SHAPING OHIO'S ENERGY FUTURE: ENERGY EFFICIENCY WORKS

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**American Council for an Energy-Efficient Economy,
Summit Blue Consulting, ICF International,
and Synapse Energy Economics**

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

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EXECUTIVE SUMMARY

The passing of Senate Bill 221 (SB 221), which was signed by Governor Ted Strickland on May 1, 2008, was a landmark event that has positioned Ohio to become a national leader in energy efficiency. SB 221 created an aggressive Energy Efficiency Resource Standard (EERS) mandating that Ohio's investor-owned utilities save at least 22% of electricity consumption by 2025, which our report clearly demonstrates is not only achievable, but can also be accomplished cost-effectively while providing significant job and financial benefits to Ohio's economy. The timing of the legislation is opportune, as rising unemployment and a deepening state budget deficit have shown that Ohio and its consumers are in great need of economic revitalization. Deployed as Ohio's "first fuel," investments in energy efficiency will facilitate this revitalization in three ways: (1) by minimizing employment losses through the creation of new "green collar" jobs; (2) by providing critical financial relief to Ohio's consumers through lower energy bills and stable rates, and; (3) by easing the strain on the state budget through lower state operating costs, enabled by the expansion of energy efficiency into state and local government buildings.

Ohio's current fiscal and economic challenges do not preclude the state from garnering considerable benefits from energy efficiency. Energy efficiency and demand response are the lowest-cost resources available to moderate short-term impacts and are also the quickest to deploy, meaning that efficiency resources begin to generate financial savings for the state and its consumers quickly, which can then be reinvested to further stimulate Ohio's ailing economy. A comprehensive state energy plan is also important in order to effectively leverage the boon of federal funding from the *American Recovery and Reinvestment Act*, which includes $6.3 billion for state and local energy efficiency and clean energy grants. So long as investments in energy efficiency are made prudently and complemented by strong programs and policies, Ohio will be able to alleviate these short-term issues and improve its economic vitality well into the future.

Policy Recommendations

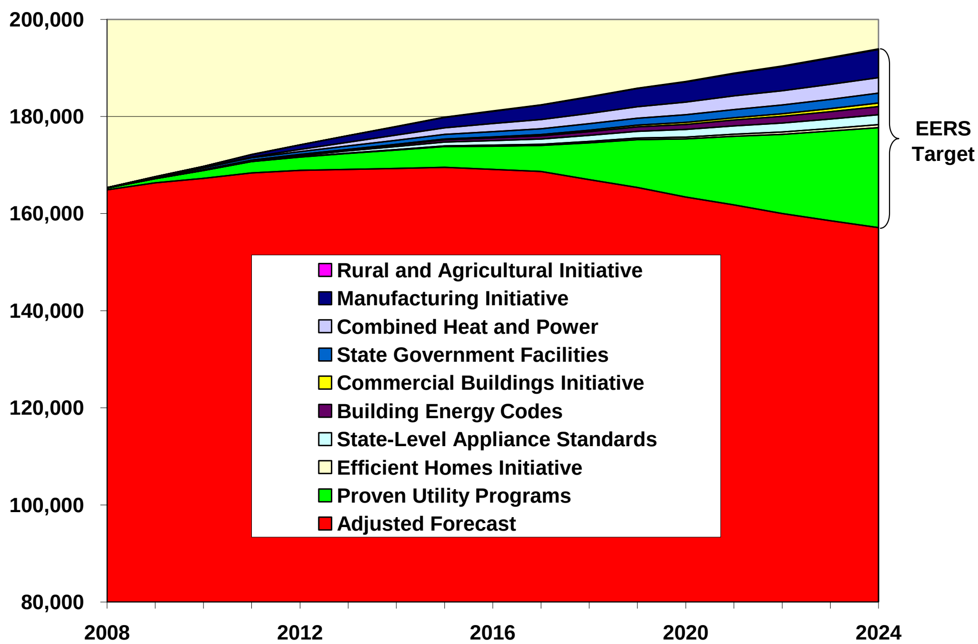
To meet the state's savings targets, ACEEE suggests a suite of ten "innovative" programs and policies (henceforth referred to as "innovative policies" or "policies") in addition to the proven utility program approaches ("programs") that are already beginning to be implemented by the state's utilities. We believe that five of these policies, which could be implemented by utilities or in cooperation with a statewide effort, should be allowed to contribute towards the EERS target. Together these policies and programs would more than satisfy the 22% savings goal; however, we did not attempt to quantify the potential for additional savings beyond the EERS target in this analysis. Our innovative policies are:

A. Energy Efficiency Resource Standard
    1. Advanced Residential Buildings Initiative
    2. Advanced Commercial Buildings Initiative
    3. Manufacturing Initiative
    4. Rural and Agricultural Initiative
    5. Combined Heat and Power

B. Complementary Policies
    6. Workforce Development
    7. State and Local Government Facilities
    8. State-Level Appliance and Equipment Efficiency Standards
    9. Building Energy Codes
    10. Expanded Demand Response Programs

Figure ES-2 shows the contribution of the individual policies and programs towards the EERS target. Our suite of innovative energy efficiency policies will contribute savings of 16,235 GWh, or 10% of Ohio's electricity needs, by 2025. This will leave only 12%, or 20,596 GWh, of the EERS target to be met by the proven programs. In this report we highlight best practice programs that have proven to be effective at reducing electricity consumption in other states across the U.S. With the combination of these innovative policies and proven utility programs, we believe that Ohio can easily satisfy the EERS target cost-effectively and with a net positive benefit to the economy.

Figure ES-1. Share of Projected Electricity Use Met by Innovative Energy Efficiency Policies & Proven Utility Programs



These policy suggestions draw from the best practice policies currently implemented throughout the country. The establishment of Ohio's EERS target represents the core of these policies, providing the foundation upon which the five supporting policies can begin to help achieve the savings goal.

In addition, we find that a suite of demand response (DR) recommendations, which focuses on shifting energy from peak periods to off-peak periods and cutting back electricity needs during periods with the highest needs, is a critical component of reducing peak demand in Ohio. Figure ES-3 presents the combined effects of energy efficiency and demand response on peak reductions.

Economic Potential of Energy Efficiency Resources

This report assesses the total cost-effective, or “economic,” potential for energy efficiency investments in Ohio. By characterizing the incremental costs and energy savings for a number of efficient technologies or measures for residential, commercial, and industrial consumers, we determine the cost-effectiveness for each measure and estimate the total energy efficiency “resource” potential. We estimate an economic potential for efficiency resources in Ohio of over 64,000 GWh, or 33% of projected electricity consumption in 2025, as illustrated by Figure ES-3 below. Our results show that contributions from cost-effective resources are not evenly distributed across all sectors, which will necessitate the development and implementation of proven programs that take this weighting into account.

Figure ES-2. Estimated Reductions in Summer Peak Demand through Energy Efficiency and Demand Response (2025 peak reduction = 11,416 MW, or 29%)

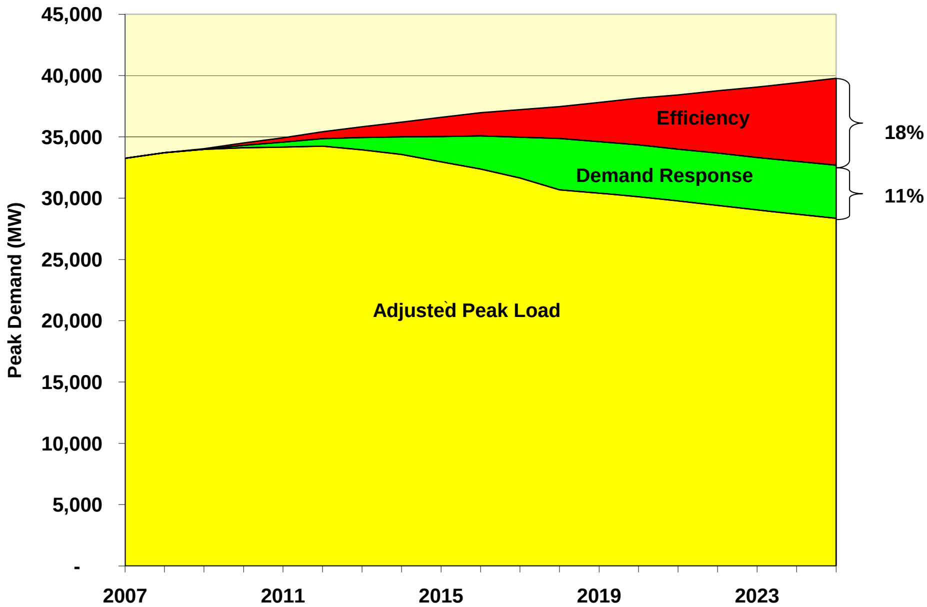
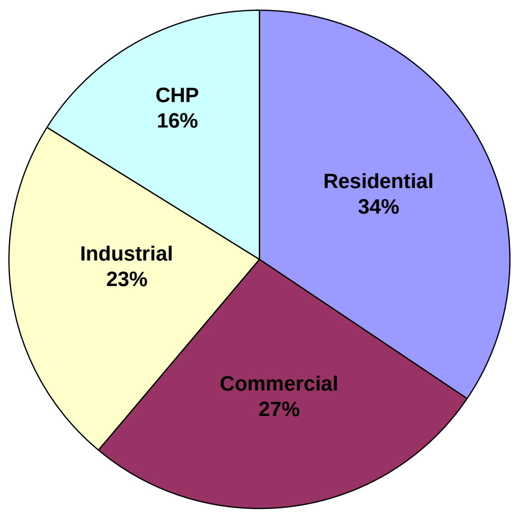


Figure ES-3. Summary of Energy Efficiency Economic Resource Potential (64,284 GWh, or 33% of Projected Electricity Consumption in 2025)



Impacts on Employment and the Economy

The energy savings from these efficiency policies and programs can cut the electricity bills for customers by a net $430 million in 2015. Net annual savings grow eight-fold to $3.3 billion in 2025. While these savings will require some public and customer investment, by 2025 net cumulative savings on electricity bills will reach almost $19 billion. These savings are the result of two effects. First, participants in energy efficiency programs will install energy efficiency measures, such as more efficient appliances or heating equipment, therefore lowering their electricity consumption and electric bills. In addition, because of the current volatility in energy prices, efficiency strategies have the added benefit of improving the balance of demand and supply in energy markets, thereby stabilizing regional electricity prices for the future.

Investments in efficiency policies and programs have the added benefit of creating new, high-quality "green-collar" jobs in Ohio and increasing both wages and Gross State Product (GSP). Our analysis shows that energy efficiency investments can create over 32,000 new jobs in Ohio by 2025 (see Table ES-1), including well-paying trade and professional jobs needed to design, install, and operate energy efficiency measures. These new jobs, including both direct and indirect employment effects, would be equivalent to over 250 new manufacturing facilities relocating to Ohio, but without the public costs for infrastructure or the environmental impacts of new plants.

Table ES-1. Economic Impact of Energy Efficiency Investments in Ohio

Macroeconomic Impacts	2015	2025
Jobs (Actual)	7,928	32,061
Wages (Million $2006)	300	1,615
GSP (Million $2006)	444	2,559

Conclusions

The State of Ohio is poised to make great strides in expanding efficiency throughout the state. As this report documents, there is tremendous potential for Ohio to become a national leader in efficiency and to take advantage of the numerous cost-effective energy efficiency and demand response opportunities that exist in the state. Nonetheless, Ohio does have some difficult decisions to make with regards to its energy future. Faced with severe budgetary constraints and a slumping economy, there may be an inclination to dispel energy efficiency in light of the present conditions. It is therefore extremely important that the momentum created by the establishment of the aggressive EERS target by legislation included in SB 221 not be lost. This legislation has sent a strong signal of Ohio's intent, which in large part contributed to its respectable ranking in ACEEE's 2008 state energy efficiency scorecard. However, Ohio will have to continue to balance its priorities in order for energy efficiency to affect its economy as beneficially as this report highlights.

The various energy efficiency and demand response policies we suggest have been successful in other states in delivering efficiency resources and reducing consumer electric expenditures. We estimate efficiency can meet 122% of the increase in the state's electricity needs over the next 17 years while meeting 188% of the increase in peak demand and reducing emissions by 12%. What is more, these policies and programs can accomplish this at a lower cost than building new supply infrastructure, while simultaneously creating over 32,000 new, high-quality "green collar" jobs by 2025.

Our suggestions are intended to be the starting point for dialog among stakeholders on how to realize the demand-side efficiency resource potential in the state, particularly given the economic challenges it faces. ACEEE's suggestions are based on our review of existing opportunities and stakeholder discussions, and reflect proposals that we think are politically viable. However, it is important to note that these suggestions will not necessarily meet all of the state's future energy needs. While energy efficiency is perhaps the only new energy resource available that can be deployed quickly in the short term and continue to contribute significantly into the long term, the state will still require additional resources to meet the remainder of new load and to replace older, dirtier generation plants as they are retired. Furthermore, additional policies and programs exist that could be implemented to realize even more of the available energy efficiency resources. Ultimately, energy efficiency can delay the immediate need for investments in infrastructure, allowing Ohio the time to rigorously consider its future resource choices.

ACKNOWLEDGMENTS

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ABOUT THE AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY (ACEEE)

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

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

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

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

[1] Acknowledgement of support from an entity is not indicative of their sponsorship or endorsement of this report.

GLOSSARY

ENERGY POLICY AND ORGANIZATIONS

(ASHRAE) American Society of Heating, Refrigerating and Air-Conditioning Engineers: Organization of over 50,000 professionals in the air-conditioning, heating, refrigerating and ventilating fields. Support the integration of increased energy efficiency in building design via technological enhancements of these systems (http://www.ashrae.org/).

Avoided Costs: The marginal costs incurred by utilities for additional electric supply resources. Used by utilities to evaluate the cost-effectiveness of energy efficiency programs.

(EERS) Energy Efficiency Resource Standard: A simple, market-based mechanism to encourage more efficient generation, transmission, and use of electricity and natural gas. An EERS consists of electric and/or gas energy savings targets for utilities. All EERS include end-user energy saving improvements that are aided and documented by utilities or other program operators. Often used in conjunction with a Renewable Portfolio Standard (RPS). (See ACEEE's fact sheet for state details: http://aceee.org/energy/state/policies/2pgEERS.pdf.)

(EISA 2007) Energy Independence and Security Act of 2007: Law covering issues from fuel economy standards for cars and trucks to renewable fuel and electricity to training programs for a "green collar" workforce to the first federal mandatory efficiency standards for appliances and lighting.

ENERGY STAR®: A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy helping residential customers save money and protect the environment through energy-efficient products and practices (http://www.energystar.gov/). Includes appliance efficiency standards and new building codes.

(EPAct) Energy Policy Act: Law directing U.S. energy policy; first passed in 1992 and major revisions were passed in 2005 and 2007.

(ESCO) Energy Service Company: Provides designs and implementation of energy savings projects. The ESCO performs an in-depth analysis of the property, designs an energy-efficient solution, installs the required elements, and maintains the system to ensure energy savings.

(ESPC) **Energy Service Performance Contracting:** A financing technique that uses cost savings from reduced energy consumption to repay ESCO's (see above) for the cost of installing energy conservation measures and other services.

(FEMP) Federal Energy Management Program: U.S. Department of Energy program "works to reduce the cost and environmental impact of the Federal government by advancing energy efficiency and water conservation, promoting the use of distributed and renewable energy, and improving utility management decisions at Federal sites" (http://www1.eere.energy.gov/femp/about/index.html).

(FERC) Federal Energy Regulation Commission: Federal agency that "regulates and oversees energy industries in the economic, environmental, and safety interests of the American public" (www.ferc.org).

(IRP) Integrated Resource Plan: A comprehensive and systematic blueprint developed by a supplier, distributor, or end-user of energy who has evaluated demand-side and supply-side resource options and economic parameters and determined which options will best help them meet their energy goals at the lowest reasonable energy, environmental, and societal cost (http://www.energycentral.com/centers/knowledge/glossary/home.cfm).

(LIHEAP) **Low-Income Home Energy Assistance Program**: A federally funded program intended to assist low-income households that pay a high proportion of household income for home energy, primarily in meeting their immediate home energy needs.

(NERC) North American Electric Reliability Corporation: NERC's mission is to improve the reliability and security of the bulk power system in North America. To achieve that, NERC develops and enforces reliability standards; monitors the bulk power system; assesses future adequacy; audits owners, operators, and users for preparedness; and educates and trains industry personnel. NERC is a self-regulatory organization that relies on the diverse and collective expertise of industry participants. As the Electric Reliability Organization, NERC is subject to audit by the U.S. Federal Energy Regulatory Commission and governmental authorities in Canada (www.nerc.com).

GENERAL REPORT TERMINOLOGY

Cumulative Savings: Sum of the total annual energy savings over a certain time frame.

Demand Side Management (DSM): Programs that focus on minimizing energy demand by influencing the quantity and use-patterns of energy consumption by end users, as opposed to supply side management, which focuses on investments in system infrastructure.

Energy Efficiency: The implementation of programs and policies that minimize the consumption of energy resources while stimulating economic growth.

Incremental Annual Savings: Energy savings occurring in a single year from the current year programs and policies only.

Percent Turnover: Percentage of technology replaced on burnout with more efficient technology. Does not include retrofits.

Potential: amount of energy savings possible

- **Achievable Potential**: Potential that could be achieved through normal market forces, new state building codes, equipment efficiency, and utility energy efficiency programs
- **Economic Potential**: Potential based on both the Technical Potential and economic considerations (e.g., system cost, avoided cost of energy)
- **Technical Potential:** Potential based on technological limitations only (no economic or other considerations)

Replace-on-Burnout: The act of waiting until a technology's end of life before replacing it with a more energy-efficient technology. Cost basis is the incremental cost of choosing a more efficient technology over a less efficient one. Incremental cost usually means incremental equipment cost with no labor cost; that is, there is no labor cost or it is the same in both cases and thus a zero-sum.

Retrofit Measure: The act of replacing a technology with a more energy-efficient technology before its end of life. Cost basis is the full cost of the new technology, including installation.

Total Annual Savings: Energy savings occurring in a single year from the current year programs and policies and counting prior year savings. Sum of all Incremental Annual Savings.

INDUSTRY and BUILDINGS TECHNOLOGY

(CHP) Combined Heat and Power: method of using waste heat from electrical generation to offset traditional process or space heating. Also called cogeneration (cogen).

Electricity Use Feedback: System that monitors home/building electricity use and provides real time feedback to occupants. This allows occupants to increase energy efficiency.

ENERGY STAR® New Homes: 15% electricity savings over a comparable size home.

HVAC: Heating, ventilation, and air conditioning system.

(NAICS) **North American Industry Classification System**: 6-digit code used to group industries by product.

UTILITY TERMS

Coincidental Peak: The sum of two or more peak loads that occur in the same time interval.

Coincidental Peak Factor: The ratio of annual peak demand savings (kW) from an energy-efficiency measure to the annual energy savings (kWh) from the measure; also called Coincidence Factor.

Demand Response: The reduction of customer energy usage at times of peak usage in order to help address system reliability, reflect market conditions and pricing, and support infrastructure optimization or deferral. Demand response programs may include dynamic pricing/tariffs, price-responsive demand bidding, contractually obligated and voluntary curtailment, and direct load control/cycling.

Deregulation: Allows a rate payer to choose other electricity providers over a local provider. Deregulation efforts vary from reducing to completely eliminating a local monopoly on electricity.

Distributed Energy Resource: Electrical power generation or storage located at or near the point of use, as well as demand-side measures

Distributed Generation: Electric power generation located at or near the point of use.

Distributed Power: Electrical power generation or storage located at or near the point of use.

Electricity Distribution: Regulating voltage to usable levels and distributing electricity to end-users from substations

Electricity Generation: Converting a primary fuel source (e.g., coal, natural gas, or wind) into electricity.

Electricity Transmission: Transport of electricity from the generation source to a distribution substation, usually via power lines.

Henry Hub: The market price for natural gas is by convention set at the Henry Hub (which is a physical location in southern Louisiana where a number of pipelines from the Gulf of Mexico originate). Futures and spot market contracts for delivery of gas are traded on the New York Mercantile Exchange (NYMEX) with regional wholesale prices set at key hubs where pipelines originate or come together. These prices are set relative to the Henry Hub price with adders for transportation and congestion.

(IOU) Investor-Owned Utility: Also known as a private utility, IOU's are utilities owned by investors or shareholders. IOU's can be listed on public stock exchanges.

(ISO) Independent System Operator: Entity that controls and administers nondiscriminatory access to electric transmission in a region or across several systems, independent from the owners of facilities.

Levelized Cost: The level of payment necessary each year to recover the total investment and interest payments at a specified interest rate over the life of the measure.

(MISO) Midwest Independent System Operator: The Midwest ISO is an independent, nonprofit organization that supports the constant availability of electricity in 15 U.S. states and the Canadian province of Manitoba.

Peak Demand: The highest level of electricity demand in the state measured in megawatts (MW) during the year.

Peak Shaving: Technologies or programs that reduce electricity demand only during peak periods (frequently combined with "valley filling" policies that shift consumption to periods of low demand. The combination is referred to as load shifting.)

PJM: PJM Interconnection is a Regional Transmission Organization that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the District of Columbia.

Power Pool: Two or more inter-connected electric systems planned and operated to supply power in the most reliable and economical manner for their combined load requirements and maintenance programs.

Renewable Generation: Electric power generation from a renewable energy source such as wind, solar, sustainably harvested biomass, or geothermal.

(RTO) Regional Transmission Organization: An independent regional transmission operator and service provider that meets certain criteria, including those related to independence and market size. Controls and manages the transmission and flow of electricity over large areas.

(REC) Rural Electric Cooperative: REC's are nonprofit, cooperative utilities that provide electricity to rural areas and are owned by all customers of that utility.

Transformer: Electrical device that changes the voltage in AC circuits from high-voltage transmission lines to low voltage distribution lines.

Wholesale Competition: A system in which a distributor of power would have the option to buy its power from a variety of power producers, and the power producers would be able to compete to sell their power to a variety of distribution companies.

Wholesale Electricity: Power that is bought and sold among utilities, non-utility generators, and other wholesale entities, such as municipalities.

Wholesale Power Market: The purchase and sale of electricity from generators to resellers (that sell to retail customers) along with the ancillary services needed to maintain reliability and power quality at the transmission level.

INTRODUCTION

The State of Ohio is one of the nation's largest users of electricity, led only by Texas, Florida, and California. Consumption in the state is projected to grow at an average annual rate of 1% between 2008-2025, and peak demand, a measure of consumption during the hottest periods of the year, is estimated to grow at 1% over that same period.[2] While these growth rates are relatively modest, the dual shocks of a slumping economy and volatile energy markets are placing an inordinate amount of financial pressure on Ohio's electricity consumers. As an added concern, rate stabilization plans (RSP) – introduced in 2006 to help moderate Ohio's transition to a deregulated electricity market – are scheduled to expire at the end of the year, which most anticipate will herald higher retail rates without intervention from utilities and their regulatory body, the Public Utilities Commission of Ohio (PUCO).

On May 1, 2008, Governor Ted Strickland signed Senate Bill (SB) 221, which included legislation mandating investments in energy efficiency and renewable energy intended to alleviate these issues, while also bolstering Ohio's workforce, cleaning its air, and leading the state down a path towards greater energy independence and sustainability. This laudably aggressive target, which through a state Energy Efficiency Resource Standard (EERS) requires investor-owned utilities to accumulate 22% reductions in electricity consumption by 2025, sets the foundation for Ohio to become a national leader in energy efficiency. Unfortunately, the collapse of financial markets and the subsequent economic recession have magnified the ramifications of the state's current budget deficit, leading many to question how Ohio and its consumers will be able to fund these investments and, ultimately, meet the 22% target.

Our report demonstrates that through a combination of innovative policies and proven utility programs, meeting the 22% target is, in fact, achievable and can be accomplished cost-effectively while concomitantly providing significant job and financial benefits to Ohio's economy. Energy efficiency and demand response can provide critical relief from short-term market impacts as they represent the least-cost resources available and are the quickest to deploy. During a time when Ohio's tax revenues are falling and its unemployment is rising, this central tenet is extremely important. And unlike supply-side energy resources, efficiency and demand response are the only resources that can begin to reduce electric bills by decreasing overall consumption, which will save the state and its consumers money that can then be reinvested in Ohio's ailing economy.

Ohio will also have assistance from federal funding to supplement its efficiency investments. On February 17, 2009, President Obama signed the economic stimulus bill, titled the *American Recovery and Reinvestment Act*, which includes $6.3 billion for state and local energy efficiency and clean energy grants. If these funds are invested prudently, it will be possible to reap benefits into the long term, especially if these resources are allocated to supporting policies like workforce education and training, energy-service performance contracting, and weatherization programs. With diligence, energy efficiency has the potential to help Ohio weather the current economic maelstrom, improving the vitality of its economy well into the years ahead.

The goal of this study is to inform policymakers and stakeholders of the opportunities for energy efficiency and demand response in Ohio, and also to suggest policies Ohio could implement to facilitate the development of these clean energy resources. We present the results in a fashion designed to help educate policymakers and the general public about the importance of energy efficiency and demand response, as well as to influence policy development in Ohio over the next several years by identifying policy and technical opportunities for achieving major energy efficiency benefits and savings.

This report is organized into the following sections:

[2] These estimates were made before the current economic downturn and may overproject near-term growth, but in the long term we anticipate increasing growth in consumption as the economy recovers.

- ***Background:*** Reviews the electricity market in Ohio, including recent actions and future opportunities regarding energy efficiency and demand response.

- ***Project Overview and Methodology:*** Provides a context for ACEEE's work with state-level energy efficiency and demand response potential studies and an overview of both the project approach and analysis methodology.

- ***Reference Case:*** Discusses the reference case electricity, peak demand, and price forecasts used in this analysis.

- ***Energy Efficiency Resource Assessment:*** Estimates the cost-effective potential, from the customer's perspective, for increased energy efficiency in the state's residential, commercial, and industrial sectors by 2025 through the adoption of specific energy-efficient technology measures. The resource assessment goes beyond what the state can achieve through penetration of specific programs and policies.

- ***Energy Efficiency Policy Analysis:*** Outlines the recommended policies for Ohio to adopt to tap into the energy efficiency resource potential. This section presents the electricity and peak demand impacts from energy efficiency, the associated costs, and an evaluation of program costs using two cost-effectiveness tests (TRC and the Participant Cost tests). Also included in this section is an estimation of carbon dioxide emissions impacts.

- ***Demand Response Analysis:*** Estimates the potential for increased demand response in Ohio and makes specific recommendations to the State.

- ***Macroeconomic Impacts:*** Estimates the impact of energy efficiency policies on Ohio's economy, employment, and energy prices.

In addition, we provide details and references to resources on most of these sections in the technical appendices that accompanies the body of this report.

BACKGROUND

In 2007, Ohio sold over 161,000 GWh, making it the nation's fourth-largest consumer of electricity. The industrial sector accounts for the greatest share of electricity consumption (36%), though the residential (33%) and commercial sectors (30%) retain only a slightly smaller share (EIA 2008a).[3] Ohio generates about 86% of its electricity from coal, almost twice the national average (see Figure 2). As a result, Ohio is the nation's largest emitter of sulfur dioxide and ranks second in both nitrogen and carbon dioxide emissions (EIA 2007b). In this section we discuss the current condition of the Ohio electricity market and the overall role of energy efficiency and related opportunities to meet the state's energy needs.

Ohio Electricity Market

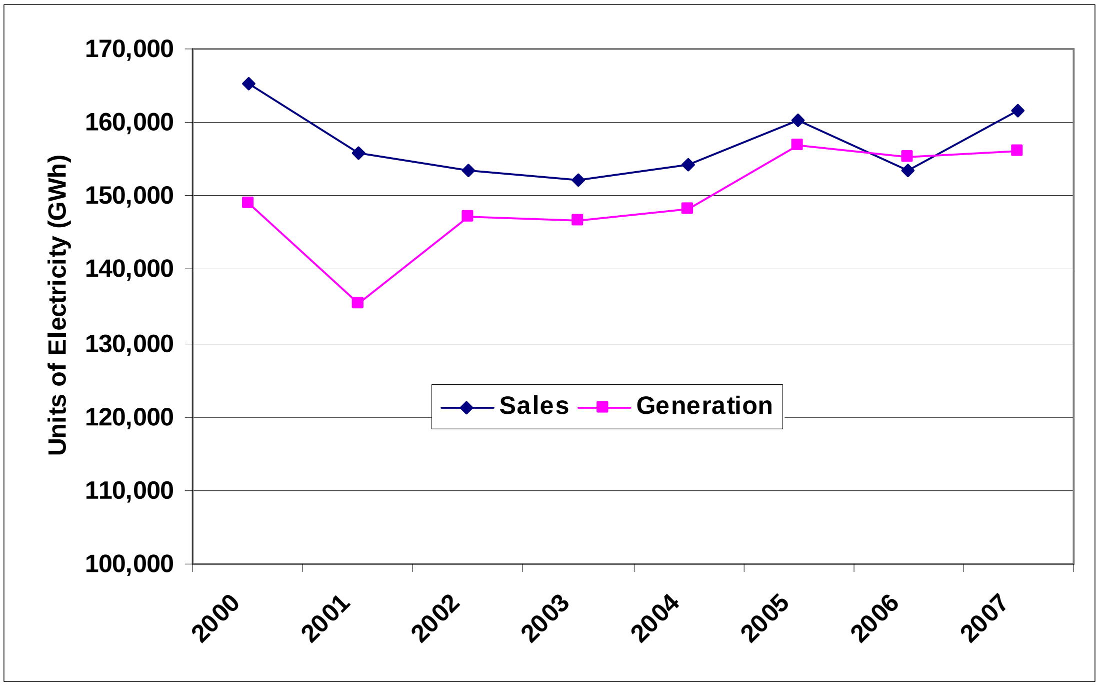
In 2007, Ohio generated 156,069 GWh of electricity yet consumed 161,547 GWh, making the state a net importer of more than 3% of its electricity generation (see Figure 1). Two regional transmission organizations (RTO) service utilities in the state: the Midwest Independent Transmission System Operator (MISO) and the PJM Interconnection (PJM), allowing Ohio utilities to purchase or sell electricity on the wholesale market.[4] The vast majority of this in-state generated electricity comes

[3] We do not cover the transportation sector in this analysis since the sector's consumption of electricity is negligible relative to the other economic sectors (for a discussion of state-level opportunities for increased efficiency in the transportation sector, see Geller et al. 2007).

[4] FirstEnergy and Duke Energy are members of MISO. AEP and DP&L are members of PJM.

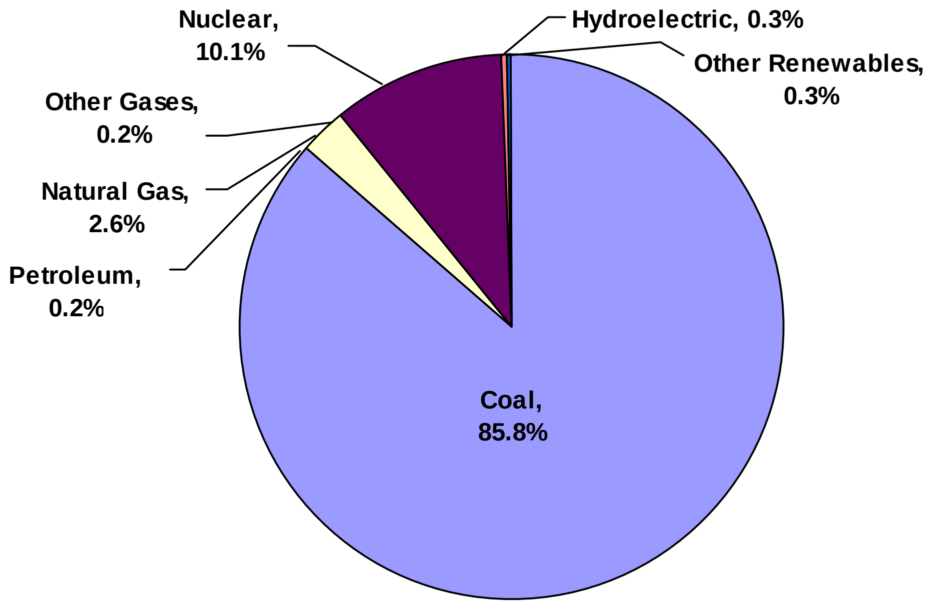
from coal (86%) and nuclear (10.1%) (see Figure 2). By comparison, the national average mix of electricity generation is 49% coal and 19% nuclear (EIA 2007b).

Figure 1. Electricity Sales and Generation in Ohio, 2000-2006



Source: EIA 2008a

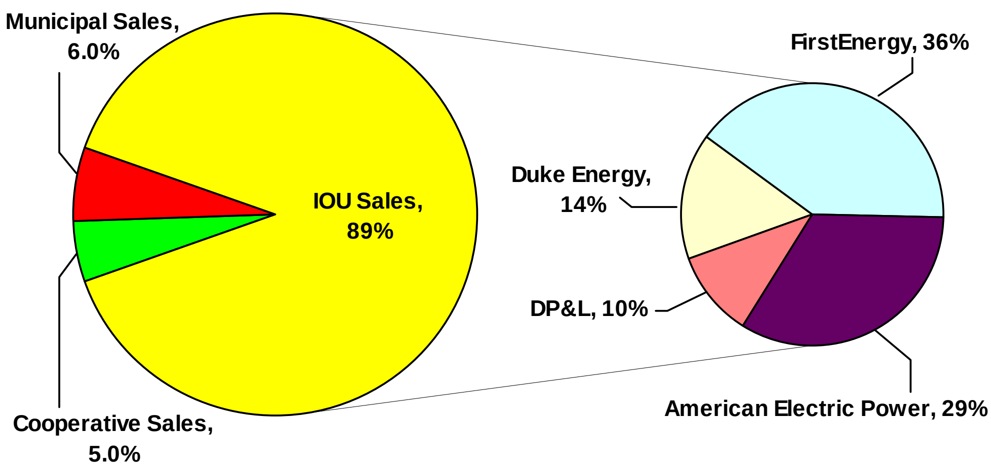
Figure 2. 2007 Ohio Electricity Generation by Fuel Type
Total Generation: 156,069 GWh



Source: EIA 2008a

Electricity is delivered in Ohio to consumers by three types of providers: investor-owned utilities (IOUs), rural electric cooperatives, and municipal electric suppliers. As can be seen in Figure 3, of the three types of providers, IOUs dominate sales in the state (89%), the two largest being FirstEnergy (36%) and AEP (29%). Duke Energy and Dayton Power & Light retain 14% and 10% of the market, respectively. Cooperatives and municipal utilities account for the remaining 11% of sales.

Figure 3. Electricity Deliveries (GWh) by Supplier in 2006



Source: EIA 2007a

The gradual introduction of deregulation starting in 2001 never had the impact on competition that was envisioned, which is evident by the fact that 86% of electricity services remain bundled, while only 8% is delivered to a third party for distribution.

Deregulation of Ohio's Electricity Market

As many states did when faced with rising electricity rates in the mid- to late-1990's, Ohio embraced deregulation in hopes of lowering retail rates for its customers. In 1999, Senate Bill (SB) 3 was passed with the intention of introducing competition into Ohio's electricity market, beginning in 2001. Included in the legislation was the imposition of a five-year market-development period where utility rates were frozen in order to facilitate competition in the market. Competition, however, failed to materialize, and as the end of the development period grew nearer, there was growing concern that the removal of rate caps would effectuate dramatic hikes in retail rates. The Public Utilities Commission of Ohio (PUCO) began to work with utilities to devise Rate Stabilization Plans (RSP) to guarantee stable, predictable rates. Most of these RSP's expire at the end of 2008, which, unattended, will leave Ohio consumers at the mercy of the market.[5]

To address this issue, legislation was included in SB 221 essentially weakening the state's commitment to deregulation in an effort to protect consumers from impending rate increases.[6] The bill requires all utilities to file a standard service offer, effective January 1st, 2009, which determines how utilities' retail rates will be set. A utility can choose between two methods to set its rates: an Electric Security Plan (ESP) or a Market Rate Option (MRO). Initially, however, all investor-owned utilities

[5] The PUCO approved Dayton Power & Light's current rate plan to extend through 2010.
[6] Please see Sections 4928.141 through 4928.143 of SB 221 for more information.

must *at least* file for an ESP, where retail rates are regulated by the PUCO. In conjunction with, or after, this initial filing, a utility may also choose to file for a Market Rate Option (MRO), where its retail rate would reflect prices in the PJM and MISO wholesale markets.[7]

By providing two ways for utilities to set their retail electricity rates, the PUCO is searching for the least-cost option: that being the plan most likely to present customers with the lowest rate. FirstEnergy was the only utility to file for an MRO, which they filed for simultaneously with their ESP, but the MRO was rejected by the PUCO on November 25, 2008 (PUCO 2008). No other Ohio utilities have shown interest in filing for an MRO. Unlike MROs, ESPs, with retail prices regulated by the PUCO, offer greater stability in prices and therefore ensure that the utilities will earn a favorable rate of return while also allowing them to recuperate any losses due to rising fuel costs.

It was believed that deregulation would produce lower retail rates by fostering competition, but since deregulation has failed to meet those expectations, the PUCO now offers these alternative methods of setting rates in the interest of Ohio customers. Nonetheless, because Ohio's electricity market remains deregulated – albeit in principle rather than in fact – when filing for an ESP, utilities are required to show that rates set by an ESP will be favorable to those set by an MRO. Additionally, for those utilities that have had an ESP approved by the PUCO that exceeds a three-year period, the PUCO requires that the ESP be reviewed every fourth year to ensure that the rates being delivered are still favorable when compared to an MRO.[8]

Utility-Level Projects

There are several major generation projects transpiring in Ohio that are aimed at meeting growing demand. The Haverhill North Coke Company completed construction of its Haverhill Generating Facility in August 2008 and began operation on December 1st, 2008. The 61 MW cogeneration facility, located in Haverhill, uses waste heat from coke ovens to generate electricity and has a maximum capacity of 75 MW. The Fremont Energy Center, owned by FirstEnergy and currently under construction in the Sandusky Township, is a 540 MW natural gas-fired combined-cycle electric generating facility with peaking capabilities of 704 MW that is scheduled to begin commercial operations in 2009. American Electric Power's (AEP) Dresden Energy Facility, also slated to begin commercial operations in 2009 and located in the Cass Township, is a 500 MW combined-cycle gas turbine, also with peaking capabilities of 704 MW (OPSB 2008a, 2008b).

Five other generation projects have been approved by the Ohio Power Siting Board (OPSB) and are in varying states of completion. Construction of the Lima Energy IGCC Station, a 580 MW base load synthetic gas plant owned by the Lima Energy Company, has been halted temporarily. Calpine Corporation's Lawrence Energy Center, an 850 MW combined-cycle gas facility, and AEP's Great Bend IGCC station have also been suspended. Construction of American Municipal Power's (AMP) 960 MW coal-fired generating station in Meigs County is scheduled to begin in the second quarter of 2009, though a request to modify a condition in its certificate is currently under investigation (OPSB 2008a, 2008b). The 135 MW FDS Coke Plant Co-Generation Facility in Toledo was approved by the OPSB October 28, 2008 and, according to their Web site, will take two years to complete (OPSB 2008a; FDS 2008).

[7] Utilities that file for an MRO and directly own, in whole or in a part, generating facilities are required to phase in the new rates, gradually transitioning to 100% market-based rates. In the first year, 90% of the new rates would be determined by the ESP and 10% would reflect the market price, ratcheting up the MRO portion each year. Ohio utilities that own their own generating facilities include American Electric Power, Dayton Power & Light, and Duke.

[8] Section 4928.143 (C) (1) of SB 221 requires utilities to conduct their own electricity price forecasts for the purposes of reviewing the benefits of an ESP versus an MRO. This has caused some concern as there is an incentive for utilities to exaggerate their price forecasts in order to make the ESPs appear more economically beneficial.

Role of Energy Efficiency

Ohio has already begun to take significant steps towards promoting energy efficiency. This momentum is vital given the bleak economic conditions and the pending expiration of RSPs, as well as the fact that Ohio generates 86% of its electricity through coal-fired power plants with no plans of reducing that mixture in the foreseeable future (OPSB 2008a). Energy efficiency has the potential to provide short- and long-term economic and social benefits to Ohio consumers, such as lowering consumer bills, abating emissions, and stimulating the economy. Though electricity is forecast to grow at a modest annual average of 1%, deploying energy efficiency in the short term will greatly reduce the need for investing in infrastructure to maintain current services and to meet growing demand in the future.

Ohio's efforts to advance energy efficiency are captured in ACEEE's *2008 State Energy Efficiency Scorecard*, which ranks states on eight energy efficiency policy and performance criteria. Ohio tied for the 18th spot in our *2008 Scorecard*, aided by recent developments that helped Ohio jump eight spots relative to our *2006 Scorecard*, giving it the rank of the third most-improved.[9] Ohio is one of the leading states dedicated to expanding combined heat and power (CHP) and, in fact, tied for 1st in the category (Eldridge et al. 2008). Ohio also provides financial incentives for energy efficiency in the form of grants for industrial efficiency projects, equal to 25% of the project cost with a maximum of $50,000 (DSIRE 2008).

Of particular importance was the introduction of SB 221 on May 1st, 2008, which included legislation encouraging the advancement and growth of alternative energy resources, specifically renewable energy and energy efficiency. SB 221 mandates an Energy Efficiency Resource Standard (EERS), which requires utilities to accumulate savings of at least 22% of consumption by 2025. Currently eighteen states have adopted some form of an EERS and of those eighteen, Ohio's EERS ranks among the more stringent (Eldridge et al. 2008). Effective as of January 1st, 2009, the annual savings target begins at 0.3% and ramps up 0.1–0.2% every year until 2014, where the target increases by 1% annually until 2019 and by 2% annually through 2024.[10] Utilities are also required to implement peak demand reduction programs beginning in 2009. Peak demand savings are targeted at 1% in the first year, followed by a 0.75% annual increase until 2018.[11]

The movement to incorporate energy efficiency is also being fostered by Ohio's utilities. Several utilities offer financial incentives for the purchase and installation of energy-efficient appliances and energy-efficient home improvements. Cleveland Electric Illuminating Co., Ohio Edison, and Toledo Edison – all subsidiaries of FirstEnergy – offer rebates to contractors and homeowners under the auspices of the Home Performance with ENERGY STAR program. FirstEnergy's rebate programs cover rebates on HVAC equipment and appliances, as well as investments in the weatherization of the home envelope. Duke Energy also offers rebates to both homeowners and contractors through its Smart Saver program, but its rebates extend only to HVAC equipment (DSIRE 2008).[12]

In leading states, energy efficiency is meeting 1–2% of the state's electricity consumption each year (Nadel 2007; Hamilton 2008) at a average cost of about 3¢ per kWh (Kushler, York, and Witte 2004),

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[9] Ohio and Maryland tied for third, both having jumped eight spots relative to our *2006 Scorecard.*

[10] The baseline for calculating savings is the average of total kilowatt hours utilities sold during the preceding three years.

[11] While the EERS target set forth in SB 221 directs utilities to accumulate savings of at least 22% of consumption by 2025, the actual requirement specifies annual savings for each year based on a percentage of the average consumption in the prior three years. While the annual percent energy savings targets sum to 22.2% in 2025, the application of the formula specified in the legislation result in a savings of 36,831 GWh in 2025, which represents just under 19% savings relative to the reference forecasted electricity consumption used in this report.

[12] For more information on these utility rebate programs, please visit the Database of State Incentives for Renewables and Efficiency (DSIRE) at www.dsireusa.org.

compared with a utility avoided cost of about 5–10¢ per kWh in Ohio (see Figure 7).[13] States across the country, including California, Connecticut, Massachusetts, Minnesota, New York, and Vermont, are realizing the benefits of energy efficiency today, having enacted policies and programs that effectively tap into their energy efficiency resources. Results from these states show that energy efficiency represents an immediate low cost, low risk strategy to help meet the state's future electricity needs (York, Kushler, and Witte 2008).

Together, energy efficiency and demand response can delay the need for expensive new supply in the form of generation and transmission investments (Elliott et al. 2007; 2007b), thus keeping the future cost of electricity affordable for the state and freeing up energy dollars to be spent on other resources that expand the state's economy. In addition, a greater share of the dollars invested in energy efficiency go to local companies that create new jobs compared with conventional electricity resources, where much of the money flows out of state to equipment manufacturers and energy suppliers.

PROJECT APPROACH AND METHODOLOGY

Stakeholder Engagement

Awareness of the demographics and political climate in the State of Ohio was an integral part of the formulation of the policies that we are suggesting. Each State in the Union is different and we do not presume that any one policy will work ubiquitously. Identifying and engaging stakeholders in Ohio, therefore, was imperative to the relevance and success of our report. We endeavored to meet in person with as many different representative groups as possible in order to better understand Ohio's specific energy structure and needs. For those we were unable to meet with personally, we conducted telephone conferences to facilitate the process. We met with several environmental groups, the PUCO, the Ohio Consumers Council (OCC), the Ohio Department of Development (ODOD), the Ohio Manufacturers Association (OMA), the Ohio Hospital Association (OHA), as well as many of the utilities, such as AEP, Buckeye Power, and American Municipal Power Ohio (AMP Ohio).[14]

One theme that surfaced quite regularly was the necessity of a trained, qualified workforce with which to implement, operate, and evaluate energy efficiency programs. These include positions such as contractors, building operators, auditors, etc. Our stakeholders were particularly emphatic about the need for properly trained workers to conduct evaluation, measurement and verification (EM&V) of efficiency programs. However, considering the high demand for these types of workers at the national level, Ohio is struggling to find qualified firms or individuals to meet its indigenous needs. Efforts to expand the workforce will therefore have to be done within the state through the cooperation of entities such as the Ohio Board of Regents, the PUCO, and the ODOD. Fortunately there are already programs in Ohio that serve the state in this capacity. We will discuss the workforce issue in greater detail in the section discussing our innovative policies.

Analysis Methodology

The following is a description of the energy efficiency analysis methodology:

- ***Reference Case Forecasts:*** The first step in conducting an energy efficiency potential study for Ohio is to collect data and to characterize the state's current and expected patterns of electricity consumption over the time period of the study (2009-2025). In the next section of this report we describe the assumed reference forecasts for electricity and

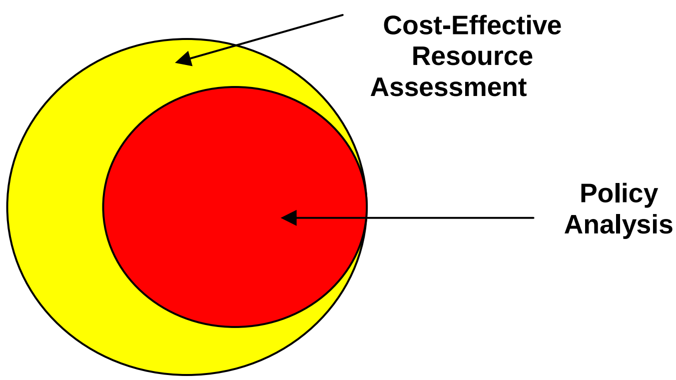
[13] The avoided cost analysis does not take into account a cost of carbon that would be imposed under a federal cap and trade program.
[14] This list is not intended to be exhaustive, but merely indicative of the steps we have taken to ensure that we incorporate the insight of as many different interest groups as possible.

peak demand. Reference case avoided costs for electric utilities, developed by Synapse Energy Economics, are described in this section along with projections of retail energy price forecasts.

- ***Energy Efficiency Resource Assessment:*** The energy efficiency resource assessment examines the overall potential in the state for increased cost-effective efficiency using technologies and practices of which we are currently aware (see Figure 4). Cost-effectiveness is evaluated from the customer's perspective (i.e., a measure is deemed cost-effective if its cost of saved energy is less than the average retail rate of energy). We review specific, efficient technology measures that are technically feasible for each sector; analyze costs, savings, and current market share/penetration; and estimate total potential from implementation of the resource mix. The technology assessment is reported by sector (i.e., residential, commercial, and industrial) and includes an analysis of potential for expanded CHP, which is prepared by ICF International.

- ***Energy Efficiency Policy Analysis:*** For this analysis, we develop a suite of energy efficiency policy recommendations based on successful models implemented in other states and in consultation with stakeholders in Ohio. This analysis assumes a reasonable program and policy penetration rate, and therefore is less than the overall resource potential (see Figure 4). We draw upon our resource assessment and evaluations of these policies in other states to estimate the energy savings and the investments required to realize the savings. The draft policy list for stakeholder review is presented after the reference forecast section in this document.

Figure 4. Levels of Energy Efficiency Potential Analysis



- ***Demand Response (DR) Analysis:*** The Demand Response Analysis, which is prepared by Summit Blue Consulting, assesses current demand response activities in Ohio, uses benchmark information to assess the potential for expanded activities in the state, and offers policy recommendations that could foster DR contributing appropriately to the resource mix in Ohio that could be used to meet electricity needs. Potential load reductions are estimated for a set of DR programs that represent the technologies and customer types that span a range of DR efforts, and are in addition to the demand reductions resulting from expanded energy efficiency investments.

- ***Macroeconomic Impacts:*** Based on the energy savings, program costs, and investment results from the policy analysis, we will then run ACEEE's macroeconomic model, DEEPER, to estimate the policy impacts on jobs, wages, and gross state product (GSP) in Ohio.

REFERENCE CASE

The first task in developing an energy efficiency and demand response potential assessment is to determine a reference case forecast of electricity consumption, peak demand, and electricity prices in the state for a "business as usual" scenario. As with all forecasts, they are subject to significant uncertainty, particularly in times such as these when the economic outlook is a major unknown. Still, it is important to understand that while the forecast will affect the final numbers, the forecast has a very minor impact on the effectiveness of the proposed policies.

In this section we report the reference case assumptions for the analysis time period, 2009-2025. Providing an historical and prospective look at electricity consumption and demand that is agreed upon by our stakeholders is crucial to the credibility of this study. Ideally this data is provided by a state's public utilities commission. While the PUCO estimated and published their own forecast in 2008, variations in historical sales arose between the data reported by the PUCO and the data reported by the Department of Energy's Energy Information Administration (EIA). Ultimately we chose to use data from the EIA to conduct our forecast. See Appendix A for further discussion and more detailed information on the reference case assumptions.

Electricity (GWh) and Peak Demand (MW)

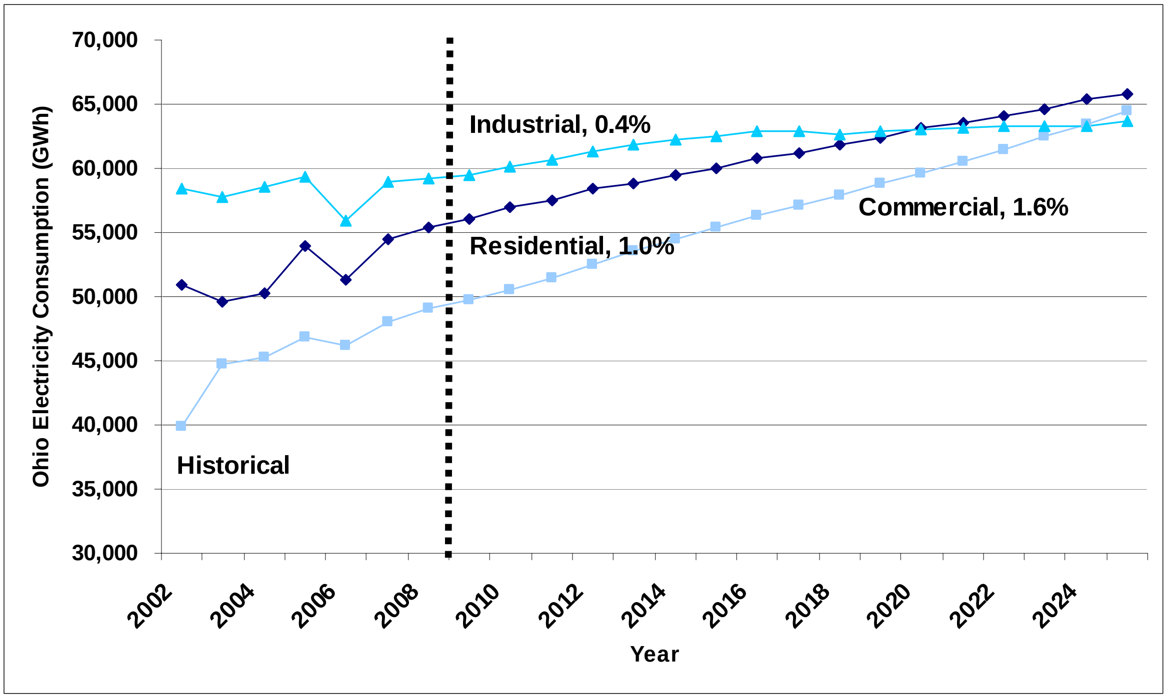
The development of the reference case for Ohio is the foundation of the quantitative analysis of the report. Our electricity consumption forecast is based on 2007 sales, the most recent year for which sales have been reported, which is then projected through 2025. For historical sales, covering 2002 through 2007, we used data from the EIA's *Electric Power Annual*, which publishes consumption data for all states individually. To estimate projected consumption, we then applied sector-specific growth rates, derived from the EIA's *Annual Energy Outlook* forecast for the East Central Area Reliability Coordination Agreement (ECARC), to actual 2007-year electric sales data. Using this methodology, we estimated total electricity consumption in the state to grow in the reference case at an average annual rate of 1.0% between 2008 and 2025, and 1.0%, 1.6%, and 0.4% in the residential, commercial, and industrial sectors, respectively (see Figure 5). Total electricity consumption in the three sectors in 2007 was 161,547 GWh and in the reference case grows to 177,954 GWh in 2015 and 193,945 GWh in 2025 (PUCO 2009).

