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Estimating the Benefits of Energy Waste Reduction in Ohio

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EXECUTIVE SUMMARY

Energy waste reduction programs create far reaching benefits. The energy savings offer customers greater control of bills, improved comfort, and improved air quality. Businesses also benefit from energy waste reduction programs through lower costs of operation and reduced energy costs over time. The energy savings also displace power plant generation, which reduces the dollars sent out of state for imported electricity and regional air pollution. Finally, energy waste reduction programs create economic growth by stimulating local economies and creating jobs.

Energy waste reduction programs provide customers discounts and rebates on appliances and services that encourage them to invest in energy waste reduction measures. By law, the programs must be cost-effective, which means the programs must cost less than the electricity they are avoiding would have otherwise cost to deliver.

Significant opportunity exists to reduce energy waste at the customer level in Ohio. A 2017 study sponsored by the Department of Energy estimated that Ohio has over 23,430 GWh of total potential energy savings by 2035.[1] A 2015 study conducted by American Electric Power estimated potential savings of over 22,280 GWh, over 50% of the 2034 forecasted sales.[2] Updated energy waste reduction potential studies show significant opportunities in other states.[3,4]

This report reviews the potential benefits associated with energy waste reduction in Ohio. We examine three potential energy waste reduction policy scenarios to forecast benefits. We also consider the benefits under multiple cost estimates for energy savings. The review of costs and benefits is intended to provide policymakers in Ohio relevant data and information to determine the best approach moving forward with energy waste reduction programs in Ohio. Our review finds energy waste reduction programs have the potential to produce significant benefits in Ohio over the next ten years.

The three scenarios analyzed include:

1. **One percent** (1%) annual savings for ten years (2021-2030)

[1] *State Level Electric Energy Efficiency Potential Estimates.* Electric Power Research Institute. Technical update, May 2017. United States Department of Energy. energy.gov/sites/prod/files/2017/05/f34/epri_state_level_electric_energy_efficiency_potential_estimates_0.pdf.
[2] AEP Ohio. 2014. Volume 1: 2015 to 2019. Energy Efficiency/Peak Demand Reduction Action Plan. aceee.org/files/pdf/aep-ohio-2015-2017-ee-pdr-plan.pdf.
[3] Pennsylvania Act 129 – Phase IV Energy Efficiency and Peak Demand Reduction Market Potential Study Report. February 28, 2020. puc.pa.gov/pcdocs/1656474.pdf.
[4] Energy Efficiency Potential in New Jersey. May 24, 2019. s3.amazonaws.com/CandI/NJ+EE+Potential+Report+-+FINAL+with+App+A-H+-+5.24.19.pdf.

2. **One- and one-half percent** (1.5%) annual savings for ten years (2021-2030)
3. **Two percent** (2%) annual savings for ten years (2021-2030)

The study estimates benefits that would accrue directly from the energy savings achieved in each scenario. We estimate four specific categories of benefits: utility system, economic, environmental, and participant bill savings. We also compare the estimated benefits against a range of potential program costs. Finally, we estimate the potential customer bill impacts associated with program spending over time, comparing two specific cost recovery approaches.

The universe of benefits discussed in this report captures many, but not all potential benefits of energy waste reduction. Other benefits include avoided renewable portfolio compliance costs, avoided compliance costs with existing environmental regulations, value of reduced capacity reserve requirements, reduced arrearages, improved comfort and safety, reduced maintenance costs, reduced price volatility exposure, and other nonenergy benefits.

Table 1 shows the estimated costs and benefits for these three scenarios. All values shown in table 1 are in present value terms, meaning the values over the 24-year period are expressed in 2021 dollars.

Table 1. Cost benefit results all scenarios, Ohio cost to achieve (NPV 2021$ millions)

	Scenario		
Benefits	**1.00%**	**1.50%**	**2.00%**
Utility System Benefits	3,553	5,330	7,106
Environmental Benefits	9,522	14,283	19,044
Total Benefits	**13,075**	**19,613**	**26,151**
Costs			
Program Costs	982.33	1,473	1,965
Total Costs	**982.33**	**1,473**	**1,965**
Net-Benefits			
Total	12,093	18,139	24,186
Cost-Benefit Ratio	**13.3**	**13.3**	**13.3**

As table 1 shows, the benefits for each scenario are significant, especially when compared against the projected costs. We describe each benefit in greater detail below.

1. **Utility system benefits:** Energy waste reduction programs provide significant benefits to the electric utility system. These benefits are achieved because energy waste reduction programs displaces traditional power generation and reduces the need for future infrastructure expansion in generation, distribution, and transmission. The displacement of traditional generation reduces system costs and saves all customers money through reduced bills in future years. Energy waste reduction programs in Ohio

also reduce the need for electricity imports. Ohio imports roughly 20% of its electricity needs from out of state, which may be avoided through local energy savings.[5]

2. **Environmental benefits:** Energy waste reduction programs produce substantial environmental benefits through reduced air pollution at power plants. As energy waste reduction programs reduce demand for electricity, fossil-fueled power plants reduce output, which reduces air emissions associated with power generation. The primary power plant emissions displaced include carbon dioxide (CO_2), nitrogen oxide (NO_X), sulfur dioxide (SO_2), and particulate matter. All these emissions produce harmful effects on human health and the natural environment. This analysis estimates the displaced CO_2, NO_X, and SO_2 emissions and quantifies the value of the avoided health harms, also known as damages.

The estimated program costs shown in table 1 are based on the most recent actual program costs per unit of saved energy in Ohio. As the results show, the programs are cost effective, even when only considering the utility system benefits.

