# 5 ENERGY EFFICIENCY IN INDUSTRY

## 5.1 INDUSTRIAL ENERGY USE IN APPALACHIA

The industrial sector currently comprises about 30 percent of overall energy use within the Appalachian Region. According to the EIA's 2008 *Annual Energy Outlook*, industrial consumption will remain large, though its market share will decrease slightly to 28 percent by 2030 (EIA, 2008a). The full baseline forecasts of industrial energy consumption in the Appalachian Region are illustrated in Figure 5.1. The difference seen in the forecast beyond 2022 reflects a projection of slower growth in energy-intensive industry nationwide, which is estimated to be –0.7 percent, relative to the 1.9 percent growth of less energy-intensive industry" (EIA, 2008a). This nationwide trend is expected to also occur in the Appalachian Region.

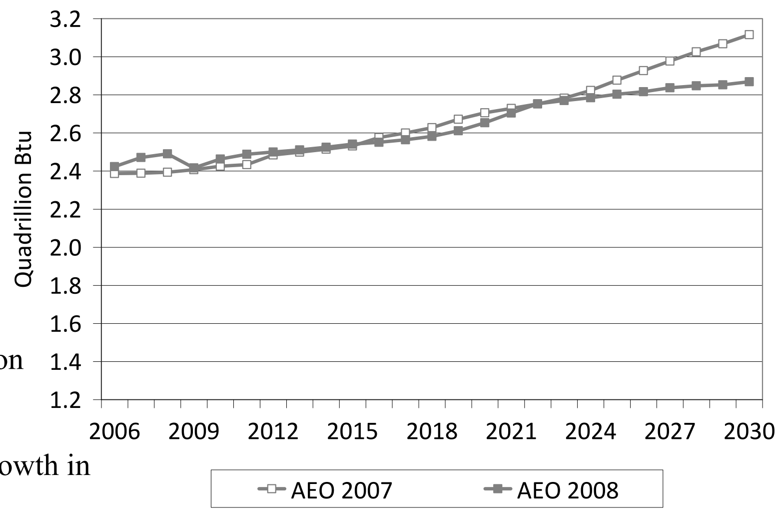


**Figure 5.1 Energy Consumption Forecast for Industry (Quads)**
(EIA, 2007a; 2008a)

Industrial users consume a wide variety of energy sources and use them as heat and work sources. Primary fuels are also used as feedstock chemicals in the manufacture of good such as plastics. Figure 5.2 illustrates the variety of energy used by Appalachian industry. Electricity and its related generation, transmission, and distribution losses account for 45 percent of the energy used by industry while liquid fuels and natural gas comprise 23 and 15 percent of industrial energy use, respectively; note that site use is not dominated by electricity as it is in the residential and commercial sectors.

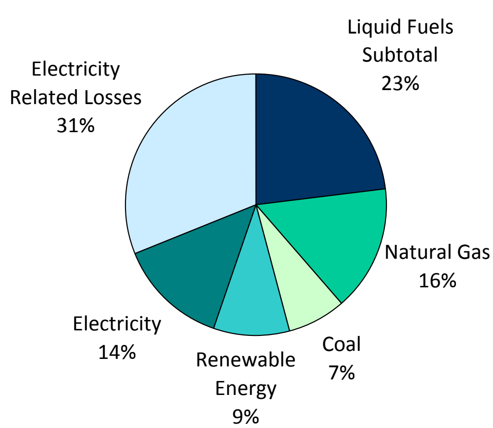


**Figure 5.2 Industrial Energy Sources by Fuel, 2006**
(EIA, 2008a)

The Appalachian Region is home to a wide variety of industries, employing residents in all of the industrial North American Classification System (NAICS) code categories. The top eight industrial employers are shown in Table 5.1. Energy-intensive industries in the Region include pulp and paper, chemical manufacturing, and mining.

**Table 5.1 Top Industrial Employers in the Appalachian Region**
(IMPLAN, 2006)

| NAICS Division | Percent of Industrial Employment |
|---|---|
| Wholesale trade | 19 |
| Transportation equipment | 7 |
| Fabricated metal products | 7 |
| Food products | 6 |
| Furniture and related products | 5 |
| Machinery manufacturing | 5 |
| Plastics and rubber products | 5 |
| Wood products | 5 |

While accounting for more energy consumption than any other sector, industry benefits from having fewer unique users; therefore, education and information dissemination can occur more rapidly and with less cost. In addition, action at one industrial site can have more impact on energy consumption than action at one residence or commercial enterprise.

Because industrial energy-efficiency improvements are often process or plant specific, it is difficult to characterize the potential for energy savings in this sector. Nevertheless, some policies can be discussed at a high level of aggregation. In particular, three policies are investigated in this study with regards to the industrial sector and are described below.

## 5.2 POLICY OPTIONS FOR INDUSTRIAL ENERGY EFFICIENCY

This study in industrial energy efficiency investigates three policies: expansion of industrial assessment centers (IACs), energy savings assessment (ESA) training, and combined heat and power (CHP) incentives. Many types of policies could be used to encourage more efficient use of energy in industry. Examples of policy actions are shown in Table 5.2. The policies and programs listed could be used as substitutions for or complementary actions to the ones that were modeled in this study. The actual form of policies adopted within the Appalachian Region will depend on the critical barriers and market failures that inhibit the market uptake of energy-efficient technologies and practices, which vary across industries and subregions of Appalachia. The specific choice of policies will also reflect the goals and capacity of state and local agencies.

