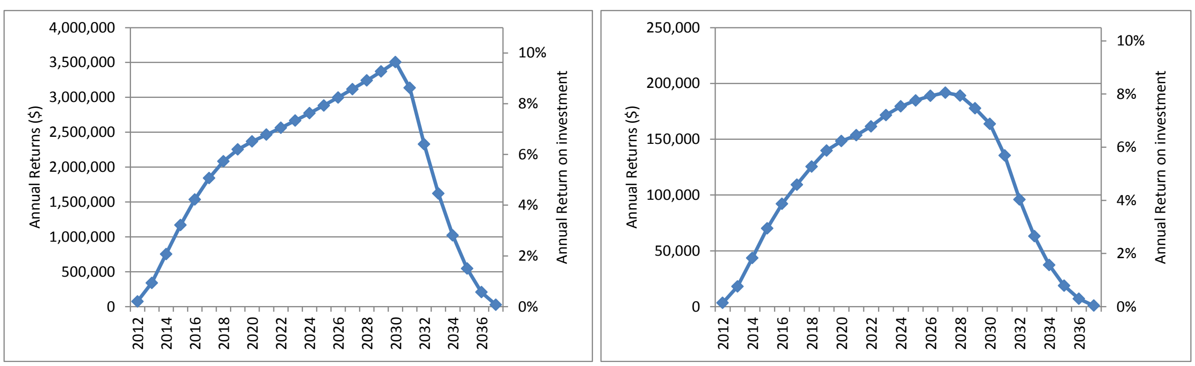
We project that with the implementation of comprehensive energy efficiency programs in line with the Energy Alliance's long-term vision, participation of approximately 69,000 households (2.45% of the market annually on average) and 460 nonprofits (5% of the market annually on average) in making energy improvements through low-interest loans and limited financial incentives by 2030, energy consumers in the region will achieve annual cost savings from reduced energy bills of nearly $22.2 million in 2020 and $59.6 million in 2030. The results for five benchmark years are summarized in Table ES-1. The vast majority of participants in the residential or commercial loan program will see positive cash flow from their energy efficiency investments starting in the first year after installation and continue seeing positive cash flow for fifteen years or more. In addition to the savings on energy costs, the energy improvements will result in a number of non-energy benefits that may be of even greater value to participants such as comfort and improved indoor air quality.

Table ES-1. Energy and Cost Results from Efficiency Investments in the Cincinnati Region

Investments (thousands 2009$)	**2010**	**2015**	**2020**	**2025**	**2030**
New efficiency investments	$ 529	$ 14,270	$16,724	$ 19,716	$ 23,053
Energy Savings					
Electricity (MWh)	179	49,667	117,591	195,078	267,913
As % of forecasted sales	0.00%	0.49%	1.19%	2.00%	2.77%
Natural Gas (MMBtu)	835	253,482	597,559	1,013,009	1,426,814
As % of forecasted sales	0.00%	1.33%	3.04%	5.02%	6.89%
Cost Savings (thousands 2009$)					
Electricity	$ 16	$ 5,566	$14,291	$ 25,241	$ 37,181
Natural Gas	$ 173	$ 3,317	$ 7,896	$ 14,702	$ 22,423
Total	$ 189	$ 8,882	$22,187	$ 39,944	$ 59,604
Payments (thousands 2009$)					
Loan Payments	$ -	$ 5,081	$15,091	$ 18,612	$ 22,375

The revolving loan funds established to meet the financing needs to achieve these energy savings will also provide healthy, low-risk returns to investors in the funds. Assuming the fund will pay out 75% of interest payments made by participants to investors annually, returns could average 5.29% and 4.60% annually from 2012 to 2037, the length of the loan programs, for the residential and commercial funds, respectively. Annual returns for each year are shown in Figure ES-2.

Figure ES-2. Annual Returns on a $37 Million Residential (Left) and $2.4 Million Nonprofit (Right) Revolving Loan Fund



Program Implementation Strategies

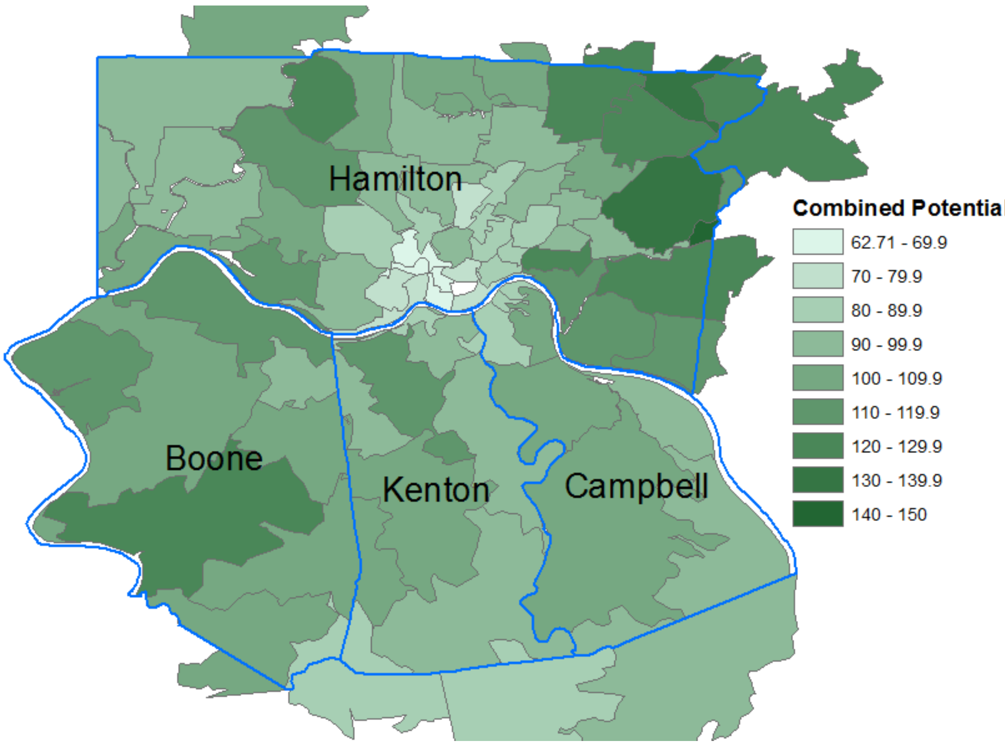
While the program participation rates identified above are high, they are achievable. Innovations in program implementation strategies—such as targeted marketing and contractor partnerships—can contribute to high participation rates and the successful implementation of the programs.

The opportunity to achieve energy savings is not equal across the region. Certain areas have a greater proportion of buildings with higher baseline energy use and characteristics that lead to higher potential energy savings. Additionally, demographic characteristics—like age, income, homeownership status, and education—have been shown to influence the likelihood of participation in energy efficiency programs. Knowledge of these variations can help the Energy Alliance to better target its marketing efforts through data-driven approaches to neighborhood canvasses, outreach to neighborhood-based organizations, and other community outreach.

We have analyzed both building characteristics and demographic variables by ZIP code to develop a combined index of energy savings potential and participation potential. This index, displayed in

Figure ES-3, provides us with a picture of where there are likely to be both above average energy savings potential and above average program participation rates. On this index an energy savings potential equal to the regional average and a participation potential equal to the national average would result in a score of 100. ZIP codes that have higher than average potential are assigned higher scores and those with a lower potential are given lower scores.

Figure ES-3. Combined Residential Energy Saving and Program Participation Potential Index



Beyond the terms of the program and efforts to market the programs, there are several other factors that influence participation. Many of these additional factors relate to the transaction itself including number and quality of transaction opportunity points, ease of transaction, salesmanship and communication about the program at a transaction point, and the motivation of the program messenger to encourage participation.

The Energy Alliance's partner contractors are the key messengers at these transaction points and have great influence on each of these transaction variables. Increasing the opportunities and motivation for contractors to encourage participation in Energy Alliance programs can in turn positively influence program participation. It is helpful to understand the business models of different types of contractors, the number and kind of transaction opportunities available to contractors which could result in participation in Energy Alliance programs, and the factors that would motivate contractors to encourage their customers to participate in Energy Alliance programs.

As a starting point for understanding these issues we have attempted to quantify the market within the Cincinnati region for certain "reactive" transactions (the purchase of replacement equipment as a result of failure or end-of-useful-life) that could be transformed into "proactive" transactions (investment in additional energy-related measures such as air sealing and insulation that will improve energy efficiency and reduce energy or equipment costs) by skilled contractors. Table ES-2 applies data on average appliance lifetimes and Cincinnati region data on residential appliance saturations to calculate an estimated number of average annual purchases for five space and water conditioning appliances. Space conditioning and water heating appliances are large markets, each in the range of

37,000 annual purchases within the Energy Alliance region. On average 7.4% of all households in the four-county region make a purchase in each of these two appliance categories every year.

Table ES-2. Regional Appliance Replacement Rate Estimates

Appliance	Average lifetime (years)[1]	Regional Appliance saturation[2]	Estimated annual purchases[3]
Gas Furnaces	23.68	70%	14,731
Central air conditioners	19.01	75%	19,661
Heat pumps	16.24	10%	3,069
Hot water heater - electric	13	38%	14,567
Hot water heater - gas	13	59%	22,617

1. Based on DOE 2010 and DOE 2011a.
2. Based on Duke Energy Ohio 2009 and Duke Energy Kentucky 2009
3. Based on estimate of 498,342 households for the four-county region from SimplyMap and the 2005-9 American Community Survey

Economic and Environmental Impacts

Energy efficiency investments made through the Energy Alliance programs should cause a chain of impacts on the larger regional economy. In addition to the direct impacts of spending on energy improvements and financing for the improvements, reduced spending on energy bills will result in the reallocation of consumer spending to other sectors of the economy, and subsequently, in additional commercial sector investment reallocation as a result of changes in consumer spending. Table ES-3 presents the forecasted direct, indirect, and induced regional economic impacts from energy savings measures. Our analysis reveals small but net positive increases in regional employment and wages resulting from the Energy Alliance programs. By 2030, net employment should increase by around 317 full-time jobs compared to projected employment in that year without the programs, equivalent to a 0.03% increase in total employment in the four counties. Total wages should increase by $13 million in 2030, an increase of 0.02% above projected wages for that year without the Energy Alliance program. Our analysis suggests that the programs have a net positive impact on gross regional product (GRP) through 2025 but a small net negative impact in 2030, less than one-tenth of 1%. When resulting improvements in productivity are taken into account the GRP impact is transformed into a small net positive in the final years.

Although these employment and wage impacts are admittedly relatively small when compared to an economy that is projected to have over 890,000 jobs accounting for $51.5 billion in income in 2030, the Energy Alliance programs clearly have a net positive impact on employment and wages. The net increase in jobs in 2030 is equivalent to the jobs created by two medium size manufacturing plants locating in the region, assuming each plant has around 160 employees. The increased annual income in 2030 is equivalent to the economic impact of 260,000 additional attendees at Cincinnati Reds games in a season, assuming the average baseball fan spends $50 on ticket and concessions per game.

Table ES-3. Total and Relative Impacts of Energy Alliance Programs on Regional Employment, Wages, and Gross Regional Product from Energy Investments and Cost Savings

Macroeconomic Impacts	2012	2015	2020	2025	2030
Employment (actual)	151	127	166	238	317
Change from Ref Case	0.02%	0.01%	0.02%	0.03%	0.03%
Wages (Million 2009 dollars)	8	6	7	10	13
Change from Ref Case	0.02%	0.01%	0.02%	0.02%	0.02%
GRP (Million 2009 dollars)	9	5	2	0	-2
Change from Ref Case	0.01%	0.01%	0.00%	0.00%	0.00%

Existing research indicates that residential and commercial property values increase due to energy efficiency improvements. Additionally, because of lower energy costs, commercial real estate generally has higher occupancy rates and sometimes commands higher rental rates, resulting in a higher return on investment. For both groups, this leads to higher property values, resulting in higher resale prices and greater economic value to the local community. The current conditions of the housing market potentially increase the market for energy-efficient retrofits and renovations by homeowners. Because many homes are on the market, owners who might otherwise relocate to another part of the metro area could choose instead to stay in their current homes and make energy efficiency investments. These investments will also serve to make existing homes and neighborhoods more competitive against new construction when the housing market rebounds.

We project that the Energy Alliance programs through 2030 will result in annual avoided air pollution emissions in 2030 of 250,000 metric tons of carbon dioxide, 340 metric tons of nitrogen oxides, and 1,640 metric tons of sulfur dioxide. These savings are above and beyond the savings from existing and planned utility-run energy efficiency programs. The emissions reductions for each pollutant under the twenty-year scenario are shown at five-year intervals in Table ES-4.

Table ES-4. Annual Avoided Emissions Estimates from the Energy Alliance Energy Efficiency Programs (Metric Tons)

	2010	2015	2020	2025	2030
Carbon Dioxide	172	46,660	110,473	183,270	249,817
Nitrogen Oxides	0.100	64	151	250	341
Sulfur Dioxide	0.002	306	725	1,203	1,640

Conclusions

Our analysis of the greater Cincinnati market and the Energy Alliance programs shows considerable potential consumer energy cost savings, including positive cash flow from energy cost savings that consistently exceed loan payments, for both residential and nonprofit participants. Investment in energy efficiency would make Hamilton, Boone, Kenton, and Campbell counties more competitive, create jobs, reduce pollution, and help homeowners and nonprofits make cross-cutting building improvements.

INTRODUCTION

The Cincinnati region is a community with a rich history reflected in its built environment. Existing buildings provide a core asset to maintaining and cultivating a sense of place in the region, an essential component of attracting human capital in a globalized world, and offer the practical physical infrastructure needed for vigorous economic activity. Additionally, Cincinnati is endeavoring to establish its reputation as a hub of innovation with a high quality of life, as reflected in regional planning efforts such as Agenda 360 and Vision 2015. Energy efficiency provides a strategic opportunity at the intersection of these two regional priorities of competitiveness and place-based investment.

The core counties of the Cincinnati region are largely built out and not experiencing much new construction in comparison to existing stock. Although this existing building stock is a community asset, much of it is also a liability from the perspective of energy use and related costs. Improvements in the energy performance of existing buildings will help improve and maintain the structures and also aid the region in staying competitive. Energy efficiency is a sound investment with positive economic returns and, in many cases, is a better choice than more traditional investment options. Additionally, the investments required for and cost savings resulting from energy efficiency improvements will create and retain jobs within the region.

The Greater Cincinnati Energy Alliance

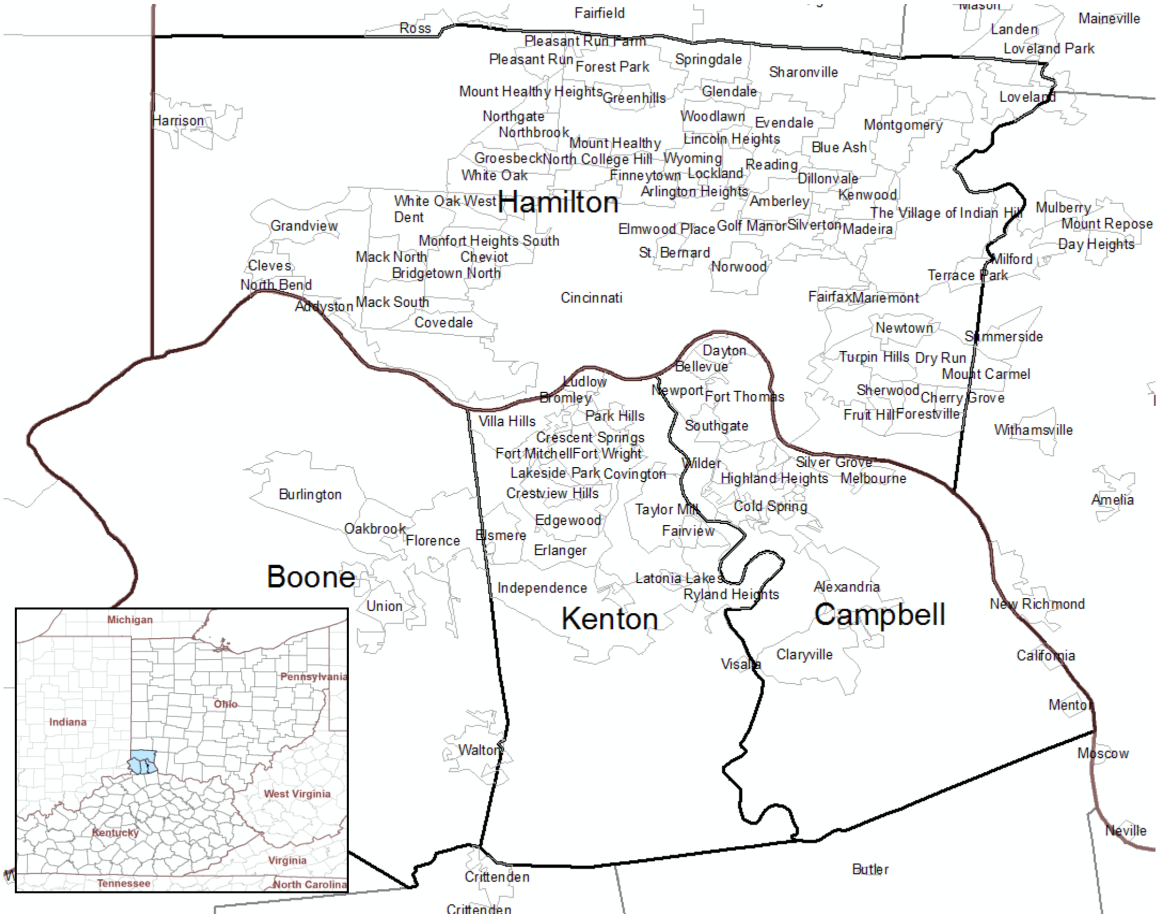
This report analyzes the opportunity provided to the Cincinnati region by the Greater Cincinnati Energy Alliance, a local nonprofit organization committed to improving energy efficiency in existing buildings, through its grant work under the Department of Energy Better Buildings Neighborhood Program. The mission of the Energy Alliance is “to facilitate investment in energy efficiency for homeowners, nonprofit organizations, and commercial building owners through outreach and education, project management, and financing solutions” (Energy Alliance 2011).

Energy efficiency is important for the regional economy as a whole, but the immediate focus of the Energy Alliance, and this report, is on single-family residential and nonprofit buildings. In choosing this focus, the Energy Alliance decided to invest in the people of the region in addition to its buildings. Energy improvements in residential buildings can have significant positive impacts on household budgets by reducing utility bills, improving the overall financial situation of families, increasing property values, and freeing up funds to be spent in the local economy and on family priorities. Helping local nonprofits—who provide the social and cultural heart of the region—to improve their energy performance and reduce their operating costs allows those organizations to spend more of their limited funds on their core mission.

The Energy Alliance helps to address barriers to energy efficiency implementation in these important sectors. Households often do not understand the energy and money savings opportunities provided by energy efficiency, do not have the time or information to make informed decisions about cost-effective energy improvements, and may not be able to easily access funds to pay for the upfront costs of energy improvements. In addition to these and other barriers seen in the owner-occupied residential sector, nonprofits have additional barriers such as split incentives between building owners and occupants and a reluctance to make use of debt financing or make capital investments outside of their core program areas.

The four counties currently served by the Energy Alliance are Hamilton in Ohio plus Boone, Kenton, and Campbell in Kentucky. The service territory is displayed in Figure 1. This area includes the city of Cincinnati and the other original river cities in Northern Kentucky, which collectively include the largest share of older single-family housing stock and the core of the urban area where the majority of nonprofit organizations are located. For the purpose of this study, the Cincinnati region will be defined as this four-county area served by the Energy Alliance.

Figure 1. The Four-County Greater Cincinnati Energy Alliance Service Region and Municipalities



Cincinnati Region Energy Efficiency Stakeholders

Energy efficiency is important to a wide range of stakeholders in the Cincinnati area. In undertaking this study we endeavored to talk to representatives of as many stakeholder groups as possible, including energy utilities, economic and community development advocates, associations for nonprofit organizations, business associations, state government, local government, regional agencies, and building contractors. In our conversations with stakeholders we wanted to learn more about the region's political climate, energy structure, and economic needs. We were also interested in learning about the perceptions, interests, or concerns of the individual stakeholders and their organizations regarding energy efficiency. We asked about the related activities in which they were currently engaged and their opinions about options for addressing barriers to energy efficiency adoption. Appendix A—Stakeholder Engagement provides a list of many of the stakeholders consulted over the course of our research.

There is a wide range of stakeholders in enhancing energy efficiency. Most stakeholders can be classified as belonging to one (or more) of three groups:

- Beneficiaries (all consumers: households and businesses, including nonprofits);
- Advocates (environmental and economic development nonprofits, government); and
- Drivers of energy efficiency practice (financial institutions, the Energy Alliance, energy efficiency industries, and utilities).

Each group typically has a variety of concerns; these may also be categorized under three broad themes:

1) Distributing and marketing of information to consumers and the public;
2) Improving the regional economy; and
3) Generating financial support.

Marketing, informing, and educating the public will help increase the implementation and consumer usage of energy efficiency practices throughout the Energy Alliance service area. Therefore, the first area of concern is distributing and marketing of information to consumers and the public to help overcome information barriers to energy efficiency investment. This includes informing consumers of energy efficiency and household consumption patterns; educating consumers to increase consumer awareness; and providing direct marketing outreach and community-based programs to increase public participation and energy savings. The stakeholders with these concerns are advocates, beneficiaries of energy efficiency investment, and drivers of efficiency practice that see increased energy efficiency investment as in their interest.

The second major area of concern is increasing spillover impacts from energy efficiency. Spillover impacts are the indirect benefits to the economy that result from investments in energy efficiency. This area of concern is important to the economic growth of the regional economy. It includes creating educational and employment opportunities in energy efficiency; providing energy use alternatives and becoming less dependent on imported fuels; training local workforce to identify, implement, and operate efficiency measures; and coordinating programs to make energy efficiency investments in buildings. The stakeholders that are concerned with spillover impacts are primarily advocates who understand the relationship between energy efficiency and economic productivity.

The third major area of concern is generating financial support and investment. This includes developing financial incentives; establishing financing options for energy efficiency; and identifying financial terms that work for financial institutions, consumers (households and businesses), and other stakeholders such as utilities. Creating financing options for consumers can enable greater energy efficiency investments and more efficient use of capital to allow a larger number of consumers to make efficiency investments using limited funds while potentially attracting more investment to the market. The stakeholders with these interests are the drivers or facilitators of energy efficiency investment, ranging from the Energy Alliance and various lenders to industries engaged in producing and installing energy efficiency technology.

In this report we will discuss issues of interest to each of these stakeholder groups.

A Cincinnatus Moment

Lucius Cincinnatus was a citizen of the Roman Republic who at a time of crisis was called upon to act as dictator of Rome. When the crisis had passed he immediately resigned from his position of power and returned to working his farm in order to allow the Republic to return to democracy. Cincinnatus and his story have come to be seen as embodying the best aspects of public service, civic virtue, leadership, and modesty. Cincinnati was named after the Society of the Cincinnati, an American civic organization devoted to honoring the values that Cincinnatus, and later President George Washington, represented. As we will show in the remainder of this report, efforts to catalyze greater investment in energy efficiency in the region, including those by the Energy Alliance, provide an opportunity to carry on this tradition of civic leadership and as a result provide great dividends to the economy and quality of life, benefiting all residents in the region.

REGIONAL ENERGY MARKET

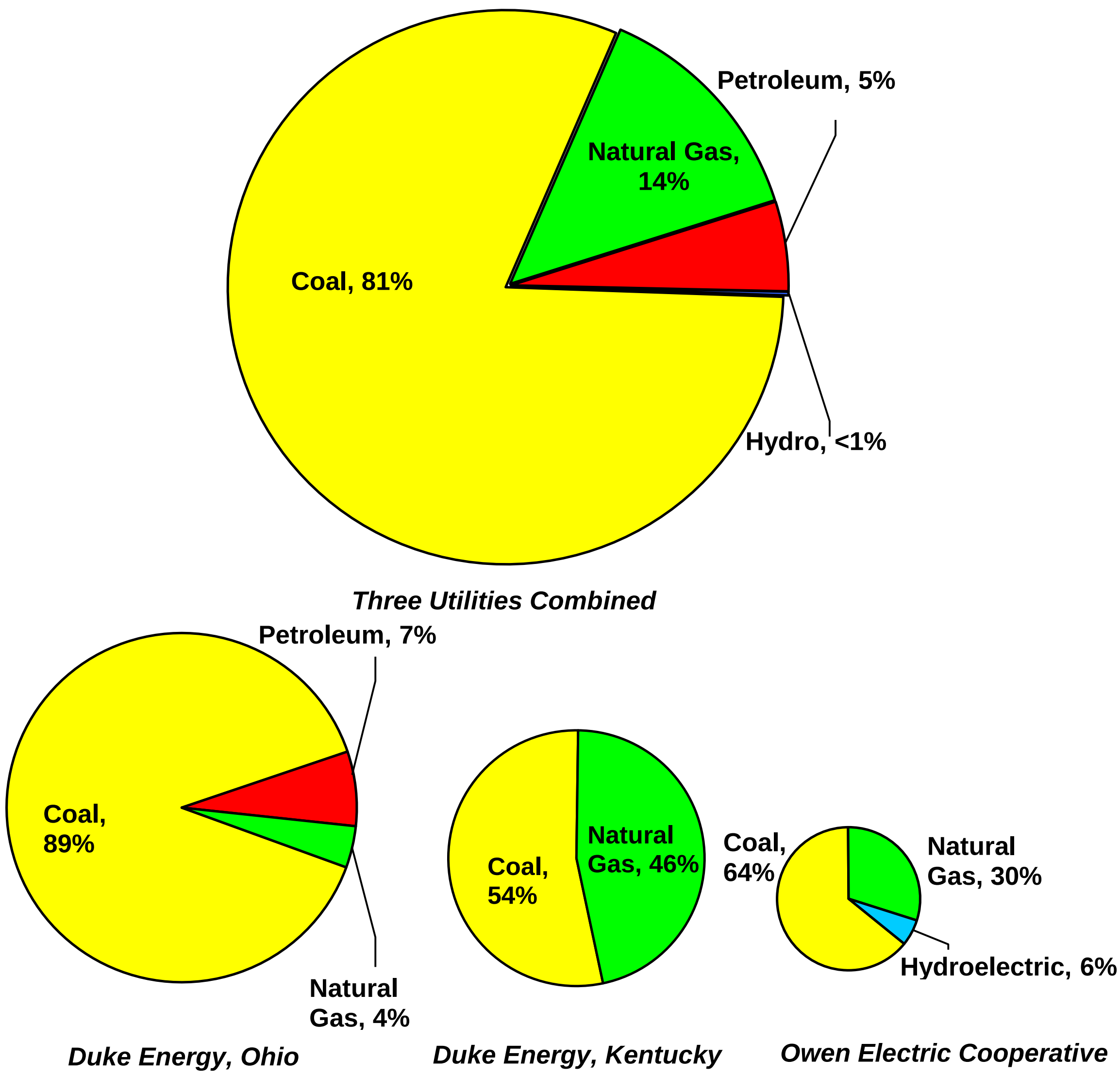
How did we get to where we are now?

Energy Providers & Electricity Generation Fuel Mix

Retail electricity in the four-county Cincinnati region is provided predominantly by two investor-owned utilities (IOUs) and one electric cooperative: Duke Energy Ohio (64.5%), Duke Energy Kentucky (28.7%), and the Owen Electric Cooperative (6.8%), a member of the East Kentucky Power Cooperative (EKPC) (EIA 2010a).

In Figure 2 below, we show the combined electricity generation fuel mix of the three utilities throughout their service territories as well as the fuel mix for the three individual utilities. It is important to note that these utilities also purchase electricity generated by other companies to sell to their retail customers. Coal dominates the fuel mix overall as well as for the individual utilities, as the source for 81% of electricity generation in the service territories.

Figure 2. Electricity Generation by Fuel Type for Utility Companies Serving the Cincinnati Region

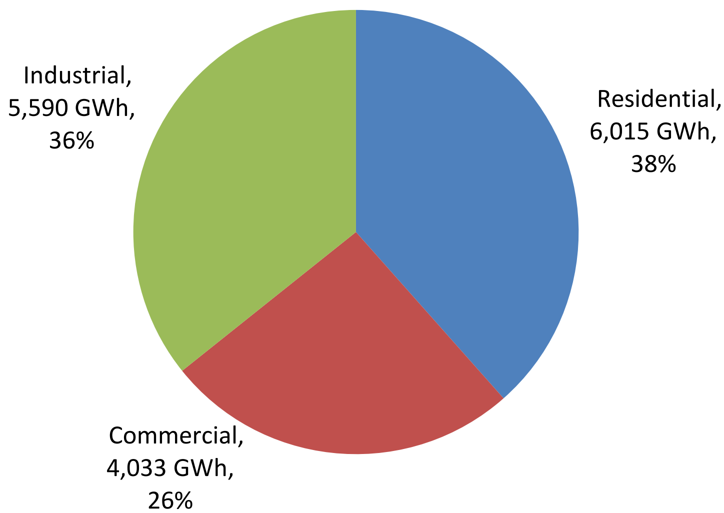


Sources: Duke Energy Ohio 2010a, Duke Energy Kentucky 2008, and EKPC 2009. Percentages for the region as a whole vary from the utility fuel mix due to rounding.

Energy Use by Sector

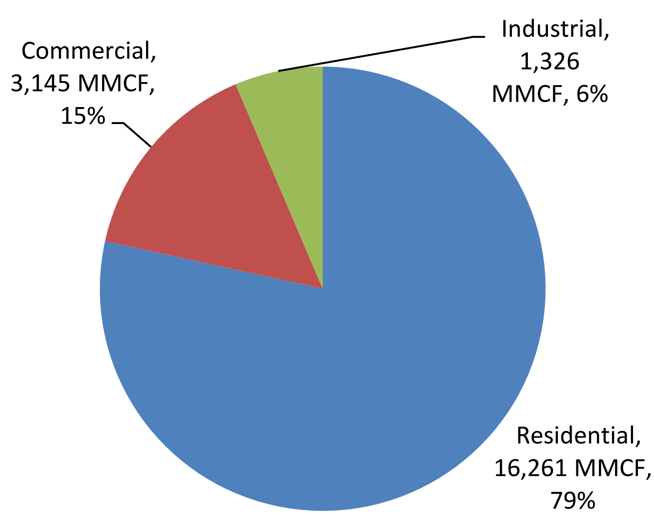
Electric energy use is typically attributed to three major sectors: residential, commercial (private and public sector office and retail space), and industrial (manufacturing facilities). Electricity use in the four-county Cincinnati region amounted to approximately 16,000 GWh in 2009. As shown in Figure 3, 38% of this was by residential customers, 26% by commercial customers, and 36% by industrial customers.

Figure 3. 2009 Electricity Sales by Sector



Natural gas sales by the two natural gas utilities, Duke Ohio and Duke Kentucky, total appoximately 21 billion cubic feet of natural gas in 2009. As shown in Figure 4, of these sales 79% are residential, 15% are commercial, and 6% are industrial.

Figure 4. 2009 Natural Gas Sales by Duke Ohio and Duke Kentucky by Sector



Reference Case

The first task in this project is to develop a reference case forecast of electricity and natural gas consumption and retail energy prices for the greater Cincinnati region. The reference case is used as a baseline by which we can measure the impacts of our individual and collective policy/program recommendations on energy consumption, retail prices, and emissions. These impacts are then fed into our macroeconomic analysis to determine the effects on economic growth and job creation, which we discuss further below. In this section we report the reference case assumptions for the analysis time period, 2008–2030, for the residential and commercial sectors only, as these two sectors are the focus of our program analysis in this study. One caveat to note is that all projections are subject to uncertainty, particularly during a period when the economic outlook is a major unknown. It is important to understand that while the forecast will affect the numbers, it has no impact on the effectiveness of the proposed policies. In other words, the *percentage* changes for energy savings are not affected by the forecast assumptions.

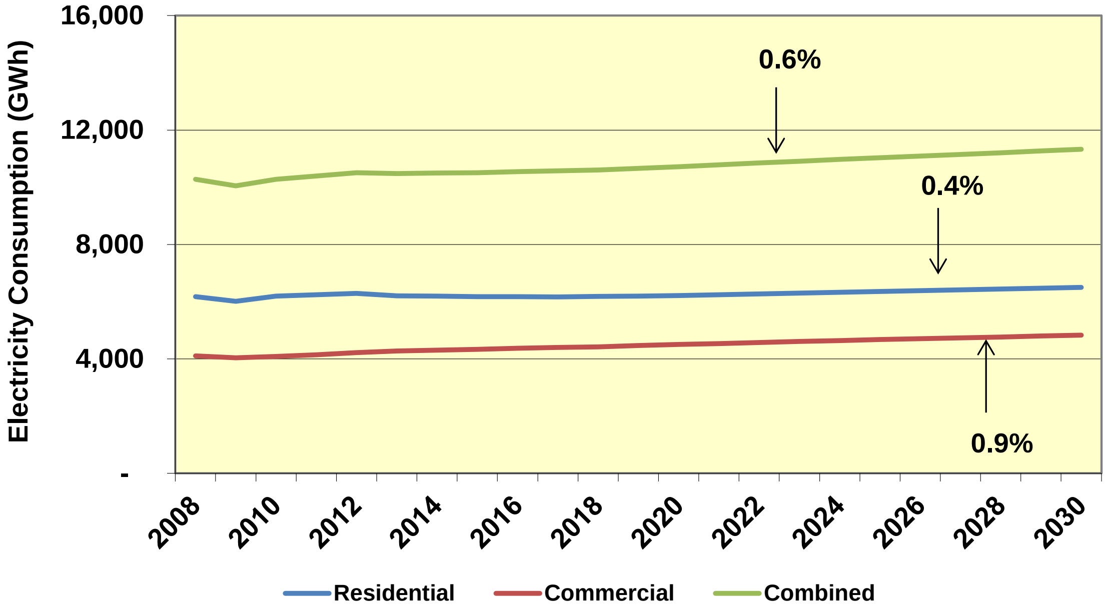
Electricity

The reference case forecast for electricity sales in the greater Cincinnati region is the foundation of the quantitative analysis of the energy efficiency policies we recommend. Our analysis focuses on the three utilities that provide the vast majority of electricity services in the four-county Cincinnati region identified above. The base year for sales in the region is 2008 and is projected through 2030 based on consumption forecasts from electric utility integrated resource plans (IRPs) and utility long-term electric forecasts filed with the utility regulatory bodies in each state (Duke Energy Kentucky 2008, EKPC 2009, Duke Energy Ohio 2010a). Federal appliance and lighting standards enacted in the *Energy Independence and Security Act (EISA) of 2007* are assumed to be accounted for in the utility forecasts, as are impacts from energy efficiency programs that were delivered prior to 2008.