An additional benefit of energy waste reduction programs is the programs stimulate the economy, increasing the state gross domestic product (GDP) and creating jobs. These benefits are created in multiple ways. First, spending on energy waste reduction programs generates direct jobs through the implementation and delivery of programs, which also stimulate many sectors of the economy. Second, the customer bill savings produced by the programs drive significant economic growth because customers inject these dollars back into the local economy. The positive benefits associated with the increased local spending driven by bill savings provide "ripple" effects through the economy creating jobs in many other sectors and boosting the local economy.

We used IMPLAN, an industry standard input/output economic model, to estimate economic benefits. Table 2 shows the results of the economic impact assessment. According to this analysis, the implementation of a 2% energy waste reduction goal would add $4.8 billion to Ohio's economy and create 172,651 job-years over the life of the program.[6]

[5] United States Energy Information Administration. Ohio Electricity Profile 2019. eia.gov/electricity/state/ohio/.
[6] A job year is equivalent to a job in any given industry over the period of one year.

Table 2. Total net economic and job creation impacts (job-years, NPV 2021$ millions)

Energy Savings Scenario	Total Value Added to GDP	Total Job-Years
1%	2,408	86,325
1.5%	3,612	129,488
2%	4,816	172,651

The programs also produce significant customer bill savings. Bill savings are the primary reason why customers invest in energy waste reduction technologies and change behavior. The bill savings drive economic growth as customers inject dollars back into the local economy. Businesses are also able to reduce operating costs and improve profit margins, while also reducing maintenance costs. Table 3 shows the projected participant bill savings for supply and distribution costs under each scenario. As the table shows, customers would save between $6 and $12 billion over the life of the energy savings depending on the scenario. Supply cost bill savings are over 60% of the total.

Table 3. Total participant bill savings (NPV 2021$ millions)

	Energy Savings Scenario		
Cost	**1.0%**	**1.5%**	**2.0%**
Supply	2,805	5,651	7,534
Distribution	3,235	3,409	4,546
Total	**6,040**	**9,060**	**12,080**

Utility sector energy waste reduction programs are generally funded through ratepayer bills. To understand the magnitude of the potential costs of funding programs at the customer level, we analyzed the bill impacts under two scenarios. The first scenario assumes all program costs are collected in one year (current practice in Ohio). The second scenario assumes all program costs would be collected over a five-year period. Collecting costs over multiple years reduces bill impacts on customers and more closely aligns cost recovery with the realization of system benefits. Table 4 shows the estimated bill impacts for an average residential customer in Ohio for the two cost recovery approaches for the three policy scenarios. As the table shows, the bill impacts would not exceed $2.50 per month for an average residential customer over the first five years, an amount which is greatly outweighed by the benefits customers receive.

Table 4. Projected monthly bill impact for average residential customer ($/month)

Scenario	Period	PY 1	PY 2	PY 3	PY 4	PY 5
1.0%	1 yr.	0.96	0.98	1.00	1.02	1.04
1.5%	1 yr.	1.44	1.47	1.50	1.52	1.56
2.0%	1 yr.	1.93	1.96	2.00	2.03	2.08
1.0%	5 yrs.	0.33	0.57	0.80	1.01	1.20
1.5%	5 yrs.	0.50	0.86	1.20	1.51	1.80
2.0%	5 yrs.	0.66	1.15	1.60	2.02	2.40

All three scenarios produced benefits that far exceeded the costs, which means bills for Ohioans are lower because of investment in energy waste reduction programs than they would be without the programs. The utility system benefits alone are cost effective, ranging between 1.7 to 3.6 times more benefits than costs (depending on the program cost assumption). Because the benefit categories are additive, each additional benefit component category only further increases the cost-effectiveness of the programs.

1 INTRODUCTION

This report estimates the costs and benefits of energy waste reduction programs in Ohio over a ten-year period (2021-2030). We examine the costs and benefits for three distinct policy scenarios, considering multiple costs and cost recovery approaches. The intent is to provide policy makers in Ohio with estimates on the potential costs and benefits of energy waste reduction programs in Ohio. We estimate four specific categories of benefits: utility system, economic, environmental, and participant bill savings. We compare the estimated benefits against a range of potential program costs. Finally, we estimate the potential customer bill impacts associated with program spending over time, comparing two specific cost recovery approaches.

Gabel Associates is an energy, environmental and public utility consulting firm with its principal office in Highland Park, New Jersey.[7] For over 25 years, the firm has provided highly focused and specialized energy consulting services and strategic insight to its clients. Gabel Associates has applied its expertise to improve the bottom line for hundreds of clients involved in virtually every sector of the energy industry. The firm has built its reputation on its extensive knowledge and rigorous analysis of energy markets. We have successfully assisted public and private sector clients implement energy plans and projects that reduce costs and enhance environmental quality. The firm possesses strong economic, financial, project development, technical, and regulatory knowledge.

Firm personnel also serve as expert witnesses on a wide range of issues at the Federal Energy Regulatory Commission ("FERC") and at State Commissions, including those related to energy and capacity markets, ratemaking and tariff design, energy efficiency/energy waste reduction, reactive rates, interconnection, renewable energy, electric vehicles, and mergers/acquisitions.

[7] gabelassociates.com

2 Policy Scenarios

This report examines the costs and benefits of three different energy waste reduction scenarios. All three scenarios are based on different annual electric energy savings performance targets for Ohio's six investor-owned utilities. Each scenario is based on achievement of annual energy waste reduction savings as a percentage of total sales. This common metric, savings as a percentage of total sales, allows a simple assessment of results and a direct comparison to other states and program implementers. This report only estimates benefits from electric energy waste reduction programs and excludes secondary natural gas savings from electric measures and programs concentrated on natural gas savings.

These scenarios are focused on performance and results and are not based on a specific approach to implementing energy waste reduction programs in Ohio. Specifically, the scenarios do not contemplate a mandated versus voluntary approach. Instead, this report focuses on estimating the costs and benefits of energy waste reduction savings performance across the State.