To forecast peak demand we adjust our data from electricity sales forecast using a system load factor, which we assumed to be 60.0%. Using this methodology, we estimate peak demand growing at an average annual rate of 1.0% over the 2008-2025 period. In 2008, peak demand is expected to reach 33,705 MW increasing to 36,586 MW by 2015 and 39,770 MW in 2025 (see Figure 6).

Utility Avoided Costs

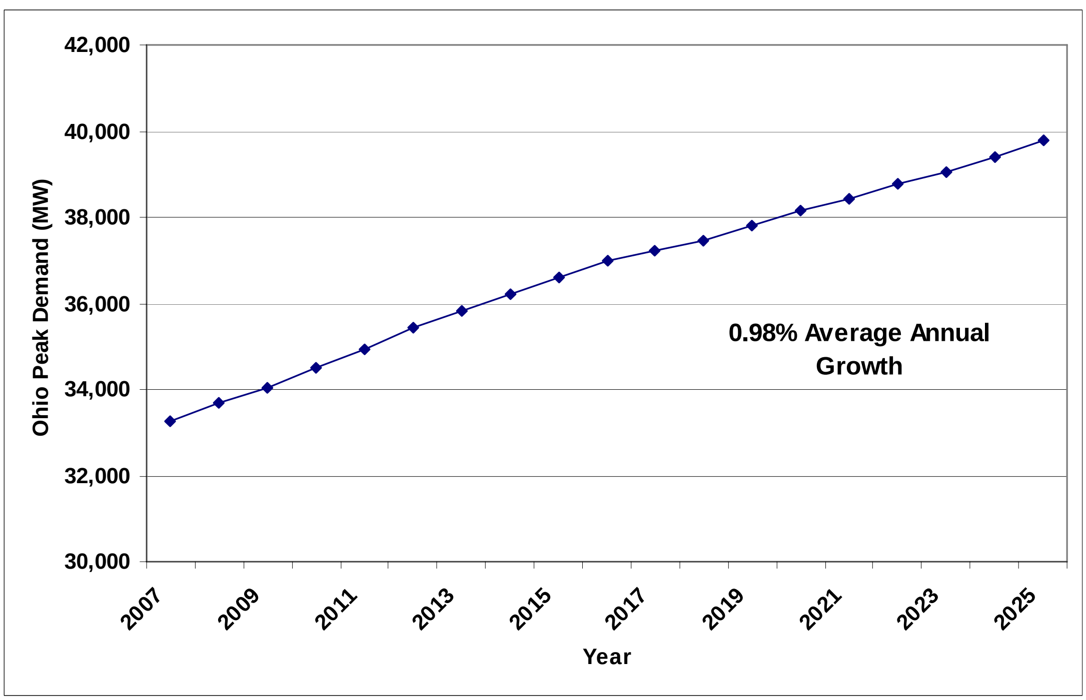
At ACEEE's request, Synapse Energy Economics developed simplified, high-level projections of utility production and avoided marginal costs. We then used these results in ACEEE's analysis to estimate the cost-effectiveness of energy efficiency measures and assess the macroeconomic impacts. The avoided cost estimates are based upon a number of simplifying and conservative assumptions. These simplifications include use of a single annual average avoided energy cost to evaluate the economics of energy efficiency measures rather than different avoided energy costs for energy efficiency measures with different load shapes. We also did not include a cost of compliance with anticipated greenhouse gas regulations. As a result, the production and avoided cost estimates should be viewed as unrealistically low. The vetting of our methodology with stakeholders revealed some concerns with the underlying assumptions. A detailed discussion of the assumptions, avoided cost estimates, and responses to these concerns can be found in Appendix A.

Figure 5. Electricity Forecast by Sector in the Reference Case, 2008-2025



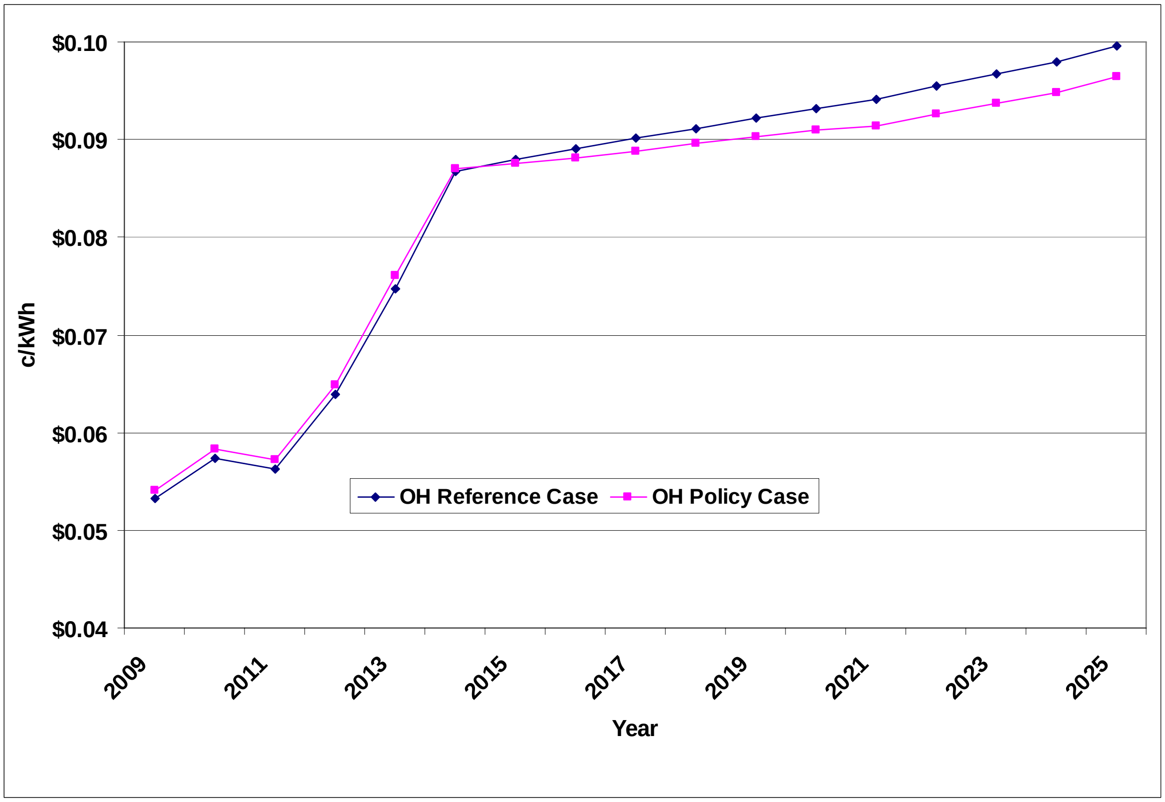
Source: EIA 2007b and 2007c

Figure 6. Ohio Peak Demand Forecast, 2008-2025



Because the level of energy efficiency and demand response measures assessed in this study significantly change the requirements of future resources, we developed two sets of production and avoided costs projections. The first case reflects the market conditions that would be anticipated in the reference case. The second case reflects the incorporation of our policy suggestions, which we discuss later. As would be anticipated, the policy case produced modestly lower avoided resource costs than the reference case, as can be seen in Figure 7. As a further conservatism in our analysis, we used this second, lower set of costs in valuing the savings that result from the analyzed policies and programs.

Figure 7. Estimates of Average Annual Avoided Resource Costs



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

Retail Price Forecast

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

Table 1 shows 2007 electricity prices in Ohio (EIA 2008a) and our estimates of retail rates by customer class over the study period. This price scenario is based on three key factors. First, we use the average generation cost of electricity in Ohio over the study period as calculated by Synapse Energy Economics (see above). Next, we use estimates of retail rate adders (the difference between generation costs and retail rates, which accounts for transmission and distribution costs) from the *Annual Energy Outlook* for the East Central Area Reliability Coordination Agreement (ECARC) (EIA 2007c). Finally, we estimate short-term decreases from falling generation costs due to lower prices in the cost of fuel inputs.

Table 1. Retail Electricity Price Forecast Scenario in Reference Case (cents per kWh in 2006$)

	2007*	2010	2015	2020	2025	Average
Residential	9.28	8.81	10.96	12.05	12.95	**11.01**
Commercial	8.42	8.22	9.99	11.07	12.11	**10.15**
Industrial	5.63	5.59	7.38	8.37	9.22	**7.44**
All Sector Average	7.69	7.34	9.31	10.27	11.03	**9.33**

Note: These figures are in real, 2006-year dollars and therefore do not take into account inflation.
* Actual rates (EIA 2008a), converted to 2006$

ENERGY EFFICIENCY COST-EFFECTIVE RESOURCE ASSESSMENT

In this section we present the results from our assessment of cost-effective efficiency resources in residential and commercial buildings, the industrial sector, and combined heat and power (CHP). We consider the cost-effectiveness of more-efficient technologies from the customer's perspective; i.e., a measure is deemed cost-effective if its cost of saved energy is less than the average retail rate of electricity for a given customer class. In Table 2 below we summarize the economic potential for energy efficiency by each sector in 2025. Our assessment includes only existing technologies and practices, but we anticipate that new and emerging technologies and market learning will significantly increase the cost-effective efficiency resource potential by 2025.

Table 2. Summary of Cost-Effective Energy Efficiency Potential in Ohio by Sector (2025)

Sector	Efficiency Potential (GWh)	As % of Electricity Consumption in 2025	As % of Sector Consumption in 2025
Residential	22,073	11%	34%
Commercial	17,140	9%	27%
Industrial	14,697	8%	23%
Combined Heat & Power	10,374	5%	8%*
Total	**64,284**	**33%**	

*Note: As percentage of commercial and industrial sectors combined

Residential Buildings

For our analysis of the potential for energy efficiency resources in Ohio’s residential sector, we considered a scenario with widespread adoption of cost-effective energy efficiency measures during the 17-year period from 2009 to 2025. We evaluated 36 efficiency measures that might be adopted in existing and new residential homes based on their relative cost-effectiveness. An upgrade to a new measure is considered cost-effective if its levelized cost[15] of conserved energy (CCE) is less than $0.1101/kWh saved, the average retail residential electricity price in Ohio over the study time period (see Table 2). All 36 measures have a levelized cost of less than $0.1101/kWh.[16] The substantial majority (83%) of the total efficiency potential has a levelized cost of 7 cents per kWh saved or less and 53% of the measures have a cost of 4 cents per kWh or less. For the sum of all measures, we estimate a levelized cost of less than 3 cents per kWh saved (see Table 2.).[17] See Appendix C.1 for a detailed methodology and specific efficiency opportunities and cost-effectiveness for residential buildings (see Table 25).

[15] Levelized cost is a level of investment necessary each year to recover the total investment over the life of the measure.
[16] We explored additional measures, but measures above this cost-threshold were dropped from the analysis.
[17] Assuming a 5% real discount rate.

Table 2. Residential Energy Efficiency Potential and Costs by End-Use

End-Use	Savings (GWh)	Savings (%)	% of Efficiency Potential	Weighted Levelized Cost of Saved Energy ($/kWh)
HVAC	8,259	13%	37%	$ 0.029
Water Heating	2,864	4%	13%	$ 0.041
Lighting	4,774	7%	22%	$ (0.003)
Refrigeration	536	1%	2%	$ 0.058
Appliances	139	0.2%	1%	$ 0.077
Furnace Fans	1,945	3%	9%	$ 0.047
Plug Loads	1,060	2%	5%	$ 0.024
Electricity Use Feedback	1,460	2%	7%	$ 0.057
Existing Homes	21,037	32%	95%	$ 0.028
New Homes	1,036	2%	5%	$ 0.045
All Electricity	**22,073**	**34%**	**100%**	**$ 0.029**

Our analysis shows an economic potential for efficiency resources in the residential sector of 22,073 GWh over the 17-year period of 2009–2025, a potential savings of 34% of the reference case electricity consumption in 2025 (Table 2). Existing homes can reduce electricity consumption by 32% through the adoption of a variety of efficiency measures (see Appendix C, Table 26). While newly constructed homes built today can readily achieve 15% energy savings (ENERGY STAR® new homes meet this level of efficiency), we also estimate that new homes can reach 30% to 50% energy savings cost-effectively. We estimate that new residential homes can yield electricity savings of about 1,036 GWh by 2025, or 5% of total potential savings in the residential sector.

In the residential sector, improved housing shell performance (e.g., insulation measures, duct sealing and repair, reduced air infiltration, and ENERGY STAR windows) and efficient heating, ventilation, and air conditioning (HVAC) equipment and systems comprise the greatest percentage of the savings achieved through electricity efficiency resources.[18] These measures account for a total of 37% of potential savings and 13% of total electricity consumption.

Substantial savings are also attributed to improvements in lighting systems and water heating (including both more efficient water heaters as well as water-consuming appliances), which constitute 22% and 13% of residential efficiency potential, respectively (see Figure 8). Both new and existing homes in Ohio can achieve considerable energy savings by replacing household incandescent light bulbs with more efficient compact fluorescent light bulbs (CFLs).[19] Additionally, measures to reduce hot water loads (such as high-efficiency clothes washers, low-flow showerheads, and water heater jackets and pipe insulation) can yield considerable savings for households with electric water heaters. More efficient water heaters, particularly advanced technologies such as heat-pump water heaters, can further reduce electricity used for water heating.

Adoption of efficient household appliances can also yield significant savings. Our analysis shows that the energy savings from replacing existing refrigerators, clothes washers, and dishwashers with units that exceed the minimum ENERGY STAR efficiency standards (Consortium for Energy Efficiency "Tier 2" in most cases), or through quality installations of these efficient models in new homes reaches 139 GWh by 2025, or 1% of total potential. Another 6% of the total savings potential can be attributed to reducing the power consumption of electronic devices that use considerable amounts of energy in standby mode. We include a measure for reducing television power consumption in active mode, which is based on ENERGY STAR Version 3.0 television specification. These measures are

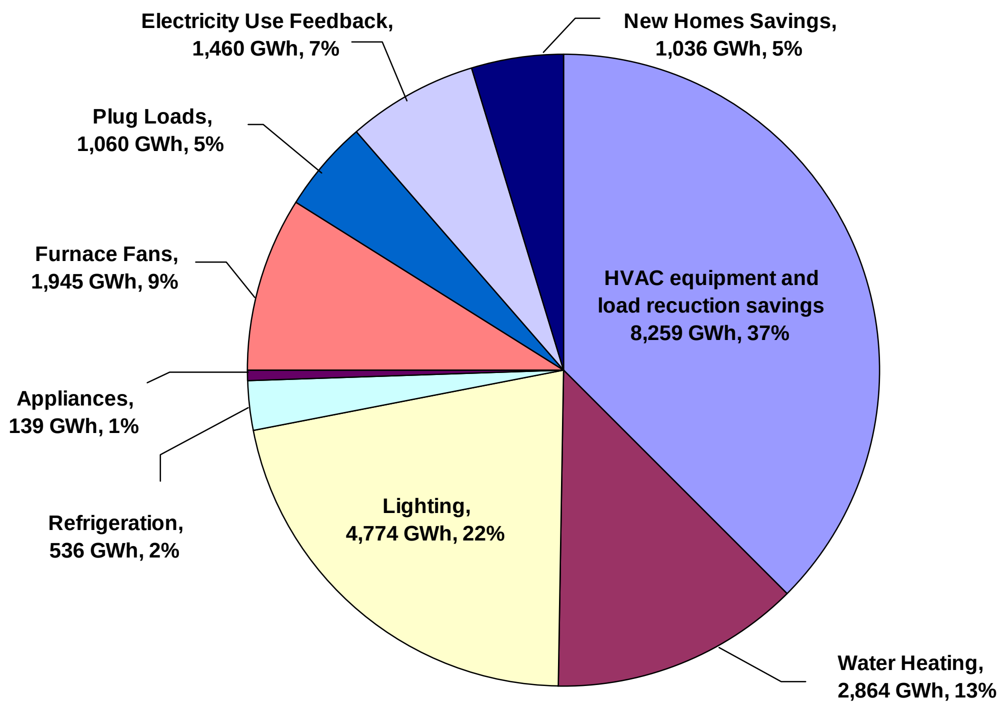
[18] Savings from air-conditioners assume a baseline of 13 SEER equipment, which is the recently updated federal standard.

[19] Efficiency provisions included in the EISA 2007 will help reduce lighting loads, which decrease potential savings attributable to CFL installation. However, this does not preclude other lighting and lighting design opportunities from having an impact. LED lighting, for example, while still an emerging technology and thus not included in this study, presents another avenue for significant energy savings in the near future.

among the most cost-effective in the residential sector. The balance of potential savings comes from installing a real-time energy use feedback mechanism. Although involving a behavioral component, in-home monitors, which allow residents to track how much electricity their house is using, have been documented to result in significant and persistent savings.

Figure 8. Residential Energy Efficiency Potential in 2025 by End-Use in Ohio

Total: 22,073 GWh, 34% of Projected Electricity Consumption in 2025



Commercial Buildings

The potential for commercial electricity savings through energy efficiency in Ohio is examined through a scenario of 37 cost-effective measures for electricity savings which would be adopted during the 17-year period from 2009 to 2025. An upgrade to a new measure is considered cost-effective if its levelized cost of conserved energy (CCE) is less than $0.1015/kWh saved, which is the average retail commercial electricity price in Ohio over the study time period (Reference Price Forecast). For the sum of all measures, the estimated levelized cost is $0.016/kWh saved (see Table 4). See Appendix C.2 for a detailed methodology and specific efficiency opportunities and cost-effectiveness for commercial buildings (See Appendix C.2, Table 29).

Table 4. Commercial Electricity Efficiency Potential and Costs by End-Use

End-Use	Savings (GWh)	Savings (%)	% of Efficiency Potential	Weighted Levelized Cost of Saved Energy ($/kWh)
HVAC	3,911	6.1%	23%	$ 0.033
Water Heating	212	0.3%	1%	$ 0.033
Refrigeration	689	1.1%	4%	$ 0.017
Lighting	8,286	12.8%	48%	$ 0.011
Office Equipment	3,356	5.2%	20%	$ 0.003
Appliances and Other	30	0.0%	0%	$ 0.029
Existing Buildings	16,484	25.6%	96%	$ 0.015
New Buildings	656	1.0%	4%	$ 0.029
Total	**17,140**	**27%**	**100%**	**$ 0.016**

Commercial buildings can reduce electricity consumption by 27% through the adoption of a variety of efficiency measures. The economic potential for efficiency resources in the commercial sector, will reduce electricity use by 17,140 GWh through the period 2008-2025.

In the commercial sector, electricity savings from efficiency resources are realized through improved 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); and efficient lighting, office equipment, and miscellaneous appliances. The largest chunk of the savings, at 48%, 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.

HVAC and office equipment also provide substantial savings, at 23% and 20% 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, and efficient clothes washers, which reduce hot water demand. Refrigeration measures include improved commercial refrigeration systems (e.g. walk-in coolers, ice makers, vending machines).

For commercial new construction, we estimate that up to 50% savings can be reached cost-effectively.

Industry

The industrial sector is the most diverse economic sector, encompassing agriculture, mining, construction and manufacturing. Because energy use and efficiency opportunities vary by individual industry, if not individual facility, it is important to develop a disaggregated forecast of industrial electricity consumption. Unfortunately, this energy use data is not available at the state level, so ACEEE has developed a method to use state-level economic data to estimate disaggregated electricity use. This study drew upon national industry data to develop a disaggregated forecast of economic activity for the sector. We then applied energy intensities derived from industry group electricity consumption data reported and the value of shipments data to characterize each sub-sector's share of the industrial sector electricity consumption and projected the energy use through 2025. Figure 10 shows the largest electricity consuming industries in Ohio in 2008 and 2025.

Figure 9. Commercial Electricity Efficiency Potential in 2025 by End-Use in Ohio
27% of Projected Electricity Use in 2025

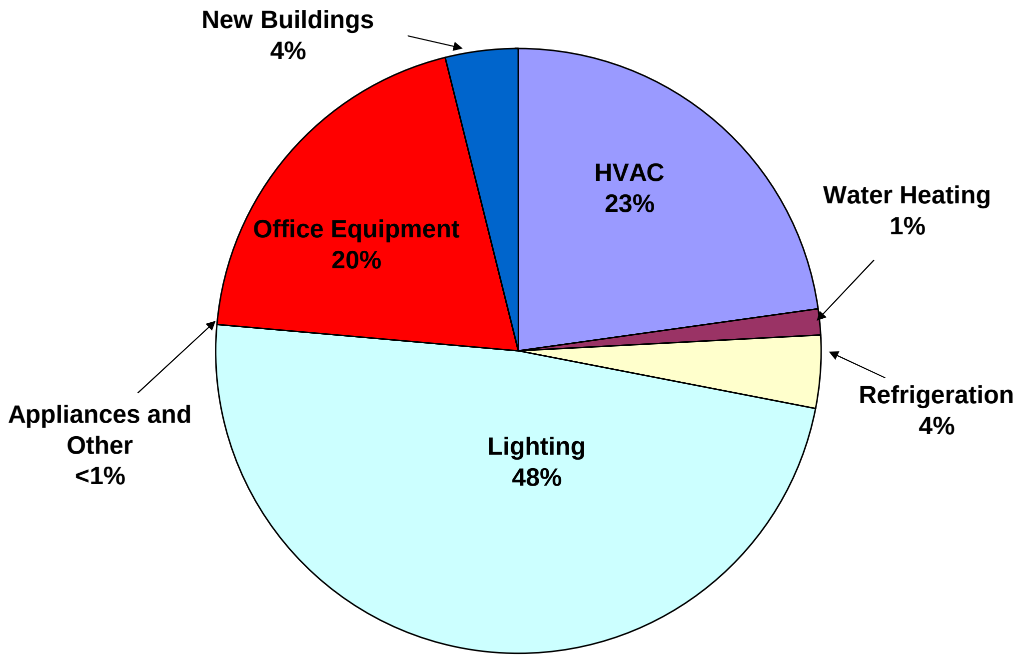
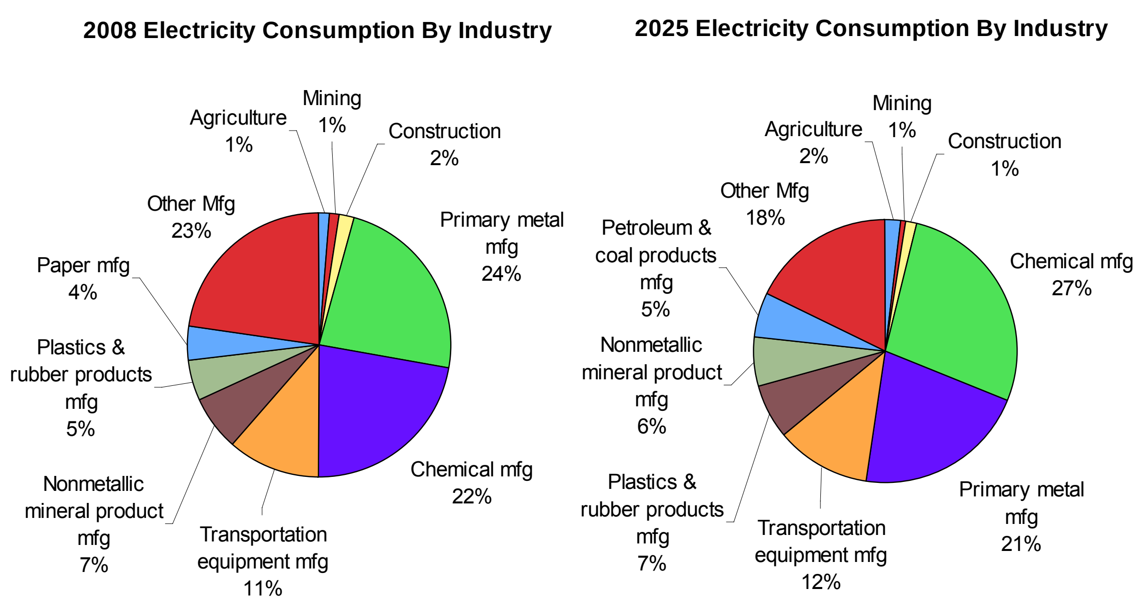


Figure 10. Estimated Electricity Consumption for the Largest Consuming Industries in Ohio in 2008 and 2025



Due to changes in economic activity and energy intensity as discussed in Appendix C, we see a significant intra-sectoral shift in electricity consumption. A small decrease in projected energy use by primary metal manufacturing coincides with a significant increase in energy use by the chemical manufacturing and plastics & rubber industries. The figure above shows their respective percentage changes in overall industrial electricity consumption. Also of note is the petroleum and coal products industry, which is projected to nearly double its energy use by 2025, and paper manufacturing, whose energy use will fall by almost half. Transportation manufacturing and machinery manufacturing will see their energy use increase by about 10% and 20%, respectively. These intra-sectoral shifts are important because they identify where new investments are being made and where energy efficiency opportunities are concentrated.

Electricity Savings

We examined 18 electricity saving measures, 10 of which were cost effective considering Ohio's 2008 average industrial electric rate of $0.0744/kWh. These measures were applied to an industry specific end-use electricity breakdown. Table 5 shows results for industrial energy efficiency potential by 2025.

Table 5. Industrial Electricity Efficiency Potential and Costs by Measure

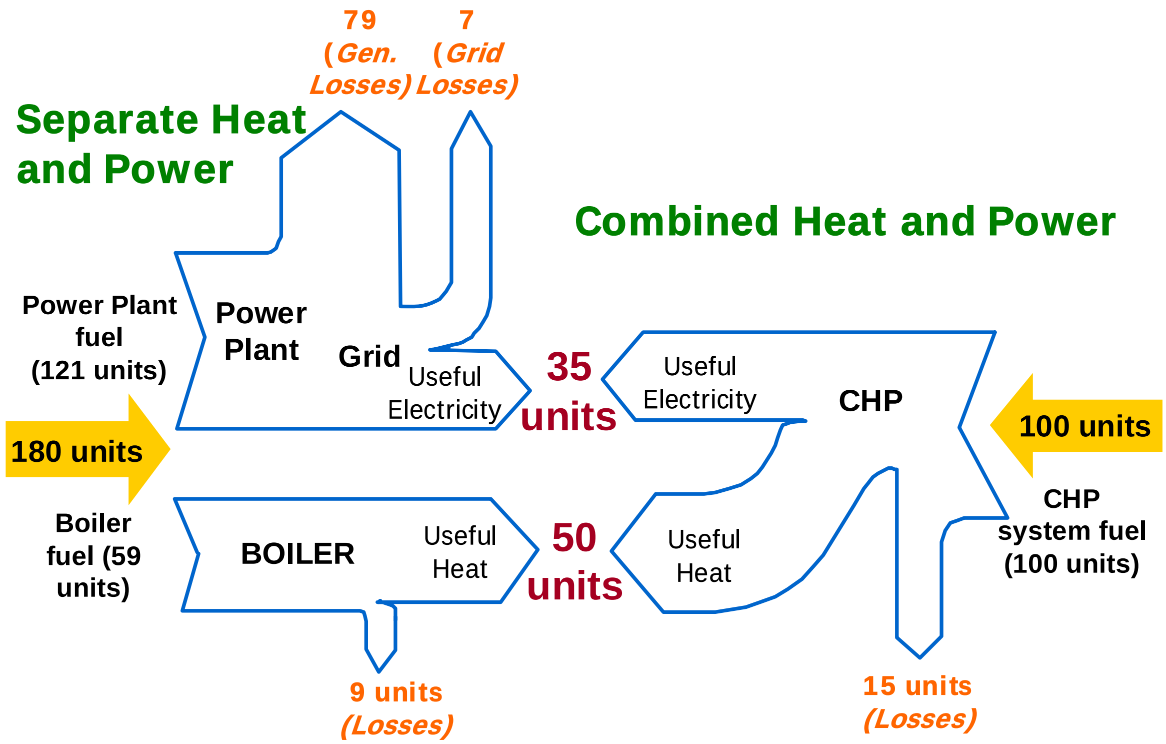
Measures	Savings Potential in 2025 (GWh)	Savings Potential in 2025 (%)	% of Efficiency Potential	Levelized Cost of Saved Energy ($/kWh)
Sensors & Controls	249	0.4%	2%	$0.014
EIS	91	0.1%	1%	$0.061
Duct/Pipe insulation	2,029	3.2%	20%	$0.052
Electric Supply	1,911	3.0%	19%	$0.010
Lighting	732	1.1%	7%	$0.020
Motors	2,352	3.7%	23%	$0.027
Compressed Air	1,015	1.6%	10%	$0.000
Pumps	1,432	2.2%	14%	$0.008
Fans	241	0.4%	2%	$0.024
Refrigeration	137	0.2%	1%	$0.003
Total	**10,191**	**16%**	**100%**	**$0.023**

This analysis found economic savings from these cross-cutting measures of 10,191 million kWh or 16% of industrial electricity use in 2025 at a levelized cost of about $0.02 per kWh saved. This analysis did not consider process-specific efficiency measures that would be applied at the individual site level because available time, funding, and data did not allow this level of analysis. However, based on experience from site assessments by the U.S. Department of Energy and other entities, we would anticipate an additional economic savings of 5–10%, primarily at large energy-intensive manufacturing facilities. The overall economic industrial efficiency resource opportunity is on the order of 21–26%. Therefore, the total economic potential for electricity savings in the industrial sector in 2025 would be about 14,967 GWh.

COMBINED HEAT AND POWER

Combined heat and power (CHP) improves efficiency by combining usable thermal energy (e.g., chilled water and steam) and power production (e.g., electricity). This co-generation process bypasses most of the thermal losses inherent in traditional thermal electricity generation, where half to two-thirds of fuel input is rejected as waste heat. By combining heat and power in a single process, CHP systems can produce fuel utilization efficiencies of 65% or greater (Elliott and Spurr 1998).

Figure 11. Schematic Comparing a Combined Heat and Power System to Separate Heat and Power Systems



For this report, Energy and Environmental Analysis (EEA), a division of ICF International, undertook an assessment of the cost-effective potential for CHP in Ohio by assessing the electricity end-uses at existing industrial, commercial, and institutional sites across the state and also considering sites that will likely be built in the future. These facilities would replace a thermal system (usually a boiler) with a CHP system that also produces power and that is primarily intended to replace purchased power that would otherwise be required at the site. EEA identified 665 MW from 45 CHP plants currently in operation. Detailed information from this analysis is provided in Appendix E.

An additional application of CHP considered by this analysis is in the production of power and cooling through the use of thermally activated technologies such as absorption refrigeration. This application has the benefit of producing electricity to satisfy onsite power requirements and displacing electrically generated cooling, which reduces demand for electricity from the grid, particularly during periods of peak demand (see Elliott and Spurr 1998).

Three levels of potential for CHP were assessed (see Appendix E for detailed results):

- *Technical Potential* represents the total capacity potential from existing and new facilities that are likely to have the appropriate physical electric and thermal load characteristics that would support a CHP system with high levels of thermal utilization during business operating hours.
- *Economic Potential* reflects the share of the technical potential capacity (and associated number of customers) that would consider the CHP investment economically acceptable according to a procedure that is described in more detail in Appendix E.
- *Cumulative Market Penetration* represents an estimate of CHP capacity that will actually enter the market between 2008 and 2025. This value discounts the economic potential to reflect non-economic screening factors and the rate that CHP is likely to actually enter the market. This potential is described in the energy efficiency policy scenarios, which are shown in the next section of the report.

The analysis identified an economic potential of around 2,600 MW of CHP capacity beyond what is already installed, assuming estimated electricity and natural gas price forecasts. In a scenario where customers installing CHP systems are given a $500 incentive per MW installed, the economic potential increases to around 4,000 MW. Policies and incentives provide an important catalyst to increasing the presence of CHP systems. In the next section, we estimate the impact that such an incentive can have on the market penetration of CHP in Ohio.

ENERGY EFFICIENCY POLICY ANALYSIS

In this section we present the suite of innovative policies and proven programs that we suggest Ohio implement in order to catalyze energy efficiency in the state.[20] We then estimate the resulting energy savings, costs, and consumer energy bill savings ($) that can be realized from their implementation. With the passing of SB 221 and the introduction of an EERS, the PUCO is now engaged in ruling how utilities will be allowed to meet the 22%+ target outlined in the EERS. Of the ten policies that we are promoting, there are five which ACEEE suggests be allowed to contribute towards the efficiency target, which have the potential to meet 10% of Ohio's electricity needs. This will leave only 12% of the EERS target to be met by the proven programs. Based on ACEEE's experience with utility programs we are confident that it is entirely feasible for them to meet and exceed 12% savings cost-effectively, however we did not attempt to quantify the degree of additional savings in this analysis.

At the end of this section we discuss the sorts of programs utilities can implement in order to satisfy the remaining 12% obligation as stipulated by the EERS. The discussion offers examples of best-practice energy efficiency programs that have proven to be successful in other states, which we take from ACEEE's report *Compendium of Champions: Chronicling Exemplary Energy Efficiency Programs from across the U.S.* (York, Kushler, and Witte 2008). In Appendix B we include a table estimating the incremental annual savings required by the EERS, which is based off of our electricity consumption forecast, and the savings that utilities will have to supplement in order to reach the percent annual EERS savings goals. The table illustrates the annual savings requirements, which are disaggregated by sector, both as a percentage as well as in GWh.

Discussion of Policies

This section provides greater detail of each of the suggested policies as well as the assumptions used in the analysis. While these policies were developed before the economic downturn, the potential for Federal stimulus funding created by the *American Recovery and Reinvestment Act* (Congress 2009) creates a unique opportunity to leverage this funding to build important human infrastructure necessary for sustained success of energy efficiency programs and policies in Ohio. The state and municipalities in the state should consider these innovative policies set forth in this section as the state prepares its plans for spending this windfall so that the Ohio will continue to benefit from this investment for years to come.[21]

Energy Efficiency Resource Standard

An Energy Efficiency Resource Standard (EERS) is a quantitative, long-term energy savings target for utilities and other entities, which is often coupled with a peak demand reduction target. Currently eighteen states, including Ohio, have adopted some form of an EERS or have established legislation directing a state agency to set an energy-savings target. This approach contrasts with many earlier state-legislated targets that were set in terms of funding levels or were relatively short term. EERS targets are typically set independently of specific program, technology, or market targets in order to

[20] The Workforce Development Initiative is not analyzed quantitatively as it is an enabling policy and does not have direct savings associated with it. Our Expanded Demand Response (DR) policy is assessed separately from the policy analysis by Summit Blue Consulting.

[21] At the time of the writing of this report, the details on conditions related to the transfer of these funds are still undecided. For current information on implementation of the federal stimulus visit: http://www.aceee.org/energy/national/fedeconomicstimulus.htm.

allow utilities maximum flexibility to find the least-cost path toward meeting the targets (Nadel et al. 2006; ACEEE 2008).

On May 1st, 2008, Governor Strickland signed SB 221, a bill created to encourage the advancement and growth of alternative energy resources, specifically renewable energy and energy efficiency. SB 221 established an EERS, which, starting in 2009, requires utilities to accumulate savings of at least 22% by 2025. The annual savings rate is set to begin at 0.3% in 2009, ramping up to 1% by 2014, followed by 1% annual savings through 2018 and 2% every year thereafter until 2025. The baseline for annual savings is the average of total kilowatt hours utilities sold during the preceding three years. The EERS is also complemented by a requirement for utilities to implement peak demand reduction programs that will save 1% in 2009, followed by 0.75% annual savings between 2010 and 2018.

The Public Utilities Commission of Ohio is currently holding rulings on what criteria should apply to the EERS as well as what policies should be allowed to contribute towards meeting the savings targets. ACEEE believes that the following criteria should apply to the EERS:

- Mandatory for Investor Owned Utilities (already included in SB 221 language)
- Voluntary commitment to lower target level by cooperatives and municipalities with some inducement
- Include incentives for exceeding savings targets, such as increased return on investment, etc.
- Require evaluation, monitoring and verification, preferably by a third-party organization

Additionally, we suggest that the following five policies – advanced residential and commercial buildings, manufacturing, rural and agricultural, and combined heat and power initiatives – be allowed to contribute towards meeting the 22%+ target. We estimate that these innovative policies will satisfy 10% of the EERS target and, along with the incentives outlined above and proven programs illustrated below, will enable utilities to surpass the 22% goal.

Advanced Residential Buildings Initiative

The development of an effective buildings program in the residential sector must focus on both new and existing homes for households of all income levels if efficiency is to be advanced on a large scale. Ohio currently has two state-sponsored residential programs in place: the Ohio *Electric Partnership Program* (EPP) and Ohio's *Home Weatherization Assistance Program* (HWAP).[22] These programs, however, focus exclusively on servicing the energy needs of low-income households. Though they have proven to be effective, we believe that there is potential to complement and broaden their scope, thus extending benefits to a larger portion of the population and, as a result, increasing the volume of electricity savings realized across the state.

Ohio's *Electric Partnership Program* (EPP) was recognized by ACEEE as one of the nation's exemplary low-income efficiency programs in our 2008 report entitled *Compendium of Champions: Chronicling Exemplary Energy Efficiency Programs from Across the U.S* (York, Kushler, and Witte 2008). EPP was designed to reduce the electric consumption of individuals in *Ohio's Percent Income Payment Plan* (PIPP) program, which assists households at or below 150% of the federal poverty level with their monthly payments (Blasnik 2006). These programs complement Ohio's *Home Weatherization Assistance Program* (HWAP), which was introduced in 1977 to provide audits and weatherization services to low-income households, as well as to improve the health, safety and overall comfort of the residents (Khawaja et al. 2006).

It is important to build upon these residential programs so that they are available to all income levels and include services beyond weatherization. Both the EPP and HWAP programs focus on weatherization assistance for low-income households in existing homes, though EPP offers equipment upgrades, such as lighting retrofits, replacement of inefficient refrigerators and freezers,

[22] More information on Ohio's residential efficiency programs is provided in the technical appendix.

and electric hot water reduction measures (Blasnik 2006) in addition to its weatherization services. An expanded weatherization initiative should redefine low-income households to include those with annual incomes up to 200% of the federal poverty level while also supporting the development of weatherization programs for existing homes for non-low-income residences.[23] Implementing energy efficiency in new construction must also be prioritized; ignoring efficiency improvements in new homes deprives Ohio of substantial energy savings and makes it more difficult to advance efficiency in the future, as these lost opportunities are more expensive and more difficult to retrofit.

The models for Ohio's residential efficiency programs should emulate ENERGY STAR's residential programs, which several states – such as New York, Vermont, and Wisconsin – have been doing for many years. For existing homes there is the Home Performance with ENERGY STAR program, which is designed as a comprehensive, whole-house approach to improving energy efficiency and comfort. The ENERGY STAR New Homes program, which is a similarly designed program that focuses on efficiency improvements during construction, can increase the efficiency of new homes 15% compared to homes built to the 2004 International Residence Code (IRC). Both programs focus not only on improving the efficiency of the home envelope, but also integrate efficient equipment, such as ENERGY STAR appliances and HVAC equipment. The incorporation of these myriad efficiency measures typically makes new homes 20-30% more efficient than standard homes.

Not all homes, new or existing, will be covered by these programs, so it is imperative that incentives are offered to households that are unable to participate. These incentives could be promoted either by utilities, or by the state through federal funding from the stimulus bill, and should establish a minimum savings of at least 20%, with greater incentives for products that generate higher savings. This sort of financial incentive, in conjunction with the advanced building initiative, also encourages contractors to purchase energy efficient appliances for new homes.

For our savings analysis of existing homes, we assume 0.5% annual savings and a participation rate (market share) of 0.5% in the first year, increasing 0.5% annually through 2016, followed by 1% annual increases through 2025. To analyze savings in new homes, we assume that new homes are able to achieve 50% savings beyond the current code, which we assume is the 2006 IECC. When the 2009 IECC becomes effective in 2011, new homes will be able to achieve 15% savings strictly from code improvements, leaving 35% still to be captured. We assume an initial participation rate of 2.5% in 2011, which doubles annually until 2014 when the 2012 IECC becomes effective. The 2012 IECC will likely deliver 30% savings beyond current code, leaving 20% savings still to be captured. Starting in 2014 we assume an annual participation rate of 20% of new homes for the remainder of the study period.[24] By the time the 2018 IECC becomes effective in 2020, which will deliver 50% savings, we assume that the program will have matured enough to allow an additional 20% savings beyond the 2018 IECC code. Under these assumptions, we estimate total savings for new and existing homes of 119 GWh in 2015 and 615 GWh in 2025, or a 0.3% reduction of total projected electricity consumption in 2025.

Advanced Commercial Buildings Initiative

Our stakeholders emphasized the necessity of a commercial buildings initiative that focuses on the ideas proposed in the Ohio Manufacturing Initiative: the need for assessments that identify energy efficiency opportunities; access to industry-specific expertise; and the need for an expansion of the trained buildings systems workforce with energy efficiency experience. Traditionally, advancing efficiency in commercial buildings was limited to efficient lighting and upgrades that focused on replacing individual pieces of equipment. While small commercial buildings will continue to reap

[23] The 2009 federal stimulus bill provides funding for low-income weatherization services as well as raises the qualification level to 200% above the poverty line.
[24] Our assumed participation rate for new homes is extremely conservative, especially for the short-term part of this analysis. For example, 57.2% of new homes in Iowa in 2006 qualified for the ENERGY STAR label, whereas 12.6% of new homes in Ohio met the ENERGY STAR standards (EPA 2007). By 2025, the ramping up of this initiative should allow Ohio to easily reach a much greater participation rate.

benefits from small-scale improvements, such as regular maintenance and individual equipment upgrades, larger commercial buildings require much broader improvements – through retrocommissioning, for example – in order to maximize energy savings.

Many retrofit programs are organized according to equipment or end-use with little emphasis on overall building performance, system optimization, or interactions among building systems. The establishment of an "Ohio Commercial Buildings Initiative" recognizes the need for programs that are tailored to address the contrasting efficiency issues between various-sized commercial buildings. A systems approach that goes beyond simple equipment upgrades to identify opportunities in system design, equipment interactions, and buildings operations and maintenance will generate greater energy savings, improve comfort, and bolster job growth through investment in training and certification for building operators, auditors, technicians, engineers, etc (Amann & Mendelsohn 2005). Again, incentives for retrofits and other commercial building upgrades could be offered by utilities, or by the state through funding allocated by the federal stimulus bill.

There are several excellent resources on how to model an effective advanced buildings program. The U.S. Department of Energy, for instance, has developed materials on how to achieve significant savings in new and existing buildings.[25] Another useful source of information is the New Buildings Institute, which has a web site on "Getting to Fifty" [percent savings].[26] ENERGY STAR also publishes a breadth of information on energy efficiency in commercial buildings and industrial plants.[27] Providing financial incentives to contractors or building owners will be crucial to guaranteeing that efficiency measures are implemented beyond what is already required by code. The Energy Policy Act of 2005 included a $1.80/square foot tax deduction for commercial building owners for each building constructed that uses 50% less than a new building designed to a national model reference code.

Combined heat and power, in conjunction with other efficiency measures, also has potential to generate significant savings in new and existing commercial buildings. H.R. 1424, titled the *Economic Stabilization Act of 2008*, includes a 10% tax credit against the cost of installing CHP systems (for the first 15MW) for systems up to 50 MW in size. Our discussions with stakeholders revealed that the health care sector – in particular hospitals and clinics, of which Ohio has well over 100 throughout the state that perpetually generate and consume considerable amounts of energy – is an excellent candidate for CHP (OHA 2008). This tax credit will provide significant impetus for the expansion of CHP systems in commercial buildings in general and help buildings in the health care sector reduce their operating costs during a time where remittances from Medicare have fallen significantly.

To estimate savings from existing buildings, we assume 1% annual savings throughout the analysis period and 1% participation rate (market share) in first year, with participation increasing by 1% annually. Savings from new construction assumes 50% savings beyond current code (IECC 2006), thereby decreasing with the adoption of new energy codes except in 2020, where we assume program implementation and participation has matured to allow for savings beyond the 50% savings from IECC 2018. In 2011 we assume an initial participation rate of 2.5%, doubling annually until 2014, when IECC 2012 becomes effective. We then assume a participation rate of 20% of new buildings for the remainder of the analysis period.[28] In 2020, when IECC 2018 becomes effective, delivering 50% savings, we assume 20% additional savings beyond IECC 2018 are achievable. Under these assumptions we estimate total savings for new and existing commercial buildings to be 133 GWh in 2015 and 715 GWh in 2025, or 0.4% of total projected electricity consumption in 2025.

[25] http://www.eere.energy.gov/buildings/highperformance/
[26] http://www.advancedbuildings.net/
[27] http://www.energystar.gov/index.cfm?c=business.bus_index
[28] Our assumed participation rate for new homes is extremely conservative, especially for the short-term part of this analysis. In other states, best practice programs for new construction in the commercial sector are achieving 50% participation rates. With time, the ramping up of this program should allow Ohio to easily meet a much greater participation rate.

Manufacturing Initiative

Based on discussions with a broad range of stakeholders involved with the manufacturing sector in Ohio, we propose a government/utility/industrial collaborative we are calling the "Ohio Efficient Manufacturing Initiative." The goal of the initiative would be to address the three key barriers to expanded industrial energy efficiency identified by the stakeholders: the need for assessments that identify energy efficiency opportunities; access to industry-specific expertise; and the need for an expansion of the trained manufacturing workforce with energy efficiency experience.

The initiative would establish Manufacturing Centers of Excellence in the model of the U.S. Department of Energy's Industrial Assessment Center (IAC)[29] program, where university engineering students are trained to conduct energy audits at industrial sites. Centers could be established at two or three main technical universities in Ohio, including The University of Dayton (UD) (the only current IAC in the state) and sites in Cleveland or Columbus. Expanding beyond the IAC model, these centers would partner with local community colleges and trade schools to bring their students into the larger network centered around the local Center of Excellence. These nearby satellite centers would extend training and associated materials to trade school and community college partners, and offer the opportunity to join the audits they conduct. Working with the Ohio Manufacturing Association and manufacturing trade associations, together with the local Manufacturing Extension Partnership (MEP) program could provide outreach to manufacturing companies that might not otherwise be aware of energy efficiency programs. Further collaboration with the Ohio Energy Office's industrial energy efficiency and sustainability programs would let the program rely on existing infrastructure and expertise on sustainability, energy, and job creation.

This initiative would provide multiple benefits to the state:

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

IAC program and implementation results recorded over the last 20 years show that this program could identify 10-20% electricity savings per facility and achieve a 50% implementation rate. Program costs for the IAC program are about $1 for every $10 saved by industry. We factor in another $0.25 per $10 saved to account for additional education costs. Under these assumptions we estimate savings of 1,721 GWh in 2015 and 5,771 GWh in 2025, or 3% of total projected electricity consumption in 2025.

We are also researching complementary policies that could leverage economic development programs to reduce Ohio's energy consumption. We also encourage the state to support an expanded federal manufacturing initiative similar to what has been suggested in recent congressional discussions.[30]

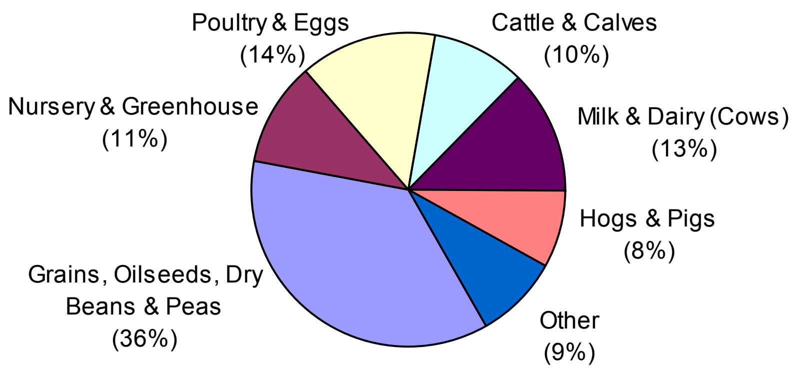
Rural and Agricultural Initiative

Agriculture makes up a little more than 1% of Ohio's industrial sector electricity use, averaging 708 GWh per year. The agricultural sector is one of the most energy-dependent sectors of our economy, relying on both direct sources of energy, such as fuels or electricity that power farm activities, or indirect energy sources such as fertilizers or other chemicals. When energy prices are unstable or increasing, farmers, ranchers and rural communities are significantly and adversely affected as

[29] For more information on the IAC program, visit: http://iac.rutgers.edu/.
[30] See http://aceee.org/industry/iac.htm.

agriculture becomes unprofitable. In 2004, electricity accounted for 21% of all energy uses on U.S. farms (Miranowski 2005). Ohio's agricultural sector produces a number of energy-intensive commodity crops, the bulk of which are grains such as soybeans, wheat and feed grains.

Figure 12. Estimated Electricity Consumption of Ohio Commodity Crops (2002)



In recent years, organizations specifically dedicated to improving efficiency on farms, ranches and rural small businesses have emerged. Existing programs are widening their focus to include agricultural energy efficiency issues and to provide more online and on-farm audits, as well as both technical and financial support. The Energy Title (IX) of the *2008 Farm Bill* provides more funding than previous legislative efforts to the Rural Energy for America Program (REAP, formerly Section 9006), which provides technical assistance and audits, as well as grants and loan guarantees for energy efficiency and renewable energy projects.[31] Although there is more money and awareness today, many states still lack the internal structure to aid their farmers, ranchers, and rural small businesses in leveraging these Farm Bill funds.[32]

The 2008 Farm Bill also authorized a new program which would provide financial assistance toward increasing the energy self-sufficiency of rural communities. The Rural Energy Self Sufficiency Initiative will fund energy assessments, help create blueprints for reducing energy use from conventional sources, and install community-based renewable energy systems.[33]

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

I. Develop an Educational Program to be administered through the Rural Electric Cooperatives, the Ohio Farm Bureau and the extension service

The Ohio Department of Agriculture, in conjunction with Ohio Department of Development, the Ohio Farm Bureau, the Ohio State Extension Service, Buckeye Power and the Ohio Rural Electric Cooperatives should establish an educational program which would disseminate information on energy efficiency best practices for farmers, ranchers and rural small businesses. This could take the

[31] Specifics on REAP project eligibility and additional information on the REAP program: http://farmenergy.org/incentives/9006faq.php#_Toc194481353.

[32] Of 1,158 applications for REAP funds in 2008, 766 were awarded grants or loan guarantees. Ohio had 12 of 22 projects awarded funds ($1,037,038). From the Environmental Law and Policy Center (ELPC)

[33] See Title VI, Energy Efficiency and Renewable Energy Programs for related program information: http://www.ers.usda.gov/FarmBill/2008/Titles/titleVIRural.htm#rural1.

form of a partnership with national organizations, such as the Rural Electricity Resource Council (RERC)[34] or the USDA-RD.[35]

There are several examples of state-specific educational programs. Southern California Edison utility runs an agriculture program that "promotes energy-efficient solutions for small and large farms, ranches, and dairies."[36] Their website provides information on a number of topics, including a *Dairy Farm Energy Efficiency Guidebook* and the Agricultural Technology Application Center (AGTAC). The latter, an "educational resource energy center," includes hands-on displays and exhibits which are open to public; demonstrations of energy-efficient technologies; educational seminars and free workshops; and provides information regarding scheduling consultations with energy experts. AGTAC "connects customers to energy-related technology solutions that are energy efficient, positive for the environment and cost competitive."[37]

In the Midwest, the Iowa Energy Center funded a project looking at the "Development of an Energy Conservation Education Program for Iowa's Livestock and Poultry Industry."[38] The work products of the study will include a curriculum, with day-long training sessions for farmers, fact-sheets and a reference manual covering energy efficiency techniques, and a training regimen for extension agricultural field specialists, to assist with the distribution of the educational materials.

Because of the regional specific nature of the agriculture sub-sector (Brown and Elliott 2003), it will be important for Ohio to tailor its programs to the unique needs of the state's agricultural industries.

II. Offer a rural audit program, building on the USDA-REAP program

Ohio utilities and extension services should make use of the reauthorized REAP program, which has $255 million dollars in mandatory funding for use over a 4-year period, to expand energy efficiency and renewable energy efforts throughout the state. ACEEE recommends that these entities provide on-site audits to farmers, ranchers and rural small businesses as a preliminary step in the REAP application process. Pinpointing areas where a farmer could save energy or implement an energy efficiency project is the first step toward identifying a successful REAP project.

Wisconsin's *Focus on Energy* program provides on-site audits with Focus energy advisors to farms and agricultural-related businesses (crop storage, grain processing, etc.). The program is marketed through multiple channels, is promoted by stakeholders including universities, extension agents, contractors, utilities and cooperatives. During the 2001-2007 period 1,500 dairy farmers participated in the program. *Focus on Energy* has promoted awareness of the Farm Bill REAP opportunities in conjunction with the Department of Agriculture and local USDA offices. Energy savings since the program began are 14.8MW, 74 kWh, and 1.4 million Therms annually (Brooks and Elliott 2007).

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

[34] RERC's web site, www.rerc.org, provides materials on energy efficiency and is a national center for information on rural electricity topics.

[35] The Ohio Dept of Development does have a Web page for the energy office and information on saving energy for industry and businesses; however, there is no agriculture or rural community-specific section. The development of that on-line resource could be one component of a future education initiative. See http://development.ohio.gov/cdd/oee/c___i_services.htm for the page in question.