**Table 5.2 Policy Actions that Support Industrial Energy Efficiency**

| Actions | Expansion of Industrial Assessment Centers | Energy Savings Assessments | Industrial Combined Heat and Power |
|---|---|---|---|
| **Research, Development, and Demonstration** | Increased equipment and system performance; reduced installed cost | Increased equipment and system performance; reduced installed cost | Increased equipment and system performance; reduced installed cost |
| **Financing** | Low or no interest loans for capital improvements | Low or no interest loans for capital improvements | Low or no-interest loans for CHP equipment purchase |
| **Financial Incentives** | *Assistance with energy audit costs*; grants and tax credits | Grants and tax credits | *Grants* and tax credits |
| **Pricing** | – | – | *Reduced rates for natural gas for CHP users* |
| **Voluntary Agreements** | N/A | N/A | N/A |
| **Regulations** | Equipment standards | Equipment standards | Net metering and feed-in tariffs; equipment standards |
| **Information Dissemination & Training** | *Campaigns to inform small- to medium-sized industrial sites of potential for energy and cost savings* | *Training for on-site personnel during first assessment;*<br>*Software tools to perform future assessments;*<br>*Campaign to inform large industrial sites of the potential for energy and cost savings* | Assessments to evaluate CHP feasibility at site;<br>*Campaign to inform industrial sites of the potential for energy and cost savings* |
| **Procurement** | Assistance with equipment procurement to lessen lead times | Assistance with equipment procurement to lessen lead times | Assistance with equipment procurement to lessen lead times |
| **Market Reforms** | Public assistance fund | Public assistance fund | Public assistance fund |
| **Planning Techniques** | Outage management to facilitate energy-efficiency upgrades; zoning and land use planning | Outage management to facilitate energy-efficiency upgrades; zoning and land use planning | Outage management to facilitate energy-efficiency upgrades; zoning and land use planning |
| **Capacity Building** | *Increase the number of industrial assessment personnel* | Software development | N/A |

This table describes policy actions available that could further the savings from the policy packages modeled in this study. The policy actions shown in *italics* are modeled in this study, while the others are not.

### 5.2.1 Research, Development, and Demonstration

Research, development, and demonstration of energy-efficient technologies are necessary to continually improve performance and reduce the cost of advanced equipment and practices, both of which affect adoption rates. The West Virginia and Maryland Industries of the Future Programs and the North Carolina Combined Heat and Power Center are examples of Appalachian organizations that are encouraging innovation in industrial energy efficiency.

The Maryland Industries of the Future Program (IFP) has several goals. Its goals related to research are to help establish relationships between universities and develop funding for research and development that supports industry in the state of Maryland. These goals could directly aid in the development of future energy-efficient technologies while also providing economic development to the Region. The North Carolina Combined Heat and Power Center supports efforts in the development and implementation of combined heat and power (CHP) systems, which can reduce energy consumption. This center partners with several other centers throughout the Appalachian Region to promote the installation of CHP systems in the Southeast and the development of improved systems for future use.

### 5.2.2 Financing

Though industrial energy-efficiency improvements can often pay for themselves within a few years, they also can require large capital investment to implement. Opportunities for loans in order to finance improvements can increase penetration of energy-efficient technologies into industry; loan programs are attractive because these loans can be repaid with the money saved by reduced energy consumption. An example of a loan program applicable to the industrial sector in the Appalachian Region is the North Carolina Energy Improvement Loan Fund (EILF). Under this program, with a bank letter of credit, an industrial site can receive a one percent loan for energy recycling or renewable energy projects or a three percent loan on projects that reduce energy demand, yield energy cost savings, or are energy-efficient.

### 5.2.3 Financial Incentives

Reducing the cost of energy-efficiency improvements through financial incentives can increase the participation in new programs, yielding energy savings for the industrial site and Appalachia. As the program grows, it may be possible to lessen the incentives once the program‘s impact is demonstrated.

Currently there are several state financial incentive programs that aid in the reduction of energy consumption in the Appalachian Region, two of which are the Kentucky Sales Tax Exemption for Manufacturing Facilities and the Ohio Energy Loan Fund (ELF) grants for energy-efficiency projects in manufacturing. Under the Kentucky program, an industrial site can receive a rebate on sales tax paid on an energy-efficiency project that maintains or increases the site‘s productivity while reducing its energy consumption by 15 percent or more. Under the Ohio ELF project, energy efficiency, distributed generation (including CHP), and renewable energy projects are eligible to apply for a grant to cover a portion of project expenses.

### 5.2.4 Regulations

Regulations can have a large impact on the availability and affordability of energy-efficient equipment. Without regulation, the availability of energy-efficiency products and equipment is dependent on market conditions. While markets could drive manufacturers to produce more efficiency components due to demand, regulations at the state or national level ensure these technologies are available to the public and provide a more secure market to those companies producing the equipment, reducing the risk of research, development, and introduction to the market.

Affordability of an efficient device is impacted not only by its purchase price; it is also greatly affected by the utility framework under which it operates. Regulations pertaining to the ―buy-back" of electricity are critical to systems that generate electricity on-site, such as CHP systems. If a site produces more electricity than it uses at that location, the following could occur: (1) the electricity is not returned to the electrical grid (wasted), (2) low feed-in tariff where the electricity is returned to the grid, and the site is paid a set rate that is less than the rate it pays to buy from the grid, (3) the electricity is returned to the grid, and the meter runs backwards (i.e., the electricity is bought by the utility at the same rate it sells electricity to the customer, called ―net metering"), or (4) high feed-in tariff where the electricity is returned to the grid, and the utility pays a premium price for it (e.g., photovoltaic power in Germany). Example scenarios (3) and (4) offer the site higher compensation, and, therefore, could aid in adoption of power-producing technologies. Table 5.3 lists net metering programs in the Appalachian Region.

**Table 5.3 Current Industrial Net Metering Programs in Appalachian Region**
(NCSC/IREC, 2008)

| State | Size Limit | Applicable Technologies |
|---|---|---|
| Georgia | Up to 100 kW | PV, Wind, Fuel Cells |
| New York | Up to 2 MW | Photovoltaics, Wind |
| North Carolina | Up to 100 kW | Photovoltaics, Landfill Gas, Wind, Biomass, Anaerobic Digestion, Small Hydroelectric |
| Pennsylvania | Up to 3 MW | Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Fuel Cells, Municipal Solid Waste, CHP/Cogeneration, Waste Coal, Coal-Mine Methane, Anaerobic Digestion, Other Distributed Generation Technologies |
| Ohio | Must be sized to meet some or all of customer's load | Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Fuel Cells, Microturbines |
| South Carolina | Up to 100 kW | Photovoltaics, Landfill Gas, Wind, Biomass, Small Hydroelectric |
| Virginia | Up to 500 kW | Solar Thermal Electric, Photovoltaics, Wind, Biomass, Hydroelectric, Geothermal Electric, Municipal Solid Waste, Tidal Energy, Wave Energy |

If high feed-in tariffs for energy-efficient systems were expanded to encompass all energy-efficient and renewable power production, distributed generation could have a large impact on reducing the Region's fossil energy consumption.