The three scenarios include:

1. **One percent** (1%) annual savings for ten years (2021-2030)
2. **One- and one-half percent** (1.5%) annual savings for ten years (2021-2030)
3. **Two percent** (2%) annual savings for ten years (2021-2030)

2.1 Data Sources and General Assumptions

All three scenarios incorporate common utility avoided costs, marginal emissions rates, commercial customer opt out, energy waste reduction program mix, measure lifetime, discount rate, energy and demand forecasts, and hypothetical utility capital structure. We evaluated multiple cost to achieve energy savings and program cost recovery approaches. Except where otherwise noted, our analysis relied on Ohio specific data. The energy waste reduction program level data, including the opt out percentage, cost to achieve, measure lifetimes, types of expected programs, and demand savings were all sourced directly from actual utility results in Ohio for 2019.[8] Relying on actual results for these variables provides the most accurate estimate of possible cost and benefit outcomes for Ohio.

We based the energy savings targets on the forecasted electric sales for all six investor-owned utilities in Ohio. The utilities include Ohio Power Company, Duke Energy Ohio, Dayton Power

[8] For the 2019 Ohio utility energy waste reduction program results, see Docket Nos. 20-1042-EL-EEC (Ohio Power), 20-0612-EL-EEC (Duke), 20-0724-EL-EEC (First Energy), and 20-0916-EL-POR (Dayton Power and Light).

and Light, Illuminating Company, Ohio Edison, and Toledo Edison.[9] The forecasts relied on the long-term forecasts from 2020 through 2030 filed at the Public Utilities Commission of Ohio (PUCO).[10] For years past 2030, consumption is expected to continue at similar growth levels of the previous ten years. The energy savings target is based on a gross savings goal, but benefits were estimated based on net energy savings. This ensures that only incremental savings from energy waste reduction measures that would not have otherwise been installed are included in the analysis. This adjustment to account for only incremental savings, known as a net-to-gross ratio, was assumed to be 90%; meaning that for 100 units of energy saved, 90 would occur as a result of the program, and 10 would have occurred regardless of whether the program had been implemented. The 90% net-to-gross ratio is sourced from recent planning factors used in Michigan. Table 5 list some additional modeling assumptions.

Table 5. General modeling assumptions

Assumption	Value	Source
Opt out percentage	22%	2019 Ohio Utility Reports
Net to gross factor	90%	2020 Michigan EE Plans
Residential savings lifetime	9.7 years	2019 Ohio Utility Reports
Business savings lifetime	13.3 years	2019 Ohio Utility Reports
Discount rate	5% nominal	

[9] Three of the six companies, Illuminating Company, Ohio Edison, and Toledo Edison are wholly owned subsidiaries of First Energy Corporation.

[10] The filed utilities sales forecasts can be found in Docket Nos. 20-0501-EL-FOR (Ohio Power), 20-0375-EL-FOR (Duke), 20-0657-EL-FOR (First Energy), and 20-0768-EL-FOR (Dayton Power and Light).

3 Benefits

This report examines four specific areas of energy waste reduction program benefits. The four areas include: avoided utility system costs, avoided air emissions (and associated avoided damages), and participant bill savings. The economic and job creation impacts related to these benefits are summarized separately in Section 4.

3.1 Utility System Benefits

Energy waste reduction programs provide significant benefits to the electric utility system. Waste reduction programs achieve these benefits by reducing the need for future spending on generation, distribution, and transmission systems. The displacement of traditional generation reduces system costs and saves all customers money through reduced bills in future years. Energy waste reduction programs in Ohio also reduce the need for electricity imports. Ohio imports roughly 20% of its electricity needs from out of state, which may be avoided through local energy savings.[11]

We estimated the future value of five specific utility system benefits. These benefits include avoided electric energy costs, avoided electric capacity costs, energy and capacity price suppression (also known as demand reduction induced price effects or DRIPE), and avoided transmission and distribution capacity. While electric energy and electric are savings realized by those installing energy efficient equipment, DRIPE and avoided transmission and distribution capacity costs are realized by all customers, regardless of whether or not they invest in energy waste reduction measures. Table 6 below shows the estimated utility system benefits for all three potential policy scenarios.

Table 6. Utility system benefits by scenario (NPV 2021$ millions)

	Energy Savings Scenario		
Benefit	**1.0%**	**1.5%**	**2.0%**
Avoided Electric Energy Costs	2,304	3,456	4,608
Avoided Electric Capacity Costs	316	474	632
Electric Energy DRIPE	804	1,205	1,607
Electric Capacity DRIPE	14	21	28
Avoided T&D Costs	116	174	232
Total Benefits	**3,553**	**5,330**	**7,106**

As the table shows, energy waste reduction programs would produce significant utility system benefits in all three scenarios. The values for each benefit and each scenario are presented in

[11] United States Energy Information Administration. Ohio Electricity Profile 2019. eia.gov/electricity/state/ohio/.

net present value terms of the benefit over the life of the energy savings. By presenting the values in net present value terms, decision makers can assess impacts across a large time period against one another.

All three scenarios assume energy waste reduction programs implemented over a ten-year period, but the programs would still produce substantial energy savings beyond the final year of implementation because savings continue for several years after implementation. The most significant benefit is the avoided electric energy costs, followed by electric energy price suppression. We describe these benefits in greater detail below, including the methodological approach used to quantify the value of each benefit across the three scenarios.

3.1.1 Avoided Electric Energy Costs

The avoided electric energy costs represent the wholesale electric market purchases that utilities avoid making because of reductions in energy usage associated with energy waste reduction programs. These costs are generally composed of fuel and operations and maintenance costs. This benefit also includes the value of avoided line losses, which are losses of electricity that naturally occur between the production and delivery of electricity to end use customers.