[36] http://www.sce.com/b-rs/agriculture/

[37] http://www.sce.com/b-sb/energy-centers/agtac/

[38] http://www.energy.iastate.edu/Efficiency/Agricultural/cs/harmon_conserv.htm

operation, and provides information on available agricultural rebate programs. Operators can also earn cash back for purchasing recommended equipment.[39]

III. Create a pool of matching funds for USDA grants

To further promote the implementation of energy-efficient technologies and projects, Ohio should establish a system benefits charge (SBC) on electric utility bills to provide funds for matching USDA-REAP grants. Current SBC-funded programs include an advanced energy program that funds combined heat and power projects and a manufacturing facilities program that promotes advanced lighting and HVAC projects, however there are currently no such programs specifically for the agricultural sector.[40] Availability of these funds could prove vital for successful REAP applications, as the USDA is considering availability of non-REAP funding as a criterion for the application ranking process.

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

One alternative to state-run programs of the type described above would be for the state to designate a non-governmental organization to implement energy efficiency programs. Examples include Vermont's *Efficiency Vermont* organization, and the *Northwest Energy Efficiency Alliance* (NEEA) which operates in the Pacific Northwest. Additionally, there are for-profit entities such as Vermont-based *EnSave* which focus specifically on improving energy efficiency in the agricultural sector. *EnSave* works in a number of states, from Maryland to Minnesota and California, implementing programs that range from dairy efficiency and diesel emission reduction to programs that operate farm energy audits and provide rebates for implementation of on-farm energy efficiency measures.

Expanded CHP and Clean Distributed Generation

Ohio has made good strides in establishing a regulatory environment that is hospitable to the deployment of CHP and clean distributed generation (generally referred to here as "CHP"), but there is still much work to be done.

Of chief concern are the recently adopted rules guiding the development of interconnection standards applicable to distributed generation, including CHP. Ohio's Administrative Code Chapter 4901:1-22-01 delineates that ideal interconnection standards should "make compliance [with interconnection standards] not unduly burdensome or expensive for any applicant […]" The code further requires that electric distribution utilities "establish uniform requirements for offering nondiscriminatory technology-neutral interconnection to customers who generate electricity" while considering the safety of utility workers and the environment.

The code relies heavily upon the IEEE's 1547 interconnection standard (http://grouper.ieee.org/groups/scc21/1547/1547_index.html), a widely accepted model for interconnection rules. Interconnection is separated into three tiers to allow for easier and more streamlined applications for small generators and includes a similarly streamlined application for medium-sized generators up to 2MW. A third tier provides a process for generators up to 20MW in

[39] More information on the Alliant Energy-IPL Farm Energy Audit program can be found on their web site: http://alliantenergy.com/docs/groups/public/documents/pub/p014750.hcsp.

[40] For more information visit the Ohio Department of Development web site, http://www.odod.state.oh.us/cdd/oee/ELFGrant.htm.

size. The Public Utilities Commission of Ohio provides a plain-language guide to interconnection via the new tiered system.[41]

Despite these nearly year-old requirements for new interconnection standards, research into the practices of Ohio utilities corroborated by anecdotal evidence suggests that utilities have not been quick to improve their interconnection practices in the manner required. In order to expand CHP in Ohio, the newly developed requirements for interconnection standards will need to be better implemented and enforced among the regulated utilities of the state.

Other significant regulatory treatments of CHP in Ohio include the inclusion of CHP as an eligible "alternative energy resource" within the context of the state's recently enacted *Alternative Energy Resource Standard,* part of Senate Bill 221. This is viewed as a favorable treatment of CHP. But there are other regulatory treatments of CHP that should be improved to further increase deployment. Developing output-based air emissions regulations, as promoted by the United States Environmental Protection Agency,[42] will incentivize more efficient use of fuel inputs, thus encouraging the deployment of the most efficient CHP systems. And the energy conversion property tax incentive that currently benefits the owners of some CHP systems is set to expire after the 2008 tax year. Since Ohio is currently phasing in a restructured tax code, an extension of this tax incentive may not be possible within the new tax paradigm; a continued emphasis, however, on reducing the costs of CHP systems is encouraged.

The economics of CHP have recently been assisted by the passage of the federal H.R. 1424, titled the *Economic Stabilization Act of 2008.*This act authorized the expansion of the Investment Tax Credit to include investments in CHP. It is a 10% tax credit against the cost of installing CHP systems (for the first 15MW) for systems up to 50 MW in size. While this tax credit is a boon for CHP deployment in the state, other Ohio-specific policies are not as favorable and may work to negate the positive influence on deployment that more favorable policies have. For example, current tariffs used by the largest utilities in Ohio to charge for standby electric service are counterproductive to the expanded implementation of CHP. PUCO may wish to review and address these tariffs and work to find solutions that make CHP projects more attractive to customers. The economics of CHP could also be improved through the power of the Ohio Air Quality Development Authority, which could leverage its ability to issue bonds to grant loans and other financial incentives to help companies address the high first costs of CHP systems. Since economic benefits of CHP systems accrue over time, using financing mechanisms to help spread out the costs could help business owners better integrate CHP systems into their long-term energy strategies.

Additional national incentives for CHP may be in the works. The *2007 Energy Independence and Security Act*'s Section 451 authorized additional funding and support for waste-heat recovery projects, which are an important subset of clean distributed generation. Though this authorization has not been funded, anecdotal evidence suggests it will garner attention in 2009.

Workforce Development

A key challenge stalling the achievement of the energy efficiency resource targets in SB 221 is the availability of a trained workforce. Energy efficiency tends to be more labor intensive than are supply resources, so developing a well-trained, indigenous workforce that can address efficiency issues across all market sectors is critical – a sentiment shared by the majority of stakeholders with whom we met. We thus see workforce development as a necessary element of many of the initiatives proposed above. But advancing efficiency in all sectors and throughout the entire state will require a workforce with training beyond the identification/assessment of efficiency opportunities: trained installers, technicians, engineers, architects, evaluation professionals, building operators, etc., all must be empowered with general and esoteric knowledge. Such investment in human capital will

[41] To view the guide, visit http://www.puco.ohio.gov/PUCO/Consumer/Information.cfm?id=6608

[42] For more information, visit the United States Environmental Protection Agency's CHP Partnership's informational page on output-based emissions: http://www.epa.gov/chp/state-policy/output.html

maximize the efficacy of efficiency programs while also providing additional benefit to the state's economy by creating new "green collar" jobs.

The advent of corporate and social environmental responsibility has already begun to influence the evolution of careers in building system design and operations, but identifying the needs of the market – in particular workforce needs – is and will continue to be an important facet of any initiative that aims to improve the energy efficiency of commercial and residential buildings, especially over the long term. Another key challenge will be coordinating the various programs. The establishment of an inter-agency stakeholder group to coordinate workforce development activities is therefore critical and should bring together entities such as Ohio's universities, the Ohio Board of Regents, the ODOD, and the PUCO. In New York, for example, the Building Performance Lab, housed at the City University of New York's (CUNY) Institute for Urban Systems, has established a stakeholder consortium that meets semiannually to "discuss the benefits and challenges of 'going green'" within the commercial sector. The consortium includes property owners and managers, labor representatives, utilities, city and state agencies, as well as other non-profits.[43] Since all of the initiatives we suggest within the context of the EERS policies include workforce training elements, the dynamics of the individual programs will be facilitated by a stakeholder group overseeing the process in general while providing the various parties a venue for exchanging and soliciting ideas. Communication within and between the programs is imperative to guarantee that individuals are obtaining the proper education to satisfy the needs of the individual market sectors as well as guaranteeing job placement once their training has been completed.

Ohio has already begun the process of bolstering workforce development. Universities are offering degrees and training not only through departmentally-sponsored programs, but also through joint programs with the State and Federal government. The Industrial Assessment Center at the University of Dayton (UDIAC) is one of 26 industrial assessment centers that are funded by the U.S. Department of Energy. With this funding, the UDIAC sends a small team of faculty, trained students, and professional staff to conduct free assessments for mid-sized industries, compiling reports with recommendations for reducing energy, waste and production costs.[44] UD has also joined forces with Wright State University, Central State University, and the Air Force Institute of Technology to offer the state's first masters program in clean and renewable energy, focusing on developing "a workforce for more than 45 existing Ohio companies with a stake in renewable energy and energy efficiency, as well as graduates who can start new businesses to create new Ohio jobs."[45] The program was approved by the Ohio Board of Regents in November 2008.

In July 2007, Ohio State University (OSU) created its Institute for Energy and the Environment (IEE), which brings together deans, faculty and researchers from OSU's five "hard" science colleges.[46] The IEE is not an academic unit, i.e., it does not confer degrees. But it aims to serve many other laudable purposes. As a single entity the IEE facilitates collaboration and communication amongst the five colleges, aiding in the dissemination of research at the state, national, and global level. It is also working to become a trusted resource for the state government, by acting as an intermediary between OSU experts and governmental leaders. One of its primary goals, however, is to assist OSU in advancing sustainability throughout its campus, both with regards to energy and environmental issues.

As part of one of the largest universities in the world, the IEE has the potential to become an invaluable resource. Though research at OSU focuses predominantly on supply-side efficiency issues – squeezing more Btu's out coal, solar radiation, etc. – it does have plans to expand its expertise in demand-side efficiency. The IEE is already involved in AEP's advanced metering infrastructure (AMI) program and has recently started a program called SMART@CAR, or Sustainable Mobility: Advanced

[43] For more information, please visit http://www.cunyurbansystems.org/pages/building-performance-lab.php
[44] For more information on this program, please visit: http://www.engr.udayton.edu/udiac/
[45] For more information on this program, please visit: http://www.udayton.edu/News/Article/?contentId=21494
[46] Biological Sciences; Engineering; Food, Agricultural and Environmental Sciences; Math and Physical Sciences; and Social and Behavioral Sciences.

Research Team at the Center for Automotive Research, which is a systems approach to developing the necessary infrastructure for electric vehicles. The IEE also plans to create an industrial assessment center and is cooperating with the University of Dayton in order to move forward with its project (Potter 2008).[47]

State and Local Government Facilities

State and local government facilities represent unique opportunities for Ohio to implement energy-efficient practices. Government buildings in Ohio represent almost 31% of electricity consumption in commercial buildings throughout the state (EIA 2006b)[48]. Employing energy efficiency in Ohio's government facilities serves as a model for others to follow, allowing Ohio to "lead by example." The Federal Government and a number of other states use Energy Savings Performance Contracts (ESPC) to implement energy efficiency projects at government facilities. Under the ESPC model, state agencies hire Energy Service Companies (ESCO) to implement projects designed to improve the energy efficiency and lower maintenance costs of the facility. The ESCO guarantees the performance of its services, and the energy savings are used to repay this project cost as shown in Figure 13 (KCC 2008; Birr 2008). This model has proven highly effective in many places both in terms of delivering energy savings and in terms of cost effectiveness (Hopper, Goldman, and McWilliams 2005).

Figure 13. Graphical Representation of How an ESPC Project Is Financed

Source: KCC (2008)

The key to the success of these projects is to bring together a project structure that can facilitate all aspects of the program, as is the case in Pennsylvania. Under that program, there are approximately three full-time equivalent staff supported by an experienced contractor:

1. Pre-qualifies ESCOs that can participate in the program;
2. Reviews and negotiates the terms of the ESPC agreements since the government facilities do not have the expertise to evaluate either the technical or contractual aspects of these projects; and
3. Reviews the completed projects to ensure that the projects are performing as agreed to in the contract.

Pennsylvania has been able to manage almost 50 projects each year, with total program and administrative costs of less than 2% of project costs (PA-GSA 2008; Birr 2008).

Ohio's EPSC program might be strengthened when compared to leading states such as Pennsylvania, Kansas, and Colorado, since it reaches only a portion of state facilities. A more robust structure and additional technical support might also be engaged. State agencies participate in

[47] For more information on the IEE, please visit http://iee.osu.edu/
[48] In lieu of a lack of state-specific data, we have used data for the East North Central region and assumed it is representative of Ohio.

efficiency programs, so significant additional energy efficiency opportunities still exist that could increase savings in state facilities. To address these opportunities, we recommend that Ohio expand its program, modeling the restructured program around the Pennsylvania experience drawing upon an expert consultant to complement the state agency staff (PA-GSA 2008). We also recommend that Ohio draw upon a national organization that has been formed with DOE support, the *Energy Services Coalition,*[49] which supports state and other entities in implementing ESPC programs (ESC 2008).

We also suggest that the program be extended to local government facilities. We understand that local governments can encounter bond rating problems with ESPC contracts because the rating entities may view these ESPC agreements as unsecured loans. To address this problem, the state should consider using its bonding authority, perhaps through the OAQDA, that would finance these EPSC projects, with the project funding paid back by the energy savings. The state should engage the rating entities on this issue.

In 1994, House Bill 7 was passed allowing state government agencies and universities to enter into performance contracts for energy projects. For state agencies, the authority to enter into performance contracts is vested in the Department of Administrative Services; for universities the authority is given to its Board of Trustees. The Ohio Revised Code Section 165 establishes guidelines for entering into performance contracts, requiring that:

- All contracts must be competitively solicited;
- Energy savings must exceed installation cost over a ten-year period;
- For projects involving cogeneration the maximum term is five years;
- Prevailing wage provisions apply;
- Such projects must pay for themselves out of operating funds and cannot require the use of capital budget funds; and
- Performance contracts for state agencies require the approval of the State Controlling Board.

Based on this model, we assume that state and municipal buildings in Ohio can achieve an average of 20% reduction in projected 2025 electricity sales and a 50% participation rate. We assume the average investment costs are consistent with the projected efficiency resource cost for the commercial sector identified in this report and that the program and administrative costs, which include evaluation, measurement, and verification, are 10% of the project cost. Under these assumptions, we estimate savings of 837 GWh in 2015 and 2,032 GWh in 2025, or 1% of total electricity sales in 2025.

State-Level Appliance and Equipment Efficiency Standards

Lighting and appliance standards, first authorized by Congress in the 1970s and legislated again in 1987, 1992, 2005, and 2007, have become a core energy policy for the United States, setting performance targets for dozens of common household and business products and systems. Individual states have played and continue to play an important role in advancing standards for the nation. In the 1980s, states' initiative in developing standards in the face of federal inaction led to the landmark National Appliance Energy Conservation Act of 1987 (NAECA). Since then, state enactment of product standards not covered by federal law has led to federal adoption of those same standards.

Only thirteen states have implemented standards on products that are not currently covered by federal standards introduced by the Energy Policy Act of 2005 (EPAct) and the Energy Independence and Security Act of 2007 (EISA). Estimates conducted by ACEEE show that appliance standards introduced by EPAct and EISA will save 53 and 178 TWh, respectively, by 2030, or 5% of the total projected electricity use for the U.S. While the usage and energy cost for a single device may seem small, the extra energy consumed by less efficient products collectively adds up to a significant amount of wasted energy. By implementing appliance standards on nine products not currently

[49] For more information on the Energy Services Coalition, see http://www.energyservicescoalition.org/about/index.html.

covered by federal legislation[50], Ohio could add a small, but not insignificant, amount of savings at negligible cost.

We first examine the potential savings and costs associated with the federal appliance standards promulgated by EPAct and EISA, which set standards for around 30 different products. We then estimate the additional savings that Ohio could realize should the state introduce standards on the recommended nine additional products (ASAP 2008). If Ohio were to implement its own state standards, it could realize 593 GWh of savings by 2015 and 2,003 GWh by 2025, or 1% of total electricity consumption in 2025. We estimate that federal appliance standards alone will contribute 3,071 GWh across all sectors in Ohio by 2015, increasing to 6,388 GWh by 2025. Federal and state standards together would yield savings of 3,664 GWh by 2015 and 8,390 GWh by 2025, or 4.3% of total electricity consumption in 2025. Our analysis of this scenario includes only state standards – savings from federal standards would be in addition but are not included.

Building Energy Codes

Building energy codes are a foundational policy to ensure that efficiency is integrated into all new buildings in Ohio. If efficiency is not incorporated at the time of construction, the new building stock represents a "lost opportunity" for energy savings because efficiency is difficult and expensive to install after construction is completed. Mandatory building energy codes are one way to target energy efficiency by requiring a minimum level of energy efficiency for all new residential and commercial buildings.

Ohio currently mandates compliance with ASHRAE 90.1-2004 for commercial buildings. For residential buildings, Ohio mandated compliance with the 2006 International Energy Conservation Code (IECC) code, but on March 31st, 2008, the 2006 IECC was dropped in favor of the 2003 IECC pending further investigation of the 2006 version. A specially appointed committee, the Public Hearing Draft Amendments Group 6, formed to review the 2006 IECC and recommended that, given the current economic downturn, the Ohio Board of Building Standards (OBBS) allow for an Ohio-specific prescriptive path that offers another, less stringent method of compliance in hopes of minimizing the financial burden on Ohio's home contractors and buyers. The OBBS convened November 7th, 2008, to hear public comments on the proposed re-adoption of the 2006 IECC and the additional prescriptive path (BCAP 2008). On December 12th, 2008, the OBBS passed Amendments Group 6, which effectively relaxed code standards on new residential construction.

A closer look at the changes recommended by the Public Hearing Draft Amendments Group 6 shows that they are counterproductive to advancing energy efficiency in Ohio. The proposed changes decrease the stringency of the state code and, consequently, could lead to a significant loss of energy efficiency statewide as well as greater energy costs for home owners. Home builders will be able to comply with the state code by following one of three paths: the 2006 IECC, the 2006 IRC, and the state-specific prescriptive path. These paths have distinctly different efficiency requirements – the 2006 IECC being the most stringent – and collectively have the potential to reduce energy efficiency in new homes significantly. Code officials will be trained to the Ohio-prescriptive path, further reducing the incentive to build homes that are energy efficient.

The implementation of the changes in Amendments Group 6 will also make it more difficult for utilities to meet the savings targets promulgated in SB 221. Allowing home builders to follow a state-specific prescriptive path, which allows equipment "trade-offs" for homes with a window-to-wall area of less than 23%, is an option that is prohibited by the 2009 IECC and one that makes Ohio unique. For example, contractors will essentially be able to trade-off a more efficient furnace instead of making improvements to the thermal envelope, such as windows or insulation. However, many utilities offer incentives for the purchase and installation of efficient furnaces as a means of decreasing energy consumption. Allowing contractors to exchange an efficient furnace for thicker insulation encourages

[50] These products include furnace fans, compact audio equipment, DVD players and recorders, portable electric spas (hot tubs), water dispensers, hot food holding cabinets, televisions, and portable light fixtures.

them to downgrade the home envelope for efficiency improvements that they are already installing. Substituting efficient HVAC equipment for an efficient home envelope will hurt energy efficiency over the life of the home because HVAC equipment typically has a lifetime half as long as envelope measures. And home owners will not necessarily replace their furnace with an equally efficient product, while a less-efficient thermal envelope will be difficult, and costly, to upgrade in the future. The availability of this trade-off could completely offset the level of energy savings that utilities can realize through furnace-incentive programs (MEEA 2008 and Misuriello 2008).

Additionally, the changes in Amendments Group 6 will redraw the climate zones created by the Department of Energy, relocating 30% of Ohio's population into a zone whose energy efficiency requirements are less stringent. Currently only nine counties reside in climate zone 5, which has less-stringent efficiency requirements. The changes in Amendments Group 6 will move an additional twenty-seven counties from climate zone 4 into climate zone 5.

Installing energy efficient products increases costs marginally, but improves the marketability of a new home by increasing comfort and minimizing energy bills through reduced consumption. While the economic concerns of Ohio's home builders should not be ignored, we believe it is imperative that Ohio's prescriptive path remain effective only temporarily. Furthermore, Ohio should be diligent about updating its energy codes by implementing new versions of the IECC as they become available. Our policy analysis reflects this ideal commitment: we assume that the 2006 IECC is the baseline efficiency standard and that Ohio will adopt the 2009 IECC, effective 2011, followed by the 2012 IECC, effective 2014, and the 2018 IECC, effective 2020. We assume enforcement of each codes starts at 70% compliance in the first year, 80% in the second year, and 90% in the third and subsequent years.[51] Given these assumptions, we estimate that savings from energy codes will reach 343 GWh by 2015 and 1707 GWh by 2025, or 0.9% of total electricity consumption in 2025.

Discussion of Proven Utility Programs

We have illustrated that the innovative policies suggested above have the potential to generate 10% of the required 22% electricity savings by 2025, giving utilities a substantial boost towards meeting the EERS target. Based on the results from our policy analysis, we estimate that these programs will only have to meet the remaining 12%, or 20,596 GWh, of the 22% EERS target. Our economic potential analysis for the residential and commercial sectors show that they account for 56% and 44% GWh, respectively, of the 39,213 GWh in total savings we estimate for those two sectors in 2025. We assume that this same ratio will apply to the relative contribution of the two sectors from future utility-run programs, which amounts to 11,594 and 9,003 GWh for the residential and commercial sectors, respectively.

There are many examples of program designs that have proven successful over the past three decades. In the text box below, we present several of these program types along with specific examples of successful implementations that are drawn from ACEEE's report *Compendium of Champions: Chronicling Exemplary Energy Efficiency Programs from across the U.S.* (York, Kushler, and Witte 2008).

Examples of Proven Energy Efficiency Programs

- ***Commercial/Industrial Lighting Programs***: Provide recommendations and incentives to businesses to increase lighting efficiency. Aiming to expedite the adoption of new technologies and decrease end-user’s energy costs, the programs focus on marketing the most advanced lighting products and encourage greater efficiency in system design and

[51] It is important to note that adopting the most recent energy codes will require a concomitant effort to enforce their implementation. Statewide verification of compliance rates is critical in determining the efficacy of energy codes in reducing electricity demand.

layout. Xcel Energy's *Lighting Efficiency* program reached 4,346 participants, saving a total of 273 GWh during the years 2002-2006.

- ***Commercial/Industrial Motor and HVAC Replacement Programs*:** Encourage the marketing and adoption of higher efficiency motors and HVAC equipment by offering rebates to distributors and end-users of qualifying equipment. Through monetary incentives and energy efficiency education, program advocates are shifting market tendencies away from a focus on initial equipment cost and toward an environment where lifecycle cost is increasingly considered by consumers. During 2006, Pacific Gas & Electric's *Motor and HVAC Distributor Program* saved a total of 16.55 GWh of electricity by offering $3.9 million in rebates.

- ***Commercial/Industrial New Construction Programs:*** Focus on training, educating, and providing financial incentives for architects, engineers, and building consultants to implement energy saving measures and technologies. By offering both prescribed and customizable incentive packages, these programs are able to influence a wide range of projects, which have in turn had the effect of raising the standards for energy efficiency in normal building practices. With its four distinct, yet combinable project "tracks," Energy Trust of Oregon, Inc.'s *Business Energy Solutions: New Buildings* program offers qualifying projects incentives of up to $465,000 each, which saved approximately 46.8 GWh of electricity and 1.2 million therms of natural gas through the end of 2007.

- ***Commercial/Industrial Retrofit Programs:*** With programs ranging from energy efficiency audits to financial assistance to even providing detailed engineering installation plans, Commercial/Industrial Retrofit Programs are designed to help implement cost-effective energy efficiency measures during new construction, expansion, renovation, and retrofit projects in commercial buildings. Programs focus on long-term energy management, peak load reduction, load management, technical analysis, and implementation assistance in order to give building owners and operators a better understanding of the energy related costs of, and potential savings for, their commercial buildings. Rocky Mountain Power and Pacific Power created approximately 100 GWh of gross electricity savings in Washington and Utah with their *Energy FinAnswer and FinAnswer Express* programs.

- ***Residential Lighting and Appliances:*** Headed by utility companies and energy nonprofits alike, Residential Lighting and Appliances Programs advocate the adoption of ENERGY STAR light bulbs, light fixtures, and home appliances through the use of rebates, marketing campaigns, advertising, community outreach, and retailer education. Lighting programs have focused on establishing and maintaining a customer base for compact fluorescent bulbs, in addition to fostering relationships between manufacturers and retailers in order to lower costs to the consumer. Appliance programs have sought to educate consumers on the long-term benefits of replacing aging, inefficient refrigerators, freezers, air conditioning units, and other large appliances with ENERGY STAR models, while providing an incentive to upgrade older models through rebates offered both for recycling old units and purchasing new ones. By selling 1.3 million CFLs during 2006 through its *ENERGY STAR Residential Lighting Program*, Arizona Public Service anticipates saving a total of 360 GWh of electricity during the lifetime of the light bulbs. Additionally, the *California Statewide Appliance Recycling Program* recycled 46,829 aging appliance units in 2007, a measure that saved 33.3 GWh of electricity in 2006.

- ***Residential Mechanical Systems Programs:*** Provide rebates and other financial incentives to contractors trained to properly install and service high-efficiency air conditioning, heat pumps, and geothermal heat-pump technologies. In addition to encouraging the purchase of energy-efficient appliances, these programs help to verify that existing equipment is appropriately installed and tuned in accordance with manufacturers' specifications, in order to optimize energy savings. Long Island Power Authority's *Cool Homes* Program has helped to introduce approximately 40,000 high-efficiency central cooling systems into the market, creating 29 GWh of annual electricity savings in 2006.

- ***Residential New Homes Programs:*** Provide incentives to builders who construct energy-efficient homes that achieve long-term, cost-effective energy savings. By addressing efficiency during the construction of homes and apartments, builders are able to maximize the financial and environmental benefits of efficient insulation, windows, air ducts, and appliances. Furthermore, ENERGY STAR certification provides developers with additional marketing strategies to attract buyers and renters. Some Residential New Homes programs also offer assistance to builders in developing efficiency objectives, and to potential buyers in locating efficient homes. With 100 participating residential builders and over 2,300 homes built to date, Rocky Mountain Power's *ENERGY STAR New Homes Program* saved 3.4 GWh of electricity during 2006.

- ***Residential Retrofit Programs:*** With an emphasis on large scale systematic retrofits, Residential Retrofit Programs are designed to reduce electric and natural gas consumption and peak-time demand of residential buildings. Financial incentives, low-interest financing, and training are offered to residents and customers interested in assessing and improving their energy efficiency. From weatherization and duct sealing to installation of new technologies, proponents of Residential Retrofit Programs direct their efforts both to buildings with the highest energy usage and constituents with the greatest financial need. Since its inception in 1993, Vermont Gas Systems, Inc.'s *HomeBase Retrofit Program* has installed over 1,600 kWh in energy saving measures, contributing to over 77,000 Mcf of natural gas savings.

- ***Low-Income Programs:*** Seek to educate and assist qualifying participants in acquiring appropriate home weatherization, energy-efficient lighting and appliances, and other efficiency improvements. By helping limited income households increase their energy efficiency and reduce energy consumption, these programs in turn minimize long-term energy costs to customers. Through its *Appliance Management Program and Low-Income Services*, National Grid has reached over 40,000 customers, creating 42 GWh of annual energy savings.

Energy Efficiency Policy Scenario Results

This section describes results from our policy analysis, including estimated electricity savings and peak demand impacts from efficiency in 2015 and 2025. More detailed results are shown in Appendix B. The demand response potential and impacts on peak demand are covered in the next section and in Appendix D.

Table 6. Summary of Electricity Savings by Policy or Program

	Annual Electricity Savings by Policy (GWh)	2015	2025	Total Savings in 2025 (%)*
	Innovative Programs & Policies			
1	Efficient Homes Initiative	119	615	0.4%
2	State-level Appliance Standards	593	2,003	1.3%
3	Building Energy Codes	343	1,707	1.1%
4	Commercial Buildings Initiative	133	715	0.5%
5	State Facilities	837	2,032	1.3%
6	CHP	1,072	3,238	2.1%
7	Manufacturing Initiative	1,721	5,771	3.7%
8	Rural and Ag. Initiative	57	155	0.1%
	Innovative Program & Policy Savings	**4,876**	**16,235**	**10.3%**
9	*Proven Utility Programs*			
	Residential	2,078	11,328	7.2%
	Commercial	1,701	9,268	5.9%
	Proven Utility Program Savings	**3,779**	**20,596**	13.1%
	Total Savings (Policy + Program)	**8,655**	**36,831**	**23.4%**
	Adjusted Electricity Forecast (GWh)	**169,299**	**157,114**	
	Savings (% Reduction in Reference Case)	**4.9%**	**19.0%**	

Notes

***** Percent relative to adjusted reference case forecast

1 Initiative broken down into programs for existing homes and new construction. Existing homes program assumes 0.5% savings throughout the analysis period and 1% participation rate in first year, with participation increasing by 1% annually. Savings from new construction assumes 50% savings beyond current code (IECC 2006), thereby decreasing with the adoption of new energy codes except in 2020, where we assume program implementation and participation has matured to allow for savings beyond the 50% savings from IECC 2018. In 2011 we assume an initial participation rate of 2.5%, doubling annually until 2014, when IECC 2012 becomes effective. We then assume a participation of 20% for the remainder of the analysis period. In 2020, when IECC 2018 becomes effective, delivering 50% savings, we assume 20% additional savings beyond IECC 2018 are achievable

2 Appliance and equipment efficiency standards were adopted at the federal level in the 2007 energy bill, which also directed DOE to set standards for additional products in the coming years. This Scenario assumes savings from these standards, which are not taken into account in the reference case load forecast. Savings and cost assumptions are from a forthcoming ACEEE and ASAP standards analysis.

3 We assume IECC 2009 is adopted, which goes into effect 2011, the IECC 2012 is adopted and goes into effect in 2014, and the IECC 2018, effective 2020. We estimate that these codes achieve a 15%, 30%, and 50% energy savings improvement beyond IECC 2006 requirements, respectively. Savings apply only to end-uses covered under building codes, which are HVAC, lighting, and water heating end-uses, or 50% of electricity consumption in new residential construction and nearly 60% of electricity consumption in commercial buildings. We assume enforcement of each code starts at 70% compliance in the first year, 80% in second year, and 90% in the third and subsequent years. Buildings analysis shows $0.47 per kWh investment cost for new ENERGY STAR homes, which achieve 15% savings, and $0.32 per kWh for new commercial buildings meeting 15% and 30% beyond code. We assume $1.5 million dollars per year to implement and enforce codes, based on recommendations in New York (NY DPS 2007). This is similar to estimates in VA that new program costs run 2-3% of building costs.

4 Initiative broken down into programs for existing buildings and new construction. Existing buildings program assumes 1% savings throughout the analysis period and 1% participation rate in first year, with participation increasing by 1% annually. We assume that 68.5% of total commercial electric floorspace is non-governmental buildings, to avoid double-counting savings attributable to state facilities program (CBECS 2003, table C17). Savings from new construction assumes 50% savings beyond current code (IECC 2006), thereby decreasing with the adoption of new energy codes except in 2020, where we assume program implementation and participation has matured to allow for savings beyond the 50% savings from IECC 2018. In 2011 we assume an initial participation rate of 2.5%, doubling annually until 2014, when IECC 2012 becomes effective. We then assume a participation of 20% for the remainder of the analysis period. In 2020, when IECC 2018 becomes effective, delivering 50% savings, we assume 20% additional savings beyond IECC 2018 are achievable.

5 We estimate 31.5% of total electric commercial floorspace is government buildings, from EIA (CBECS 2003, table C17). We then assume a savings rate of 20% and a participation rate of 50% over the period of the analysis.

6 We assume a $500 incentive per MW for CHP facilities.

7 This scenario assumes that the number of industrial assessments ramps up from 50 to 200 in first three years, that each assessment identifies 15% electricity savings, and that 50% of identified savings are implemented. Project costs assume the average investment cost per kWh from the industrial sector analysis ($0.28/kWh) and program cost is assumed to be 12.5% of projected cost savings to the end-user.

8 Based on similar programs and values from the State of Wisconsin Focus on Energy 2007 Semiannual Report, we assume the average cost of conserved energy at $0.025/kWh, that program & administrative costs are 24% of the cost of investment, and that customers cover half of the investment cost.

9 Savings for proven programs are the difference between EERS requirements and policy savings. Sector savings are then allocated based on the contribution to economic potential savings of the residential and commercial sectors.

Table 7. Summary of Summer Peak Demand Reductions by Sector (MW)

Sector	2015	2025	Total Savings in 2025 (%)
Residential	637	3,801	10%
Commercial	328	1,121	3%
Industrial	585	2,159	5%
Total Savings (MW)	**1,550**	**7,081**	**18%**
% Reduction (relative to forecast)	**4%**	**18%**	

Cost and Benefits from Policy Analysis

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

The costs needed to run the efficiency policies suggested in our policy analysis and to achieve the estimated electricity savings include both the investments in efficient technologies or measures and the administrative or marketing costs to run programs and administer policies. The technology investments might include any combination of incentives paid to customers or direct consumer costs. See Table 8 for a breakdown of the estimated costs of the policies from our analysis. See Appendix B for estimates of Total Resource Costs.

Table 8. Annual Energy Efficiency Costs from Policy Analysis (Millions of 2006$)

	2015	2025
Customer Investments	$ 380	$ 823
Incentives Paid to Customers	$ 126	$ 390
Admin/Marketing Costs	$ 28	$ 99
Total Costs	**$ 533**	**$ 1,312**

Note: These costs are undiscounted and shown in real 2006$

The chapter on macroeconomic impacts uses these cost assumptions to estimate impacts of the efficiency policies on the economy, including overall benefits to customers. Here, we report a net present value (NPV) analysis of costs and benefits to society and to participants. The next two tables (see Table 9 and 10) show results from the TRC test and the Participant Cost test, respectively, with a breakdown of total costs and benefits (present value in 2006$) by policy type and by sector over the study time period (2008–2025). Readers should note that although the study time period ends in 2025, savings from the efficiency measures persist over the lifetime of each specific measure. Accounting for these additional savings beyond the study time period would yield additional benefits and therefore a higher benefit/cost ratio.

The TRC test, as shown in Table 9, evaluates the net benefits of energy efficiency to the region as a whole. This test considers total costs, including investments in efficiency measures (whether incurred by customers or through incentives) and administrative or marketing costs. Benefits in the TRC test are the avoided costs of energy, or the marginal generation costs that utilities avoid by reducing electricity consumption through energy efficiency. The avoided energy resource costs were determined by the analysis by Synapse Energy Economics (see Appendix A). The TRC test, which shows an overall benefit-to-cost ratio of 1.7, suggests a net positive benefit to Ohio as a whole from implementing these efficiency programs and policies. Accounting for additional savings beyond the study time period would yield a benefit/cost ratio of 2.9.

See Figure 14 for a representation of the results using three different discount rates.

Table 9. Total Resource Cost (TRC) Test (2008-2025) (Millions of 2006$)

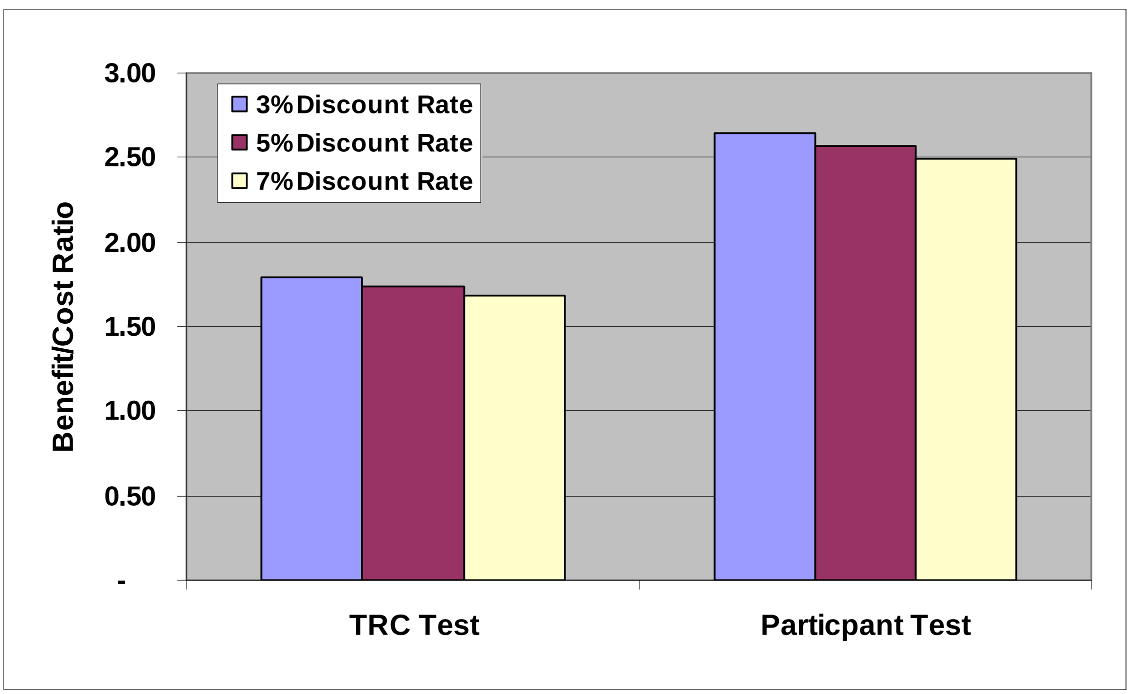
By Policy/Program	NPV Costs	NPV Benefits	Net Benefit	B/C Ratio
Innovative Programs & Policies				
Efficient Homes Initiative	$ 164	$ 194	$ 29	1.2
State-level Appliance Standards	$ 566	$ 795	$ 229	1.4
Building Energy Codes	$ 439	$ 541	$ 102	1.2
Commercial Buildings Initiative	$ 195	$ 220	$ 25	1.1
State Facilities	$ 253	$ 926	$ 673	3.7
CHP	$ 1,232	$ 1,340	$ 109	1.1
Manufacturing Initiative	$ 1,016	$ 2,200	$ 1,184	2.2
Rural and Ag. Initiative	$ 3	$ 66	$ 63	21.3
Proven Utility Programs				
Residential	$ 2,250	$ 3,436	$ 1,186	1.5
Commercial	$ 1,095	$ 2,811	$ 1,716	2.6
Total	**$ 7,214**	**$ 12,528**	**$ 5,314**	**1.7**
By Sector	**NPV Costs**	**NPV Benefits**	**Net Benefit**	**B/C Ratio**
Residential	$ 3,196	$ 4,733	$ 1,537	1.5
Commercial	$ 2,377	$ 4,862	$ 2,485	2.0
Industrial	$ 1,642	$ 2,934	$ 1,292	1.8
Total	**$ 7,214**	**$ 12,528**	**$ 5,314**	**1.7**

The Participant Cost test, as shown in Table 10, takes the perspective of a customer installing an energy efficiency measure in order to determine whether the participant benefits. The costs are the costs to customers for purchasing or installing energy efficiency and the benefits are the savings on customers' electricity bills due to reduced consumption plus any incentives paid to the customers. Again, this analysis only takes into account costs and benefits through 2025, even though customer savings on electric bills would continue well past 2025. Without accounting for the benefits that persist after measures installed in 2025, the Participant Cost test yields a positive benefit to participants, with a benefit/cost ratio of 1.9. Accounting for additional savings beyond the study time period would yield a benefit/cost ratio of 4.0.

Table 10. Participant Cost Test (2008-2025) (Millions of 2006$)

By Policy/Program	NPV Costs	NPV Benefits	Net Benefit	B/C Ratio
Innovative Programs & Policies				
Efficient Homes Initiative	$ 131	$ 309	$ 178	2.4
State-level Appliance Standards	$ 564	$ 1,056	$ 491	1.9
Building Energy Codes	$ 425	$ 711	$ 286	1.7
Commercial Buildings Initiative	$ 156	$ 332	$ 176	2.1
State Facilities	$ 230	$ 1,156	$ 926	5.0
CHP	$ 1,232	$ 1,881	$ 649	1.5
Manufacturing Initiative	$ 978	$ 2,060	$ 1,081	2.1
Rural and Ag. Initiative	$ 2	$ 63	$ 61	25.2
Proven Utility Programs				
Residential	$ 2,000	$ 5,643	$ 3,643	2.8
Commercial	$ 996	$ 4,014	$ 3,019	4.0
Total	**$ 6,715**	**$ 17,225**	**$ 10,510**	**2.6**
By Sector	**NPV Costs**	**NPV Benefits**	**Net Benefit**	**B/C Ratio**
Residential	$ 2,905	$ 7,432	$ 4,527	2.6
Commercial	$ 2,207	$ 6,833	$ 4,626	3.1
Industrial	$ 1,603	$ 2,960	$ 1,357	1.8
Total	**$ 6,715**	**$ 17,225**	**$ 10,510**	**2.6**

Figure 14. Results of TRC and Participant Cost Tests Using Three Discount Rates



ASSESSMENT OF DEMAND RESPONSE POTENTIAL

This section defines Demand Response (DR), assesses current DR activities in Ohio, uses benchmark information to assess DR potential in Ohio, and concludes with policy recommendations that could foster DR contributing appropriately to the resource mix in Ohio that can be used to meet electricity needs. Potential load reductions from DR are estimated for set of DR programs that represent the technologies and customer types that span a range of DR efforts.

Defining Demand Response

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

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

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

Rationale for Investigating Demand Response

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

- **Ensure reliability** – DR provides load reductions on the customer side of the meter that can help alleviate system emergencies and help create a robust resource portfolio of both demand-side and supply-side resources that meet reliability objectives.
- **Reduce supply costs** – DR may be less expensive per megawatt than other resource alternatives.
- **Manage operational and economic risk through portfolio diversification –** DR capability is a resource that can diversify peaking capabilities. This creates an alternative means of meeting peak demand and reduces the risk that utilities will suffer financially due to transmission constraints, fuel supply disruptions, or increases in fuel costs.
- **Provide customers with greater control over electric bills –** DR programs would allow customers to save on their electric bills by shifting their consumption away from higher cost hours and/or responding to DR events.
- **Address legislative/regulatory interest in DR –** Recent legislation, Ohio House Bill 2200, calls for peak load reduction, smart meter deployment, and the availability of time-based rates for all customers.

Background of Demand Response in Ohio

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

Ohio utilities serves a population of over 11.5 million, generation over 155 million megawatt hours of electricity, that is expected to have a system peak load of almost 30,000 MW in 2009 (ACEEE base case for Ohio).

Electricity demand in Ohio has fluctuated over the past 15 years (EIA 2009). Total consumption has grown only slightly. Total retail sales in 2007 in Ohio totaled 161.5 billion kWh. This is an aggregate figure for all sectors, including industrial, commercial and residential.

Ohio has been and likely will continue to be a modest importer of energy and likewise be dependent on out-of-state capacity. In 2007, in-state generation provided less than 97% of total Ohio retail sales, thus requiring import of approximately 3% (EIA 2008a).

Role of Demand Response in Ohio's Resource Portfolio

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

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

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

Assessment of Demand Response Potential in Ohio

Table 11 shows the resulting load shed reductions possible for Ohio, by sector, for years 2015, 2020, and 2025. Load impacts grow rapidly through 2018 as program implementation takes hold. After 2018, the program impacts increase at the same rate as the forecasted growth in peak demand.

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

The high scenario results show a reduction in peak demand of 3,078 MW is possible by 2015 (8.4% of peak demand); 6,293 MW is possible by 2020 (16.4% of peak demand); and 6,471 MW is possible by 2025 (16.2% of peak demand).

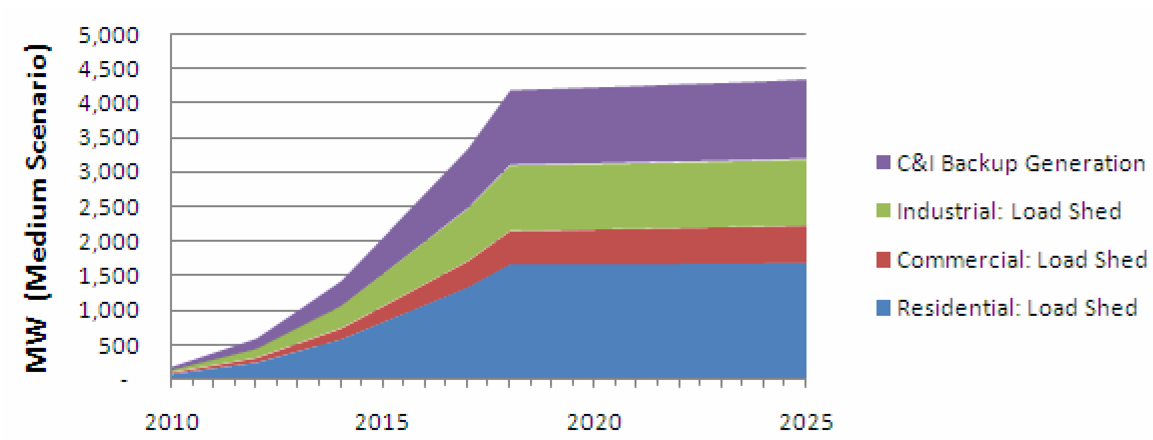
The more conservative medium scenario results show a reduction in peak demand of 2,052 MW is possible by 2015 (5.6% of peak demand); 4,193 MW is possible by 2020 (11.0% of peak demand); and 4,309MW is possible by 2025 (10.8% of peak demand).

Table 11. Summary of Potential DR in Ohio, By Sector, for Years 2015, 2020, and 2025a

	Low Scenario			Medium Scenario			High Scenario		
	2015	**2020**	**2025**	**2015**	**2020**	**2025**	**2015**	**2020**	**2025**
Load Sheds (MW):									
Residential	502	1,008	1,017	837	1,680	1,696	1,172	2,352	2,374
Commercial	86	184	199	228	491	531	428	921	996
Industrial	206	415	420	464	933	944	824	1,660	1,678
C&I Backup Generation (MW)	393	817	854	524	1,089	1,138	655	1,361	1,423
Total DR Potential (MW)	1,186	2,424	2,490	2,052	4,193	4,309	3,078	6,293	6,471
DR Potential as % of Total Peak Demand	3.2%	6.4%	6.3%	5.6%	11.0%	10.8%	8.4%	16.4%	16.2%
a. See Section 3 for underlying data and assumptions.									

Figure 15 shows the resulting load shed reductions possible for Ohio, by sector, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 15. Potential DR Load Reduction in Ohio by Sector (MW)



These estimates reflect the level of effort put forth and utilities are recommended to set targets for the high scenarios. These estimates are based on assumptions regarding growth rates, participation rates, and program design. These factors are discussed in Chapter 3. In developing these DR potential estimates, the integration of DR with select energy efficiency activities was considered to help ensure that load impacts were not double counted. The estimated load reduction per program participant is conservatively estimated to account for increased energy efficiency in the future.

Recommendations

Key recommendations include:

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

- *Appropriate financial incentives for the Ohio' utilities either for programs administered directly by the utilities or for outsourcing DR efforts to aggregators.* The basic premise is that a utility's least-cost plan should also be its most profitable plan. Developing these incentives poses some complexities in that MW's in that DR programs likely will be bid into PJM's DR programs and will receive financial payments from PJM. Whether this provides adequate incentives for the appropriate development of DR programs in Ohio should be examined.

- *Combine and cross-market EE and DR programs.* These can include new building codes and standards that include not only EE construction and equipment, but also the installation of addressable and dispatchable equipment. This can include addressable thermostats in new residences and the installation of addressable energy management systems in commercial and industrial buildings that can reduce loads in select end-uses across the building/facility. In addition, energy audits of residential or commercial facilities can also include an assessment of whether that facility is a good candidate for participation in a DR program through the identification of dispatchable loads. Furthermore, building commissioning and retro-commissioning EE programs that are becoming popular in many commercial and industrial sector programs have the energy management system as a core component of program delivery. At this time, the application of auto-DR can be assessed and marketed to the customer along with the EE savings from these site-commissioning programs.

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

- *Increase clarity and coordination between the Federal and State agencies and programs.* While states have primary jurisdiction over retail demand response, the FERC has jurisdiction over demand response in wholesale markets. Greater clarity and coordination between the Federal and State programs is needed. At the Federal level, both EPACT and EISA contain multiple provisions on demand response and smart grid technologies. EISA authorized a matching grant program to offset the costs of Smart Grid investments.

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

MACROECONOMIC IMPACTS: IMPACT OF POLICIES AND PROGRAMS ON OHIO'S ECONOMY, EMPLOYMENT, AND ENERGY PRICES

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

A recent meta-review of some past 48 energy policy studies done within the United States suggests that if investments in more efficient technologies are cost-effective, the impacts on the economy should be small but net positive (Laitner and McKinney 2008). As shown elsewhere in the report, it turns out that from a total resource cost perspective, the benefits (i.e., the energy bill savings) outweigh both the policy costs and investments by about two and one-half times. In other words, the energy efficiency policy recommendations highlighted in the policy scenario result in a substantial savings for households and businesses compared to the costs of implementing the policies. As we also discuss below, this consumer energy bill savings can drive a significant increase in the number of net new jobs within the Ohio.[52] In fact, continued investments in energy efficiency resources would maintain the energy resource benefits for many years into the future, well beyond the period of analysis examined in this report.[53] The state therefore has the opportunity to transition its energy markets to a more sustainable pattern of energy production and consumption in ways that benefit consumers.

A quick glance at the results in Table 12 below, detail the benefits that will accrue to the state of Ohio when policies encourage a more efficient use of energy resources. Further discussion in this section will provide an overview of the DEEPER model and more detailed background information for the state of Ohio.

Table 12. Economic Impact of Energy Efficiency Investment in Ohio

Macroeconomic Impacts	2010	2015	2020	2025
Jobs (Actual)	1,582	7,928	19,506	32,061
Wages (Million $2006)	$50	$300	$851	$1,615
GSP (Million $2006)	$58	$444	$1,310	$2,559

Methodology

The macroeconomic evaluation that we report in this chapter is undertaken in three separate steps. First, we calibrate ACEEE's economic assessment model called DEEPER (Dynamic Energy Efficiency Policy Evaluation Routine) to reflect the economic profile of the Ohio economy (Laitner and McKinney 2009). This is done for the period 2006 (the base year of the model) through 2025 (the last year of the analysis). In this respect, we incorporate the anticipated investment and spending patterns that are suggested by the standard forecast modeling assumptions. These range from typical spending by businesses and households in the analytical period to the anticipated construction of new electric power plants and other energy-related spending that might also be highlighted in the forecast. Second, we transform the set of key efficiency scenario results from the policy analysis into the direct inputs which are needed for the economic model. The resulting inputs include such parameters as:

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

[53] As we note elsewhere, the policy analysis ends in the year 2025. Yet, many of the investments we describe have a technology of perhaps 15 years. This means that investments made in 2025 would continue to pay for themselves through perhaps the year 2044 and beyond; and none of those ongoing energy bill savings are reflected in the analysis described in this chapter.

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

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

Illustrating the Methodology: Ohio Jobs From Efficiency Gains

To illustrate how a job impact analysis might be done, we will use the simplified example of installing one hundred million dollars of efficiency improvements within large office buildings throughout Ohio. Office buildings (traditionally large users of energy due to heating and air-conditioning loads, significant use of electronic office equipment, and the large numbers of persons employed and served) provide substantial opportunities for energy-saving investments. The results of this example are summarized in Table 13.

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

Table 13. Illustrative Example: Job Impacts from Commercial Building Efficiency Improvement

Expenditure Category	Amount (Million $)	Employment Coefficient	Job Impact
Installing Efficiency Improvements in Year One	$100	13	1,300
Diverting Expenditures to Fund Efficiency Improvements	$-100	12	-1,200
Energy Bill Savings in Years One through 15	$200	12	2,400
Lower Utility Revenues in Years One through 15	$-200	5	-1,000
Net 15-Year Change	$0.0		1,500

Note: The employment multipliers are adapted from the appropriate sector multipliers from IMPLAN. The benefit-cost ratio is assumed to be 2.0. The jobs impact is the result of multiplying the row change in expenditure by the row multiplier. The sum of these products yields a working estimate of total net job-years over the 15-year time horizon. To find the average annual net jobs in this simplified analysis we would divide the total job-years by 15 years which, of course, gives us an estimated net gain of 100 jobs per year for each of the 15 years. For more details, see the text that follows.

The analysis assumes that we are interested in the net effect of employment and other economic changes. This means we must first examine all changes in household and business expenditures – both positive and negative – that result from a movement toward greater levels of energy efficiency. Although more detailed and complicated within the DEEPER model, for this heuristic exercise we then multiply each change in expenditures by the appropriate sector employment coefficient (adapted from IMPLAN). The sum of these products will then yield the net result for which we are looking.

In our example above, there are four separate changes in expenditures, each with their separate impact. As Table 13 indicates, the net impact of the scenario suggests a cumulative gain of 1,500 jobs in each of the 15-year period of analysis. This translates into an average net increase of 100 jobs each year for 15 years. In other words, the $100 million efficiency investment made in Ohio's office buildings is projected to sustain an average of 100 jobs each year over a 15-year period compared to a "business-as-usual" scenario.

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

First, it was assumed that only 72% of both the efficiency investments and the savings are spent within Ohio. We based this initial value on the Minnesota IMPLAN Group, Inc. (IMPLAN 2007) dataset as it describes local purchase patterns that typically now occur in the state. We anticipate that this is a conservative assumption since most efficiency and renewable energy installations are likely (or could be) carried out by local contractors and dealers. If the set of policies encourages greater local participation so that the share was increased to 90%, for example, the net jobs might grow another 15% compared to our standard scenario exercise. At the same time, the scenario also assumes Ohio provides only 40% of the manufactured products consumed within the state. But again, a concerted effort to build manufacturing capacity for the set of clean energy technologies would increase the benefits from developing a broader in-state energy efficiency and renewable energy manufacturing capability.