Duke Energy, for both Ohio and Kentucky, issued two electricity consumption forecasts in its IRPs: one that does not incorporate savings from efficiency programs and one that does. EKPC did not adjust its forecast accordingly. Nonetheless, we created two forecasts as well: the “Before EE” case, which does not incorporate savings from Duke Energy efficiency programs; and the “After EE” case, which does incorporate savings from existing programs. Additionally, given that the forecasts were conducted for the entire territory and not specifically for the four counties considered in this report, we had to make assumptions on how to apportion the forecasts so that they represent consumption patterns in those four counties. More information on this methodology can be found in Appendix B—Reference Case Methodology.

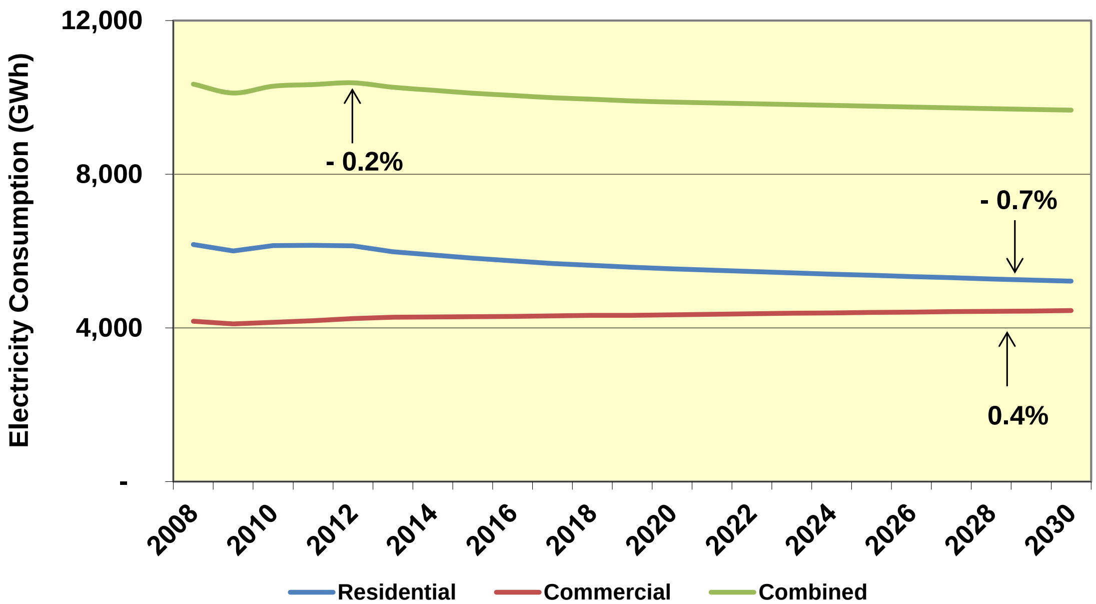
To estimate projected electricity sales we summed the sector-specific forecasts reported in the utility filings referenced above, adjusted to reflect consumption patterns in the four counties only. Using this methodology, we estimate that total electricity consumption in the four-county Cincinnati region in the “Before EE” case will grow at an average annual rate of 0.6% between 2008 and 2030, and 0.4% and 0.9% in the residential and commercial sectors, respectively (see Figure 5). In 2008, electricity sales in the residential and commercial sectors reached 6,200 GWh and 4,100 GWh, respectively, for a total of 10,300 GWh for the region. Using the growth rates we estimated above, sales are estimated to increase to around 11,300 GWh by 2030.

Figure 5. Annual Electricity Retail Sales Forecast and Average Annual Growth Rate By Sector, Before EE, 2008–2030



In the "After EE" case, we estimate that total electricity consumption in the Cincinnati region will decline at an average annual rate of 0.2% between 2008 and 2030, based on a 0.7% annual decrease in the residential sector and a 0.4% annual increase in the commercial sector (including nonprofits) (see Figure 6). Again, in 2008, electricity sales in the residential and commercial sectors reached 6,200 GWh and 4,100 GWh, respectively, for a total of 10,300 GWh for the region. Using the growth rates we estimated above, sales are estimated to decrease to around 9,700 GWh by 2030.

Figure 6. Annual Electricity Retail Sales Forecast and Average Annual Growth Rate By Sector, After EE, 2008–2030



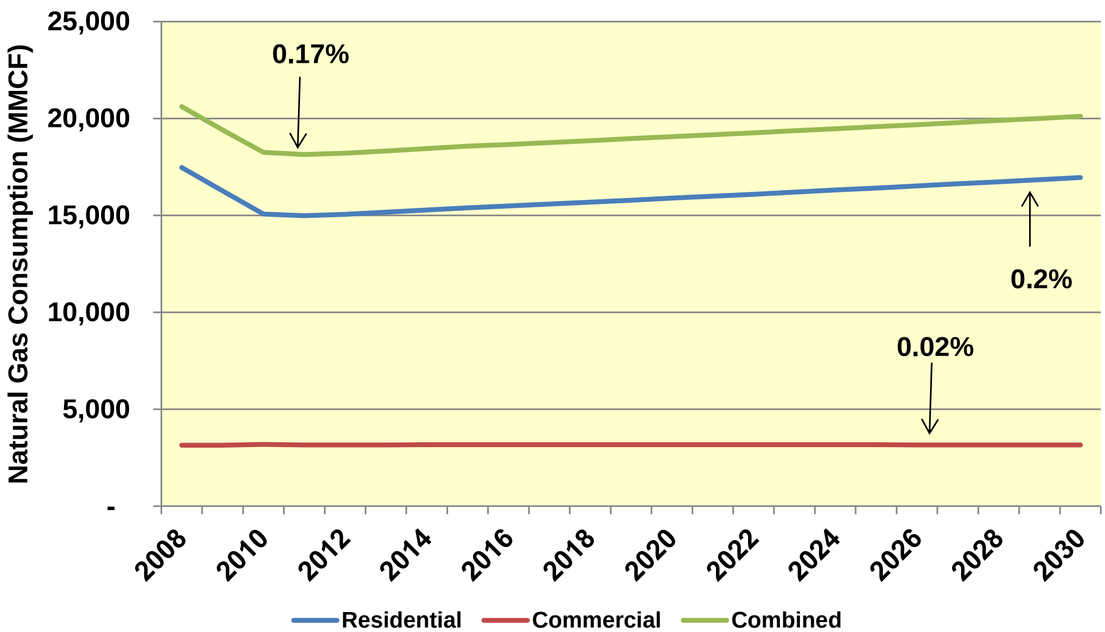
Natural Gas

Our natural gas consumption forecast focuses on the two utilities that provide natural gas services to customers in the four-county region: Duke Energy Ohio and Duke Energy Kentucky. Owen Electric Cooperative provides only electricity services. The base year for sales in the region is 2008 and is projected through 2030 based on consumption forecasts from Duke Energy Ohio's long-term natural gas forecast (Duke Energy Ohio 2010b). Duke Energy Kentucky, however, is not required to file a long-term natural gas forecast, so there was no existing forecast to reference. As with the electricity forecast, federal appliance and lighting standards enacted in the *Energy Independence and Security Act (EISA) of 2007* are assumed to be accounted for in the utility forecasts, as are impacts from energy efficiency programs that were delivered prior to 2008.

Unlike the electricity forecast, Duke Energy Ohio did not report two forecasts to differentiate projected consumption based on the estimated impacts of efficiency programs on natural gas consumption. Given that the forecasts were conducted for the entirety of Duke's service territories and not specifically for the four counties considered in this report, we had to make assumptions on how to apportion the forecasts so that they represent consumption patterns in those four counties only. Furthermore, we used natural gas sales in Duke Ohio's service territory as a proxy for natural gas sales in Kentucky because there is no Kentucky-specific forecast available. More information on this methodology can be found in Appendix B—Reference Case Methodology.

To estimate projected natural gas sales we summed the sector-specific forecasts reported in the utility filing referenced above, and adjusted to reflect consumption patterns in the four counties only. Using this methodology, we estimate that total natural gas consumption in the four-county Cincinnati region will grow at an average annual rate of 0.17% between 2008 and 2030, and 0.20% and 0.02% in the residential and commercial sectors, respectively. In 2008, natural gas sales in the residential and commercial sectors reached 17.5 million cubic feet (MMCF) and 3.1 MMCF, respectively, for a combined total of 20.6 MMCF for the region. Following a two-year decline in 2009 and 2010 caused by the economic recession, we estimate that natural gas sales will grow to around 20.1 MMCF by 2030 (see Figure 7).

Figure 7. Annual Natural Gas Retail Sales Forecast and Average Annual Growth Rate by Sector, 2008–2030



Retail Price Forecast

We also developed reference case scenarios for retail electricity and natural gas prices for Ohio and Kentucky. The price forecasts do not reflect any effect arising from changes in utility avoided costs that are a result from energy savings generated by existing efficiency programs. Readers should also note that we do not intend to project future energy prices in the Cincinnati region precisely for either the short or long term. Rather, our goal is to suggest possible scenarios based on data from credible sources, and to use these scenarios to estimate impacts from energy efficiency programs on customers in the region.

Electricity

Table 1 shows 2009 electricity prices (¢/kWh) for the Cincinnati region, based on retail prices reported in the EIA's *Electric Power Monthly,* and our projections of retail rates by customer class over the study period (EIA 2010b). Ultimately, the price forecast is a weighted average (by households) of the statewide prices we forecasted for both Ohio and Kentucky and, therefore, may not exactly reflect actual consumer rates in the Cincinnati region or the rates of particular utilities. The price forecasts for Ohio and Kentucky are based on two key factors. First, we used the average statewide generation cost of electricity in each state projected over the study period, which is based on a number of assumptions, including fleet additions and retirements as documented in utility integrated resource plans (IRPs) from both states. Second, we use estimates of retail rate adders (the difference between generation costs and retail rates, which accounts for transmission and distribution costs), by customer class, from the 2010 *Annual Energy Outlook* for the East Central Area Reliability Council (ECARC) (EIA 2010c). The estimates of the average generation costs and retail adders are then summed to determine retail rates for each customer class. Electricity prices are projected to rise primarily due to costs associated with supply-side investments, such as additional generating capacity and transmission- and distribution-related infrastructure.

Table 1. Retail Electricity Price Forecast Scenario in Reference Case (cents per kWh in 2009$)

	2009	2015	2020	2025	2030	2009–2030 % Increase
Residential	9.0	11.3	12.3	13.0	13.9	**54.4%**
Commercial	8.6	10.2	11.8	12.1	13.2	**53.5%**
Industrial	6.2	7.3	8.3	9.1	10.0	**61.3%**
All Sector Average	**7.4**	**9.5**	**10.1**	**10.5**	**11.0**	**48.6%**

Note: These figures are in real 2009-year dollars and, therefore, do not take into account inflation.

Natural Gas

Table 2 shows 2009 natural gas prices (2009$/MMBtu) for the Cincinnati region, based on retail prices reported by the EIA, and our projections of retail rates by customer class over the study period (EIA 2010d). Again, the final price forecast is a weighted average (by households) of the statewide natural gas prices we forecasted for both Ohio and Kentucky. First we used long-term Henry Hub wholesale price projections for each state, taken from the 2010 *Annual Energy Outlook* for the ECARC region (EIA 2010c). We then generated estimates of 2009 retail adders by customer class (the difference between the 2009 Henry Hub wholesale price and 2009 retail prices for each state) and summed the adders with the wholesale price projections to determine retail rates by customer class.

Table 2. Retail Natural Gas Price Forecast Scenario in Reference Case (2009$/MMBtu)

	2009	2015	2020	2025	2030	2009–2030 % Increase
Residential	13.0	13.2	13.2	14.5	15.5	**19.2%**
Commercial	10.2	10.3	10.4	11.7	12.8	**25.5%**
Industrial	8.8	9.0	9.0	10.4	11.4	**29.5%**

Note: These figures are in real, 2009-year dollars and, therefore, do not take into account inflation.

EXISTING ASSESSMENTS OF ENERGY EFFICIENCY POTENTIAL

What might the future hold?

We conducted a meta-analysis to review and summarize key information from several energy efficiency market potential studies that have been conducted at the national, regional, and state level in order to provide points of reference for what the greater Cincinnati region could expect from increased investments in energy efficiency. Table 3 compares the results of these studies, showing the cumulative achievable savings estimated over the study period, the percent savings (cumulative savings relative to sales in the base year or forecasted sales in the final year of the study period), the time frame of the study for which that potential was estimated, and the average annual savings.

National Energy Efficiency Potential

Our review of national energy efficiency potential studies examines one recent nationwide study conducted by McKinsey & Company (McKinsey 2009), one by the Electric Policy Research Institute (EPRI 2009) and two meta-analyses conducted by ACEEE in 2004 and 2008 (Nadel et al. 2004, Laitner & McKinney 2008). Combined, these meta-analyses evaluated dozens of statewide, regional, and national energy efficiency potential studies, providing a useful perspective on both the range and average potential energy savings across the country. The EPRI study estimated incremental annual reductions between 0.37% and 0.51%[1], the McKinsey & Company study projected annual average electricity savings of 1.0%, and the 2004 and 2008 meta-analyses found 1.5% and 1.9%, respectively. Extrapolating these average annual savings potentials across 16 years results in an efficiency potential in the range of 16–30% through 2025.

Southeast Energy Efficiency Alliance Potential Study for the Appalachian Region

In 2009, the Southeast Energy Efficiency Alliance, in coordination with the Appalachian Regional Commission, the Georgia Institute of Technology, the Alliance to Save Energy, and ACEEE, conducted an energy efficiency potential analysis for the Appalachian region, including parts of Ohio and Kentucky (ARC 2009). The study considered electricity, natural gas, and fuel oil in its analysis. Over 20 years, between 2010 and 2030, the study found that cost-effective investments in energy efficiency across the residential, commercial, and industrial sectors could help meet 24% of projected consumption in the region by 2030, or an annual average savings of 1.2% per year.

ACEEE Energy Efficiency Potential Study for the State of Ohio

In March 2009, ACEEE released its energy efficiency potential study for the state of Ohio (Neubauer et al. 2009). The study's intent was to evaluate the feasibility of meeting the annual electric savings targets mandated by Senate Bill 221, which amount to savings of 22% in 2022. Since the SB 221 targets are for electricity only, ACEEE did not analyze the potential for fossil

[1] These values were estimated by dividing the *incremental* annual savings in 2030 for two scenarios—a reasonable achievable potential scenario and maximum achievable potential scenario—over the 22-year period spanning 2008 through 2030. As incremental values, they only take into account savings generated from measures installed in 2030 and not savings generated from installations in previous years. Sales in 2030 were used as the baseline.

fuel savings. ACEEE found that the state could cost-effectively meet the SB 221 targets with a mix of innovative policies and utility programs. ACEEE estimated that, between 2009 and 2025, energy efficiency could save 23.5% by 2025, as a percent of projected sales in that year, or average annual savings of about 1.4% per year across the residential, commercial, and industrial sectors.

Energy Efficiency in the South: Kentucky Profile

In April 2010, Georgia Tech and Duke University released *Energy Efficiency in the South*, an energy efficiency potential study for the Southeastern region. For each state, the report included profiles detailing the level of energy efficiency savings that could be achieved, by sector, through investments in a recommended suite of energy efficiency policies and programs. The study estimates that in 2030 Kentucky could generate savings equivalent to 11% of 2007 sales (Brown et al. 2010).

Duke Energy Ohio and Kentucky Efficiency Potential Studies

In 2009, Duke Energy, Inc. released two energy efficiency potential studies for its service territories in Ohio and Kentucky, which are based around the Cincinnati metropolitan region. Both studies looked only at the potential for electricity savings. In the studies Duke analyzed the energy efficiency potential relative to its five-year demand-side management action plan for the residential, commercial, and industrial sectors; i.e., over a five-year time period, between 2009 and 2013. In its studies Duke estimated cumulative savings over five years of 3.1 and 3.4% in Ohio and Kentucky, respectively, as a percent of projected sales in 2013. On an annual basis, this amounts to between 0.6 and 0.7% savings per year.

Table 3. Comparison of Energy Efficiency Potential across National, Regional, and State Potential Studies

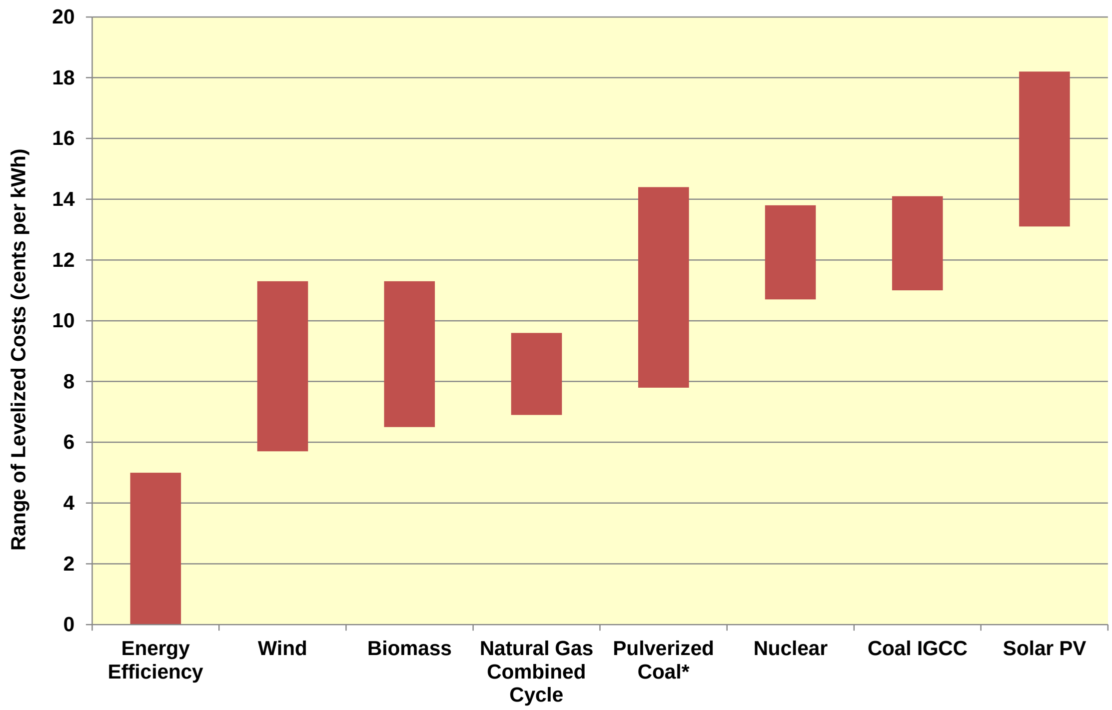
Study	Efficiency Potential (GWh)	Percent Savings	Time Frame	Average Annual Percent Savings
National				
EPRI 2009[2]	398–544 TWh	8–11%	22 Years	0.37–0.51%
McKinsey 2009	9.1 quadrillion Btu	23%	23 years	1%
Laitner & McKinney 2008	NA	23%	12-year average	2%
Nadel et al. 2004—Elec. Potential	NA	21.5%	14 years	1.5%
Nadel et al. 2004—Gas Potential	NA	22%	14 years	1.5%
Regional				
ARC 2009	23.2 quadrillion Btu	24%	20 years	1.2%
State				
Neubauer et al. 2009	37,000 GWh	23%	17 years	1.4%
Brown et al. 2010[3]	0.22 quadrillion Btu	11%	20 years	NA
Duke Energy Ohio 2009	684 GWh	3.1%	5 years	0.6%
Duke Energy Kentucky 2009	136 GWh	3.4%	5 years	0.7%

[2] See Footnote 1
[3] The efficiency savings potential listed for Kentucky is for the annual savings achieved *in* 2030, instead of the cumulative annual savings as was reported for the other studies.

Cost of Energy Efficiency

Meeting energy demands through energy efficiency costs considerably less than all new generation capacity options. A 2009 review of utility energy efficiency programs from around the U.S. found that the cost of saved electricity ranged from $0.016 to $0.033 per kWh, with an average of $.0.025 per kWh. For natural gas efficiency programs the cost of saved energy to the utility was between $0.27 and $0.55 per therm, averaging $0.37 per therm (Friedrich et al. 2009). These costs are consistently one-third or less the cost to utilities of new electricity generation—regardless of fuel—or natural gas supply. Figure 8 illustrates this point by comparing the range of levelized costs for energy efficiency to those of other electricity resources.

Figure 8. Electricity Resource Utility Cost Ranges

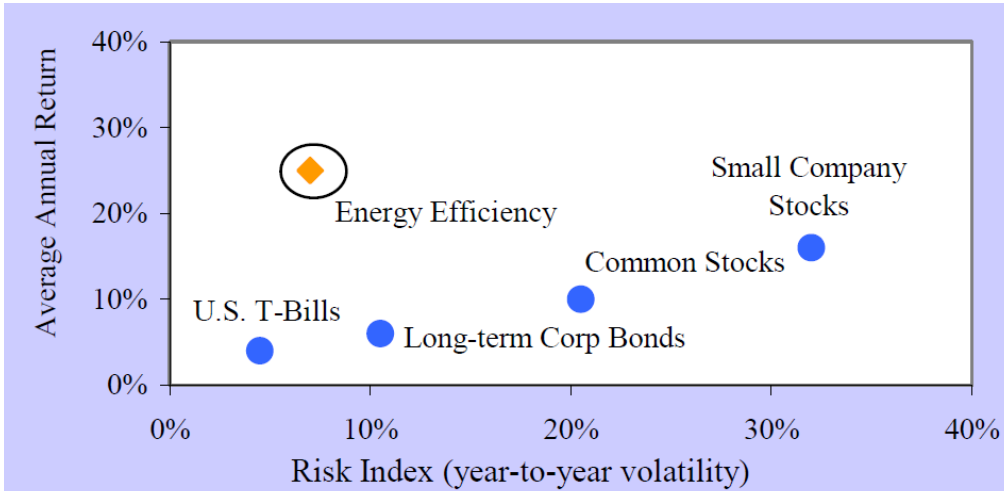


Notes: All data from Lazard 2009. High-end range of advanced pulverized coal includes 90% carbon capture and compression.

Return on Energy Efficiency Investments

From an investment perspective energy efficiency provides relatively high returns with low risk. Adapting an analysis from the Vanguard Group, ACEEE determined that the returns on typical energy efficiency investments are roughly equivalent to small company stocks while the risks are similar to U.S. Treasury Bills, as displayed in Figure 9 (Ehrhardt-Martinez and Laitner 2008). Consistent and predictable energy cost savings from energy efficiency makes it an attractive investment.

Figure 9. Comparing Energy Efficiency to Other Investments



Source: Ehrhardt-Martinez and Laitner 2008

Social and Economic Characteristics

How does energy efficiency relate to our regional prosperity?

Increased investment in energy efficiency would make Hamilton, Boone, Kenton, and Campbell counties more competitive, create jobs, and help homeowners and businesses make cross-cutting building improvements while saving money on utility bills.

While this study looks at the impacts of efficiency investments in owner occupied single-family homes and buildings serving nonprofit organizations, there are large opportunities for energy efficiency in other sectors as well. The benefits of energy efficiency can decrease the operating costs of small businesses and energy intensive industries. Energy efficiency can decrease the need for new generation capacity resulting in lower capital costs for utilities and, in turn, lower energy prices for consumers. The remainder of this section describes the demographic and economic characteristics of the Cincinnati region as they relate to energy efficiency.

Housing and Cost of Living

The four-county Energy Alliance region constitutes the core of the 15-county Cincinnati Metropolitan Statistical Area (MSA). One of the strengths of the MSA is that it is an affordable place to live. According to the *Our Region by the Numbers* report produced by the regional planning efforts Agenda 360 and Vision 2015, 88.2% of homes sold in the Cincinnati MSA in 2009 were considered affordable to a family earning the area median income (2010). By this measure Cincinnati is the third most affordable region of twelve peer regions identified in the report, which average as 83.7% for the metric. Cincinnati's affordability has also been recently recognized in Kiplinger's list of "10 Best Value Cities for 2011," in which it was the largest MSA to be included (Kiplinger 2011). Because people in the region spend less of their income on housing, energy costs likely make up a larger than average portion of their household expenses. In addition, lower housing costs may also mean that households have more disposable income to save or invest in energy efficiency or spend on other priorities.

Another metric in the Agenda 360 report concerns the overall cost of living in the Cincinnati MSA. Compared to the national average of 100.0 and the peer region average of 95.9, in 2009, Cincinnati had the fourth lowest cost of living among the twelve peer regions, with a rating of 91.1 for this metric. Lower costs of living make the region more competitive. Energy efficiency improvements can improve cost of living even further and contribute to the region's competitive advantage.

At the present time, the conditions of the housing market potentially increase the market for energy efficiency retrofits and renovations by homeowners. Because many homes are on the market, owners who might otherwise relocate to another part of the metro area could choose instead to stay in their current homes and make energy efficiency investments.[4] These investments will also serve to make existing homes and neighborhoods more competitive against new construction when the housing market rebounds. This could also apply to owners of single-family rental properties, who can reduce the cost of ownership and make their properties more attractive to prospective renters. Thus, the current housing market potentially provides additional points that can be used in marketing the Energy Alliance's programs.

Most of the anticipated population and household growth in the Cincinnati MSA between 2010 and 2020 will occur outside the four-county Energy Alliance (EA) region. Population projections by EMSI show a 2.1% increase in the EA region, which is less than half the national rate of 4.3% and even further behind the 5.0% rate for the rest of the MSA (EMSI 2011a). Similar numbers would be expected for household growth, and the numbers may be even lower for residential construction in areas such as the EA region where vacancy rates currently are above average. The implication of these projections is that the energy efficiency of existing residential and non-residential buildings is particularly important in the EA counties where retrofit investment will be the primary way of achieving increases in energy efficiency.

Employment

The Cincinnati MSA has historically had a lower unemployment rate than the U.S. During the 1990s, it was 1.2% lower, but in the first half of the 2000s, it was only 0.5% lower. From 2005 through 2007, it reversed this pattern, and the MSA unemployment rate was 0.4% higher than the national rate. Most recently, the picture has improved slightly, and the two rates are now virtually the same. This loss of an advantage in its unemployment rate makes the MSA less likely to produce stronger population and employment growth in the future.

Employers in the four-county Energy Alliance region account for nearly two thirds of all jobs in the MSA, according to the latest 2011 estimates. From 2001 to 2011, employment in the region declined from 842,000 to 801,000, while the entire MSA experienced a slight increase from 1,220,000 to 1,243,000 jobs. On the other hand, compensation in the four-county region is about 9% higher than in the MSA as a whole, or about 30% higher than in the other counties of the MSA.

More than half of all employment in the four counties served by the Energy Alliance region lies within two broad industry sectors: Education, Health and Government; and Professional and Household Services.[5] In these two sectors, the Energy Alliance region accounts for an overwhelming majority share of all MSA employment (68.0% and 70.5% respectively). These are also the two broad sectors which account for the largest share of U.S. employment. In all other industry sectors, the Energy Alliance region accounts for a markedly smaller portion of MSA jobs as shown in Table 4.

[4] This is true even for people whose homes have depreciated in value, but not for those who are "upside down" on their mortgages because they will be unable to recover any of their investment [based on an unpublished study that is unavailable for citation].

[5] This includes five major industry areas: Information; Professional, Scientific, and Technical Services; Management of Companies and Enterprises; Administrative and Support and Waste Management and Remediation Services; and Other Services.

Table 4. Employment by Industry for the Cincinnati MSA and the Energy Alliance Counties

Industry Sector	EA counties 2011	MSA 2011	EA counties as % of MSA	Share of EA counties	Share of U.S.
Educ, Health, Govt	212,441	312,228	68.0%	26.5%	27.5%
Prof & Hhld Services	196,235	278,303	70.5%	24.5%	21.0%
Trade, Trspn, Utilities	141,614	233,591	60.6%	17.7%	18.8%
Finan, Insur, Real Estate	74,880	120,768	62.0%	9.4%	11.1%
Arts, Ent'm't, Hotel, Eating	74,293	121,119	61.3%	9.3%	9.7%
Manufacturing	65,293	105,541	61.9%	8.2%	8.5%
Construction	33,412	59,642	56.0%	4.2%	4.8%
Agriculture and Extraction	2,569	11,922	21.5%	0.3%	1.0%
Total	**800,739**	**1,243,114**	**64.4%**	**100%**	**100%**

Source: EMSI Complete Employment estimate for 1st Quarter 2011 (EMSI 2011b), based on employment data from Quarterly Census of Employment and Wages (QCEW) produced by the Bureau of Labor Statistics (BLS), the Regional Economic Information System (REIS) published by the Bureau of Economic Analysis (BEA), and County Business Patterns (CBP) and Nonemployer Statistics (NES) published by the U.S. Census Bureau.

The strongest industries, based on their relative employment concentration (location quotient) for both the Energy Alliance region and the MSA are: Management of Companies and Enterprises, Wholesale Trade, and Manufacturing. One other major industry, Health Care and Social Assistance, is strong in the Energy Alliance region but only slightly above average for the MSA as a whole. Particularly notable for the work of the Energy Alliance is the concentration of Health Care and Social Assistance. Programs targeted toward nonprofits working in these sectors may help to improve the region's existing competitive advantage in these sectors.

ENERGY EFFICIENCY POTENTIAL IN CINCINNATI'S BUILDINGS

What energy efficiency is economically available in our community?

Cincinnati was dubbed the number one remodeling market in the country in a study published by Remodeling Magazine in January 2011 (Alfano 2011). While energy efficiency improvements are only one kind of remodeling and remodeling activity is only one indicator of the market for building energy efficiency improvements, this nonetheless is a positive sign for the market opportunity in the region. In this section we establish the economic potential for energy efficiency improvements in single-family residential buildings and buildings owned by or serving nonprofit organizations. Then in the next section we analyze the potential impact of specific programmatic approaches to encourage the implementation of energy efficiency measures.

Single-Family Residential Buildings

For our analysis of energy efficiency potential for Cincinnati's single-family residential sector, we used a residential building energy modeling software package, the Targeted Retrofit Energy Analysis Tool, or TREAT, to compute the average baseline energy use for a Cincinnati single-family home and several options for suites of efficiency retrofits. The baseline home was computed using a representative variety of housing characteristics derived from regional and national datasets. We input these housing characteristics into TREAT to model a typical home. We modeled over 45 different permutations of "typical" Cincinnati homes by varying model inputs such as the square footage of the home and the type of heating equipment. We consider the weighted average of these permutations to be representative of a "typical" home. Although it is extremely unlikely that any home in Cincinnati looks exactly like this weighted average (for heating it would heat have half the home with a furnace, a quarter with heat pump and a quarter with electric resistance heating), it should give a reasonably accurate average of the energy use of homes in the region, broken down by end use—data that is not otherwise available on a regional basis. Table 5 shows the baseline annual energy use (a combination of gas & electricity) for the average Cincinnati home.

Appendix C—Efficiency Potential Methodology f or Single-Family Residential Buildings describes in detail our methodology for determining building energy use, building characteristics, and modeling the impact of energy efficiency measures. Our modeling is based on best available data as described in detail in Table 33 in Appendix C—Efficiency Potential Methodology for Single-Family Residential Buildings. However, due to the limitations of this methodology, as well as the inherent margins of error associated with energy modeling, it is important to pay more attention to the *relative* savings rather than the *absolute savings* (i.e., the percentage savings rather than the kWh or Btu's of savings). Percentage savings is the more accurate indicator, because the savings calculation error and baseline calculation error should line up in the same direction, minimizing the total error when calculating percentages.

Table 5. Baseline Annual Energy Use at Site in an Average Cincinnati Region Single-Family Home

Fuel	Energy Use	Units
Electric	14,200	kWh
Gas	750	therms
Total	**123**	**MMBtu**

Energy Savings Potential

Six different efficiency packages were modeled using the TREAT software. Each package consists of a suite of efficiency retrofit measures that could be relatively easily implemented in most homes. The measures included in each of these packages are described in Table 6.

Table 6. Measures Included In Each Modeled Residential Energy Efficiency Package

	Attic insulation	Duct sealing	Infiltration reduction	Efficient windows	Efficient AC	Efficient heating	Efficient dishwasher or refrigerator replacement
Package 1: Baseline package	X	X	X				
Package 2: Windows package	X	X	X	X			
Package 3: Comprehensive package—low end	X	X	X		X		X
Package 4: Comprehensive package—high end	X	X	X			X	X
Package 5: HVAC package	X	X	X		X	X	
Package 6: Appliances package	X	X	X				two replacements

Nearly all of the packages were cost-effective, defined as the cost of a unit of saved energy being less than the cost of a unit of used energy to the consumer, even when using the full installed costs of the measures (as opposed to incremental costs only—the premium paid for efficient products). The one exception is the package that includes new energy-efficient windows; windows are rarely cost-effective on an energy basis alone, but they are included here because they are a measure that people are interested in for non-energy reasons (aesthetics, comfort, etc.). Windows are one good example of a home improvement measure that is widely seen as highly desirable but is not cost effective, although there are many more. Such measures when combined in an overall package with several more cost-effective energy saving measures can be partially subsidized through the inexpensive energy cost savings. It is also important to note that none of these packages include any water efficiency measures, because TREAT does not model these measures and they are not a focus of the Energy Alliance program. There are many additional inexpensive and cost-effective water measures that can result in considerable cost savings in communities with consumption-based water and sewer rates. Table 7 shows the average simple payback periods in years for each efficiency package analyzed.