### 5.2.5 Information Dissemination and Training

As shown in Table 5.2, information dissemination and training are important to all three of the policy bundles investigated in this study. Educating the industrial owners and workforce is key to propagating adoption of energy-efficient equipment and practices. An example of an information dissemination and training program active in the Appalachian Region is the North Carolina Energy Management Program Industry Extension. This organization develops and implements educational material and holds workshops in the area of industrial energy efficiency. The group also conducts industrial surveys and gathers information related to current system configurations and operations to provide guidance to those interested in improving site energy efficiency.

In addition to state-specific programs, another organization that could provide assistance with public education is the Hollings Manufacturing Extension Partnership (MEP). The groups participating in this partnership are publically-funded, not-for-profit state or university entities that assist manufacturing facilities in a wide variety of ways, from streamlining processes to implementing energy-savings programs (NIST, 2008). This well-established partnership could aid in information dissemination and training throughout the Appalachian Region.

## 5.3 MODELED SAVINGS IN APPALACHIAN INDUSTRY

The following sections describe each of the modeled policies in more detail and estimate potential energy savings as well as the costs associated with implementation of each policy. At the end of the chapter, aggregated results for the sector are reported along with a discussion of the findings. Greater detail on the modeling methodology used to estimate the potential for industrial energy-efficiency improvements can be found in Appendix D.

### 5.3.1 Expanded Industrial Assessment Center Initiative (IACs)

Currently, there are 26 DOE Industrial Assessment Centers (IACs) located throughout the U.S. (DOE/EERE, 2008a). These centers are university-based, and teams comprised of both faculty and students perform thorough analyses at small to medium-sized industrial facilities[24] within their local region. These assessments suggest savings improvements in energy efficiency, waste minimization, pollution prevention, and productivity. Table 5.4 illustrates the activities of this program in the Appalachian states, including number of assessments and implementation rate of recommendations.

[24] less than $2.5 million in energy expenditures per year (Soderlund, 2008)

**Table 5.4 IAC Assessments to Date**
(DOE/EERE, 2008a)

| State | Number of Assessments | Recommended Actions | Average Payback (years) | Implemented Actions | Average Payback (years) | Implementation Rate (%) |
|---|---|---|---|---|---|---|
| Alabama | 116 | 849 | 1.5 | 334 | 1.3 | 39 |
| Georgia | 648 | 4,401 | 1.6 | 1,905 | 1.6 | 43 |
| Kentucky | 202 | 1,269 | 1.2 | 462 | 1.0 | 36 |
| Maryland | 42 | 361 | 1.0 | 181 | 0.9 | 50 |
| Mississippi | 300 | 1,971 | 1.1 | 701 | 0.8 | 36 |
| North Carolina | 319 | 2,488 | 1.0 | 1,187 | 0.7 | 48 |
| New York | 498 | 3,552 | 1.1 | 1,727 | 0.9 | 49 |
| Ohio | 853 | 5,808 | 1.1 | 2,968 | 1.0 | 51 |
| Pennsylvania | 341 | 2,933 | 1.1 | 1,343 | 0.9 | 46 |
| South Carolina | 92 | 668 | 1.5 | 308 | 1.4 | 46 |
| Tennessee | 468 | 2,989 | 1.0 | 1,367 | 0.8 | 46 |
| Virginia | 258 | 1,708 | 1.2 | 775 | 1.2 | 45 |
| West Virginia | 110 | 1,147 | 1.6 | 622 | 1.9 | 54 |

Most of the recommended improvements have corresponding energy savings. For example, it was recommended to an aircraft parts manufacturer in West Virginia that it should switch to a more efficient light source. This switch would save an estimated 686 MW-hr of electricity per year, which is 6.6 percent of the site's annual electricity use. The replacement would pay for itself in little over a year (DOE/EERE, 2008a). Other projects, such as improving logistics within each site, primarily yield financial savings; however, energy savings could be a secondary benefit.

Expanding the capacity of Industrial Assessment Centers in Appalachia, through added personnel at existing locations and increasing the number of affiliated universities in the Region, could greatly improve the energy efficiency of industry in the Region. In 2007, the states that comprise the Appalachian Region benefitted from 163 industrial assessments from 11 centers. Based on population-weighting, approximately 40 of those occurred within the boundaries of ARC.

To support the expansion of industrial assessment within the Appalachian Region, several programs were investigated. These policy components are shown in Table 5.2. These three components will aid in reaching nearly 100 percent of sites by 2030. To reach as many small- to medium-sized locations as possible, advertising, and information will be needed. In addition, program personnel may need to travel to sites for in-person visits to discuss the benefits of industrial assessment. Once sites request an assessment, personnel should be available to act. In order to increase the number of industrial assessments within the Region, additional personnel will be added at current industrial assessment centers located within the Region. If needed, additional universities could be asked to join a center to keep up with demand.

In order to model the potential benefits of increasing IAC capacity, findings from recent industrial assessments were compiled for each NAICS code in each Appalachian subregion. The resulting information was used with Appalachian Region employment statistics and population growth estimates to determine potential energy savings.

The results of implementing increased IAC capacity are shown in Tables 5.5 and 5.6. Details of the IAC modeling, including base data, assumptions, and methodology are detailed in Appendix D.1.