Second, an adjustment in the employment impacts was made to account for assumed future changes in labor productivity. As outlined in the Bureau of Labor Statistics Outlook 2006–2016, productivity rates are expected to vary widely among sectors (BLS 2007). For instance, drawing from the BLS data we would expect that electric utilities might increase labor productivity by 1.8% annually while the business and personal service sectors of the economy might increase productivity by 2.2% per year. This means, for example, that we might expect a one million dollar expenditure for utility services in the year 2025 would support only 68% of the jobs that the same expenditure would have supported in 2008, while other services sectors of the economy would support only 62% of the jobs as in 2008.

Third, for purposes of estimating energy bill savings, it was assumed that all energy prices within Ohio would follow the same growth rate as those published by the Energy Information Administration in its *Annual Energy Outlook* (EIA 2008). Fourth, it was assumed that approximately 80% of the efficiency investments' upgrades are financed by bank loans that carry an average 8% interest rate over a five-year period. To limit the scope of the analysis, however, no parameters were established to account for any changes in interest rates as less capital-intensive technologies (i.e., efficiency investments) are substituted for conventional supply strategies, or in labor participation rates – all of which might affect overall spending patterns. Fortunately, however, it is unlikely that these sensitivities would greatly impact the overall outcome of this analysis.

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

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

Sixth, it should be noted that the full effects of the efficiency investments are not accounted for since the savings beyond 2025 are not incorporated in the analysis. Nor does the analysis include other benefits and costs that can stem from the efficiency investments. Non-energy benefits can include increased worker productivity, comfort and safety, and water savings, while non-energy costs can include aesthetic issues associated with compact fluorescent lamps and increased maintenance costs due to a lack of familiarity with new energy-efficiency equipment (NAPEE 2007b, 3-8). Productivity benefits, for example, can be substantial, especially in the industrial sector. Industrial investments that increase energy efficiency often result in achieving other economic goals such as improved product quality, lower capital and operating costs, increased employee productivity, or capturing specialized product markets (see, for example, Worrell et al. 2003). To the extent these "co-benefits" exceed any non-energy costs, the economic impacts of an energy efficiency initiative in Ohio would be more favorable than those reported here. Finally, although we show how the calculations would look from an employment perspective, we don't show the same kind of data or assumptions for either income or for impacts on the Gross State Product (the sum of value-added contributions to the Ohio State economy). Nonetheless, the approach is very similar to that described for net job impacts.

Impacts of Recommended Energy Efficiency Policies

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

Table 14 presents the changes in consumer expenditures that result from these policies. While the first row in the table presents the full cost of the energy efficiency policies, programs and investments, the utility customers will likely borrow a portion of the money to pay for these investments. Thus, "annual consumer outlays," estimated at about $193 million 2010, rise to nearly $2.1 billion in 2025. These outlays include actual "out-of-pocket" spending for programs and investments, along with money borrowed to underwrite the larger technology investments. The annual energy bill savings reported in Table 14 are a function of reduced energy purchases from the many Ohio utilities and other energy providers within the state.

As we further highlight in the table that follows, the annual energy bill savings begins with a modest first year benefit of $58 million. As more and more investments are directed toward the purchase of more energy-efficient technologies, the annual consumer energy bill savings rise to about $1 billion by 2025.

Table 14. Financial Impacts from Energy Efficiency Policy Scenario

(Millions of 2006 $)	2010	2015	2020	2025
Annual Consumer Outlays	$193	$723	$1,496	$2,146
Annual Energy Savings	$111	$1,154	$2,961	$5,461
Energy Bill Adjustment Savings	$58	$267	$626	$1,059
Annual Net Consumer Savings	-$23	$431	$1,465	$3,314
Cumulative Net Energy Savings	$9	$954	$5,951	$18,980

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

Readers should note from Table 14 that in the early years and especially as the policies ramp up quickly to stimulate a greater level of efficiency improvements, the consumer outlays outweigh the energy bill savings. In 2010, the net annual savings are negative at $-23 million and a positive $431 million by 2015. These savings mount steadily through the year 2025 by when they reach an estimated $3.2 billion net annual savings for the state as a whole. The last row of the table highlights cumulative impacts. By 2025, the net cumulative savings over the period 2010 through 2025 show a strong net positive result, reaching nearly $18.9 billion.

At this point we then have the financial flows estimated as they are distributed across the end-use sectors described earlier in the report. The question then becomes what might be the impacts on the state economy as we've been able to evaluate them for a given year using the DEEPER model. The modeling then evaluates impact on jobs and wages sector-by-sector, and evaluates their contribution to Ohio's Gross State Product (GSP), which is a sum of the net gain in value-added contributions provided by the energy productivity gains throughout all sectors of the state economy. As with the previous table on financial impacts, Table 15 highlights the net impacts for the benchmark years 2010, 2015, 2020 and 2025.

Table 15. Economic Impact of Energy Efficiency Investment in Ohio

Macroeconomic Impacts	2010	2015	2020	2025
Jobs (Actual)	1,582	7,928	19,506	32,061
Wages (Million $2006)	$50	$300	$851	$1,615
GSP (Million $2006)	$58	$444	$1,310	$2,559

Given both the financial flows and the modeling framework, the analysis suggests a net contribution to the state's employment base as measured by full-time jobs equivalent. In the year 2010 we see a net increase of 1,582 jobs which increases to a significantly larger total of 32,061 jobs by 2025. The early years of the policy scenarios show small net cost to the economy. Yet we continue to see a net increase in jobs. How is this possible?

In Ohio, the electric power and the natural gas service sectors directly and indirectly employ about 3.0 and 1.5 jobs, respectively, for every $1 million of spending. But, sectors vital to energy efficiency improvements like construction, utilize 8.5 jobs per $1 million of spending. Once job gains and losses are netted out in each year, the analysis suggests that, by diverting expenditures away from non-labor intensive energy sectors, the cost-effective energy policies can positively impact the larger Ohio economy – even in the early years, but especially in the later years of the analysis as the energy savings continue to mount.

To highlight the results of this analysis in a little more detail, Figure 16 provides year-by-year impacts on net jobs within Ohio. Figure 17 highlights the anticipated net gain to the state's wage and salary compensation and Gross State Product, both measured in millions of 2006 dollars.

Figure 16. Net Job Impacts for Ohio (2008-2025)

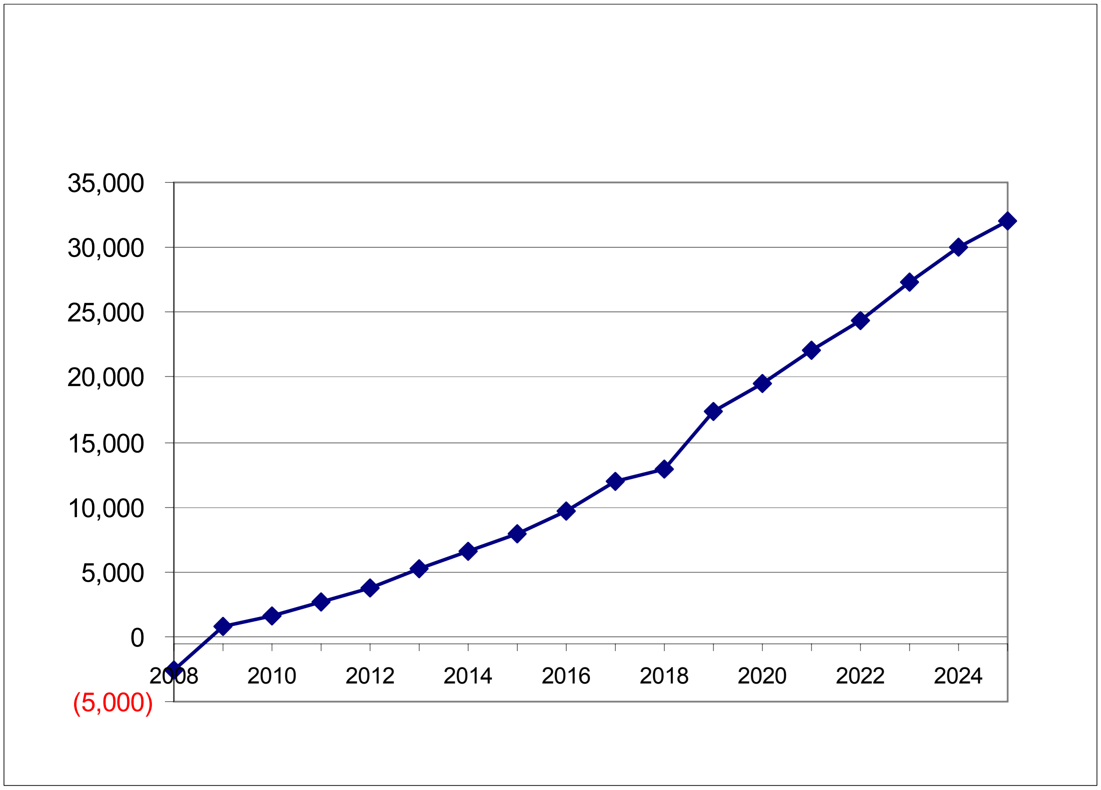


Figure 17. Wages and Gross State Product Impacts for Ohio

The end result of this policy analysis, then, suggests that an early program stimulus which drives a higher level of efficiency investments can actually increase economic impact, creating an average of 4,624 net new jobs from 2010-2015, and rising to an estimated average of 20,726 net new jobs over the last decade of the analysis. This is roughly equivalent to the employment that would be directly and indirectly supported by the construction and operation of 256 small manufacturing plants within Ohio. As indicated by Figure 17, these investments also increase both wages and Gross State Product throughout Ohio.

In short, the more efficient use of energy resources provides a cost-effective redirection of spending away from less labor-intensive sectors into those sectors that provide a greater number of jobs within Ohio. Similarly, cost-effective energy productivity gains also redirect spending away from sectors that provide a smaller rate of value-added into those sectors with slightly higher levels of value-added returns per dollar of revenue. The extent to which these benefits are realized will depend on the willingness of business and policy leaders to implement the recommendations that are at the heart of this report and found earlier in this assessment. It is also important to note that these results are not finalized. Several policy areas remain to be incorporated into the DEEPER model, including onsite solar. It is expected that finalized results will estimate a higher impact on job creation and GSP.

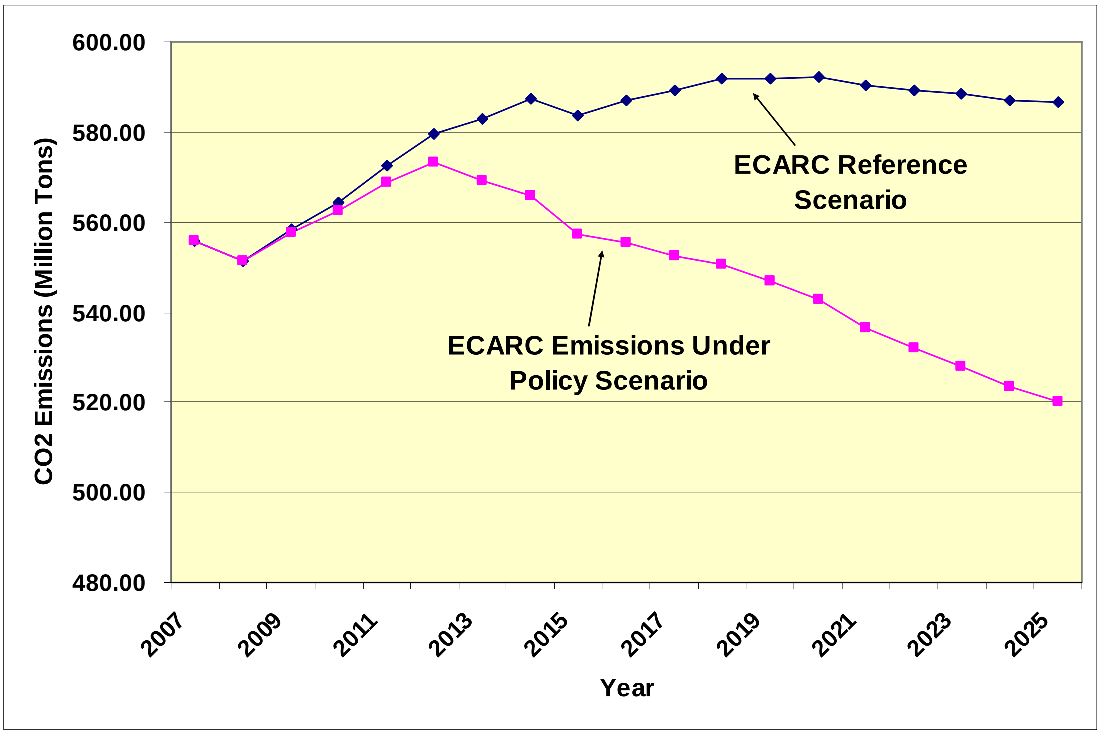
Emissions Impacts in Policy Scenario

Meeting the demand for electricity through efficiency resources reduces electricity generation; thus, any environmental impacts that would result can be avoided. Efficiency represents a cost-effective strategy to reduce global warming emissions. One caveat of the avoided emissions from efficiency that readers should note is that Ohio imports about 3% of its electricity from outside the state.

Therefore, not all of the electricity avoided through efficiency is attributable to power plants in Ohio, but rather from the PJM and MISO wholesale power markets in which Ohio participates.

The policies we suggest would reduce carbon dioxide (CO_2) emissions in the East Central Area Reliability Council (ECARC) by 5.9 million tons in 2015 and almost 20 million tons in 2025, or 1% and 3% of total emissions in the region, respectively (see Figure 18). Through 2025, energy efficiency can reduce CO_2 emissions cumulatively by around 152 million tons. In 2006, Ohio accounted for 142 million tons of CO_2 emission, more than 26% of regional emissions (EIA 2007a). Because electricity savings from efficiency policies in Ohio will have an impact across the ECARC, we therefore estimate these CO_2 reductions from energy efficiency programs and policies relative to the entire region.

Figure 18. ECARC CO_2 Emissions in Reference and Policy Scenario

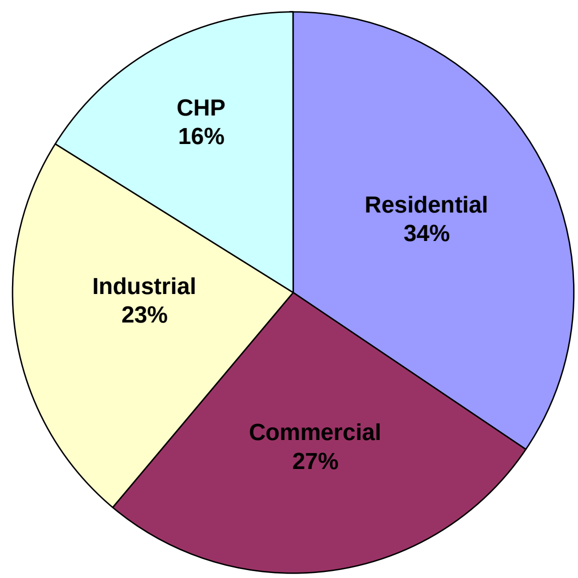


Summary of Findings

Energy Efficiency Resource Potential

ACEEE's assessment of the economic potential for energy efficiency resources in Ohio estimates efficiency resources equivalent to 33% of the electricity needs of the state in 2025. Energy efficiency resources are identified across all sectors: residential, commercial, and industrial (see Figure 19), which highlights the important fact that everyone in Ohio can make contributions to improve energy efficiency across the state. Combined heat and power and demand response contribute further to the potential for both lower electricity consumption and reduced peak demand.

Figure 19. Summary of Energy Efficiency Resource Economic Potential (64,284 GWh or 33% of Projected Electricity Consumption in 2025)



Impacts of Energy Efficiency and Demand Response

In our policy discussion above, ACEEE suggested a suite of energy efficiency and demand response policies and programs that would enable Ohio to tap into its energy efficiency resource potential. The impacts of these policies and programs on electricity consumption in Ohio over the period of this analysis are shown in Figure 20. The combined effects of efficiency and demand response on overall summer peak demand are shown in Table 16 and Figure 21.

Consumer Savings

The energy savings from these efficiency policies and programs can cut the electricity bills for customers by a net $430 million in 2015. Net annual savings grow eight-fold to $3.3 billion in 2025. While these savings will require some public and customer investment, by 2025 net cumulative savings on electricity bills will reach almost $19 billion. These savings are the result of two effects. First, participants in energy efficiency programs will install energy efficiency measures, such as more efficient appliances or heating equipment, therefore lowering their electricity consumption and electric bills. In addition, because of the current volatility in energy prices, efficiency strategies have the added benefit of improving the balance of demand and supply in energy markets, thereby stabilizing regional electricity prices for the future.

Figure 20. Estimated Reductions in Electricity Use in Ohio through Energy Efficiency

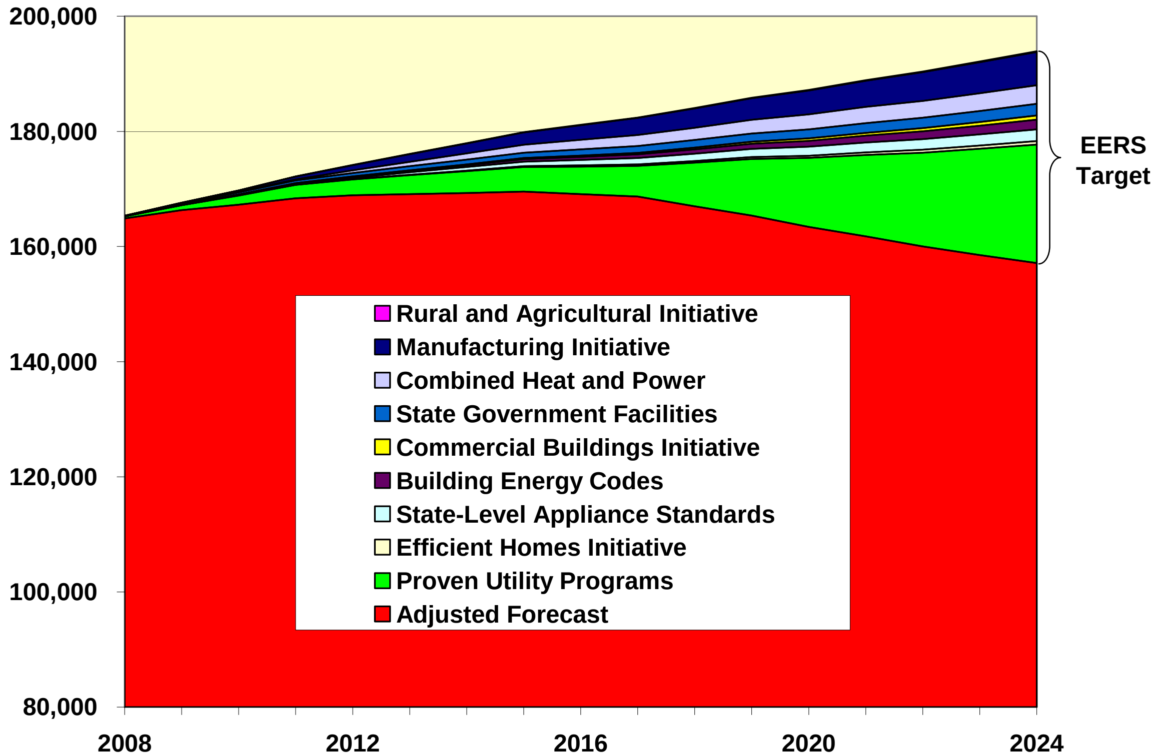


Table 16. Summary of Peak Demand Reduction Potential in Ohio

	2015	2025	% Reduction
Energy Efficiency Peak Reductions	1,550	7,081	18%
Demand Response Peak Reductions	2,064	4,335	11%
Total Peak Reductions	3,615	11,416	**29%**
% Reduction (total relative to forecast)	**10%**	**29%**	

Macroeconomic Impacts

Investments in efficiency policies and programs have the added benefit of creating new, high-quality "green-collar" jobs in Ohio and increasing both wages and Gross State Product (GSP). Our analysis shows that energy efficiency investments can create over 32,000 new jobs in Ohio by 2025 (see Table 17) including well-paying trade and professional jobs needed to design, install, and operate energy efficiency measures. These new jobs, including both direct and indirect employment effects, would be equivalent to over 300 new manufacturing facilities relocating to Ohio, but without the public costs for infrastructure or the environmental impacts of new plants.

Figure 21. Estimated Reductions in Summer Peak Demand through Energy Efficiency and Demand Response (2025 peak reduction = 11,416 or 29%)

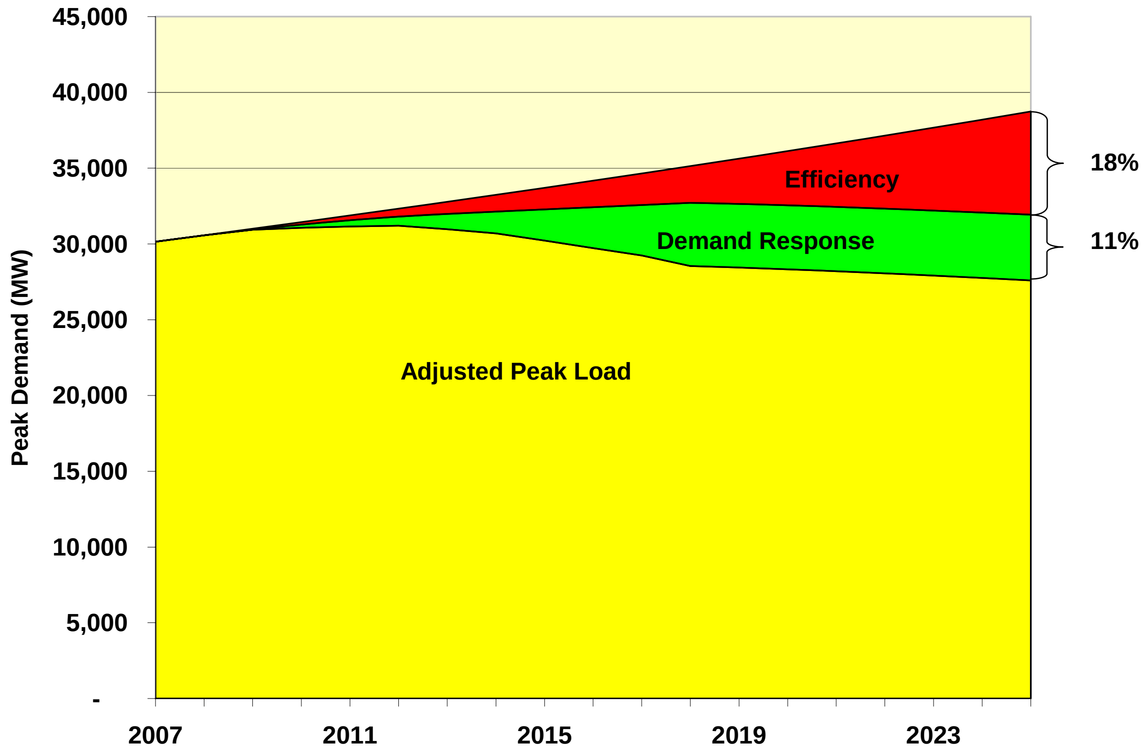


Table 17. Economic Impact of Energy Efficiency Investments in Ohio

Macroeconomic Impacts	2015	2025
Jobs (Actual)	7,928	32,604
Wages (Million $2006)	300	1,615
GSP (Million $2006)	444	2,559

Discussion and Recommendations

ACEEE offers this report to the state of Ohio to help inform its deliberations on energy and climate change policies. We have attempted to tailor our nationwide experiences to the specific needs and opportunities of the state, recognizing that what is implemented with respect to programs and policies should be a decision of the citizens through their elected officials.

The objectives of this report are threefold:

- to engage various stakeholders in Ohio who have a vested interest in energy issues on the political viability of energy efficiency
- to perform an analysis of the potential for increased energy efficiency in Ohio and to make and analyze specific policy suggestions tailored to Ohio; and
- to inform the dialogue of Ohio stakeholders as energy efficiency policies and programs are considered utilizing the study's findings and to provide ongoing follow-up (as resources allow) to interested parties.

Our intention is that this report be used as a roadmap for further development of energy efficiency policies and programs. In preparing this report, ACEEE has drawn upon almost three decades of experience working on energy efficiency policies and programs. Our policy suggestions and examples of utility-run programs are based upon our assessment of "best practices." We have attempted in many places to identify resources that are available for further development, and stand prepared to assist Ohio with additional information and referrals. Ohio's policymakers must focus on what policies and program options they are committed to pursuing.

Role of Key Policymakers

The review of our policy suggestions included possible entities that are well-positioned to lead their implementation. In our prior research, we have documented that many of these policies and programs can be successfully implemented by a number of different entities, though the choice remains with the policymakers.

- ***The Governor*** – Governor Strickland has already established himself as a key figure in the advancement of energy efficiency across the state of Ohio. In August 2007, Governor Strickland announced his Energy, Jobs, and Progress plan, which effectively set the gears in motion for the introduction and subsequent passing of SB 221 in April of 2008. The Governor has the potential to implement at least parts of a number of our suggestions, including the expansion of the state and local facilities initiative. In part, the Governor's most important role may be to use his position to raise awareness among the policy community and the public as to the role of energy efficiency in utility and climate policy. The Governor will also have to play a role in securing long-term funding for state-sponsored initiatives.
- ***Legislature*** – The Ohio legislature has already played a key role in setting Ohio on its current energy path and will continue to play a pivotal role because of its ability to both fund and direct energy policy for the state. The legislature should consider such steps as adoption of state appliance and equipment efficiency standards; updating state residential and commercial energy codes as they are introduced by the IECC and ASHRAE; and allocating funds from the American Recovery and Investment Act. The legislature will also have to secure long-term funding for these initiatives.
- ***Electric Utilities*** – Ohio's investor-owned utilities are legally obligated to meet the efficiency requirements set by SB 221. The suite of policies we have suggested the PUCO allow to contribute towards the EERS will meet a significant part of the target so that utilities will only have to rely on their own proven programs to meet 12% of the 22% consumption savings target.
- ***Ohio Air Quality Development Authority*** – The OAQDA, through its bond underwriting capability, has the authority to fund programs directly impacting activities that contribute to air pollution within the state. Because energy efficiency has the ancillary benefit of reducing emissions attributable to electricity generation, OAQDA funding can be utilized for a number of efficiency programs.
- ***State Agencies*** – Various agencies would have a significant role in implementing provisions such as the advanced buildings initiatives, as well as the manufacturing and agricultural/rural initiatives. These agencies would also be involved in the education and outreach effort that would be crucial in engaging the state's consumers with the information needed for them to make informed energy investment decisions. Funding from the American Recovery and Reinvestment Act will be available for these purposes, but there will be a need to secure long-term funding as well. Long-term funding could come from future climate change legislation mandated at the federal level or through utility rates.
- ***Local Governments*** – Local government entities are uniquely positioned to implement several important policies such as building energy codes and programs for local government facilities (as discussed in Elliott and Eldridge 2007). Funding from the American Recovery and Investment Act will be available for these purposes.

- ***State Educational System*** – With the identification of Ohio's workforce as a key requirement, the state educational system would be responsible for ensuring that a trained workforce is developed to fill the jobs that increased investment in energy efficiency would create.

Industrial Self-Direct

SB-221 includes a provision, which can be implemented at the option of the PUCO, to allow for large electric consumers to opt-out of paying utility energy efficiency program charges if they implement energy efficiency projects at their own facilities at their own expense. The motivation for this results from a perception by some large consumers that the programs offered to them by the utilities are not responsive to their needs (ELCON 2008). The history of this type of provision has been mixed, with some self-direct programs not requiring rigorous evaluation, measurement and verification of the customer implemented measures. In these instances, it's been very difficult to determine if the savings projected by industrial customers has been achieved.[54] To address this concern, the PUCO could require that the customer who chooses to self-direct retain at their own expense a commission-approved contactor to undertake an assessment of the savings to ensure that they are in compliance with their savings obligation.

As an alternative, the PUCO and the utilities can ensure that program offerings are responsive to the needs of the manufacturing sector. This approach is consistent with our recommendation for the establishment of the *Ohio Manufacturing Initiative* that we have proposed as part of the suite of innovative policies, based on our consultation with Ohio industrial trade associations. We see this approach as preferred for both the state – since industrial energy efficiency savings tend to be lower cost than other sectors – and the customers – since they receive the benefits of a program tailored specifically to meet their needs. It also helps ensure that the lessons learned and institutional knowledge gained by administering efficiency programs to the largest industrial customers benefits future industrial customers. This approach has worked well with the Oregon Energy Trust and BC Hydro in Canada.[55]

Program and Policy Implementation

Beyond the obligation of Ohio's private utilities to implement energy efficiency, there are many entities in the electricity market, both consumers and providers, which have voiced their support for energy efficiency and are willing to invest voluntarily. Leveraging these other market players could increase the prevalence of energy efficiency significantly. For example, the OMA, through its Energy Efficiency Collaborative, and the University of Dayton, through its IAC program, are beginning or have already begun to deliver services to the manufacturing community, so building on these existing efforts allows expanded services to be delivered more quickly. Our meeting with the Ohio Hospital Association revealed that integrating distributed generation, such as combined heat and power, into their operations could reduce their operating costs in light of their perpetual need for massive amounts of electric power. Buckeye Power, Inc., an electric cooperative owned by Ohio's 25 rural electric cooperatives, has also taken a keen interest in energy efficiency, though demographics and the sparse service areas of these cooperatives preclude them from achieving the level of savings expected from Ohio's IOU's.

Evaluation, Measurement, and Verification (EM&V)

The implementation of energy efficiency policies and programs must include a mechanism that emphasizes transparency and ensures success. Funding of and participation in efficiency programs will only be guaranteed, however, if policymakers and consumers are cognizant of the benefits these programs are delivering, which, of course, also requires that these benefits be verified. An inherent

[54] From discussions between Anna Chittum and multiple industrial energy efficiency program managers, January – March 2009.
[55] Ibid.

element of any attempt to advance energy efficiency is an indigenous entity dedicated to the evaluation, measurement, and verification of efficiency programs. As the utility regulatory body, the PUCO is ideally situated to command this role. However, adding EM&V to the PUCO's obligations would require time to organize and staff so that it would be able to fully engage in its new duties.

Allocation of Benefits from Energy Efficiency

Reducing total electricity consumption is an effect of energy efficiency that avails customers through lower electricity bills, but can be a bane for utilities as lower sales mean lower revenues. Naturally there is concern from IOU's and their shareholders that, over time, dwindling revenues could impede utilities' ability to provide energy services due to decreased earnings or financial margins. To counter this phenomenon, IOU's have expressed their interest in pursuing cost recovery in order to guarantee a return on their efficiency investments, which can be done through decoupling, performance-based incentives, or some other rate mechanism (EPA 2007b). ACEEE does not support one method over another, but it is vital that energy efficiency benefits be allocated fairly between ratepayers and shareholders alike. Nonetheless, it is also important that utilities earn profits equivalent to what they would under a supply-only scenario.

CONCLUSIONS

The State of Ohio is poised to make great strides in expanding efficiency throughout the state. As this report documents, there is tremendous potential for Ohio to become a national leader in efficiency and to take advantage of the numerous cost-effective energy efficiency and demand response opportunities that exist in the state. Nonetheless, Ohio does have some difficult decisions to make with regards to its energy future. Faced with severe budgetary constraints and a slumping economy, there may be an inclination to dispel energy efficiency in light of the present conditions. Regrettably, the ramifications of a bleak economic outlook have already begun to impact important energy policy decisions, such as the state's rollback of its building energy codes. It is therefore extremely important that the momentum created by the establishment of the aggressive EERS target by legislation included in SB 221 not be lost. This legislation has sent a strong signal of Ohio's intent, which in large part contributed to its respectable ranking in ACEEE's 2008 state energy efficiency scorecard. However, Ohio will have to continue to balance its priorities in order for energy efficiency to affect its economy as beneficially as this report highlights.

The various energy efficiency and demand response policies we suggest have been successful in other states at delivering efficiency resources and reducing consumer electric expenditures. We estimate efficiency can meet 122% of the increase in the state's electricity needs over the next 17 years, while meeting 188% of the increase in peak demand and reducing emissions by over 12%. What is more, these policies and programs can accomplish this at a lower cost than building new supply infrastructure, while simultaneously creating over 32,000 new, high-quality "green collar" jobs by 2025.

Our suggestions are intended to be the starting point for dialog among stakeholders on how to realize the demand-side efficiency resource potential in the state, particularly given the economic challenges it faces. ACEEE's suggestions are based on our review of existing opportunities and stakeholder discussions, and reflect proposals that we think are politically viable. However, it is important to note that these suggestions will not necessarily meet all of the state's future energy needs. While energy efficiency is perhaps the only new energy resource available that can be deployed quickly in the short term and continue to contribute significantly into the long term, the state will still require additional resources to meet any new load while replacing older, dirtier generation plants as they are retired. Furthermore, additional policies and programs exist that could be implemented to realize even more of the available energy efficiency resources. Ultimately, energy efficiency can delay the immediate need for investments in infrastructure, allowing Ohio the time to rigorously consider its future resource choices.

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APPENDIX A – REFERENCE CASE

A.1. Projection of Electricity Consumption and Peak Demand

The development of the reference case for Ohio is the foundation of the quantitative analysis of the report. The first task in developing an energy efficiency and demand response potential assessment is to determine a reference case forecast of energy consumption, peak demand, and electricity prices in the state in a "business as usual" scenario. As with all forecasts, they are subject to significant uncertainty, particularly in times such as we are in when the economic outlook is a major unknown. It is however important to understand that while the forecast may affect the final numbers resulting from the analysis, that the forecast has very minor impact of the effectiveness of the proposed policies, particularly in the long-run.

When developing a reference case, it is preferable to use forecasts that are specific to the state or region and that are agreed upon by key stakeholders. Initially we used a report released by the Public Utilities Commission of Ohio (PUCO) in 2008 forecasting electricity consumption and peak demand over the 2008-2027 period, which included historical data starting in 2002. However, the historical data from the PUCO forecast were not consistent with consumption data from the Energy Information Administration's *Electric Power Annual* (EIA 2007b) and *Annual Energy Outlook* (EIA 2007c) and neither reflected current economic conditions in their projections. We elected to use the forecast we estimated based on the EIA's data until we were able to clear up the reasons for the variations between the PUCO and the EIA forecasts.

In the meantime, several key stakeholders voiced their concern about basing our forecast off data from the EIA as opposed to using the PUCO forecast. Ultimately the PUCO responded about the variations, noting that the 2008 forecast had been made with data several years old and providing an updated forecast using the most recent data. However, the updated forecast has not yet been published and did not include a breakdown of electricity consumption by sector. We thus chose to continue to use the forecast we developed based on the EIA data because it was not significantly different in the long-term from the PUCO forecast. We also felt our forecast was more current and that we had a greater understanding of the strengths and deficiencies of our forecast than we did with the PUCO forecast.

A.1.1 Electricity Consumption Forecast

To develop our electricity consumption forecast we used a number of data sources. For historical sales, covering 2002 through 2007, we used data from the EIA's *Electric Power Annual* (EIA 2007b), which publishes consumption data for all states individually. To estimate projected consumption, we then applied sector-specific growth rates, derived from the EIA's *Annual Energy Outlook* (EIA 2007c) forecast for the East Central Area Reliability Coordination Agreement (ECARC), to actual 2007-year electric sales data. Using this methodology, we estimated total electricity consumption in the state to grow in the reference case at an average annual rate of 1.0% between 2008 and 2025, and 1.0%, 1.6%, and 0.4% in the residential, commercial, and industrial sectors, respectively (see Figure 5). Total electricity consumption in the three sectors in 2007 was 161,547 GWh and in the reference case grows to 177,954 GWh in 2015 and 193,945 GWh in 2025 (PUCO 2009).

A.1.2 Peak Demand Forecast

To forecast peak demand we adjust our data from the electricity sales forecast using a system load factor, which we assumed to be 60.0%. Using this methodology, we estimate peak demand growing at an average annual rate of 1% over the 2008-2025 period. In 2008, peak demand is expected to reach 33,705 MW increasing to 36,586 MW by 2015 and 39,770 MW in 2025.

Table 18. Retail Electricity Sales and Peak Demand Forecast

	2010	2015	2020	2025	Average Annual Growth Rate
Electricity (GWh)					
Residential	56,925	60,011	63,217	65,748	**1.01%**
Commercial	50,571	55,383	59,662	64,510	**1.63%**
Industrial	60,112	62,559	62,974	63,688	**0.43%**
Total	**167,607**	**177,954**	**185,853**	**193,945**	**0.98%**
Summer Peak Demand (MW)					
Total	**34,497**	**36,586**	**38,612**	**39,770**	**0.98%**

A.1.3. Ohio Population Forecast

Population estimates were needed for this analysis to determine per-capita sales data. We consulted Economy.com (2008) for data on population in the State of Ohio. According to this source, population in Ohio will grow at an average annual rate of about 0.21%.

Table 19. Ohio Population Forecast

	2010	2015	2020	2025	Average Annual Growth Rate
Population Estimate	11,509,050	11,574,410	11,696,320	11,883,570	0.20%

A.2. Projection of supply prices and avoided costs

Synapse Energy Economics developed projections of supply prices and avoided costs used in this analysis. These estimates were developed based on key input assumptions that were developed as part of the stakeholder engagement process. Synapse then developed a simplified Electricity Planning and Costing Model to develop the projections. As noted in the main report, two set of projections were developed for the reference and moderate policy cases.

A.2.1. Caveats

The projections of production costs and avoided costs presented in this memo are based upon a number of simplifying and conservative assumptions that the stakeholder group consider reasonable for the purpose of this high-level policy study. These simplifications include use of a single annual average avoided energy costs to evaluate the economics of energy efficiency measures rather than different avoided energy costs for energy efficiency measures with different load shapes. In addition, Synapse Energy Economics considers it unrealistic to rely upon projections that exclude the cost of compliance with anticipated CO_2 emission regulations.

A.2.2. Key Assumptions

This section describes the key inputs to the electricity model that Synapse Energy Economics has developed for this project (Synapse electricity cost model), the rationale for the proposed values and the sources of those values. The final inputs are based upon a set of draft inputs developed by

Synapse[56] that ACEEE reviewed with key stakeholders in Ohio. The key substantive difference between these final input assumptions and the draft input assumptions was the use of a lower peak load factor, from 66.2% to 60.0%.

The memo also provides a description of the Electricity Cost model that we use to estimate future production costs and avoided costs.

Changes from the December 8 version, Deliverable 1A, are indicated in ***italics***.

A.2.3. Input Assumptions

The key inputs to the electricity model are presented under the following thirteen categories:

- Basic Modeling assumptions
- Base year Sales and revenues
- Base year Load and resource Balance
- In-State Base Year Generation Resource Performance and Cost Data
- New Generation Resource Performance and Cost Data
- Fuel Types
- Annual Energy and Peak Load
- Capacity retirements
- Capacity additions
- Fuel prices
- Purchased Power Costs
- Carbon Emission Costs
- Wholesale Market Prices

Basic Modeling Assumptions:

- The base year is 2007. All monetary values are reported in constant 2006 year dollars unless noted otherwise.
- The study period begins in 2008 and ends in 2030, an analysis period of 23 years.
- The reporting period is 2009 through 2025, a total of 17 years.
- The financial parameters for costing resource additions are as follows:
    - Inflation Rate. 2.50%. Rationale - the twenty year average (1987-2006) derived from the chained GDP deflator is 2.47%.
    - Nominal Discount Rate. 10.0%. This represents the value for an independent power producer with a mix of equity and bond financing. Based on a 50/50 equity/debt mix with 12% for equity and 8% for debt. Used for levelization of capital expenditures. Actual rates for specific projects will vary depending on the nature of the project and the implementing entity.

[56] Deliverable 1A Draft Input Assumptions for Electricity Cost Model, December 8, 2008.

- Real Discount Rate. ***7.32%***. Derived from the Nominal Discount Rate and the Inflation Rate.
- Income Tax Rate. Federal rate of 35% and Ohio state corporate rate of 6.8%. Property tax rate at the nominal level of 0.5% per annum of the initial plant cost (local rates vary considerably). Used for capital cost levelization.

A.2.4. Base Year Sales and Revenues

The historic sales and revenues data are obtained from the EIA's "State Electric Profile" Table 8 (http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html). This has been supplemented with data for 2007 from the EIA "Electric Power Monthly" report of March 2008 which contains data through December of 2007 (Tables 5.4 and 5.5) (http://www.eia.doe.gov/cneaf/electricity/epm/epm_ex_bkis.html). The historic data indicates that Ohio is net exporter and generates about 12% more electricity than it needs. Likewise the capacity in Ohio is in excess of the in-state peak loads.

A.2.5. Base Year Load and Resource Balance

The historic sales and revenues data are obtained from the EIA's "State Electric Profile" Tables 5, 8 and 10 (http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html). This has been supplemented with data for 2007 from the EIA "Electric Power Monthly" report of March 2008 which contains data through December of 2007 (tables 1.6, 4.6, 4.20, 4.12 and 4.13) (http://www.eia.doe.gov/cneaf/electricity/epm/epm_ex_bkis.html).

Our forecasts of future net imports and exports of electricity are based on this reference year data and thus are consistent with the existing transmission system. We did not model or forecast projected changes in transmission transfer capability. Instead, our model assumes that future imports and exports will be at the same relative level as in the recent past and that transmission transfer capability will change in the future to match load growth and that level of relative imports and exports.

A.2.6. In-State Base Year Generation Resource Performance and Cost Data

From the above EIA data, we have the generation, CO_2 emissions and fuel costs for each generating group. From that we can derive the average heat rate for each group and the fuel component of the generation costs. To that we add typical industry values for O&M. Also from that EIA data we have the historic capacity factors associated with resource group. Those historic patterns are used to set the basis for future performance.

The capacity factors used are the historic average for all plants using a given fuel in the state. Some newer plants do much better, but because there is so much coal capacity in Ohio some older coal plants must cycle and follow load. The data includes average historic emission rate data for all pollutants. Emission allowance costs for pollutants, other than CO_2, are reflected in the O&M costs.

A.2.7. New Generation Resource Performance and Cost Data

For new generation resources we have used the technology parameters from the AEO 2008 Assumptions document. For capital costs we have used our professional judgment based on a number of sources to reflect current cost expectations for new construction. The costs represent the all-in costs, including construction financing costs, as of the year of operation. No CO_2 retrofit costs are assumed other than the allowance cost of CO_2 emissions. Fixed costs of new capacity are allocated over the generation from that new capacity based on the expected operating capacity factor of the new resource.

A.2.8. Fuel Types

We use the three basic fuel types as specified in the EIA documents (Coal, Petroleum and Natural Gas) with the addition of nuclear and biomass.

A.2.9. Annual Energy and Peak Load

For energy and peak loads we have used the ACEEE Reference Case Forecast as of 11/24/08 that increases historic load at the rates as represented in the AEO 2008 report for the East-Central region. A system load factor of ***60%*** based on 2007 load data is used to produce future peak loads based on forecasted energy use.

A.2.10. Capacity Retirements

There is very little information about future plant retirements and a variety of unknown circumstances may either work in favor of or against individual plants. We have attempted to reflect the generation retirements (Future Deactivation) posted on the PJM website as well as the aging of plants in future years. Ultimately we forecast modest gradual retirement of existing resources in the model. But it is quite likely that many existing plants will be retrofitted and their lives extended.

A.2.11. Capacity Additions

In order to meet future load growth, new generation resources must be added to the existing generation mix.

The electricity model is not a capacity expansion model that optimizes capacity additions by choosing among a set of resource alternatives to develop a least cost expansion plan. Instead, we will add new resources “manually” to meet reserve needs. Our analysis will consider three sets of additions:

- Planned Additions—Near-term proposed new additions or uprates to existing plants that are in development or advanced stages of permitting and have a high likelihood of reaching commercial operation;
- RPS Additions—Renewable generators that are added to meet existing or anticipated renewable portfolio standards (RPS) in each state; and,
- Generic Additions—New, generic conventional resources that are added to meet the residual capacity need after adding planned and RPS additions.

<u>Planned Additions</u>

Description: Our near-term entry forecast is guided by the projects in the PJM Interconnection Queue plus the expected addition of some additional future coal resources based upon market conditions in MISO and in Ohio in general based on the types of projects in the PJM queue. Looking at the 2010-2013 period for Ohio, the mix is about 85% coal, 13% wind and 2% for a mix of various other types. Based on this we have added 2,200 MW of new coal capacity by 2012. For PJM as a whole though, the queue is 66% natural gas and new natural gas generation is also likely in Ohio depending on load growth and other factors.

***Data Sources**:* PJM Interconnection Queue Requests.

<u>AEPS Additions</u>

In 2008, Ohio enacted S.B. 221 establishing an Alternative Energy Portfolio Standard (AEPS) (enacted 5/1/2008 and effective 1/1/2009) with alternative energy and renewable generation requirements. The renewable requirement takes effect in 2009 and increases to a target of 12.5% by 2024. The solar component of this requirement increases to 0.5% of retail sales in that target year.

Eligible renewable resources are defined to include the following technologies: solar photovoltaics (PV), solar thermal, wind, geothermal, biomass, biologically derived methane gas, landfill gas, certain non-treated waste biomass products, fuel cells that generate electricity and qualified hydroelectric facilities.[57]

The specific mix of these resources is not known, but we have assumed for the renewables (less the solar component) that 1/3 of the energy will come from wind and 2/3 from biomass.

The operating characteristics are based on AEO 2008 and Synapse estimates derived from experience elsewhere in the US.

Generic Additions

In order to reliably serve the forecasted load in the mid- to long-term portion of the forecast period, new generic additions will need to be added to the model. A range of generation technologies was initially considered for this purpose, including gas/oil-fired combined-cycle, gas/oil combustion turbines, conventional coal, and nuclear. We use the mix represented in the PJM Interconnection Queue as the guide.

Generic additions based on requirements after the AEPS additions specified above are based on meeting a system-wide reserve goal. For these generic additions we use a mix of 30% conventional coal, 35% NGCC and 35% gas peakers.

A.2.12. Fuel Prices

We start with fuel prices reported for the base year of 2007. In general the price forecasts are basically long-term reflecting underlying conditions as presented in the Annual Energy Outlook of 2008 (Table 64). We have however updated those AEO forecasts of natural gas and crude oil prices based on market conditions as of 11/13/2008.

We used several sources to reflect current prices through mid 2008, and expectations for the future.

- For natural gas our projection of wholesale prices in Ohio for the next twelve years is equal to the Henry Hub price per the NYMEX futures as of November 13, 2008 plus a basis differential based on the state and Henry Hub prices in the reference year. After that point we apply the relative price trends from the AEO 2008 modeling.
- Petroleum prices are set at a historically determined multiple of natural gas prices.
- For coal we use the reported base year cost scaled by the relative year to year changes from AEO 2008.

A.2.13. Power Purchase and Sale Prices

Ohio utilities operate in two wholesale electricity markets. AEP and Dayton Power & Light operate in PJM, while Duke Ohio and FirstEnergy operate in MISO. The prices for wholesale electric energy delivered in Ohio from each of those two markets are very similar. Using 2007 as the reference year, the annual average energy price at the PJM Ohio Hub was $46.18/MWh while the annual average prices to FirstEnergy from MISO was $45.57/MWh in the Real Time market and $46.13/MWh in the Day Ahead market. Thus the price for the PJM Ohio Hub is a reasonable estimate of wholesale energy prices to Ohio for either ISO.

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[57] Information obtained from DSIRE (Database of State Incentives for Renewables & Efficiency). *Ohio Incentives for Renewables and Efficiency – Alternative Energy Resource Standard.* 12/5/08 at http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=OH14R&state=OH&CurrentPageID=1&RE=1&EE=1

This wholesale energy market price is applied to the interstate net purchase/sale of energy and thus is only a relatively small factor in the final model results. As noted earlier, our model assumes that future imports and exports will be at the same relative levels as in the recent past and that prices for those imports/exports will follow the same trajectory as average prices in Ohio.

The price forecast is discussed in Section 13 below.

A.2.14. Carbon Emission Costs

Carbon compliance costs are set at the Synapse 2008 mid-case level (see Schlissel 2008).

A.2.15. Wholesale Market Prices

Since much of Ohio operates within the deregulated PJM and MISO markets, any changes in load will be reflected as savings or costs based on those market prices. This consists of two major components - the Energy and the Capacity markets.

The starting point for the market energy price forecast are the PJM futures market Energy futures for the PJM Western Hub are traded in NYMEX and are available through 2012. However those prices are then adjusted to reflect Ohio markets. The first step is to calculate the differential between the Ohio and the PJM Western Hub. The calculations begin with the actual 2007 price for the PJM Ohio Hub, which was $46.12/MWh. This annual average price was $13.59 below the 2007 annual average price for the PJM Western hub. Also as noted in Section 11, the 2007 Ohio energy prices in both PJM and MISO were nearly the same, so this forecast is applicable for the entire state. Our forecasts of prices for the Ohio consist of futures prices for the PJM Western Hub plus the "basis differential" between the PJM Western Hub and the Ohio markets. This represents a whole state energy price consistent with historic data.

For the capacity cost we use the RTO prices from the PJM RPM auction which are also available through 2012. The energy and capacity prices are then combined to produce a total market-based avoided cost.

The market price is an approximation that reflects general behavior, but does not capture the details of any specific purchase and sale agreements. This price also only applies to the interstate net purchase/sale of energy and thus only a relatively small component of the final model results.

A.3. Electricity Planning and Costing Model

This model was developed by Synapse for ACEEE's clean energy state studies.

A.3.1. Background

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

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

ACEEE retained Synapse to provide three deliverables to support these studies

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

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

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

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

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

A.3.2. Methodology

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

A.3.3. Base Year Data

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

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

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

A.3.4. Future Years

We begin with the forecast of annual demand and energy in each future year provided by the ACEEE stakeholder group.

Next we develop a physical plan to meet the load in each of those future years. This is done in the model via the following steps:

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

A.3.5. Calculate Production Costs

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

States with Regulated Wholesale Markets

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

6. Calculate total cost of generation from existing in-state resources, purchases from out-of-state resources, and new in-state resources.
    a. The unit production costs of existing in-state generation includes variable operating costs plus fixed costs.[58] The aggregate cost of generation from these resources decline over time as existing coal, oil and gas plants are retired, while the existing nuclear plants with low operating costs continue operation;
    b. The unit production costs of new in-state generation consists of the levelized capital cost of new capacity additions plus their variable operating costs. The capacity cost of new capacity additions are levelized using the capital recovery factors developed in the Capital Recovery Calculation (CRC) worksheet.

[58] For existing resources fixed costs are estimated on an aggregate basis based on the base year difference between fuel and other variable costs and the retail revenues less a retail markup component.

   c. The cost of power imported or exported is indexed to the generation-weighted average cost of generation from the in-state resources, i.e., existing and new. That is, the base-year import/export price changes in parallel with the in-state cost, e.g. an x% change of in-state production costs is reflected in an x% change of import/export prices. The rationale is that relative changes of in-state costs will be reflected outside the state as well.

States with Deregulated Wholesale Markets

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

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

A.3.6. Calculate Avoided Costs

States with Regulated Wholesale Markets

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

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

States with Deregulated Wholesale Markets

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

11. Near-term years for which futures prices are available, e.g. first 4 to 5 years.
    a. Avoided energy cost – This is calculated from the energy futures market prices with appropriate historic-based adjustments for the state service area.
    b. Avoided capacity cost – This is based on the available appropriate capacity market results.
    c. Total avoided cost – This is obtained by combining the avoided energy cost with the avoided capacity cost using the base year system load factor to arrive at the combined total avoided cost on a per MWh basis.

12. Long-term years for which futures prices are not available. After the period for which futures are available, the total avoided costs, avoided capacity cost, and avoided energy cost are developed in the same manner as for regulated states, in steps 8, 9 and 10.

A.4. Reference Case Electricity Supply Prices and Avoided Costs

This section presents Synapse's projections of *Reference Case* electricity supply prices and avoided costs for Ohio. The projections are outputs from the electricity costing model that Synapse has developed for this project. The inputs to the model and the structure of the model are described above.

A.4.1 Reference Case Electricity Supply Prices

There reference case load forecast, load forecast, and supply prices are presented in Table 20. The supply forecast exceeds the load forecast by the level of estimated losses in transmission and distribution. The supply prices include the projected incremental generation costs each year, the retail margin each year and the resulting total average retail rate.

A.4.2. Avoided Electricity Costs

The avoided costs are presented in Table 21. The avoided capacity costs are presented in $/kW-year while the avoided electric energy costs are given in ¢/kWh.

Table 20. Reference Case Load, Supply and Price Forecasts

All costs in constant 2006 dollars.

