FILE

78

PUCO EXHIBIT FILING

Date of Hearing: 1/28/2019

Case No. 18-501-EL-FOR, 18-1392-EL-RDR, 18-1393-EL-ATA

PUCO Case Caption: 2018 Long-Term Forecast Report of Ohio Power Company and Related Matters, Application of Ohio Power Company for Approval to Enter Into Renewable Energy Purchase Agreements for Inclusion in the Renewable Generation Rider, and Application of Ohio Power Company for approval to Amend its Tariffs.

List of exhibits being filed: Volume IX

AEP 23, 24, 25

Reporter's Signature: Karen Sue Gibson

Date Submitted:

BEFORE THE PUBLIC UTILITIES COMMISSION OF OHIO

- - -

In the Matter of the 2018 Long-Term Forecast Report of Ohio Power Company and Related Matters.	:	Case No. 18-501-EL-FOR
In the Matter of the Application of Ohio Power Company for Approval to Enter Into Renewable Energy Purchase Agreements for Inclusion in the Renewable Generation Rider.	:	Case No. 18-1392-EL-RDR
In the Matter of the Application of Ohio Power Company for Approval to Amend its Tariffs.	:	Case No. 18-1393-EL-ATA

- - -

PROCEEDINGS

before Ms. Sarah Parrot and Ms. Greta See, Attorney Examiners, at the Public Utilities Commission of Ohio, 180 East Broad Street, Room 11-A, Columbus, Ohio, called at 9:00 a.m. on Monday, January 28, 2019.

- - -

VOLUME IX

- - -

ARMSTRONG & OKEY, INC.
222 East Town Street, Second Floor
Columbus, Ohio 43215-5201
(614) 224-9481 - (800) 223-9481

- - -

October 5, 2018

100% Renewable offers	27
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0739 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

October 12, 2018

100% Renewable offers	27
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0749 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

October 19, 2018

100% Renewable offers	26
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0749 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

October 26, 2018

100% Renewable offers	29
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0749 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

November 2, 2018

100% Renewable offers	29
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0749 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

November 9, 2018

100% Renewable offers	29
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0739 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

November 16, 2018

100% Renewable offers	29
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0749 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

November 23, 2018

100% Renewable offers	29
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0769 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

November 30, 2018

100% Renewable offers	29
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0759 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

December 7, 2018

100% Renewable offers	35
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable

$0.0759 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

December 14, 2018

100% Renewable offers	35
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable

Energy Choice Ohio
powered by choice

Published on Friday, December 14, 2018 at 6:00 AM
American Electric Power

$0.0749 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

December 21, 2018

100% Renewable offers	35
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable

$0.0729 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

December 28, 2018

100% Renewable offers	36
IGS 100% Renewable offers	1

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable

$0.0729 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

January 4, 2019

100% Renewable offers	36
IGS 100% Renewable offers	2

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0729 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 12 months | 100% Renewable
$0.0789 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 12 Billing Cycles. 100% Ohio Wind Energy.
This is not a promotional offer.
This is not a introductory offer.

January 11, 2019

100% Renewable offers	36
IGS 100% Renewable offers	2

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0729 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 12 months | 100% Renewable
$0.0789 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 12 Billing Cycles. 100% Ohio Wind Energy.
This is not a promotional offer.
This is not a introductory offer.

January 18, 2019

100% Renewable offers	36
IGS 100% Renewable offers	2

IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 36 months | 100% Renewable
$0.0719 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 36 Billing Cycles. 100% Green Energy.
This is not a promotional offer.
This is not a introductory offer.