**Table 5.5 Energy Savings from IACs**

| Year | Electricity Savings (GWh) | Natural Gas Savings (trillion Btu) | Fuel Oil Savings (trillion Btu) | Total Primary Energy Saved (trillion Btu) | % of Sector Primary Energy |
|---|---|---|---|---|---|
| **2010** | 10 | 0.06 | 0.00 | 0.17 | 0.01 |
| **2013** | 631 | 3.27 | 0.00 | 10.45 | 0.42 |
| **2020** | 3,243 | 16.75 | 0.00 | 53.63 | 2.18 |
| **2030** | 7,261 | 37.37 | 0.00 | 119.95 | 4.87 |

**Table 5.6 Costs and Savings from IACs**

| Year | Energy Savings (million 2006$) | Admin Costs (million 2006$) | Investment Costs (million 2006$) |
|---|---|---|---|
| **2010** | 0.84 | 0.68 | 1.81 |
| **2013** | 46.94 | 2.45 | 43.30 |
| **2020** | 238.45 | 2.96 | 55.08 |
| **2030** | 582.80 | 3.15 | 59.31 |

These savings figures assume that IACs are able to increase from approximately 40 assessments per year in the Appalachian Region to having assessed nearly all small- to medium-sized facilities by 2030 through an increase in workforce and number of centers located in or near the 13-state Region. In 2010, the increase in IAC capacity is minimal; however, by 2020, it is estimated that the total energy used by industry in Appalachia could be reduced by 2.2 percent. By 2030, the energy savings could increase to 4.9 percent of the projected sector use. This represents only part of the energy-efficiency gains possible in the Region and is additive to the other industrial policy efficiency gains.

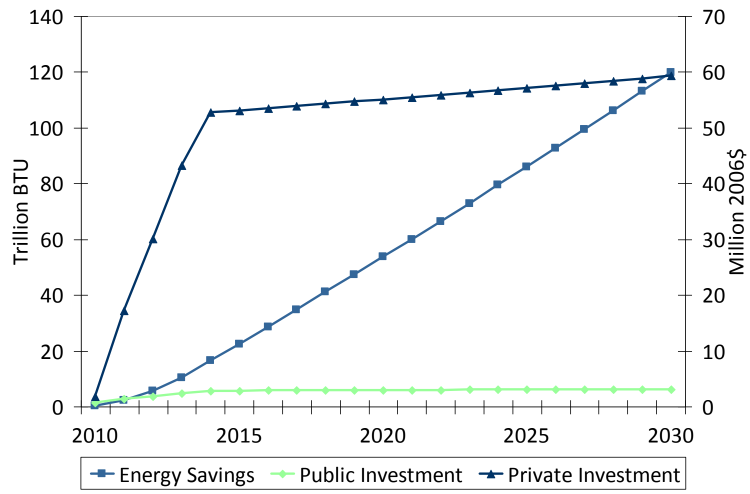


**Figure 5.3 Annual Investment and Energy Savings from IACs, 2010-2030**

The Expanded Industrial Assessment Centers Initiative is cost-effective with a benefit-to-cost ratio of about 5.0 for participants and about 5.9 for society. With $57.3 million in program spending, which includes the cost of each assessment, and an additional $1 billion in customer investments for capital improvements over the 2010-2030 period, the Appalachian Region could see net cumulative savings of 2.5 quads, cutting $11.9 billion from energy bills by 2050. This is the equivalent of about 4.9 percent of the EIA's forecast consumption in 2030, or 29.6 percent of forecast growth (EIA, 2008a).

### 5.3.2 Increasing Energy Savings Assessments

Like industrial assessments, energy savings assessments (ESAs) can provide plant and facility managers with the tools they need to take control of their energy use; however, these assessments take place at large industrial sites and only on one system at a time.[25] The impact of energy savings assessments on energy and economic savings has been documented by the U.S. DOE's Save Energy Now program. Save Energy Now assessments conducted in 2006 included identification of ways to reduce natural gas use in steam and process heat as well as on-site training of appropriate personnel to use the Save Energy Now software. Approximately 16 assessments were performed in the Appalachian Region during this time. These assessments were focused and quick (three days) and integrally involved the plant personnel to achieve buy in and capacity building for future in-house assessments. While only considering natural gas consumption in steam and process heat, the 200 assessments, which occurred nationwide, found an average of 8.8 percent energy savings annually with a payback of less than two years for most recommendations (Wright et al., 2007). An example of the results of one site energy savings assessment is shown in Table 5.7.

[25] Large industrial sites are defined by DOE as those having greater than $2.5 million in energy expenditures per year (Soderlund, 2008)

| **Table 5.7 Example of Save Energy Now Energy Savings Assessments**<br>(DOE/EERE, 2008b) | |
|---|---|
| **Shaw Industries (Flooring Manufacturing), Dalton, GA** | |
| **System Assessed:** | Steam |
| **Recommendations Implemented:** | Boiler control optimization, installation of waste water heat exchanger, stack economizer |
| **Annual Energy Savings:** | 93,000 MMBtu |
| **Annual Energy Cost Savings:** | $872,000 |
| **Simple Payback of Projects:** | 1.7 years |

The programs that support energy savings assessment and training are shown in Table 5.2. These components are similar to the ones described above; however, two additional pieces aid in reaching the targeted number of systems: training of on-site personnel and software tools for second generation (and beyond) assessments. When the first assessment is conducted at a site, plant personnel are trained to perform future assessments on other large, energy-intensive systems within the plant and given software tools to aid them with this work. Once successful training has taken place, a site is self-sufficient and can continue to discover energy savings as resources allow.

While not modeled in the current study, adhering to standards such as ANSI/MSE 2000:2005 is one way to insure proper prioritization of energy-efficiency projects and sustained benefits of systems already implemented. An initial ESA could be the springboard for a manufacturing facility to get started on the ANSI/MSE 2000:2005 path. This standard provides a framework for industrial sites to continuously improve energy efficiency while maintaining accountability for past, current, and future projects through a feedback loop between technical personnel and management (Meffert, 2007). Though equivalent benefits of following ANSI/MSE 2000:2005 can be achieved through continuing to conduct ESAs by onsite personnel, following a standard may make it easier for a facility to achieve maximum energy savings.