Table 7. Payback Periods for Each Modeled Residential Efficiency Package

	Efficiency package options					
	1	**2**	**3**	**4**	**5**	**6**
Payback period (yrs)—using full installed cost	3.5	17.5	6.5	6.8	6.7	6.4
Payback period (yrs)—using incremental cost only	3.5	4.4	3.6	4.4	3.6	3.0

As an example, Figure 10 shows how the total energy savings from different measures compare, as modeled on a very large home with a basement and a gas furnace (at 5.5% of the market this is one of the largest permutation groups from our 45 modeled building characteristic permutations). Source energy is used for this chart, which includes the energy used by power plants to generate electricity for the home. The total energy savings (both electricity and natural gas) from any one of the six packages of measures modeled on this particular home range from 32 to 41%. These numbers will vary based on the characteristics of the particular home being modeled.

Figures 11 and 12 display total baseline energy use disaggregated by fuel, electricity and natural gas respectively, as well as how each efficiency measure could reduce energy use. These figures display site energy, the energy use from the consumer’s perspective (the amount of energy directly used in the home).

Figure 10. Total Energy Use and Savings Potential for one Modeled Home Disaggregated by Measure (MMBtu)

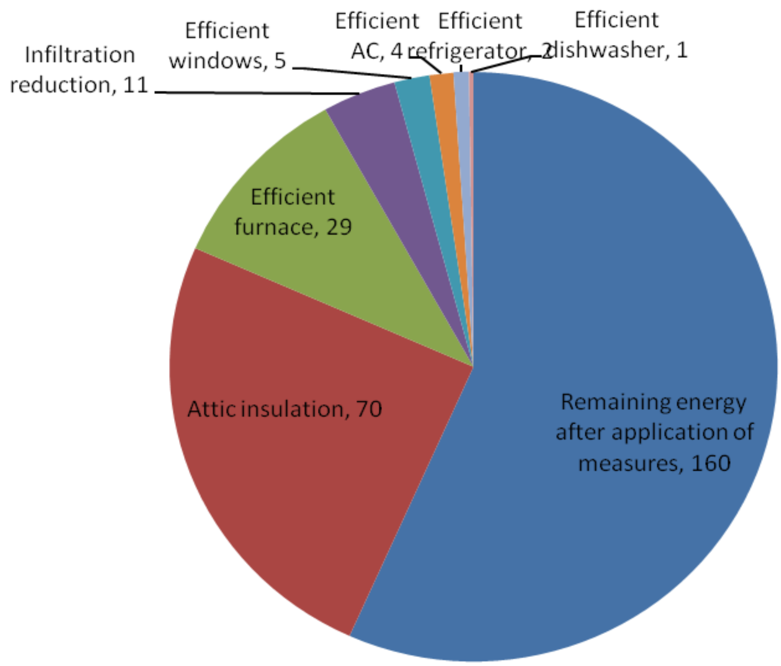


Figure 11. Electric (Site) Energy Use and Savings of an Example Home

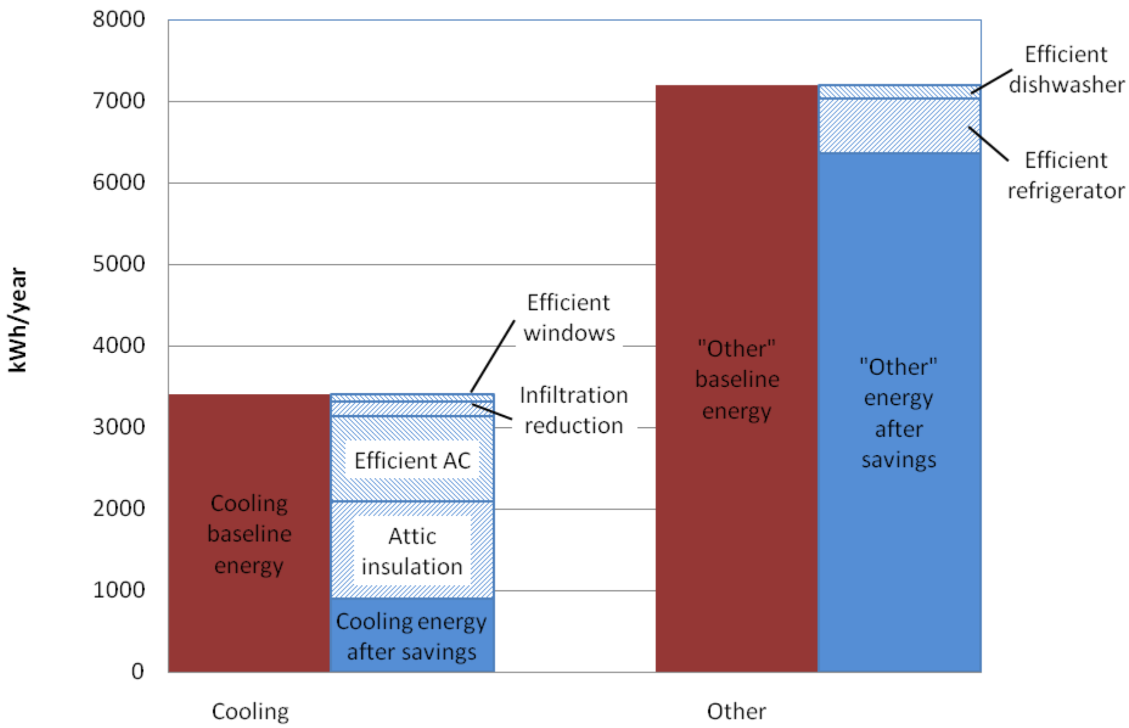
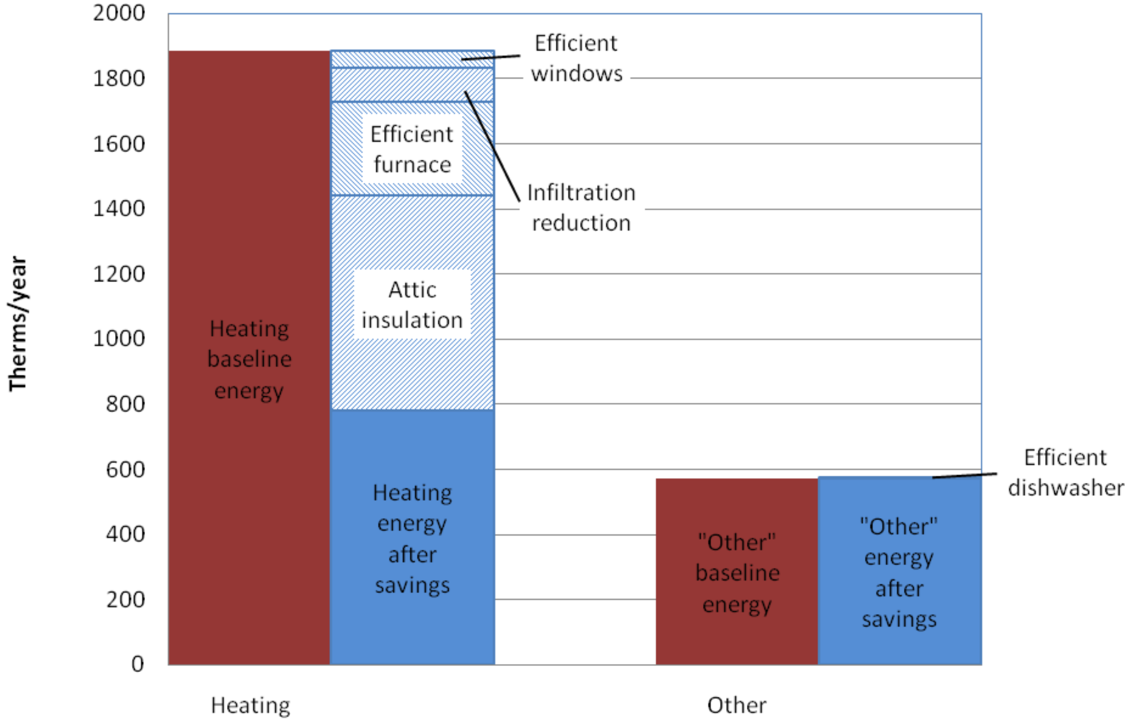


Figure 12. Natural Gas Energy Use of a Model Home



Homes Meeting Efficiency Improvement Thresholds

Table 8 shows for each package the median energy savings percentage resulting from each package for all homes modeled and the percentage of homes that could meet or exceed a specific percentage savings threshold. This was derived by computing the savings level from each package for each of the 45 modeled permutations of a typical Cincinnati home, and then aggregating the proportion of homes represented by each permutation that achieved each savings level. As shown, nearly all homes could achieve 15% energy savings, especially with the comprehensive packages. At the other end of the spectrum, there are a handful of homes that could potentially achieve up to 40% or greater savings from every package.

Table 8. Percentage of Homes that Could Achieve Savings Thresholds from each Energy Improvement Package

	Package					
	1	**2**	**3**	**4**	**5**	**6**
Median savings	20%	24%	22%	28%	28%	22%
% Savings	*% of homes achieving level of savings*					
15%	89%	93%	99%	97%	99%	94%
20%	56%	83%	84%	91%	92%	83%
25%	18%	29%	24%	91%	91%	19%
30%	8%	8%	8%	35%	35%	8%
35%	5%	7%	5%	10%	12%	5%
40%	5%	5%	5%	5%	8%	5%

Nonprofit Buildings

In this section we determine the potential for electricity savings through energy efficiency in nonprofit commercial buildings in the greater Cincinnati region.

Electricity

Electricity savings potential is examined through a scenario of 28 cost-effective measures which would be adopted during the 21-year period from 2010 to 2030. An upgrade to a new measure is considered cost-effective to a consumer if its levelized cost of conserved energy (CCE) is less than $0.1091/kWh saved, which is the average retail commercial electricity price in the greater Cincinnati region over the study time period, using the price forecasts from Tables 1 and 2. For the sum of all measures, the estimated levelized cost is $0.022/kWh saved (see Table 9). See Appendix D—Efficiency Potential Methodology for Commercial Nonprofit Buildings and Table 40 for a detailed methodology and specific efficiency opportunities and cost-effectiveness for electricity savings in commercial nonprofit buildings.

Table 9. Commercial Nonprofit Electricity Efficiency Potential and Costs by End-Use

End-Use	Savings (MWh)	Savings (%)	% of Efficiency Potential	Weighted Levelized Cost of Saved Energy ($/kWh)
HVAC	36,000	8.3%	34%	$0.033
Water Heating	1,000	0.3%	1%	$0.032
Refrigeration	3,000	0.7%	3%	$0.020
Lighting	44,000	10.2%	41%	$0.024
Office Equipment	22,000	5.1%	21%	$0.003
Total	**106,000**	**24.5%**	**100%**	**$0.022**

We project that by 2030 the commercial nonprofit building sector in the region can reduce electricity consumption by 24.5% compared to a business as usual baseline, as shown in Figure 13. This economic potential for efficiency resources in the sector will reduce electricity use by 106 GWh annually by 2030.

Figure 13. 2030 Electricity Consumption Baseline and Forecast with Efficiency Savings

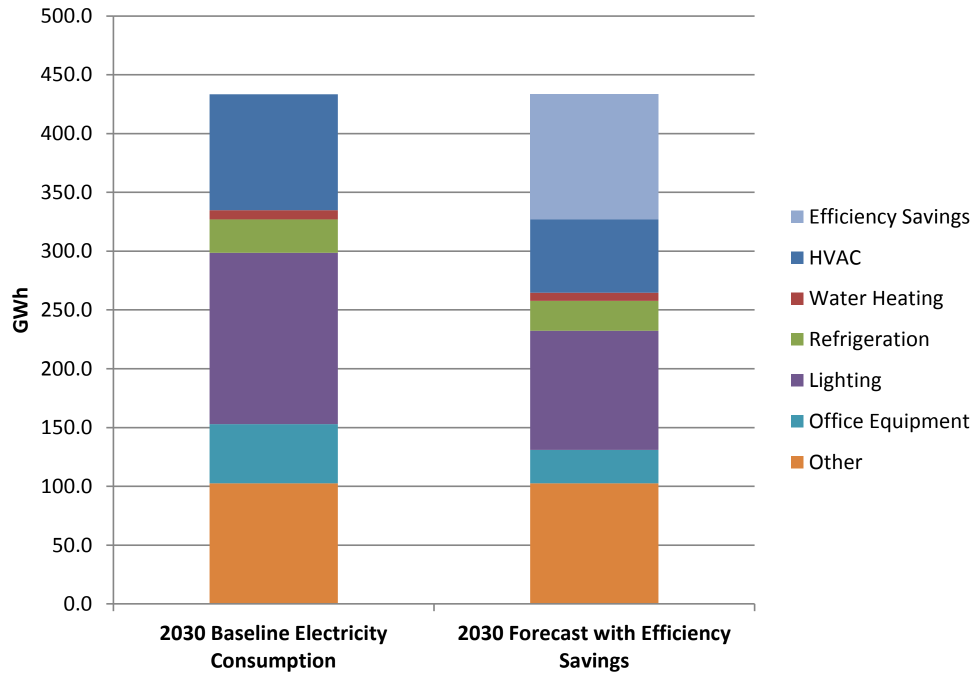
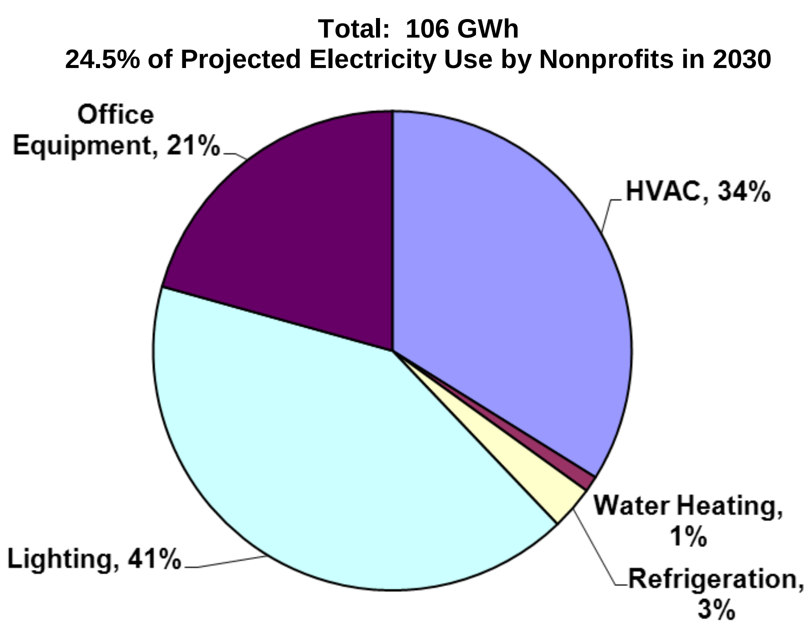


Figure 14. Commercial Nonprofit Electricity Savings Potential by End-Use for the Greater Cincinnati Region



In the commercial nonprofit sector, electricity savings are achieved through the adoption of a variety of end-use efficiency measures as shown in Figure 14. These savings are realized through improved heating, ventilation and air conditioning (HVAC) equipment, controls and building shell measures (e.g., roof insulation and new windows); improved water heating (e.g., heat pump water heaters); more efficient refrigeration systems (e.g., ENERGY STAR® vending machines); efficient lighting; and office equipment. The largest portion of the savings, at 41%, is improved lighting efficiency. This includes more efficient light bulbs such as fluorescent and HID, as well as improved lighting controls such as daylight dimming systems and occupancy sensor. In accordance with federal lighting efficiency standards mandated in the Energy Independence and Security Act of 2007 (EISA), we curtail savings attributed to replacing traditional incandescent light bulbs with compact fluorescent bulbs in 2013.

HVAC and office equipment also provide substantial savings, at 34% and 21% respectively. HVAC measures include improved shell measures (e.g., roof insulation and improved windows), better heating and cooling systems (e.g., high efficiency chillers and heat pumps), and better controls (e.g., dual enthalpy controls and energy management system installations). Improved office equipment includes more efficient computers, printers, copiers, etc., as well as turning off this equipment after hours.

Water heating measures include heat pump water heaters. Refrigeration measures include improved commercial refrigeration systems (e.g., reach-in coolers and freezers, vending machines, and vending misers).

Natural Gas

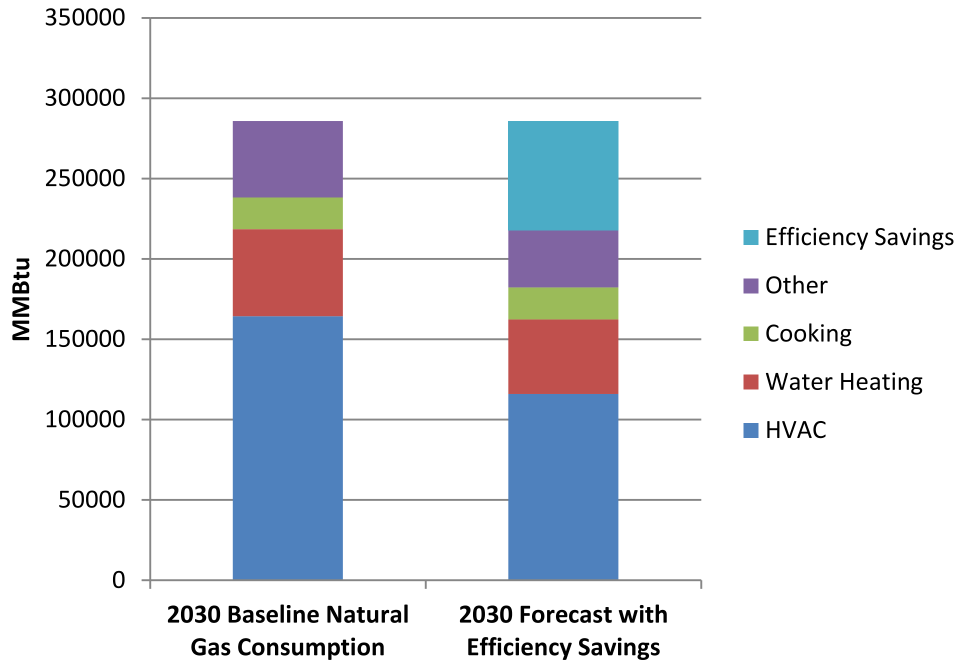
The potential for natural gas savings through energy efficiency in the greater Cincinnati region's commercial nonprofit building sector is examined through a scenario of 18 cost-effective measures for gas savings which would be adopted during the 21-year period from 2010 to 2030. An upgrade to a new measure is considered cost-effective if its CCE is less than $11.08 per MMBtu saved, which is the average retail natural gas price in the greater Cincinnati region over the study time period in the reference case price forecast. For the sum of all measures, the estimated levelized cost is $5.23 per MMBtu saved (see Table 10). See Appendix D—Efficiency Potential for Methodology for Commercial Nonprofit Buildings and Table 41 for a detailed methodology and specific efficiency opportunities and cost-effectiveness for natural gas savings in commercial nonprofit buildings.

Table 10. Commercial Natural Gas Efficiency Potential and Costs by End-Use

End-Use	Savings (MMBtu)	Savings over Reference Case (%)	% of Efficiency Potential	Weighted Levelized Cost of Saved Energy ($/MMBtu)
HVAC equipment & controls	44,000	15.3%	64%	$2.07
Building shell	5,000	1.7%	7%	$0.36
Water Heating	8,000	2.7%	11%	$4.87
Other	12,000	4.2%	18%	$6.02
Total Gas	**68,000**	**23.8%**	**100%**	**$5.23**

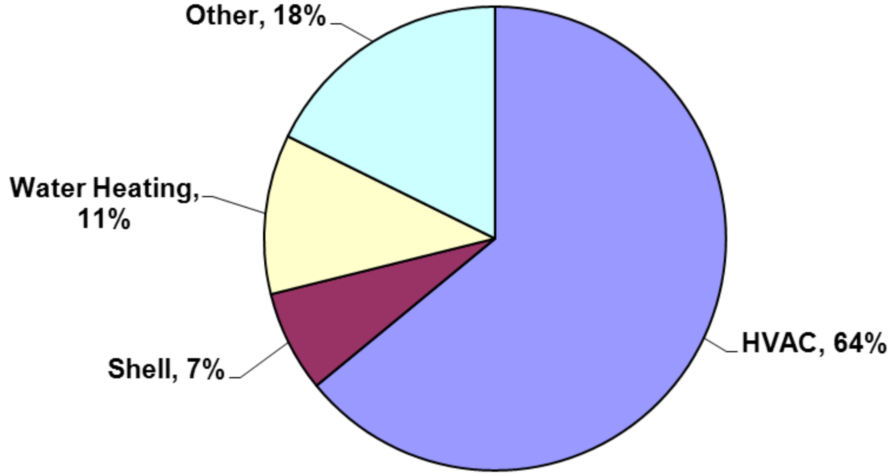
Commercial buildings can reduce natural gas consumption by 23.8% in 2030 through the adoption of a variety of efficiency measures as shown in Figure 15. The economic potential for efficiency resources in the commercial sector will reduce natural gas use by over 68 billion Btu annually by 2030.

Figure 15. 2030 Natural Gas Consumption Baseline and Forecast with Efficiency Savings



In the commercial sector, gas savings from efficiency resources are realized through improved HVAC equipment, controls and building shell measures (e.g., duct sealing and roof and pipe insulation); improved water heating (e.g., condensing gas water heaters); and retrocommissioning (a systematic process to optimize building performance through operation and maintenance tune-up activities and diagnostic testing to identify problems in mechanical systems, controls, and lighting). The savings from each of these measures are shown in Figure 16. The largest share of the savings is improved HVAC measures (64%), including heating system measures, and improved controls. Heating equipment includes equipment appropriate for buildings across a variety of sizes, and includes furnaces, rooftop units, and boilers. Boilers have the largest potential for energy savings of all the measures analyzed. Building shell measures include roof insulation and low-e windows and contribute 7% of the projected savings potential. Water heating upgrades also offer significant savings with 18% of the total resource potential, or 12,000 MMBtu.

Figure 16. Commercial Nonprofit Natural Gas Savings Potential by End Use for the Greater Cincinnati Region



PROGRAM POTENTIAL

What is the market potential to implement energy efficiency in our buildings?

Addressing Barriers to Efficiency Implementation

The energy efficiency potential of buildings in the four-county Cincinnati area is large. However, many barriers exist that currently prevent the implementation of cost effective energy improvements and gaining the resulting cost savings, even for building owners who pay the energy bill (LBNL 2010, McKinsey 2009). Information about building and community energy use and savings opportunities are often completely lacking for building owners and users. Even if owners have a basic understanding of actions that can be taken, uncertainty about the level of savings that will result can remain. Very few areas of the U.S. have a robust number of contractors or building service providers who focus their business on the assessment of whole building energy use or providing improvements in building energy performance. Finally, the upfront cost of energy improvements can be substantial, but it is often very difficult to find financing that is simple to access and on terms that allow for consumers to immediately see the positive financial impacts of their investments. The combined difficulty of identifying improvements, identifying the level of savings that will result, finding a contractor, getting financing, and implementing improvements results in high transaction costs for building owners. All of these factors combined have historically meant that energy improvements have been perceived by consumers as confusing, difficult, and not worth the trouble. Although these are the main barriers there are others that are important for specific building types.

The Greater Cincinnati Energy Alliance is one of many organizations around the country who have systematically developed programs to address these barriers. The Energy Alliance provides home and nonprofit building energy assessments at discounted costs to provide consumers with information about their energy use and the costs and savings of specific energy saving improvements appropriate for their building. The organization works with contractors and other stakeholders in the workforce and business communities to build a network of building energy service professions through providing access to training, certification, marketing, business development opportunities. The Energy Alliance also provides financial incentives to consumers who choose to make building energy improvements. This combination of programs has successfully begun to develop greater consumer understanding of energy saving opportunities and benefits while connecting consumers with the businesses and financial arrangement needed to create simple and commonsense transactions.

As the Energy Alliance works to improve and sustain their approach, additional programs have come under consideration. These include a number of new financing approaches that will allow the organization to use their federal grant funds to leverage private investments and provide consumers with better financial returns from their investments. We have analyzed the market for the Energy Alliance's existing and potential residential programs as well as their programs for energy improvements in buildings serving nonprofit organizations. We have also analyzed the impacts of the implementation of these programs under multiple scenarios and compared their performance to other available terms to fund building energy improvements.

Sector-Based Financing—Single-Family Homes

The Energy Alliance has partnered with AFC First, a lender with experience in energy efficiency finance in other markets, to launch a residential loan program called the Greater Cincinnati Home Energy Loan Program (GC-HELP). This program establishes a revolving loan fund to provide low interest loans of 6.99% over a term of up to ten years that will allow homeowners to finance 100% of their qualifying energy efficiency investments. AFC First will originate and service the loans and the Energy Alliance will purchase loans from AFC First the meet the program guidelines. The terms of GC-HELP are described in Table 11. Our analysis of single-family home programs includes both the phase-out of the Energy Alliance's existing incentive-only program and the ramp-up of the GC-HELP loan program.

Table 11. GC-HELP Loan Program Terms

Interest Rate	6.99% for consumers who have a Home Energy Audit	Interest rate is based on similar programs offered nationwide, but terms under 7% are not otherwise available in the Cincinnati market. However, the Energy Alliance believes that this term will approximate a future market-based rate to minimize the need for continued subsidization.
Min/Max Loan Size	Tier 1 $1,000—$20,000; Tier 2 $1,000—$7,500	Tier 1 is for higher credit consumers—limits are based on Kentucky Home Performance (KHP) and conforming market.
Percent of costs covered	100%	All eligible energy-related expenses net of incentives, including energy performance assessments, can be financed under this program.
Loan Tenor/Term	Up to 10 years, but limited to life of the asset	Based on conforming market and KHP. GCEA will assign asset lives to eligible measures.
Underwriting Criteria / Credit requirements	680, 50% DTI Max—Tier 1 640, 45% DTI Max—Tier 2	Terms will be based on meeting the residential home performance loan requirements for the secondary market, ability to attract investors and protection of GCEA loan capital.
Security Interest	Unsecured	Based on projected average size of a loan, unsecured was determined to be the most effective for this market.
Additional Incentives	15% incentive on eligible measures	Currently, GCEA offers residential customers 35% incentive under our Allocated EECBG programs. The reduction in incentive reflects the fact that the terms on this loan program are subsidized by the GCEA. These incentives can be adjusted at any time by the GCEA and will likely be phased out by 2014.

Based on Energy Alliance document as of March 2011

Market Size and Program Variables

For our analysis of the Energy Alliance residential programs we first determined the size of the market to be served by the program. Using data from the 2005–2009 American Community Survey we determined an estimate of 300,000 total occupied, single-family, detached homes for the four-county region. We narrowed down these results further based on the number of homes meeting a threshold of 20% or greater energy saving potential from sealing and insulation measures alone (56%) as determined through our residential building analysis for a total of over 167,000 households. Although there are considerable cost-effective energy savings to be gained in buildings that do not meet this threshold, we use this variable to represent the homes with the most cost-effective energy savings opportunities and those investments that are most likely to look attractive to a homeowner. Finally, we then filtered these results by households that are owner-occupied (a requirement of participating in the Energy Alliance residential program) and with household income levels above 200% of poverty level (households below this income level are served by the low-income weatherization providers People Working Cooperatively and the Hamilton County Community Action Agency in Hamilton County and The Northern Kentucky Community Action Commission in northern Kentucky). While for the Cincinnati MSA as a whole the portion of the population below 200% of poverty is 25.9% (Agenda 360 and Vision 2015 2010), our calculations for the owner-occupied households in the four-county region result in only 16.5% below 200% of poverty. This final narrowing results in a total market size of 83.5% of the homes with 20% or greater savings opportunity, or nearly 140,000 homes in the four-county area.

We used an average total investment in energy improvements, or job size, of $4,350 and corresponding average energy savings throughout the course of the time period modeled. Projected energy prices for each year are taken from our reference case. These costs and savings are based on Package 5 from our residential buildings analysis, consisting of comprehensive air and duct sealing and insulation with HVAC and air conditioning improvements. Although this is one of the more expensive packages modeled, it is also the most reflective of the typical investments seen so far under the Energy Alliance programs. Additionally, it is important to note that many Energy Alliance program participants make even greater investments through the program, including in eligible distributed energy generation technologies such as geothermal systems. Also, a weighted average measure life for all modeled energy efficiency measures are applied based on our residential modeling: 18 years for both electricity and natural gas measures.

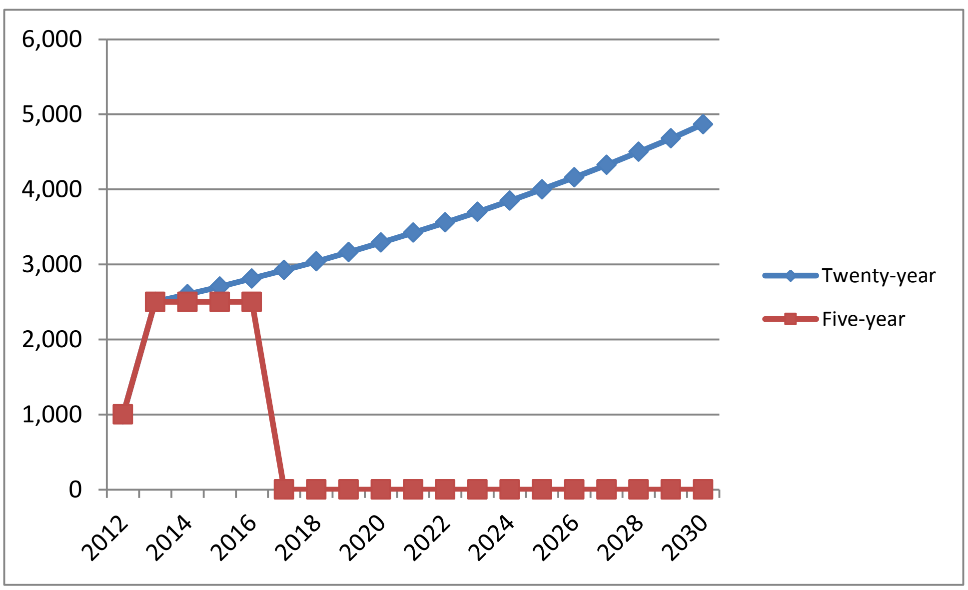
These investments and resulting savings are then applied to the long-term goals as established by the Energy Alliance, for both numbers of energy assessments and number of homes making energy improvement investments, over the coming years. Participants in the loan program are projected to ramp up to 2,500 annually by 2013 and continue to increase by 4% annually throughout the time period. These are high but achievable goals that are in keeping with the performance of the best-in-class residential energy efficiency loan programs elsewhere in North America (Fuller 2008). The number of annual home energy assessments is projected to remain three times larger than the level of homes making energy investments until 2018, but become increasingly smaller numbers in later years as the majority of homes in the defined market have been assessed. The likely financial conditions for that year, namely sources and level of incentives for customer investments, are also applied based on best available information. This accounts for the disappearance of the Energy Alliance's incentive-only program by 2013, the complete ramp-down of direct the Energy Alliance's cost share incentives for participants in the loan program by 2014, and the assumption that existing federal incentives will similarly disappear starting in 2014, while existing Duke Energy incentives will continue throughout the entire study period.

It is assumed that starting in 2012 all costs not covered by incentives are financed at 6.99% over an average term of seven years through the GC-HELP program. It is important to note that based on the experience of similar programs elsewhere in the country it is unlikely that all participants in Energy Alliance programs, such as energy assessments, who choose to make energy improvements would select GC-HELP for their financing. For example, a comprehensive residential energy improvement program in Austin, Texas saw only 20% of participants select the financing sponsored by the program, while the remainder financed the measures they installed out-of-pocket or through other means (LBNL 2011). Other options that could be used by homeowners to finance energy improvements include an Energy Efficient Mortgage, such as those offered by the Federal Housing Administration and the Department of Veteran's Affairs (ENERGY STAR 2011), the FHA PowerSaver pilot loan program (DOE 2011b), or a home equity line of credit. Additionally, as the market for home energy improvements expands private banks may begin to offer new products to serve the market. Keeping in mind this experience elsewhere, our analysis likely overestimates the total demand on the GC-HELP program in particular; however it does reflect the overall demand for financing in general that will be required to meet the goals set down by the Energy Alliance.

Implementation Scenarios

With all of these variables in place we are able to apply a year-by-year model of the costs and performance of the CG-HELP residential loan program. We have two main scenarios: one in which the finance program is relatively short-lived and operates from 2012 to 2016 before disappearing from the market and a second in which the program operates from 2012 through 2030, the end of the time period modeled. For the five-year scenario participation ramps up to 2,500 homes making improvements by 2013 and stays flat at that level through 2016. In the twenty-year scenario follows the same path through 2013 and participation ramps up by 4% annually through 2030. Participation in the loan program under the two scenarios is compared in Figure 17. The annual participation rate as a percentage of the identified market is 1.58% on average for the five-year scenario and 2.45% on average under the twenty-year scenario. These two scenarios also include impacts from the Energy Alliance's incentive only program from 2010 through 2013.

Figure 17. Annual Participation in the GC-HELP Loan Program



The two scenarios are intended to represent two possible futures for building energy improvement financing in the Cincinnati area: a big push that achieves significant participation over several years but with that ends up not being sustained or the development of a program that becomes well established in the region and continues to grow over the coming decades. Annual investment, energy savings and cost savings results at five year intervals for the two scenarios are reproduced in Table 12 and Table 13. These numbers are the results in each sample year rather than being cumulative of previous years. Finally, it is important to note that in these tables the same costs are presented twice, once as investments in the year of installation of energy efficiency measures and again as payments in the years that those costs are paid off by the consumer. As a result the costs in each year in the table should not be added together to determine total cost for the year, doing so would result in double counting. Instead the numbers serve as a guide to show when new energy efficiency measures are being implemented and when costs are paid by participants in the programs.