CASE: **Ohio Reference Case - 1/16/09**

Category	Units	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Load Forecast																		
Retail Energy	GWh	165,334	167,560	169,652	172,047	174,016	175,872	177,709	179,587	180,817	182,011	183,632	185,362	186,657	188,317	189,744	191,427	193,173
Retail Demand	MW	31,456	31,880	32,278	32,733	33,108	33,461	33,811	34,168	34,402	34,629	34,938	35,267	35,513	35,829	36,100	36,421	36,753
Supply Forecast																		
Capacity Requirement	MW	39,144	39,672	40,167	40,734	41,200	41,639	42,074	42,519	42,810	43,093	43,477	43,886	44,193	44,586	44,924	45,322	45,736
Capacity Sources																		
In-State Capacity	MW	33,842	33,586	33,900	34,278	34,753	36,543	36,377	36,918	37,275	37,531	37,827	38,230	38,612	38,877	39,290	39,565	39,969
Out-of-State Capacity	MW	5,302	6,086	6,267	6,456	6,447	5,096	5,698	5,601	5,535	5,562	5,650	5,656	5,581	5,709	5,634	5,757	5,767
Total Capacity Provided	MW	39,144	39,672	40,167	40,734	41,200	41,639	42,074	42,519	42,810	43,093	43,477	43,886	44,193	44,586	44,924	45,322	45,736
Energy Requirement	GWh	178,907	181,316	183,580	186,171	188,302	190,310	192,298	194,331	195,662	196,953	198,707	200,579	201,981	203,778	205,321	207,143	209,032
Energy Sources																		
In-State Generation	GWh	155,357	154,247	155,392	156,771	158,501	167,503	168,005	171,747	174,650	177,099	179,759	182,925	185,987	188,521	191,727	194,306	197,470
Out-of-State Generation	GWh	23,550	27,070	28,188	29,400	29,800	22,807	24,293	22,584	21,011	19,855	18,948	17,654	15,995	15,256	13,594	12,836	11,562
Total Energy Provided	GWh	178,907	181,316	183,580	186,171	188,302	190,310	192,298	194,331	195,662	196,953	198,707	200,579	201,981	203,778	205,321	207,143	209,032
Supply Price Forecast																		
Average Production Cost	¢/kWh	5.01	5.09	5.18	5.24	6.53	6.86	7.06	7.29	7.51	7.72	7.92	8.12	8.30	8.50	8.70	8.89	9.09
Retail Adder	¢/kWh	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42
Average Retail Rate	¢/kWh	7.43	7.51	7.60	7.66	8.95	9.28	9.48	9.71	9.93	10.14	10.34	10.54	10.72	10.92	11.12	11.31	11.51

Table 21. Reference Case Avoided Costs

All costs in constant 2006 dollars.

CASE:	**Ohio Reference Case - 1/16/09**																	
Category	Units	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Avoided Costs by costing period																		
Avoided Resource Cost	¢/kWh	5.40	5.83	5.73	6.50	7.62	8.71	8.78	8.84	8.92	9.00	9.08	9.17	9.23	9.37	9.49	9.63	9.80
Avoided Capacity Cost	$/kW-yr	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23
	¢/kWh	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
Avoided Energy Only Cost	¢/kWh	3.97	4.40	4.30	5.07	6.18	7.28	7.35	7.41	7.49	7.57	7.65	7.74	7.80	7.94	8.06	8.20	8.37

Notes: Avoided Resource Costs represent avoided production costs (fuel, O&M, CO2) for all resources, plus levelized capital costs for new resources.
Avoided Capacity Cost in $/kw-yr is converted into an energy cost equivalent (c/kWh) using the system load factor.
Avoided Energy Cost represents Total Avoided Resource Cost less Avoided Capacity Cost expressed as energy cost equivalent.

A.5 Policy Case Electricity Supply Prices and Avoided Costs

This section presents Synapse's projections of *Policy Case* electricity supply prices and avoided costs for Ohio. The projections are outputs from the electricity costing model that Synapse has developed for this project as discussed above. ACEEE provided the Policy Case Load Forecast.

A.5.1. Policy Case Electricity Supply Prices

The Policy Case load forecast, supply forecast, and supply prices are presented in Table 22. The supply forecast exceeds the load forecast by the level of estimated losses in transmission and distribution. The supply prices include the projected incremental generation costs each year, the retail margin each year and the resulting total average retail rate.

A.5.2. Avoided Electricity Costs

The avoided costs are present in Table 21. The avoided capacity costs are presented in $/kW-year while avoided electric energy costs are given in ¢/kWh.

Table 22. Policy Case Load, Supply and Price Forecasts

All costs in constant 2006 dollars.																		
CASE:	**Ohio Policy Case - 3/10/09**																	
Category	Units	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Load Forecast																		
Retail Energy	GWh	164,884	166,312	167,280	168,382	168,889	169,108	169,299	169,528	169,117	168,675	166,959	165,374	163,380	161,788	160,009	158,514	157,114
Retail Demand	MW	31,371	31,642	31,826	32,036	32,133	32,174	32,211	32,254	32,176	32,092	31,765	31,464	31,084	30,782	30,443	30,159	29,892
Supply Forecast																		
Capacity Requirement	MW	39,038	39,376	39,605	39,866	39,986	40,038	40,083	40,137	40,040	39,935	39,529	39,154	38,682	38,305	37,884	37,530	37,198
Capacity Sources																		
In-State Capacity	MW	33,842	33,519	33,695	33,865	34,087	35,261	34,881	35,014	35,055	34,949	34,890	34,433	34,194	33,734	33,497	33,111	32,878
Out-of-State Capacity	MW	5,196	5,857	5,910	6,001	5,899	4,777	5,202	5,123	4,985	4,986	4,639	4,721	4,488	4,570	4,386	4,419	4,320
Total Capacity Provided	MW	39,038	39,376	39,605	39,866	39,986	40,038	40,083	40,137	40,040	39,935	39,529	39,154	38,682	38,305	37,884	37,530	37,198
Energy Requirement	GWh	178,421	179,966	181,013	182,206	182,754	182,992	183,197	183,445	183,001	182,523	180,666	178,950	176,793	175,070	173,145	171,528	170,012
Energy Sources																		
In-State Generation	GWh	155,356	154,009	154,658	155,292	156,106	162,272	161,747	163,558	164,934	165,638	166,507	165,554	165,561	164,564	164,581	163,915	163,954
Out-of-State Generation	GWh	23,065	25,956	26,355	26,914	26,649	20,720	21,450	19,887	18,067	16,885	14,159	13,397	11,232	10,506	8,564	7,612	6,058
Total Energy Provided	GWh	178,421	179,966	181,013	182,206	182,754	182,992	183,197	183,445	183,001	182,523	180,666	178,950	176,793	175,070	173,145	171,528	170,012
Supply Price Forecast																		
Average Production Cost	¢/kWh	5.02	5.09	5.17	5.22	6.51	6.80	7.00	7.22	7.44	7.63	7.83	8.01	8.19	8.37	8.55	8.73	8.92
Retail Adder	¢/kWh	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42
Average Retail Rate	¢/kWh	7.44	7.51	7.59	7.64	8.93	9.22	9.42	9.64	9.86	10.05	10.25	10.43	10.61	10.79	10.97	11.15	11.34

All costs in constant 2006 dollars.

CASE:	Ohio Policy Case - 3/10/09																	
Category	Units	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Avoided Costs by costing period																		
Avoided Resource Cost	¢/kWh	5.40	5.83	5.73	6.49	7.61	8.70	8.76	8.81	8.88	8.96	9.03	9.10	9.14	9.26	9.37	9.48	9.64
Avoided Capacity Cost	$/kW-yr	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23	75.23
	¢/kWh	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
Avoided Energy Only Cost	¢/kWh	3.97	4.40	4.30	5.06	6.18	7.27	7.33	7.38	7.45	7.53	7.60	7.67	7.71	7.83	7.94	8.05	8.21

Notes: Avoided Resource Costs represent avoided production costs (fuel, O&M, CO2) for all resources, plus levelized capital costs for new resources.
Avoided Capacity Cost in $/kw-yr is converted into an energy cost equivalent (c/kWh) using the system load factor.
Avoided Energy Cost represents Total Avoided Resource Cost less Avoided Capacity Cost expressed as energy cost equivalent.

A.6. Responses to Questions Regarding the Avoided Cost Methodology

The process of vetting the methodology for our avoided cost analysis revealed the overall comment that "…it appears that some of the assumptions used in the analysis result in a relatively high avoided cost number." That overall comment is based upon comments regarding several specific assumptions. Following are our responses, *in italics*, to those each specific comments.

1) Basic Modeling Assumptions. Financial Parameters

a) The discount rate at (8%) seems low. Is it reflective of the new credit realities?

We use a nominal discount rate of 10% and a real discount rate of 7.32%. (There is an error on page 2 of the memo where a real rate of 5.85% is given.). We believe that these are reasonable assumptions for long-term planning.

b) Is an Allowance for Funds Used During Construction (AFUDC) for modifying the plant cost included in this analysis? As used in the calculation of installed plant capital cost, AFUDC represents the time value of money during construction and is based on an internal rate equal to the weighted cost of capital.

The installed plant cost, including construction financing, is converted into a levelized cost that appears in the market in the year the plant comes on line. We do not reflect any pre-operation construction expenses in earlier year costs or electricity prices.

3) Base Year Load and Resource Balance. Was the transmission transfer capability taken into account for the amount of imported resources?

Net imported/exported electricity is based on reference year data and thus consistent with the existing transmission system. We did not model or forecast projected changes in transmission transfer capability. Instead, our model assumes that future imports and exports will be at the same relative level as in the recent past and that transmission transfer capability will change in the future to match load growth and that level of relative imports and exports.

4) In-State Base Year Generation Resource Performance and Cost

a) Isn't the actual capacity factor shown for Coal low?

The capacity factor used is the historic average for all coal plants in the state. Some newer plants do much better, but because there is so much coal capacity in Ohio some older plants must cycle and follow load.

b) Does the dataset include any emission rate and allowance cost data for SO_2?

The data includes average historic emission rate data for all pollutants. Emission allowance costs for pollutants, other than CO_2*, are reflected in the O&M costs.*

5) New Generation Resource Performance and Cost

a) Is the Total Plant Cost ($/kW) overnight or installed? Does the capital cost reflect and transmission upgrades or retrofits for CO_2 control equipment?

Total plant cost is "installed," including construction interest. No CO_2 *retrofit costs are assumed other than the allowance cost of* CO_2 *emissions.*

b) Isn't the Capital Levelization Factor rather low considering the high discount rate (10%)?

The Capital Levelization Factor is reasonable since it is expressed in real dollars.

c) Are the total fixed costs of each new capacity option adjusted by its equivalent availability in order to account for differing availabilities (including seasonal derates) among the options.

Fixed costs of new capacity are allocated over its generation based on the operating capacity factor of the new resource, not its availability factor.

8) Capacity Retirements in-State. Do the projected retirements reflect any of the generation retirements (Future Deactivation) posted on the PJM website?

We have attempted to reflect those listings as well as to take into consideration the aging of plants in future years. But that all is very uncertain and has only minor effects on avoided costs per se.

9) Capacity Additions In-State

a) Are the active generation queues considered as well as the PJM Interconnection Queue that is used as a guide for the new generation capacity mix.

Yes we have tried to do so, along with the addition of some additional future coal resources to reflect conditions in MISO and in Ohio in general.

b) For the renewables, will they be based on the Ohio Renewable Portfolio Standard (enacted 5/1/2008 and effective 1/1/2009) for a target of 12.5% by year 2024?

We have done so based on our understanding of that standard.

10) Fuel Prices. Aren't the fuel prices used lower than the consensus of industry and consultants' recent forecasts?

In general the price forecasts are basically long-term reflecting underlying conditions as presented in the Annual Energy Outlook of 2008 (Table 64). We have however updated those AEO forecasts of natural gas and crude oil prices based on market conditions as of 11/13/2008.

APPENDIX B – ENERGY EFFICIENCY POLICY ANALYSIS

B.1. Electricity Savings, Peak Demand Reductions, and Costs from Policy Analysis

Table 23. Electricity Savings from Policy Analysis

	Annual Electricity Savings by Policy (GWh)	2010	2015	2020	2025	Total Savings in 2025 (%)*
	Innovative Programs & Policies					
1	Efficient Homes Initiative	4	119	327	615	0.4%
2	State-level Appliance Standards	23	593	1,423	2,003	1.3%
3	Building Energy Codes		343	880	1,707	1.1%
4	Commercial Buildings Initiative	10	133	361	715	0.5%
5	State Facilities	239	837	1,434	2,032	1.3%
6	CHP	87	1,072	2,366	3,238	2.1%
7	Manufacturing Initiative	51	1,721	3,746	5,771	3.7%
8	Rural and Ag. Initiative	9	57	106	155	0.1%
	Innovative Program & Policy Savings	**424**	**4,876**	**10,644**	**16,235**	**10.3%**
9	*Proven Utility Programs*					
	Residential	480	2,078	5,410	11,328	7.2%
	Commercial	392	1,701	4,426	9,268	5.9%
	Proven Utility Program Savings	**872**	**3,779**	**9,836**	**20,596**	13.1%
	Total Savings (Policy + Program)	**1,295**	**8,655**	**20,480**	**36,831**	**23.4%**
	Adjusted Electricity Forecast (GWh)	**166,312**	**169,299**	**165,374**	**157,114**	
	Savings (% Reduction in Reference Case)	**0.8%**	**4.9%**	**11.0%**	**19.0%**	

Notes

***** Percent relative to adjusted reference case forecast

Initiative broken down into programs for existing homes and new construction. Existing homes program assumes 0.5% savings throughout the analysis period and 1% participation rate in first year, with participation increasing by 1% annually. Savings from new construction assumes 50% savings beyond current code (IECC 2006), thereby decreasing with the adoption of new energy codes except in 2020, where we assume program implementation and participation has matured to allow for savings beyond the 50% savings from IECC 2018. In 2011 we assume an initial participation rate of 2.5%, doubling annually until 2014, when IECC 2012 becomes effective. We then assume a participation rate of 20% for the remainder of the analysis period. In 2020, when IECC 2018 becomes effective, delivering 50% savings, we
1 assume 20% additional savings beyond IECC 2018 are achievable

Appliance and equipment efficiency standards were adopted at the federal level in the 2007 energy bill, which also directed DOE to set standards for additional products in the coming years. This Scenario assumes savings from these standards, which are not taken into
2 account in the reference case load forecast. Savings and cost assumptions are from a forthcoming ACEEE and ASAP standards analysis.
We assume IECC 2009 is adopted, which goes into effect 2011, the IECC 2012 is adopted and goes into effect in 2014, and the IECC 2018, effective 2020. We estimate that these codes achieve a 15%, 30%, and 50% energy savings improvement beyond IECC 2006 requirements, respectively. Savings apply only to end-uses covered under building codes, which are HVAC, lighting, and water heating end-uses, or 50% of electricity consumption in new residential construction and nearly 60% of electricity consumption in commercial buildings. We assume enforcement of each code starts at 70% compliance in the first year, 80% in second year, and 90% in the third and subsequent years. Buildings analysis shows $0.47 per kWh investment cost for new ENERGY STAR homes, which achieve 15% savings, and $0.32 per kWh for new commercial buildings meeting 15% and 30% beyond code. We assume $1.5 million dollars per year to implement and enforce codes, based on recommendations in New York (NY DPS 2007). This is similar to estimates in VA that new program costs run 2-3% of building
3 costs.
Initiative broken down into programs for existing buildings and new construction. Existing buildings program assumes 1% savings throughout the analysis period and 1% participation rate in first year, with participation increasing by 1% annually. We assume that 68.5% of total commercial electric floorspace is non-governmental buildings, to avoid double-counting savings attributable to state facilities program (CBECS 2003, table C17). Savings from new construction assumes 50% savings beyond current code (IECC 2006), thereby decreasing with the adoption of new energy codes except in 2020, where we assume program implementation and participation has matured to allow for savings beyond the 50% savings from IECC 2018. In 2011 we assume an initial participation rate of 2.5%, doubling annually until 2014, when IECC 2012 becomes effective. We then assume a participation rate of 20% for the remainder of the analysis period. In 2020, when
4 IECC 2018 becomes effective, delivering 50% savings, we assume 20% additional savings beyond IECC 2018 are achievable.

We estimate 31.5% of total electric commercial floorspace is government buildings, from EIA (CBECS 2003, table C17). We then assume a
5 savings rate of 20% and a participation rate of 50% over the period of the analysis.

6 We assume a $500 incentive per MW for CHP facilities.

This scenario assumes that the number of industrial assessments ramps up from 50 to 200 in first three years, that each assessment identifies 15% electricity savings, and that 50% of identified savings are implemented. Project costs assume the average investment cost per
7 kWh from the industrial sector analysis ($0.28/kWh) and program cost is assumed to be 12.5% of projected cost savings to the end-user.
Based on similar programs and values from the State of Wisconsin Focus on Energy 2007 Semiannual Report, we assume the average cost of conserved energy at $0.025/kWh, that program & administrative costs are 24% of the cost of investment, and that customers cover half of
8 the investment cost.

Savings for proven programs are the difference between EERS requirements and policy savings. Sector savings are then allocated based
9 on the contribution to economic potential savings of the residential and commercial sectors.

Table 24. Summer Peak Demand Reductions from Policy Analysis (MW)

Sector	2010	2015	2020	2025	Total Savings in 2025 (%)
Residential	104	637	1,771	3,801	10%
Commercial	56	328	687	1,121	3%
Industrial	26	585	1,349	2,159	5%
Total Savings (MW)	**186**	**1,550**	**3,807**	**7,081**	**18%**
% Reduction (relative to forecast)	**0.5%**	**4%**	**10%**	**18%**	

Table 25. Total Resource Costs* from the Policy Analysis (Million 2006$)

By Policy/Program	2010	2015	2020	2025
Innovative Programs & Policies				
Efficient Homes Initiative	$ 1	$ 17	$ 22	$ 27
State-level Appliance Standards	$ 26	$ 64	$ 64	$ 64
Building Energy Codes	$ -	$ 42	$ 57	$ 76
Commercial Buildings Initiative	$ 3	$ 15	$ 26	$ 40
State Facilities	$ 22	$ 22	$ 22	$ 22
CHP	$ 14	$ 124	$ 169	$ 218
Manufacturing Initiative	$ 16	$ 115	$ 115	$ 115
Rural and Ag. Initiative	$ 0.3	$ 0.3	$ 0.3	$ 0.3
Proven Utility Programs				
Residential	$ 92	$ 91	$ 397	$ 507
Commercial	$ 44	$ 43	$ 188	$ 242
Total	**$ 219**	**$ 533**	**$ 1,062**	**$ 1,312**

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

Figure 22. Incremental Annual Savings Requirements from EERS (% and GWh)

	2009	2010	2011	2012	2013	2014	2015
Efficient Homes Initiative	1	3	8	15	27	32	34
State-level Appliance Standards	-	23	46	46	116	186	178
Building Energy Codes	-	-	60	54	54	82	93
Commercial Buildings Initiative	3	7	16	20	25	29	33
State Facilities	120	120	120	120	120	120	120
CHP	-	87	29	29	309	309	309
Manufacturing Initiative	-	51	152	304	405	405	405
Rural and Ag. Initiative	-	9	9	10	10	10	10
Policy Savings	**124**	**299**	**439**	**596**	**1,064**	**1,172**	**1,181**
Savings as Percent of Forecasted Sales	**0.08%**	**0.18%**	**0.27%**	**0.36%**	**0.63%**	**0.68%**	**0.68%**
Proven Utility Programs							
Residential	195	285	394	403	243	280	279
Commercial	159	233	322	330	199	229	228
Utility Program Savings	**354**	**518**	**715**	**733**	**442**	**510**	**507**
Total Savings (Policy+Progam)	**479**	**817**	**1,155**	**1,329**	**1,506**	**1,682**	**1,688**
EERS Annual Savings Requirements (%)	0.30%	0.50%	0.70%	0.80%	0.90%	1%	1%
EERS Incr. Annual Svgs. Requirements (GWh)	**479**	**817**	**1,155**	**1,329**	**1,506**	**1,682**	**1,688**
Difference (%)	0.2%	0.3%	0.4%	0.4%	0.3%	0.3%	0.3%
Difference (GWh)	**354**	**518**	**715**	**733**	**442**	**510**	**507**

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Efficient Homes Initiative	35	38	42	45	48	51	54	57	61	64
State-level Appliance Standards	170	170	169	169	152	152	152	116	80	80
Building Energy Codes	104	108	103	95	127	151	169	164	166	176
Commercial Buildings Initiative	37	42	46	48	54	60	65	70	76	83
State Facilities	120	120	120	120	120	120	120	120	120	120
CHP	309	309	225	225	225	225	225	141	141	141
Manufacturing Initiative	405	405	405	405	405	405	405	405	405	405
Rural and Ag. Initiative	10	10	10	10	10	10	10	10	10	10
Policy Savings	**1,190**	**1,202**	**1,119**	**1,117**	**1,141**	**1,173**	**1,200**	**1,082**	**1,058**	**1,077**

0.68%	**0.68%**	**0.62%**	**0.62%**	**0.62%**	**0.64%**	**0.65%**	**0.58%**	**0.56%**	**0.57%**
276	270	316	1,246	1,223	1,192	1,157	1,203	1,197	1,169
226	221	258	1,019	1,001	975	947	985	979	956
501	**492**	**574**	**2,265**	**2,224**	**2,167**	**2,105**	**2,188**	**2,177**	**2,125**
1,691	**1,693**	**1,693**	**3,382**	**3,365**	**3,340**	**3,305**	**3,270**	**3,235**	**3,202**
1%	1%	1%	2%	2%	2%	2%	2%	2%	2%
1,691	**1,693**	**1,693**	**3,382**	**3,365**	**3,340**	**3,305**	**3,270**	**3,235**	**3,202**
0.3%	0.3%	0.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%
501	**492**	**574**	**2,265**	**2,224**	**2,167**	**2,105**	**2,188**	**2,177**	**2,125**

B.2. Carbon Dioxide Emissions Reductions

To estimate annual regional emissions reductions, we first took data on projected electricity generation and carbon dioxide emissions over the 2008-2025 period for the East Central Area Reliability Coordination Agreement (ECARC) region as reported by the *Annual Energy Outlook* (EIA 2007c). We then calculated an *output emission rate*, defined as the ratio of emissions (lbs) to electricity generation (MWh). Using data from the Emissions and Generation Resource Integrated Database (eGRID) on subregional emissions rates and converting to standard tons (EPA 2007a), we calculated a *net marginal emissions factor* (ton/MWh), which is our *output emissions rate* multiplied by the ratio of marginal to average emissions rate. We then took out *emissions factor* and multiplied Ohio's estimated electricity savings (GWh) from the Policy Analysis in order to determine the regional *carbon dioxide emissions savings* for the 17-year period.

APPENDIX C – ENERGY EFFICIENCY RESOURCE ASSESSMENT

C.1. Residential Buildings

C.1.1. Overview of Approach

We analyzed thirty-six electricity efficiency measures for existing residential buildings, which are grouped by end-use (HVAC, water heating, refrigeration, appliances, lighting, furnace fans, and plug loads) and three measures for new residential buildings (see Table 25). For each measure, we estimated average measure lifetime, electricity savings (kWh) and costs per home upon replacement of the product or retrofitting of the measure. For a replacement-on-burnout measure,[59] the cost is the incremental cost of the efficient technology compared to the baseline technology. For retrofit measures, where existing equipment is not being replaced, such as improved insulation and infiltration reduction, the cost is the full installation cost of the measure. For measures modeled as replacement-on-burnout, the baseline is set according to the current market for that product, so the baseline efficiency is the minimum efficiency standard of that product. For measures modeled as retrofit, the baseline efficiency is that of estimated energy use in existing Ohio homes.

A measure is determined to be cost-effective if its levelized cost of saved energy, or cost of conserved energy (CCE), is less than $0.1101/kWh, the current average residential cost of electricity in Ohio (EIA 2008a). Estimated levelized costs for each efficiency measure, which assume a discount rate of 5%, are shown in Table 25. Equation one shows the calculation for cost of conserved energy.

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

[59] In a replacement-on-burnout scenario, a consumer purchases the more efficient product at the time of replacement of that product.

Table 25. Residential Energy Efficiency Measure Characterizations

Measures	End-Use Category	Annual savings per household (kWh)	Cost of Saved Energy ($/kWh)	Pass Cost-Effective Test?	% Turnover	Adjustment Factor	Interaction Factor	% End Use Savings	Total Savings in 2025
Existing Building					**2025**		**2025**	**2025**	
Seal Ductwork	HVAC (load)	753	$ 0.0799	yes	85%	30%	100%	8%	1,013
Insulate Ductwork, R-8	HVAC (load)	602	$ 0.0318	yes	68%	43%	92%	7%	855
Infiltration reduction	HVAC (load)	753	$ 0.0128	yes	100%	44%	85%	12%	1,485
Insulation, ceiling, R-11 to R-38	HVAC (load)	703	$ 0.0077	yes	85%	28%	71%	5%	623
Insulation, ceiling, R-19 to R-38	HVAC (load)	314	$ 0.0172	yes	85%	41%	71%	3%	409
Blow-in wall insulation	HVAC (load)	1,129	$ 0.0140	yes	57%	15%	60%	2%	299
Estar Window, from single pane	HVAC (load)	3,794	$ 0.0077	yes	57%	15%	56%	7%	951
Estar Window, from double pane	HVAC (load)	596	$ 0.0491	yes	57%	55%	56%	4%	551
Cool Roof shingles	HVAC (load)	271	$ 0.0415	yes	85%	78%	36%	3%	339
HVAC Load Reducing Measures								**51%**	
Central HP (heating cycle); HSPF 9	HVAC (equip.)	2,823	$ 0.0303	yes	94%	5%	49%	2%	316
GSHP w/ desuperheater (14 EER)	HVAC (equip.)	2,530	$ 0.0812	yes	94%	1%	49%	0%	42
Central AC (cooling cycle) SEER 15	HVAC (equip.)	624	$ 0.0127	yes	94%	63%	49%	8%	975
ENERGY STAR Dehumidifier	HVAC (equip.)	213	$ 0.0159	yes	100%	6%	49%	0%	33
ENERGY STAR Room A/C (CEE Tier 2, 11.8 EER)	HVAC (equip.)	85	$ 0.0378	yes	100%	26%	49%	0%	57
Ceiling Fan (including light kit)	HVAC (equip.)	243	$ 0.0709	yes	100%	49%	49%	2%	310
HVAC Equipment Measures								**13%**	
TOTAL HVAC								**64%**	**8,259**
High-efficiency showerheads	Water Heating	234	$ 0.0127	yes	100%	60%	100%	17%	740
Faucet aerators	Water Heating	47	$ 0.0194	yes	100%	65%	100%	4%	160
Water heater pipe insulation	Water Heating	65	$ 0.0460	yes	100%	88%	100%	7%	302
H-axis clothes washer (2.0 MEF) (water heating)	Water Heating	232	$ 0.0640	yes	100%	65%	100%	19%	796
Dishwasher (Electric WH; 0.72 EF) (water heating)	Water Heating	37	$ 0.0647	yes	100%	85%	100%	4%	166
Efficient electric water heater (0.93 EF)	Water Heating	113	$ 0.0625	yes	100%	7%	53%	1%	23
Heat pump water heater (COP = 2.0)	Water Heating	2,103	$ 0.0427	yes	100%	12%	53%	16%	676
Water Heating Savings								**68%**	**2,864**
Refrigerator (20%)	Refrigeration	114	$ 0.0465	yes	89%	75%	100%	7%	404

Measures	End-Use Category	Annual savings per household (kWh)	Cost of Saved Energy ($/kWh)	Pass Cost-Effective Test?	% Turnover	Adjustment Factor	Interaction Factor	% End Use Savings	Total Savings in 2025
Refrigerator (25%)	Refrigeration	29	$ 0.0929	yes	89%	98%	100%	2%	132
Refrigeration Savings								**9%**	**536**
CFL, Advanced Incandescent Replacements	Lighting	1,005	$ (0.0032)	yes	100%	90%	100%	58%	4,774
Lighting Savings								**58%**	**4,774**
H-axis clothes washer (2.0 MEF)	Appliances	26	$ 0.0774	yes	100%	65%	100%	3%	89
Dishwasher (Electric WH; 0.68 EF)	Appliances	11	$ 0.0761	yes	100%	85%	100%	1%	49
Appliances Savings								**4%**	**139**
Efficient Furnace Fan (Heating Season)	Furnace Fans	367	$ 0.0473	yes	100%	67%	100%	41%	1,299
Efficient Furnace Fan (Cooling Season)	Furnace Fans	182	$ 0.0471	yes	100%	67%	100%	20%	646
Furnace Fan Savings								**61%**	**1,945**
ENERGY STAR Version 3.0 Television Spec.	Plug Loads	52	$ 0.0947	yes	100%	74%	100%	1%	50
Set-Top Box Power Reduction	Plug Loads	120	$ 0.0293	yes	100%	58%	100%	3%	90
1-watt standby power	Plug Loads	264	$ 0.0196	yes	100%	66%	100%	7%	920
Total Plug Load Savings								**11%**	**1,060**
In-home energy feedback monitor	All	525	$ 0.0573	yes	100%	79%	66%	3%	1,460
New Construction Building Measures									
New home 15% better than code (ENERGY STAR home)	New Construction	1,172	$ 0.0447	yes	100%	17%	100%	2%	66
New home 30% better than code (Proposed Building Code)	New Construction	2,345	$ 0.0411	yes	100%	35%	100%	8%	301
New home 50% better than code (Tax-credit-eligible)	New Construction	3,908	$ 0.0462	yes	100%	47%	100%	18%	669
New Homes Subtotal									**1,036**

C.1.2. Existing Buildings

To estimate the efficiency resource potential in existing homes in Ohio by 2025, we first adjusted individual measure savings by an *Adjustment Factor*. This factor accounts for the technical feasibility of efficiency measures (the percent of Ohio homes that satisfy the base case conditions and other technical prerequisites such as number of household members, heating fuel type, etc.) and the current market share of products that already meet the efficiency criteria. These assumptions are made explicit in Table 25.

We then adjusted savings from the improved building envelope (insulation, windows, infiltration reduction, and duct sealing) to account for the reduced heating and cooling loads imparted by each of the envelope measures. Then we adjusted HVAC equipment savings to account for savings already realized from the reduced loads. Similarly, we adjusted water heating equipment savings to account for reduced water heating loads from the use of more efficient clothes washers, low-flow shower heads, water heater pipe insulation, and faucet aerators. The multiplier for these adjustments is called the *Interaction Factor.*

We then adjusted replacement measures with lifetimes more than 17 years to only account for the percent turning over in 17 years, which represents the time period of the analysis. Note that the multiplier, *Percent Turnover,* is only applicable to products being replaced upon burnout and not retrofit measures such as insulation and duct sealing and testing. These retrofit measures therefore have 100% of measures "turning over."

Equation 2 shows our calculation for efficiency resource potential, incorporating the three factors discussed above:

Equation 2. *Efficiency Resource Potential = ∑ (Annual Savings per Measure (kWh))* x *(Percent Turnover) x (Adjustment Factor)* x *(Interaction Factor)*

To calculate the efficiency resource potential savings by end-use in 2025, we present the savings as a percent of end-use electricity consumption (assuming current electricity consumption by end-use from AEO 2007). For the non-HVAC savings, we then multiply the "% savings" by projected residential electricity consumption for that end-use in 2025 to estimate the total savings potential in that year (see Equation 2). We assume that savings in the residential new construction sector cover projected new HVAC consumption, and therefore multiply the HVAC "% savings" by 2008 electricity consumption of this end use. See Equation 3 for a summary of how we derive the savings estimate for existing residential buildings.

Equation 3. *Efficiency Resource Potential by end-use in 2025 (GWh) = (% End-Use Savings)* x *(Electricity Consumption by sector in 2025* (GWh))*
* 2008 for HVAC

New Construction

We estimate savings from new construction in a similar manner as existing home measures. We looked at three levels of efficiency in new homes: 15%, 30%, and 50% better than current energy code. In estimating new home energy savings, we use a similar approach as building codes, which address HVAC consumption only. We estimated *% Applicable* by allocating each home into one of the three bins, with 15% predominating the early years and 50% the later years. See Equation four for a summary of how we calculate savings in new construction.

Equation 4. *Efficiency Resource Potential in 2025 (GWh) = (% HVAC savings per home) x (Percent Applicable) x (Projected new HVAC consumption between 2008 and 2025 (GWh))*

C.1.3. Efficiency Measures

In-home energy feedback monitor

Measure Description: A device installed inside the home that communicates with the electric meter and displays real-time electricity use information to occupants.

Basecase: Average metered home with no feedback mechanism other than monthly utility bills

Data Explanation: Total households applicable (80%) from RECS 2005 (EIA 2008). Baseline electricity consumption is for an average household excluding multifamily buildings above four units from RECS (EIA 2008). Cost includes cost of product ($150) plus one hour of installation from Parker 2006. Percent savings (10%) from Stein 2004 and Hydro One 2006. Useful life (11 years) assumed to be similar to programmable thermostat, from ACEEE 2006. Penetration in residential sector technically achievable in all metered residential units.

Duct Sealing

Measure Description: Professional duct-sealing service suitable for retrofits and new construction, involving testing and either hand-applied or aerosol-based mastic (Jump 2006).

Basecase: Single-family home with a forced-air furnace and air conditioner.

Data Explanation: Baseline energy use from RECS (EIA 2008) depending on primary fuel use, plus a 25% adder representing high-use homes. Savings (10%) in each season (cooling and heating) is derived from 80% reduction in duct leakage (Jump 1996), which comprises half of the 20% of total HVAC energy use that can be associated with duct-related energy losses (the other half being by conduction [Hammurlund 1992; Proctor 1993]). A cost of $750 is mature-market cost of Aeroseal, from Bourne et al 1999. Applies to top 50% of residential homes with forced-air systems. Measure life is 20 years (SWEEP 2002)

Duct Insulation

Measure Description: R8 insulation applied to exposed ductwork in unconditioned spaces.

Basecase: Single-family home with a forced-air furnace and air conditioner with uninsulated ductwork passing through un-conditioned space (attic, un-finished basement, garage)

Data Explanation: Baseline energy use from RECS 2005 (EIA 2008) depending on primary fuel use, plus a 25% adder representing high-use homes. Savings from SWEEP, based on 10% heating/cooling energy use in forced-air system associated with conductive duct losses. Cost are $0.15–$0.20 per square foot of floor area. Floor area (1800 sq. ft) based off average floor area of colonial and ranch single family detached from ACEEE 1994. Applies to top 50% of residential homes with forced-air systems. Useful life is 25 years (SWEEP 2002).

Blower-Door Aided Infiltration Reduction

Measure Description: Application of foam and/or caulk around leakage areas applied and tested by a professional using a blower-door.

Basecase: Household with higher-than average heating and cooling energy use.

Data Explanation: Baseline energy use from RECS (EIA 2008) depending on primary fuel use, plus a 25% adder representing high-use homes. Savings of 10% from MT Screening Reports. Cost of $0.46/s.f. from XENERGY 2001. Useful life of 10 years from SWEEP 2002. Savings applied to percentage of homes that report drafts (44%), from RECS (EIA 2008).

Attic Insulation

Measure Description: Add insulation in attic floor to R-38.

Basecase: R-11assumed for houses reported to be "well insulated."

Data Explanation: Savings average of colonial and ranch savings for R11-R30 attic insulation from NYSERDA 1994, increased by multiplier (1.09) to incorporate savings from upgrading to R38. Total households applicable (28%) average from RECS 2008 for house that are "well insulated" and houses that are "not well insulated" (EIA 2008). Baseline energy use from RECS 2005 (EIA 2008) depending on primary fuel use, plus a 25% adder representing high-use homes. Cost of $0.70/s.f. from DEER database (CEC 2005a). Assumes 1000 s.f. of insulation needed. Useful measure life of 20 years from NYSERDA (2003).

Attic Insulation

Measure Description: Add insulation in attic floor to R-38.

Basecase: R-19 assumed for houses reported to be "well insulated."

Data Explanation: Savings average of colonial and ranch savings for R19-R30 attic insulation from NYSERDA 1994, increased by multiplier (1.34) to incorporate savings from upgrading to R38. Total households applicable (41%) from RECS 2008 for house that are "well insulated" (EIA 2008). Baseline energy use from RECS 2005 (EIA 2008) depending on primary fuel use, plus a 25% adder representing high-use homes. Cost of $0.70/s.f. from DEER database (CEC 2005a). Assumes 1000 s.f. of insulation needed. Useful measure life of 20 years from NYSERDA 2003.

Blow-in Cellulose Wall Insulation

Measure Description: Add blow-in cellulose insulation to un-insulated wall cavities

Basecase: Average-sized single-family home with wood-frame construction built before 1970.

Data Explanation: Total households applicable (15%) from RECS 2008 for houses that are "not well insulated" (EIA 2008). Baseline energy use from RECS 2005 (EIA 2008), depending on primary fuel use, plus a 25% adder representing high-use homes. Savings of 15% and 1700 s.f. of uninsulated wall space are based on average of colonial and ranch single-family detached house types from 1994 ACEEE study on Gas EE opportunities in Long Island. Cost of $1.32/s.f. (unit and installation cost) from DEER database (CEC 2005a). Useful measure life of 30 years from NYSERDA 2003.

Cool Roof Shingles

Measure Description: Roof shingles that meet ENERGY STAR residential requirements for reflectivity and thermal emittance due to light color or other material properties.

Basecase: Standard high-pitched residential roof with dark asphalt shingles

Data Explanation: Baseline electricity reflects cooling load only, from RECS 2005 (EIA 2008). Savings of 20% of cooling load and cost ($.10/s.f.) are from ACEEE Emerging Technologies analysis (Sachs et al 2004). Roof area (1400 sq. ft) based off assumption of 1000 sq. ft for attic area, multiplied by 1.4 (roof area generally 1.4 times greater than the area of the attic). Percent of homes applicable (86%) are the percent of households with asphalt shingles, from Dejarlais 2006 presentation (CEE Cool Roofs workshop). Market share (10%) and measure life (20 years) are from Sanchez et al. 2007.

ENERGY STAR Windows

Measure Description: Window replacements that meet regional ENERGY STAR requirements for U value and solar heat gain coefficient (SHGC).

Basecase: Replacement of 20 *single-pane* windows measuring approximately 15 s.f. each.

Data Explanation: Baseline energy use from RECS 2005 (EIA 2008). Savings (36%) from ratio of U-values associated with upgrading from single pane (U-value = 1.10) to ENERGY STAR (U-value = .40), from Lekcie et al. 1981. Number of units (20) from ACEEE 2006. Incremental cost assumes 300 sq. ft. of windows at $1.50 per sq. ft. (NEEP 2006). Measure life (30) from SWEEP 2002. Percent of applicable households (50%) based on ENERGY STAR market share data.

ENERGY STAR Windows

Measure Description: Window replacements that meet regional ENERGY STAR requirements for U value and solar heat gain coefficient (SHGC).

Basecase: Replacement of 20 *double-pane* windows measuring approximately 15 s.f. each.

Data Explanation: Baseline energy use from RECS 2005 (EIA 2008). Savings (9%) from ratio of U-values associated with upgrading from double pane (U-value = .49) to ENERGY STAR (U-value = .40), from Lekcie et al. 1981. Number of units (20) from ACEEE 2006. Incremental cost assumes 300 sq. ft. of windows at $1.50 per sq. ft. (NEEP 2006).

Measure life (30) from SWEEP 2002. Percent of applicable households (50%) based on ENERGY STAR market share data.

High-efficiency Central Air Conditioner (cooling only)
Measure Description: SEER 15

Basecase: Current federal standard: SEER 13

Data Explanation: Baseline consumption from RECS 2005 (EIA 2008). Percent savings (27%) and incremental cost from ENERGY STAR calculator for Central Air Conditioners using Columbus, OH, as a proxy. Assumed not to be used in conjunction with programmable thermostat. Market share (9%) from Sanchez et al. 2007, assumed to be half of market share for ENERGY STAR qualified unit with SEER = 15. Percent applicable (64%) equivalent to households with central AC, with and w/o heat pump (EIA 2003). Measure life (18 years) from DOE TSD (DOE 2001).

High-efficiency Heat Pump (heating only)
Measure Description: HSPF 9

Basecase: Current federal standard: HSPF 7.7

Data Explanation: Baseline consumption from RECS 2005 (EIA 2008). Percent savings (22%) and incremental cost ($1000) from ENERGY STAR calculator for Air-Source Heat Pumps using Richmond, VA, as a proxy and apportioned based on heating hours for Richmond, VA. Assumed not to be used in conjunction with programmable thermostat. Market share (11%) from Sanchez et al. 2007, assumed to be half of market share for ENERGY STAR qualified unit with HSPF = 8.2. Measure life (18 years) from DOE TSD (DOE 2001).

Efficient Furnace Fan (heating season)
Measure Description: High efficiency, ECM fan

Basecase: PSC fan

Data Explanation: Baseline electricity consumption from Lutz (2004), accounting for parasitics and adjusted by ratio of national to state HDD. Percent applicable (75%) equivalent to sum of households with forced air systems (EIA 2008). Electricity savings (425 kWh, 41%) from Pigg (2003) and adjusted by ratio of national to state HDD. Incremental costs ($200) from Sachs & Smith 2004, apportioned by ratio of national to state CDD ($161), although report notes that incremental costs will drop to $25-$45 upon market maturity. Incremental costs apportioned for heating season from ratio of heating season savings to total annual savings.

Efficient Furnace Fan (cooling season)
Measure Description: High efficiency, ECM fan

Basecase: PSC fan

Data Explanation: Baseline electricity consumption from Lutz (2004), accounting for parasitics and adjusted by ratio of national to state CDD. Percent applicable (58%) equivalent to sum of households with forced air systems (EIA 2003). Electricity savings (103 kWh, 21%) from Pigg (2008) and adjusted by ratio of national to state CDD ($39). Incremental costs ($200) from Sachs & Smith 2004, apportioned by ratio of seasonal savings, although report notes that incremental costs will drop to $25-$45 upon market maturity. Incremental costs apportioned for cooling season from ratio of cooling season savings to total annual savings.

Ground-Source Heat Pump
Measure Description: Closed ground-source heat pump with EER 14.

Basecase: Conventional air-source heat pump of SEER 13, HSPF 7.7

Data Explanation: Baseline energy use (for homes with electricity as primary fuel multiplied by 2 for high-use homes) and market penetration (of heat pumps) from RECS 2001(EIA 2003). New measure savings (21%) and cost ($2400) from ACEEE Emerging Technologies analysis (Sachs 2007). Analysis assumes technical feasibility in 10% of houses with forced-air electric heat (0.3%). Measure life (18 years) from Sachs 2007.

Ground-Source Heat Pump with Desuperheater (space heating)
Measure Description: HSPF 14

Basecase: Current federal standard: HSPF 7.7

Data Explanation: Total households applicable 1% (10% of house with electric heat and ducts) from RECS 2005 (EIA 2008). New measure savings (21%) and cost ($1,000 per ton) from ACEEE Emerging Technologies analysis (Sachs 2007). Analysis assumes technical feasibility in 10% of houses with electric forced-air heat (0.3%). Measure life (18 years) from Sachs 2007.

Ground-Source Heat Pump with Desuperheater (water heating only)
Measure Description: HSPF 9

Basecase: Current federal standard: HSPF 7.7

Data Explanation: Baseline energy use and market penetration (of heat pumps) from RECS 2005 (EIA 2008). New measure savings (25%) and cost ($1,000 per ton) from ACEEE Emerging Technologies analysis (Sachs 2007). Analysis assumes technical feasibility in 10% of houses with electric forced-air heat (0.3%). Measure life (18 years) from Sachs 2007.

Efficient Electric Storage Water Heater
Measure Description: 50-gallon electric storage water heater, 0.93 EF

Basecase: Current federal standard for typical, 50-gallon electric storage water heater, 0.90 EF

Data Explanation: Baseline consumption from GAMA water heater directory. Savings (3%) derived from EF increase. Incremental cost ($70) from Amann et al. 2007. Measure life (14 years) from NYSERDA 2003. Percent applicable (29%) equivalent to houses with electric water heaters (EIA 2003). Market share (36%) estimated based on percent of products on the market meeting EF 0.93 in the GAMA product database (GAMA 2007).

Heat Pump Water Heater
Measure Description: Either add-on or integrated heat-pump that uses the evaporation-compression cycle to extract heat from surrounding air to heat water in a conventional storage tank. COP 2.0 or above.

Basecase: Current federal standard for typical, 50-gallon electric storage water heater, 0.90 EF

Data Explanation: Baseline consumption from GAMA water heater directory. Percent applicable (10%) equivalent to households with electric water heaters multiplied by percentage of households that have three or more occupants (EIA 2008). Percent Savings (60%) and measure life (14.5 years) are from Sachs, et al 2004. Incremental cost ($910) based off electric heat pump with COP=2.2, from Amann et al. 2007 (Consumer Guide).

High-efficiency showerheads
Measure Description: 2.0 gallons per minute (gpm) showerhead

Basecase: Assumes electric water heater meeting current federal standard (see Electric Storage Water heater above). Showerhead meets federal requirements of 2.5 gpm

Data Explanation: Baseline consumption from RECS 2005 (EIA 2008) depending on primary water heating fuel. Savings (10%) from Brown et al. 1987. Cost estimate ($23) for a low-cost, basic model from the DEER database (CEC 2005a). Useful measure life of 9 years from Efficiency Vermont 2005. Percent of households applicable (29%) is percentage of households with electric water heating (EIA 2003).

Faucet Aerators
Measure Description: 1.5 gallons per minute (gpm) faucet aerator

Basecase: Assumes electric water heater meeting current federal standard (see Electric Storage Water heater above). Baseline aerator meets federal requirements of 2.5 gpm

Data Explanation: Baseline consumption from RECS 2005 (EIA 2008) depending on primary water heating fuel. Savings (2%) from Frontier Associates (2006). Cost estimate ($7) for a low-cost, basic model from the DEER database (CEC 2005a). Percent of homes applicable (29%) is percentage of households with electric water heating (EIA 2003).

Water Heater Pipe Insulation
Measure Description: Insulating 10 feet of exposed pipe in unconditioned space, ¾” thick.

Basecase: Assumes electric water heater meeting current federal standard (see Electric Storage Water heater above).

Data Explanation: Baseline consumption from RECS 2005 (EIA 2008) depending on primary water heating fuel. Savings estimate from CL&P 2007. Costs ($28) from DEER Database based off $0.37 per linear foot equipment cost and $2.44 per linear foot installation cost (CEC 2005a). Useful life of insulation 13 years from Efficiency Vermont 2005. Percent of homes applicable (29%) is percentage of households with electric water heating (EIA 2003).

Efficient Dehumidifier
Measure Description: Replacement dehumidifier that is ENERGY STAR certified based on the 2008 ENERGY STAR specification.

Basecase: Dehumidifier that meets current (2005) federal energy standards.

Data Explanation: Baseline and incremental costs ($150) and electricity consumption from ENERGY STAR calculator. Percent applicable (14%) equivalent to percent of households with a dehumidifier (EIA 2008). Percent savings (19%), measure life (12 years), and market share (60%) from Sanchez et al. 2007.

Efficient Room Air Conditioner
Measure Description: ENERGY STAR Room A/C (10000 Btu unit at 10.8 EER).

Basecase: Room A/C that meets 2000 federal energy standards (10000 Btu at 9.8 EER)

Data Explanation: Baseline consumption, savings, and incremental cost from ENERGY STAR savings calculator. Percent homes applicable (28%) based on number of units per home from RECS 2005 (EIA 2008). Measure life (13 years) from Sanchez et al. 2007. Market share (49%) from ENERGY STAR 2006 appliance sales data.

Refrigerator Tier I
Measure Description: Replacement refrigerator that meets 2008 ENERGY STAR requirements (20% better than federal standard)

Basecase: Refrigerator that meets current 2001 federal energy standards.

Data Explanation: Baseline consumption, incremental cost ($64) and measure life (19 years) from ACEEE analysis for PG&E/CA Title 24 (PG&E 2007). Market share (31%) from Sanchez et al. 2007.

Refrigerator Tier II
Measure Description: Replacement refrigerator that exceeds federal energy standard by 25% (CEE Tier 2)

Basecase: Refrigerator that meets current 2001 federal energy standards.

Data Explanation: Baseline consumption, incremental cost ($33) and measure life (19 years) from ACEEE analysis for PG&E/CA Title 24 (PG&E 2007).

Horizontal-Axis Clothes Washer (appliances)
Measure Description: Front-loading (H-axis) clothes washer meeting ENERGY STAR requirements (2.0 MEF)

Basecase: Federal standard for clothes washers: 1.26 MEF

Data Explanation: Savings (20%) from ENERGY STAR savings calculator, isolating appliance energy savings only. Incremental cost ($20) apportioned based on percentage of electricity consumption not dedicated to water heating. Percent of homes applicable (20%) based on appliance saturation data from RECS 2005 (EIA 2008). 2006 market share (33%) from EPA 2007c. Measure life (14 years) is from Sanchez et al. 2007.

Horizontal-Axis Clothes Washer (water heating)
Measure Description: Front-loading (H-axis) clothes washer meeting ENERGY STAR requirements (2.0 MEF)

Basecase: Federal standard for clothes washers: 1.26 MEF

Data Explanation: Savings (20%) from ENERGY STAR savings calculator, isolating water heating energy savings only. Incremental cost ($180) apportioned based on percentage of electricity consumption dedicated to water heating.

Percent of homes applicable (20%) based on appliance saturation data from RECS 2005 (EIA 2008). 2006 market share (33%) from EPA 2007c. Measure life (14 years) is from Sanchez et al. 2007.

Efficient Dishwasher (appliances)
Measure Description: Dishwasher meeting 2011 ENERGY STAR requirement of 0.72 EF

Basecase: Dishwasher meeting 2010 federal energy standard of 0.62 EF

Data Explanation: Incremental cost ($30) and electricity savings from DOE 2007 Technical Support Document, isolating appliance energy savings only. Percent applicable (55%) equivalent to households with a dishwasher. Incremental cost apportioned based off ratio of electricity savings between the appliance and electricity used for water heating. Measure life (13 years) is from Sanchez et al. 2007. Market share (15%) from April 2007 LBL analysis on the AHAM-efficiency advocate agreement.

Efficient Dishwasher (water heating)
Measure Description: Dishwasher meeting 2011 ENERGY STAR requirement of 0.72 EF

Basecase: Dishwasher meeting 2010 federal energy standard of 0.62 EF

Data Explanation: Incremental cost ($30) and energy savings from DOE 2007 Technical Support Document, isolating water heating energy savings only. Percent applicable (16%) equivalent to households with dishwasher and electric water heater. Incremental cost apportioned based off ratio of electricity savings between the appliance and electricity used for water heating. Measure life (13 years) is from Sanchez et al. 2007. Market share (15%) from April 2007 LBL analysis on the AHAM-efficiency advocate agreement.

Ceiling Fan
Measure Description: ENERGY STAR certified ceiling fan

Basecase: Standard ceiling fan as defined by ENERGY STAR

Data Explanation: Baseline consumption, new measure consumption, and incremental cost ($185) from ENERGY STAR calculator. 2.15 units per household assumed from RECS 2005. Percent applicable (74%) equivalent to number of households with a ceiling fan. Baseline and new measure consumption, as well as units per household, specific to East North Central region. Measure life (10 years) and market share (24%) are from Sanchez et al. 2007.

Compact Fluorescent Lighting
Measure Description: Savings from the 17-watt equivalent to baseline lamp (75%) applied to 80% of baseline incandescent lamp hours.

Basecase: Baseline house requires 25,659 incandescent lamp-hours per year; average incandescent wattage is 63 watts based on 2001 federal government lighting inventory survey (DOE 2002).

Data Explanation: Measure of 80% replacement by lamp-hours is ACEEE assumption based on a conservative estimate of feasible applications. Applies to all households. Market share (10%) from ACEEE estimate based on EPA's estimate of ENERGY STAR lamp sales in 2007 and ACEEE's estimate of total lamp sales.

Active Mode Efficiency for Televisions
Measure Description: ENERGY STAR Television Specification, Version 3.0

Basecase: Average of all TVs from ENERGY STAR data set (CEE 2008).

Data Explanation: Baseline consumption, new measure consumption, measure life (6 yrs), and savings from CEE 2008.

Low Power Set-Top Boxes
Measure Description: Require digital set-top boxes to have a maximum sleep state power level of 10 watts and to automatically enter sleep mode after 4 hours without user input.

Basecase: Typical house with 1.9 set top boxes.

Data Explanation: All data except cost is from Rainer (2008). No reliable incremental cost data is available. In the case of set-top boxes, efficiency measures are largely software-related, likely resulting in very low cost per kWh saved per household. Our cost estimate is set to result in a levelized cost similar to that for TVs.

One-Watt Standby for All Household Electronics
Measure Description: All new electronics devices required to have maximum "off" mode power level of 1 watt.

Basecase: Typical house with 17-20 devices.

Data Explanation: Baseline consumption, savings, incremental costs and measure life available from ACEEE 2004 emerging technologies analysis (Sachs et al. 2004). Penetration of new measure assumed by averaging market shares of all ENERGY STAR home electronics equipment.

ENERGY STAR New Home
Measure Description: New home that uses 15% less energy than code

Basecase: Code-compliant home (proposed 2008 IECC residential code revision)

Data Explanation: Baseline equals delivered HVAC and water heating energy use per household (across all households) from AEO (2007). Incremental costs ($805) and market share (5%) from personal communication with Shadid (2007). Percent applicable for new homes assume that 30% and 50% new buildings are phased-in one to two years prior to enactment of codes (30% in 2012 and 50% in 2020).

Advanced Building Code New Home
Measure Description: New home that uses 30% less energy than code

Basecase: Code-compliant home (proposed 2008 IECC residential code revision)

Data Explanation: Baseline equals delivered HVAC and water heating energy use per household (across all households) from AEO (2007). Incremental costs ($1480) and market share (0%) from personal communication with Shadid (2007). Percent applicable for new homes assume that 30% and 50% new buildings are phased-in one to two years prior to enactment of codes (30% in 2012 and 50% in 2020).

Tax-Credit-Eligible New Home
Measure Description: New home that uses 50% less energy than code.

Basecase: Code-compliant home (proposed 2008 IECC residential code revision)

Data Explanation: Baseline equals delivered HVAC and water heating energy use per household (across all households) from AEO (2007). Incremental costs ($2775) and market share (0%) from personal communication with Shadid (2007). Percent applicable for new homes assume that 30% and 50% new buildings are phased-in one to two years prior to enactment of codes (30% in 2012 and 50% in 2020).