Information gathered by the Save Energy Now program was used as a basis to estimate the potential of energy-savings assessments under various policy scenarios. The results of Increasing Energy Savings Assessments are shown in Tables 5.8 and 5.9. The policy bundle is estimated to cut the Region's industrial consumption by five percent in 2020, growing to 16.8 percent in 2030 when 413 trillion Btu are estimated to be saved. Details of the ESA program modeling, including data, assumptions, and methodology are shown in Appendix D.2.

**Table 5.8 Energy Savings from Increasing Assessments and Training**

| Year | Electricity Savings | Natural Gas Savings | Fuel Oil Savings | Total Primary Energy Saved | % of Sector Primary Energy |
|---|---|---|---|---|---|
| | (GWh) | (trillion Btu) | (trillion Btu) | (trillion Btu) | |
| **2010** | 106 | 1.06 | 0.00 | 2.26 | 0.09 |
| **2013** | 914 | 7.67 | 0.00 | 18.07 | 0.73 |
| **2020** | 6,422 | 50.14 | 0.00 | 123.18 | 5.00 |
| **2030** | 21,344 | 170.34 | 0.00 | 413.08 | 16.77 |

**Table 5.9 Costs and Savings from Increasing Assessments and Training**

| Year | Energy Savings | Admin Costs | Investment Costs |
|---|---|---|---|
| | (million 2006$) | (million 2006$) | (million 2006$) |
| **2010** | 11.65 | 0.88 | 14.74 |
| **2013** | 84.38 | 0.88 | 55.88 |
| **2020** | 565.60 | 1.15 | 395.16 |
| **2030** | 2,103.57 | 1.33 | 1,137.71 |

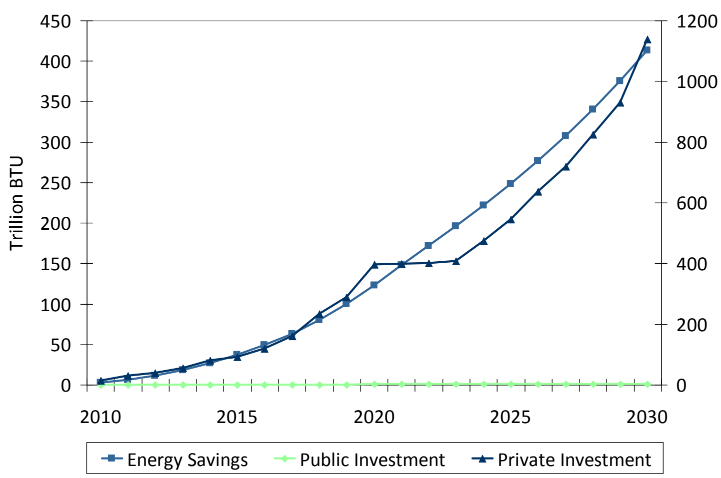


**Figure 5.4 Annual Investment and Savings from Increased Assessments, 2010-2030**

Figure 5.4 shows low public investment (administrative costs and incentives). Unlike the IAC program, the financial costs of each assessment are incurred by each industrial site; therefore, the public investment for the ESA program is lower, averaging about $1 million each year. In contrast, private levels of investment grow to $1.1 billion in 2030, while the value of energy savings is nearly twice as great – at $2.1 billion.

Increasing Energy Savings Assessments is cost-effective with a benefit-to-cost ratio of about 2.8 for participants and about 3.3 for society. With $23 million in program spending and an additional $8 billion in customer investments over the 2010-2030 period, the Appalachian Region could see net cumulative savings of 8.7 quads, saving $43.3 billion in energy bills by 2030. This is the equivalent of about 16.8 percent of the EIA's forecast consumption in 2030, or 101.8 percent of forecast growth (EIA, 2008a).

**Box 5.1 Industrial R&D: Super Boiler**

A combination of enhanced design features could increase industrial package boiler efficiency from 85 percent to 95 percent fuel-to-steam efficiency (Madgett, 2008). For improved heat transfer, super boilers use advanced firetubes with extended surfaces that help achieve a compact design, which reduces size, weight, and footprint. The advanced heat recovery system combines compact economizers, a humidifying air heater, and a patented transport membrane condenser. Many boilers used today are more than 40 years old, suggesting a large energy-savings opportunity (Gemmer, 2007). This technology provides compelling economic benefits to accelerate replacement of aging boilers.

**Figure 5.5 Laboratory Prototype Boiler (Rabovister and Knight, 2005)**

The super boiler is estimated to be six to12 percent more efficient than a conventional boiler. The first commercial demonstrations have been installed and sales are expected to begin around 2009 or 2010. There is not yet a complete study on the market penetration potential of this technology, but its target market is approximately 53 percent of the total boiler market. Boilers have traditionally been replaced at an average of about one percent per year (Energetics, 2008). However, with the current opportunities presented by the large number of aging boilers, we can expect a higher replacement rate than this over the next decade.

In addition to the need to replace aging boilers, increasing energy costs can accelerate boiler replacement. With incentives such as tax credits or rebates for companies purchasing super boilers, replacement of conventional boilers could be increased even further. The Appalachian Region, particularly the southern portion, makes heavy use of boilers, and widespread installation of a more efficient boiler could mean tremendous savings, in energy and financial cost. The first demonstration super boiler has a projected payback of less than two years and saves thousands of dollars in energy costs annually (Energetics, 2008).