Table 12. Energy and Cost Results from Residential Five-Year Program Scenario

Investments (thousands 2009$)	**2010**	**2015**	**2020**	**2025**	**2030**
New efficiency investments	$ 425	$ 12,375	$ -	$ -	$ -
Energy Savings					
Electricity (MWh)	142	43,284	58,284	58,284	42,000
Natural Gas (MMBtu)	799	243,473	327,848	327,848	236,250
Cost Savings (thousands 2009$)					
Electricity	$ 13	$ 4,908	$ 7,158	$ 7,591	$ 5,852
Natural Gas	$ 173	$ 3,200	$ 4,380	$ 4,776	$ 4,017
Total	$ 186	$ 8,108	$ 11,538	$ 12,366	$ 9,869
Payments (thousands 2009$)					
Loan Payments	$ -	$ 4,652	$ 6,082	$ -	$ -

Table 13. Energy and Cost Results from Residential Twenty-Year Program Scenario

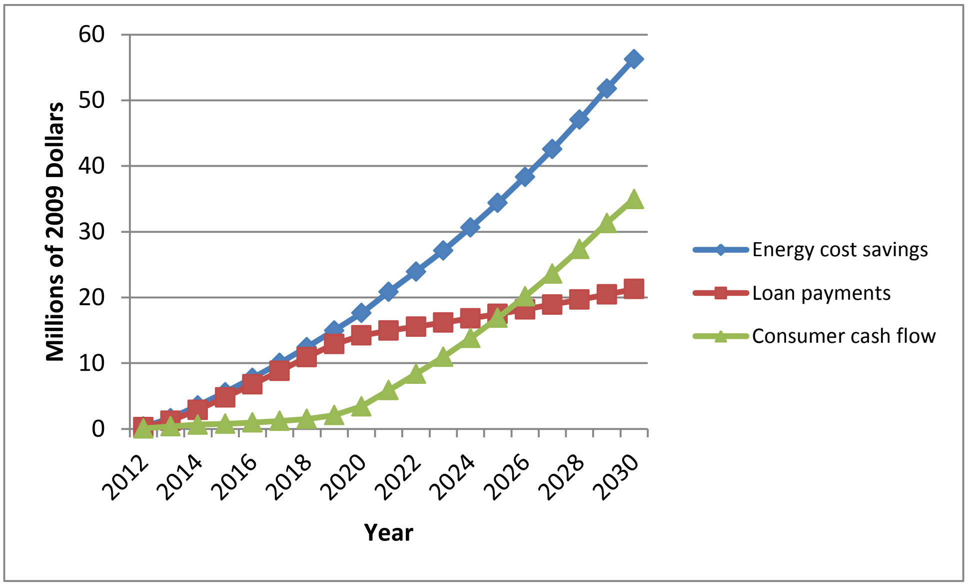
Investments (thousands 2009$)	**2010**	**2015**	**2020**	**2025**	**2030**
New efficiency investments	$ 425	$ 13,385	$ 15,628	$ 18,400	$ 22,176
Energy Savings					
Electricity (MWh)	142	44,092	103,836	176,528	248,640
Natural Gas (MMBtu)	799	248,018	584,078	992,970	1,398,600
Cost Savings (thousands 2009$)					
Electricity	$ 13	$ 5,000	$ 12,753	$ 22,990	$ 34,646
Natural Gas	$ 173	$ 3,260	$ 7,756	$ 14,433	$ 22,063
Total	$ 186	$ 8,260	$ 20,509	$ 37,424	$ 56,708
Payments (thousands 2009$)					
Loan Payments	$ -	$ 4,796	$ 14,210	$ 17,489	$ 21,269

The only major differences between the scenarios are the time period over which investments are made and the subsequent level of investments over the study period. All other variables remain the same. To best describe the full potential of the program we chose to focus primarily on the twenty-year scenario. Even at the end of the twenty-year scenario the market opportunity for cost effective energy savings has still not been exhausted; a total of nearly 69,000 homes will have been improved by 2030 leaving untouched an additional 71,000 of the originally identified market of 140,000. The potential for the program to expand beyond this scenario is significant.

Impacts on Households

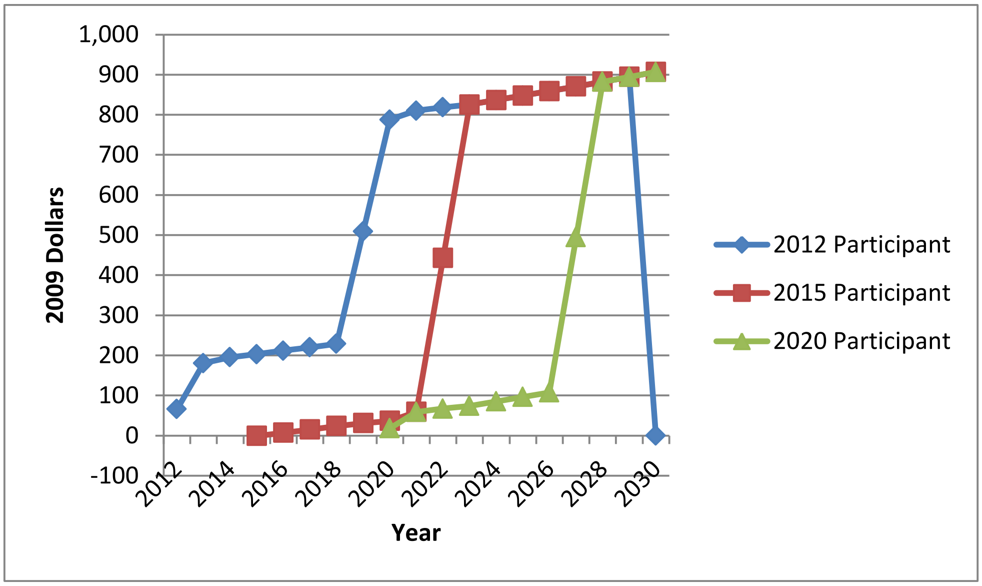
The twenty-year scenario produces considerable cost savings for households. The residential loan program, which represents the bulk of investments and energy savings over the 20 years, results in a positive participant cash flow of $66,000 in 2012, its first year of operation. Cash flow increases each year to nearly $34 million in annual consumer savings in 2030. Consumer cash flow speeds up dramatically starting in 2020 as the early loans disbursed through the program are paid off while consumer energy savings continue for several more years. Figure 18 displays the relationship between loan costs, energy cost savings, and consumer cash flow.

Figure 18. Program-Wide Annual Energy Cost Savings, Loan Payments, and Consumer Cash Flow for Residential Loan Program



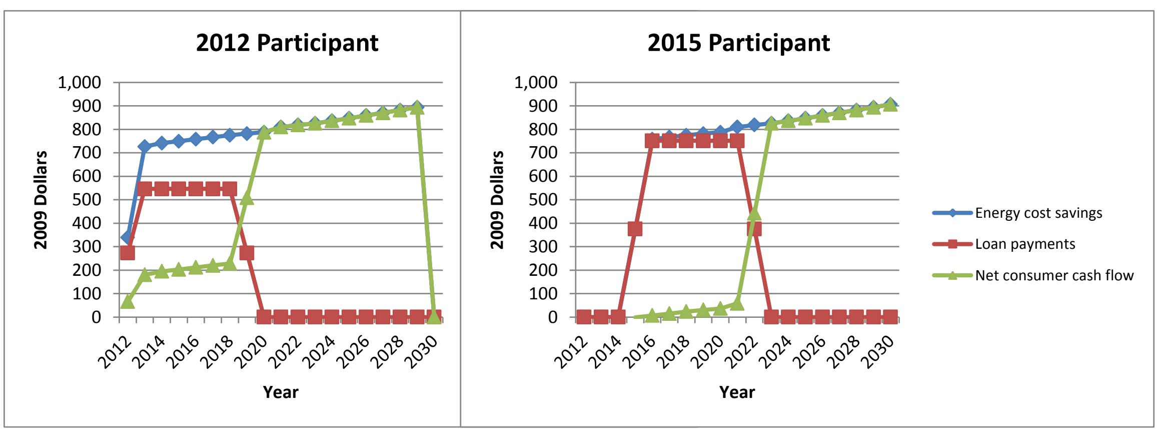
Individual household participants will experience a similar pattern of savings. Figure 19 shows cash flow from the perspective of a participant making energy improvements to their home in three example years. Our model assumes that the average new participant in any given year will join in the middle of the year, and as a result only see a half year of energy savings and make half a year's worth of loan payments. As a result, participants make their final loan payments in the first six months of their eighth year and make no payments in the second six months. Participants in 2012 benefit from higher cost matching incentives from both the Energy Alliance and the federal government. The result is higher immediate positive annual cash flow, ranging from $66 up to $229 during the term of the loan. Participants making energy improvements in 2015 and 2020 see lower cost savings during the term of their loans due to the expiration of Energy Alliance and Federal incentives. 2015 participants actually experience a negative cash flow impact of $1 during their first year. However, 2015 and 2020 participants experience a rising positive and increasing cash flow impact for every other year of their loan term ranging from $7 to $108 annually. After the loans are paid off average participants making the same investments from each of the different years receive identical energy savings based on energy costs in that year until the lifespans of the energy improvement measures are exhausted. The annual cash flow benefits after loans are paid off range from $788 to $907 and rise each year because of energy cost increases. Because the residential measures modeled have an average lifespan of 18 years, and for simplicity sake the model considers all savings to expire at that point, (although in reality some savings will expire earlier and some will persist for many more years) only participants from 2012 see their annual cost savings disappear by 2030. Although it is not included in this model, it is important to note that this drop in energy and consumer savings could be avoided by an additional investment in energy efficiency measures near the end of the life cycle of the previous measures.

Figure 19. Average Annual Cash Flow Change for Residential Loan Program Participant Households in Years 2012, 2015, and 2020



For a 2012 participant, the average annual net household cost savings, or net positive cash flow, is $569 over the 18-year period in which energy savings are obtained. Even after cash incentives expire in the later years, participants in 2015 and 2020 still achieve average annual cost savings of over $500. Figure 20 provides the dollar figures for both energy cost savings and loan payments that result in the net change in cash flow for participants in 2012 and 2015. Although the average participant in both years is modeled to undertake $4,350 in energy improvements, annual loan payments for a 2012 participant are around $200 less during the repayment years because upfront incentive payments resulted in a smaller initial loan size.

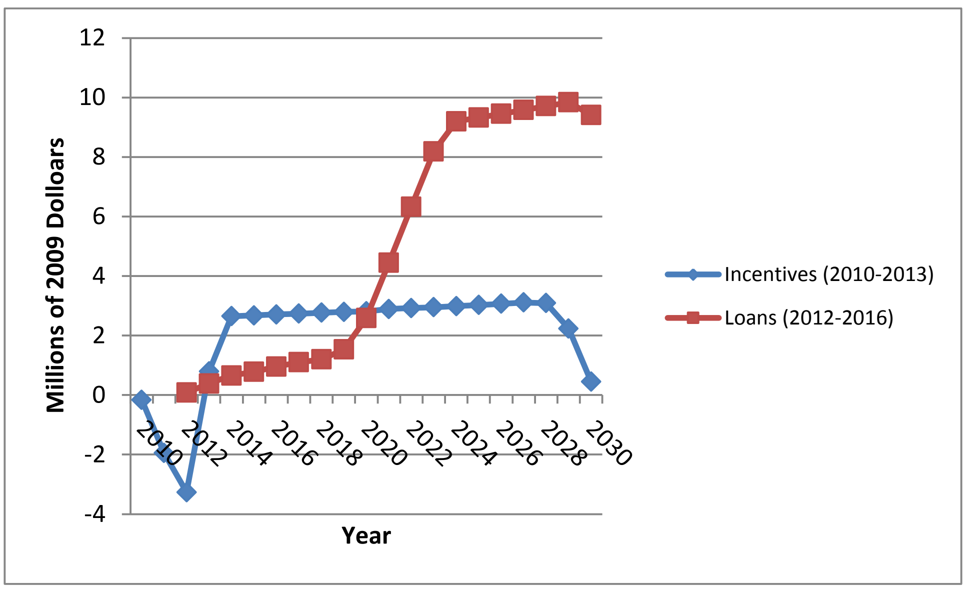
Figure 20. Energy Cost Savings, Loan Payments and Net Consumer Cash Flow for Participant Households in 2012 and 2015



Perhaps the most significant feature of this cash flow analysis from the consumer perspective is that net cost savings are achieved in the first year. Because the entire cost of energy improvements are financed, participants need not contribute funds from out-of-pocket and cost savings from reduced energy consumption are more than enough to cover loan payments. From the consumer perspective this a “good deal” even for present-biased consumers. The challenges of the current cash flow situation of eligible borrowers and upfront costs of energy efficiency measures—so often significant barriers to energy efficiency investment—can be largely addressed as a result of this loan product.

From the cash flow perspective this loan product stands in contrast to the existing Energy Alliance financial incentive program. While the loan product allows customers to see positive cash flow right away, financial incentives that supplement out-of-pocket customer spending only shorten the length of time that customers will experience negative cash flow. Figure 21 compares the cash flow results of the Energy Alliance incentive-only program to the loan program as implemented between 2010 and 2016 in the five-year scenario. Although the programs begin operating at different times and have different levels of participation in the scenario, the differing patterns in the chart are illustrative of the different impacts on household consumer cash flow over time. Under the financial incentive program (which includes just fewer than 3,600 participants over four years) total costs to consumers outweigh benefits until 2013 when new investments under the program are ramping down. At the low point in 2012 consumer cash flow is negative by $3.26 million, before bouncing back up after all upfront spending has been made. From 2014 through the expiration of the benefits from the energy saving measures begin in 2029 costumers see considerable and steadily increasing savings ranging from $2.6 to $3.1 million annually. The loan program (which includes 11,000 participants over five years) provides a net positive consumer cash flow in its first year of $80,000 to its first 1,000 participants. Cash flow remains positive but low through the first eight years of the program, peaking at just over $1.5 million, as participants are making loan payments. As loans begin to be paid off positive cash flow greatly increases again until plateauing at a high but steadily increasing level of nearly $10 million annually until the energy efficiency measures begin to expire in 2030.

Figure 21. Comparative Total Annual Cash Flow in Residential Five-Year Scenario from Financial Incentives and Loans



Note that these are the average results under the assumptions of the twenty-year scenario. Not every participant will experience these same savings. Variations in the choices of measures installed, contractor costs, energy costs, financing terms, and the impact of market competition, among other variables, will result in different monetary savings. On the other hand, energy efficiency is a low-risk investment. While monetary savings variations will be significant between participants and even from year-to-year, the energy savings that a single participant will experience from year-to-year will be largely consistent (within a small range of variation due to weather, behavior, and other factors). In other words, same efficiency measures can be expected to perform consistently across their useful lifetime reducing the risk presented by variations in energy prices.

It is also important to highlight that although the energy cost savings of this investment may be compelling for many households, there are a number of non-energy benefits which may be of even greater value to consumers. Many energy efficiency measures increase home comfort by decreasing air infiltration and drafts, improving air flow, and providing healthier indoor air quality. In many cases energy performance improvements make areas of homes that were previously either too hot or too cold more comfortable for regular use (Amann 2006). This is in addition to the economic benefits of energy cost savings, such as freeing up funds to be put toward other household priorities of personal importance like major purchases, vacations, or education.

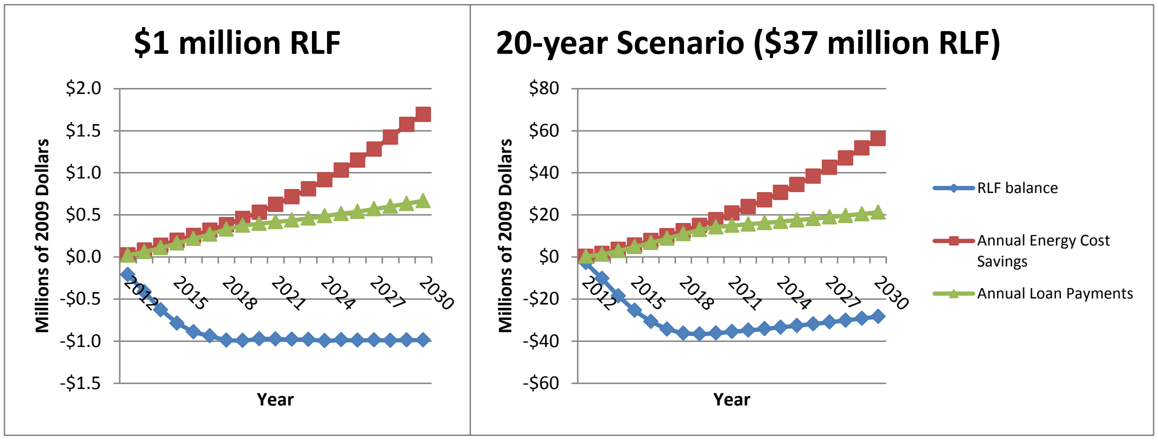
Program Constraints

The major constraints on the impact of the loan programs are the fund size, financing terms, and level of participation.

The GC-HELP program establishes a revolving loan fund (RLF) that is the basis of capital made available for lending activity. The Energy Alliance may use the maximum amount allowed from their Department of Energy grant, 20% or $3.4 million, to seed this fund. As the only existing source of capital for the loan program, the size of this fund limits the lending activity possible under the GC-HELP program. To determine the size of fund needed to meet the goals of the Energy Alliance and using the average loan size, incentives, and years of repayment described earlier in the scenarios. We also assume a loan loss of 5% of loan principle and that the fund pays out 75% of interest payments from borrowers to investors and that the remainder of payments are reinvested into the fund. This loan loss reserve assumption is conservative and based on the performance of similar unsecured energy loan programs it is likely higher than would be needed. For example, as of 2008 the Keystone HELP program in Pennsylvania had a default rate of less than 0.5% and a delinquency rate of less than 1% (Fuller 2008). A broader sample is provided by a 2011 ACEEE review of over two dozen existing loan programs for residential and commercial energy efficiency improvements that found a range of default rates from 0-3%, with most near the low end of the range (Hayes et al. 2011).

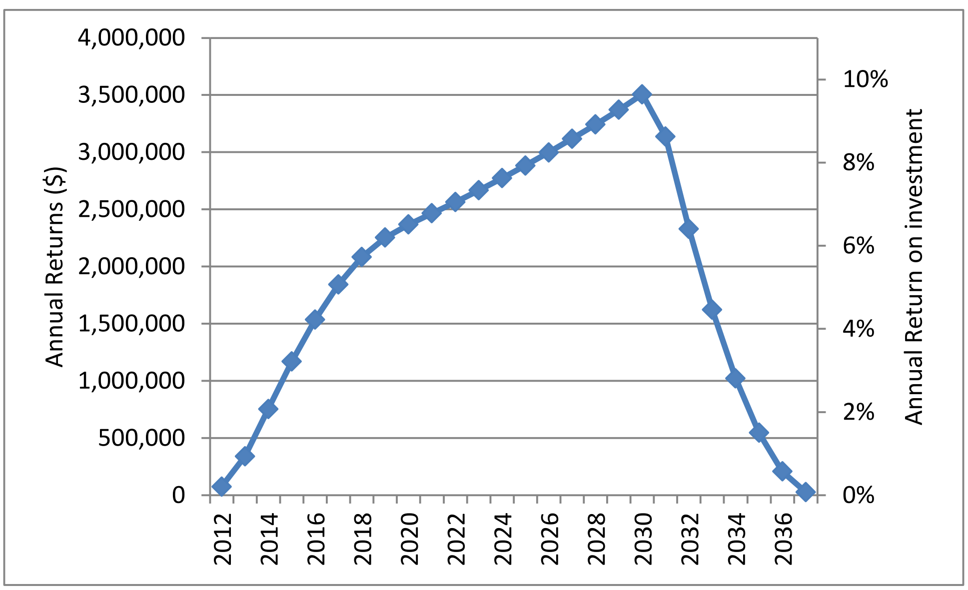
Using these terms, for every $1 million in the revolving loan fund the program is able to finance just under 2,000 home energy improvement projects over the study period resulting in annual consumer savings of 7.36 million kWh, 414,000 therms and $1.69 million in 2030. The Energy Alliance will require a considerably larger revolving loan fund to achieve their household participation goals. In order to fully finance the twenty-year residential scenario through a revolving loan fund, a fund size of just under $37 million will be required. At this level of participation, the difference between payments and lending amounts will peak in 2019 and a slightly smaller fund size will be required after that year. These two fund size scenarios are compared in Figure 22.

Figure 22. Energy Savings and Loan Payments Varied by Size of Available Residential Revolving Loan Fund



The large revolving loan fund required to meet the goals of the twenty-year scenario means that considerable additional investment will be need to capitalize the fund. The fund should provide an attractive investment, particularly for institutional investors, as it will provide stable, consistent and significant returns. With the fund paying out to investors 75% of participant interest payments, the annual rate of return for the fully capitalized $37 million fund averages 5.29% from 2012 through 2037 and 3.01% for the first seven years through 2018. Returns peak in 2030 as the program stops lending, but continue through 2037 as loans continue to be paid down. Figure 23 shows annual returns through 2037 in dollar and percentage terms.

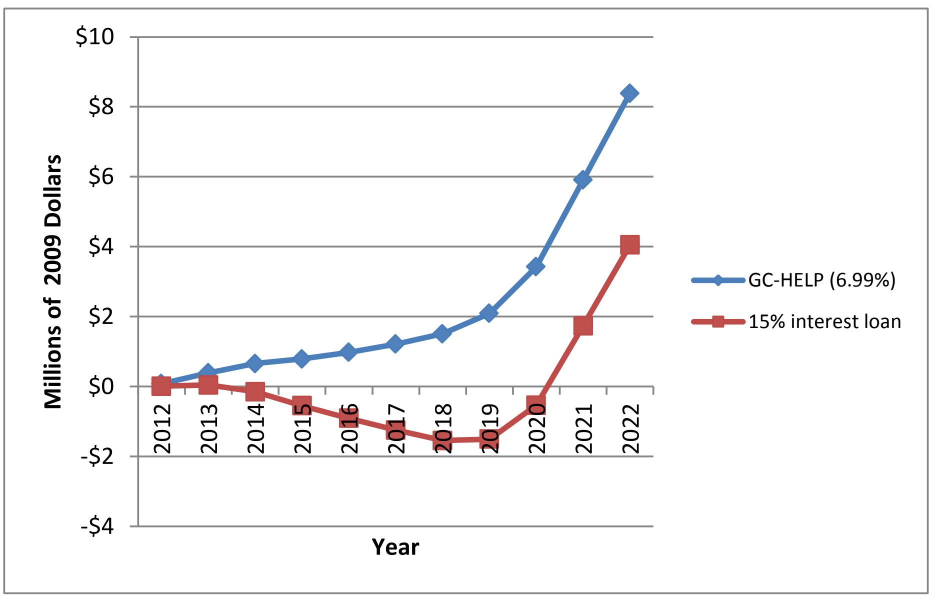
Figure 23. Annual Returns on the $37 Million Residential Revolving Loan Fund



The financing terms of the loan program as described in Table 11 also have the potential to limit the pool of consumers for whom the program makes financial sense. However, the Energy Alliance has already taken significant steps to optimize the terms of the loan program from the customer perspective. Other financing programs for home energy improvements do exist but one of their disadvantages is their high interest rate. Figure 24 provides a comparison of total participant cash flow between the GC-HELP program and EnergyLoan, an existing home energy loan product from AFC First with a 14.99 to 15.99% interest rate (AFC 2011). The EnergyLoan program uses market rate funds from Fannie Mae without any buy-down mechanism, resulting in the higher interest rate. Such high interest rate loan programs can have negative cash flow impacts for participants. The effect is similar to the incentive-only program except that the negative impact is spread out over the length of the loan and is therefore less severe in any particular year, rather than all accruing in the first few years of participation.

Likely the most serious constraints on the program will be consumer demand and participation. Financing alone will not address all barriers to participation. Of 150 energy efficiency loan programs identified in a 2008 study, most reached less than 0.1% of their potential customers in 2007. Programs with higher participation were identified as having networks of contractors who actively market the finance programs to their customers (Fuller 2008). Information and transaction cost barriers are often persistent and can cause low participation in energy efficiency programs. Programs must be designed specifically to understand and address these barriers. Working through contractors and other existing networks to market the product is an essential part of a developing a financing product that works. The Energy Alliance already has begun to develop a strong group of participation contractors and relationships with many social networks. These efforts will need to be strengthened as the GC-HELP loan program becomes the main product offered by the Energy Alliance.

Figure 24. Comparative Total Annual Participant Cash Flow for Residential Loans at 6.99% and 15% Interest



Sector-Based Financing—Nonprofits

The Energy Alliance has also identified nonprofit organizations as an important market segment to serve. Within the nonprofit sector the Energy Alliance has identified six organizational types that it aims to serve; these include health, education, cultural, recreational, social service, and religious organizations. In particular the Energy Alliance is initially focused on nonprofits who own or rent a large amount of square footage (approximately 25,000 square feet or more), in part because at this scale the energy and cost savings of any one energy efficiency project are larger and potentially more attractive to decision-makers, and as a result the transaction costs are relatively low. In addition to the valuable services they provide to the region, nonprofit organizations are seen as important leaders and messengers in the community. Through leading by example these organization have the opportunity to motivate households and businesses to take energy efficiency actions.

According to *Holding Our Community Together: The Nonprofits of Greater Cincinnati*, a March 2011 report, there are a total of 7,700 nonprofits in the Cincinnati MSA. About 2,200 of these nonprofits have annual revenues of $2,500 or greater and 932 of them have revenues in the latest reported year of $250,000 or more, including 514 with revenues of over $1 million (Deardurff 2011). Nearly 80% of these 514 nonprofits fall into one of the six types targeted by the Energy Alliance.

The Energy Alliance is exploring options to help finance energy improvements to buildings that house or are owned by nonprofit organizations. This analysis attempts to establish the size and characteristics of this market, establish a scenario for the implementation of energy efficiency measures, and analyze the impacts of a loan financing program aimed at the nonprofit market. Although the Energy Alliance does not yet have a loan program in place for this market segment, we will look at a hypothetical program similar in design to the GC-HELP program.

Market Size and Program Variables

Using the results from our nonprofit building energy efficiency potential analysis we are able to establish an approximation of the size of the market of nonprofit buildings over 25,000 square feet segmented by building type. First we developed an estimate of nonprofit building square footage in the four-county Cincinnati region derived from the baseline commercial building energy use in our reference case. We used this square footage estimate to scale North East Central region data from the EIA Commercial Building Energy Consumption Survey (CBECS) to the Cincinnati region. Finally we used national data on number of establishments by legal form of organization and NAICS sectors to estimate the number and size of commercial buildings that serve nonprofits disaggregated by building type (Census 2008). Although considerable research (such as Deardurff 2011) has been completed on the economic characteristics of the nonprofit sector in the Cincinnati region, little if any research has looked comprehensively at the characteristics of the buildings serving nonprofits in the region. As a result we chose to scale widely accepted Midwest regional and U.S. datasets to the Cincinnati region.

Through this exercise we were able to determine estimates of total square footage, number of buildings, electricity intensity and natural gas intensity for five different nonprofit building types (Office, Education, Health Care, Public Assembly, and Religious as defined by CBECS) as shown in Table 14. This resulted in an estimated total of 1,350 nonprofit buildings in the four-county area with an average size of 19,600 square feet. Even within these building types buildings vary in size greatly. Because the Energy Alliance is interested in targeting nonprofit buildings with the greatest energy use, we used the average building size for each of these building types to estimate the percent of buildings in each type greater than or equal to 25,000 square feet. The result was an estimate of just under 470 total nonprofit buildings of 25,000 square feet or greater. The detailed results by Building Type are reproduced in Table 15.

Table 14. Building Characteristics of Nonprofit Building Types for Study Region

Building Types	%	Total NP Floorspace (mil. Sq. ft.)	%	Number of Buildings	Electricity Intensity (kWh/sq. ft.)	NG Intensity (1000 BTU/sq.	Avg. Bldg. Size (1000 sq. ft.)
Office	22%	5.91	27%	361	18.9	45.1	16
Education	35%	9.20	12%	157	7.9	56.3	59
Health Care	5%	1.34	4%	49	24.2	103.7	28
Public Assembly	6%	1.71	5%	67	12.3	66.2	25
Religious Worship	31%	8.32	53%	717	4.3	47.7	12
Total	100%	26.49	100%	1352	13.8	54.7	20

Table 15. Building Characteristics by Nonprofit Building Type

Building Type	Buildings	Average sq. ft.	Buildings over 25,000 sq. ft.
Office	361	16,343	72
Education	157	58,529	118
Health care	49	27,550	29
Public Assembly	67	25,400	34
Religious	717	11,613	215
Total	**1,352**	**19,598**	**468**

Next, based on results from our economic potential analysis for nonprofit buildings we developed eight energy efficiency measure packages that vary based on the type of energy improvements and whether they were applied in a building that used electricity only or a building with electricity and natural gas. We then calculated the costs and energy savings of each of these measures as applied to the average building in each of the five building types. Details of measures included in each of the packages and average costs and energy savings for each package as applied to an average nonprofit building in the region are reproduced in Table 16. This information for each of the five building types is included in Table 42 in Appendix D—Efficiency Potential Methodology for Commercial Nonprofit Buildings.

Table 16. Costs and Energy Savings from Eight Packages as Applied to an Average Cincinnati Region Nonprofit Building

			Costs	***Energy Savings***	
Package			*$*	*kWh*	*thems*
Natural Gas and Electric					
1	**Envelope**	duct testing and sealing, roof insultation, efficient ventalation and motors	$21,917	18,657	1,980
2	**Envelope & lighting**	all envelope measures plus florescent lighting improvements, replace incandescant lamps, occupancy sensor for lighting	$25,852	59,088	1,980
3	**Envelope & HVAC**	all envelope measures plus high efficiency unitary AC & HP [65-135 kbtu], HVAC tuneup, high efficiency rooftop furnace unit, programable thermostat	$23,804	28,427	2,575
4	**Envelope, HVAC & lighting**	all measures from packages 1-3	$27,740	68,858	2,575
All Electric					
5	**Envelope**	duct testing and sealing, roof insultation, efficient ventalation and motors	$12,345	20,900	0
6	**Envelope & lighting**	all envelope measures plus florescent lighting improvements, replace incandescant lamps, occupancy sensor for lighting	$16,281	61,331	0
7	**Envelope & HVAC**	all envelope measures plus high efficiency unitary AC & HP [135-240 kbtu], HVAC tuneup, heat pump water heater, high efficiency chiller system	$27,885	48,050	0
8	**Envelope, HVAC & lighting**	all measures from packages 5-7	$31,820	88,481	0

For the implementation of energy efficiency measures in this market over a twenty-year period we developed average per building costs based on the weighted average of package 4 and package 7 to account for the mix of buildings in the region using electric only and both electric and gas with a roughly similar amount of investment into each building type. From 2010 through 2019 we used an average participant building size equivalent to 27,500 square feet (equivalent to the size of an average Health Care building) and from 2020 through 2030 an average building size of 25,400 square feet (equivalent to the size of an average Public Assembly building). This deployment scenario assumes that a larger number of smaller buildings will participate in the program in its later years, with the average participant building eventually nearing the 25,000 square foot threshold. The average energy efficiency measure life is calculated based on the average of all measures by fuel: 17 years for natural gas measures and 11 years for electricity measures.

From 2010 through 2013 a financial incentive program from the Energy Alliance paying for 25% of eligible energy improvements is in operation for at least part of the market. A loan program providing 6.99% interest and 100% financing for eligible energy improvements starts operation in 2012 and becomes the only financing mechanism starting in 2014 after the financial incentives are phased out. The loan program is coupled with a 15% financial incentive from the Energy Alliance for its first two years but starting in 2014 no financial incentives are available from the Energy Alliance and no others are factored into the financial analysis.

Implementation Scenarios

We developed two implementation scenarios—five-year and twenty-year—in a similar fashion to the residential loan analysis.

Participation in both scenarios tracks with the goals set by the Energy Alliance for the first few years and, under the twenty-year scenario, steadily ramps up to 90 energy assessments and 30 whole-building energy improvement projects each year by 2022. The program ramps down in 2028 through 2030 as nearly all buildings in the large nonprofit building market have received energy performance improvements. Under the five-year scenario participation peaks at 60 assessments and 20 energy improvement projects in 2014 through 2016, the last year of the program. Figure 25 displays the annual participation in the loan program under the two scenarios. The annual participation rate as a percentage of the identified market is 3.42% on average for the five-year scenario and 5% on average under the twenty-year scenario, Annual investments, loan payments, energy savings and cost saving results at five year intervals from the loan and financial incentive program combined in the two scenarios are reproduced in Table 17 and Table 18.