C.2. Commercial Buildings

C.2.1. Baseline End-Use Electricity Consumption

To estimate the resource potential for efficiency in commercial buildings in Ohio, we first develop a disaggregate characterization of baseline electricity consumption in the state for current electricity use and a reference load forecast (see Table 27). Highly disaggregated commercial electricity consumption data is unfortunately not available at the state level. To estimate these data, we start with current electricity consumption for the Ohio commercial sector (EIA 2008) and a forecast out to 2025 based on PJM forecasts, and we disaggregate by end-use using average regional data from CBECS 2003 (EIA 2006b) and AEO 2007 (EIA 2007c).

Table 27. Baseline Commercial Electricity Consumption by End-Use (GWh)

End-Use	2009	%	2015	%	2025	%
Heating	1,746	4%	1,972	4%	2,070	3%
Cooling	5,286	11%	5,972	11%	6,738	10%
Ventilation	2,502	5%	2,826	5%	3,135	5%
HVAC subtotal	9,534	19%	10,770	19%	11,943	19%
Water Heating	1,350	3%	1,525	3%	1,565	2%
Refrigeration	2,927	6%	3,306	6%	3,639	6%
Lighting	17,628	36%	19,913	36%	22,178	34%
Office Equipment	7,055	14%	7,970	14%	10,253	16%
Other	10,533	21%	11,899	21%	14,932	23%
Total	**49,027**	**100%**	**55,383**	**100%**	**64,510**	**100%**

Next, we estimate commercial square footage in the state using electricity intensity data (kWh per square foot) by census region from CBECS (EIA 2006b). We use the East North Central region to estimate an overall electricity intensity for the state of Ohio of 13.8 kWh per square foot. Total electricity consumption in the state divided by the electricity intensity provides an estimate of commercial floorspace. Using this methodology, we estimate 3,553 million square feet of commercial floorspace in the state.

C.2.2. Measure Cost-Effectiveness

We then analyze 34 efficiency measures for existing commercial buildings and 3 new construction whole-building measures to examine the cost-effective energy efficiency resource potential. For each efficiency measure, we estimate electricity 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 measure's useful life. Savings and costs are incremental to an assumed *Baseline Measure*. We estimate savings (kWh) 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 $0.1015/kWh, the estimated current average commercial cost of electricity in Ohio. The estimated CCE for each efficiency measure, which assume a discount rate of 5%, are shown in the measure descriptions below. Equation 1 shows the calculation for cost of conserved energy.

Our assumed *Baseline Measure*, *Annual Savings per Measure, Measure Cost, Measure Lifetime, and CCE* are reported for each of the efficiency measures in the list of measure descriptions below. We group the 33 efficiency measures for existing commercial buildings by end-use and list the 3 new building measures last.

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

C.2.3. Total Statewide Resource Potential

For each measure, we then derive *Annual Savings per Measure* on a per square foot basis *(kWh 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 Electricity Intensity* for that end-use. The assumed baseline intensities for each end use are shown in Table 28. As an example, for a specific lighting measure we multiply its percent savings by the baseline electricity intensity (kWh per square foot) for the lighting end-use.

Table 28. Commercial End-Use Baseline Electricity Intensities (kWh per s.f.)

End-Use	2009
Heating	0.5
Cooling	1.5
Ventilation	0.7
HVAC Subtotal	2.7
Water Heating	0.4
Cooking	0.1
Lighting	5.0
Refrigeration	0.8
Office Equipment	2.0
Other	2.8
Total	**13.8**

To estimate the total efficiency resource potential in existing commercial buildings in Ohio by 2025, 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 Ohio 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. These assumptions are outlined in each of the efficiency measure descriptions below.

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 7 and 17 years to only account for the percent turning over in 7 and 17 years, which represents the benchmark years of 2015 and 2025, 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 state’s commercial buildings sector.

Equation 3. *Efficiency Resource Potential in 2015 and 2025 (GWh) = (Annual Savings per Measure (kWh per square foot)) x (Commercial floor space in Ohio in millions of square feet) x (Percent Applicable)* x *(Interaction Factor) x (Percent Turnover)*

C.2.4. Efficiency Measures

Table 29 shows the thirty-eight efficiency measures examined for this analysis, grouped by end-use costs, savings (kWh) per product or square foot, *Percent Applicable, Interaction Factor, Percent Turnover,* and total savings potential (GWh) in 2025. Detailed descriptions of each measure are given below, grouped by end-use.

HVAC

1. Duct testing and sealing

Measure Description: Testing and sealing air distribution ducts saves energy. This measure assumes supply and return ducts will be fully sealed.

Basecase: The basecase assumes air loss of 29% of fan flow, and leakage of 15% of the system flow.

Data Explanation: Percent savings of 6% apply to whole-building electricity consumption (SWEEP 2002). An incremental cost of $3,375, which assumes $300 per ton, a 10 year lifetime, and 25% applicability are ACEEE estimates. The levelized cost is calculated to be 1.8 cents/kWh.

2. Cool roof

Measure Description: This measure involves installing a sun-reflective coating on the roof of a building with a flat top. This reduces air conditioning energy loads by reducing the solar energy absorbed by the roof.

Basecase: The baseline electricity intensity for HVAC end uses in Ohio (2.7 kWh/ft^2/year) is used as the basecase.

Data Explanation: We assume 4% HVAC load savings (ACEEE 1997) off the baseline electricity intensity for HVAC end-uses in Ohio (CBECS 2003), an incremental cost of $0.25 per ft^2 (SWEEP 2002), and a 20-year average lifetime (SWEEP 2002). Percent applicable (80%) is an ACEEE estimate. Savings and cost per unit are based on a 15,000 ft^2 building from ACEEE Mid-Atlantic study (1997). The levelized cost is calculated to be 5.5 cents/kWh.

3. Roof insulation

Measure Description: Fiberglass or cellulose insulation material in roof cavities will reduce heat transfer, though the type of building construction limits insulation possibilities. R-values describe the performance factor for insulation levels.

Basecase: The basecase electricity intensity for this measure was disaggregated from the post-savings electricity intensity and the percentage of savings.

Data Explanation: We assume 3% savings and a post-savings electricity intensity of 0.28 kWh/ft^2/year, based on an average of four building types (ACEEE 1997). An average lifetime of 25 years (CL&P 2007) and an incremental cost of 12 cents/ft^2 were also assumed. The levelized cost is 30 cents/kWh.

4. Double Pane Low-Emissivity Windows

Measure Description: Double-pane windows have insulating air- or gas-filled spaces between each pane, which resist heat flow. Low-emissivity (low-e) glass has a special surface coating to reduce heat transfer back through the window, and a window's R-value represents the amount of heat transfer back through a window. Low-e windows are particularly useful in climates with heavy cooling loads, because they can reflect anywhere from 40% to 70% of the heat that is normally transmitted through clear glass. The Solar Heat Gain Coefficient (SHGC) represents the fraction of solar energy transferred through a window. For example, a low-e window with a 0.4 SHGC keeps out 60% of the sun's heat.

Basecase: The basecase electricity intensity for this measure was disaggregated from the post-savings electricity intensity and the percent savings.

Data Explanation: Percent savings of 3% apply to whole-building electricity consumption (ACEEE 1997). Incremental costs assume $2 per window (SWEEP 2002). A measure life of 25 years is from SWEEP 2002. Percent applicable is an ACEEE estimate. The levelized cost is calculated to be 2 cents/kWh.

5. Ventilation fans with Variable-Frequency Drive

Measure Description: Variable Frequency Drive (VFD) controls the speed of a motor by adjusting the frequency of incoming power. By controlling the speed of a motor, the output of the system can be matched to the requirements of the process, thereby improving efficiency.

Basecase: The basecase unit is a 50 hp fan with 60% load factor, 93% efficiency (ODP, EPAct levels) and 3653 operating hours/year (21-50 hp category from ACEEE standards savings analysis).

Data Explanation: We assume 25% savings applies to ventilation only (ACEEE 1997), which is a conservative estimate. We estimate a $6,650 incremental cost, which assumes $125/hp for VFD and $8/hp for a better fan, and a 10-year measure life (SWEEP 2002). ACEEE estimates that this measure can apply to 40% of systems. The levelized cost is calculated to be 3.9 cents/kWh.

6. High-Efficiency Unitary AC/HP
65,000 Btu — 135 Btu
135,000 Btu — 240,000 Btu

Measure Description: Unitary packaged air conditioners and heat pumps represent the heating, ventilating, and air conditioning (HVAC) equipment class with the greatest energy use in the commercial sector in the United States, and are used in approximately 48% of the cooled floor space in the commercial sector (DOE 2004). High efficiency units have a greater energy efficiency ratio (EER).

Basecase: The assumed basecase unit meets the 2010 federal efficiency standard. Baseline electricity intensity for this end-use,2.7 kWh per ft^2, is the estimated HVAC consumption in commercial buildings in Ohio. This is data from the East North Central region from EIA's commercial buildings survey (EIA 2006b).

Data Explanation: This measure includes two size ranges; the first is 65,000 Btu to 135,000 Btu, and the second is 135,000 Btu to 240,000 Btu. The measure assumes a 12 EER unit relative to the 2010 federal standard, which ranges from about 10.4 EER to 11.2 EER, depending on the unit type and size. The energy savings average 1,070 kWh (7.2%) for the smaller unit and 3,371 kWh (10.8%) for the larger unit. We assume a measure lifetime of 15 years (LBNL 2003). Incremental costs (average $629 for 65 kBtu to135 kBtu and $1,415 for 135 kBtu to 240 kBtu) are derived from DOE's Technical Support Document (DOE 2004). Percent applicable (33% for 65 kBtu to135 kBtu), and the percent of floorspace with cooling from unitary equipment are also from DOE's Technical Support Document (DOE 2004). The levelized cost is calculated to be 4–5.7 cents/kWh, depending on unit type and size.

7. High-Efficiency Packaged Terminal AC/HP

Measure Description: PTACs and PTHPs are self-contained heating and air-conditioning units encased inside a sleeve specifically designed to go through the exterior building wall. The basic design of a PTAC is comprised of a compressor, an evaporator, a condenser, a fan, and an enclosure. They are primarily used to provide space conditioning for commercial facilities such as hotels, hospitals, apartments, dormitories, schools, and offices. High-efficiency units have a higher energy efficiency ratio (EER) for cooling units and coefficient of performance (COP) for heat pumps.

Basecase: Consistent with all HVAC-related measures, the baseline electricity intensity is 2.7 kWh per ft^2, which is the estimated HVAC consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey (EIA 2006b).

Data Explanation: We assume that high efficiency units save an average of 7.8%, or 226 kWh per unit, relative to a basecase, which is based on an ACEEE submission to ASHRAE using web data. The measure life is 15 years (ASHRAE 90.1-1999). Percent applicable is 5%, which is the percent of cooling floorspace from packaged terminal units (ADL 2001). The levelized cost is calculated to be 3.8 cents/kWh.

8. Efficient Room Air Conditioner

Measure Description: An ENERGY STAR room AC must be at least a 10% improvement over the 2000 federal standard (an average 8000 Btu unit must have a 10.8 EER).

Basecase: The assumed basecase unit is a room A/C that meets 2000 federal energy standards (an average 8000 Btu unit has a 9.8 EER) and uses an average of 677 kWh per unit. Baseline electricity intensity for this end-use, 1.5 kWh per ft^2, is the estimated cooling consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey (EIA 2006).

Data Explanation: We assume an ENERGY STAR room AC uses 590 kWh per year, saves 9% of basecase energy, and has an incremental cost of $30 (ENERGY STAR calculator). We assume a measure life of 9 years (ENERGY STAR calculator), a current market share of 52% (EPA 2007c), and percent applicable assumes 4% of cooling floorspace uses room AC units (ADL 2001). The levelized cost is calculated to be 4.3 cents/kWh.

9. High-Efficiency Chiller

Measure Description: "Chillers" are the hearts of very large air-conditioning systems for buildings and campuses with central chilled water systems. A centrifugal chiller utilizes the vapor compression cycle to chill water and reject the heat collected from the chilled water plus the heat from the compressor to a second water loop controlled by a cooling tower.

Basecase: The basecase unit assumes 0.634 kW/ton T24 from DEER for an average 150 ton system and 1,593 national average full-load operating hours from the ASHRAE 90.1-1999 analysis. Baseline electricity intensity for this end-use, 2.7 kWh per ft^2, is the estimated HVAC consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey (EIA 2006b).

Data Explanation: We assume the new measure has 20% savings, which is derived from estimates provided in SWEEP 2002 and ACEEE 1997. The lifetime estimate of 23 years is from the ASHRAE Handbook (HVAC Applications). Incremental costs are $9,900 and assume a 150 ton average unit (CEC 2005a). Percent applicable (33%) assumes percentage of cooling floorspace using chillers (ADL 2001). The levelized cost is calculated to be 2.4 cents/kWh.

10. Dual-Enthalpy Economizer

Measure Description: Economizers modulate the amount of outside air introduced into the ventilation system based on the relative temperature and humidity of the outside and return air. If the enthalpy, or the latent and sensible heat, of the outside air is less than that of the return air when space cooling is required, then the outside air is allowed to reduce or eliminate the cooling requirement of the AC equipment.

Basecase: Baseline electricity intensity, 1.5 kWh per ft^2, is the estimated cooling consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey (EIA 2006b).

Data Explanation: Savings per unit assume 276 kWh (20% savings) per ton for an average 11-ton unit (CL&P 2007). Average measure life is 10 years (CL&P 2007). Incremental costs per unit are from NYSERDA 2003. Percent applicable is the portion of cooling square footage represented by packaged AC and HP units, and assumes that 90% of these unitary systems could benefit from economizers (ACEEE estimate). It also assumes a 5% current market share (ACEEE estimate). The levelized cost is calculated to be 3.8 cents/kWh.

11. Demand-Controlled Ventilation

Measure Description: Often, HVAC systems are designed to supply ventilated air based on assumed occupancy levels, resulting in over-ventilation. Demand-controlled ventilation monitors CO_2 levels in different zones and delivers the required ventilation only when and where it is needed.

Basecase: The basecase is standard ventilation electricity consumption for a 50,000 ft^2 office building, or about 40,000 kWh/year (Sachs et al. 2004). Baseline electricity intensity for this end-use, 0.7 kWh per ft^2, is the estimated ventilation consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey (EIA 2006b).

Data Explanation: We assume 20% savings for this measure (ET 2004). Energy use per unit is 32,000 kWh/year, assuming a 50,000 ft^2 building (Sachs et al. 2004). The lifetime estimate is 15 years, and incremental costs are $3,450 (Sachs et al. 2004). The measure is applicable to 90% of larger (60%) cooling units (Sachs et al. 2004). The levelized cost is calculated to be 4.2 cents/kWh.

12. HVAC Tune-up

Measure Description: Most HVAC technicians lack interest, training, equipment and methods to perform quality refrigerant charge and airflow (RCA) tune-ups. Because many new and existing air conditioners have improper RCA, which reduces efficiency, there is significant potential for energy savings by diagnosing and correcting RCA.

Basecase: The assumed basecase unit is a 4.5 ton commercial unitary AC/HP per California program experience (CPUC 2006), estimated to use 8,396 annual kWh per the unitary AC/HP measure. The base electricity intensity for the HVAC end-use is 3.4 kWh/ ft^2, the average for small buildings less than 25,000 ft^2, for which this measure is applicable.

Data Explanation: We assume 11% savings from this measure according to California's DEER database (CEC 2005a) and the California Refrigerant and Air Charge (RCA) program report (CPUC 2006). We assume that 60% of units have improper RCA (CPUC 2006), and therefore this measure is applicable to 60% of unitary HVAC units in buildings less than or equal to 25,000 ft^2 (CBECS 2003; E N Central region). We estimate an average measure life of 3 years, as units need to be periodically re-tuned. We assume a cost of $158 for this measure, based on a $35/ton labor cost (CEC 2005a) and an assumed 4.5-ton unit. The levelized cost is calculated to be 6.3 cents/kWh.

13. Energy Management System (EMS)

Measure Description: An Energy Management System (EMS) is a computerized system that collects, analyzes and displays information on HVAC, lighting, refrigeration, and other commercial building subsystems to aid commercial building and facility energy managers, financial managers, and electric utilities in reducing energy use in buildings.

Basecase: Baseline electricity intensity is the average HVAC end-use consumption in Ohio, estimated from CBECS (EIA 2006b) to be the average of consumption in the East North Central region.

Data Explanation: We assume 10% cooling savings and 7.5% heating and ventilation savings from an installed EMS (NYSERDA 2003). We estimate a 15-year measure life for the system. We assume total incremental costs of $19,333 for a 60,000 ft^2 building, which is derived from NYSERDA 2003, and assume a third of this ($6,380) for this measure by assuming the cost is spread equally among electric HVAC, gas HVAC and lighting. Percent applicable is an ACEEE estimate. The levelized cost is calculated to be 5.8 cents/kWh.

13. Retrocommissioning

Measure Description: Commercial building performance tends to degrade over time, and many new buildings do not perform as designed, requiring periodic upgrades to restore system functions to optimal performance. Retrocommissioning (RCx) is a systematic process to optimize building performance through O&M tune-up activities and diagnostic testing to identify problems in mechanical systems, controls, and lighting. The best candidates for RCx are buildings over 50,000 or 100,000 ft2.

Basecase: The baseline is electricity intensity for HVAC and lighting end-uses in buildings greater than 50,000 ft2 (8 kWh/ ft2), which is based on data from CBECS (EIA 2006b). We take the average of the East North Central region to estimate electricity intensity in Ohio buildings.

Data Explanation: We assume 10% savings for HVAC and lighting end-uses (Sachs et al. 2004) in all commercial floorspace for buildings greater than 100,000 ft2, and 50% of floorspace in buildings 50,000 ft2 or greater based on data from CBECS (EIA 2006b). Xcel Energy’s RCx program results estimate an average RCx useful life of 7 years (Xcel Energy 2006). We assume a $0.25 cost per ft2 (Sachs et al. 2004). The levelized cost is calculated to be 5.4 cents/kWh.

Water Heating Measures

14. Heat Pump Water Heater

Measure Description: A heat pump water heater uses electricity to move heat from one place to another, rather than a less efficient electric resistance water heater which uses electricity to generate the heat directly. The heat source is the outside air or air in the basement where the unit is located.

Basecase: The basecase is standard electric water heating, with electricity consumption of 22,831 kWh/year (derived from energy savings and percent savings). Baseline electricity intensity for this end-use, 0.38 kWh per ft^2, is the estimated water heating consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA’s commercial buildings survey.

Data Explanation: We assumed a 62% savings, based on a simple coefficient of performance ratio. The assumed 14,155 kWh savings, $4,067 incremental cost, and 12 year lifetime estimates are from NYSERDA 2003. Percent applicable is based on engineering estimates for NYSERDA 2003, which assumes the measure is applicable to 70% of food service floorspace and 30% of lodging, education, and health care floorspace. Percent applicable is then multiplied by 2, since these building types are more energy and hot-water intensive than the average commercial building. The levelized cost is calculated to be 3.2 cents/kWh.

15. Efficient Commercial Clothes Washer (water heating portion)

Measure Description: A high-efficiency commercial clothes washer saves both energy and water, and as a result reduces water heating loads. For a high-efficiency clothes washer, we assume a unit with an MEF of 2.0, which represents about 80% of products on ENERGY STAR's product lists.

Basecase: The basecase unit is a clothes washer that meets DOE's federal efficiency standard of 1.26 MEF. An average unit consumes 1,136 kWh annually for water heating, which is derived from DOE 2007. Baseline electricity intensity for this end-use is 0.38 kWh/ft^2/year (water heating portion only).

Data Explanation: Savings on electric water heating from this measure assume a 2.0 MEF clothes washer uses an average 431 kWh annually, for a 62% savings, which is derived from DOE's TSD (DOE 2007). We assume the measure is applicable to the 17% of units that have electric water heating, and assume a 20% market share of efficient products. The overall stock estimate is based on national stock data (DOE 2007) and prorated to Ohio based on commercial building floorspace. We assume an incremental cost for an efficient unit is $316 and an 11-year measure life (DOE 2007). The levelized cost is calculated to be 3.2 cents/kWh.

<u>Refrigeration Measures</u>

16. Efficient Walk-In Refrigerators & Freezers

Measure Description: Walk-in refrigerators and freezers (walk-ins) are medium and low-temperature refrigerated spaces that can be walked into, and that are used to maintain the temperature of pre-cooled materials (not to rapidly cool down materials from warmer temperatures). A high-efficiency walk-in is defined as meeting the 2004 CEC standard for walk-ins. This includes prescriptive requirements such as higher levels of insulation, motor types, and the use of automatic door-closers (Nadel et al. 2006).

Basecase: The baseline energy use for an average walk-in is 18,859 kWh/year (Nadel et al. 2006). Baseline electricity intensity for this end-use, 0.82 kWh per ft^2, is the estimated refrigeration energy consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey.

Data Explanation: For a high-efficiency walk-in unit, we assume 44% savings over a baseline unit, or 8220 kWh/year, $957 incremental cost, and a 12 year measure lifetime (Nadel et al. 2006), which are based on a PG&E CASE study (2005). We estimate percent applicable as the 18% of refrigeration energy use attributed to walk-ins (ADL 2006) and estimate a 50% current market share of high-efficiency products (ACEEE estimate). The levelized cost is calculated to be 1.3 cents/kWh.

17. Efficient Reach-In Coolers & Freezers

Measure Description: This measure includes high-efficiency packaged commercial reach-in refrigerators and freezers with solid doors, and refrigerators with transparent doors such as beverage merchandisers. High-efficiency units are those that meet the CEE Tier 2 performance standard, as estimated in PG&E 2005.

Basecase: We assume a baseline unit, which is one that meets that upcoming (2009 or 2010) federal standard, uses 4,027 kWh per year. This is weighted by sales of unit type per PG&E 2004. Baseline electricity intensity for this end-use, 0.82 kWh per ft^2, is the estimated refrigeration energy consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey.

Data Explanation: The savings estimate for a high-efficiency unit, 31% savings or 1,268 kWh per year, is a weighted average of different types of reach-ins that meet CEE's Tier 2 performance standard (PG&E 2005). We estimate an average lifetime of 9 years and an incremental cost of $341, both per PG&E 2005. We estimate percent applicable as the percent of refrigeration energy use attributed to reach-ins and beverage merchandisers, or 17% (ADL 2006), and assume a 10% current market share of high-efficiency products per PG&E 2005. The levelized cost is calculated to be 2.0 cents/kWh.

18. Efficient Ice-Maker

Measure Description: Commercial ice makers, which are used in hospitals, hotels, and food service and preservation, have energy savings potential largely in their refrigeration systems. We assume an efficient icemaker meets CEC's Tier 2 level of energy savings, which incorporate improved compressors, heat exchangers, and controls, as well as better insulation and gaskets.

Basecase: The baseline energy use, 3,338 kWh per year, is a weighted average of different types of ice-makers that meet the 2010 standard. Baseline electricity intensity for this end-use, 0.82 kWh per ft^2, is the estimated refrigeration energy consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey.

Data Explanation: The 16% savings estimate for a high-efficiency unit, or 542 kWh per year, is a weighted average of different types of ice-makers that meet CEC's tier 2 energy savings (PG&E 2005). We estimate an average lifetime of 10 years and an incremental cost of $100, both per PG&E 2005. We estimate percent applicable as the percent of refrigeration energy use attributed to ice-makers, or 10% (ADL 2006), and assume a 10% current market share of high-efficiency products per PG&E 2005 and ACEEE judgment. The levelized cost is calculated to be 2.4 cents/kWh.

19. Efficient Built-up Refrigeration System

Measure Description: Built-up or supermarket refrigeration systems are primarily made up of refrigerated display cases for holding food for self-service shopping, as well as machine room cooling technologies. More efficient built-up systems include improved machine room technologies (evaporative condensers, mechanical sub-cooling, and heat reclaim), high-efficiency evaporative fan motors, hot gas defrost, liquid-suction heat exchangers, antisweat control, and defrost control.

Basecase: The measure baseline is 1,600,000 kWh for a 45,000 ft^2 supermarket with a built-up refrigeration system. Baseline electricity intensity for this end-use, 0.82 kWh per ft^2, is the estimated refrigeration energy consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey.

Data Explanation: Per-unit savings of 336,000 kWh (21%) are from ADL 1996 and assume an average new 45,000 ft^2 supermarket with a 5-year payback. We estimate percent applicable as the percent of refrigeration energy use attributed to built-up refrigeration, or 33% (ADL 1996). Incremental cost ($37,000) and lifetime (10 years) are from ADL 1996. The levelized cost is calculated to be 1.4 cents/kWh.

20. Efficient Vending Machine

Measure Description: ENERGY STAR vending machines must consume 50% less energy than standard machines. Under the Tier II ENERGY STAR level, this translates to a maximum energy consumption of 6.53 kWh/day for a 650-can machine.

Basecase: A Tier I ENERGY STAR level vending machine is assumed to be the basecase. On average, it uses 2,816 kWh per year (ENERGY STAR calculator for a 600 can machine). Baseline electricity intensity for this end-use, 0.82 kWh per ft^2, is the estimated refrigeration energy consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA's commercial buildings survey.

Data Explanation: Per unit savings of 18% (509 kWh/year) are estimated from ASAP 2007 based on ENERGY STAR calculator estimates. Likewise, an incremental cost of $30, and a lifetime estimate of 10 years are from ASAP 2007. We estimate percent applicable as the percent of refrigeration energy use attributed to built-up refrigeration, or 13% (NYSERDA 2003). Stock estimates are from the 2005 TSD (DOE 2005). The levelized cost is calculated to be 0.8 cents/kWh.

21. Vending Miser

Measure Description: A Vending Miser is an energy control device for refrigerated vending machines. Using an occupancy sensor, the control turns off the machine's lights and duty cycles the compressor based on ambient air temperature.

Basecase: The basecase unit is an efficient vending machine that meets the ENERGY STAR tier II level and uses 2,309 kWh per year (ENERGY STAR calculator for a 600 can machine). Baseline electricity intensity is for the refrigeration end-use (0.82 kWh/ ft^2).

Data Explanation: We assume 35% savings for this measure based on manufacturer data (usatech.com 2008), an incremental cost of $167 (NYSERDA 2003), and a measure life of 10 years (NYSERDA 2003). The levelized cost is calculated to be 2.7 cents/kWh.

<u>Appliances</u>

22. Efficient Hot Food Holding Cabinets

Measure Description: Commercial hot food holding cabinets are used in the commercial kitchen industry primarily for keeping food at safe serving temperature, without drying it out or further cooking it. These cabinets can also be used to keep plates warm and to transport food for catering events. High efficiency models differ mainly in that they are better insulated.

Basecase: The basecase unit is an uninsulated cabinet that consumes 5,190 kWh per year. This was calculated from CASE (2004) using a simple average of three sizes of cabinets, and then weighting the average using CASE figures for insulated cabinets.

Data Explanation: The energy savings from an insulated holding cabinet are 1,815 kWh per year (35% savings), with an incremental cost of $453, and an estimated 15 year lifetime (ASAP 2007, based on PG&E CASE study (2004)). Percent applicable refers to the 25% of holding cabinets that are currently uninsulated (ASAP 2007, based on PG&E CASE study (2004)). The levelized cost is calculated to be 2.4 cents/kWh.

23. Efficient Commercial Clothes Washer (excluding hot water energy)

Measure Description: A high-efficiency commercial clothes washer saves both energy and water. For a high-efficiency clothes washer, we assume a unit with an MEF of 2.0, which represent about 80% of products on ENERGY STAR's product lists.

Basecase: The basecase unit is a clothes washer that meets DOE’s federal efficiency standard of 1.26 MEF. An average unit consumes 1,530 kWh annually for non-water heating uses, which is derived from DOE 2007.

Data Explanation: Electric savings from this measure assume a 2.0 MEF clothes washer uses an average 1,191 kWh annually, for a 22% savings, which is derived from DOE's TSD (DOE 2007). We assume the measure is applicable to the 39% of units that have electric dryer heating (removal of moisture from clothes), and assume a 20% market share of efficient products. The overall stock estimate is based on national stock data (DOE 2007) and prorated to Ohio based on commercial building floorspace. We assume an incremental cost for an efficient unit is $316 and an 11-year measure life (DOE 2007). The levelized cost is calculated to be 3.7 cents/kWh.

Lighting Measures

24. Fluorescent Lighting Improvements

Measure Description: The new measure assumes extra-efficient ballasts and high-lumen lamps are installed with no change in light level (low ballast factor).

Basecase: Basecase watts per square foot reflects current installed fixtures. This includes 84,000 annual tube fluorescent kWh used per average 14,000 ft^2 commercial building (Navigant 2002). On average, fluorescent lights are operated 9.7 hours/day. We assume 2-lamp standard T8 fixtures and electronic ballasts as the baseline, plus a small number of existing 3-lamp T12 fixtures with magnetic ballasts that are not likely to be replaced in the absence of programs over the time horizon.

Data Explanation: We assume a percent savings of 27%.The incremental costs are $2 extra per ballast, and $1 extra for each of 2 lamps. The percent applicable (56%) is the fluorescent percent of total commercial lighting kWh (Navigant 2002). The levelized cost is calculated to be 0.7 cents/kWh.

25. HID Lighting Improvements

Measure Description: Metal halide lamps produce light by passing an electric arc through a mixture of gases. Efficiency improvements in metal halide lamps include pulse start lamp technology, electronic ballasts, and improved fixtures.

Basecase: Same basecase as #27 (Fluorescent lighting improvements).

Data Explanation: The new measure savings and costs are from a PG&E CASE study on Metal Halide Lamps & Fixtures (PG&E 2004). Energy savings were 447 kWh per year (26%), and incremental costs were $60. Percent applicable (12%) is the percentage of commercial electricity use for lighting that comes from HIDs (Navigant 2002). The levelized cost is calculated to be 6.3 cents/kWh.

26. Replace Incandescent Lamps

Measure Description: The new measure assumes that 4 average 75 W incandescent lamps are replaced with 23 W CFLs. It is assumed that the lights operate 9.5 hours per day.

Basecase: Same basecase as #27 (Fluorescent lighting improvements).

Data Explanation: Energy savings are 180 kWh per year, or 69%. Incremental costs include $10 in the cost of 4 CFLs, but save $32 in labor for replacing the bulbs, so the result is a cost savings. Percent applicable assumes that 32% of commercial electricity use for lighting is from incandescents (Navigant 2002), and ACEEE estimates that 70% of sockets are applicable for the new measure. The levelized cost is calculated to be -1.3 cents/kWh.

27. Occupancy Sensor for Lighting

Measure Description: Installation of occupancy sensors can greatly reduce lighting energy demands in commercial spaces, by automatically turning off lights in unoccupied spaces.

Basecase: Same basecase as #27 (Fluorescent lighting improvements).

Data Explanation: Energy savings of 361 kWh per year (NYSERDA 2003) assumes 30% energy reduction in individual offices and rooms and 7.5% reduction in open spaces (ACEEE estimate). Incremental cost ($48) and lifetime (10 years) estimates are from NYSERDA 2003. Percent applicable (38%) is from ACEEE 2004. The levelized cost is calculated to be 1.7 cents/kWh.

28. Daylight Dimming System

Measure Description: A daylight dimming system automatically dims electric lights to take advantage (or “harvest”) natural daylight.

Basecase: Same basecase as #27 (Fluorescent lighting improvements).

Data Explanation: Energy savings are estimated to be 143 kWh per year, or 35% (NYSERDA 2003). Savings apply for lamps on the perimeters of buildings (25% applicable – PIER 2003). Incremental cost ($68) and lifetime (20 years) estimates are from NYSERDA (2003). The levelized cost is calculated to be 3.8 cents/kWh.

29. Outdoor Lighting – Controls

Measure Description: This measure includes a variety of lighting control technologies for exterior lights.

Basecase: No basecase data was available for this measure.

Data Explanation: We assume a savings of 174 kWh, or 20%, from lighting controls. Incremental costs of $43 are from DEER 2001 and assume each control on average controls three fixtures. Percent applicable of 30% is an ACEEE estimate. The levelized cost is calculated to be 2.5 cents/kWh.

Miscellaneous

30. Office Equipment

Measure Description: This measure assumes a high-efficiency fax, printer, computer display, internal power supply, and a low mass copier.

Basecase: Baseline electricity use is 2886 kWh per year (NYSERDA 2003). Baseline electricity intensity for this end-use, 2.0 kWh per ft^2, is the estimated office equipment energy consumption in commercial buildings in Ohio. This is based on the East North Central region from EIA’s commercial buildings survey.

Data Explanation: Energy savings were 1410 kWh per year (49%), lifetime was 5 years, and incremental costs were $20. Percent applicable is estimated to be (50%) (NYSERDA 2003). The levelized cost is calculated to be 0.3 cents/kWh.

31. Turn off appliances

Measure Description: This measure involves turning off, or putting into a low-power state: vending machines, computers, monitors, printers and copiers.

Basecase: Baseline electricity use is 1.1 kWh/ft2, based on data from CBECS, LBNL, and ENERGY STAR.

Data Explanation: Energy savings were 9114 kWh per year (40%), lifetime was 5 years, and incremental costs were $0. Percent applicable is 100%, as data for the savings already took into account the number of buildings that already shut down equipment after hours/. The levelized cost is $0/kWh

New Buildings

32. Efficient New Building (15% Savings)

Measure Description: Incorporating energy efficiency into building design is best achieved at the time of construction. New buildings can achieve major energy savings in heating and cooling, as well as energy-saving appliances.

Basecase: Basecase of 7.2 kWh per ft^2 is an estimate of HVAC, water heating, and lighting end-use electricity intensity for new buildings in Ohio, derived from data for buildings built from 2000-2003 (EIA 2006).

Data Explanation: Incremental cost of $0.35 per ft^2 and measure life of 17 years are from NGRID 2007. Percent applicable of 18% for this new buildings measure assume that 30% and 50% new buildings savings are phased in one to two years prior to enactment of codes in the policy scenarios (30% in 2012 and 50% in 2020). The levelized cost is calculated to be 2.9 cents/kWh.

33. Efficient New Building (30% Savings)

Measure Description: Incorporating energy efficiency into building design is best achieved at the time of construction. New buildings can achieve major energy savings in heating and cooling, as well as energy-saving appliances.

Basecase: Basecase of 7.2 kWh per ft^2 is an estimate of HVAC, water heating, and lighting end-use electricity intensity for new VA buildings, derived from data for buildings built from 2000-2003 (EIA 2006).

Data Explanation: In New York, estimates show that commercial buildings can reach 30% beyond code at an investment of $0.54/kWh. To be conservative, we estimate $0.70/kWh by doubling the costs of a 15%-beyond-code building. Measure life of 17 years is from NGRID 2007. Percent applicable of 35% for 30% savings new buildings assume that 30% and 50% new buildings savings are phased in one to two years prior to enactment of codes in the policy scenarios (30% in 2012 and 50% in 2020). The levelized cost is calculated to be 2.9 cents/kWh.

34. Tax-Credit Eligible Building (50% Savings)

Measure Description: A federal tax incentive is available for new buildings that are constructed to save at least 50% of the heating, cooling, ventilation, water heating, and interior lighting cost of a building that meets ASHRAE standard 90.1-2001.

Basecase: Basecase of 7.2 kWh per ft^2 is an estimate of HVAC, water heating, and lighting end-use electricity intensity for new buildings in Ohio, derived from data for buildings built from 2000-2003 (EIA 2006).

Data Explanation: Incremental costs of $1.20 per ft^2 are from ACEEE 2004. Measure life of 17 years is from NGRID 2007. The levelized cost is calculated to be 3.0 cents/kWh

Table 29. Commercial Energy Efficiency Measure Characterizations

Measures	Measure Life (Years)	Annual kWh svgs per unit	2007 Ohio Stock	kWh svgs per s.f.	Increment-al cost per unit	Increment -al cost per s.f.	Cost of Conserved Energy (2006$/kWh saved)	Adjust-ment Factor	% Turn-over	Inter-action Factor	Savings in 2025 (GWh)
Existing Buildings											
<u>HVAC</u>											
HVAC tuneup (smaller buildings)	10	24,828	NA	0.53	$ 3,375	NA	$ 0.018	25%	100%	100%	472
Energy management system install	20	5,513	NA	0.10	$ 3,750	$ 0.25	$ 0.055	80%	85%	100%	240
Cool roof	25	NA	NA	0.28	NA	$ 0.12	$ 0.030	35%	100%	100%	345
Roof insulation	25	NA	NA	0.26	NA	$ 0.07	$ 0.020	75%	68%	100%	480
Low-e windows	10	21,977	NA	0.18	$ 6,650	NA	$ 0.039	40%	100%	86%	<u>216</u>
Load-Reducing Measures Subtotal											**1,753**
High-effic. unitary AC & HP	15	1,070	NA	0.19	$ 629	NA	$ 0.057	33%	100%	84%	191
High-effic. unitary AC & HP (65-135 kBtu)	15	3,371	NA	0.29	$ 1,415	NA	$ 0.040	15%	100%	84%	130
High-effic. unitary AC & HP (135-240 kBtu)	15	226	NA	0.21	$ 88	NA	$ 0.038	5%	100%	84%	31
Packaged Terminal HP and AC	13	87	NA	0.19	$ 35	NA	$ 0.043	4%	100%	84%	22
Efficient room air conditioner	23	30,347	NA	0.54	$ 9,900	NA	$ 0.024	33%	74%	84%	<u>393</u>
HVAC Equipment Measures Subtotal											**767**
High-efficiency chiller system	10	3,036	NA	0.30	$ 889	NA	$ 0.038	46%	100%	77%	380
Dual Enthalpy Control	15	8,000	NA	0.14	$ 3,450	NA	$ 0.042	54%	100%	77%	209
Retrocommissioning	3	924	NA	0.37	$ 158	NA	$ 0.063	20%	100%	77%	200
Duct testing and sealing	10	14,308	NA	0.24	$ 6,380	NA	$ 0.058	33%	100%	77%	217
Measures	7	NA	NA	0.30	NA	$ 0.25	$ 0.054	46%	100%	77%	<u>385</u>
HVAC Control Measures Subtotal											**<u>1,391</u>**
HVAC Subtotal											**3,911**
<u>Water Heating</u>											
Energy star commercial clothes washer	11	705	108824	0.00	$ 316	NA	$ 0.037	14%	100%	100%	10
Demand-Controlled Ventilation	12	14,155	NA	0.24	$ 4,067	NA	$ 0.032	24%	100%	99%	<u>202</u>
											212
<u>Refrigeration</u>											
Heat pump water heater	12	8,220		0.36	$ 957	NA	$ 0.013	9%	100%	100%	116
Walk-in coolers & freezers	9	1,268		0.26	$ 177	NA	$ 0.020	15%	100%	100%	143
Reach-in coolers & freezers	10	542		0.13	$ 100	NA	$ 0.024	9%	100%	100%	44
Ice-makers	10	336,00		0.17	$ 37,000	NA	$ 0.014	33%	100%	100%	202
Supermarket (built-up) refrigeration	10	507		0.15	$ 30	NA	$ 0.008	13%	100%	100%	71
Vending machines (to tier 2 ENERGY STAR level)	10	808		0.24	$ 167	NA	$ 0.027	13%	100%	100%	<u>113</u>

Measures	Measure Life (Years)	Annual kWh svgs per unit	2007 Ohio Stock	kWh svgs per s.f.	Increment-al cost per unit	Increment -al cost per s.f.	Cost of Conserved Energy (2006$/kWh saved)	Adjust-ment Factor	% Turn-over	Inter-action Factor	Savings in 2025 (GWh)
Refrigeration Subtotal											**689**
Lighting											
Energy star commercial clothes washer	13	64	0	1.36	$ 4	NA	$ 0.007	56%	100%	100%	2,698
Fluorescent lighting improvements	2	447	0	1.29	$ 60	NA	$ 0.063	12%	100%	100%	552
HID lighting improvements	13	180	0	3.44	$ (22)	NA	$ (0.013)	22%	100%	100%	2,738
Replace incandescent lamps	10	361	0	0.93	$ 48	NA	$ 0.017	38%	100%	71%	904
Occupancy sensor for lighting	20	143	0	1.74	$ 68	NA	$ 0.038	25%	85%	67%	876
Measures	7	NA	NA	0.50	NA	$ 0.25	$ 0.054	46%	100%	63%	519
Outdoor lighting -- improved efficiency	14	174	0	NA	$ 43	NA	$ 0.025	30%	100%	100%	-
											8,286
Office Equipment											
Outdoor lighting -- controls	5	1,410	0	0.97	$ 0	$ 20.00	$ 0.003	50%	100%	100%	1,723
Turn off office equipment after-hours	5	9,557	0	0.56	$ -	$ -	$ -	100%	100%	82%	1,633
											3,356
Appliances/Other											
Vending miser	15	1,815	41763.	NA	$ 453	NA	$ 0.024	25%	100%	100%	19
Hot Food Holding Cabinets	11	339	108824	NA	$ 316	NA	$ 0.037	31%	100%	100%	11
											30
Total Existing											**16,484**
New Buildings											
Turn off office equipment after-hours	17	NA	0	1.09	NA	$ 0.35	$ 0.029	18%	100%	100%	107
Efficient new building (15% savings)	17	NA	0	2.17	NA	$ 0.70	$ 0.029	35%	100%	100%	428
Efficient new building (30% savings)	17	NA	0	3.60	NA	$ 1.20	$ 0.030	6%	100%	100%	121
											656
											17,140

C.3. Industrial Sector

Overview of Approach

The analysis of electricity savings potential was accomplished in several steps. First, the industrial market in Ohio was characterized at a disaggregated level and electricity consumption for key end-uses was estimated. Then cost effective energy-saving measures were selected based on the projected average retail industrial electricity price. The economic potential savings for these measures was estimated by applying the efficiency measures to electricity end-use consumption. The following sections described the process for estimating the savings potential in Ohio.

Market Characterization and Estimation of Base Year Electricity Consumption

The industrial sector is made up of a diverse group of economic entities spanning agriculture, mining, construction and manufacturing. Significant diversity exists within most of these industry sub-sectors, with the greatest diversity within manufacturing. The various product categories within manufacturing are classified using the North American Industrial Classification System (NAICS) (Census 2002).[60]

Comprehensive, highly-disaggregated electricity data for the industrial sector is not available at the state level. To estimate the electricity consumption, this study drew upon a number of resources, all using the NAICS system and a consistent sample methodology. Fortunately, a conjunction of the various economic censuses for each state allows us to use a common base-year of 2002.

We then used national industry energy intensities derived from industry group electricity consumption data reported in the *2005 Annual Energy Outlook* (AEO) (EIA 2005) and value of shipments data reported in the *2002 Annual Survey of Manufacturing* (ASM) (Census 2005) to apportion industrial energy consumption. These intensities were then applied to the value of shipments data for the manufacturing energy groups (three-digit NAICS) in Ohio. These energy consumption estimates were then used to estimate the share of the industrial sector electricity consumption for each sub-sector.

Preparation of Baseline Industrial Electricity Forecast

As is the case for state-level energy consumption data, no state-by-state disaggregated electricity consumption forecasts are publicly available. Several alternate data sources were used to calculate estimated energy consumption growth rates for each state and sub-sector. We made the assumption that energy consumption will be a function of gross state value of shipments (VOS). Electricity consumption, however, will not grow at the same rate as value of shipments. This is because in general, energy intensity (energy consumed per value of output) decreases with time.

Because state-level disaggregated economic growth projections are not publicly available, data was used from Moody's Economy.com. The average growth rate for specific industrial-subsectors was estimated based on Economy.com's estimates of gross state product. We used this estimated industrial energy consumption distribution to apportion the EIA estimate (2005) of industrial energy consumption.

The industry sector is comprised of four sub-sectors: Manufacturing, Mining, Agriculture, and Construction. The manufacturing sector is broken down into 21 subsectors, defined by three digit NAICS codes. In order to most closely match available data from the *ASM* and *AEO*, three subsectors were further broken down to four digit NAICS codes: chemical manufacturing, nonmetallic mineral product manufacturing, and primary metal manufacturing. Table 30 below shows the estimated electrical consumption for all these subsectors in Ohio in 2008.

[60] The industry sector is comprised of four sub-sectors: Manufacturing, Mining, Agriculture, and Construction. Each sub-sector is further broken down into individual industry groups reflecting the many different definitions for the term 'industrial.'

Table 30. 2008 Base-Case Electricity Consumption by Industry in Ohio

Industry	NAICS Code	Electricity (GWh)	(%)
Agriculture	**11**	844	1%
Mining	**21**	592	1%
Construction	**23**	1,236	2%
Food mfg	311	1,987	3%
Beverage & tobacco product mfg	312	607	1%
Textile mills	313	70	0%
Textile product mills	314	91	0%
Apparel mfg	315	55	0%
Leather & allied product mfg	316	27	0%
Wood product mfg	321	487	1%
Paper mfg	322	2,506	4%
Printing & related support activities	323	882	1%
Petroleum & coal products mfg	324	1,670	3%
Chemical mfg	325	13,184	22%
Pharmaceutical & medicine mfg	*3254*	*797*	*1%*
All other chemical products	*-3253,3255-*	*12,387*	*21%*
Plastics & rubber products mfg	326	2,988	5%
Nonmetallic mineral product mfg	327	3,936	7%
Glass & glass product mfg	*3272*	*877*	*1%*
Cement & concrete product mfg	*3273*	*2,545*	*4%*
Other minerals	*3271,3274-*	*514*	*1%*
Primary metal mfg	331	13,765	23%
Iron & steel mills & ferroalloy mfg	*3311*	*4,180*	*7%*
Steel product mfg from purchased steel	*3312*	*1,775*	*3%*
Alumina and Aluminum	*3313*	*3,975*	*7%*
Nonferrous Metals, except Aluminum	*3314*	*2,133*	*4%*
Foundries	*3315*	*1,702*	*3%*
Fabricated metal product mfg	332	2,154	4%
Machinery mfg	333	1,736	3%
Computer & electronic product mfg	334	911	2%
Electrical equipment, appliance, & component mfg	335	1,144	2%
Transportation equipment mfg	336	6,723	11%
Furniture & related product mfg	337	685	1%
Miscellaneous mfg	339	967	2%
Total Industrial Sector		59,246	100%

Market Characterization Results

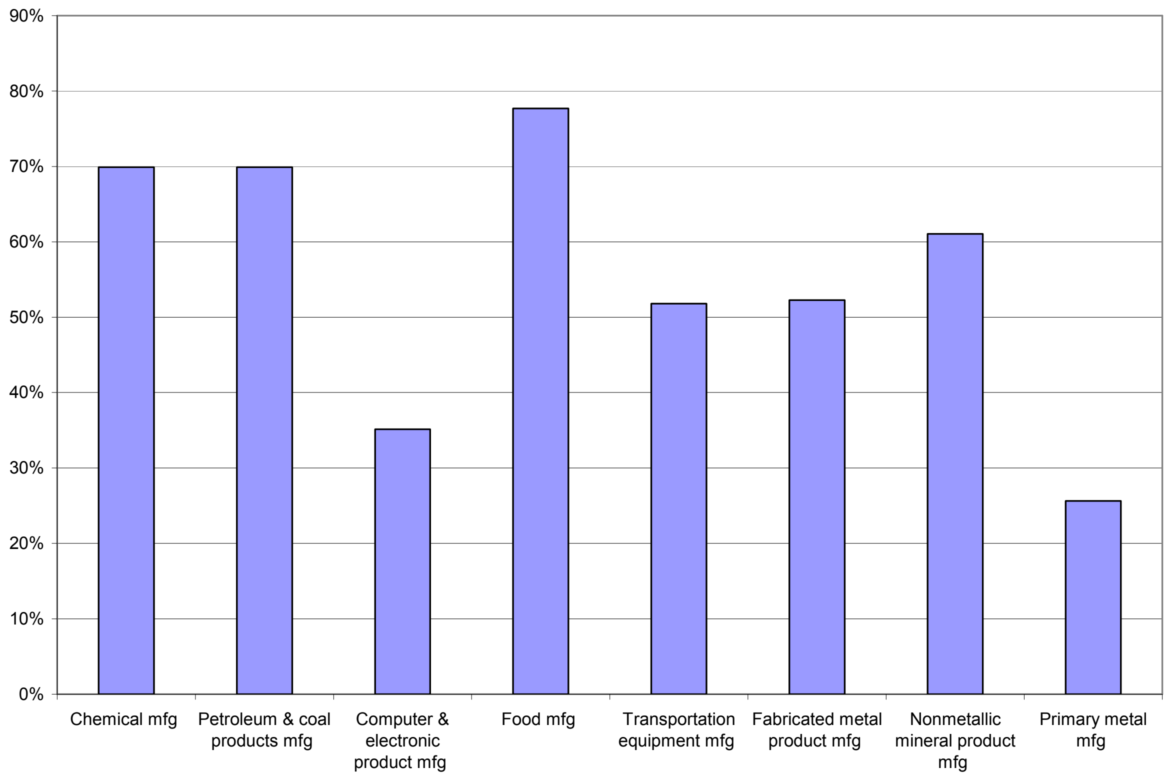
In 2008, the State of Ohio industrial sector consumed 59,246 GWh of electricity. Within the manufacturing sector, the chemical, primary metal, and transportation equipment manufacturing industries are the largest consumers of energy, accounting for over 55% of industrial electricity consumption.

Industrial Electricity End Uses

In order to determine the electricity savings for any technology, the fraction of the electricity to which the technology is applicable must be determined. Much of the energy consumed by industry is directly involved in processes required to produce various products. Electricity accounts for about a third of the primary energy used by industries (EIA 2005). Electricity is used for many purposes, the most important being to run motors, provide lighting, provide heating, and to drive electrochemical processes.

While detailed end-use data is only available for each manufacturing sub-sector and group through the MECS survey (EIA 2005), motor systems are estimated to consume 60% of the industrial electricity (Xenergy 1998). The fraction of total electricity attributed to motors is presented in Figure 23.

Figure 23. Percent of Total Electricity Consumption by Motor Systems

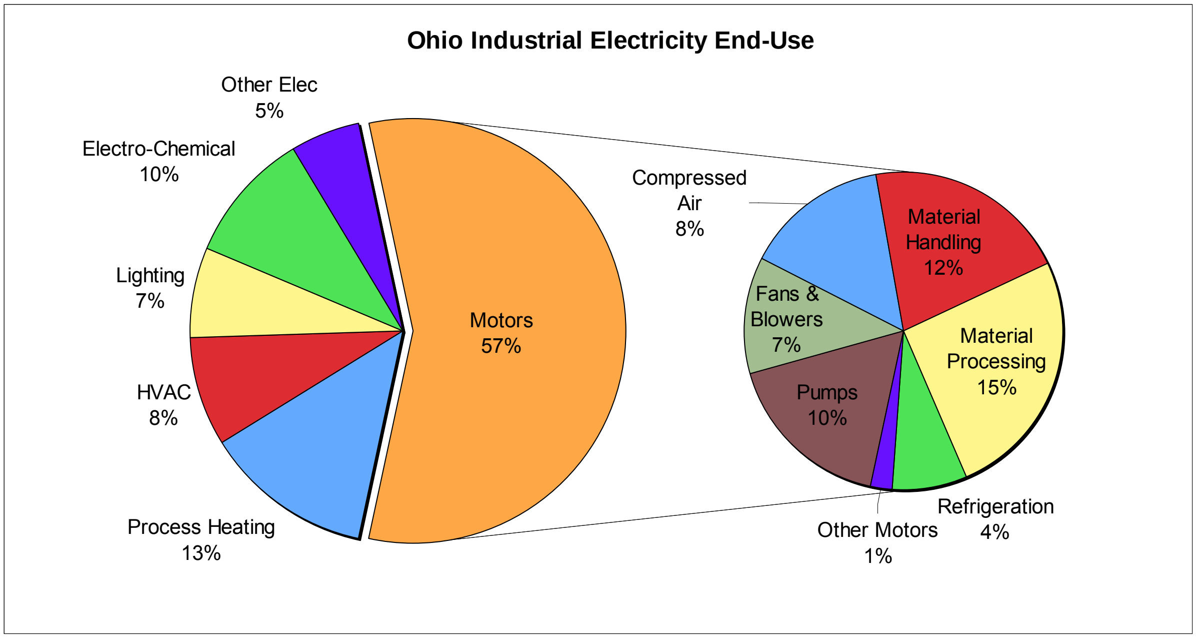


Source: XENERGY (1998)

Motors are used for many diverse applications from fluids (pumps, fans, and air and refrigeration compressors) to materials handling and processing (conveyors, machine tools and other processing equipment). The distribution of these motor uses varies significantly by industry, with material processing being the largest consumer in the sector.

Figure 24 shows the total weighted average of end-use electricity consumption in Ohio with a breakdown of motors use in the state.

Figure 24. Weighted Average of Total Industrial Electricity End-Uses in Ohio with Breakdown of Industrial Motor System End-Uses



While lighting and space conditioning represent a relatively small share of the overall industrial sector electricity consumption, they are important in some of the key industries found in the region such as transportation equipment manufacturing and other mechanical manufacturing and assembling industries, and the electricity savings potential can be significant.

Overview of Efficiency Measures Analyzed

The first step in our technology assessment was to collect limited information on a broad "universe" of potential technologies. Our key sources of information included the U.S. Department of Energy, Office of Industrial Technologies; the Center for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET); Lawrence Berkeley National Laboratory (LBNL) and American Council for an Energy-Efficient Economy reports; and information from NYSERDA. We did not collect any primary data on technology performance.