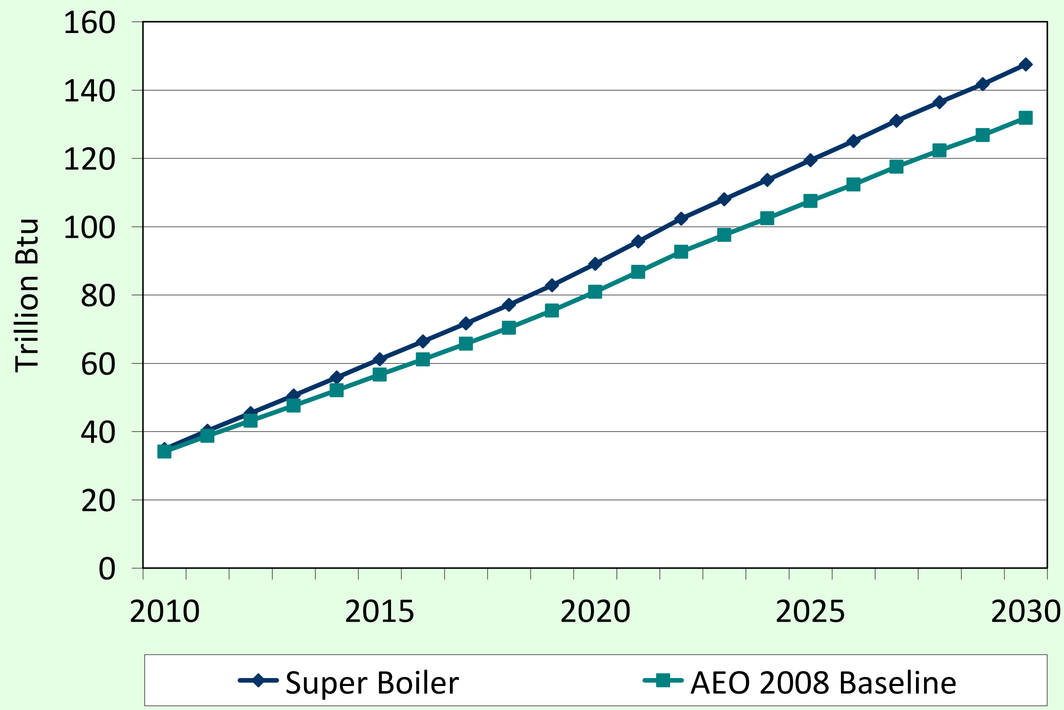


**Figure 5.6 Comparison of Estimated Energy Savings from Super Boiler to Industrial Baseline Consumption (trillion Btu), 2010-2030**

Currently, about 32 percent of all primary energy used in the industrial sector goes to powering boilers within the Appalachian Region (EIA, 1998; 2002). Assuming that super boilers replace one percent of all boilers within the Appalachian region annually, and the average improvement in efficiency with the super boiler is 10 percent. This new technology could save a total of 172 trillion Btu between 2010 and 2030, in addition to projected baseline savings.

A 10 percent improvement in energy efficiency over a conventional new boiler can mean thousands of dollars saved in energy costs for an industrial site. Replacing only one percent of conventional boilers annually, the super boiler would deliver significant industry-wide savings. Still, policies that support the purchase and installation of energy-efficient technologies like the super boiler could result in even greater savings for industry.

### 5.3.3 Supporting Combined Heat and Power with Incentives

Combined heat and power (CHP) can offer significant energy use reductions by avoiding energy waste through heat loss. Many CHP systems consist of a prime mover, which produces electricity. The prime mover is coupled with one or more thermally-activated technologies, and these thermal systems use the prime mover's hot exhaust as an energy input to create a useful product such as steam or hot water that would otherwise be generated by using other high-value energy sources such as electricity or natural gas. The systems considered in the current study are of this type. Other types of systems could make use of fluids compressed to aid in transport (e.g., district steam used for space heating) that, instead of being throttled down to a site's required system pressure, is coupled with a turbine, which generates power while also reducing pressure. These types of systems are not modeled in this analysis; however, they do have the potential to yield additional energy savings for the Appalachian Region. Other forms of recycled energy systems recover heat from an industrial process stream (e.g., a coking plant) and reuse it to drive another, lower temperature process (e.g., a drying operation). Such recycled energy systems are evaluated in industrial and energy savings assessments; therefore, they were not included in the CHP portion of this study.

To determine the savings industrial CHP systems could yield, the current state of these systems in the Region must be established. It is estimated that there are currently six GW of installed CHP prime mover capacity at 198 sites within the ARC Region (EEA, 2007). CHP system performance and cost information were used to model CHP systems in order to quantify energy savings and financial costs for the Region in today's market. The information gained from these models, coupled with current industrial installation figures and growth projections, led to an estimation of the potential for savings for the Region under various policy regimes.

The policies and programs evaluated in support of industrial CHP are shown in Table 5.2. Facilities may need assistance in identifying where CHP makes the most sense in their processes; training and information or audit programs could be helpful with this process. Also, managers may not be able to identify funds to cover the up-front cost of an upgrade. Grants and tax credits can reduce the first cost while low-interest loan programs, which can be paid back through energy cost savings, can reduce the financial hurdle of the investment without creating a large public burden.[26]

Currently few states in the Appalachian Region have energy policies that support CHP installations; however, other states have aggressive incentive programs and other financial assistance to aid in increasing energy efficiency through the use of waste heat. Connecticut is one such state. A summary of Connecticut's energy programs related to CHP is provided in Table 5.10.

[26] This is the sort of program offered by Energy Service Companies (ESCOs) which are not always trusted by industry due to their process specific needs. Industrial managers may require training and financial assistance in lieu of ESCO services to allow for protection of what might be a trade secret.

**Table 5.10 Summary of CHP-Supportive Policies in Connecticut**
(Energetics, 2006)

| Type of Assistance | Applicability and Amount | Requirements and Limits |
|---|---|---|
| Grants for Customer-side Distributed Generation (DG) | Based-loaded systems: $450/kW | 85 percent Capacity Factor during Peak Loads, max of 65 MW |
| Back-up Electricity Rates | Reduced electricity rates for customer-side DG projects by eliminating backup rates and demand ratchets for DG projects. | |
| Natural Gas Rates | Rebate of customer's natural gas delivery charge | |
| Streamlined Interconnection | | <65 MW |
| Renewable Portfolio Standard | Includes CHP as a technology to meet requirements | |
| Grants for New Technologies | Five awards of $10,000 each | CT resident or CT business with less then 30 employees |
| Long-term Loans for Customer-side DG | $150 million available | |

The suite of policies listed in Table 5.10 includes grants, loans, special rates, and ease of interconnection with the electrical grid. Any or all of these programs could be implemented to ensure the viability of a CHP program in the Appalachian Region.