Figure 25. Annual Participation in Nonprofit Loan Program

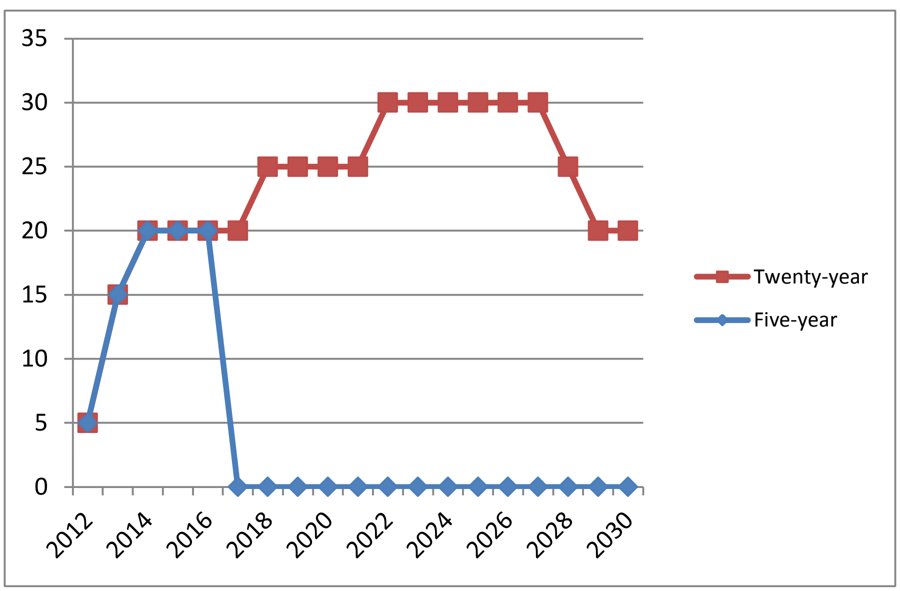


Table 17. Energy and Cost Results from Nonprofit Five-Year Program Scenario

Investments (thousands 2009$)	**2010**	**2015**	**2020**	**2025**	**2030**
New efficiency investments	$ 104	$ 735	$ -	$ -	$ -
Energy Savings					
Electricity (MWh)	37	5,575	7,775	2,934	-
Natural Gas (MMBtu)	36	5,464	7,621	4,745	4,314
Cost Savings (thousands 2009$)					
Electricity	$ 3	$ 566	$ 869	$ 356	$ -
Natural Gas	$ 0	$ 56	$ 79	$ 89	$ 55
Total	$ 3	$ 623	$ 949	$ 445	$ 55
Payments (thousands 2009$)					
Loan Payments	$ -	$ 268	$ 368	$ -	$ -

Table 18. Energy and Cost Results from Nonprofit Twenty-Year Program Scenario

Investments (thousands 2009$)	**2010**	**2015**	**2020**	**2025**	**2030**
New efficiency investments	$ 104	$ 885	$1,096	$1,316	$ 877
Energy Savings					
Electricity (MWh)	37	5,575	13,755	18,550	19,273
Natural Gas (MMBtu)	36	5,464	13,482	20,039	28,214
Cost Savings (thousands 2009$)					
Electricity	$ 3	$ 566	$1,538	$2,251	$2,535
Natural Gas	$ 0	$ 56	$ 140	$ 269	$ 360
Total	$ 3	$ 623	$1,678	$2,520	$2,895
Payments (thousands 2009$)					
Loan Payments	$ -	$ 285	$ 881	$1,123	$1,106

The twenty-year scenario results in energy improvements to 460 nonprofit buildings. The market segment of nonprofit buildings of 25,000 square feet and larger is essentially exhausted at the end of the scenario, however the entire market of approximately 875 nonprofit buildings below 25,000 square feet remains. At the end of the five year scenario, 350 buildings above 25,000 square feet are left unimproved.

Impacts on Nonprofits

The loan program results in annual net positive cash flow for participants totaling over $5,500 starting in 2012, the first year of the program. Cash flow impacts increase each year through 2030, totaling nearly $1.8 million in that year. Figure 26 presents the loan payments by participants, energy cost savings received and resulting annual net cash flow impact on participant nonprofits from the twenty-year scenario. Note that these are the average results under the assumptions of the twenty-year scenario. Not every participant will experience these same savings and cash flow. The same caveats that were previously discussed in the residential analysis also apply to the nonprofit loan program.

Figure 26. Program-Wide Annual Energy Cost Savings, Loan Payments, and Consumer Cash Flow for Nonprofit Loan Program

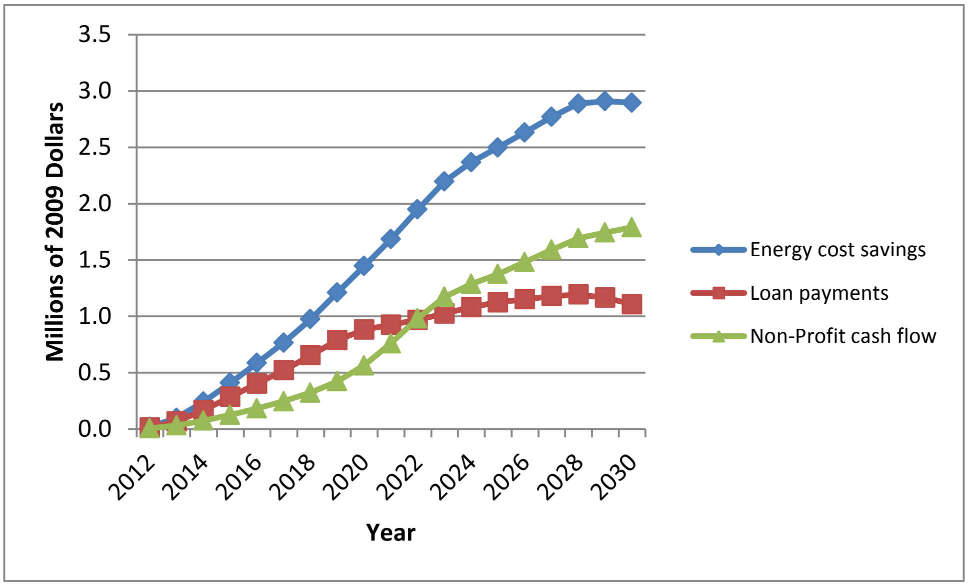


Figure 27 presents the same information from the perspective of an individual nonprofit participating in the program in three example years. Similarly to the residential scenario all participants see positive cash flow impacts starting in the first year which increase modestly each year during the length of the loan. Once the loan is paid-off cash flow increases considerably until the measure life of the electric measures expire after the eleventh year. Cash flow impacts are modest but remain positive until the natural gas measures expire after the seventeenth year at which time they drop to zero. Participants in later years see higher cash flow impacts mostly as a result of higher energy prices in the later years. For a 2012 participant, the average annual net cost savings, or net positive cash flow, is $3,600 over the 17-year period in which energy savings are obtained. Participants in 2015 and 2020 achieve average annual cost savings of $3,000 or more.

From the participant cash flow perspective the loan program is superior to a financial incentive program. Figure 28 compares total net annual participant cash flow between the financial incentive program and loan program included in the five-year scenario. The financial incentive program has sharply negative impacts on cash flow during the first three years after participation in the program before recovering starting in the fourth year and providing positive impacts for approximately the next decade until electricity measures expire after a decade. Under the loan program cash flow for participants is positive starting in the first year and increases every year until electricity measures expire.

Figure 27. Average Annual Cash Flow Change for Nonprofit Loan Program Participant Organizations in Years 2012, 2015, and 2020

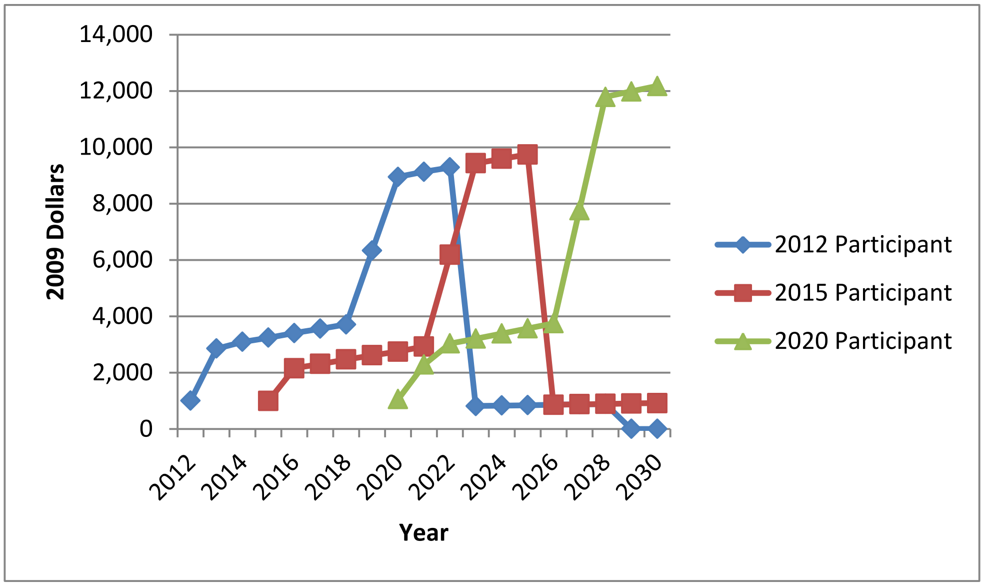
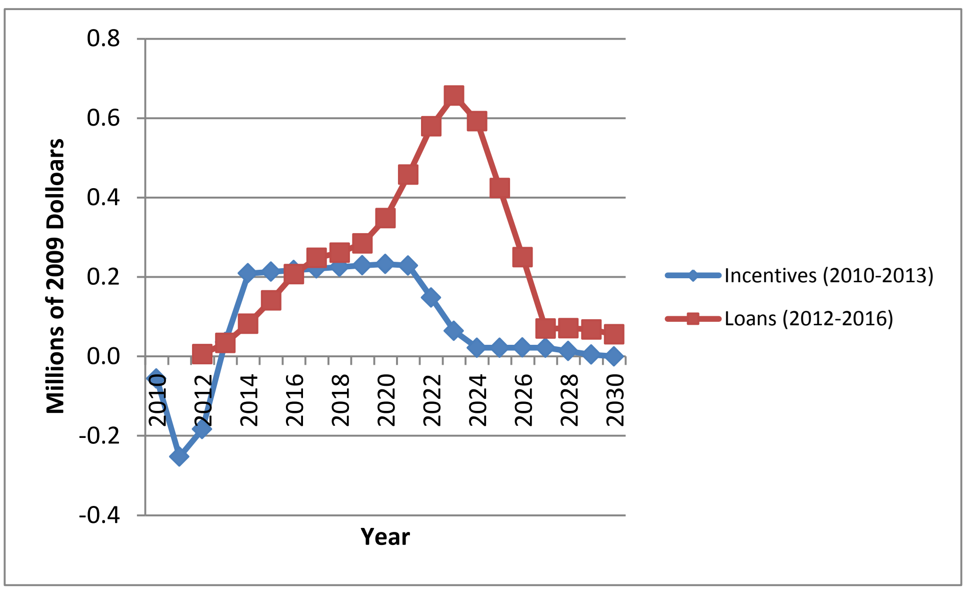


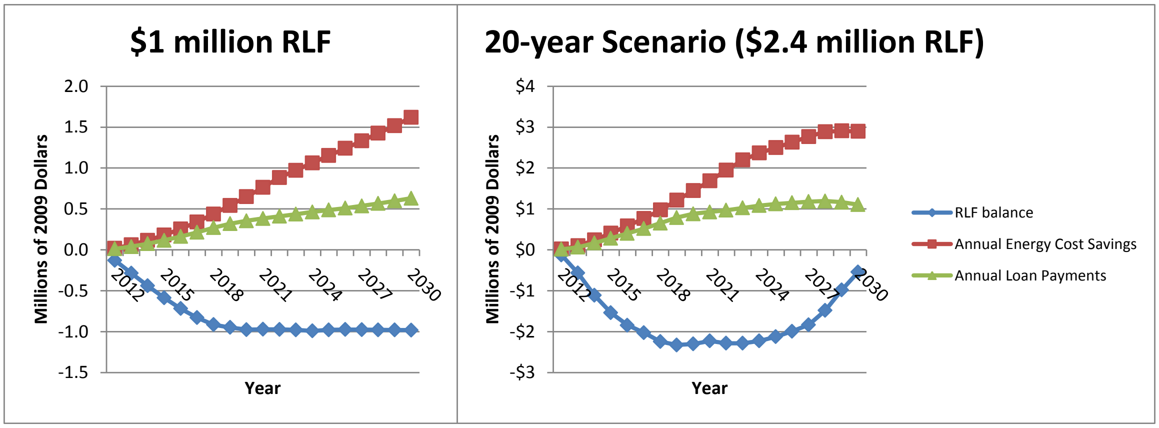
Figure 28. Comparative Total Annual Cash Flow in Nonprofit Five-Year Scenario from Financial Incentives and Loans



Program Constraints

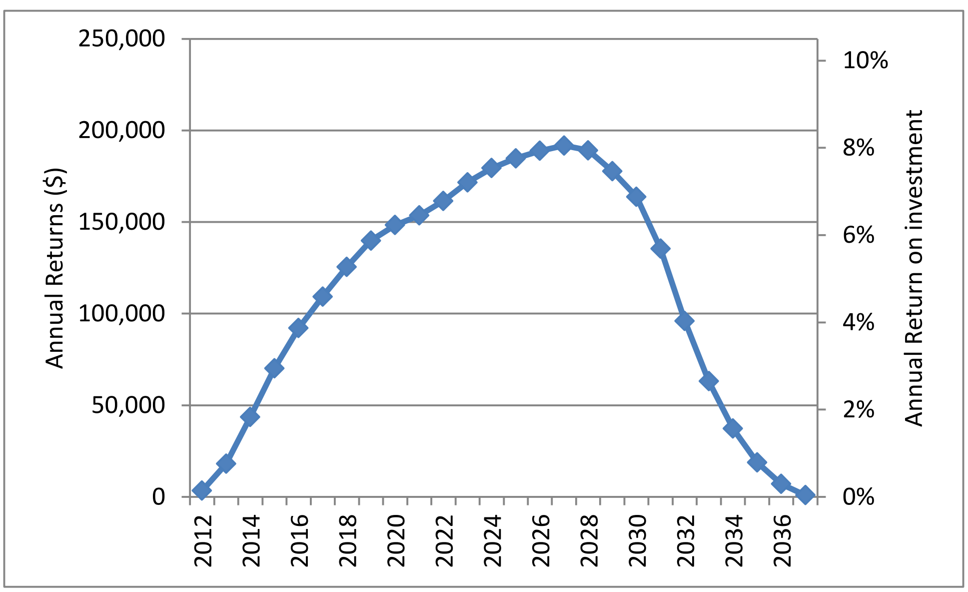
The loan program will be constrained by the amount of funds available for lending to consumers. Using a revolving loan fund (RLF) structure at the terms previously described and assuming 5% loan loss and with the fund paying out to investors 75% of participant interest payments, for every $1 million available in the fund the program will be able to finance a total of just under 240 nonprofit energy improvement projects over the study period resulting in annual participant savings of 10.9 million kWh, 147,000 therms, and over $1.6 million in energy bills in 2030. In order to accomplish the goals set under the twenty-year scenario the Energy Alliance will require a larger revolving loan fund of at least $2.4 million. These two fund sizes and their impacts are compared in Figure 29.

Figure 29. Energy Savings and Loan Payments Varied by Size of Available Nonprofit Revolving Loan Fund



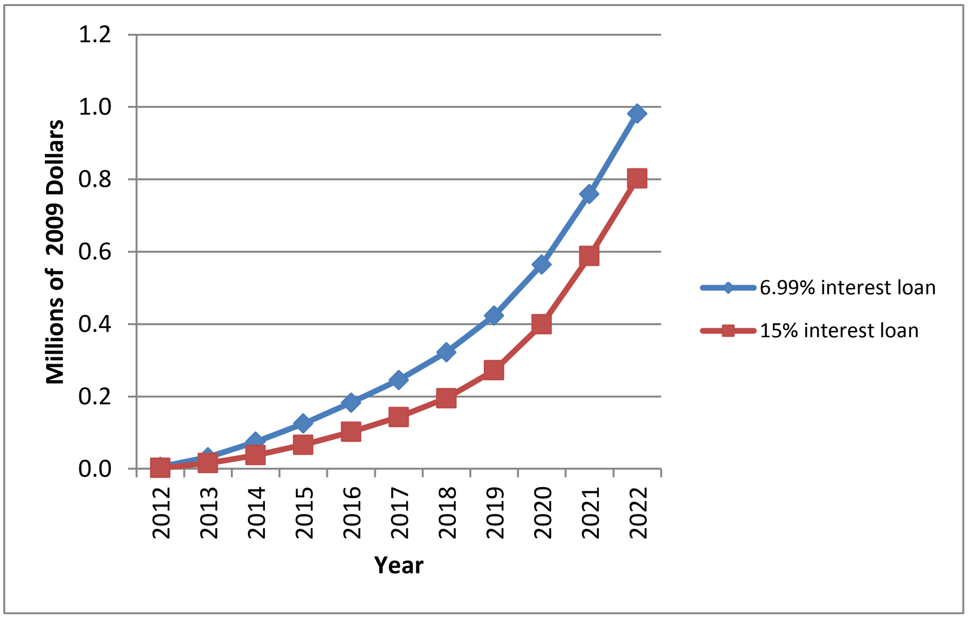
This revolving loan fund should provide an attractive investment because, similar to the residential revolving loan fund, it will provide stable, consistent and significant returns. With the fund paying out to investors 75% of participant interest payments, the annual rate of return for the fully capitalized $2.4 million fund averages 4.60% from 2012 through 2037 and 2.75% for the first seven years through 2018. Returns peak in 2027 as the program slows lending, but continue through 2037 until all loans are paid down. Figure 30 shows annual returns through 2037 in dollar and percentage terms.

Figure 30. Annual Returns on the $2.4 Million Nonprofit Revolving Loan Fund



The interest rate provided by the loan program also has the potential to constrain the program through its impact on the speed at which the revolving loan fund is recapitalized on one hand and the impact rates may have on participation on the other. Nonprofits would be less likely to participate in the program if the interest rate had a negative effect on their cash flow and their ability to carry out their core mission. In Figure 31 we compare total participant cash flow at 6.99% and 15% interest rates. The higher interest rate has a noticeable but small relative negative impact on participant cash flow. Even at the higher interest rate the loan program has a positive net impact on cash flow in each year starting in the year of participation. The result differs significantly from the residential analysis in large part because of the higher level of energy savings that results from each dollar of investment, especially with regard to electricity measures. This analysis shows that higher interest rates in a nonprofit loan program will likely not have as negative an impact on consumer cash flow when compared to a residential program.

Figure 31. Comparative Total Annual Participant Cash Flow for Nonprofit Loans at 6.99% and 15% Interest



Summary

Our analysis shows considerable consumer energy cost savings, including positive cash flow from energy cost savings that consistently exceed loan payments, for both residential and nonprofit program scenarios. The combined results of the five-year and twenty-year scenarios are presented in Table 19 and Table 20 respectively. Under the twenty-year scenario the programs by 2030 will have a combined annual impact of saving 268,000 MWh of electricity and over 1,425,000 MMBtu of natural gas. This 2030 savings is equivalent to 2.77% of forecasted electricity sales and 6.89% of forecasted natural gas sales for the residential and commercial sectors in the “After EE” case. The energy savings would result in a gross utility bill savings of nearly $60 million annually. These savings are more than twice the total consumer spending on energy efficiency, all done through loan payments, in that year.

While these targets are high, they are achievable. Innovations in targeted marketing and contractor partnerships, to be discussed next, can contribute to high participation rates and the successful implementation of the programs.

Table 19. Energy and Cost Results from Residential and Nonprofit Five-Year Program Scenarios

Investments (thousands 2009$)	**2010**	**2015**	**2020**	**2025**	**2030**
New efficiency investments	$ 529	$ 13,110	$ -	$ -	$ -
Energy Savings					
Electricity (MWh)	179	48,859	66,059	61,218	42,000
As % of forecasted sales	0.00%	0.48%	0.67%	0.63%	0.43%
Natural Gas (MMBtu)	835	248,937	335,469	332,593	240,564
As % of forecasted sales	0.00%	1.30%	1.71%	1.65%	1.16%
Cost Savings (thousands 2009$)					
Electricity	$ 16	$ 5,474	$ 8,028	$ 7,947	$ 5,852
Natural Gas	$ 173	$ 3,257	$ 4,459	$ 4,865	$ 4,072
Total	$ 189	$ 8,731	$ 12,486	$ 12,812	$ 9,924
Payments (thousands 2009$)					
Loan Payments	$ -	$ 4,920	$ 6,450	$ -	$ -

Table 20. Energy and Cost Results from Residential and Nonprofit Twenty-Year Program Scenarios

Investments (thousands 2009$)	**2010**	**2015**	**2020**	**2025**	**2030**
New efficiency investments	$ 529	$ 14,270	$ 16,724	$ 19,716	$ 23,053
Energy Savings					
Electricity (MWh)	179	49,667	117,591	195,078	267,913
As % of forecasted sales	0.00%	0.49%	1.19%	2.00%	2.77%
Natural Gas (MMBtu)	835	253,482	597,559	1,013,009	1,426,814
As % of forecasted sales	0.00%	1.33%	3.04%	5.02%	6.89%
Cost Savings (thousands 2009$)					
Electricity	$ 16	$ 5,566	$ 14,291	$ 25,241	$ 37,181
Natural Gas	$ 173	$ 3,317	$ 7,896	$ 14,702	$ 22,423
Total	$ 189	$ 8,882	$ 22,187	$ 39,944	$ 59,604
Payments (thousands 2009$)					
Loan Payments	$ -	$ 5,081	$ 15,091	$ 18,612	$ 22,375

IMPLEMENTATION STRATEGIES

How do we capture the market potential for energy efficiency?

The previous sections established that the market for energy improvements and that the costs savings available are both large. However, experience with energy efficiency programs has shown that building owners are unlikely to capture these savings without education and encouragement. Targeted marketing and partnerships with contractors are two of the most important tools available to ensure that program participation is high enough to meet the program goals.

Targeted Marketing

The opportunity to achieve energy savings is not equal across the region. Certain areas have a greater proportion of buildings with higher baseline energy use and characteristics that lead to higher potential energy savings. Additionally, demographic characteristics—like age, income, homeownership status and education—have been shown to influence the likelihood of participation in energy efficiency programs. Some demographic variables, like income, creditworthiness, and homeownership status, are also eligibility criteria for Energy Alliance programs. These demographic variables also vary geographically. Knowledge of these variations can help the Energy Alliance to better target their marketing efforts through data-driven approaches to neighborhood canvasses, outreach to neighborhood-based organizations, and other community outreach.

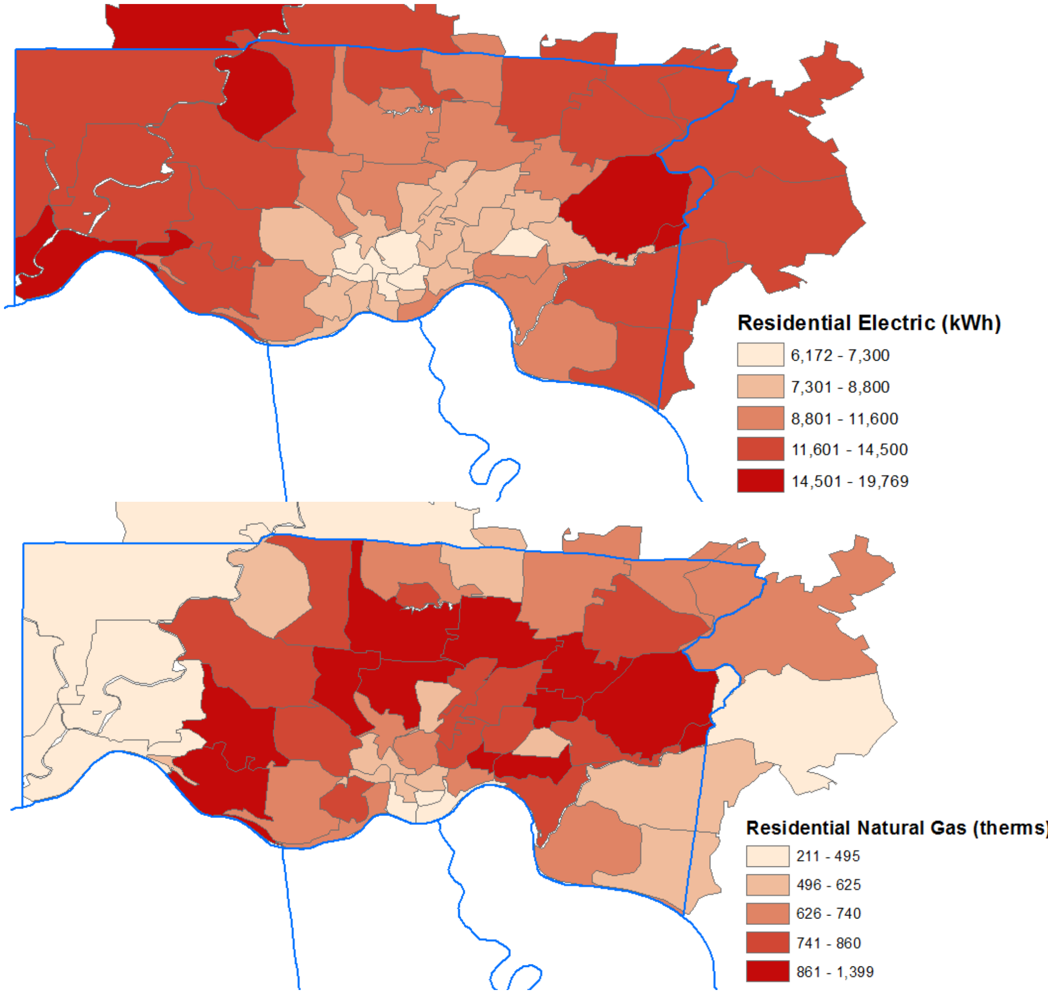
This section presents a ZIP code level analysis of several of these variables in the residential market to better understand the geography of energy consumption, energy saving potential, and likely program participation and eligibility.

Energy Consumption

Based on electricity and natural gas consumption data aggregated by ZIP code that we obtained from Duke Energy, we were able to analyze the geographic distribution of average annual energy consumption for calendar year 2010 for both residential and commercial customers in Hamilton County, Ohio. Data was not immediately available for the Kentucky counties served by the Energy Alliance. For the sake of comparability between fuels and to better understand the market share of natural gas heating, our calculations of averages are based on the total number of electric accounts. For example, to derive the average residential natural gas consumption for a ZIP code we divided the total natural gas consumption in therms from all accounts with electricity only or electricity and natural gas service by the total number of such accounts. While this process makes sense for electricity, it is somewhat counterintuitive for natural gas because electricity service is nearly ubiquitous and natural gas service is less common. However, our goal for the natural gas consumption analysis was to derive an average that includes customers both with and without natural gas service. The number of electricity accounts was the closest proxy available for total customers served. Because a small number of customer accounts are natural gas only our method slightly undercounts natural gas consumption.

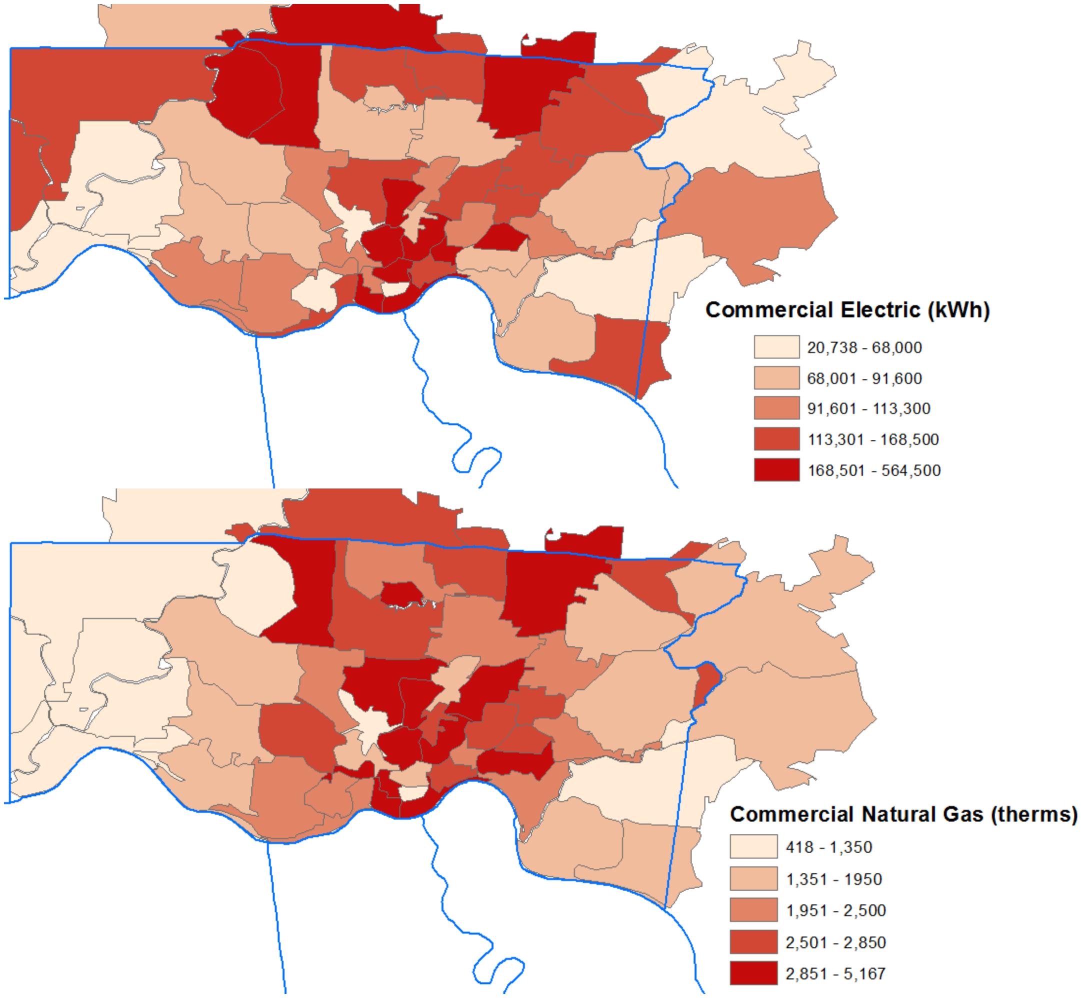
Residential energy consumption varies considerably across the county as shown in Figure 32. The most notable pattern is for electricity: consumption per account is notably lower in the historic core of Cincinnati and increases almost concentrically as one moves further from the city center. Likely this pattern is caused primarily by increasing home sizes further from the city center. The natural gas pattern is less notable, but consumption is lower in the city center and in more rural or exurban areas while it is higher in suburban areas. This “doughnut effect” is likely the result of smaller homes in the city center and lower levels of utility natural gas service in rural and exurban areas, but further research would be required to conclude this with confidence. From the county-wide perspective, the mean annual residential electricity consumption of all ZIP codes is 10,754 kWh while mean annual natural gas consumption averages 680 therms. These numbers are slightly below the average consumption numbers that we calculated, prior to receiving actual consumption data, in our residential energy savings potential analysis. It is important to note that these county-wide averages are not weighted by the number of accounts in each ZIP code and that they are for Hamilton County only.

Figure 32. Average Annual Residential Energy Consumption per Account by ZIP code of Duke Energy Electric Customers in Hamilton County in 2010



As shown in Figure 33, the geographic pattern of commercial energy consumption is less immediately pronounced when compared to residential consumption. However, it is likely that the pattern is the result of concentrations of large commercial energy consumers or their relative absence in a ZIP code. A quick comparison of the high consuming ZIP codes and the location of some large commercial consumers—like downtown offices, hospitals and universities—shows that they overlap. However more research would be required to better understand the pattern of commercial consumption. From the county-wide perspective, the mean annual commercial electricity consumption of all ZIP codes is 126,632 kWh while mean annual natural gas consumption averages 2,196 therms.