Oftentimes, no one source provided all of the information we sought for our assessment (energy use, energy savings compared to average current technology, investment cost, operating cost savings, lifetime, etc.). We therefore made our best effort to combine readily available information along with expert judgment where necessary.

We sought to identify technologies that could have a large potential impact in terms of saving energy. These may be technologies that are specific to one process or one industry sector, or so-called "cross-cutting" technologies that are applicable to a variety of sectors. In estimating energy savings, we first identified the specific energy savings of each technology by comparing the energy used by the efficient technology to the energy required by current processes. Our second step was to "scale up" this savings estimate to see how much energy savings—for industry overall—this technology would achieve. For the most part, we derived specific energy savings information from the various technology assessment studies noted above.

In scaling up the technology-specific energy savings, we relied on our general knowledge of the various industrial processes to which this technology could be applied. We also took into account structural limitations to the penetration of the technology. Additionally, we recognized that market penetration, in the absence of significant policy support, can take time given the slowness of stock turnover in many industrial facilities.

Measures

We identified 14 measures that were cost effective at the average projected industrial electricity rates in Ohio of $0.0744/kWh (see Table 31). The cost and performance of these measures has been developed over the past decade by ACEEE from research into the individual measures and review of past project performance. The costs of many of these measures has increased in recent years as a result of significant increases in key commodity costs such as copper, steel and aluminum, as well as overall manufacturing costs due to energy prices and market pressures. The estimates presented in Table 31) represent ACEEE's most current estimates. We present the full normalized installed measure cost (i.e., the full cost required to install a measure per unit of saved energy) as well as the levelized cost (i.e., the annual cost of the measure amortized over the life of the measure).

Table 31. Cost and Performance of Industrial Measures

		Cost of Saved Energy		
Measure	Measure Life	Installed Cost/kWh	Levelized cost/kWh	Annual Savings for End-Use
Sensors & Controls	15	$0.145	$0.014	3%
Energy Information Sys.	15	$0.635	$0.061	1%
Duct/Pipe insulation	20	$0.653	$0.052	20%
Electric supply	15	$0.104	$0.010	3%
Lighting	15	$0.212	$0.020	23%
Advanced efficient motors	25	$0.491	$0.035	6%
Motor management	5	$0.079	$0.018	1%
Lubricants	1	$0.000	$0.000	3%
Motor system optimization	15	$0.097	$0.009	1%
Compressed air manage	1	$0.000	$0.000	17%
Compressed air -advanced	15	$0.001	$0.000	4%
Pumps	15	$0.083	$0.008	20%
Fans	15	$0.249	$0.024	6%
Refrigeration	15	$0.034	$0.003	10%

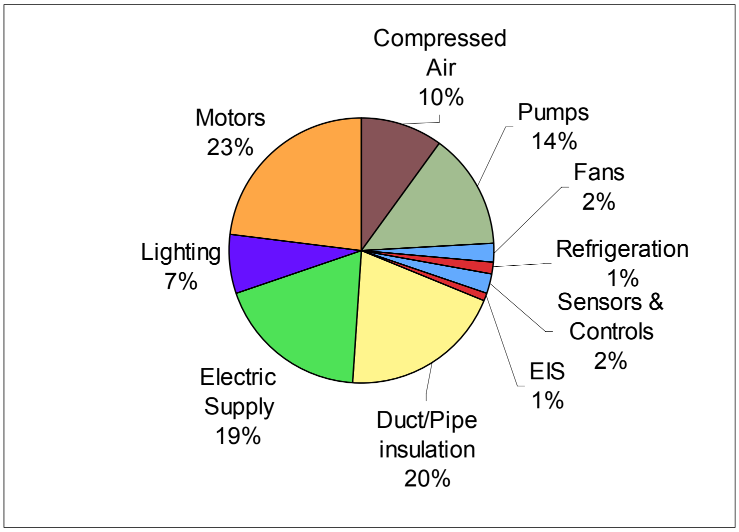
In addition, we estimated the average normalized cost of industrial energy efficiency investments to be $0.275/kWh saved. This estimate was arrived at by estimating the sum of the annual incremental savings for each measure in each industry based on end-use energy distribution and dividing the corresponding total investment required.

Potential for Energy Savings

In Ohio, a diverse set of efficiency measures will provide electricity savings for industry. The application of these measures contributes to total economic electric savings potential of 16%. These savings are distributed as presented in

Figure 25.

Figure 25. Fraction of Savings Electricity Potential by Measure



In addition, this analysis did not consider process-specific efficiency measures that would be applied at the individual site level because available data does not allow this level of analysis. However, based on experience from site assessments by U.S. Department of Energy and others entities, we would anticipate an additional economic savings of 5-10%, primarily at large energy intensive manufacturing facilities. Therefore, the overall economic industrial efficiency resource opportunity for electricity is on the order of 21-26%.

APPENDIX D – DEMAND RESPONSE ANALYSIS

D.1. Introduction

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

D.1.1. Objectives of this Assessment

This assessment develops estimates of DR potential for Ohio. Potential load reductions from DR are estimated for the residential, commercial, and industrial sectors (see Section 3). The assessment also includes discussions of reductions possible from other DR programs, such as DR rate designs (see Section 3.6).

D.1.2. Role of Demand Response in Ohio's Resource Portfolio

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

D.1.3. Summary of DR Potential Estimates in Ohio

Table 32 shows the resulting load shed reductions possible for Ohio, by sector, for years 2015, 2020, and 2025. Load impacts grow rapidly through 2018 as program implementation takes hold. After 2018, the program impacts increase at the same rate as the forecasted growth in peak demand.

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

The high scenario results show a reduction in peak demand of 3,078 MW is possible by 2015 (8.4% of peak demand); 6,293 MW is possible by 2020 (16.4% of peak demand); and 6,471 MW is possible by 2025 (16.2% of peak demand).

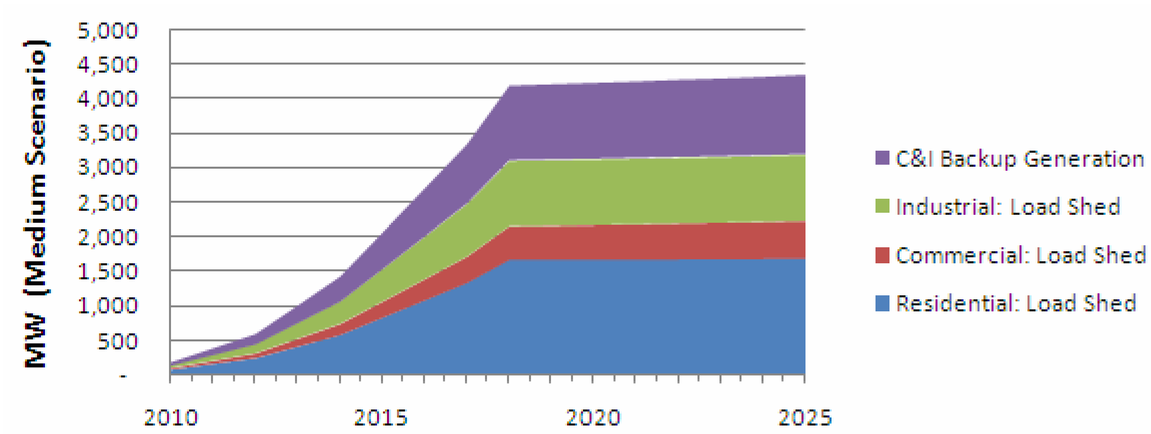
The more conservative medium scenario results show a reduction in peak demand of 2,052 MW is possible by 2015 (5.6% of peak demand); 4,193 MW is possible by 2020 (11.0% of peak demand); and 4,309MW is possible by 2025 (10.8% of peak demand).

Table 32. Summary of Potential DR in Ohio, By Sector, for Years 2015, 2020, and 2025

	Low Scenario			Medium Scenario			High Scenario		
	2015	**2020**	**2025**	**2015**	**2020**	**2025**	**2015**	**2020**	**2025**
Load Sheds (MW):									
Residential	502	1,008	1,017	837	1,680	1,696	1,172	2,352	2,374
Commercial	86	184	199	228	491	531	428	921	996
Industrial	206	415	420	464	933	944	824	1,660	1,678
C&I Backup Generation (MW)	393	817	854	524	1,089	1,138	655	1,361	1,423
Total DR Potential (MW)	1,186	2,424	2,490	2,052	4,193	4,309	3,078	6,296	6,471
DR Potential as % of Total Peak Demand	3.2%	6.4%	6.3%	5.6%	11.0%	10.8%	8.4%	16.4%	16.2%
a. See Section 3 for underlying data and assumptions.									

Figure 26 shows the resulting load shed reductions possible for Ohio, by sector, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 26. Potential DR Load Reductions in Ohio by Sector (MW)



D.2. Defining Demand Response

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

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

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

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

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

D.3. Rationale for Demand Response

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

- **Ensure reliability** – DR provides load reductions on the customer side of the meter that can help alleviate system emergencies and help create a robust resource portfolio of both demand-side and supply-side resources that meet reliability objectives.
- **Reduce supply costs** – DR may be a less expensive option per megawatt than other resource alternatives. DR resources compete directly with supply-side resources in many regions of the country. Portfolios that help lower the increase in customers' expenditures on electricity over time represent an increasingly important attribute from the perspective of many energy customers.
- **Manage operational and economic risk through portfolio diversification** – DR capability is a resource that can diversify peaking capabilities. This creates an alternative means of meeting peak demand and reduces the risk that utilities will suffer financially due to transmission constraints, fuel supply disruptions, or increases in fuel costs.
- **Provide customers with greater control over electric bills –** DR programs would allow customers to save on their electric bills by shifting their consumption away from higher cost hours and/or responding to DR events. The ability to manage increases in energy costs has increased in importance for both residential and commercial customers. Standard residential and commercial tariffs provide customers with relatively few opportunities to manage their bills.
- **Address legislative/regulatory interest in DR –** Ohio's adopted renewable portfolio standards (RPS) include demand side options among the means by which the standards can be met. Senate Bill 221 includes strong standards for renewable energy and energy efficiency that will result in 12.5% of Ohio's electricity coming from renewable sources of power and a 22% cumulative reduction in energy usage by 2025. Also, EPACT 1252 has been adopted in Ohio, requiring electric distribution companies to offer dynamic pricing to all customer classes and to make available smart meters to all customers.

DR is gaining greater acceptance among both utilities and regulators in the United States. A 2006 FERC survey found that 234 "entities" were offering direct load control programs and the FERC's assessment noted that "there has been a recent upsurge in interest and activity in DR nationally and, in particular, regional markets" (FERC 2006).[61] The recent proliferation of DR offerings has been promoted in part by utilities hoping to reduce system peaks while offering customers more control over electric bills and in part by regulators. Although federal legislation has not been the driver behind the trend, it is one of many indications, at all levels of government and industry, of the growing support for DR.[62]

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

D.4. Assessment Methods

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

- Review of existing information regarding Ohio's customer base including:
    - Customer counts and average annual energy consumption by market segment;
    - Forecasts of future energy consumption and customer counts by market segment;
    - Previous DSM planning and potential studies.
- Review of additional publicly-available secondary sources including:
    - U.S. DOE's Commercial Building Energy Consumption Survey (CBECS) and Residential Energy Consumption Survey (RECS) data;
    - Previous studies relevant to the current effort completed by Summit Blue in other regions as well as entities in other jurisdictions.
- Development of baseline profiles for residential and commercial customers. These profiles include current and forecast numbers of customers by market segment and electricity use profiles by segment.
- Incorporation of ACEEE baseline data and reference case into analysis.
- Obtaining state-level data when possible and estimation of information for the State of Ohio, when state-level data was not available.

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

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

- Development of a spreadsheet approach for estimating peak demand reduction potential associated with the DR programs/technologies deemed to be most applicable to Ohio. Estimates are developed for three scenarios—low, medium and high case scenarios.
- Conference calls with ACEEE staff and industry professionals to discuss assessment processes and legislative, regulatory, and other factors specific to the State of Ohio.
- Incorporation of all sources of information and references into report, noting on each figure the source of the information.
- Revision of draft report based on comments from ACEEE, industry specialists and utility commenters.

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

D.4.1. State of Ohio - Background

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

Ohio utilities serves a population of over 11.5 million, generation over 155 million megawatt hours of electricity, that is expected to have a system peak load of almost 30,000 MW in 2009 (ACEEE base case for Ohio).

Electricity demand in Ohio has fluctuated over the past 15 years (EIA 2009). Total consumption has grown only slightly. Total retail sales in 2007 in Ohio totaled 161.5 billion kWh. This is an aggregate figure for all sectors, including industrial, commercial and residential.

Ohio has been and likely will continue to be a modest importer of energy and likewise be dependent on out-of-state capacity. In 2007, in-state generation provided 89% of total Ohio retail sales, thus requiring import of approximately 11% (EIA 2009).

Most of Ohio is located within the PJM regional transmission organization (RTO), the largest power region in the US with installed capacity of over 164,000 MW. PJM covers 11 states including Pennsylvania, New Jersey, Maryland, Delaware, Virginia, and parts of Ohio, Indiana, Illinois, Michigan and North Carolina. See Section 2.2 for a discussion of PJM's DR programs.

The five largest electricity retailers in Ohio are the following entities, with percent contribution in parentheses:

- Ohio Power Co (17%)
- Ohio Edison Co (13%)
- Duke Energy Ohio Inc (13%)
- Columbus Southern Power Co (13%)
- Cleveland Electric Illum Co (11%) (EIA 2009).

D.4.2. Assessment of Utility DR Activities

The PJM Interconnection provides opportunities for DR to realize value for demand reductions in the Energy, Capacity, Synchronized Reserve, and Regulation markets. The FERC authorized PJM to provide these opportunities as permanent features of these markets in early 2006 (PJM 2008a).

The PJM Economic Load Response Program enables customers to voluntarily respond to PJM Locational Marginal Price ("LMP") prices by reducing consumption and receiving a payment for the reduction. The growth of participation by end-use customers since 2002 is significant, with over 225,000 MWh of participation in 2006 (PJM 2008a).

Under the Reliability Pricing Model (RPM), customers can offer DR as a forward capacity resource. DR providers can submit offers to provide a demand reduction as a capacity resource in the forward RPM auctions. In the first annual RPM auction which was held in April 2007 for the 2007/2008 planning period, 127.6 MW of demand response offers were cleared (PJM 2008a).[63]

PJM held a symposium on DR in May, 2007 that was attended by a broad mix of stakeholders and subject matter experts. One of the most prominent themes to emerge from the symposium was the need for coordination between retail and wholesale markets in order to increase DR participation in PJM's markets. The participants at the PJM Symposium on DR identified priority opportunities, which formed the basis of a "Demand Response Roadmap" to guide action (PJM 2008b).

Duke Energy offers the following programs:

- Smart $aver Incentive Program for rebates on products ranging from clothes washers to window films to chillers. Incentives are prescriptive, based on the efficiency and capacity of equipment.
- PowerShare pricing program, in which participants are remunerated for reducing load below a customer-specific baseline during summer weekdays when market prices are high. There are two options: a voluntary and mandatory one. Payments are higher for the mandatory program, but there is a penalty for not meeting the committed load shed during notified events.
- Real Time Pricing Program, in which participants are alternatively credited or charged, based on the hourly price, for usage below or above a pre-determined customer baseline load profile.

Ohio Edison (a subsidiary of First Energy) offers an interruptible option and a voluntary real-time pricing rate:

- OE's Interruptible Rider is for customers on the General Service Large rate (with an interruptible load of at least 1000 kW), who can curtail within 10 minutes of notification. A demand credit is given each month per kVA of interruptible load based on the customer's load that is coincident with the utility's peak demands.
- A "block-and-swing" Experimental Market Based Tariff is available where customers designate a market exposure percentage representing the amount of usage to be applied to real-time pricing. The market exposure percentage must be at least 5% but not more than 30%.

Toledo Edison and the Illuminating Company (Cleveland Electric), both subsidiaries of First Energy, also offer an Experimental Market Based Tariff to customers whose peak load is greater than 100 kW. The customer designates a market exposure percentage representing the amount of usage to be applied to real-time pricing. The remaining usage is priced under a fixed price tariff.

D.4.3. Assessment of Current State Policies Affecting DR

Many states have put in place renewable portfolio standards (RPS) to ensure that a minimum amount of renewable energy is included in the portfolio of the electricity resources serving a state. Many RPS include demand side options among the means by which the standards can be met. In April 2008, a unanimous vote in the Ohio State Senate passed Sub Senate Bill 221 that was previously passed by

[63] It is not known at this time what portion of PJM DR reductions have been fulfilled by Ohio customers.

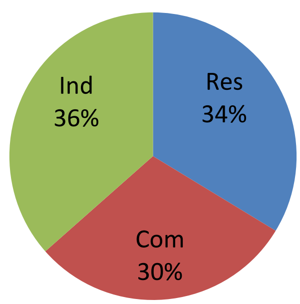
the Ohio House. Included in the legislation are strong standards for renewable energy and energy efficiency that will result in 12.5% of Ohio's electricity coming from renewable sources of power and a 22% cumulative reduction in energy usage by 2025.

Section 1252 of the Energy Policy Act of 2005 (EPACT) includes demand side management provisions (in the form of a new PURPA Standard on Demand Response and Advanced Metering) and directed States and other bodies with authority over utilities to determine whether utilities under their jurisdiction to implement such. Ohio opened a proceeding in December 2005. Via a March 2007 Finding and Order, the Ohio Commission adopted EPACT 1252 and directed electric distribution companies to offer dynamic pricing to all customer classes and to make available smart meters to all customers. This proceeding is still open, however, and further activity is planned. In May 2007, the Commission opened a new proceeding to facilitate a series of technical workshops on EPACT 1252. So far, there have been two workshops: one in July 2007 and one in September 2007.

D.4.4. Energy and Peak Demands

Use of energy in Ohio is distributed to end use categories as follows: 34% residential, 30% commercial, and 36% industrial sectors (see Figure 27). Energy consumption in Ohio's industrial sector ranks among the highest in the Nation (EIA 2009).

Figure 27. Energy Sales in Ohio by Sector (2007)

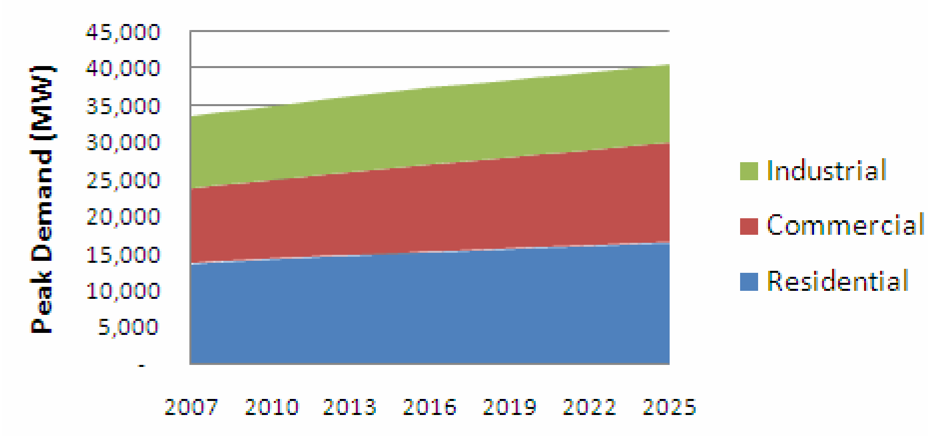


Source: EIA (2008a)

In 2007, the total summer peak load was 33,259 MW and is projected to grow an average of 1% per year through 2025.

Figure 28 displays peak demand by sector. In 2007, residential peak demand was 13,443 MW (41%); commercial was 9,900 MW (30%); and industrial was 9,717 MW (29%).

Figure 28. Peak Demand by Sector in Ohio (MW)



Source: ACEEE Reference Case for Ohio

Smart Grids and Advanced Metering Infrastructure (AMI)

The 2005 EPAct provisions for DR and Smart Metering has lead to a number of states and utilities piloting and implementing a Smart Grid, or sometimes referred to as Advanced Metering Infrastructure (AMI).

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

AMI provides:

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

Smart Energy Pricing provides:

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

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

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

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

D.5. Assessment of DR Potential in Ohio

This section examines and quantifies DR potential in Ohio. Section 5.1 outlines the general DR program categories, while Sections 5.2 and 5.3 outline the DR potential in the residential and commercial /industrial sectors, respectively. Section 5.4 discusses the load reduction potential from backup generation and Section 5.5 explains the issues surrounding rate pricing, even though benefits from this form of DR are not quantified in this analysis. Section 5.6 concludes with a summary of DR potential in Ohio.

D.5.1. Demand Response Program Categories

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

Resource Category	Characteristics
Direct Load Control (DLC)	Direct load control (DLC) programs have typically been mass-market programs directed at residential and small commercial (<100 kW peak demand) air conditioning and other appliances. However, an emerging trend is to target commercial buildings with what has become known as Automated Demand Response or Auto-DR. Increased use and functionality of energy management systems at commercial sites and an increased interest by commercial customers in participating in these programs is driving growth in automated commercial curtailment in response to a utility signal. The common factor in these programs is that they are actuated directly by the utility and require the installation of control and communications infrastructure to facilitate the control process.
Callable Customer Load Response	With this type of program, utilities offer customers incentives to reduce their electric demand for specified periods of time when notified by the utility. These programs include curtailable and interruptible rate programs and demand bidding/buyback programs. Curtailable and interruptible rate programs can be used as "emergency demand response" if the advanced notice requirements are short enough. All customer load response programs require communications protocols to notify customers and appropriate metering to assess customer response.
Scheduled Load Control	This is a class of programs where customers schedule load reductions at pre-determined times and in pre-determined amounts. A variant on this theme is thermal energy storage which employs fixed asset technology to reduce air conditioning loads consistently during peak afternoon load periods.
Time-differentiated Rates	Pricing programs can employ rates that vary over time to encourage customers to reduce their demand for electricity in response to economic signals—in some cases these load reductions can be automated when a price trigger is exceeded. An example is a critical peak price which is "called" by the utility or system operator. In response to this critical price, residential customers can have AC cycling or temperature setbacks automatically deployed. Similar automated responses can be deployed by commercial customers. These rate programs are not analyzed for this assessment, but are further discussed in Section 3.5.

D.5.2. DR for Residential Customers

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

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

Residential Control Strategies

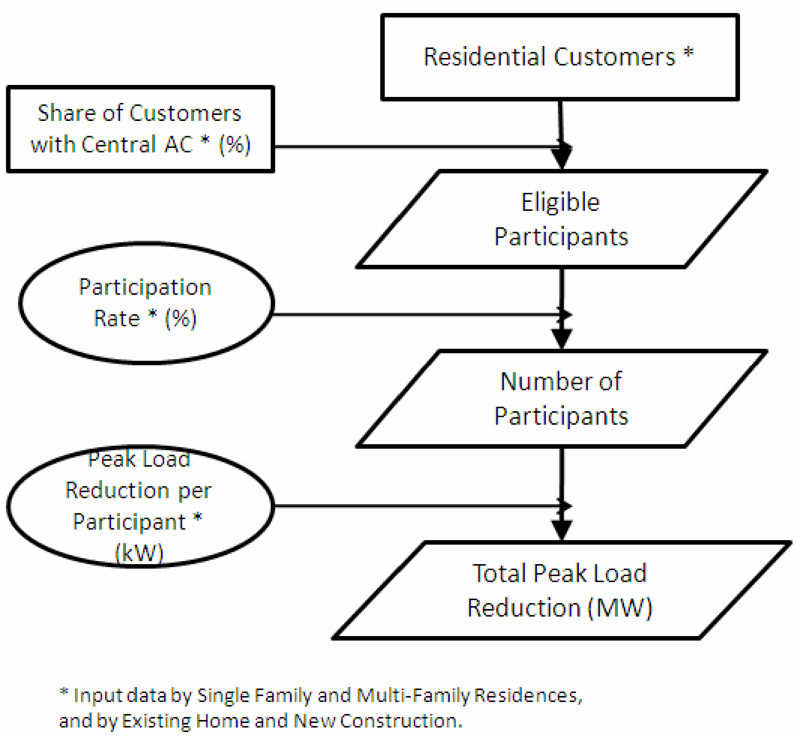
There are two basic types of control strategies: AC cycling and temperature offset. AC cycling limits ACs being on to a certain number of minutes than they otherwise would have been on. Some techniques limit ACs to being on for 50% of the minutes they would otherwise have been on. A temperature offset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

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

Assessment of DR Potential in Residential Homes in Ohio

For Ohio, estimates for possible load reductions for residential housing units were obtained by applying the methodology displayed in Figure 29.

Figure 29. Residential Peak Load Reduction



The figure shows how load reductions and participations rates are applied to housing data. Items listed in rectangular shapes are factual inputs; items in circular shapes are assumptions; and items in parallelogram shapes are results.

D.5.3. Load Reductions

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

Even with this variability, a review of reported impacts does show some general consistencies. As expected, impacts increase as the duty cycle goes up. Table 33 shows the average reported kW impact based on 20 load control impact studies for programs based on the duty cycle used. These results support the oft-quoted rule-of-thumb that the load impact for 50% duty cycling is 1 kW per customer, which is the impact used in this analysis. However, many homes will experience an impact greater than I kW, especially newer homes.

Table 33. Average Load Impacts by Cycling Strategy for AC DLC Programs

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

Source: Summit Blue 2007b.

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

Eligible Residential Customers

All residential customers with central air-conditioning that live in areas that can receive control signals are considered eligible for the direct load control program. This includes single family and multi-family housing units. Residential accounts without central AC are assumed to have no participation. The ACEEE Reference Case reports that 64% of all housing units have CAC in Ohio – both single family and multi-family.

Multi-family housing units often have building tenants which are not the account holders, therefore accounts are often aggregated into buildings. Some accounts have a master meter for the entire building, including tenants. Some accounts are for the “common” building loads (i.e., those loads that are part of a building account such as elevators, A/C (if applicable), lobby lighting, etc.), but individual tenants in these buildings have their own accounts. There, multi-family units often have fewer units with central AC than single family. However, in this analysis, due to data constraints, 64% was applied to both single and multi-family customers, and leads to a more conservative estimate of impacts.

Residential Participation Rates

Participation rates experienced in AC DLC programs vary across utilities typically from 7% of eligible customers to 40%, depending upon the effort made in maintaining and marketing the program (Summit Blue 2007a). The utilities with the low levels of participation had essentially stopped marketing the program in recent years. Utilities with programs with sustained attention to customer retention or recruitment show higher participation rates than utilities with one-time or intermittent promotion. In Maryland, BG&E’s Demand Response Service program anticipates a residential participation rate of 50%, or approximately 450,000 controlled units (BGE 2007). The pilot phase of this program was conducted from June 1 through September 30, 2007, and 58% received a "smart" load control switch, and 42% had a "smart" thermostat installed (BGE 2007). One study examined 15 AC DLC programs nationwide and found an average of 24% participation for eligible customers (Summit Blue 2008a).[64] For this analysis, 3 typical yet conservative scenarios were used: a low scenario of 15% for eligible customers; a medium scenario of 25%; and a high scenario of 35%.

Results

Table 34 displays the input data and results. In summary, the results for residential programs reveal that a medium scenario reduction of 837MW is possible by 2015 (with 502MW possible by the low scenario, and 1,172MW by the high scenario). By 2020, 1,680MW is achievable through the medium scenario (with 1,008MW possible by the low scenario, and 2,352MW by the high).

Table 34. Potential Load Reduction from AC-DLC In Ohio Residential Homes, in years 2015 and 2020

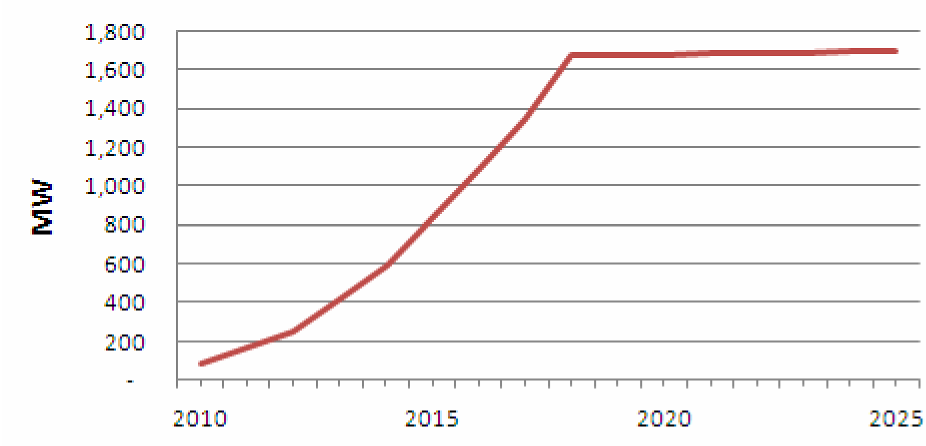
INPUTS	**2015**	**2020**
Residential Peak Demand (MW)	14,826	15,618
Residential Customers (in thousands)[a]: Total	11,472	11,513
Single Family	8,777	8,793
Multi-Family	2,695	2,720
Eligible Residential Customers: Single and Multi-Family[b]	64%	
Load Reduction per AC-DLC per Single-Family Unit (kW)	1.0	
Load Reduction per AC-DLC per Multi-Family Unit (kW)	0.6	
DR Participation Rates of eligible customers:		
Low Scenario	25%	
Medium Scenario	25%	
High Scenario[c]	35%	
RESULTS	**2015**	**2020**
Residential Potential DR Load Reduction (MW):		
Low Scenario	502	1,008
Medium Scenario	837	1,680
High Scenario	1,172	2,352

Notes:
a. Residential customers reflect number of housing units, as reported from Economy.com.
b. Analysis assumes residences with central AC are eligible. Residential accounts without central AC are assumed to have no participation. Central AC percents obtained from ACEEE Reference Case.
c. Higher participation than applied in the High Scenario is possible through design of program features, such as "opt-out" participation where participants are included in a program unless they chose to "opt-out."

Figure 30 shows the resulting residential load shed reductions possible for Ohio, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 30. Potential Residential Load Shed in Ohio (Medium Scenario)

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



D.5.4. Room Air Conditioners

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

D.5.5 Other Appliances

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

D.6. Commercial and Industrial DR Potential in Ohio

Appropriate commercial sector DR programs will vary according to customer size and the type of facility. Direct load control of space conditioner equipment is a primary DR strategy intended for small commercial customers (e.g., under 100 kW peak load), although TOU rates combined with promising new thermal energy storage technologies could prove an effective combination. Mid-to-large commercial customers and smaller industrial customers could best be targeted for a curtailable load program requiring several hours of advanced notification or, where practical, for an Auto-DR program that can deliver load reductions with no more than ten minutes of advance notice. Thermal energy storage and other scheduled load control programs may also be applicable for some larger buildings or water pumping customers. In this assessment of DR potential, the focus is on the use of direct load control and curtailable load response programs. Studies have shown that pricing programs, specifically dispatchable pricing programs such as critical peak pricing (CPP) programs can provide similar impacts. These pricing programs are discussed in Section 5.2. However, for the purposes of this assessment, a focus on these load response programs is believed to be able to fully represent the DR potential, even though pricing programs could be used instead of these curtailable load programs with equal, or in some cases, greater efficiency.

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

- Small business direct load control (air conditioning)—Small commercial customers (under 100 kW peak load) account for a majority of customer accounts but typically only about one-quarter of total commercial load. Due to the nature of small businesses, particularly their small staffs for which energy management is a relatively low priority, it is not practical to rely on active customer response to load control events. Thus, small businesses may best be viewed in the same way as residential customers for purposes of DR.

- Curtailable load program—This program would be applicable to commercial and industrial customers willing to commit to self-activated load reductions of a minimum of perhaps 50 kW in response to a notice and request from a utility. The minimum curtailment threshold is designed to improve program cost-effectiveness by ensuring that recruitment and technical assistance costs are used for customers who can deliver significant load reductions. Advanced notice requirements would likely be two hours— long enough to allow customers an opportunity to prepare but short enough to maintain the DR resource as a viable resource that can be dispatched by operations staff. Enabling technologies would vary greatly, but utilities would educate customers about alternatives and could work with equipment vendors to facilitate equipment acquisition and installation. Incentives would be paid as capacity payment (in $/kW-month) or a discount on the customers' demand charges. Utilities could also offer a voluntary version of the program to attract greater participation. Customers would not commit to load reductions, but incentives would be lower and would be paid only on the reductions achieved during curtailment events.

- Automated demand response (Auto-DR)—This program would be marketed to facilities such as high-rise office buildings and large retail businesses that have energy management and control systems (EMCS) that monitor and control HVAC systems, lighting, and other building functions. The benefits of Auto-DR over curtailable load programs include customer loads curtailments with as little as ten minutes notice and greater assurance that customers will reduce loads by at least their contracted amount. Incentives would be paid as either capacity payments or demand charge discounts, but would be greater than for curtailable load program participants due to the additional technology investment that may be required and the allowance of curtailments on relatively short notice. Utilities would offer extensive technical assistance in setting up Auto-DR capability and would potentially provide financial assistance as well for customers making long-term commitments.

- Scheduled load control programs (including thermal energy storage)—Scheduled load control can help reduce utility peak demand, especially through shifting of space cooling loads enabled by thermal energy storage technologies. Large-customer TES systems could be promoted along with customer commitments to reduce operation of chillers or rooftop air conditioners during specified peak hours. Customers' return on investment can be increased by encouraging migration to a TOU rate, which would offer a rate discount for many of the hours that TES systems are recharging cooling capacity. Water pumping systems are typically good candidates for scheduled load control programs and utilities can investigate opportunities in the municipal water supply and irrigation sectors. Other, less traditional, opportunities may also be available, such as the leisure/resort industry's limiting recharging of electric golf carts to off-peak hours.

- Emergency under-frequency relay (program add-on)—Under-frequency relays (UFRs) automatically shut off electrical circuits in response to the circuits exceeding pre-set voltage thresholds specified by the utility. Use of UFRs is a valuable addition to a DR portfolio because the load response is both automatic and virtually instantaneous. UFRs can best be integrated into another DR program where participants are already engaging in load curtailment activities. It is expected that some customers who might consider participating in a DR program will not be willing to allow loads to be controlled via UFR since they would not receive any advanced notice. Incentives would also need to be greater to attract participants and provide acceptable compensation. However, the benefits of UFRs warrant their consideration as part of a utility's proposed DR portfolio.

D.6.1. Commercial DR Potential in Ohio

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

First, assumptions were made on the percentage of commercial customers who are willing to participate in DR programs. One study applied commercial participation rates ranging from 11% to 48% for commercial customers (Summit Blue 2008a). Table 35 displays participation rates for various types of commercial customers, disaggregated into two different peak demand categories (<300kW and >300kW).

Table 35. Examples of Commercial Load Shed Participation Rates

	Peak Category	
Customer Segment	<300kW	>300kW
Office Buildings	11% - 15%	45% - 48%
Hospitals	13%	48%
Hotels	14%	45%
Educational Facilities	13%	43%
Retail	11%	42%
Supermarkets	12%	33%
Restaurants	11%	39%
Other Government Facilities	15%	44%
Entertainment	13%	41%

Source: Summit Blue 2008a.

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

Then, assumptions were made for curtailment rates, based on existing estimates of the fraction of load that has been shed by commercial customers enrolled in event-based DR programs callable by the utility.

Table 36. Examples of Commercial Curtailment Rates

displays curtailment rates for various types of commercial customers, which range from 13% to 43%. For the purposes of this analysis, 3 conservative scenarios were applied: a low curtailment rate of 15%, a medium curtailment rate of 20%, and a high rate of 25%.

Table 36. Examples of Commercial Curtailment Rates

Customer Segment	Average Curtailment Rate
Office Buildings	21%
Hospitals	18%
Hotels	15%
Educational Facilities	22%
Retail	18%
Supermarkets	13%
Restaurants	17%
Other Government Facilities	38%
Entertainment	43%

Source: Summit Blue 2008a

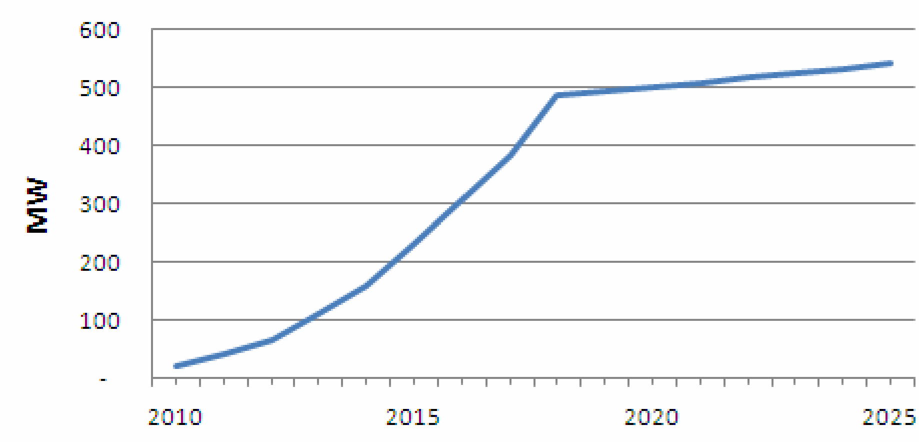
Table 37 displays the input data and results. In summary, the commercial sector results reveal that a medium scenario reduction of 232MW is possible by 2015 (with 86 MW possible by the low scenario, and 428 MW by the high). By 2020, 491 MW is achievable through the medium scenario (with 184 MW possible by the low scenario, and 921 MW by the high).

Table 37. Potential Commercial Load Shed in Ohio, in Years 2015 and 2020

INPUTS	**2015**	**2020**
Commercial Peak Demand (MW)	11,402	12,283
Load Shed Participation Rates:		
Low	10%	
Medium	20%	
High	30%	
Curtailment Rates:		
Low	15%	
Medium	20%	
High	25%	
RESULTS	**2015**	**2020**
Commercial DR load reductions (MW):		
Low	86	184
Medium	228	491
High	428	921

Figure 31 shows the resulting commercial load shed reductions possible for Ohio, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 31. Potential Commercial Load Shed in Ohio (Medium Scenario)



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

Industrial DR Potential in Ohio

A similar analysis was conducted for the industrial sector: load shed participation rates and curtailment rates were applied to industrial peak demand. A previous study found industrial participation rates to vary from 25% for facilities <300kW, to 50% for >300kW (Summit Blue 2008a). For this study, the following rates were applied to participation: Low (20%); Medium (30%); and High (40%).

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

Table 38. Potential Industrial Load Shed in Ohio, for years 2015 and 2020

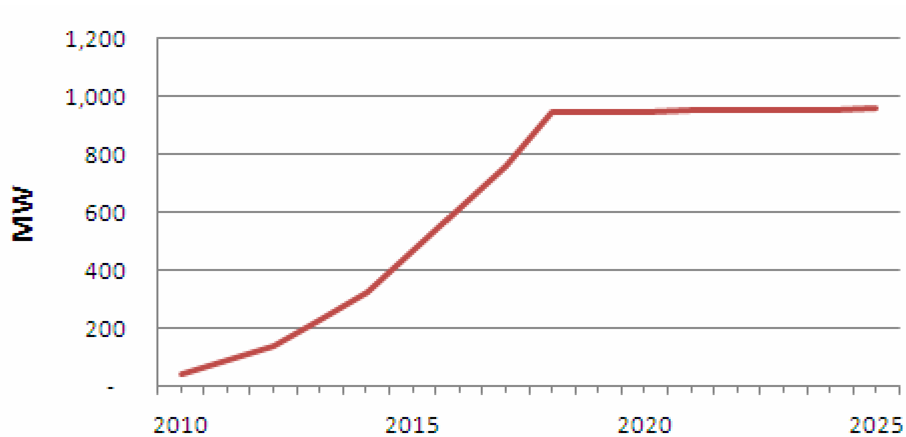
displays the input data and results. In summary, the industrial sector results reveal that a medium scenario reduction of 464 MW is possible by 2015 (with 206 MW possible by the low scenario, and 824 MW by the high). By 2020, 933 MW is achievable through the medium scenario (with 415 MW possible by the low scenario, and 1,660 MW by the high).

Table 38. Potential Industrial Load Shed in Ohio, for years 2015 and 2020

INPUTS	2015	2020
Industrial Peak Demand (MW)	10,304	10,372
Load Participation Rates:		
Low	20%	
Medium	30%	
High	40%	
Curtailment Rates:		
Low	20%	
Medium	30%	
High	40%	
RESULTS	**2015**	**2020**
Industrial DR load reductions (MW):		
Low	206	415
Medium	464	933
High	824	1,660

Figure 32 shows the resulting industrial load shed reductions possible for Ohio, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 32. Potential Industrial Load Shed in Ohio (Medium Scenario)



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

D.6.2. Commercial and Industrial Backup Generation Potential in OH

Emergency backup generation is a prominent component of a callable load program strategy. Some of the emergency generators not currently participating in DR programs may not be permitted for use as a DR resource and regulations may further limit the availability of emergency generation for DR. In some cases, backup generators may not be equipped with the start-up equipment to allow the generator to participate in short-term notification programs. Utilities could consider a program to assist customers with equipment specification and set-up to promote DR program participation by backup generators.

In some instances, there may be environmental restrictions on emergency generation. Emissions of emergency generation may be regulated, and the future of such regulations may add some uncertainty. However, some areas have been able to have such restrictions lifted during system emergencies.

Two approaches can increase the amount of emergency generation in DR programs: 1) facilitating customer-owned generation, and 2) utility ownership of the generation, which is used to provide additional reliability for customers willing to locate the equipment at their facilities.

Customer-Owned Emergency Generation

To increase customer-owned emergency generation, utilities may assist customers with ownership of grid-synchronized emergency generation. Utilities may offer to pay for all equipment necessary for parallel interconnection with the utility grid, as well as all maintenance and fuel expenses. Once operational, the standby generators can be monitored and dispatched from a utility's control center, and they can also provide backup power during an outage. An additional benefit to the customer relative to typical backup generation is the seamless transition to and from the generator without the usual momentary power interruption.

Utility-Owned Emergency Generation

A second approach to increasing the availability of emergency generation for DR is by locating generation at customer sites that can be owned by a utility. Through this type of program, the customer receives emergency generation capability during system outages in exchange for paying a monthly fee consisting of both levelized capital costs and operation and maintenance costs. Participants would likely receive capacity payments ($/kW-month) and/or energy payments ($/kWh) in exchange for granting a utility to dispatch the units for a limited number of events and total hours per year.

Backup Generation in Ohio

Total Ohio back-up generation capacity for 2015 is estimated at approximately 2,618 MW.[65] Additional analysis revealed that the commercial and industrial back-up capacity, each, is almost half of the total capacity, 1,309 MW.[66] Assuming a medium scenario that 40% of the total backup in Ohio is available for load shed, then 524 MW of backup generation is available by 2015 and 1,089 MW is available by 2020 (see

[65] Back-up generation capacity in Ohio was estimated from form EIA-861 filings submitted by utilities nationwide (EIA, 2006). However, only utilities providing approximately one-quarter of total kWh report these numbers. It was assumed that the prevalence and usage of distributed generation in the remaining 75% of utilities is similar.

[66] The analysis first determined the back-up generator population nation-wide, and then scaled the data down to the New England region (CBECS resolution), accounting for proportional differences in building stock nation-wide and region-wide. The region-wide results were then scaled down to Ohio specifically using the ratio of Ohio population to regional population.

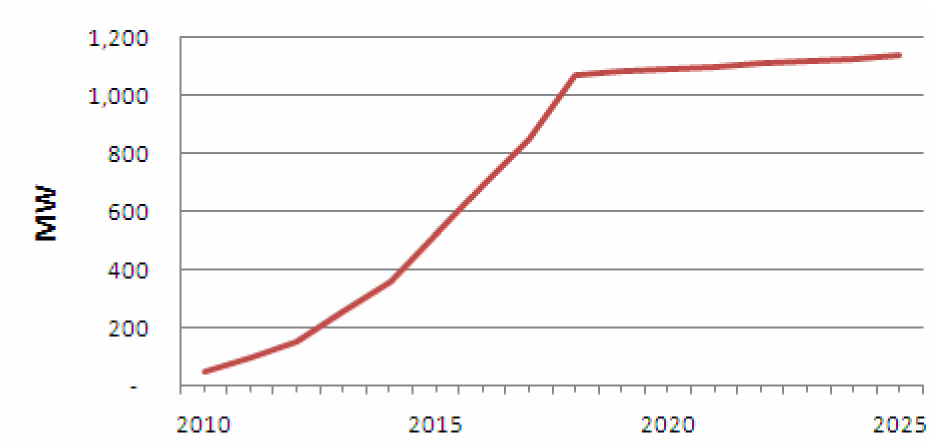
Table 39. Potential Reductions from C&I Backup Generation in Ohio, in Years 2015 and 2020a

). The low scenario estimates a 393 MW reduction by 2015 and an 817 MW reduction by 2020. The high scenario estimates a 655 MW reduction by 2015 and a 1,361 MW reduction by 2020.

Table 39. Potential Reductions from C&I Backup Generation in Ohio, in Years 2015 and 2020[a]		
INPUTS	**2015**	**2020**
Total Backup Generation Capacity in OH (MW)	2,618	2,722
Backup Generation Potential (%):		
Low	30%	
Medium	40%	
High	50%	
RESULTS	**2015**	**2020**
Potential Reduction from C&I Backup Generation (MW):		
Low	393	817
Medium	524	1,089
High	655	1,361

Figure 33 shows the resulting commercial and industrial backup generation reductions possible for Ohio, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 33. Potential Reductions from C&I Backup Generation



D.6.3. Pricing and Rates

In this assessment of DR potential, the focus is on the use of direct load control and curtailable load response programs callable by the utility. Studies have shown that pricing programs, specifically dispatchable pricing programs such as critical peak pricing (CPP) programs can provide similar impacts; however, for the purposes of this assessment, a focus on the these load response programs is believed to be able to fully represent the DR potential, even though pricing programs could be used instead of these curtailable load programs with equal, or in some cases, greater efficiency.

New rates may be introduced as part of a DR program, and may include real-time prices, or other time-differentiated rates, for commercial and industrial customers, and a modification of any existing residential time-of-use (TOU) rates. Any new rate structures would be designed to reduce system demand during peak periods and provide an opportunity for customers to reduce electric bills through load shifting.

Critical peak pricing (CPP) is a viable option for inclusion in a DR portfolio. In FERC's 2006 survey of utilities offering DR programs (citation below), roughly 25 entities reported offering at least one CPP tariff. However, many of the tariffs were pilot programs only, and almost all of the 11,000 participants were residential customers. The apparent lack of commercial CPP programs is supported by a 2006 survey of pricing and DR programs commissioned by the U.S. EPA (below), which found only four large-customer CPP programs, all of them in California. The pilot programs in California linked the CPP rate with "automated demand response" technologies that provide most of the impact. The CPP rate itself, and the price incentive that it creates, is not the driver behind the load reductions.

As stated, rate pricing options were not analyzed in this analysis. Event-based pricing programs achieve impacts very similar to the callable load programs presented above. Pilot studies and tariff evaluations of TOU-CPP programs[67] show the load reductions for called events are similar in magnitude to air conditioning DLC programs. This is not surprising in that most TOU-CPP participants use a programmable-automated thermostat to respond to CPP events in a manner similar to a DLC strategy. One difference is that the customer response is less under the control of the program or system operator that could change cycling strategies or thermostat set points across different events or different hours within an event. Similarly, demand-bid programs are simply calls for target load sheds, i.e., those bid into the program.

In general, the direct load shed programs seem to provide greater MW of participation and more reliable reductions. However, the use of either TOU-CPP or a demand-bid program represents a point of view or policy position that price should be a centerpiece of the DR effort and help customers see prices in the electricity markets. From a point of view of simplicity and attaining firm capacity reductions, the direct load shed programs may offer some advantages. Ultimately, the choice between these direct load shed programs and pricing programs may come down to customer preferences and decisions by policy makers on the emphasis of DR efforts.

A time-differentiated rate is another option to consider that may not be "callable." Such rates include day-ahead real-time pricing (RTP), two-part RTP tariffs, and standard TOU rates. Although they are not "callable" in that the rate is generally in effect every day, there may be synergies between time-differentiated rates and callable load programs. In general, an RTP option will result in customers learning how to reduce energy consumption on essentially a daily basis when prices tend to be high (e.g., summer season afternoons and early evenings). Customers do not tend to track exact hourly prices, but they know when prices are likely to be higher (e.g., summer season afternoons with higher prices on hot days).[68] The benefits to the customer come from reducing consumption across many summer days when prices are high, rather than a focus on reduction during system event days. In general, the reductions on system peak days are roughly the same as on any summer day when prices are reasonably high. As a result, an RTP option can provide substantial benefits by increasing overall market and system efficiency through shifting loads from high priced periods to periods with lower prices. However, these tariffs may not provide the needed load relief on system-constrained event days.[69, 70]

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[67] See Public Service Electric and Gas Company, "Evaluation of the MyPower Pricing Pilot Program," prepared by Summit Blue Consulting, 2007; and the California Energy Commission, "Impact evaluation of the California Statewide Pricing Pilot—Final Report," March 16, 2005. http://www.energy.ca.gov/demandresponse/documents/index.htmll#group3

[68] See evaluations of the hourly pricing experiment offered by ComEd and the Chicago Energy Cooperative performed by Summit Blue Consulting (2003 through 2006).

[69] One way to make an RTP tariff more like an event-based DR program is to overlay a critical peak pricing (CPP) component on the RTP tariff where unusually high prices would be posted to customers with some notification period. Otherwise, it is unlikely that the high levels of reduction needed for system-event days would be attained.

[70] The complementary of event-based load shed programs with RTP tariffs is assessed in: Violette, D., R. Freeman, and C. Neil. "*DR Valuation and Market Analysis—Volume II: Assessing the DR Benefits and Costs*," Prepared for the International Energy Agency, TASK XIII, Demand-Side Programme, Demand Response Resources, January 6, 2006. Updated results are presented in: Violette, D. and R. Freeman; "*Integrating Demand Side Resource Evaluations in Resource Planning*;" Proceedings of the International Energy Program Evaluation Conference (IEPEC), Chicago, August 2007 (also at www.IEPEC.com).

Summary of DR Potential Estimates in Ohio

Table 40 shows the resulting load shed reductions possible for Ohio, by sector, for years 2015, 2020, and 2025. Load impacts grow rapidly through 2018 as program implementation takes hold. After 2018, the program impacts increase at the same rate as the forecasted growth in peak demand.

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

The high scenario results show a reduction in peak demand of 3,078 MW is possible by 2015 (8.4% of peak demand); 6,293 MW is possible by 2020 (16.4% of peak demand); and 6,471 MW is possible by 2025 (16.2% of peak demand).

The more conservative medium scenario results show a reduction in peak demand of 2,052MW is possible by 2015 (5.6% of peak demand); 4,193MW is possible by 2020 (11.0% of peak demand); and 4,309 MW is possible by 2025 (10.8% of peak demand).

These estimated reductions in peak demand are within a range to be expected for a population of Ohio’s size. Estimates of DR in other states show that the estimates calculated here for Ohio are reasonable: 15% reductions in peak demand in Florida are possible by 2023 (Elliot et al. 2007a), and 13% are possible in Texas, also by year 2023 (Elliot et al. 2007b). DR potential for a utility in New York was estimated to be 9.3% of peak demand in 2017 (Summit Blue 2008a). This finding is similar to that of a recent analysis estimating that peak load reductions from DR in the Northeast will be 8.2% of system peak load in 2020 and more than 11% by 2030 (EPRI and EEI 2008). Estimation methods differ among the studies, but nonetheless show that the 10.8% reductions in Ohio are realistic for the medium scenario by 2020.

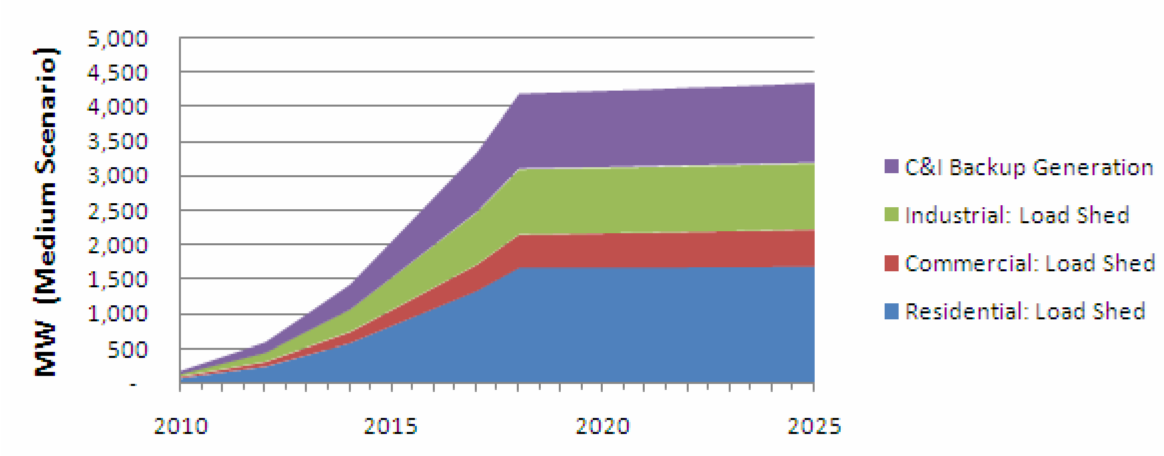
Table 40. Summary of Potential DR in Ohio, By Sector, for Years 2015, 2020, and 2025[a]

	Low Scenario			Medium Scenario			High Scenario		
	2015	**2020**	**2025**	**2015**	**2020**	**2025**	**2015**	**2020**	**2025**
Load Sheds (MW):									
Residential	502	1,008	1,017	837	1,680	1,696	1,172	2,352	2,374
Commercial	86	184	199	228	491	531	428	921	996
Industrial	206	415	420	464	933	944	824	1,660	1,678
C&I Backup Generation (MW)	393	817	854	524	1,089	1,138	655	1,361	1,423
Total DR Potential (MW)	1,186	2,424	2,490	2,052	4,193	4,309	3,078	6,293	6,471
DR Potential as % of Total Peak Demand	3.2%	6.4%	6.3%	5.6%	11.0%	10.8%	8.4%	16.4%	16.2%

a. See Section 3 for underlying data and assumptions.