The results of increasing CHP capacity within the Appalachian Region are shown in Tables 5.11 and 5.12. These results suggest that supporting CHP with incentives would generate less energy savings than either of the other two policy bundles. Specifically, 1.6 percent of the Region's industrial energy consumption is estimated to be cut in 2020, rising to nearly four percent in 2030. Details of the CHP modeling, including base data, assumptions, and methodology are shown in Appendix D.3.

| Table 5.11 Energy Savings from Supported CHP | | | | | |
|---|---|---|---|---|---|
| Year | Electricity Savings | Natural Gas Savings | Fuel Oil Savings | Total Primary Energy Saved | % of Sector Primary Energy |
| | (GWh) | (trillion Btu) | (trillion Btu) | (trillion Btu) | |
| **2010** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **2013** | 2,793 | -20.10 | 0.00 | 11.67 | 0.47 |
| **2020** | 9,655 | -69.46 | 0.00 | 40.35 | 1.64 |
| **2030** | 21,081 | -151.66 | 0.00 | 88.10 | 3.58 |

| Table 5.12 Costs and Savings from Supported CHP | | | |
|---|---|---|---|
| Year | Energy Savings | Admin Costs | Investment Costs |
| | (million 2006$) | (million 2006$) | (million 2006$) |
| **2010** | 0.00 | 0.61 | 0.00 |
| **2013** | 28.07 | 0.88 | 180.04 |
| **2020** | 104.03 | 1.51 | 194.78 |
| **2030** | 128.14 | 2.95 | 238.67 |

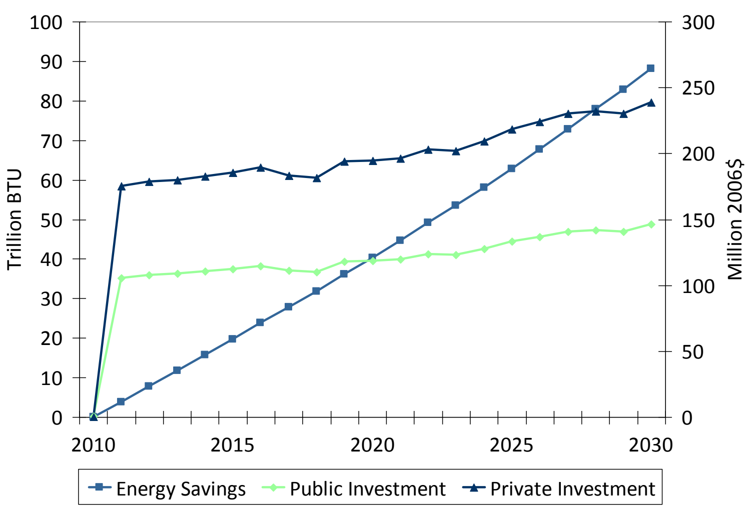


**Figure 5.7 Annual Investment and Energy Savings from Supported CHP, 2010-2030**

Figure 5.7 shows the annual investments by private and public entities and the energy savings from supporting CHP. This policy bundle is supported by a large public cost-share throughout the study horizon. These incentives rise rapidly to more than $100 million in 2011 and continue to increase throughout the 20-year time frame. Reducing and eventually eliminating these incentives would perhaps represent a more defensible public policy for the Region.

Supporting Combined Heat and Power with Incentives is not cost-effective as modeled with a benefit-to-cost ratio of about 0.6 for participants and about 0.3 for total resource costs; low forecast electricity prices drive this result. CHP is cost-effective for many individual industrial and commercial facilities. With $2.5

billion in program spending and an additional $4 billion in customer investments over the 2010-2030 period, the Appalachian Region could see net cumulative savings of 1.9 quads, saving $3.3 billion in energy bills by 2050. This is the equivalent of 3.6 percent of the EIA's forecast consumption in 2030, or 21.7 percent of forecast growth (EIA, 2008a).

## 5.4 SUMMARY OF RESULTS FOR INDUSTRIAL ENERGY EFFICIENCY

Based on the industrial program and policy bundles described above, ESAs have the largest potential for energy savings (Figure 5.8)

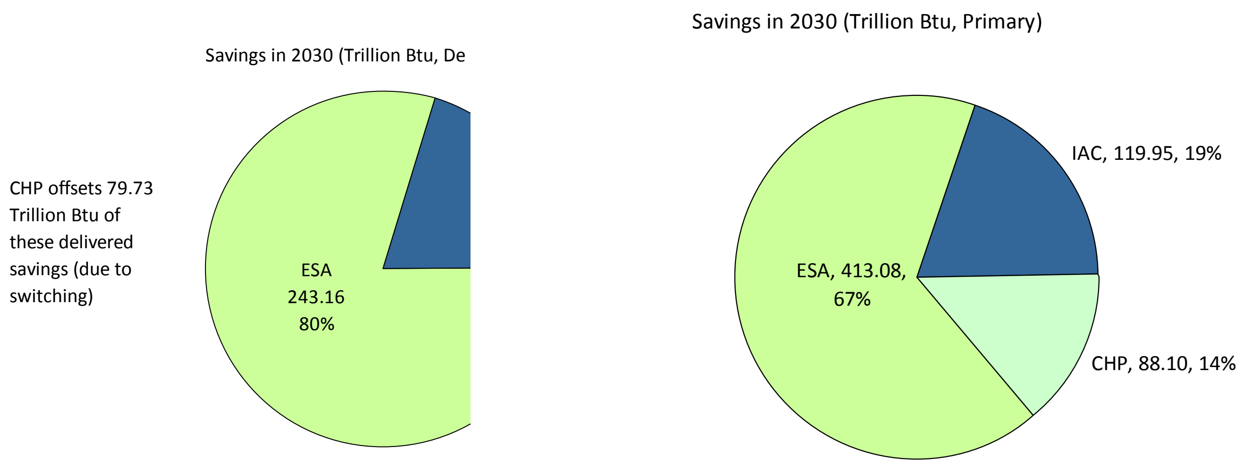


**Figure 5.8 Industrial Energy Savings by Policy Package (trillion Btu), 2030**

Figure 5.9 shows that implementation of these policy bundles could eliminate the growth in industrial energy consumption forecast, actually reducing consumption to levels below those in 2006, for the Appalachian Region to 2030. Savings with these three policies are estimated to be 27 percent of forecast consumption in 2030.