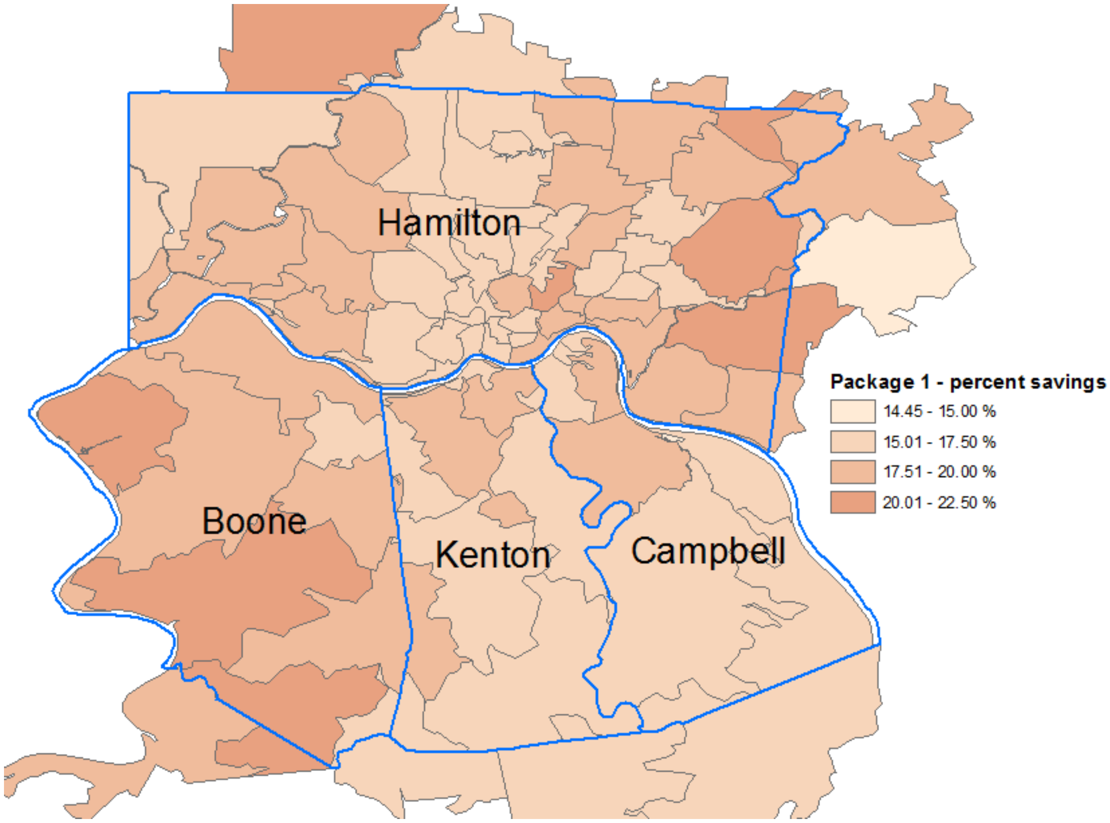
Figure 33. Average Annual Commercial Energy Consumption per Account by ZIP code of Duke Energy Electric Customers in Hamilton County in 2010



Energy Savings Potential

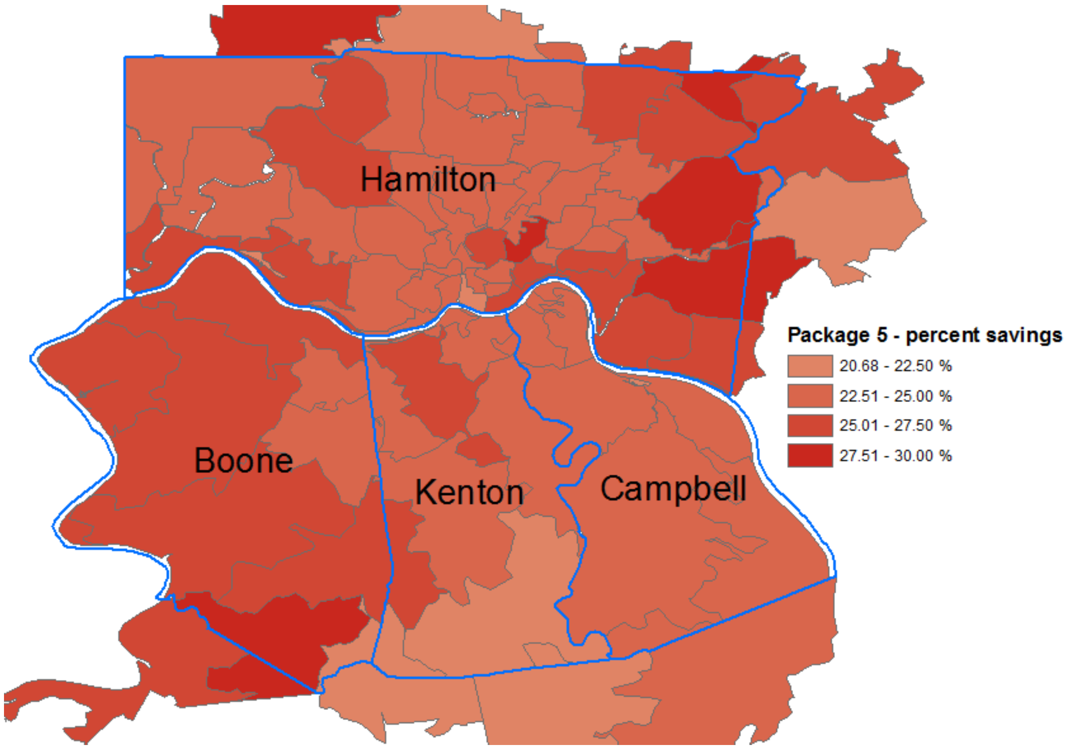
We used the same modeling methodology as applied to region-wide residential energy efficiency potential analysis to determine energy savings potential for the same six measure packages at the ZIP code level. There were two pieces of data specific to each ZIP code that we used to scale the analysis to the geography. These data included prevalence of primary heating fuel (obtained from the 2000 U.S. Census) and the distribution of housing sizes between five square footage quintiles in each ZIP code (obtained from the county Auditor/Property Valuation Administrator in each of the four counties and then stripped of any identifying information and aggregated by the Ohio-Kentucky-Indiana Regional Council of Governments). The percent energy saving potential of an average home implementing the measures in Package 1 (attic insulation, duct sealing, and infiltration reductions) is presented in Figure 34 for each ZIP code. The average percent savings from Package 5 (the combination of Package 1 and efficient heating and cooling improvements) is presented in Figure 35. Both figures show total energy savings potential (percent of total MMBtu saved) from electricity and natural gas combined.

Figure 34. Average Household Percent Energy Savings from Residential Package 1



In general, the energy efficiency potential pattern that results from this analysis shows particularly large savings potential in areas with large average home sizes or above average levels of natural gas use for heating. Age of buildings was not included as a variable in this analysis as it is less closely correlated with energy savings potential than building size. However, as a result it is possible that this analysis underestimates energy savings potential in the older core communities and suburbs of the region which may have a particularly large number of homes with poor energy performance.

Figure 35. Average Household Percent Energy Savings from Residential Package 5



Participation Potential

Market segmentation has been adopted by many energy efficiency program planners as a technique to identify the best use of limited marketing resources. Many market segmentation studies have identified demographic variables most commonly associated with higher levels of participation in energy efficiency program. The household variables most commonly associated with higher levels of participation in these studies include age (35–65), income ($50,000 or higher), homeowners, and education (college level or higher) (LBNL 2010). Several other variables have also been identified such as age of home and households without children. Although we have not undertaken a market segmentation analysis for the region we have applied the variables identified in other studies to analyze existing regional demographic data.

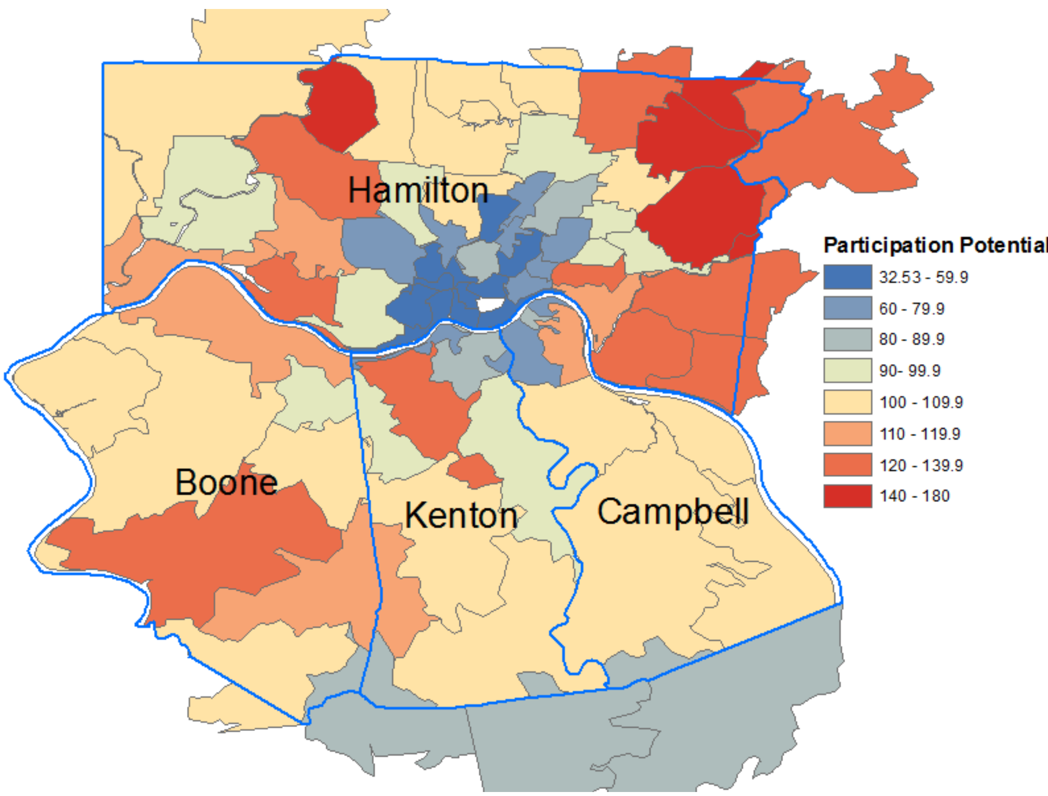
For our purposes we used data on five variables to give provide a simple, and likely overly simplistic, first attempt at characterizing the potential level of participation in the Energy Alliance's residential programs in each ZIP code. The variables we include are population between 45 and 65 years old, households with an annual income of $50,000 or above, households with both a head of household between 45 and 64 years old and an annual income of $50,000 or above, population with a Bachelor's Degree or higher education, and households that are owner occupied. We did not include building ages and households with children as variables. The data for each of these was obtained from the SimplyMap data system and are based on the U.S. Census and the American Community Survey. The value of each variable in each ZIP code was adjusted to be made relative to value of 100 representing the national average. Each variable was weighted as shown in Table 21 for inclusion in an overall participation potential index. The weightings are based on our literature review and the judgment of the research team.

Table 21. Variable Weightings as Applied to the Participation Potential Index

Metric	Weighting
Owner occupied (% owner occupied)	35%
Education (% Bachelor's Degree or higher, 2010)	25%
Age/Income (# HH 45-64, Inc $50,000+)	20%
Age (% population 45-64	10%
Income (% HH income of $50,000+)	10%

The participation potential index scores for each of the ZIP codes are presented in Figure 36. A score of 100 is equivalent to the national average. A score above 100 represents greater than average participation potential while as score below represents below average potential.

Figure 36. Residential Participation Potential Index

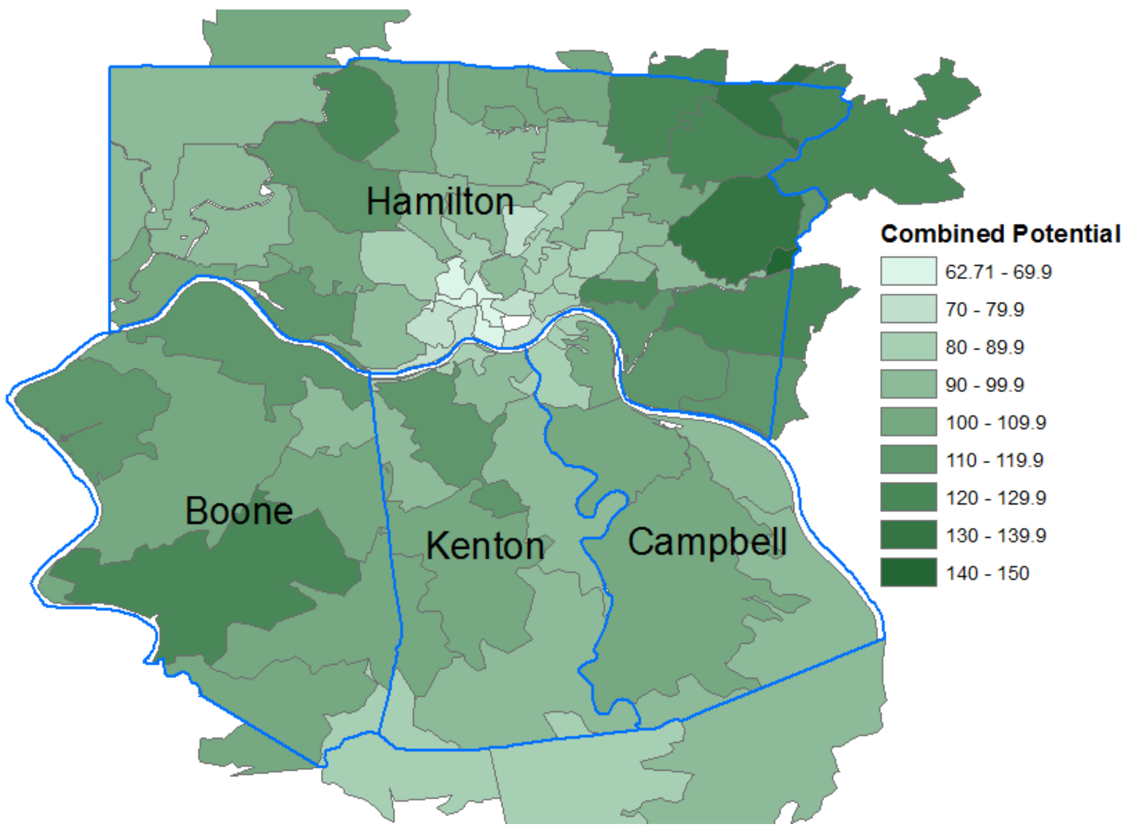


Based on this analysis, participation potential is higher in suburban communities than in the historic core of the region. However, it is important to approach these results with several caveats in mind. First, this analysis does not take into account age of buildings, which, some research has shown, may also make homeowners more likely to invest in energy efficiency (Action Research 2010). As a result, it is possible that this index underestimates participation potential in the historic core. Secondly, the goal of market segmentation is to identify those households that are easiest to reach. However, targeting the households that are more likely to participate will not necessarily result in the greatest energy savings or the greatest economic and social benefits from reduced household energy spending. Market segments that may be more difficult to reach may also see greater household benefits from energy savings. The Energy Alliance should also consider these equity-related issues when developing their marketing strategies.

Combined Potential

Finally, we developed a combined index that equally weights the variation from the regional average in energy savings potential from Package 5 with the variables from the participation potential index. This new index, displayed in Figure 37, provides us with a picture of where there are likely to be both above average energy savings potential and above average program participation rates. On this index an energy savings potential equal to the regional average and a participation potential equal to the national average would result in a score of 100. ZIP codes that have higher than average potential are given a higher score and those with a lower potential a lower score.

Figure 37. Residential Combined Potential Index



We have provided the Energy Alliance with the raw datasets that were compiled to undertake these ZIP code level potential analyses. These include many more additional demographic and building-related data points beyond what is described here. While this analysis provides a first attempt to characterize neighborhood potential based on available data and experience from other programs, Energy Alliance staff will gain improved knowledge from on-the-ground experience through their outreach efforts and should not hesitate to update the variables and weightings used in this index to better reflect their experience and the characteristics of the regional market.

Contractors Partnerships

Beyond the terms of the program and efforts to market the programs, there are several other factors that influence participation. Many of these additional factors relate to the transaction itself including number and quality of transaction opportunity points, ease of transaction, salesmanship and communication about the program at a transaction point, and the motivation of the program messenger to encourage participation. The Energy Alliance's partner contractors are the key messengers at these transaction points and have great influence on each of these transaction variables. Increasing the opportunities and motivation for contractors to encourage participation in Energy Alliance programs can in turn positively influence program participation.

As the Energy Alliance prioritizes its contractor partnership efforts it is helpful to understand the business models of different types of contractors, the number and kind of transaction opportunities available to contractors which could result in participation in Energy Alliance programs, and the factors that would motivate contractors to encourage their customers to participate in Energy Alliance programs. In order to begin shed some light on these questions we have attempted to quantify the market within the Cincinnati region for certain "reactive" transactions (the purchase of replacement equipment as a result of failure or end-of-useful-life) that could be transformed into "proactive" transactions (investment in additional energy related measures such as air sealing and insulation that will improve energy efficiency and reduce energy or equipment costs). Data is available on total number of energy-related home improvement purchases disaggregated by appliance type and purchase amount category. This information and the percent of households making these purchases in all of the ZIP codes overlapping with the four counties are shown Table 22. Based on the number of households spending over $1,000 annually, the largest energy-related improvement markets include roofing and exterior siding, followed by central heating and water heating.

Table 22. Percent of Households Buying, Number of Households Buying, and Estimated Total Spending on Select Home Improvements in 2008

	Buying			**Spending over $1,000**			**Total Spending (million $)**	
	Hshlds	Percent		Hshlds	Percent			
	Region	*Region*	*U.S.*	*Region*	*Region*	*U.S.*	*Region*	*U.S.*
ATTIC FANS/VENTS	14,111	1.47%	1.79%	2,154	0.22%	0.34%	$6.96	$2,102
CENTRAL HEATING GAS/OIL	14,647	1.54%	1.51%	9,408	1.00%	0.89%	$16.81	$3,880
HOT WATER HEATER	44,745	4.63%	4.84%	7,391	0.78%	0.79%	$28.16	$6,967
INSUL FOR CEIL,FLOOR,WALL	21,408	2.26%	2.63%	4,453	0.47%	0.60%	$11.07	$3,337
OUTDOOR/EXTERIOR SIDING	19,611	2.04%	1.95%	13,550	1.39%	1.25%	$22.88	$4,955
ROOFING	35,224	3.67%	3.92%	24,232	2.51%	2.80%	$41.05	$10,780
WEATHERSTRIPPING	34,648	3.61%	4.22%	462	0.05%	0.07%	$3.49	$1,272
WINDOWS - INSULATED/THERMAL	32,386	3.38%	4.06%	4,000	2.14%	0.43%	$23.01	$6,817
WINDOWS-NON-INSLTD/NON-THRML	7,591	0.79%	0.89%	1,355	0.40%	0.06%	$3.92	$1,084

Source: Experian® Simmons[SM] National Consumer Study, Fall 2007 (Simmons 2007). Note: percents are based on total households from the American Community Survey as of 2010: 526,847 for all ZIP codes that overlap with the four-county region and 118,402,143 for the U.S.

Another way to approach this analysis is through data on appliance lifetimes and replacement rates. Table 23 applies data on average appliance lifetimes from U.S. Department of Energy appliance standard rulemakings and Cincinnati region data on appliance saturations from a Duke Energy appliance survey to calculate an estimated number of average annual purchases for five space and water conditioning appliances. This analysis confirms the implication of the purchase data: space conditioning and water heating appliances are large markets, each in the range of 37,000 annual purchases within the region.

Table 23. Regional Appliance Replacement Rate Estimates

Appliance	Average lifetime (years)[1]	Regional Appliance saturation[2]	Estimated annual purchases[3]
Gas Furnaces	23.68	70%	14,731
Central air conditioners	19.01	75%	19,661
Heat pumps	16.24	10%	3,069
Hot water heater - electric	13	38%	14,567
Hot water heater - gas	13	59%	22,617

1. Based on DOE 2010 and DOE 2011a.
2. Based on Duke Energy Ohio 2009 and Duke Energy Kentucky 2009
3. Based on estimate of 498,342 households for the four-county region from SimplyMap and the 2005-9 American Community Survey

It is important to note that this data includes all purchases of these appliances and does not distinguish between reactive and proactive purchases. However, this data helps to establish a baseline of how often households make purchases in the various home improvement categories and, as a result, how many transaction points exist at which to encourage homeowners to take a more comprehensive approach to energy improvements.

The Energy Alliance loan programs provide one opportunity to motivate contractors with energy-related products to encourage proactive energy saving investments. Some contractors will contribute their own funds to buy-down the interest rate on financing for their equipment. The interest rate available to contractors through financing programs from appliance wholesalers is often nearly 20%. When contractors buy-down the financing for customers their costs can be even higher. For contractors using appliance finance programs, a loan program like that offered by the Energy Alliance with attractive terms that they don't have to subsidize with their own funds may be a good incentive to promote the programs to their customers.

Economic, Social and Environmental Impacts

What does energy efficiency mean to the future prosperity of the region?

Macroeconomic Analysis—Jobs and Economic Productivity

Using a macroeconomic model developed by ACEEE, the Dynamic Energy Efficiency Policy Evaluation Routine, or DEEPER, we analyzed the regional economic impacts of the combined residential and nonprofit twenty-year scenarios (the details of the DEEPER model are described in Appendix E—Methodology of the DEEPER Modeling System). Using the inputs of program costs, investments, annual payments, and energy bill savings we are able to derive outputs of net changes to employment, wages, and gross regional product for the four-county region.

Program Costs and Financial Impacts

Other than program costs, the values for each of these inputs has been previously described. For program and administrative costs we used an assumption of 40% of energy efficiency investments starting in 2010 and decreasing to 20% by 2017 and remaining at that level through 2030 for the residential program. For the nonprofit program 2010 program costs are 20% of investments, decreasing to 12.5% by 2014 and remaining at that level through 2030. These assumptions correspond to current Energy Alliance costs and future program cost goals. For investments made through the loan programs we also added an additional 3.99% of lending amounts to the program costs to correspond to the servicing fee that the Energy Alliance will pay under the terms of the GC-HELP program with the assumption that a similar fee will be in place for any nonprofit loan program as well.

These program costs are an important additional variable for understanding the cost effectiveness of the program on an economy-wide scale. Table 24 presents the annual economy-wide financial impacts of the Energy Alliance programs on the Cincinnati region in five benchmark years. When program costs are accounted for, the model reveals a net negative cost impact on the region as a result of the program for most of its first decade. The net cost savings turn positive from 2020 to 2030 resulting in annual net savings of $30 million to the economy in 2030. Decreased administrative costs, especially in the early years of the programs, would help to create greater economy-wide net positive savings and to achieve them earlier.

Table 24. Financial Impacts of all Energy Alliance Programs in the Twenty-Year Scenario

Financial Impacts (Million 2009 Dollars)	2012	2015	2020	2025	2030
Program Cost	5	4	4	5	5
Investments	16	14	17	20	23
Annual Payments	5	11	17	20	25
Energy Bill Savings	2	9	22	40	60
Net Savings	-7	-6	2	15	30

Macroeconomic Impacts

Energy efficiency investments made through the Energy Alliance programs should cause a chain of impacts on the larger regional economy. In addition to direct impacts of spending on energy improvements and financing for the improvements, reduced spending on energy bills results in consumer spending being reallocated to other sectors of the economy and in additional commercial sector investment reallocation as a result of changes in consumer spending. Table 25 presents the results of these direct, indirect and induced regional economic impacts of energy saving measures. Small but net positive increases in regional employment and wages result from the Energy Alliance programs. By 2030 net employment has increased by around 317 full time jobs compared to projected employment in that year without the programs, equivalent to a 0.03% increase in total employment in the four counties. Wages increase by $13 million in 2030, an increase of 0.02% above projected wages for that year without the Energy Alliance program. The programs have a net positive impact on gross regional product (GRP) through 2025 but a small net negative impact in 2030, less than one-tenth of 1%. Figure 38 presents annual employment and income impacts for each year through 2030.

Table 25. Total and Relative Impacts of Energy Alliance Programs on Regional Employment, Wages, and Gross Regional Product from Energy Investments and Cost Savings

Macroeconomic Impacts	2012	2015	2020	2025	2030
Employment (actual)	151	127	166	238	317
Change from Ref Case	0.02%	0.01%	0.02%	0.03%	0.03%
Wages (Million 2009 dollars)	8	6	7	10	13
Change from Ref Case	0.02%	0.01%	0.02%	0.02%	0.02%
GSP (Million 2009 dollars)	9	5	2	0	-2
Change from Ref Case	0.01%	0.01%	0.00%	0.00%	0.00%

Although these employment and wage impacts are admittedly relatively small when compared to an economy that is projected to have over 890,000 jobs accounting for $51.5 billion in income in 2030, a few real life equivalents may help to put the positive impact of these numbers in context. The net increase in jobs in 2030 is equivalent to the jobs created by two medium size manufacturing plants locating in the region, assuming each plant has around 160 employees. The increased annual income in 2030 is equivalent to economic impact of 260,000 additional attendees at Cincinnati Reds games in a season, assuming the average baseball fan spends $50 on ticket and concessions per game.

The economic impacts from the Energy Alliance programs are the result of changes to spending patterns in the regional economy resulting from efficiency investments and subsequent energy savings. In other words, the program-generated changes in consumer behavior will cause the reallocation of current spending to different sectors of the economy, as a result of efficiency investments and energy bill savings. Since each sector is characterized by different levels of labor intensity (the portion of every dollar spent on wages) and value-added intensity (the portion of every dollar spent on equipment), the proposed policies catalyze changes in employment, wages, and GRP. To demonstrate these impacts, Table 26 shows changes in employment for three aggregated sectors that represent the entire economy of the four-county region. As a result of decreased energy consumption and spending, employment in the Extractive and Energy sector decreases. However, because the labor intensity is higher in the other two sectors of the economy (Construction and Manufacturing and Trade and Services), as spending is shifted to those sectors more jobs are created than were lost in the Extractive and Energy sector resulting in a net gain in employment. Intensity factors also help to explain the drop in GRP in 2030. The Extractive and Energy sector has a higher value-added intensity than the two other sectors of the economy. As a result, as spending decreases in that sector the value-added of the same sector declines over time eventually turning the net GRP impacts negative. These intensity factors for the sectors of the Cincinnati economy are presented in Table 27.

Figure 38. Impacts of Energy Alliance Programs on Regional Employment and Wages

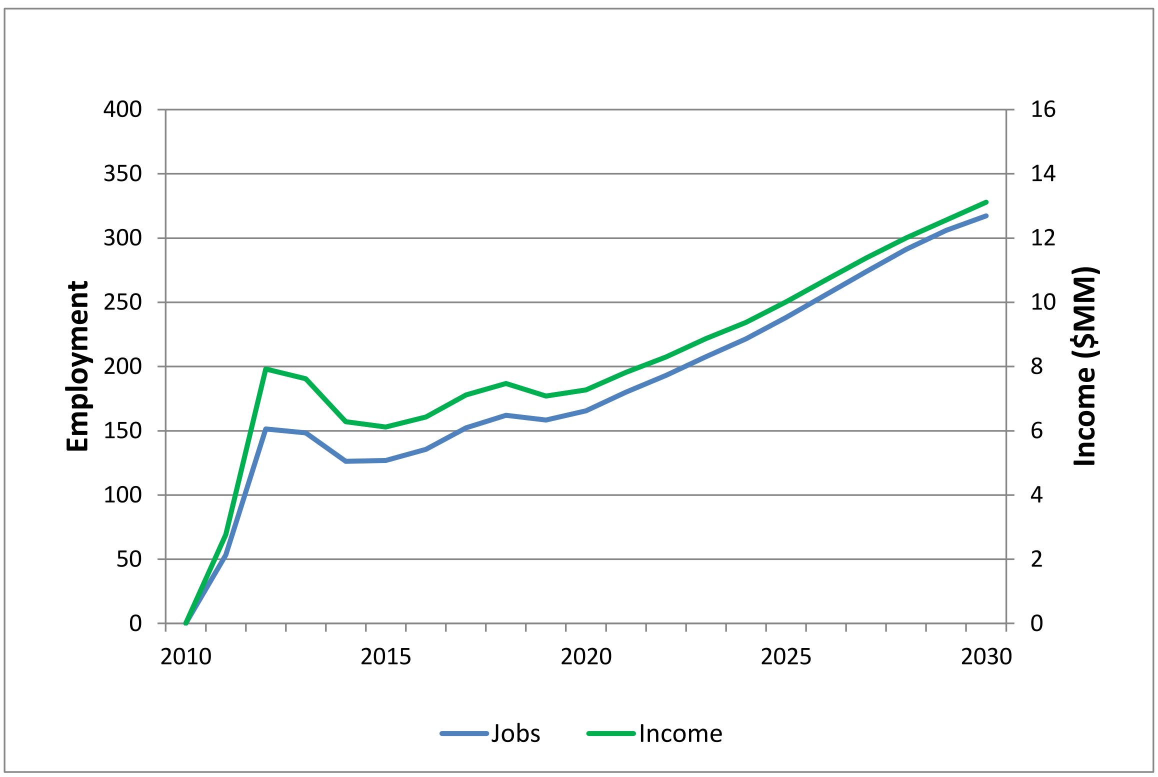


Table 26. Impacts on Employment by Economic Sector

Sector Categories	2012	2015	2020	2025	2030
Extractive and Energy Sectors	-3	-14	-30	-46	-59
Construction and Manufacturing	122	105	111	119	126
Trade and Services	33	36	85	166	251
Net Total Jobs	**151**	**127**	**166**	**238**	**317**

Table 27. Key Economic Coefficients for Cincinnati by Major Aggregate Sectors

Sectors	Jobs**	Wages#	Value-Added#
Extract	12.34	0.63	0.95
Energy	6.45	0.41	0.96
Const/Mfg	8.52	0.47	0.75
Service	16.03	0.78	1.21

** Total (direct, indirect, and induced) Jobs per Million 2009 Dollars of economic activity

Total (direct, indirect, and induced) Wage and Value-Added Contribution per 2009 Dollar of economic activity (where value-added is the contribution to Gross Regional Product)

Sensitivity Analyses

Cost of living impacts. Although wages and employment both increase under this scenario, the average wage per employee decreases by about 0.01%. However, the decrease in cost of living resulting from the $30 million in net consumer savings on energy bills in that year results in the equivalent of a net increase in income of 0.05%. These adjustments are presented in Table 28.

Table 28. Wage and Cost of Living Impacts of Energy Alliance Programs

Year 2030	Reference Case	With Programs	Including Energy Cost savings
Jobs (actual)	893,300	893,617	893,617
Total Income (millions of 2009 $)	51,570	51,583	51,583
Change in cost of living (millions of 2009 $)	0	0	-30
Average Wage (2009 dollars)	57,730	57,724	57,757
Change in Average Wage (percent)	0.00%	-0.01%	0.05%

Impacts of non-energy benefits on productivity. It is important to note that the economic impacts reported above only included the impacts on the economy resulting from spending on energy efficiency measures and energy cost savings. However there are a number of non-energy benefits from investments in energy efficiency that have been documented as resulting in improvements in economic productivity. These non-energy benefits include, among others, healthier indoor environments and a more productive workforce.

Several studies, including Amann 2006 and Worrell et al. 2003, have documented the scale of the economic benefits of these non-energy benefits. Using this research as a guide, we have factored in estimates of productivity gains from energy efficiency investments equivalent to 20% of total energy bill savings resulting from the residential programs and 40% of those from the nonprofit programs. The additional of these productivity adjustment factors increases the net impact of the Energy Alliance programs for employment, wages and GRP as shown in Table 29.

Table 29. Total and Relative Impacts of the Energy Alliance Programs on Regional Employment, Wages, and Gross Regional Product including the Effects of Productivity Gains

Macroeconomic Impacts	2012	2015	2020	2025	2030
Employment (actual)	154	141	200	297	400
Change from Ref Case	0.02%	0.02%	0.02%	0.03%	0.04%
Wages (Million 2009 dollars)	8	7	9	13	18
Change from Ref Case	0.02%	0.02%	0.02%	0.03%	0.03%
GSP (Million 2009 dollars)	9	6	5	5	6
Change from Ref Case	0.01%	0.01%	0.01%	0.01%	0.01%

Economic Impact of Energy Efficiency Improvements on Property Values

Energy efficiency improvements produce a number of economic benefits for households, businesses, and communities. These improvements (along with changes in behavior) can substantially reduce energy consumption and, consequently, energy cost and the demand for more energy production capacity.

Residential property value increases due to these improvements, and they may also result in greater comfort for household members. Because of lower energy costs, commercial real estate generally has higher occupancy rates and sometimes commands higher rental rates, resulting in a higher return on investment.

For both groups, this leads to higher property values and greater economic value to the local community.

Broadly speaking, there is a positive relationship between energy efficiency improvements and property values. Regardless of the age and the type of the property, almost every property is positively affected by energy efficiency improvements. In this section, the relationship between sale prices of residential and commercial properties and energy efficiency improvements is examined. Even though much of the literature emphasizes the effect of those improvements on sale prices of new homes (Lande 2008), the results can be applied to retrofitted buildings.

Residential Property Values

Many studies have found that energy-efficient residential properties have higher values (Laquatra et al. 2002). However, the true value of these improvements may not be fully represented because of a lack of information on the part of appraisers and homebuyers.

Some studies have investigated whether appraisers take energy efficiency improvements into account while calculating the value of a residential property. The latest one, in 2010, reported that although the literature emphasizes the relationship between energy efficiency improvements and retail prices, mortgage underwriting standards do not consider energy cost (Nevin 2010). On the question of whether energy efficiency is valued by prospective homeowners, homebuyers do not try to calculate the present value of long-term energy savings, but some buyers consider utility costs before making an offer.

If the studies reporting the benefits of energy efficiency are accurate, retrofitting 1,000 homes with improvements that reduce their annual energy bills by an average of $250 a year may generate an average home value gain of $5,000 (Lande 2008), or an increase of $5,000,000 in their collective market value.

For several reasons, the realization of these increases in property values will not be immediate. From the homeowner's perspective, the best time to realize the increase in home value is when a house is sold, and county appraisal processes make it somewhat likely that this will occur. According to the 2000 Census, Hamilton County homeowners had a median of 11 years in their current house; applying this to 70% of retrofitted homes and a two-year delay because of appraisal to the remaining 30% means that home value gains will be delayed by an average of about eight years.

Energy efficiency improvements are also a form of home maintenance. Analyses indicate that, after considering other relevant factors, the maintenance of the property plays an important role in determining its value. The level of maintenance is the primary action a homeowner can choose that may impact the value of the property, as an individual exercises little or no control over changes to the surrounding area or "functional obsolescence" due to changes in technology and layout designs. While maintenance may not completely offset the impact of neighborhood characteristics or changes over time, it may guard against the depreciation of the property's value.

In summary, energy-efficient maintenance confers benefits in a manner similar to more capital-intensive improvements (even very modest energy efficiency spending has an effect), and better functionality generates higher value, plus there is an impact on surrounding properties.

Another consideration is that energy costs are a larger burden for low-income households compared to higher income households. While the Energy Alliance programs are primarily targeted toward higher income households, the still benefit low-income households because of outreach efforts and referrals to the low-income weatherization providers in the region. Additionally, for households near but above the Energy Alliance eligibility threshold of 200% of the poverty level, energy costs are still a larger portion of their cost of living than for the average Cincinnati household. Lack of funding, lack of coordination and lack of understanding of the social and economic benefits of energy efficiency improvements are obstacles to reducing energy costs for lower income households. Low-income households tend to live in less energy-efficient homes, and current policy initiatives aimed at low income energy needs address only a small share of the overall hardship. Therefore improving the energy efficiency conditions of housing units occupied by low-income households could lower their energy costs and provide a remedy for the hardship they have.

A study by the UC Economics Center was performed analyzing the impact of the condition of residential properties and the work of a local organization (People Working Cooperatively, or PWC) on sale prices. This study found that, after controlling for other neighborhood and property characteristics, including home condition, receiving PWC's home repair and weatherization services played an important role in property condition, and therefore in property value (Pitzer et al. 2011).