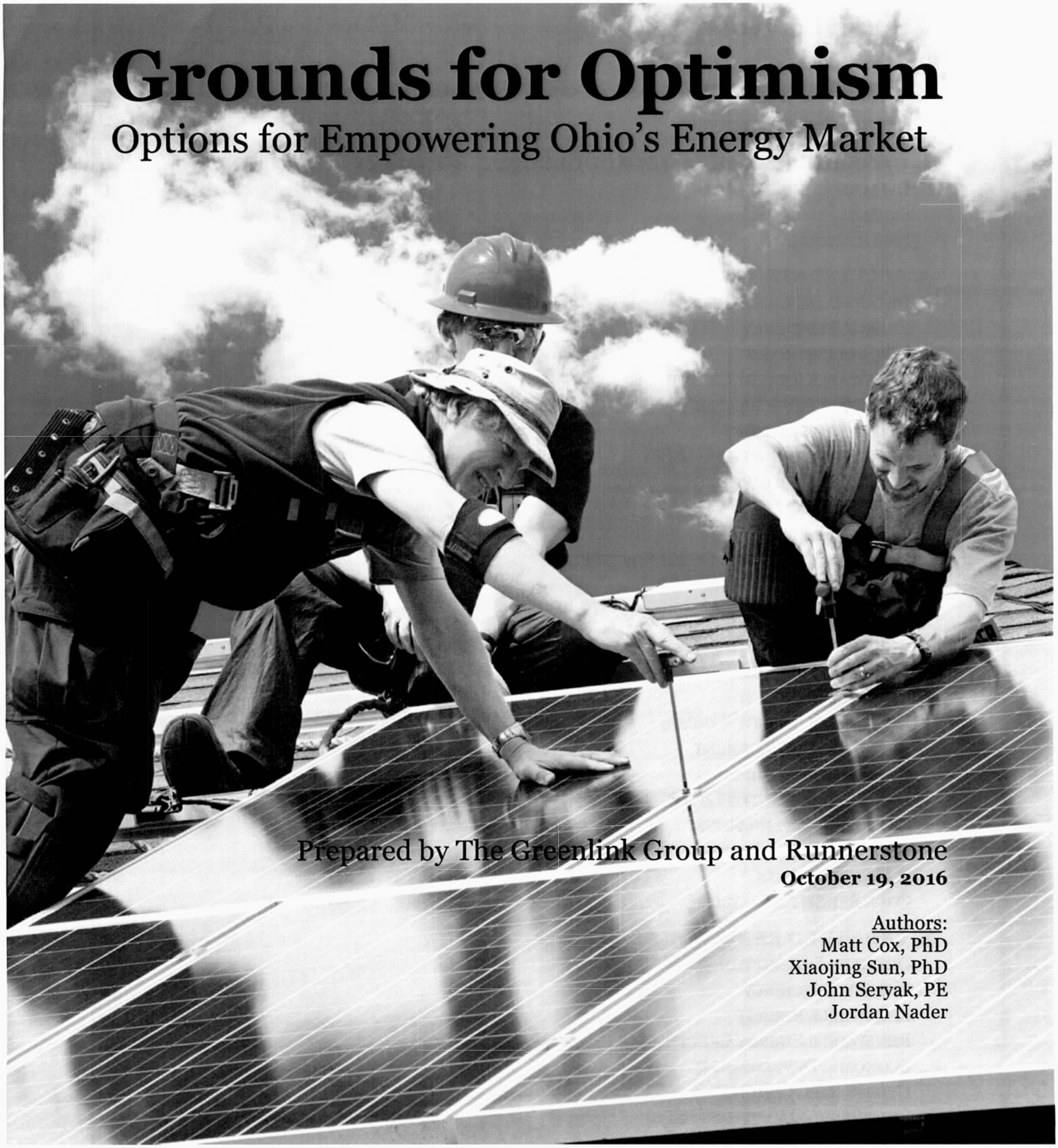
IGS Energy
(800) 280-4474

Rate Type: Fixed | Term Length: 12 months | 100% Renewable
$0.0779 per kWh | Monthly Fee: $0 | Early Termination Fee: $99

Additional Information: Fixed rate for 12 Billing Cycles. 100% Ohio Wind Energy.
This is not a promotional offer.
This is not a introductory offer.

Grounds for Optimism

Options for Empowering Ohio's Energy Market



Prepared by The Greenlink Group and Runnerstone

October 19, 2016

Authors:
Matt Cox, PhD
Xiaojing Sun, PhD
John Seryak, PE
Jordan Nader

greenlink

RUNNERSTONE
INFORMATION IS POWER

Table of Contents

Executive Summary

Ohio policymakers have expressed interest in a set of renewable energy and efficiency policies that would maximize financial benefits to the state, while keeping Ohio on track to meet potential future environmental regulations. To evaluate the most effective mix of resources that would meet these two objectives, the Greenlink Group, in consultation with Runnerstone, produced four forecasts of the state's electricity market: a baseline case that models an extended freeze of Ohio's renewable and energy-efficiency standards, and three scenarios based on varying, but achievable, levels of renewable energy and energy efficiency.

Each of the three alternative scenarios would meet potential federal carbon reduction regulations as well as provide financial benefits to the state. Responding to concerns of Ohio policymakers regarding existing law, each of the scenarios – Accelerated Efficiency, Intermediate Pathway, and Expanded Renewables – also reduces the efficiency and renewable standard levels established in Senate Bill (S.B.) 221/310 and is based on clear trends and achievable targets within the state's growing clean energy industry. Our analysis found that the Accelerated Efficiency scenario offers the most economic and environmental benefits of the three options.

This report also offers for consideration five market-focused reforms that would advance energy innovation and investment within Ohio.

1. Ensure all electricity generator incumbents do not receive unfair advantages over new competitors
2. Modify the wind farm siting rules that block development
3. Allow on-bill repayment to spur investments in energy efficiency projects
4. Adopt a market for energy efficiency credits
5. Maintain and promote volumetric electric rate structures that incorporate price signals.