Ohio utilities operate as part of a regional wholesale market called PJM. To calculate the avoided electric energy costs, a blend of congestion-adjusted energy market forward trading price for PJM-Western Hub, the most liquidly traded zone in PJM, and forecasted prices from the Energy Information Administration ("EIA") in its 2020 Annual Energy Outlook generation reference case for the PJM/West region were used.[12] A marginal losses adjustment was applied using the average loss factor contained in the Ohio utility long term forecast filings.

3.1.2 Avoided Electric Capacity Costs

One of the primary benefits of energy waste reduction programs is avoiding or delaying the construction of or need for new power plants. While Ohio utilities do not own power plants, they purchase electric capacity from PJM on behalf of their customers and supply it to homes and businesses. Efficiency programs reduce demand across all hours of the year, reducing the amount of capacity needed to supply Ohio's electric customers.

The forecasted value of avoided capacity purchases for delivery year 2022/2023, the next period which has yet to hold a capacity auction, were estimated based on the average of the

[12] United States Energy Information Administration. Annual Energy Outlook 2020. Table 54. Electric Power Projections by Electricity Market Module Region (Reference Case, PJM/East Region). eia.gov/outlooks/aeo/data/browser/#/?id=62-AEO2020&region=5-10&cases=ref2020&start=2018&end=2050&f=A&linechart=ref2020-d112119a.130-62-AEO2020.5-10&map=&ctype=linechart&sourcekey=0.

previous three capacity auctions.[13] We forecasted all subsequent years, beginning in delivery years 2023/2024 based upon escalations from the EIA in its 2020 Annual Energy Outlook. These values were also adjusted for losses. In addition, the savings associated with capacity reductions were delayed to account for the fact that PJM procures capacity on a forward basis.

3.1.3 Demand Reduction Induced Price Effects (Energy and Capacity)

Waste reduction programs reduce customer usage throughout the year, but they add even greater value by reducing customer usage at peak times of peak energy usage, or peak demand. In addition to the direct energy savings to customers, waste reduction programs also have an impact on market pricing dynamics, causing prices to decrease relative to if no waste reduction had occurred. The demand reduction induced price effect ("DRIPE") price suppression impact is a benefit that captures the reduction in wholesale electric energy and capacity prices to all customers, not just participants, because of energy waste reduction. PJM wholesale markets are fundamentally supply and demand based – therefore, downward movement in the demand curve because of reduced consumption result in less expensive electricity used to meet customer demands. If either market "clears" at a lower price, the associated reductions in market prices flow through to all customers. A 2019 study of this benefit in Ohio found that the price suppression benefits to all customers in Ohio from the 2017 energy waste reduction programs were estimated to be approximately $2 per month for a typical residential customer.[14] Other jurisdictions have also estimated similarly high DRIPE benefits.[15,16]

This report estimates the DRIPE benefit for wholesale energy and capacity price suppression effects. This benefit accrues to all customers in Ohio because costs are reduced for all customers. The energy market DRIPE impact was calculated based on a predictive regression model that determined how energy prices in Ohio changed as a result of changes to load and natural gas prices. The capacity market DRIPE impact was calculated based upon data from PJM's scenario analysis of past base residual auctions to determine the impact of changes in load on the capacity clearing price.

[13] PJM Interconnection. 2020. Capacity Market. pjm.com/markets-and-operations/rpm.aspx.
[14] Chernick, P. 2019. *Energy Efficiency Benefits to All Customers: Price Mitigating Effects for Ohio.* Resource Insight, Inc. June 12. resourceinsight.com/wp-content/uploads/2019/06/Energy-Efficiency-Benefits-to-All-Customers.pdf.
[15] Neme, C. and P. Chernick. 2015. *The Value of Demand Reduction Induced Price Effects.* Regulatory Assistance Project. March 19. raponline.org/wp-content/uploads/2016/05/efg-ri-dripewebinarslidedeck-2015-mar-18-revised.pdf.
[16] Synapse Energy Economics. 2018. *Avoided Energy Supply Components in New England: 2018 Report.* October 24. synapse-energy.com/sites/default/files/AESC-2018-17-080-Oct-ReRelease.pdf.

3.1.4 Avoided Transmission and Distribution Capacity

Energy waste reduction programs produce small demand savings by each customer, but in aggregate can result in significant reductions to demand across the Ohio footprint. These demand savings can avoid or delay the need for future expansion of transmission and distribution capacity. Transmission and distribution systems are constructed to serve maximum or peak demand. As demand increases over time, the utilities invest in new transmission and distribution lines to accommodate the increasing demand. The value of avoiding or delaying these costs can be substantial. This benefit also reduces costs for all customers on the electric system, not just those who participate in programs.

We assumed an avoided transmission and distribution value of $30/kW-year for this analysis. This means that each year, for every MW that is reduced through the programs, customers will save $30,000. For context, Ohio has approximately 30,000 MWs of total load in PJM; therefore a 1% reduction could result in transmission and distribution savings of approximately $8 million per year. This figure is conservative when compared to other electric companies who have estimated this benefit in energy waste reduction cost benefit analysis. Depending on the utility, this value can exceed $200/kW-year. A 2014 study found an average value of $66.03/kW-year, but the study included several northeastern utilities with higher distribution and transmission costs.[17] Our assumption of $30/kW-year is less than half of this average.