The estimates indicate that, on average, if two identical homes in the same neighborhood are sold during the same period and one of those identical homes was a PWC client at least once prior to the sale then the PWC home's sale price would be about 10.6% greater than the non-PWC home. In 2009, the average PWC home had a sale price of about $70,000. Thus, about $7,000 of the value of this home was preserved by PWC's efforts.

Additionally, the estimates indicate that each home in a neighborhood surrounding a home serviced by PWC is associated with a 1.9% higher sale price. The overall average sale price in 2009 was about $134,230. Thus, every PWC home in the neighborhood contributed on average about $2,600 in value. In 2009 there were on average 1.42 PWC homes around a given property, with a maximum of two PWC homes. Thus, on average PWC properties contributed

about $3,700 to the sale price of other homes in the neighborhood, with a maximum potential impact of PWC's efforts of $5,200 on the average house in 2009. Investments in properties resulted in greater property values for surrounding properties.
Another recent study found that prospective buyers of new homes who were surveyed state that increased home value was the most important factor while deciding on the energy efficiency package, followed by monthly cash flow (a combination of mortgage and energy costs) (Sparti 2006).

When these prospective homebuyers were provided certain information about a range of energy efficiency packages, they selected those expected to produce certain economic benefits, particularly increased home value and positive monthly cash flow. This also has implications for the design of effective marketing of residential retrofit programs.

Commercial Property Values

A useful measure of the impact of energy efficiency improvement on property values is the sale price. Benefits of the increased value of a property can be analyzed from real estate developer's point of view and nonprofit organization's point of view separately.

Benefits to Nonprofit Organizations

From nonprofit organizations' point of view, energy efficiency improvements have benefits in terms of three aspects: reduction of operating costs, tax benefits, and external benefits.

Since the nonprofit organizations do not distribute its profit to owners or shareholders, nonprofit organizations are not concerned about sale prices of a property. Instead, they seek to decrease their operation and management costs through energy efficiency improvements. Therefore, savings created by energy cost reduction is important for nonprofit organizations.

Secondly, nonprofit organizations are usually tax exempt. Because it is believed that nonprofit organizations activities' provide many societal benefits, nonprofit organizations are promoted by government through incentives. Arguably, tax incentives are the largest category of incentives used to promote nonprofit organizations. When the value of a property increases the amount of tax revenue that the property provides to local governments increases automatically. Since most nonprofit organizations do not pay property taxes, the increase in the tax can be accepted as a saving from the nonprofit organizations' point of view: they get a property asset of greater value without increased taxes.

Lastly, nonprofits that make energy efficiency investments promote similar behavior by other property owners. This occurs for at least two reasons: because nonprofits have an influence on their members/stakeholders and because they tend to be viewed as doing things that are good for the community so their actions provide an example for the general community to follow.

Benefits to Real Estate Investors

Many studies in the literature show that, there is a positive correlation between energy efficiency improvements and commercial property values (Burr 2008, Chappell and Corps 2009, Eichholtz et al. 2009, Miller et al. 2008, Pivo and Fisher 2010, Richard Ellis Group 2009, ULI 2010). Energy efficiency improvements affect property values in a number of ways. One way to measure the impact of improvements is to analyze sale prices. The difference in sale prices of two similar properties can be examined to indicate the importance of energy efficiency improvements on property values.

From the real estate developer's point of view, the retrofitting of a building through energy efficiency improvements create additional costs, but at the same time they are beneficial, due to the fact that they help to attract and retain tenants. Additionally, in the long term, energy efficiency improvements create savings that are reflected in lower operating costs, and, where those savings are realized by tenants, also create higher rents and occupancy rates and lower turnover.

To sum up, the way in which energy efficiency translates into value is not simple and is often indirect, and may alternatively be found in other factors (e.g., higher rents, or savings in tenant operating costs) rather than higher capital value.

Net Operating Income is one of the most important financial performance indicators for real estate developers and appraisers. Additionally, according to the Institute for Market Transformation, banks and insurance companies are beginning to reward efficient property with better financing and lower premiums (IMT 2011).

Vacancy and turnover rates affect net operating income indirectly. Energy efficient buildings tend to have lower vacancy and turnover rates, and, in ENERGY STAR buildings, higher similar occupancy rates with higher rents are observed (Miller et al. 2008, Richard Ellis Group 2009, ULI 2010).

Conclusion

Both residential and commercial properties are positively affected by energy efficiency improvements. While the expected outcome of energy efficiency improvements differs between real estate investors and nonprofit organizations, the reduction of costs and the increase in the value are important for both stakeholders.

Furthermore, energy efficiency improvements affect consumer choices. As a result, being energy efficient also enables better marketing strategies. Improving the energy efficiency conditions of households could lower their energy bills, and consequently improve their quality of life.

Emissions Analysis

One additional benefit of energy efficiency is the reduction of air pollution that results from electricity generation and other energy use. The Cincinnati region could see considerable public health benefits from reduced air pollution. The American Lung Association, in its State of the Air 2011 report, ranked the Cincinnati-Middletown-Wilmington, OH-KY-IN metro region as the ninth most polluted U.S. city for year round participle pollution (ALA 2011). Additionally, energy efficiency can decrease energy-related greenhouse gas pollution that contributes to climate change.

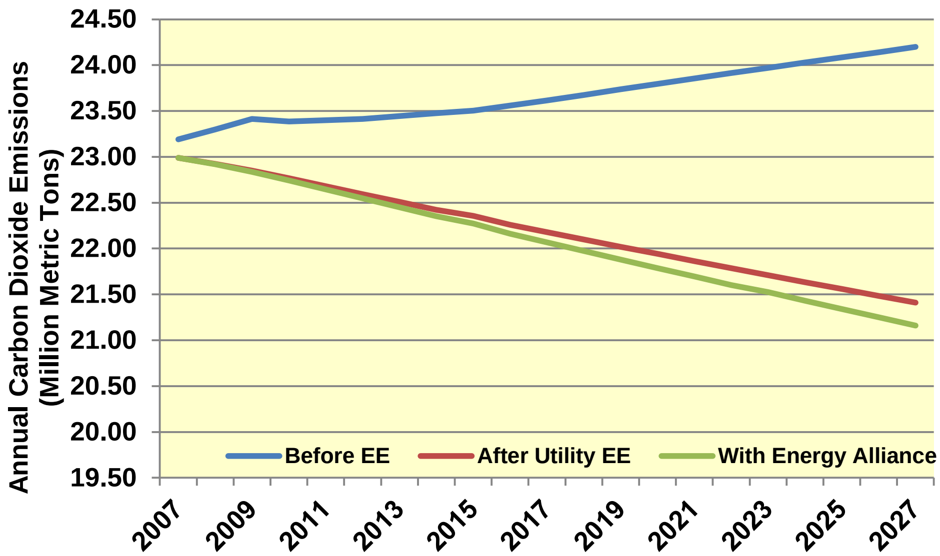
Meeting electricity demand through energy efficiency resources reduces the need for electricity generation, which has a concomitant impact on emissions that are a by-product of that generation. As such, energy efficiency also represents a cost-effective strategy to reduce air pollution that can damage human health and contribute to climate change. In this section, we present our estimates of the avoided electricity-related emissions resulting from the residential and nonprofit twenty-year scenarios for energy efficiency investments in the Cincinnati region, which include estimates of carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur dioxide (SO_2). We do not analyze the emissions impacts from improved natural gas efficiency. A detailed description of our methodology is included in Appendix F—Avoided Emissions Methodology.

Using this methodology, we were able to determine baseline emissions projections for CO_2, NO_x, and SO_2 resulting from the activities of seven major electricity generating power plants serving Duke Energy in the Cincinnati region over the 2008–2030 period, using growth rates from both the “Before EE” and “After EE” retail sales forecast to project future emissions. We estimate annual baseline emissions in 2008 of almost 23.1 million metric tons for CO_2, 38,500 metric tons for NO_x, and 110,080 metric tons of SO_2. By 2030, the business as usual case, “Before EE,” results in 24.2 million, 39,100, and 110,900 metric tons respectively. Under the “After EE” forecast we estimate that emissions for CO_2, NO_x, and SO_2 will decline to 21.4 million, 36,500, and 101,470 metric tons, respectively. An analysis of the twenty-year Energy Alliance program scenarios results in additional annual avoided emissions in 2030 of 250,000 metric tons of carbon dioxide, 340 metric tons of nitrogen oxides, and 1,640 metric tons of sulfur dioxide. These savings are above and beyond the savings from the utility-run energy efficiency program included in the "After EE" scenario. The emissions reductions for each pollutant under the twenty-year scenario are shown at five year intervals in Table 30 and the impact of the three scenarios on carbon dioxide emissions over time is displayed in Figure 39.

Table 30. Annual Avoided Emissions Estimates from the Energy Alliance Energy Efficiency Programs (Metric Tons)

	2010	2015	2020	2025	2030
Carbon Dioxide	172	46,660	110,473	183,270	249,817
Nitrogen Oxides	0.100	64	151	250	341
Sulfur Dioxide	0.002	306	725	1,203	1,640

Figure 39. Annual Carbon Dioxide Emissions Estimates from Energy Efficiency Programs, 2010–2030 (Million Metric Tons)



The annual avoided carbon dioxide emissions from the Energy Alliance programs alone in 2030 is equivalent to taking 49,000 vehicles off the road for a year or avoiding the consumption of 28 million gallons of gasoline. Bringing it back to buildings, the savings are equivalent to the total annual energy-related emissions 21,700 homes (EPA 2011).

CONCLUSION

The Cincinnati region has a considerable opportunity to greatly improve the efficiency of energy use in its buildings and reap the economic and social benefits that will result. With the proper effort and program structure the energy saving scenarios described within this report can be achieved cost effectively. Our analysis shows that investments increasing to $23 million annually in 2030 can result in cost savings to consumers of $60 million annually in 2030 and provide energy cost savings for decades into the future. These investments will provide investors with a return competitive with traditional investments at lower risk. They will also result in approximately 317 additional jobs in the region in 2030, all while significantly reducing energy-related air pollution.

Innovative programs, innovative program delivery methods, and partnerships with investors and contractors will be required to achieve these or related goals. Many of these implementation strategies are currently under development by the Energy Alliance and some of them have been described in this report. However, this report should be seen as a starting point for expanded conversation among stakeholders in the region around how to best capture the opportunity for energy efficiency, resulting in joint action.

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APPENDIX A—STAKEHOLDER ENGAGEMENT

ACEEE and the Economics Center held a series of meetings beginning in December 2010 with stakeholders identified by the Greater Cincinnati Energy Alliance. These meetings, the topics and issues identified in them, and subsequent discussions formed the basis of the topics covered in the report. Below is a list of stakeholders consulted in the course of this research or invited to comment on drafts of the report. By naming these individuals and their organizations we do not mean to imply endorsement of the report, instead our intention to acknowledge their contributions and to thank them.

Last name, First name	Organization
Boberg, Mike	ArtsWave
Colten, Lee	Kentucky Division of Efficiency & Conservation
Deardurff, Dayle	Union Institute & University
Duvall, Whitney	Owen Electric
Falkin, Larry	City of Cincinnati
Fischer, Ian	Clean Energy Solutions, Inc.
Fuller, Merrian	Lawrence Berkeley National Laboratory
Gaspari, Alfred	Greater Cincinnati Energy Alliance
Gibson, Kimberly	Edison Welding Institute
Glick, Lilah	Greater Cincinnati Energy Alliance
Golliher, Jeanne M	Cincinnati Development Fund
Holzhauser, Andy	Greater Cincinnati Energy Alliance
Killins, Robert	Greater Cincinnati Foundation
Lawrence, Jared	Duke Energy
Lindeman, Al	Perfection Group
Lubin, Gary	Episcopal Diocese of Southern Ohio
Miller, Travis	Ohio-Kentucky-Indiana Regional Council of Governments
Mills, Galen	Cincinnati Area Board of Realtors®
Moertl, Peg	PNC Bank
Morgan, Steve J.	Clean Energy Solutions, Inc.
O'Brien, Lisa	U.S. Bank
Seelmeyer, Brent	Cancer Family Care
Shuey, David	Ohio-Kentucky-Indiana Regional Council of Governments
Stagaman, Mary	Cincinnati USA Regional Chamber
Steffens, Suzanne	Leadership Council of Human Services Executives
Stevie, Richard	Duke Energy
Stieritz, Tony	Archdiocese of Cincinnati
Urbanik, Janice	Greater Cincinnati Workforce Network
Wiles, Tom	Duke Energy
Wisniewski, Mike	North Side Bank and Trust Company

APPENDIX B—REFERENCE CASE METHODOLOGY

The reference case is used as a baseline by which we can measure the impacts of our individual and collective policy/program recommendations on energy consumption, retail prices, and emissions. In this section we discuss the methodology for our electric and natural gas price and consumption forecasts for the analysis time period, 2008–2030.

Electricity

The reference case forecast for electricity sales in the greater Cincinnati region is the foundation of the quantitative analysis of the energy efficiency policies we recommend. Our analysis focuses on the three utilities that provide the vast majority of electricity services in the four-county Cincinnati region. The base year for sales in the region is 2008 and is projected through 2030 based on consumption forecasts from electric utility integrated resource plans (IRPs) and utility long-term forecasts filed with the utility regulatory bodies in both states (Duke Energy Kentucky 2008, EKPC 2009, Duke Energy Ohio 2010a). Federal appliance and lighting standards enacted in the *Energy Independence and Security Act (EISA) of 2007* are assumed to be accounted for in the utility forecasts, as are impacts from energy efficiency programs that were delivered prior to 2008.

Duke Energy, for both Ohio and Kentucky, issued two electricity consumption forecasts in its IRPs: one that does not incorporate savings from efficiency programs and one that does. EKPC did not adjust its forecast accordingly. Nonetheless, we created two forecasts as well: the "Before EE" case, which does not incorporate savings from efficiency programs; and the "After EE" case, which does incorporate projected savings from existing programs. Additionally, given that the forecasts were conducted for the entire territory and not specifically to the four counties considered in this report, we had to make assumptions on how to apportion the forecasts so that they represent consumption patterns in those four counties. We only had to apportion Duke Ohio's sales as Duke Kentucky's service territory does not extend outside the three northern Kentucky counties considered part of the Cincinnati region.

Residential

In order to apportion Duke's residential electricity consumption forecast for its Ohio service territory so that it represents the Hamilton County only, we had to determine the percentage of Duke's electric customer accounts in Hamilton County. To do so, we first needed to calculate the number of customers with electric accounts only, natural gas accounts only, and the two combined. In its energy efficiency potential study for the state of Ohio (Duke Energy Ohio 2009), Duke reports 593,768 electric accounts (customers), of which 60% also have natural gas accounts, or 356,261 customers, and 40% have electric accounts only, or 237,507 accounts. Additionally, Duke reports 377,385 natural gas accounts, of which 95% also have electric accounts, or 358,516 customers, and 5% have natural gas accounts only, or 18,869 accounts. Based on these numbers, we determined that 357,388 customers have both electricity and natural gas accounts (we took the average of the two as the reported percentages were not exact) while 237,507 only have electric accounts and 18,869 have only natural gas accounts. In total, there are 613,764 accounts in the Duke Ohio service territory.

Table 31. Breakdown of Residential Customers in Duke Ohio's Service Territory, 2010

	Electric	Natural Gas	Total
Electric only	237,507	—	237,507
Natural gas only	—	18,869	18,869
Electric and natural gas	356,261	358,516	357,388
Total	**593,768**	**377,385**	**613,764**

Using the average number of accounts with both electric and natural gas service, we determined that 96.9% (594,895) of Duke Ohio's customers have electric accounts. Using data from the U.S. Census, we determined that there are 354,870 households in Hamilton County. Assuming that Hamilton County is entirely served by Duke Ohio, there are 343,869 customers that have electric accounts (354,870 * 96.9%) with Duke. With a total of 594,895 customers with electric accounts in Duke Ohio's service territory, we estimate that 58% of Duke Ohio's electric accounts are in Hamilton County (343,869 ÷ 594,895). We then adjusted Duke's annual projections for residential electricity consumption by 58% in order to apportion the consumption forecast so that it is representative of Hamilton County only.

Commercial

To apportion the Duke's commercial consumption forecast for its Ohio service territory so that it represents Hamilton County only, we used employment as a proxy. According to Duke's efficiency potential study for Ohio, total non-farm employment in Duke's service territory is 1,580,993. In Hamilton County, total non-farm employment is 629,182, or 39.7% of employment in Duke's service territory. We then adjusted this percentage by the ratio of commercial floor space with electric service (1,050 million square feet) to the total commercial square footage in Duke's service territory (1,078 million square feet), or 97.5%, to determine the portion of commercial electric sales in Hamilton County only, which equals 38.8%. We then adjusted Duke's annual projections for commercial electricity consumption by 38.8% so that it is representative of Hamilton County only.

Natural Gas

Our natural gas consumption forecast focuses on the two utilities that provide natural gas services to customers in the four-county region: Duke Energy Ohio and Duke Energy Kentucky. Owen Electric Cooperative provides electric services only. The base year for sales in the region is 2008 and is projected through 2030 based on consumption forecasts from Duke Energy Ohio's long-term natural gas forecast (Duke Energy Ohio 2010b). Duke Energy Kentucky, however, is not required to file a long-term natural gas forecast, so there was no existing forecast to reference. As with the electricity forecast, federal appliance and lighting standards enacted in the *Energy Independence and Security Act (EISA) of 2007* are assumed to be accounted for in the utility forecasts, as are impacts from energy efficiency programs that were delivered prior to 2008.

Unlike the electricity forecast, Duke Energy Ohio did not report two forecasts to differentiate projected consumption based on the estimated impacts of efficiency programs on natural gas consumption. However, given that the forecasts were conducted for the entirety of Duke's service territories and not specifically to the four counties considered in this report, we had to make assumptions on how to apportion the forecasts so that they represent consumption patterns in those four counties only. Furthermore, we had to use natural gas sales in Duke Ohio's service territory as a proxy for natural gas sales in Kentucky because there is no Kentucky-specific natural gas forecast to reference.

Residential

In order to apportion Duke's residential natural gas consumption forecast for its Ohio service territory so that it represents Hamilton County only, we had to determine the percentage of Duke's natural gas customer accounts in Hamilton County. As with the electric forecast, we determined the number of households in Hamilton County (354,870). Of the 613,764 accounts in Duke Ohio's service territory, 376,257 have natural gas service (357,388 + 18,869), or 61.3%. Assuming that Hamilton County is entirely served by Duke Ohio, this means that 217,535 customers in Hamilton County have natural gas accounts (354,870 * 61.3%) with Duke. With a total of 376,257 customers with natural gas accounts in Duke's service territory, we estimate that 58% of Duke's natural gas accounts are in Hamilton County (217,535 ÷ 376,257). We then adjusted Duke's annual projections for residential electricity consumption by 58% in order to apportion the consumption forecast so that it is representative of Hamilton County only.

To determine Duke Kentucky's natural gas consumption forecast for the residential sector, we used data on natural gas consumption per customer for Ohio in 2007 as a proxy. The methodology for Duke Ohio's natural gas customers above yielded sales of 14,861 MMCF in 2007. With 376,257 natural gas customers, this amounts to 0.039 MMCF per customer annually. We then determined the number of Duke Kentucky customers with natural gas service using the same methodology as above. In Duke's energy efficiency potential study for the state of Kentucky (Duke Energy Kentucky 2009), Duke reports 116,879 electric accounts, of which 60% also have natural gas accounts, or 70,127 customers, and 40% have electric accounts only, or 46,752 customers. Additionally, Duke reports 86,048 natural gas accounts, of which 80% also have electric accounts, or 68,838 customers, and 20% have natural gas accounts only, or 17,120 customers. Based on these numbers, we determined that 69,482 customers have both electricity and natural gas accounts (the average of the two) while 46,752 only have electric accounts and 17,210 have only natural gas accounts. In total, there are 133,444 accounts in the Duke Kentucky service territory.

Table 32. Breakdown of Residential Customers in Duke Kentucky's Service Territory, 2010

	Electric	Natural Gas	Total
Electric only	46,752	—	46,752
Natural gas only	—	17,210	17,210
Electric and natural gas	70,127	68,838	69,782
Total	**116,879**	**86,048**	**133,444**

Using the average number of accounts with both electric and natural gas service (69,782), we determined that there are 86,692 natural gas accounts in Duke Kentucky's service territory (69,782 + 17,210). Using the estimation of usage per customer above, we estimate residential natural gas sales of 3,399 MMCF in 2007. We then used annual growth rates from the Duke Ohio residential natural gas forecast to estimate forecasted consumption for natural gas consumption in Kentucky's residential sector.

Commercial

To determine natural gas consumption for Duke Kentucky's commercial sector, we began by determining the amount of commercial floor space serviced by natural gas. According to Duke Kentucky's 2009 energy efficiency potential study, 193.9 million square feet of 260.6 million total square feet is serviced by natural gas. We then estimate usage per square foot from Ohio for 2007, taken from the Duke Ohio potential study, as a proxy for usage per square foot in Kentucky. From the Duke Ohio potential study we estimate a usage per square foot of 4.133 MMCF / million square feet. By multiplying the usage per square foot for 2007 (4.133 MMCF / million square feet) by the total floor space serviced by natural gas (193.9 million square feet), we estimate natural gas consumption of 801 MMCF for Kentucky's commercial sector in 2007. We then project out natural consumption by using annual growth rates from the Duke Ohio commercial natural gas forecast.

Industrial

From Duke Kentucky's 2009 potential study we determined that there is a total of 31.7 million square feet of industrial floor space in the state. 20.4 million square feet of the total floor space in the Duke Kentucky territory is serviced by natural gas. Using the usage per square foot estimated for Duke Kentucky's commercial customers for 2007 (4.133 MMCF / million square feet), we estimated consumption in 2007 of 84 MMCF. We then project out natural consumption by using annual growth rates from the Duke Ohio industrial natural gas forecast.

APPENDIX C—EFFICIENCY POTENTIAL METHODOLOGY FOR SINGLE-FAMILY RESIDENTIAL BUILDINGS

The residential modeling package, TREAT, was used to model the residential efficiency potential in the housing stock in Cincinnati. TREAT is a residential energy modeling tool often used by energy auditors and building designers. It uses a variety of inputs, including house characteristics, appliances, and weather data to model the expected energy use of a particular home. It also includes a library of efficiency measures that can be used to model potential efficiency improvements. TREAT was used to establish a baseline as well as model the effects of efficiency improvement measures on the average Cincinnati single-family house.

Establishing a Baseline

We gathered baseline data about the housing stock in Cincinnati to input into the TREAT model. We collected Cincinnati- and Ohio-specific data from the Greater Cincinnati Energy Alliance and local utilities, filling in the blanks where necessary with regional and national data from the Residential Energy Consumption Survey (RECS), the Building America baseline model, and several other sources. We modeled over 45 different permutations of "typical" Cincinnati homes by varying model inputs such as the square footage of the home, the type of heating equipment, and the type of foundation (basement, crawlspace, or slab-on-grade). More than 20 of these configurations were modeled using TREAT, and the rest were extrapolated from the modeled configurations. TREAT takes these inputs and calculates energy use (electricity and natural gas). The baseline was calculated as a weighted average of all the different model permutations. Table 33 gives the data collected for the various TREAT inputs (with multiple values for different percentages of the population, in some cases). For inputs without values, either the default TREAT value was used, or a value had to be derived.

Table 33. TREAT Input Data

Treat Input Categories	Treat Inputs	Cincinnati Value	 % of Homes	Data Source
General	City	Cincinnati		
	Stories	2	Median	Greater Cincinnati Energy Alliance (GCEA)
	# Bedrooms	3	(2.84 is avg)	RECS
	# Occupants	3		
	Wall color	Default		
	Roof color	Default		
	Foundation type	Basement Crawlspace Slab	55% 22% 23%	RECS
	If basement, is it heated?	No		
	Attic	Vented		
	Air leakage	4003	Average CFM50	GCEA
	Shielding	Default		
Surface Construction	Walls	Brick Siding or wood	38% 62%	RECS
	Ceiling	R23 No insulation (R-4)	18% 82%	GCEA home age; Building America stats for default
	Ground	0.75 wood, 2x10, no insulation, carpet w/ pad		ACEEE estimate (Sachs)

Treat Input Categories	Treat Inputs	Cincinnati		Data Source
		Value	% of Homes	
	Foundation—Basement wall	8" block R2; 4" concrete adjacent to ground		ACEEE estimate (Sachs)
	Foundation—Crawl space	chose 4" concrete		Estimate, based on option with lowest R-Value
Windows	Glazing	Single Double	31% 66%	RECS
	Frame type	Wood/vinyl, operable		
	Size	Default		
Layout	Ceiling height	Default		
	Shape of the house	Rectangle		ACEEE estimate
	Dimensions	840 1250 1750 2250 4138	12% 35% 26% 14% 13%	1st quintile: avg of >1000sf homes in Hamilton county 2nd-4th quintiles: avg of min and max range of quintile 5th quintile: avg of RECS for E N Central >=2500 sf Source: OKI Fiscal Impact Analysis Model, and county auditors from each GCEA county
	Quantity of windows on each wall	13 for entire house		RECS
	Direction house points	Default		
	Space type	Whole building		
	Is the space cooled?	Yes		
	Programmable thermostat?	No		
	Hours per day occupied	13.4		
Exterior doors	Quantity of doors on each wall	1		
	Door type	Wood		
	Size	Default		
	U-Value	Arbitrarily selected		
Heating	Heating type	Furnace Heat pump Elec resistance	Majority (90+%) of NG heat 44% of electric 56% of electric	GCEA RECS for EN Central RECS for EN Central
	Heating fuel	Gas	77%	Average of American Community Survey and Duke survey
	Capacity			
	Efficiency	80% AFUE 7.7 HSPF		GCEA Current federal minimum
	Location	Put in the vented attic, or basement where applicable		ACEEE estimate
	Year of heating equipment			
	Supply temperature	Default		
Air conditioning	Capacity			
	SEER	10	Median	GCEA
	Supply temperature	Default		

Treat Input Categories	Treat Inputs	Cincinnati		
		Value	% of Homes	Data Source
	Year of cooling equipment			
	Number of units	1		
	Type of unit	Central	Majority (90+%)	GCEA
Fans	Ventilated area			
	Ventilation rate			
	Heat recovery effectiveness			
	Hours/day used			
Hot Water	Type of unit	Tank storage		ACEEE estimate
	Hot water fuel	Gas		ACEEE estimate, based on heating fuel
	Tank volume	40 gallons		Building America default
	Input			Use TREAT to determine
	Supply temperature			
	Additional insulation R-Value			
	Number of units			
	Solar fraction of water heating			
	Year			
	Thermal efficiency	45 EF		Building America default
Hot Water Piping	Insulation R-Value	Defaults		
	Total area of piping			
	Recirculating system			
	% Piping running through each space			
Hot Water Demand	Usage adjustment multiplier	Defaults		
	Are dishes handwashed			
Lighting	Watts per fixture	Defaults		
	Hours/day used			
	# of fixtures			
Appliances	Refrigerator	1	1.424	Duke
	Clothes Dryer	1	0.787	Duke
	Clothes Washer	1	0.953	Duke
	TVs	3	3.012	Duke
	Freezer	0	0.42	Duke
	Dishwasher	1	0.787	Duke
	Microwave	1	1.061	Duke
	Computer	1		ACEEE estimate
	Room AC	0	0.333	Duke
	Oven/range	1	0.787	Duke

To “true up” the model, we compared the baseline energy use to average energy use from RECS. As needed we adjusted the energy use to more closely align with RECS values. However, due to the “roughness” of this methodology (as opposed to hard data), as well as the inherent margins of error associated with energy modeling, it is important to pay more attention to the *relative* savings rather than the *absolute savings* (i.e., the percent savings rather than the kWh or Btu's of savings). Although we made attempts to get as close as reasonably possible on the absolute energy numbers (for instance, by normalizing against RECS data) it is no substitute for real, end-use billing data. Percent savings is the more accurate indicator, because the savings calculation error and baseline calculation error should line up in the same direction, minimizing the total error when calculating percentages.

Efficiency Potential Analysis

Six different efficiency "packages" were modeled for each of the baseline modeling runs, resulting in energy savings calculations for each run and each package. An efficiency package consists of several efficiency measures grouped together. One of the advantages of using modeling software is that the interaction factors between various measures are automatically calculated. For instance, when lighting is switched from incandescents to CFLs, the cooling load decreases and the heating load increases. These interactions are difficult to account for without the assistance of modeling software. Because TREAT displays both the savings from individual measures and the overall savings of all the measures as a package, this phenomenon can be quantified: in many of the scenarios, the sum of the individual measure savings was roughly double the actual savings of the measures as a package.

The six efficiency packages that were modeled included:

1. *Baseline package*: Includes attic insulation to R-38 levels, duct sealing, and building envelope infiltration reductions.

2. *Windows package*: Includes everything from baseline package as well as window replacements with energy-efficient windows.

3. *Comprehensive package—low end*: Includes everything from baseline package as well as SEER 16 central AC (this represents the low-savings HVAC replacement, as AC improvements result in less energy saved than a furnace) and an ENERGY STAR dishwasher (as a representative major appliance with lower-than average energy use). This package is meant to illustrate the minimum range of savings possible with a comprehensive[6] retrofit.

4. *Comprehensive package—high end*: Includes everything from baseline package as well as a new heating system (94 AFUE furnace, or 8.5 HSPF heat pump, depending on the base fuel) and an ENERGY STAR refrigerator. This package represents the maximum rage of potential savings from comprehensive retrofit.

5. *HVAC package*: Includes everything from the baseline package, as well as new heating and air conditioning systems (94 AFUE furnace, or 8.5 HSPF heat pump, and SEER 15 central AC).

6. *Appliances package*: Includes everything from the baseline package, as well as replacing 2 standard appliances with ENERGY STAR appliances (a dishwasher and refrigerator).

For each individual measure, most of the inputs to the TREAT model were pre-programmed into TREAT. These included energy savings and measure lifetime. Measure cost data came from various sources, as shown in Table 34.

[6] In this case "comprehensive retrofit" specifically means a retrofit that includes attic insulation, duct sealing, infiltration reduction, one HVAC upgrade and one major appliance upgrade.

Table 34. Cost Data for Residential Efficiency Measures

Efficiency Measure	Base Cost	Efficient Measure Cost	Incremental Cost	Source
Efficient central AC (16 SEER…highest CEE tier)	959	1344	385	DOE 2010
includes duct sealing	0	750	750	Cost of Aeroseal
Infiltration reduction (25% better than baseline)	0	100	100	ACEEE estimate
Insulation to R-38	0	593.6	593.6	CEC 2005
Dishwasher (ENERGY STAR)	538	550	12	ENERGY STAR 2011
Efficient furnace (94 AFUE)	1050	1570	520	DOE 2007
includes duct sealing	0	750	750	Cost of Aeroseal
Refrigerator (ENERGY STAR, top-freezer configuration)	1150	1180	30	ENERGY STAR 2011
Windows (premium double-glazed)		450	641	RS Means 2008; NEEA 2002
Efficient HP (8.5 HSPF, 15 SEER…highest CEE tier)	1255	1497	242	DOE 2010

APPENDIX D—EFFICIENCY POTENTIAL METHODOLOGY FOR COMMERCIAL NONPROFIT BUILDINGS

Baseline End-Use Electricity and Natural Gas Consumption

To estimate the resource potential for energy efficiency in commercial nonprofit buildings in the greater Cincinnati region, we first develop a disaggregated characterization of baseline electricity and natural gas consumption for all commercial buildings in the region for current use and a reference load forecast.

We apportion this forecast to nonprofit commercial buildings for the greater Cincinnati region by multiplying the energy forecast by the percentage of commercial square footage in the East North Central census region that is used for activities that include nonprofit use as reported by EIA's Commercial Building Energy Consumption Survey (CBECS). CBECS building categories devoted to nonprofit activities include offices, education, health care, public assembly, and religious worship. Building types that we excluded from this potential study include retail, warehouse, food sales and service, and lodging.

We then multiply the apportioned energy forecast by the percent of establishments in each of the applicable business sectors that are nonprofit, as reported by the U.S. Census National American Industry Classification System (NAICS) dataset. The industry types that we included in this analysis are offices, educational services, healthcare and social services, arts, entertainment and recreation, and religious. Through this methodology we estimate that commercial nonprofit buildings consumed 366 GWh of electricity and 288,000 MBtu in 2010. We project that electricity use will increase to 433 GWh by 2030 and natural gas use will decline slightly to 286,000 MBtu over the same period. See Tables 35 and 36 for detailed end-use breakouts of electricity and natural gas baseline forecasts for the commercial nonprofit sector.

Table 35. Baseline Commercial Nonprofit Electricity Consumption by End-Use (GWh)

End-Use	2010	%	2020	%	2030	%
Heating	14	4%	15	4%	15	3%
Cooling	44	12%	44	11%	46	11%
Ventilation	31	9%	36	9%	38	9%
HVAC subtotal	*90*	*24%*	*94*	*23%*	*99*	*23%*
Water Heating	8	2%	8	2%	8	2%
Refrigeration	28	8%	28	7%	28	7%
Lighting	127	35%	138	34%	138	34%
Office Equipment	42	11%	47	12%	50	12%
Other	72	20%	89	22%	103	24%
Total	366	100%	403	100%	433	100%

Table 36. Baseline Commercial Nonprofit Natural Gas Consumption by End-Use (MMBtu)

End-Use	2009	%	2020	%	2030	%
Heating	170,000	59%	167,000	58%	163,000	57%
Cooling	2,000	1%	1,000	1%	1,000	0%
HVAC subtotal	*172,000*	*60%*	*169,000*	*59%*	*164,000*	*58%*
Water Heating	52,000	18%	53,000	19%	54,000	19%
Cooking	19,000	7%	19,000	7%	20,000	7%
Other	45,000	16%	46,000	16%	48,000	17%
Total	288,000	100%	287,000	100%	286,000	100%

Next, we estimate commercial nonprofit square footage in the region using electricity intensity data (kWh per square foot and Btu per square foot) by census region as reported in CBECS (see Table 37). While this method provides a reasonable approximation of floorspace, it cannot take into account for the specific building density and variegation in the region.