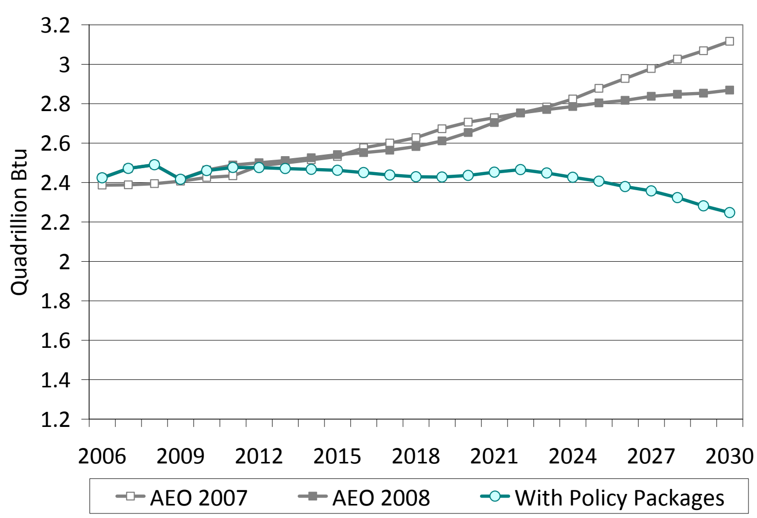


**Figure 5.9 Industrial Energy Consumption With and Without Energy Efficiency (2010-2030)**

Figure 5.10 shows how investments and energy savings change over time for the industrial policy packages. Although the public contribution to the CHP policy is quite large, private investment is much larger.

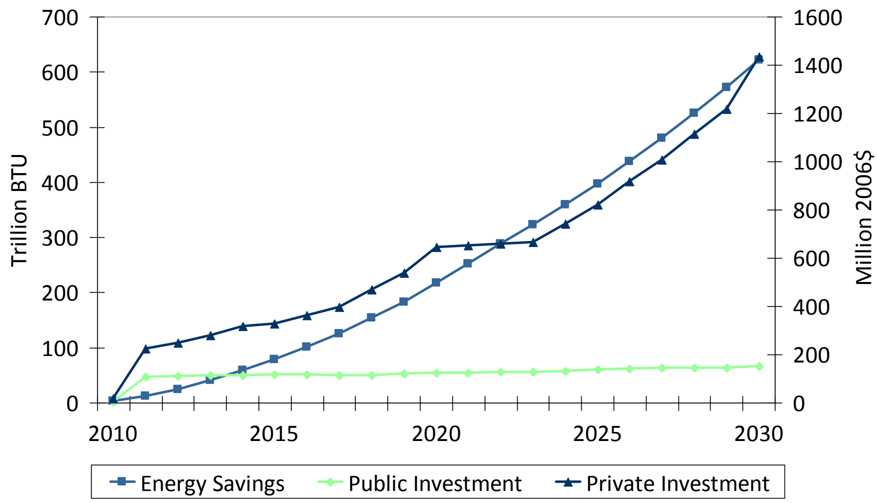


**Figure 5.10 Annual Investment and Energy Savings from Industrial Policy Package, 2010-2030**

These estimated savings are similar to other efficiency studies for states in the Region. A recent report by ACEEE et al. (2008) presented an industrial potential for Virginia of 25 percent of their forecast electricity consumption in 2025 without CHP (they combined commercial and industrial CHP in their analysis). Efficiency potential studies completed for Georgia Power and the Georgia Environmental Facilities Authority found maximum achievable electric efficiencies of 10 percent over 10 years and 6.6 percent over five years, respectively (ICF, 2005; Nexant, 2007). Similarly, a study for North Carolina found a maximum achievable potential for industrial electric efficiency of 12 percent over a 10 year horizon (GDS Associates, 2006). An efficiency potential study for Kentucky modeled cost effective industrial electricity savings of 15.5 percent and natural gas savings of 10.3 percent over 10 years in that state (KPPC, 2007).

A summary of the economic tests performed on the various industrial policies is shown in Table 5.13.

**Table 5.13 Summary of Economic Tests for Industrial Policy Bundles**

| | IAC | ESA | CHP | Total |
|---|---|---|---|---|
| **Participants Test** | | | | |
| **NPV Benefits (billion 2006$)** | 1.86 | 5.57 | 1.53 | 8.96 |
| **NPV Costs (billion 2006$)** | 0.37 | 1.96 | 2.38 | 4.70 |
| **Net Benefits-Costs (billion 2006$)** | 1.49 | 3.61 | -0.84 | 4.26 |
| **B/C Ratio** | 5.03 | 2.84 | 0.65 | 1.91 |
| **Total Resource Cost Test** | | | | |
| **NPV Benefits (billion 2006$)** | 3.00 | 9.53 | 0.97 | 13.51 |
| **NPV Costs (billion 2006$)** | 0.51 | 2.89 | 3.09 | 6.50 |
| **Net Benefits-Costs (billion 2006$)** | 2.49 | 6.64 | -2.12 | 7.01 |
| **B/C Ratio** | 5.85 | 3.30 | 0.31 | 2.08 |

The Industrial Policy Package is cost-effective with a benefit-to-cost ratio of about 1.9 for participants and about 2.1 for society. With $2.5 billion in program spending and an additional $13.1 billion in customer investments over the 2010-2030 period, the Appalachian Region could see net cumulative savings of 13.0 quads, saving $58.5 billion in energy bills by 2050. This is the equivalent of about 27.9 percent of the EIA's forecast consumption in 2030, or 153 percent of forecast growth (EIA, 2008a).