3.2 Environmental Benefits

Energy waste reduction programs produce substantial environmental benefits through reduced air pollution from power plants. As demand for electricity is reduced through energy waste reduction programs, fossil-fueled power plants reduce output, which reduces emissions (air pollution) associated with power generation. The primary power plant emissions displaced include carbon dioxide (CO_2), nitrogen oxide (NO_X), sulfur dioxide (SO_2), and particulate matter. All these emissions produce harmful effects on human health and the natural environment. This analysis estimates the reduced CO_2, NO_X, and SO_2 pollution and quantifies the value of the avoided health effects.

[17] Mendota Group. 2014. Benchmarking Transmission and Distribution Costs Avoided by Energy Efficiency Investments. October 23. mendotagroup.com/wp-content/uploads/2018/01/PSCo-Benchmarking-Avoided-TD-Costs.pdf.

3.2.1 Avoided Air Pollution

The volume of avoided air pollution was estimated using marginal emissions rates sourced from the Emissions and Generation Resource Integrated Database (eGRID).[18] This data source relies on publicly available emissions data for nearly all electric power generation in the United States. The non-baseload tons per MWh estimate from the most recent eGRID data release (currently eGRID2018 released in March 2020) was used to estimate reduced CO_2, NO_X, and SO_2 emissions. These rates were then de-escalated over time based upon emissions rates from the most recent EIA Annual Energy Outlook (currently 2020) for the PJM/West region. We de-escalated the amounts to reflect the likely shift away from fossil-based generation towards less polluting generation sources. Table 7 shows the estimated avoided air emissions for the three energy savings policy scenarios. The value shown in the table is the total avoided pollution for the life of the energy savings in each scenario.

Table 7. Avoided air emissions by pollutant (tons)

	Energy Savings Scenario		
Pollutant	**1.0%**	**1.5%**	**2.0%**
CO_2	93,421,733	140,132,599	186,843,466
SO_2	68,849	103,274	137,698
NO_X	62,073	93,110	124,147

3.2.2 Avoided Emissions Damages

We base the social costs estimates on human and environmental health harms. Air pollution causes significant health harms resulting in lost workdays, hospital visits, asthma, respiratory disease, and increased morbidity for adults and children. Carbon dioxide emissions are a significant contributor to human induced climate change, which causes increased wildfires, droughts, hurricanes, and other costly weather events. Climate change also contributes to rising sea levels, which present significant costs to coastal communities. The negative social costs driven by power plant pollution are substantial and energy waste reduction programs reduce them substantially.

To estimate the avoided damages for CO_2 we used the "Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866" produced by the Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.[19] The avoided damages from SO_2 and NO_X, were estimated using the February 2018 Technical Support Document Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors by the U.S.

[18] United States Environmental Protection Agency. Emissions and Generation Resource Integrated Database (eGRID). Released 1/28/2020, Revised 3/9/2020. epa.gov/energy/emissions-generation-resource-integrated-database-egrid.
[19] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. 2016 Technical Support Document: -Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis -Under Executive Order 12866. August 2016. epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf.

Environmental Protection Agency Office of Air and Radiation Office of Air Quality Planning and Standards.[20] These sources quantify the social costs or damages to human health and the environment per unit of pollution. To estimate the potential benefit, the per unit damage value is multiplied by the avoided air emissions.

Table 8 shows the estimated avoided social costs by pollutant for the three energy savings policy scenarios.

Table 8. Avoided emissions damages (NPV 2021$ millions)

	Energy Savings Scenario		
Pollutant	**1.0%**	**1.5%**	**2.0%**
CO_2	4,168	6,252	8,336
SO_2	4,733	7,100	9,466
NO_X	621	931	1,242
Total	**9,522**	**14,283**	**19,044**

3.3 Participant Bill Savings

Energy waste reduction program savings produce significant electric bill savings for customers that modify behavior and invest in efficient technologies. Bill savings are the primary reason customers engage in energy waste reduction programs and are the largest driver of economic benefits. Electric customers in Ohio pay utilities for both electricity supply and delivery of electricity on a monthly basis. We estimate bill savings for both parts of the bill.

To estimate the bill savings associated with supply for residential and small/medium commercial customers, we used the cost to compare energy price posted on the Public Utilities Commission of Ohio website.[21] For large commercial and industrial customers, we used the wholesale price of electricity because there is no cost to compare for these customers. We escalated supply costs by the same escalations used for avoided electric energy and capacity costs to reflect the increase in supply costs over time. Table 9 shows the participate supply bill savings for each scenario.

[20] United States Environmental Protection Agency. 2018. Technical Support Document: Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors. epa.gov/sites/production/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf.

[21] Public Utilities Commission of Ohio. Energy Choice Ohio. Accessed online on October 15, 2020. energychoice.ohio.gov/.

Table 9. Supply cost bill savings (NPV 2021$ millions)

Sector	Energy Savings Scenario		
	1.0%	1.5%	2.0%
Residential	1,611	2,416	3,222
Business	2,156	3,235	4,313
Total	3,767	5,651	7,534

To estimate bill savings for the delivery of electricity, we relied on publicly available tariff data for all six investor-owned companies. Using this data, we estimated the total effective price per kWh or kW for each tariff option for most electric rate options. We then weighted the effective rates by the total sales in 2019 to determine a weighted average effective rate for residential and commercial customers. We used these rates to estimate the direct participant bill savings. Table 10 shows the estimated participant distribution bill savings over the life of the measures for all three energy savings scenarios. It is expected that a small portion of these bill savings could be recovered from participants at a later date but were not removed from the values shown.