Table 37. Commercial Nonprofit Buildings Floorspace (s.f.)

Building Type	Total Floorspace (thousand s.f.)
Office	5,900
Education	9,200
Health Care	1,300
Public Assembly	1,700
Religious Worship	8,300
Total	26,500

We use the East North Central census region to estimate overall energy intensity for the greater Cincinnati region of 11.0 kWh per square foot for electricity use and 66.9 MBtu per square foot for natural gas use (see Tables 38 and 39). Total electricity and natural gas consumption for commercial nonprofit buildings divided by the electricity and natural gas intensity, respectively, provides an estimate of commercial floorspace for each fuel. Using this methodology, we estimate 26.5 million square feet of commercial nonprofit floorspace using electricity and 5.3 million square feet of commercial nonprofit floorspace using natural gas.

Table 38. Commercial Nonprofit End-Use Baseline Electricity Intensities (kWh per s.f.)

End-Use	kWh/s.f.	MBtu/s.f.
Heating	0.4	45.0
Cooling	1.3	—
Ventilation	0.7	—
Water Heating	0.2	14.4
Cooking	0.1	5.1
Lighting	5.2	—
Refrigeration	0.8	—
Office Equipment	1.4	—
Other	1.0	2.4
HVAC Subtotal	2.4	45.0
Total	11.0	66.9

Table 39. Commercial Nonprofit End-Use Baseline Natural Gas Intensities (MBtu per s.f.)

End Use	2009
Heating	45.0
Cooling	—
Ventilation	—
Water Heating	14.4
Cooking	5.1
Other	2.4
HVAC Subtotal	45.0
Total	66.9

To estimate the energy intensity of buildings different fuels in the greater Cincinnati region we use data reported by CBECS and EIA. According to data collected in CBECS, the East North Central region, where the Ohio portion of the greater Cincinnati region is located, has natural gas intensity above the national average, while electricity intensity is below the national average. To account for the margin of error in the sample size of the CBECS survey, we average these regional numbers with EIA's national average as reported in the Annual Energy Outlook. For a building using only electricity, this average intensity is used to calculate base load and potential savings. For a building using both natural gas and electricity, we use only the data reported by CBECS, to account for the relatively higher natural gas intensity and lower electricity intensity in a building with this split fuel mix.

Measure Cost-Effectiveness

We then analyze 28 efficiency measures for buildings using electricity and 18 measures for buildings using natural gas to examine the cost-effective energy efficiency resource potential. For each efficiency measure, we estimate electricity and gas savings (*Annual Savings per Measure)* and incremental cost (*Measure Cost)* in a "replacement on burnout scenario," which assumes that the product is replaced or the measure is installed at the end of the existing measure's useful life. Savings and costs are incremental to an assumed *Baseline Measure*. We estimate savings (kWh and MMBtu) and costs ($) on a per-unit and/or a per-square foot commercial floorspace basis. For each measure we also assume a *Measure Lifetime*, or the estimated useful life of the product.

A measure is determined to be cost-effective if its levelized cost of saved energy, or cost of conserved energy (CCE), is less than average commercial cost of energy in the greater Cincinnati region over the period of analysis (10.91 cents/kWh for electricity and 11.08 $/MMBtu for natural gas). Equation 1 shows the calculation for cost of conserved energy.

Equation 1. CCE = PMT ((Discount Rate), (Measure Lifetime), (Measure Cost)) / (Annual Savings per Measure (kWh))

Total Greater Cincinnati Region Resource Potential

For each measure, we then derive *Annual Savings per Measure* on a per square foot basis *(kWh per square foot and MBtu per square foot)* for the applicable end-use. For measures that we only have savings on a per-unit or per-building basis, we first derive the percent savings and multiply by the *Baseline Intensity* for that end-use.

To estimate the total efficiency resource potential in existing commercial nonprofit buildings in the greater Cincinnati region by 2030, we must first adjust the individual measure savings by an *Adjustment Factor* (see Equation 2). This factor accounts for two adjustments: the technical feasibility of efficiency measures, called the *Percent Applicable* (the percent of floorspace that satisfy the base case conditions and other technical prerequisites such as heating fuel type and cooling equipment, etc.); and the *Current Market Share*, or the percent of products that already meet the efficiency criteria.

Equation 2. Adjustment Factor = Percent Applicable x (1-Current Market Share).

We then adjust total savings for interactions among individual measures. For example, we must adjust HVAC equipment savings downward to account for savings already realized through improved building envelope measures (insulation and windows), which reduce heating and cooling loads. Similarly, we adjust water heating equipment savings to account for reduced water heating loads from the use of more efficient clothes washers. The multiplier for these adjustments is called the *Interaction Factor.*

Finally, we adjust replacement measures with lifetimes more than 11 and 21 years to only account for the percent turning over in 11 and 21 years, which represents the benchmark years of 2020 and 2030, respectively. Note that the multiplier, *Percent Turnover,* is only applicable to products being replaced upon burnout and not retrofit measures such as insulation. These retrofit measures therefore have 100% of measures "turning over."

We then calculate the resource potential for each measure in the state using Equation 3, which takes into account all of the adjustments described above. The sum of the resource potential from all measures is the overall energy efficiency resource potential in the region's commercial nonprofit buildings sector.

Equation 3. Efficiency Resource Potential in 2020 and 2030 (GWh) = (Annual Savings per Measure (kWh per square foot)) x (Commercial floor space in the greater Cincinnati region in millions of square feet) x (Percent Applicable) x (Interaction Factor) x (Percent Turnover)

Table 40. Commercial Nonprofit Building Electricity Measure Characterizations

Measures	Measure Life (Years)	Annual kWh svgs per unit	2007 Cincinnati Stock	kWh Svgs per s.f.	Incremen-tal Cost per Unit	Incremen-tal Cost per s.f.	Cost of Conserved Energy (2006$/kWh saved)	Adjust-ment Factor	% Turn-over	Interac-tion Factor	Sav-ings in 2030 (GWh)
Building Shell											
Cool roof	20	5,500	NA	0.13	$ 3,750	$ 0.25	$ 0.05	25%	100%	100%	3
Roof insulation	25	NA	NA	0.28	NA	$ 0.12	$ 0.03	35%	100%	100%	3
Low-e windows	25	NA	NA	0.26	NA	$ 0.07	$ 0.02	75%	84%	100%	4
											10
HVAC											
Duct testing and sealing	10	24,800	NA	0.53	$ 3,380	NA	$ 0.02	25%	100%	100%	4
Efficient ventilation fans & motors w VFD	10	21,900	NA	0.30	$ 6,650	NA	$ 0.04	40%	100%	87%	3
HVAC Load-Reducing Measures Subtotal											**7**
High-effic. unitary AC & HP (65–135 kBtu)	15	1,100	NA	0.24	$ 630	NA	$ 0.06	33%	100%	84%	2
High-effic. unitary AC & HP (135–240 kBtu)	15	3,400	NA	0.37	$ 1,420	NA	$ 0.04	15%	100%	84%	1
Packaged Terminal HP and AC	15	200	NA	0.26	$ 90	NA	$ 0.04	5%	100%	84%	0.3
Efficient room air conditioner	13	100	NA	0.21	$ 40	NA	$ 0.04	4%	100%	84%	0.2
High-efficiency chiller system	23	30,300	NA	0.68	$ 9,900	NA	$ 0.02	33%	91%	84%	5
HVAC Equipment Measures Subtotal											**8**
Dual Enthalpy Control	10	3,000	NA	0.34	$ 890	NA	$ 0.04	46%	100%	76%	3
Demand-Controlled Ventilation	15	8,000	NA	0.24	$ 3,450	NA	$ 0.04	54%	100%	76%	3
HVAC tuneup (smaller buildings)	3	900	NA	0.44	$ 160	NA	$ 0.06	21%	100%	76%	2
Energy management system install	10	17,700	NA	0.29	$ 6,380	NA	$ 0.05	33%	100%	76%	2
Retrocommissioning	7	NA	NA	0.32	NA	$ 0.25	$ 0.05	42%	100%	76%	3
HVAC Control Measures Subtotal											**12**
HVAC Subtotal											**26**
Water Heating											
Heat pump water heater	12	14,200	NA	0.18	$ 4,070	NA	$ 0.03	24%	100%	100%	1
											1
Refrigeration											
Reach-in coolers & freezers	9	1,300		0.33	$ 180	NA	$ 0.02	15%	100%	100%	1
Vending machines (to Tier 2 ENERGY STAR level)	10	500		0.19	$ 30	NA	$ 0.01	13%	100%	100%	1
Vending miser	10	800		0.30	$ 170	NA	$ 0.03	13%	100%	100%	1
											3
Lighting											
Fluorescent lighting improvements	13	100	—	1.31	$ 4	NA	$ 0.01	56%	100%	100%	19
HID lighting improvements	2	400	—	1.25	$ 60	NA	$ 0.06	12%	100%	100%	4
Replace incandescent lamps with CFLs	13	200	—	3.32	$ (22)	NA	$ (0.01)	22%	100%	100%	6
Occupancy sensor for lighting	10	400	—	0.90	$ 50	NA	$ 0.02	38%	100%	84%	8
Daylight dimming system	20	100		1.68	$ 70	NA	$ 0.04	25%	100%	79%	9

Measures	Measure Life (Years)	Annual kWh svgs per unit	2007 Cincinnati Stock	kWh Svgs per s.f.	Incremen-tal Cost per Unit	Incremen-tal Cost per s.f.	Cost of Conserved Energy (2006$/kWh saved)	Adjust-ment Factor	% Turn-over	Interac-tion Factor	Sav-ings in 2030 (GWh)
			—								
Retrocommissioning	7	NA	—	0.54	NA	NA	$ 0.05	42%	100%	73%	4
											50
Office Equipment											
Office equipment	5	1,400	—	0.77	$ 0.01	$ 20	$ 0.003	50%	100%	100%	10
Turn off office equipment after-hours	5	12,500	—	0.56	$ —	$ —	$ —	100%	100%	80%	12
											22
										TOTAL	**112**

Table 41. Commercial Nonprofit Natural Gas Measure Characterizations

Measures	Measure Life (Years)	Annual MMBtu Svgs per Unit	2007 Cincinnati Stock	MBtu Svgs per s.f.	Incremental Cost per Unit	Incremental Cost per s.f.	Cost of Conserved Energy (2006$/MM Btu saved)	Adjustment Factor	% Turnover	Interaction Factor	Savings in 2030 (GWh)
Building Shell											
Roof insulation	25	23		1.02	—	$ 0.06	$ 4.26	35%	84%	100%	2,000
Low-e windows	25	22		0.98	—	$ 0.04	$ 2.82	75%	84%	100%	3,000
Building Shell Measures Subtotal											**5,000**
HVAC											
Boiler tune-up	2	30	NA	1.44	$ 250	$ —	$ 4.17	7%	100%	100%	500
Duct sealing	25	130	NA	6.03	$ 7,000	$ —	$ 3.68	23%	84%	100%	6,000
Pipe insulation—heating	15	10	NA	0.65	$ 450	$ —	$ 3.00	12%	100%	100%	400
Load-Reducing Measures Subtotal											**7,000**
High Efficiency rooftop furnace unit	15	28	NA	1.26	$ 1,000	$ —	$ 3.42	35%	100%	96%	2,000
High efficiency standalone furnace	18	16	NA	0.71	$ 460	$ —	$ 2.51	1%	100%	96%	<100
High efficiency main/front-end boiler	24	399	NA	17.83	$ 4,130	$ —	$ 0.75	37%	88%	96%	29,000
HVAC Equipment Measures Subtotal											**32,000**
Programmable thermostat	12	4	NA	2.45	$ 100	$ —	$ 2.66	8%	100%	77%	1,000
Demand-controlled ventilation	15	43	NA	1.92	$ 3,450	$ —	$ 7.75	54%	100%	77%	4,000
Outdoor temperature boiler reset	15	14	NA	0.65	$ 600	$ —	$ 4.00	1%	100%	77%	<100
HVAC Control Measures Subtotal											**5,000**
HVAC Subtotal											**44,000**
Water Heating											
Tank insulation	15	4		0.20	$ 470	$ —	$ 10.22	16%	100%	100%	200
Pipe insulation—water heating	15	4		0.20	$ 450	$ —	$ 9.87	11%	100%	100%	100
Load-Reducing Measures Subtotal											**300**
Circulation pump time clock	15	7		0.29	$ 140	$ 0.01	$ 2.09	5%	100%	99%	100
Control Measures Subtotal											**100**
Condensing DHW stand-alone tank	15	79	NA	3.53	$ 1,100	$ —	$ 1.34	33%	100%	99%	6,000
Indirect-fired DHW off space heating boiler	25	65		2.90	$ 4,000	$ —	$ 4.38	7%	68%	99%	1,000
Tankless high-modulating water heater	15	45		2.01	$ 650	$ —	$ 1.39	4%	100%	99%	300
Equipment Measures Subtotal											**7,000**
Miscellaneous											
Retrocommissioning	7	95	NA	4.25	$ —	$ 0.15	$ 6.02	54%	100%	100%	12,000
											12,000
										TOTAL	**68,000**

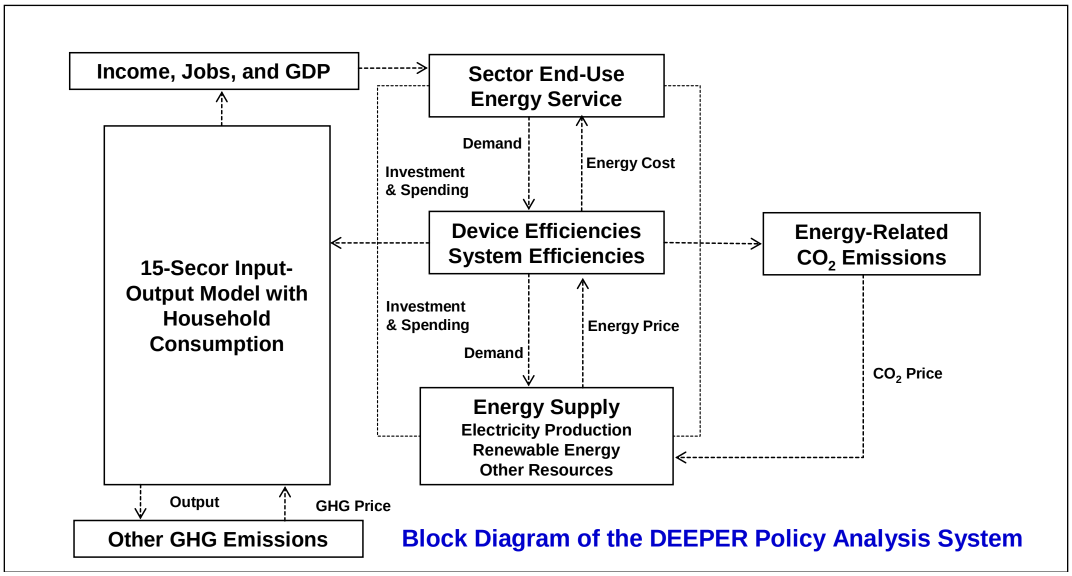
Table 42. Costs and Energy Savings from Eight Packages as Applied to Five Types of Cincinnati Region Nonprofit Buildings

			Average Per Building Annual Savings and Upfront Costs																	
			Average Building			**Office Building**			**Education Building**			**Health care Building**			**Public Assembly Building**			**Religious Building**		
			Costs	***Energy Savings***		***Costs***	***Energy Savings***		***Costs***	***Energy Savings***		***Costs***	***Energy Savings***		***Costs***	***Energy Savings***		***Costs***	***Energy Savings***	
Package			*$*	*kWh*	*therms*	*$*	*kWh*	*therms*	*$*	*kWh*	*therms*	*$*	*kWh*	*therms*	*$*	*kWh*	*therms*	*$*	*kWh*	*therms*
Natural Gas and Electric																				
1	**Envelope**	duct testing and sealing, roof insultation, efficient ventalation and motors	$21,917	18,657	1,980	$21,331	15,558	1,651	$28,920	55,718	5,914	$23,347	26,227	2,784	$22,960	24,180	2,566	$20,480	11,055	1,173
2	**Envelope & lighting**	all envelope measures plus florescent lighting improvements, replace incandescant lamps, occupancy sensor for lighting	$25,852	59,088	1,980	$24,613	49,274	1,651	$40,673	176,462	5,914	$28,879	83,061	2,784	$28,061	76,579	2,566	$22,812	35,012	1,173
3	**Envelope & HVAC**	all envelope measures plus high efficiency unitary AC & HP [65-135 kbtu], HVAC tuneup, high efficiency rooftop furnace unit, programable thermostat	$23,804	28,427	2,575	$23,218	23,705	2,147	$30,807	84,895	7,689	$25,234	39,960	3,619	$24,848	36,842	3,337	$22,367	16,844	1,526
4	**Envelope, HVAC & lighting**	all measures from packages 1-3	$27,740	68,858	2,575	$26,500	57,421	2,147	$42,560	205,639	7,689	$30,767	96,795	3,619	$29,948	89,241	3,337	$24,699	40,801	1,526
All Electric																				
5	**Envelope**	duct testing and sealing, roof insultation, efficient ventalation and motors	$12,345	20,900	0	$11,960	17,429	0	$16,955	62,416	0	$13,287	29,380	0	$13,032	27,087	0	$11,400	12,384	0
6	**Envelope & lighting**	all envelope measures plus florescent lighting improvements, replace incandescant lamps, occupancy sensor for lighting	$16,281	61,331	0	$15,242	51,144	0	$28,708	183,161	0	$18,819	86,214	0	$18,133	79,486	0	$13,732	36,341	0
7	**Envelope & HVAC**	all envelope measures plus high efficiency unitary AC & HP [135-240 kbtu], HVAC tuneup, heat pump water heater, high efficiency chiller system	$27,885	48,050	0	$27,499	40,069	0	$32,494	143,498	0	$28,826	67,545	0	$28,572	62,274	0	$26,939	28,472	0
8	**Envelope, HVAC & lighting**	all measures from packages 5-7	$31,820	88,481	0	$30,781	73,785	0	$44,248	264,242	0	$34,359	124,380	0	$33,672	114,673	0	$29,271	52,429	0

APPENDIX E—METHODOLOGY OF THE DEEPER MODELING SYSTEM

The **D**ynamic **E**nergy **E**fficiency **P**olicy **E**valuation **R**outine—the DEEPER Modeling System—is a 15-sector quasi-dynamic input-output model of the U.S. economy. Although an updated model with a new name, the DEEPER model has a 19-year history of use and development. The model is used to evaluate the macroeconomic impacts of a variety of energy efficiency, renewable energy, and climate policies at the regional, state, and national level.[7] In this analysis, the DEEPER model focuses on the use of energy in all sectors of the economy. DEEPER is an Excel-based analytical tool with three linked modules combining approximately two dozen interdependent worksheets. The primary analytic modules are: (i) the Energy and Emissions Module, (ii) the Electricity Production Module, and (iii) the Macroeconomic Module.[8] The block diagram of the DEEPER Modeling System below lays out the analytical framework of the model:

Figure 40. Diagram of the DEEPER Model



The timeframe for evaluating policies within the model at the national level is 2010 through 2050, or in the case of evaluating the proposed policy/program recommendations in this study, the period 2011 through 2030. For the purposes of this analysis, the estimated changes to spending and investment patterns resulting from the proposed policy packages as estimated in the main body of the report are mapped into the model. The model then compares the changed patterns to the employment impacts assumed within the standard reference case.

The model outcomes are usually driven by the demands for energy services and alternative investment patterns as they are shaped by changes in policies and prices. In this case, however, because the economy-wide impacts for the proposed policies are reasonably small, we maintain the current set of electricity and other prices as established by the *Annual Energy Outlook 2011* projections (EIA 2011). This tends to provide a conservative result because even small downward pressure on the price of remaining uses of energy would provide further net benefits to the larger economy. Although the DEEPER Model is not a general equilibrium

[7] Please note two items. First, the model solves recursively, meaning that the current year set of prices and quantities is dependent on the previous years' results. As the model moves through time, there are price-quantity adjustments and adjustments uncorrelated to price to key elasticities and coefficients within the model. Second, it is possible to expand and reduce the number of sectors in the model with minor programming changes. The problem is to provide sufficient detail to show key negative and positive impacts while maintaining a model of manageable size. If the analyst chooses to reflect a different mix of sectors and stay within the 15 x 15 matrix, that can be easily accomplished. Expanding the number of sectors will require some minor programming changes and adjustments to handle the larger matrix. The current mix of 15 sectors reflects the analyst's efforts to exhibit key outcomes while maintaining a model of manageable size.

[8] See Laitner et al. (1998) for an example of an earlier set of modeling results. Laitner and McKinney (2008) also review past modeling efforts using this modeling framework.

model, it does provide sufficient accounting detail to match import-adjusted changes in investments and expenditures within one sector of the economy and balance them against changes in other sectors.[9]

The DEEPER Model is benchmarked to the Ohio and Kentucky macroeconomic parameters of Economy.com (2011) and the *Annual Energy Outlook* 2011 (EIA 2011), which now extends out through 2035—five years past the period of analysis referenced here.

Table 43. Reference Case Assumptions for Key Indicators in Benchmark Years

Indicator	2010	2012	2020	2030	Average Annual Growth Rate 2010-2030
Total Population (4 County Area, Thousands)	1,224	1,232	1,270	1,317	0.4%
Total Employment (Thousands)	856.42	878.86	917.46	925.74	0.1%
Gross Regional Product (Billions of 2009 Dollars)	69.9	74.2	84.3	94.0	0.4%
Four-County Residential Electricity Consumption (Million kWh)	6191.5	6289.3	6217.5	6497.4	0.4%
Four-County Commercial Electricity Consumption (Million kWh)	4163.1	4301.9	4594.5	4936.4	0.9%
Four-County Residential Natural Gas Consumption (Thousand mmBtu)	15063.3	15047.0	15883.8	16951.6	0.6%
Four-County Commercial Natural Gas Consumption (Thousand mmBtu)	3180.2	3156.0	3173.5	3156.7	-0.01%
Four-County Residential Electricity Price (2009 $/kWh)	0.09	0.09	0.12	0.14	2.3%
Four-County Commerical Electricity Price (2009 $/kWh)	0.08	0.09	0.11	0.13	2.3%
Four-County Residential Natural Gas Price (2009 $/mmBtu)	13.49	13.37	13.18	15.52	0.7%
Four-County Commercial Natural Gas Price (2009 $/mmBtu)	10.66	10.55	10.38	12.77	0.9%
Four-County Residential Electricity Bill (Billion 2009 $)	55.7	59.4	76.4	90.5	2.5%
Four-County Commercial Electricity Bill (Billion 2009 $)	35.0	36.4	51.4	64.9	3.2%
Four-County Residential Natural Gas Bill (Billion 2009 $)	203.2	201.2	209.3	263.2	1.3%
Four-County Commercial Natural Gas Bill (Billion 2009 $)	33.9	33.3	33.0	40.3	0.9%
Sources: Moody's Analytics, U.S. 2009 Census, IMPLAN 2009, EIA, Synapse, ACEEE (value-added)					

The main reference case assumptions are shown in Table 43 for key benchmark years 2010 through 2030—including the year 2012 which is the first major impact year for this analysis. In general the Cincinnati Region's economy is expected to grow at a rate of about 0.4% (rounded) annually; total end-use electricity consumption will decline 0.2% per year, and natural gas consumption will grow 0.17% (rounded) per year. Rising energy prices, growing at about 1.9% per year for electricity and 1.0% per year for natural gas (in real terms with all values in 2009 dollars) will increase total household electricity and natural gas expenditures at an annual rate of about 2.5% and 1.3% respectively. Commercial electricity and natural gas expenditures will increase at an annual rate of 3.2% and 0.9%. This will escalate electricity expenditures from an estimated $95.8 billion in 2012 to about $155.5 billion by 2030, and natural gas expenditures should increase from $234.4 billion to $303.5 billion.

In the macroeconomic module of DEEPER, a set of spreadsheets contains the "production recipe" for the U.S. economy for a given "base year." For this study, the base year used was 2009. The input-output (or I-O) data, currently purchased from the Minnesota IMPLAN Group (IMPLAN 2011), is essentially a set of economic accounts that specifies how different sectors of the economy buy (purchase inputs) from and sell (deliver outputs) to each other. Further details on this set of linkages can be found in Hanson and Laitner (2009).

For this study, the model was run to evaluate impacts of the selected policies upon 15 different sectors, including: Agriculture, Oil and Gas Extraction, Coal Mining, Other Mining, Electric Utilities, Natural Gas Distribution, Construction, Manufacturing, Wholesale Trade, Transportation and Other Public Utilities

[9] When both equilibrium and dynamic input-output models use the same technology assumptions, both models should generate reasonably comparable set of outcomes. See Hanson and Laitner (2005) for a diagnostic assessment which reached that conclusion.

(including water and sewage), Retail Trade, Services, Finance, Government, and Households.[10] As described below, examining the job intensities of the different sectors provides early insights of likely scenario outcomes.

The principal energy-related sectors of the U.S. economy, as shown in the IMPLAN data (2011) for the Cincinnati region, are not especially job-intensive. It turns out, for example, that the energy sector in this region supports only 6 direct and indirect jobs for every one million dollars of revenue received in the form of annual energy bill payments. The rest of the economy, on the other hand, supports between 9 and 16 direct and indirect jobs per million dollars of receipts. *A productive investment in energy efficiency that pays for itself (e.g., a million dollar investment results in net savings greater than a million dollars) over a short period of time will generate a net energy bill savings that can be spent for the purchase of goods and services other than energy.* In this case, the impact of a one million dollar energy bill savings suggests there may be roughly a net gain of about 10 jobs (that is, 16 jobs supported by a more typical set of consumer purchases compared to the 6 total jobs supported by the electric utilities). Depending on the sectoral interactions, however, this difference may widen or close as the changed pattern of spending works its way through the model, and as changes in labor productivity changes the number of jobs needed in each sector over a period of time.[11]

Based on the scenarios mapped into DEEPER, the set of worksheets in the Macroeconomic Module translates the selected energy policies into an annual array of physical energy impacts, investment flows, and energy expenditures over the desired period of analysis. DEEPER evaluates the policy-driven investment path for the various retrofit financing strategies, as well as the implied energy bill savings anticipated over the modeling time horizon (again, through 2030 for this analysis). It also evaluates the impacts of avoided or reduced investments and expenditures otherwise required by the electric and natural gas generation sectors. These quantities and expenditures feed directly into the final demand worksheet of the module. The final demand worksheet provides the detailed accounting that is needed to generate the implied net changes in sector spending.

Once the mix of positive and negative changes in spending and investments has been established, the net spending changes in each year of the model are converted into sector-specific changes in final demand. This then drives the input-output model according to the following predictive model:

$$X = (I-A)^{-1} * Y$$

where:

X = total industry output by sector
I = an identity matrix consisting of a series of 0's and 1's in a row and column format for each sector (with the 1's organized along the diagonal of the matrix)
A = the matrix of production coefficients for each row and column within the matrix (in effect, how each column buys products from other sectors and how each row sells products to all other sectors)
Y = final demand, which is a column of net changes in spending by each sector as that spending pattern is affected by the policy case assumptions (changes in energy prices, energy consumption, investments, etc.)

This set of relationships can also be interpreted as

$$\Delta X = (I-A)^{-1} * \Delta Y$$

[10] Household spending is allocated to each of the sectors using the personal consumption expenditure data provided in the IMPLAN data set.
[11] Note that unlike many policy models, DEEPER also captures sector trends in labor productivity. That means the number of jobs needed per million dollars of revenue will decline over time according to sector-specific trends published by BLS (2009). For example, if we assume a 1.9% labor productivity improvement over a 20-year period, one million dollars today might provide work for 12 people; by the year 2030, however, it might be more like 8 jobs.

which reads, a change in total sector output equals the expression $(I-A)^{-1}$ times a change in final demand for each sector.[12] Employment quantities are adjusted annually according to exogenous assumptions about labor productivity in each of the sectors within the DEEPER Modeling System (based on Bureau of Labor Statistics forecasts; see BLS 2009). From a more operational standpoint, the macroeconomic module of the DEEPER Model traces how each set of changes in spending will work or ripple its way through the U.S. economy in each year of the assessment period. The end result is a net change in jobs, income, and GDP (or value-added; GRP in this study).

For each year of the analytical time horizon (i.e., 2012 to 2030 for the efficiency gains evaluated in this report), the model copies each set of results into this module in a way that can also be exported to a separate report. For purposes of this separate report, and absent any anomalous outcomes in the intervening years, we highlight the decadal results in order to focus attention on the differences in results emerging from various alternative policy scenarios. For a review of how an I-O framework might be integrated into other kinds of modeling activities, see Hanson and Laitner (2009). While the DEEPER Model is not an equilibrium model, as explained previously in this appendix, we borrow some key concepts of mapping technology representation for DEEPER, and use the general scheme outlined in Hanson and Laitner (2009). Among other things, this includes an economic accounting to ensure resources are sufficiently available to meet the expected consumer and other final demands reflected in different policy scenarios.

[12] Perhaps one way to understand the notation $(I-A)^{-1}$ is to think of this as the positive or negative impact multiplier depending on whether the change in spending is positive or negative for a given sector within a given year.

APPENDIX F—AVOIDED EMISSIONS METHODOLOGY

Estimating avoided emissions is an arduous task whose complexity can vary depending on the preferred methodology, which is a function of the preferred level of accuracy of the estimates. ACEEE chose a simplified methodology that provides a reasonable and defensible estimation of avoided emissions. Prior to discussing the methodology we used, there are a number of caveats we must understand so that the justification for using our chosen methodology is clear.

First, few states/cities generate all of the electricity they consume on net: frequently electricity is imported from or exported to neighboring region, making it difficult to attribute avoided emissions to a particular region. Second, transmission constraints affect the dispatch of units within a region that respond to load changes as well as the feasibility of importing energy from generation sources outside the region. The rate of avoided emissions can therefore change depending on where the load reductions are actually occurring and, as a result, what generating units are being affected.

Finally, the period of time covered in the analysis adds yet another dimension to the choice of methodology: power systems adjust to changes in load differently in the short term (0-5 years) than in the long term (5-15 years). In the short term, analyses are concerned primarily with how the implementation of an energy efficiency program or the addition of a new plant will affect how generating units are "dispatched" within a power system. This effect occurs because different types of generating units are dispatched to provide baseload electricity compared to those that are dispatched to meet additional electricity demand during intermediate and peak hours. Therefore avoided emissions rates will vary depending on the type of generating units dispatched.

In the long term, analyses instead focus on how energy efficiency or clean generation will impact capacity additions and retirements. Falling demand for electricity catalyzed by energy efficiency lowers market prices, which influences investment decisions: lower electricity prices decrease demand for new plants and also make market entry less attractive to potential entrants. This change causes the composition of a power system or utility's "fleet" to vary over time. Different types of units generate varying levels of emissions as do different units of the same type, so predicting the composition of a fleet is imperative for determining the amount of emissions that will be avoided over a certain period of time.

Methodology

To estimate annual regional emissions reductions, we utilized the Environmental Protection Agency's *Emissions & Generation Resource Integrated Database* (eGRID), which is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the United States (EPA 2010). The eGRID database provides data on a plant-by-plant basis, allowing us to differentiate between baseload (typically coal or nuclear) and marginal generation (typically oil or natural gas), which is crucial to estimating avoided emissions as discussed above.

Despite the long-term focus of this report, ACEEE assumes that the fleet of generation facilities and the emission rates of those facilities do not change over time. This is a simplifying assumption, as investments in energy efficiency and renewable energy supply over the next twenty years will likely reduce operations at some facilities and perhaps force others into retirement. Determining which facilities will reduce their operations or be retired requires a detailed, rigorous analysis in-and-of-itself: analysts consider variables such as load duration curves and plant capacity factors, often as part of a system dispatch model, to determine where and when operations will be scaled back. ACEEE did not expend the resources to conduct such an assessment. We instead took a relatively conservative approach of assuming all avoided emissions will come from marginal generation units and none from baseload units.

We identified seven electricity generation plants in or near the four-county Cincinnati region all of which serve the Duke Energy service territories in Ohio and Kentucky. Four of these plants provide baseload generation capacity and are coal fired: Fort Miami, W H Zimmer, Walter C Beckjord, and East Bend. We also included three plants which provide marginal generation capacity. Two of these plants are natural gas fired (Madison and Woodsdale) and one is oil-fired (Dicks Creek). To establish our baseline emissions projections, we used net annual generation values (MWh) for each facility as reported by eGRID and applied average annual growth rates drawn from our retail electric sales forecast for Duke Energy Ohio to those values to determine net annual generation throughout the study period. eGRID also provides annual output emission rates for each facility, given in pounds per megawatt-hour (lbs/MWh), which we use to determine the baseline emissions of CO_2, NO_x, and SO_2 for each facility:

Equation 1

*Annual emissions (metric tons) = Annual generation (MWh) * annual emission rate (lbs/MWh) ÷ 2200 lbs/metric ton*

Using the cumulative electricity savings estimates from our program analysis and the same annual output emissions rates, we are able to estimate the cumulative emissions savings in each year for each facility. The electricity savings estimates were apportioned to each facility based on a facility's annual generation relative to the total generation of all three facilities. This is another simplifying assumption because operations at a facility are not necessarily scaled back based on the volume of generation:

Equation 2

*Cumulative Annual Avoided Emissions (metric tons) = Cumulative annual energy savings (MWh) * annual emission rate (lbs/MWh) ÷ 2200 lbs/metric ton*

Finally, we assumed that decreased in sales first impact the dispatch and operation of the marginal plants. Only when the need for the marginal plants to provide capacity were completely displaced do we assume a lower generation level from the baseload plants. This is yet another simplifying assumption used in the absence of data on likely actual dispatch between these plants.