Figure 34 shows the resulting load shed reductions possible for Ohio, by sector, from year 2010, when load reductions are expected to begin, through year 2025.

Figure 34. Potential DR Load Reductions in Ohio by Sector (MW)



These estimates reflect the level of effort put forth and utilities are recommended to set targets for the high scenarios. These estimates include assumptions based on utility experience regarding growth rates, participation rates, and program design, among others, and will adjust accordingly if differing assumptions are made. The assumptions made are believed to be conservative, and reflect minimum achievable DR potential. For example, participation rates for all of the sectors are based on experience in other states, and are based primarily on customer awareness, the ability to have automated response, and the adequacy of reward. If the statewide education program now required in Ohio promotes DR programs and adequate incentives are offered, then participation rates higher than the medium scenario are entirely realistic.

Recommendations

This assessment indicates that the system peak demand can be reduced by approximately 11.0% or 4,193 MW in 2020 in the medium case. In the high case, the reduction can be as high as 16.4% or 6,293 MW. The high case is considered to be within a reasonable range if aggressive action begins by the end of 2009, providing for a twelve-year rollout of the DR efforts (at the beginning of 2010 through the end of 2020).

Key recommendations include:

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

- Appropriate financial incentives for the Ohio' utilities either for programs administered directly by the utilities or for outsourcing DR efforts to aggregators. The basic premise is that a utility's least-cost plan should also be its most profitable plan. Developing these incentives poses some complexities in that MW's in that DR programs likely will be bid into PJM's DR programs and will receive financial payments from PJM. Whether this provides adequate incentives for the appropriate development of DR programs in Ohio should be examined.

- Combine and cross-market EE and DR programs. These can include new building codes and standards that include not only EE construction and equipment, but also the installation of addressable and dispatchable equipment. This can include addressable thermostats in new residences and the installation of addressable energy management systems in commercial and industrial buildings that can reduce loads in select end-uses across the building/facility. In addition, energy audits of residential or commercial facilities can also include an assessment of whether that facility is a good candidate for participation in a DR program through the identification of dispatchable loads. Furthermore, building commissioning and retro-commissioning EE programs that are becoming popular in many commercial and industrial sector programs have the energy management system as a core component of program delivery. At this time, the application of auto-DR can be assessed and marketed to the customer along with the EE savings from these site-commissioning programs.

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

- Increase clarity and coordination between the Federal and State agencies and programs. While states have primary jurisdiction over retail demand response, the FERC has jurisdiction over demand response in wholesale markets. Greater clarity and coordination between the Federal and State programs is needed. At the Federal level, both EPACT and EISA contain multiple provisions on demand response and smart grid technologies. EISA authorized a matching grant program to offset the costs of Smart Grid investments.

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

APPENDIX E – COMBINED HEAT AND POWER

E.1. Technical Potential for CHP

This section provides an estimate of the technical market potential for combined heat and power (CHP) in the industrial, commercial/institutional, and multi-family residential market sectors. Two different types of CHP markets were included in the evaluation of technical potential. Both of these markets were evaluated for high load factor (80% and above) and low load factor (51%) applications resulting in four distinct market segments that are analyzed.

E.1.1. Traditional CHP

Traditional CHP electrical output is produced to meet all or a portion of the base load for a facility and the thermal energy is used to provide steam or hot water. Depending on the type of facility, the appropriate sizing could be either electric or thermal limited. Industrial facilities often have "excess" thermal load compared to their on-site electric load. Commercial facilities almost always have excess electric load compared to their thermal load. Two sub-categories were considered:

High load factor applications: This market provides for continuous or nearly continuous operation. It includes all industrial applications and round-the-clock commercial/institutional operations such colleges, hospitals, hotels, and prisons.

Low load factor applications: Some commercial and institutional markets provide an opportunity for coincident electric/thermal loads for a period of 3,500 to 5,000 hours per year. This sector includes applications such as office buildings, schools, and laundries.

E.1.2. Combined Cooling Heating and Power (CCHP)

All or a portion of the thermal output of a CHP system can be converted to air conditioning or refrigeration with the addition of a thermally activated cooling system. This type of system can potentially open up the benefits of CHP to facilities that do not have the year-round thermal load to support a traditional CHP system. A typical system would provide the annual hot water load, a portion of the space heating load in the winter months and a portion of the cooling load in during the summer months. Two sub-categories were considered:

Low load factor applications. These represent markets that otherwise could not support CHP due to a lack of thermal load.

Incremental high load factor applications: These markets represent round-the-clock commercial/institutional facilities that could support traditional CHP, but with cooling, incremental capacity could be added while maintaining a high level of utilization of the thermal energy from the CHP system. All of the market segments in this category are also included in the high load factor traditional market segment, so only the incremental capacity for these markets is added to the overall totals.

The estimation of technical market potential consists of the following elements:

- Identification of applications where CHP provides a reasonable fit to the electric and thermal needs of the user. Target applications were identified based on reviewing the electric and thermal energy consumption data for various building types and industrial facilities.
- Quantification of the number and size distribution of target applications. Several data sources were used to identify the number of applications by sector that meet the thermal and electric load requirements for CHP.
- Estimation of CHP potential in terms of megawatt (MW) capacity. Total CHP potential is

then derived for each target application based on the number of target facilities in each size category and sizing criteria appropriate for each sector.

- Subtraction of existing CHP from the identified sites to determine the remaining technical market potential.

The technical market potential does not consider screening for economic rate of return, or other factors such as ability to retrofit, owner interest in applying CHP, capital availability, natural gas availability, and variation of energy consumption within customer application/size class. The technical potential as outlined is useful in understanding the potential size and size distribution of the target CHP markets in the state. Identifying technical market potential is a preliminary step in the assessment of market penetration.

The basic approach to developing the technical potential is described below:

- *Identify existing CHP in the state.* The analysis of CHP potential starts with the identification of existing CHP. In Ohio, there are 45 operating CHP plants totaling 665 MW of capacity. Of this existing CHP capacity, 55% of the sites and 85% of the capacity are in the industrial sector. This existing CHP capacity is deducted from any identified technical potential. A summary of the existing CHP capacity by industry is shown in Table 41.

- *Identify applications where CHP provides a reasonable fit to the electric and thermal needs of the user*. Target applications were identified based on reviewing the electric and thermal energy (heating and cooling) consumption data for various building types and industrial facilities. Data sources include the DOE EIA *Commercial Buildings Energy Consumption Survey (CBECS),* the DOE *Manufacturing Energy Consumption Survey (MECS)* and various market summaries developed by DOE, Gas Technology Institute (GRI), and the American Gas Association. Existing CHP installations in the commercial/institutional and industrial sectors were also reviewed to understand the required profile for CHP applications and to identify target applications.

- *Quantify the number and size distribution of target applications*. Once applications that could technically support CHP were identified, the iMarket, Inc*. MarketPlace Database* and the *Major Industrial Plant Database* (MIPD) from IHI were utilized to identify potential CHP sites by SIC code or application, and location (county). The *MarketPlace Database* is based on the Dun and Bradstreet financial listings and includes information on economic activity (8 digit SIC), location (metropolitan area, county, electric utility service area, state) and size (employees) for commercial, institutional and industrial facilities. In addition, for select SICs limited energy consumption information (electric and gas consumption, electric and gas expenditures) is provided based on data from Wharton Econometric Forecasting (WEFA). MIPD has detailed energy and process data for 16,000 of the largest energy consuming industrial plants in the United States. The *MarketPlace Database* and MIPD were used to identify the number of facilities in target CHP applications and to group them into size categories based on average electric demand in kilowatt-hours.

- *Estimate CHP potential in terms of MW capacity.* Total CHP potential was then derived for each target application based on the number of target facilities in each size category. It was assumed that the CHP system would be sized to meet the average site electric demand for the target applications unless thermal loads (heating and cooling) limited electric capacity. Tables 42 through 44 present the specific target market sectors, the number of potential sites and the potential MW contribution from CHP. There are two distinct applications and two levels of annual load making for four market segments in all. In traditional CHP, the thermal energy is recovered and used for heating, process steam, or hot water. In cooling CHP, the system provides both heating and cooling needs for the facility. High load factor applications operate at 80% load factor and above; low load factor applications operate at an assumed average of 4500 hours per year (51%) load factor. The high load factor cooling applications are also applications for traditional CHP, though the cooling applications have 25-30% more capacity than traditional. Therefore, the totals for the entire state, all four market segments, discounts these applications to avoid double counting.

- *Estimate the growth of new facilities in the target market sectors.* The technical potential included economic projections for growth through 2025 by target market sectors in Ohio. The growth factors used in the analysis for growth between the present and 2025 by individual sector are shown in Table 45. These growth projections provided by ACEEE were used in this analysis as an estimate of the growth in new facilities. In cases where an economic sector is declining, it was assumed that no new facilities would be added to the technical potential for CHP. Based on these growth rates the total technical market potential is summarized in Table 46.

Table 41. Ohio Existing CHP Facilities

SIC	Industry Description	Sites	Cap. kW
24	Lumber and Wood Products	2	10,900
2511	Wood Household Furniture	1	1,000
26	Paper	6	151,730
28	Chemicals	6	47,425
2911	Petroleum Refining	1	6,000
30	Rubber and Plastics	2	41,900
33	Primary Metals	4	102,050
35	Industrial Machinery	1	700
37	Transportation Equipment	1	75
39	Miscellaneous Manufacturing	1	200,000
49	Utilities	4	8,625
7011	Hotels and Motels	1	100
7991	Physical Fitness Facility	1	150
80	Health Services	2	1,765
82	Educational Services	6	73,573
8412	Museums and Art Galleries	1	240
8811	Private Households	1	115
91	Executive, Legislative, General Government	3	16,615
9711	Military Base	1	2,075
	Total	45	665,038

Table 42. Ohio Technical Market Potential for CHP in Existing Facilities – Industrial Sector

SICs	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
Industrial (Traditional, High Load Factor													
20	Food	242	36.3	90	67.5	62	155.0	21	262.5	3	225.0	418	746.3
22	Textiles	43	4.8	12	6.8	2	3.8	0	0.0	0	0.0	57	15.3
24	Lumber and Wood	234	7.0	31	4.7	10	5.0	2	5.0	1	15.0	278	36.7
25	Furniture	21	0.9	2	0.5	0	0.0	0	0.0	0	0.0	23	1.4
26	Paper	173	26.0	107	80.3	89	222.5	2	25.0	0	0.0	371	353.7
27	Printing/Publishing	121	18.2	5	3.8	0	0.0	0	0.0	0	0.0	126	21.9
28	Chemicals	254	38.1	108	81.0	135	337.5	37	462.5	22	1,650.0	556	2,569.1
29	Petroleum Refining	128	19.2	11	8.3	6	15.0	0	0.0	0	0.0	145	42.5
30	Rubber/Misc. Plastics	361	16.2	339	76.3	203	152.3	31	116.3	0	0.0	934	361.0
32	Stone/Clay/Glass	14	2.1	6	4.5	1	2.5	1	12.5	3	225.0	25	246.6
33	Primary Metals	80	3.0	56	10.5	45	28.1	5	15.6	1	18.8	187	76.0
34	Fabricated Metals	409	18.4	88	19.8	41	30.8	0	0.0	0	0.0	538	69.0
35	Machinery/Computer Equip	23	0.9	1	0.2	4	2.5	0	0.0	0	0.0	28	3.6
37	Transportation Equip.	98	7.4	69	25.9	106	132.5	29	181.3	13	487.5	315	834.5
38	Instruments	21	1.6	3	1.1	0	0.0	0	0.0	0	0.0	24	2.7
39	Misc. Manufacturing	26	1.0	5	0.9	1	0.6	0	0.0	0	0.0	32	2.5
	Total Industrial	2248	201.0	933	391.8	705	1,088.0	128	1,080.6	43	2,621.3	4057	5,382.7

Table 43. Ohio Technical Market Potential for CHP in Existing Facilities – Commercial, Traditional CHP

SICs	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
Commercial, Multifamily(Traditional, High Load Factor)													
6513	Apartments	381	28.6	138	51.8	21	26.3					540	106.6
4222, 5142	Warehouses	15	2.3	22	16.5	5	12.5					42	31.3
4941, 4952	Water Treatment/Sanitary	103	15.5	71	53.3	33	82.5	1	12.5			208	163.7
7011, 7041	Hotels	893	100.5	169	95.1	34	63.8					1096	259.3
8051, 8052, 8059	Nursing Homes	664	99.6	388	291.0	32	80.0					1084	470.6
8062, 8063, 8069	Hospitals	106	15.9	59	44.3	128	320.0	3	37.5			296	417.7
8221, 8222	Colleges/Universities	106	15.9	80	60.0	54	135.0	16	200.0	2	50.0	258	460.9
9223, 9211 (Courts), 9224 (firehouses)	Prisons	10	1.5	31	23.3	38	95.0	8	100.0			87	219.8
	Total C/I High LF	2278	279.6	958	635.1	345	815.0	28	350.0	2	50.0	3611	2,129.7
Commercial (Traditional, Low Load Factor)													
7211, 7213, 7218	Laundries	71	10.7	2	1.5							73	12.2
7542	Carwashes	113	17.0									113	17.0
7991, 00, 01	Health Clubs	144	21.6	19	14.3							163	35.9
7992, 7997-9904, 7997-9906	Golf/Country Clubs	328	49.2	25	18.8							353	68.0
8211, 8243, 8249, 8299	Schools	1227	46.0	233	43.7	23	14.4	4	12.5			1487	116.6
8412	Museums	60	9.0	10	7.5							70	16.5
	Total C/I Low LF	1943	153.4	289	85.7	23	14.4	4	12.5			2259	266.0
	Total C/I Traditional	4221	433.1	1247	720.8	368	829.4	32	362.5	2	50.0	5870	2,395.7

Table 44. Ohio Technical Market Potential for CHP in Existing Facilities – Commercial, Cooling

SICs	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
Commercial Cooling, High Load Factor													
7011, 7041	Hotels- Cooling	894	134.1	169	126.75	34	85.0					1097	345.9
8051, 8052, 8059	Nursing Homes- Cooling	664	119.5	388	349.2	32	96.0					1084	564.7
8062, 8063, 8069	Hospitals- Cooling	106	19.1	60	54	129	387.0	3	45.0			298	505.1
	Total Cooling High LF	1664	272.7	617	529.95	195	568.0	3	45.0			2479	1,415.7
Commercial Cooling, Low Load Factor													
5411, 5421, 5451, 5461, 5499	Food Sales	1619	121.4	232	87.0	20	25.0					1871	233.4
5812, 00, 01, 03, 05, 07, 08	Restaurants	2402	180.2	15	5.6							2417	185.8
43	Post Offices	189	28.4									189	28.4
4581	Airports	17	2.6	1	0.8							18	3.3
52,53,56,57	Big Box Retail	1252	187.8	304	228.0	105	262.5					1661	678.3
7832	Movie Theaters	71	10.7									71	10.7
6512	Office Buildings - Cooling	2773	208.0	1213	454.875	347	433.8					4333	1,096.6
	Total Cooling Low LF	8323	738.9	1765	776.25	472	721.3					10560	2,236.4
	Total Cooling	9987	1,011.6	2382	1306.2	667	1,289.3	3	45.0			13039	3,652.1
	Total C/I All Types	12544	1,253.8	3012	1,656.0	840	1,721.0	32	376.0	2	50.0	16430	3,491.3

Note: High Load factor cooling adds only 30% to the total C/I MW potential because the sites are already included in High LF Traditional. The 30% represents the incremental capacity offered by adding cooling.

Table 45. Ohio Sector Growth Projections Through 2025

SIC Code	Market Sector	2008-2025 Real Growth
20	Food	14.6%
22	Textiles	2.6%
24	Lumber and Wood	15.4%
25	Furniture	15.4%
26	Paper	15.4%
27	Printing/Publishing	2.6%
28	Chemicals	71.7%
29	Petroleum Refining	71.7%
30	Rubber/Misc. Plastics	71.7%
32	Stone/Clay/Glass	39.8%
33	Primary Metals	28.4%
34	Fabricated Metals	28.4%
35	Machinery/Computer Equip	67.5%
37	Transportation Equip.	43.9%
38	Instruments	28.8%
39	Misc. Manufacturing	15.4%
43	Post Offices	15.6%
4581	Airports	15.6%
6512	Office Buildings - Cooling	0.0%
6513	Apartments	0.0%
7542	Carwashes	0.0%
7832	Movie Theaters	17.6%
8412	Museums	17.6%
4222, 5142	Warehouses	77.6%
4941, 4952	Water Treatment/Sanitary	20.6%
52,53,56,57	Big Box Retail	25.1%
5411, 5421, 5451, 5461, 5499	Food Sales	25.1%
5812, 00, 01, 03, 05, 07, 08	Restaurants	17.6%
7011, 7041	Hotels	17.6%
7011, 7041	Hotels- Cooling	17.6%
7211, 7213, 7218	Laundries	0.0%
7991, 00, 01	Health Clubs	17.6%
7992, 7997-9904, 7997-9906	Golf/Country Clubs	17.6%
8051, 8052, 8059	Nursing Homes	2.0%
8051, 8052, 8059	Nursing Homes- Cooling	2.0%
8062, 8063, 8069	Hospitals	2.0%
8062, 8063, 8069	Hospitals- Cooling	2.0%
8211, 8243, 8249, 8299	Schools	2.0%
8221, 8222	Colleges/Universities	2.0%
9223, 9211 (Courts), 9224 (firehouses)	Prisons	0.1%

Table 46. CHP Market Segments, Ohio Existing Facilities and Expected Growth 2008-2025

Market	50-500 kW MW	500-1 MW (MW)	1-5 MW (MW)	5-20 MW (MW)	>20 MW (MW)	Total MW
Traditional High Load Factor Market						
Existing Facilities	481	1,027	1,903	1,287	2,975	7,672
New Facilities	251	542	985	673	1,865	4,316
Total	732	1,569	2,888	1,960	4,840	11,988
Traditional Low Load Factor Market						
Existing Facilities	153	86	14	13	0	266
New Facilities	86	50	7	6	0	149
Total	239	136	21	19	0	415
Cooling CHP High Load Factor Market (partially additive)						
Existing Facilities	273	530	568	45	0	1,416
New Facilities	158	285	295	15	0	752
Total	430	815	863	60	0	2,168
Cooling CHP Low Load Factor Market						
Existing Facilities	739	776	721	0	0	2,236
New Facilities	529	518	478	0	0	1,524
Total	1,268	1,294	1,199	0	0	3,760
Total Market including Incremental Cooling Load						
Existing Facilities	1,455	2,048	2,809	1,313	2,975	10,600
New Facilities	913	1,195	1,558	683	1,865	6,215
Total	2,368	3,243	4,367	1,997	4,840	16,814

Note: High load factor cooling market is comprised of a portion of the traditional high load factor market that has both heating and cooling loads. The total high load factor cooling market is shown, but only 30% of it is incremental to the portion already counted in the traditional high load factor market. Growth rates were extrapolated for the 2020-2025 market penetration forecast.

E.2. Energy Price Projections

The expected future relationship between purchased natural gas and electricity prices, called the *spark spread* in this context, is one major determinant of the ability of a facility with electric and thermal energy requirements to cost-effectively utilize CHP. For this screening analysis, a fairly simple methodology was used:

E.2.1. Electric Price Estimation

- Retail electric price forecasts EIA's Annual Energy Forecast for 2007 were used as the starting point for the analysis. ACEEE provided state by state estimates. The annual price forecasts provided were converted to 5 year averages for use in the market penetration model. These prices are shown in **Table E-7**.
- The electricity price assumptions for the high load factor CHP applications were as follows

- 50-500 kW – Commercial average price
- 500 kW to 5 MW – Industrial average price
- 5 MW and above – 90% of industrial average price

- Price adjustments for customer load factor were defined as follows:
  - High load factor – 100% of the estimated value
  - Low load factor – 120% of the estimated value
  - Peak cooling load – 150% of the estimated value
- For a customer generating a portion of his own power with CHP, standby charges are estimated at 15% of the defined average electric rate. Therefore, when considering CHP, only 85% of a customer's rate can be avoided.

E.2.2. Natural Gas Price Estimation

- The natural gas price assumptions are based on the industrial retail price shown in the table.
  - All customer boiler fuel is assumed at the industrial rate except for the CHP market below 500 kW where the boiler gas price is assumed to be $0.50/MMBtu higher
  - All CHP fuel is assumed to be at a $0.60/MMBt discount to the retail industrial price.

Table 47. Input Price Forecast (EIA-AEO 2007) and Ohio Industrial Electric Price Estimation

Ohio Energy Prices	Avg. 2007-2009	Avg.2010-2014	Avg.2015-2019	Avg.2020-2024
Ohio Retail Electricity Prices (2006$/kWh)				
Residential	$0.091	$0.101	$0.116	$0.126
Commercial	$0.083	$0.094	$0.106	$0.117
Industrial	$0.056	$0.067	$0.080	$0.089
Ohio Retail Natural Gas Prices (2006$/MMbtu)				
Residential	$13.729	$12.531	$12.782	$13.262
Commercial	$12.135	$10.709	$10.829	$11.193
Industrial	$10.813	$9.046	$9.209	$9.662

E.3. CHP Technology Cost and Performance

The CHP system itself is the engine that drives the economic savings. The cost and performance characteristics of CHP systems determine the economics of meeting the site's electric and thermal loads. A representative sample of commercially and emerging CHP systems was selected to profile performance and cost characteristics in combined heat and power (CHP) applications. The selected systems range in capacity from approximately 100 – 20,000 kW. The technologies include gas-fired reciprocating engines, gas turbines, microturbines and fuel cells. The appropriate technologies were allowed to compete for market share in the penetration model. In the smaller market sizes, reciprocating engines competed with microturbines and fuel cells. In intermediate sizes (1 to 20 MW), reciprocating engines competed with gas turbines.

Cost and performance estimates for the CHP systems were based on work being undertaken for the EPA.[71] The foundation for these updates is based on work previously conducted for NYSERDA,[72] on

[71] EPA CHP Partnership Program, Technology Characterizations, December 2007 (under review).

peer-reviewed technology characterizations that Energy and Environmental Analysis (EEA) developed for the National Renewable Energy Laboratory (NREL 2003) and on follow-on work conducted by DE Solutions for Oak Ridge National Laboratory (ORNL 2004). Additional emissions characteristics and cost and performance estimates for emissions control technologies were based on ongoing work EEA is conducting for EPRI (EPRI 2005). Data is presented for a range of sizes that include basic electrical performance characteristics, CHP performance characteristics (power to heat ratio), equipment cost estimates, maintenance cost estimates, emission profiles with and without after-treatment control, and emissions control cost estimates. The technology characteristics are presented for three years: 2005, 2010, 2020. The 2007-2010 estimates are based on current commercially available and emerging technologies. The cost and performance estimates for 2010-2015 and 2015-2020 reflect current technology development paths and currently planned government and industry funding. These projections were based on estimates included in the three references mentioned above. NOx, CO and VOC emissions estimates in lb/MWh are presented for each technology both with and without aftertreatment control (AT). For this analysis, aftertreatment was only included for the 800 kW and 3000 kW engines. The installed costs in Tables 48 through 51 are based on typical national averages.

[72] *Combined Heat and Power Potential for New York State*, Energy Nexus Group (later became part of EEA), for NYSERDA, May 2002.

Table 48. Reciprocating Engine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2007-2010	2010-2015	2016-2020
100 kW	Installed Costs, $/kW	$2,210	$1,925	$1,568
	Heat Rate, Btu/kWh	12,000	10,830	10,500
	Electric Efficiency, %	28.4%	31.5%	32.5%
	Thermal Output, Btu/kWh	6100	5093	4874
	O&M Costs, $/kWh	0.022	0.013	0.012
	NOx Emissions, lbs/MWh (w/ AT)	0.10	0.15	0.15
	CO Emissions w/AT, lb/MWh	0.32	0.60	0.30
	VOC Emissions w/AT, lb/MWh	0.10	0.09	0.05
	PMT 10 Emissions, lb/MWh	0.11	0.11	0.11
	SO_2 Emissions, lb/MWh	0.0068	0.0064	0.0062
	After-treatment Cost, $/kW	incl.	incl.	incl.
800 kW	Installed Costs, $/kW	$1,640	$1,443	$1,246
	Heat Rate, Btu/kWh	9,760	9,750	9,225
	Electric Efficiency, %	35.0%	35.0%	37.0%
	Thermal Output, Btu/kWh	2313	3791	3250
	O&M Costs, $/kWh	0.013	0.01	0.009
	NOx Emissions, lbs/MWh (w/ AT)	0.5	1.24	0.93
	CO Emissions w/AT, lb/MWh	1.87	0.45	0.31
	VOC Emissions w/AT, lb/MWh	0.47	0.05	0.05
	PMT 10 Emissions, lb/MWh	0.10	0.01	0.01
	SO_2 Emissions, lb/MWh	0.0068	0.0057	0.0054
	After-treatment Cost, $/kW	300	190	140
3000 kW	Installed Costs, $/kW	$1,130	$1,100	$1,041
	Heat Rate, Btu/kWh	9,492	8,750	8,325
	Electric Efficiency, %	35.9%	39.0%	41.0%
	Thermal Output, Btu/kWh	3510	3189	2982
	O&M Costs, $/kWh	0.011	0.0083	0.008
	NOx Emissions, lbs/MWh (w/ AT)	1.52	1.24	0.775
	CO Emissions w/AT, lb/MWh	0.78	0.31	0.31
	VOC Emissions w/AT, lb/MWh	0.34	0.10	0.10
	PMT 10 Emissions, lb/MWh	0.01	0.01	0.01
	SO_2 Emissions, lb/MWh	0.0057	0.0051	0.0049
	After-treatment Cost, $/kW	200	130	100
5000 kW	Installed Costs, $/kW	$1,130	$1,099	$1,038
	Heat Rate, Btu/kWh	8,758	8,325	7,935
	Electric Efficiency, %	39.0%	41.0%	43.0%
	Thermal Output, Btu/kWh	3046	2797	2605
	O&M Costs, $/kWh	0.009	0.008	0.008
	NOx Emissions, lbs/MWh (w/ AT)	1.55	1.24	0.775
	CO Emissions w/AT, lb/MWh	0.75	0.31	0.31
	VOC Emissions w/AT, lb/MWh	0.22	0.10	0.10
	PMT 10 Emissions, lb/MWh	0.01	0.01	0.01
	SO_2 Emissions, lb/MWh	0.0054	0.0049	0.0047
	After-treatment Cost, $/kW	150	115	80

Table 49. Microturbine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2007-2010	2010-2015	2016-2020
60 kW	Installed Costs, $/kW	$2,739	$2,037	$1,743
	Heat Rate, Btu/kWh	13,891	12,500	11,375
	Electric Efficiency, %	24.6%	27.3%	30.0%
	Thermal Output, Btu/kWh	6308	3791	3102
	O&M Costs, $/kWh	0.022	0.016	0.012
	NOx Emissions, lbs/MWh (w/ AT)	0.15	0.14	0.13
	CO Emissions w/AT, lb/MWh	0.24	0.22	0.20
	VOC Emissions w/AT, lb/MWh	0.03	0.03	0.02
	PMT 10 Emissions, lb/MWh	0.22	0.20	0.19
	SO_2 Emissions, lb/MWh	0.0079	0.0074	0.0067
	After-treatment Cost, $/kW			
250 KW	Installed Costs, $/kW	$2,684	$2,147	$1,610
	Heat Rate, Btu/kWh	13,080	11,750	10,825
	Electric Efficiency, %	2.6%	29.0%	31.5%
	Thermal Output, Btu/kWh	4800	3412	2625
	O&M Costs, $/kWh	0.015	0.013	0.012
	NOx Emissions, lbs/MWh (w/ AT)	0.43	0.24	0.13
	CO Emissions w/AT, lb/MWh	0.26	0.26	0.24
	VOC Emissions w/AT, lb/MWh	0.03	0.03	0.02
	PMT 10 Emissions, lb/MWh	0.18	0.18	0.16
	SO_2 Emissions, lb/MWh	0.0070	0.0069	0.0064
	After-treatment Cost, $/kW	500	200	90

Table 50. Fuel Cell Cost and Performance Characteristics

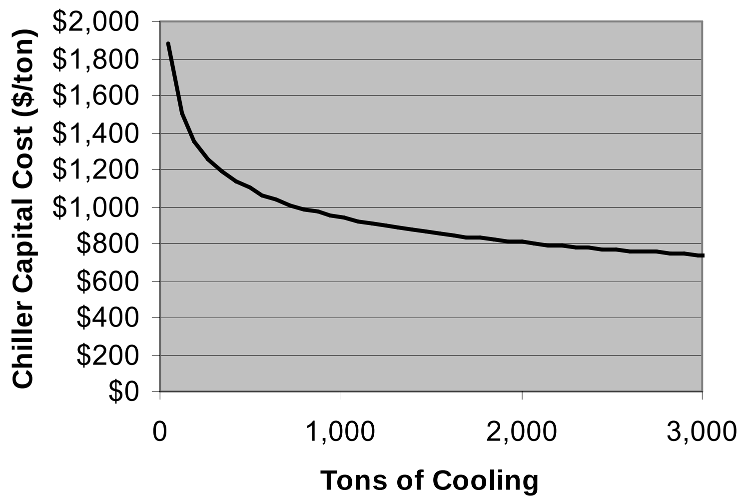
CHP System	Characteristic/Year Available	2007-2010	2010-2015	2016-2020
200 kW PAFC in 2005 150 kW PEMFC in outyears	Installed Costs, $/kW	$6,310	$4,782	$3,587
	Heat Rate, Btu/kWh	9,480	9,480	8,980
	Electric Efficiency, %	36.0%	36.0%	38.0%
	Thermal Output, Btu/kWh	4250	3482	3281
	O&M Costs, $/kWh	0.038	0.017	0.015
	NOx Emissions, lbs/MWh (w/ AT)	0.06	0.05	0.04
	CO Emissions w/AT, lb/MWh	0.07	0.07	0.07
	VOC Emissions w/AT, lb/MWh	0.01	0.01	0.01
	PMT 10 Emissions, lb/MWh	0.00	0.00	0.00
	SO_2 Emissions, lb/MWh	0.0057	0.0056	0.0053
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.
300 kW MCFC	Installed Costs, $/kW	$5,580	$4,699	$3,671
	Heat Rate, Btu/kWh	8,022	7,125	6,920
	Electric Efficiency, %	42.5%	47.9%	49.3%
	Thermal Output, Btu/kWh	1600	1723	1602
	O&M Costs, $/kWh	0.035	0.02	0.015
	NOx Emissions, lbs/MWh (w/ AT)	0.1	0.05	0.04
	CO Emissions w/AT, lb/MWh	0.07	0.05	0.04
	VOC Emissions w/AT, lb/MWh	0.01	0.01	0.01
	PMT 10 Emissions, lb/MWh	0.00	0.00	0.00
	SO_2 Emissions, lb/MWh	0.0057	0.0042	0.0041
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.
1200 kW MCFC	Installed Costs, $/kW	$5,250	$4,523	$3,554
	Heat Rate, Btu/kWh	8,022	7,110	6,820
	Electric Efficiency, %	42.5%	48.0%	50.0%
	Thermal Output, Btu/kWh	1583	1706	1503
	O&M Costs, $/kWh	0.032	0.019	0.015
	NOx Emissions, lbs/MWh (w/ AT)	0.05	0.05	0.04
	CO Emissions w/AT, lb/MWh	0.04	0.04	0.03
	VOC Emissions w/AT, lb/MWh	0.01	0.01	0.01
	PMT 10 Emissions, lb/MWh	0.00	0.00	0.00
	SO_2 Emissions, lb/MWh	0.0044	0.0042	0.0040
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.

Table 51. Gas Turbine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2007-2010	2010-2015	2016-2020
3000 KW GT	Installed Costs, $/kW	$1,690	$1,560	$1,300
	Heat Rate, Btu/kWh	13,100	12,650	11,200
	Electric Efficiency, %	26.0%	27.0%	30.5%
	Thermal Output, Btu/kWh	5018	4489	4062
	O&M Costs, $/kWh	0.0074	0.0065	0.006
	NOx Emissions, lbs/MWh (w/ AT)	0.68	0.38	0.2
	CO Emissions w/AT, lb/MWh	0.55	0.53	0.47
	VOC Emissions w/AT, lb/MWh	0.03	0.03	0.02
	PMT 10 Emissions, lb/MWh	0.21	0.20	0.18
	SO_2 Emissions, lb/MWh	0.0070	0.0069	0.0069
	After-treatment Cost, $/kW	210	175	150
10 MW GT	Installed Costs, $/kW	$1,298	$1,342	$1,200
	Heat Rate, Btu/kWh	11,765	10,800	9,950
	Electric Efficiency, %	29.0%	31.6%	34.3%
	Thermal Output, Btu/kWh	4674	4062	3630
	O&M Costs, $/kWh	0.007	0.006	0.005
	NOx Emissions, lbs/MWh (w/ AT)	0.67	0.37	0.2
	CO Emissions w/AT, lb/MWh	0.50	0.46	0.42
	VOC Emissions w/AT, lb/MWh	0.02	0.02	0.02
	PMT 10 Emissions, lb/MWh	0.20	0.18	0.17
	SO_2 Emissions, lb/MWh	0.0069	0.0064	0.0059
	After-treatment Cost, $/kW	140	125	100
40 MW GT	Installed Costs, $/kW	$972	$944	$916
	Heat Rate, Btu/kWh	9,220	8,865	8,595
	Electric Efficiency, %	37.0%	38.5%	39.7%
	Thermal Output, Btu/kWh	3189	3019	2892
	O&M Costs, $/kWh	0.004	0.004	0.004
	NOx Emissions, lbs/MWh (w/ AT)	0.55	0.2	0.1
	CO Emissions w/AT, lb/MWh	0.04	0.04	0.04
	VOC Emissions w/AT, lb/MWh	0.01	0.01	0.01
	PMT 10 Emissions, lb/MWh	0.16	0.15	0.15
	SO_2 Emissions, lb/MWh	0.0054	0.0052	0.0051
	After-treatment Cost, $/kW	90	75	40

In the cooling markets, an additional cost was added to reflect the costs of adding chiller capacity to the CHP system. These costs depend on the sizing of the absorption chiller which in turn depends on the amount of usable waste heat that the CHP system produces. Figure 35 shows this cost approximation.

Figure 35. Absorption Chiller Capital Costs



E.4. Market Penetration Analysis

EEA has developed a CHP market penetration model that estimates cumulative CHP market penetration in 5-yrar increments. For this analysis, the forecast periods are 2012, 2017, and 2022. These results are interpolated to the output years 2010, 2015, 2020, and 2025. The target market is comprised of the facilities that make up the technical market potential as defined in previously in this section. Thee economic competition module in the market penetration model compares CHP technologies to purchased fuel and power in 5 different sizes and 4 different CHP application types. The calculated payback determines the potential pool of customers that would consider accepting the CHP investment as economic. Additional, non economic screening factors are applied that limit the pool of customers that can accept CHP in any given market/size. Based on this calculated economic potential, a market diffusion model is used to determine the cumulative market penetration for each 5-year time period. The cumulative market penetration, economic potential and technical potential are defined as follows:

- *Technical potential* represents the total capacity potential from existing and new facilities that are likely to have the appropriate physical electric and thermal load characteristics that would support a CHP system with high levels of thermal utilization during business operating hours.
- *Economic potential*, as shown in the table, reflects the share of the technical potential capacity (and associated number of customers) that would consider the CHP investment economically acceptable according to a procedure that is described in more detail below.
- *Cumulative market penetration* represents an estimate of CHP capacity that will actually enter the market between 2008 and 2025. This value discounts the economic potential to reflect non-economic screening factors and the rate that CHP is likely to actually enter the market.

In addition to segmenting the market by size, as shown in the table, the analysis is conducted in four separate CHP market applications (high load and low load factor traditional CHP and high and low load factor CHP with cooling.) These markets are considered individually because both the annual load factor and the installation and operation of thermally activated cooling has an impact on the system economics.

Economic potential is determined by an evaluation of the competitiveness of CHP versus purchased fuel and electricity. The projected future fuel and electricity prices and the cost and performance of CHP technologies determine the economic competitiveness of CHP in each market. CHP technology and performance assumptions appropriate to each size category and region were selected to represent the competition in that size range (Table 52). Additional assumptions were made for the competitive analysis. Technologies below 1 MW in electrical capacity are assumed to have an economic life of 10 years. Larger systems are assumed to have an economic life of 15 years. Capital related amortization costs were based on a 10% discount rate. Based on their operating characteristics (each category and each size bin within the category have specific assumptions about the annual hours of CHP operation (80-90% for the high load factor cases with appropriate adjustments for low load factor facilities), the share of recoverable thermal energy that gets utilized (80%-90%), and the share of useful thermal energy that is used for cooling compared to traditional heating. The economic figure-of-merit chosen to reflect this competition in the market penetration model is simple payback.[73] While not the most sophisticated measure of a project's performance, it is nevertheless widely understood by all classes of customers.

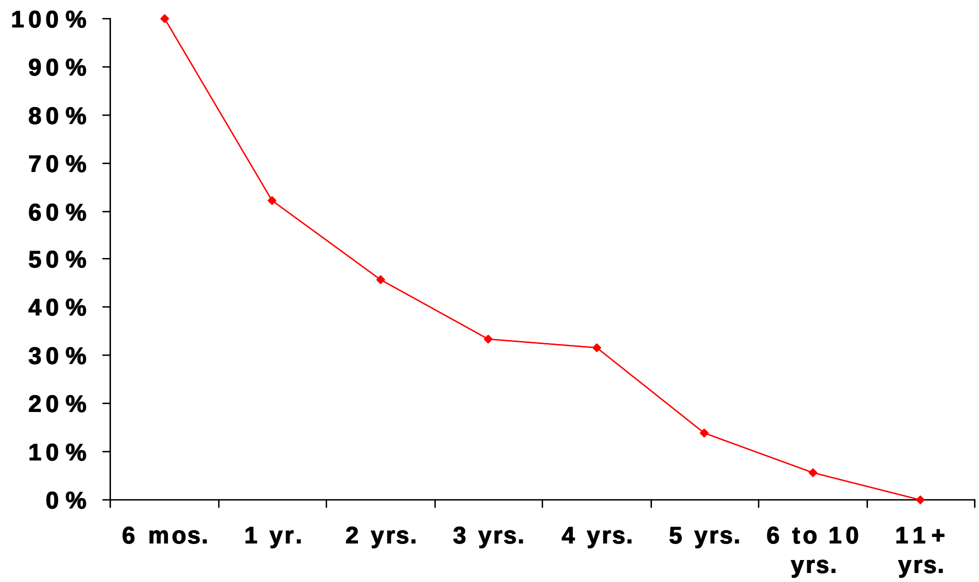
Table 52. Technology Competition Assumed within Each Size Category

Market Size Bins	*Competing Technologies*
50 - 500 kW	100 kW Recip Engine
	70 kW Microturbine
	150 kW PEM Fuel Cell
500 - 1,000 kW	300 kW Recip Engine (multiple units)
	70 kW Microturbine (multiple units)
	250 kW MC/SO Fuel Cell (multiple units)
1 - 5 MW	3 MW Recip Engine
	3 MW Gas Turbine
	2 MW MC Fuel Cell
5 - 20 MW	5 MW Recip Engine
	5 MW Gas Turbine
20 - 100 MW	40 MW Gas Turbine

Rather than use a single payback value, such as 3-years or 5-years as the determinant of economic potential, we have based the market acceptance rate on a survey of commercial and industrial facility operators concerning the payback required for them to consider installing CHP. Figure 36 shows the percentage of survey respondents that would accept CHP investments at different payback levels (CEC 2005b). As can be seen from the figure, more than 30% of customers would reject a project that promised to return their initial investment in just one year. A little more than half would reject a project with a payback of 2 years. This type of payback translates into a project with an ROI of between 49-100%. Potential explanations for rejecting a project with such high returns is that the average customer does not believe that the results are real and is protecting himself from this perceived risk by requiring very high projected returns before a project would be accepted, or that the facility is very capital limited and is rationing its capital raising capability for higher priority projects (market expansion, product improvement, etc.).

[73] Simple payback is the number of years that it takes for the annual operating savings to repay the initial capital investment.

Figure 36. Customer Payback Acceptance Curve



Source: *Primen's 2003 Distributed Energy Market Survey*

For each market segment, the economic potential represents the technical potential multiplied by the share of customers that would accept the payback calculated in the economic competition module.

The estimation of market penetration includes both a non-economic screening factor and a factor that estimates the rate of market penetration (diffusion). The non-economic screening factor was applied to reflect the share of each market size category (i.e., applications of 50 to 500 kW, applications of 500 to 1,000 kW, etc) within the economic potential that would be willing and able to consider CHP at all. These factors range from 32% in the smallest size bin (50-500 kW) to 64% in the largest size bin (more than 20 MW). These factors are intended to take the place of a much more detailed screening that would eliminate customers that do not actually have appropriate electric and thermal loads in spite of being within the target markets, do not use gas or have access to gas, do not have the space to install a system, do not have the capital or credit worthiness to consider investment, or are otherwise unaware, indifferent, or hostile to the idea of adding CHP. The specific value for each size bin was established based on an evaluation of EIA facility survey data and gas use statistics from the iMarket database.

The rate of market penetration is based on a *Bass diffusion curve* with allowance for growth in the maximum market. This function determines cumulative market penetration for each 5-year period. Smaller size systems are assumed to take a longer time to reach maximum market penetration than larger systems. Cumulative market penetration using a Bass diffusion curve takes a typical S-shaped curve. In the generalized form used in this analysis, growth in the number of ultimate adopters is allowed. The curves shape is determined by an initial market penetration estimate, growth rate of the technical market potential, and two factors described as *internal market influence* and *external market influence*.

The cumulative market penetration factors reflect the economic potential multiplied by the non-economic screening factor (maximum market potential) and by the Bass model market cumulative market penetration estimate.

Once the market penetration is determined, the competing technology shares within a size/utility bin are based on a *logit function* calculated on the comparison of the system paybacks. The greatest market share goes to the lowest cost technology, but more expensive technologies receive some market share depending on how close they are to the technology with the lowest payback. (This technology allocation feature is part of the EEA CHP model that is not specifically used for this analysis.)

Two cases were run to show the effects of providing an economic stimulus for CHP market penetration consisting of a capital cost reduction of $500/kW for all CHP systems 5 MW and below. The results of the base case, without incentives, are shown in Table 53. Table 54 shows the results of the $500/kW incentive case.

Table 53. Market Penetration Results for Base Case

CHP Measurement	2010	2015	2020	2025
Cumulative Market Penetration (MW)				
Industrial	0	294	678	937
Commercial/Institutional	0	57	170	263
Total	0	351	848	1,200
Avoided Cooling	0	4	11	15
Scenario Grand Total	0	355	859	1,215
Annual Electric Energy (Million kWh)				
Industrial	0	2023	5014	7,055
Commercial/Institutional	269	543	1085	1,728
Total	269	2565	6099	8,783
Avoided Cooling	0	9	30	49
Scenario Grand Total	269	2,574	6,128	8,832
Incremental Onsite Fuel (billion Btu/year)				
Industrial	0	11,782	27,025	37,161
Commercial/Institutional	0	2,153	6,316	9,742
Total	0	13,935	33,341	46,903
Cumulative Investment (million 2006$)	$0	$380	$942	$1,351
Cumulative Incentive Payments (Million 2006$)	$0	$1	$7	$14

Note: Incentive Payments in the Base Case represent fuel cell tax credits

Table 54. Market Penetration Results for $500/kW Incentive Case

CHP Measurement	2010	2015	2020	2025
Cumulative Market Penetration (MW)				
Industrial	4	379	876	1,209
Commercial/Institutional	3	140	370	546
Total	7	520	1246	1,755
Avoided Cooling	1	16	36	44
Scenario Grand Total	9	536	1,282	1,799
Annual Electric Energy (Million kWh)				
Industrial	41	2548	6140	8,564
Commercial/Institutional	309	1055	2254	3,360
Total	351	3603	8394	11,924
Avoided Cooling	6	44	100	145
Scenario Grand Total	356	3,647	8,494	12,069
Incremental Onsite Fuel (billion Btu/year)				
Industrial	117	14,690	33,771	46,446
Commercial/Institutional	86	4,985	13,161	19,375
Total	203	19,674	46,933	65,820
Cumulative Investment (million 2006$)	$5	$446	$1,045	$1,452
Cumulative Incentive Payments (Million 2006$)	$7	$183	$477	$705

APPENDIX F – THE DEEPER MODEL AND MACRO MODEL

The Dynamic Energy Efficiency Policy Evaluation Routine—or the DEEPER Model—is a 15-sector quasi-dynamic input-output impact model of the U.S. economy.[74] Although an updated model with a new name, the model has a 15-year history of use and development. See, for example, Laitner, Bernow, and DeCicco (1998) and Laitner (2007) for a review of past modeling efforts. The model is generally used to evaluate the macroeconomic impacts of a variety of energy efficiency (including renewable energy) and climate policies at both the state and national level. The national model now evaluates policies for the period 2008 through 2050. Although, the DEEPER Model for the Ohio specific analysis will cover the period between 2008 through 2025. As it is now designed, the model solves for the set of energy prices that achieves a desired and exogenously determined level of greenhouse gas emissions (below some previously defined reference case). Although the model does include non-CO_2 emissions and other emissions reduction opportunities, it currently focuses on energy-related CO_2 emissions and on the prices, policies, and programs necessary to achieve the desired emissions reductions. DEEPER is an Excel-based analytical tool that consists generally of six sets of key modules or groups of worksheets. These six sets of modules now include:

Global data: The information in this module consists of the economic time series data and key model coefficients and parameters necessary to generate the final model results. The time series data includes the projected reference case energy quantities such as trillion Btus and kilowatt-hours, as well as the key energy prices associated with their use. It also includes the projected gross domestic product, wages and salary earnings, and levels of employment as well as information on key technology cost and performance characteristics. The sources of economic information include data from the Energy Information Administration, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and Economy.com. The cost and performance characterization of key technologies is derived from available studies completed by ACEEE and others, as well as data from the Energy Information Administration's (EIA) National Energy Modeling System (NEMS). One of the more critical assumptions in this study is that alternative patterns of electricity consumption will change and/or defer the mix of investments in conventional power plants. Although we can independently generate these impacts within DEEPER, we can also substitute assumptions from the ICF Integrated Planning Model (IPM) and similar models as they may have different characterizations of avoided costs or alternative patterns of power plant investment and spending.

Macroeconomic model: This set of modules contains the "production recipe" for the region's economy for a given "base year"—in this case, 2006, which is the latest year for which a complete set of economic accounts are available for the regional economy. The I-O data, currently purchased from the Minnesota IMPLAN Group (IMPLAN 2007), is essentially a set of input-output accounts that specify how different sectors of the economy buy (purchase inputs) from and sell (deliver outputs) to each other. In this case, the model is now designed to evaluate impacts for 15 different sectors, including: Agriculture, Oil and Gas Extraction, Coal Mining, Other Mining, Electric Utilities, Natural Gas Distribution, Construction, Manufacturing, Wholesale Trade, Transportation and Other Public Utilities (including water and sewage), Retail Trade, Services, Finance, Government, and Households.

Investment, Expenditures and Energy Savings: Based on the scenarios mapped into the model, this worksheet translates the energy policies into a dynamic array of physical energy impacts, investment flows, and energy expenditures over the desired period of analysis. It estimates the needed investment path for an alternative mix of energy efficiency and other technologies (including efficiency gains on both the end-use and the supply side). It also provides an estimate of the avoided investments needed by the electric generation sector. These quantities and expenditures feed

[74] There is nothing particularly special about this number of sectors. The problem is to provide sufficient detail to show key negative and positive impacts while maintaining a manageable sized model. If we choose to reflect a different mix of sectors and stay within the 15 x 15 matrix, that can be done easily. If we wish to expand the number of sectors, that would take some minor programming changes or adjustments to reflect the larger matrix.

directly into the final demand module of the model which then provides the accounting that is needed to generate the set of annual changes in final demand (see the related module description below).

Price dynamics: There are two critical drivers that impact energy prices within DEEPER. The first is a set of carbon charges that are added to retail prices of energy depending on the level of desired level of emission reductions and also depending on the available set of alternatives to achieve those reductions. The second is the price of energy as it might be affected by changed consumption patterns. In this case DEEPER employs an independent algorithm to generate energy price impacts as they reflect changed demand. Hence, the reduced demand for natural gas in the end-use sectors, for example, might offset increased demand by utility generators. If the net change is a decrease in total natural gas consumption, the wellhead prices might be lowered. Depending on the magnitude of the carbon charge, the change in retail prices might either be higher or lower than the set of reference case prices. This, in turn, will impact the demand for energy as it is reflected in the appropriate modules. In effect, then, DEEPER scenarios rely on both a change in prices and quantities to reflect changes in overall investments and expenditures.

Final demand: Once the changes in spending and investments have been established and adjusted to reflect changes in prices within the other modules of DEEPER, the net spending changes in each year of the model are converted into sector-specific changes in final demand. This, in turn, drives the input-output model according to the following predictive model:

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

where:

X = total industry output by sector

I = an identity matrix consisting of a series of 0’s and 1’s in a row and column format for each sector (with the 1’s organized along the diagonal of the matrix)

A = the production or accounting matrix also consisting of a set of production coefficients for each row and column within the matrix

Y = final demand, which is a column of net changes in final demand by sector

This set of relationships can also be interpreted as

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

which reads: a change in total sector output equals $(I-A)^{-1}$ times a change in final demand for each sector. Employment quantities are adjusted annually according to exogenous assumptions about labor productivity in each of the sectors (based on Bureau of Labor Statistics forecasts).

Results: For each year of the analytical time horizon (again out to 2025 for the Ohio specific analysis), the model copies each set of results into this module in a way that can also be exported to a separate report.

Further results from Ohio’s DEEPER analysis is provided to show macroeconomic trends between 5-year time periods. Although similar 2015 & 2025 results were presented in the body of this report, differences between 5-year time periods offer more reference points for the reader to understand Ohio’s macroeconomic trends under the efficiency scenario. This section highlights the net changes Ohio’s economy will experience as the result of our efficiency scenario.

Table 55. Changes in Ohio Electricity Production and Financial Impacts from Energy Efficiency Policy Scenario: 2010, 2015, 2020 & 2025

(Millions of 2006 $)	2010	2015	2020	2025
Efficiency Gains (GWh)	1,383	9,728	22,845	40,069
Change from Reference Case	2.3%	15.5%	36.3%	62.9%
Policy Cost	$89	$154	$413	$489
Investment	$214	$629	$1,152	$1,382
Annual Consumer Outlays	$193	$723	$1,496	$2,146
Annual Electricity Savings	$111	$1,154	$2,961	$5,461
Electricity Supply Cost Adjustment	$58	$267	$626	$1,059
Net Consumer Savings	-$23	$431	$1,465	$3,314
Net Cumulative Energy Savings	$9	$954	$5,951	$18,980

The macroeconomic module of the DEEPER model traces how each set of changes works or ripples its way through the Ohio economy in each year of the assessment period, see Table 55. This module estimates the number of jobs and amount of wages each sector provides the Ohio economy. Changes in sectoral spending are provided in Table 56 below.

Table 56. Changes in Sector Spending (Millions of 2006 Dollars)

Sector	2010	2015	2020	2025
Agriculture	$0.5	$7.8	$29.1	$47.1
Oil and Gas Extraction	$0.3	$5.0	$21.5	$32.3
Coal Mining	$0.0	$0.1	$0.6	$0.9
Other Mining	$0.2	$3.2	$13.9	$20.8
Construction	$121.0	$195.9	$479.1	$719.0
Manufacturing	$8.4	$115.1	$362.1	$648.0
Petroleum Refining	$2.8	$40.8	$163.1	$255.0
Electric Utility Services	-$44.5	-$167.0	-$388.6	-$656.8
Natural Gas Utility Services	-$52.6	-$397.2	-$1,040.5	-$1,690.5
Transportation Other Public Utilities	-$3.0	$3.0	$14.0	$35.0
Wholesale Trade	$9.9	$150.8	$415.2	$809.2
Services	$40.1	$464.3	$1,278.1	$2,462.2
Financial Services	-$11.7	$48.1	$125.1	$244.4
Governmental Services	$5.0	$13.2	$36.5	$58.5

There are other support spreadsheets as well as routines in visual basic programming that support the automated generation of model results and reporting. For more detail on the model assumptions and economic relationships, please refer to the forthcoming model documentation (Laitner 2009). For a review of how an I-O framework might be integrated into other kinds of modeling activities, see Hanson and Laitner (2007). While not an equilibrium model, we borrow from some key concepts of mapping technology representation into DEEPER using the general scheme outlined in Laitner and Hanson (2007).