Table 10. Participant distribution cost bill savings (NPV 2021$ millions)

Sector	Energy Savings Scenario		
	1.0%	1.5%	2.0%
Residential	1,194	1,792	2,389
Business	1,079	1,618	2,157
Total	2,273	3,409	4,546

Customers realize substantial bill savings on both the electricity supply and delivery over the estimated ten-year life of the programs. Table 11 shows the total participant bill savings., which include both electricity supply and delivery bill savings. As noted above, we would expect a small portion of the distribution bill savings to be reallocated back to participants at a later time.[22]

[22] The effective rates included riders and other charges than may be recovered in later years if the electric utility was unable to recover all authorized revenues in the year in question. Electric utilities in Ohio are decoupled, meaning revenue shortfalls because of weather, economic conditions, or lost sales from energy waste reduction will be recovered in future periods. If a revenue shortfall exists, a company collects the unrecovered revenues from all customers and any lost bill savings are reallocated across a large number of customers. Therefore, it is unclear exactly what, if any, bill savings would be recovered from program participants at a later date.

Table 11. Total participant bill savings (NPV 2021$ millions)

Sector	Energy Savings Scenario		
	1.0%	1.5%	2.0%
Residential	2,805	4,208	5,610
Business	3,235	4,852	6,470
Total	6,040	9,060	12,080

4 Economic Impacts and Job Creation

Energy waste reduction programs can be a powerful tool for local economic development and job creation. While cost effective energy waste reduction programs provide many other benefits including lower utility system costs, improved health outcomes, and lower bills for program participants, the job creation and local economic growth benefits are critical and provide added value especially as states begin to recover from the COVID-19 pandemic.

Economic development benefits were estimated using IMPLAN, a widely used industry standard input/output model. IMPLAN estimates changes in the local economy based on spending and revenue changes to specific industries. IMPLAN is based on the interdependency between economic sectors, which allows estimations of impacts to the economy and ripple effects from changes in spending to specific sectors. The data in IMPLAN is sourced directly from the U.S. Bureau of Economic Analysis, Department of Agriculture, Bureau of Labor Statistics, and Census Bureau (among many other public sources).[23]

The economic impacts and job creation are categorized into direct, indirect, and induced impacts and jobs created. Direct impacts and jobs are those caused from the initial dollar spent or saved in the exact industry that dollar was spent or saved. Indirect impacts and jobs are those generated in the supply chain and support industries that are directly impacted by an expenditure. Induced jobs are those generated by the re-spending of received income resulting from direct and indirect job creation in the affected region. The indirect and induced jobs are created in many industries across the economy.

We modeled four distinct disruptions to the economy as a result of investing in energy waste reduction programs: (1) program expenditures; (2) participant bill savings; (3) ratepayer costs; and (4) lost revenue to generators. Program expenditures and participant bill savings represent positive impacts, while ratepayer costs and lost revenue to generators represent negative impacts. The summation of these four disruptions represents the net economic impact or jobs created as a result of energy waste reduction program spending in Ohio.

Economic impacts are evaluated by the amount of value they add to the state GDP. Job impacts are categorized by job-years created. A job-year is not a full-time permanent employee but refers to a job in a specific industry over a one-year time period. A job year is not always equal to a full time equivalent. For some industries, a job-year is greater than a full time equivalent, but for others, it can be less.
Table 12 summarizes the total net increase to the state GDP for the scenarios. The table shows the net effects, meaning all four components of the analysis were aggregated to produce the results. As noted in the description of potential costs, we relied on two estimates of the cost

[23] IMPLAN. Data Sources. implan.com/data-sources/.

to achieve energy savings; those being the actual cost to achieve of recent program expenditures in Ohio and in Michigan. The Ohio cost to achieve is based on the most recent cost of saved energy for the 2019 results. The Michigan cost of saved energy is based the most recently filed program plans for Michigan's two largest electric utilities, DTE and Consumers Energy.[24] All results shown in table 12 assume a five-year amortization of total energy waste reduction program expenditures.

Table 12. Increase in Ohio state GDP by scenario and sector (NPV 2021$ millions)

Energy Savings Scenario	Cost to Achieve Scenario	Residential Value Added to GDP	Business Value Added to GDP	Total Value Added to GDP
1%	Ohio	1,018	1,390	2,408
	Michigan	1,187	1,350	2,538
1.5%	Ohio	1,526	2,085	3,612
	Michigan	1,781	2,026	3,807
2%	Ohio	2,035	2,780	4,816
	Michigan	2,375	2,701	5,076

We estimated job creation using the same method described above. Table 13 shows the estimated job-year creation driven by the three scenarios under two cost of saved energy assumptions. Please note, a job-year is not a full-time permanent employee but refers to a job in a specific industry over a one-year time period. Values represent the total job-year creation over the life of the energy savings.

Table 13. Job-year creation by scenario and sector (NPV 2021$ millions)

Energy Savings Scenario	Cost to Achieve Scenario	Residential Job-Years	Business Job-Years	Total Job-Years
1%	Ohio	36,219	50,106	86,325
	Michigan	37,742	48,989	86,731
1.5%	Ohio	54,328	75,160	129,488
	Michigan	56,613	73,484	130,097
2%	Ohio	72,438	100,213	172,651
	Michigan	75,484	97,978	173,463

As tables 12 and 13 show, implementation of the savings target would produce significant economic benefits. Under the base cost and 1% energy savings scenario, which assumes a

lower cost to deliver the program, $2.4 billion and 86,000 job-years would be added to the Ohio economy. Under the higher cost and 1% savings scenario, $2.5 billion and over 87,000 job-years would be added to the economy. All economic benefits shown in table 12 and 13 would accrue over the life of the energy savings.

4.1 Impact of Program Expenditures

Program expenditures are the funds spent by program administrators to implement and deliver energy waste reduction programs. These include the costs of energy waste reduction measures, the costs of installing energy waste reduction measures, and the costs of administering and overseeing energy waste reduction programs. This spending includes program implementation staff, utility staff, trade allies, installers, evaluators, and others. These create jobs in many industries and sectors that span retail, construction, engineering, plumbing, and other services. The spending also employs people in manufacturing, construction, wholesale trade, professional building services, retail services, and other industries.

We estimated the economic impacts and job creation of energy waste reduction program expenditures by using a program-by-program approach to break out materials and labor, mapping spending into specific industries within IMPLAN. The spending breakdown (i.e. customer incentives, program marketing, and other administrative costs) were derived from the historic spending structure of programs in Ohio.

4.2 Impact of Customer Bill Savings

Customer bill savings produced by the programs drive significant economic growth because customers inject these dollars back into the local economy. The positive benefits associated with the increased local spending driven by bill savings provide "ripple" effects through the economy creating jobs in many other sectors and boosting the local economy. Customer bill savings are partially offset by increases in customer bills related to the cost recovery of the avoided distribution costs. Because distribution costs are decoupled from energy usage in Ohio, these costs are ultimately recollected from customers. Therefore, we only calculated impacts associated with retail supply costs.

For bill savings, we mapped the increased disposable income to households by income level and to relevant commercial industries.

4.3 Impact of Ratepayer Costs

Ratepayers often fund costs associated with implementing energy waste reduction programs. These costs result in higher rates and bills associated with the cost recovery of energy waste

reduction programs. The reduction in disposable income has the inverse impact as customer bill savings, and results in less money being spent throughout the economy.

To capture the negative economic impacts of higher rates and bills from the cost recovery associated with the programs, we calculated a proxy revenue requirement assuming that all costs would be expensed in the year they were spent. These costs were assumed to be borne by all ratepayers, not just those that qualify as low-income.

4.4 Impact of Generator Lost Revenues

The deregulated energy market in Ohio allows customers to choose their own energy supplier. It also means that energy suppliers, who are not regulated by the Commission, cannot collect lost revenues from customers. These lost revenues impact the energy suppliers as a corporate entity, but also their employees.

To capture the negative economic impacts of lost revenue to generators, we calculated the value of lost supply charges to customers based upon supply in Ohio. However, it is important to note that Ohio imports a portion of its energy from out of state, which means that a reduction of one MWh of consumption due to energy waste reduction does not mean that an Ohio based company would reduce its sales by one MWh.

5 Costs

Energy waste reduction program costs include costs expended by utilities to deliver the energy waste reduction programs. These costs include direct incentives to customers, administrative and implementation costs, marketing, evaluation, and other costs associated with program development and delivery. We relied on Ohio specific costs from programs delivered in 2019 to estimate future costs of programs. We calculated a weighted average of the cost of each unit of energy saved based on the results of all six Ohio utilities in 2019. We also considered an alternate cost of saved energy sensitivity based on a regional peer, Michigan. The Michigan cost to achieve is based on the weighted average of cost to achieve presented in the most recent program filings by Michigan's two largest electric utilities, DTE and Consumers Energy. We did not include participant costs in this analysis. Table 14 shows the first-year cost to achieve assumption by sector for our analysis based on this review.

Table 14. First year cost to achieve assumptions ($/first-year kWh saved)

Sector	Michigan	Ohio
Residential	0.26	0.10
Business	0.17	0.09

Using these values, we estimated the total cost of program for each scenario. Table 15 shows the net present value of program costs for each energy savings scenario under the Michigan and Ohio cost sensitivity.

Table 15. Program costs by scenario based on Michigan and Ohio assumptions (NPV 2021$ millions)

	Energy Savings Scenario		
State	1.0%	1.5%	2.0%
Ohio	982	1,473	1,965
Michigan	2,050	3,075	4,100

6 Customer Bill Impacts

Utilities recover energy waste reduction program costs from electric customers through rates. Utilities in Ohio have historically recovered annual program costs over a one-year period, known as "expensing" costs. Many utilities around the country utilize a different cost recovery approach for energy waste reduction. These utilities are permitted to invest capital in energy waste reduction and recover annual program costs over a multiple year period, earning a return on the unamortized balance. This approach utilized elsewhere in the country is analogous to how utilities invest and recover costs in typical electric distribution infrastructure By amortizing costs and spreading them out over multiple years, utilities are able to reduce bill impacts on customers, more closely align cost recovery with the realization of system benefits, and increase the attractiveness of investments in energy waste reductions.

We estimated bill impacts for all six scenarios (three energy savings and two cost to achieve). To do so, we estimated the revenue requirements per year for all six scenarios. We used the cost of capital weighted for all six Ohio utilities to estimate the return on investment. We also assumed 20% of program costs would be expensed in the amortization scenario (not all costs would be amortized) because it is unlikely the Public Utilities Commission of Ohio would allow the utilities to earn a return on the entire investment (for example, internal utility labor is often required to be expensed rather than amortized). Table 16 shows the monthly bill impact for an average residential customer in Ohio for ten years under all six scenarios.

Table 16. Projected monthly bill impact for average residential customer, expensing scenario ($/month)

Scenario	Cost	PY 1	PY 2	PY 3	PY 4	PY 5	PY 6	PY 7	PY 8	PY 9	PY 10
1.0%	OH	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14
1.5%	OH	1.44	1.47	1.50	1.52	1.56	1.59	1.62	1.65	1.68	1.72
2.0%	OH	1.93	1.96	2.00	2.03	2.08	2.11	2.15	2.20	2.24	2.29
1.0%	MI	2.41	2.45	2.49	2.54	2.60	2.64	2.69	2.75	2.80	2.86
1.5%	MI	3.61	3.68	3.74	3.81	3.89	3.96	4.04	4.12	4.21	4.29
2.0%	MI	4.81	4.90	4.99	5.08	5.19	5.28	5.38	5.49	5.61	5.72

Table 17 shows the monthly bill impacts for an average residential customer assuming program costs are amortized over a five-year period, with the utility earning a return on investment.

Table 17. Projected monthly bill impact for average residential customer, amortizing scenario ($/month)

Scenario	Cost	PY 1	PY 2	PY 3	PY 4	PY 5	PY 6	PY 7	PY 8	PY 9	PY 10
1.0%	OH	0.33	0.57	0.80	1.01	1.20	1.29	1.32	1.35	1.37	1.40
1.5%	OH	0.50	0.86	1.20	1.51	1.80	1.94	1.98	2.02	2.06	2.10
2.0%	OH	0.66	1.15	1.60	2.02	2.40	2.59	2.64	2.69	2.74	2.80
1.0%	MI	0.83	1.44	2.00	2.52	3.00	3.24	3.30	3.36	3.43	3.50
1.5%	MI	1.24	2.15	3.00	3.78	4.50	4.85	4.95	5.04	5.14	5.24
2.0%	MI	1.65	2.87	4.00	5.04	6.00	6.47	6.59	6.72	6.86	6.99

As can be seen in tables 16 and 17 above, the ability to amortize costs over time reduces the annual bill impact to customers, even accounting for the provision of a return on investment to the utility.

7 Cost Benefit Summary and Conclusions

The universe of benefits discussed in this report captures many, but not all potential benefits of energy waste reduction. Other benefits include avoided renewable portfolio compliance costs, avoided compliance costs with existing environmental regulations, value of reduced capacity reserve requirements, reduced arrearages, improve comfort and safety, reduced maintenance costs, reduced price volatility exposure, and other nonenergy benefits.

When tabulated together, the benefits and costs provide a clear picture of the cost-effectiveness of prospective energy waste reduction programs in Ohio. Table 18 shows the cost benefit results for the three scenarios assuming the Ohio cost to achieve.

Table 18. Cost benefit results all scenarios, Ohio cost to achieve (NPV 2021$ millions)

	Scenario		
Benefits	**1.00%**	**1.50%**	**2.00%**
Avoided Electric Energy Costs	2,304	3,456	4,608
Avoided Electric Capacity Costs	316	474	632
Electric Energy DRIPE	804	1,205	1,607
Electric Capacity DRIPE	14	21	28
Avoided T&D Costs	116	174	232
Avoided CO_2 Emissions Damages	4,168	6,252	8,336
Avoided SO_2 Emissions Damages	4,733	7,100	9,466
Avoided NOx Emissions Damages	621	931	1,242
Total Benefits	**13,075**	**19,613**	**26,151**
Costs			
Program Costs	982	1,473	1,965
Total Costs	**982**	**1,473**	**1,965**
Net-Benefits			
Total	12,093	18,139	24,186
Cost-Benefit Ratio	**13.3**	**13.3**	**13.3**

Table 19 shows the cost benefit results for the three scenarios assuming the Michigan cost to achieve.

Table 19. Cost benefit results all scenarios, Michigan cost to achieve (NPV 2021$ millions)

	Scenario		
Benefits	**1.00%**	**1.50%**	**2.00%**
Avoided Electric Energy Costs	2,304	3,456	4,608
Avoided Electric Capacity Costs	316	474	632
Electric Energy DRIPE	804	1,205	1,607
Electric Capacity DRIPE	14	21	28
Avoided T&D Costs	116	174	232
Avoided CO_2 Emissions Damages	4,168	6,252	8,336
Avoided SO_2 Emissions Damages	4,733	7,100	9,466
Avoided NOx Emissions Damages	621	931	1,242
Total Benefits	**13,075**	**19,613**	**26,151**
Costs			
Program Costs	2,050	3,075	4,100
Total Costs	**2,050**	**3,075**	**4,100**
Net-Benefits			
Total	11,025	16,538	22,051
Cost-Benefit Ratio	**6.4**	**6.4**	**6.4**

Organizing each of the benefits into categories provides additional perspective into how and where the benefits from energy waste reduction flow. Table 19 arranges all nine benefits into four distinct categories. These categories are:

1) Utility system benefits, consisting of avoided electric energy costs, avoided electric capacity costs, and avoided T&D costs;
2) DRIPE benefits, consisting of electric energy DRIPE and electric capacity DRIPE; and
3) Emissions benefits, consisting of avoided CO_2 emissions damages, avoided SO_2 emissions damages, and avoided NOx emissions damages.

Table 20 displays the cost-benefit ratio of each individual component category. The sum of each individual category is equal to the total benefits, and total cost-benefit ratio, for each cost to achieve scenario.

Table 20. Cost benefit results by component category

Benefit Type	Cost Assumption	
	Ohio	Michigan
Direct Energy Benefits	2.8	1.3
DRIPE Benefits	0.8	0.4
Emissions Benefits	9.7	4.6
Total	**13.3**	**6.4**

These energy waste reduction programs also will have a direct impact on Ohio's economy. The economic impact assessment also demonstrated the potential for benefits through increases to the Ohio GDP and creation of jobs. Table 21 shows the results of this analysis.

Table 21. Economic impacts and job creation (2021$ millions, job-years)

Energy Savings Scenario	Cost to Achieve Scenario	Total Value Added to GDP	Total Job-Years
1%	Ohio	2,408	86,325
	Michigan	2,538	86,731
1.50%	Ohio	3,612	129,488
	Michigan	3,807	130,097
2%	Ohio	4,816	172,651
	Michigan	5,076	173,463

Overall energy waste reduction programs can produce substantial benefits for Ohio, even assuming program costs increase over time. As seen in table 20, the direct energy benefits alone are cost effective, ranging between 1.3 to 2.8 times more benefits than costs. Because these categories are additive, each additional benefit component category only further increases the cost-effectiveness of the programs. Overall, without consideration of environmental impacts, which are substantial, the programs would deliver 2.7 to 3.6 times the benefits as their costs to Ohio and its residents.