Model Results

Compared to baseline, each of the three scenarios produces net economic benefits for Ohio. To appreciate how those benefits vary, this report evaluates each scenario according to several factors:

- Net-Benefit and Benefit-to-Cost Ratio – These standard economic metrics show that the best results come from Accelerated Efficiency, although Intermediate Pathway and Expanded Renewables are close behind.
- Jobs – The renewable energy and energy efficiency industries, according to these scenarios, are expected to create between 82,300 and 136,000 new jobs in Ohio. Wind energy development, which is labor intensive and has Ohio supply chain manufacturers, is the major driver to such job growth.
- Payroll – These clean energy businesses are poised to increase Ohio's payroll by between \$4.6 billion and \$7.6 billion by 2030. Again, wind energy development generates the highest payrolls.
- GDP – The three scenarios enhance Ohio's GDP by \$6.7 billion to \$10.7 billion by 2030. Higher GDP gains are associated with greater levels of wind development.

- Health – Each scenario would avoid pollution, leading to reduced health-care costs. Savings are expected to be approximately $800 million annually in the near term and reaching $3 billion per year by 2030. Accelerated Efficiency achieves the most health care cost reductions.
- Electric Bill Impacts – The scenarios would provide customer savings between $28.8 and $50.9 million in 2030. Accelerated Efficiency offers the most cost reductions for consumers, while Intermediate Pathway produces the least of the three options.
- Clean Power Plan – Each scenario puts Ohio on a path to comply with the federal Clean Power Plan if it should be necessary. A state implementation plan (SIP) can successfully build on any of these three approaches.

The table below presents three annual benchmarks simulated for the Accelerated Efficiency, Intermediate Pathway and Expanded Renewables scenarios. See Appendix A for year-by-year benchmarks.

Description	Accelerated Efficiency		Intermediate Pathway		Expanded Renewables	
Year						
2017	3.5%	1.0%	3.5%	1.0%	3.5%	0.5%
2020	6.5%	1.3%	6.5%	1.0%	7.5%	0.5%
2026	10.0%	1.5%	12.5%	1.0%	19.5%	0.5%
2030	11.0%	1.5%	13.5%	1.5%	19.5%	1.0%
Through 2030	11.0%	18.5%	13.5%	16.0%	19.5%	10.3%
2009-2026	10.0%	16.7%	12.5%	14.2%	19.5%	9.2%
SB 221/310	12.5%	22.0%	12.5%	22.0%	12.5%	22.0%

In all, these scenarios represent no-regret strategies that will avoid handcuffing the state and maintain flexibility for Ohio. They would also place Ohio in line with what other states have already adopted and, in many cases, achieved. Regarding energy efficiency savings, for instance, Accelerated Efficiency's 2030 goals, although lower than called for in current Ohio law, were achieved by six states in 2014 and were nearly achieved by several Ohio utilities in that year. Regarding renewable energy goals, 21 U.S. states and territories have adopted more aggressive renewable portfolio standards than called for by Expanded Renewables. Stated frankly, all three scenarios set achievable and conservative goals that are in line with what other states, and even several of Ohio's own utilities, have adopted.

1. Study Background

This report summarizes the results of a study of potential energy future pathways for the State of Ohio. In 2014, the State of Ohio passed and then implemented a freeze on its renewable portfolio standard and its energy efficiency resource standard, accompanied with some land-use law modifications that stalled the development of wind energy in state. As a result, progress in utilizing these resource bases has reverted to efforts voluntarily undertaken by various actors, such as utilities and businesses, who frequently find their market incentives in opposition.

The freeze that was established in 2014 under SB 310 expires at the end of 2016, at which time, Ohio will revert to the previously-established renewable energy and energy efficiency standards from SB 221 unless the government acts to avoid this outcome. Several proposals have emerged, although none have yet received the necessary legislative and gubernatorial approvals.

In light of this context, Runnerstone contracted with The Greenlink Group to investigate the potential outcomes of several policy scenarios that could advance Ohio's energy future. These scenarios emphasize different aspects of the energy landscape and provide detailed and thoroughly-researched insights on the anticipated outcomes of choosing one over another, enabling policymakers to have the best available information in forming a preference. Each scenario was carefully crafted with current market, technological, and regulatory landscapes in mind. By using this approach, the scenario design and the analysis provide policymakers with a non-arbitrary rationale for evaluating the scenarios.

To evaluate these scenarios, Greenlink used its ATHENIA[1] model. The ATHENIA model is an electricity system simulation tool with the purpose of replicating the hourly characteristics and costs of electricity operations to shed light on the likely future impact of decisions regarding those operations. ATHENIA couples a sophisticated characterization of electricity demand by various sectors and end uses with an algorithmically-driven assessment of the use of all electricity generating units within the specified territory, which makes use of machine learning, probabilistic statistical simulations, and historical relationships to understand the behavior of the electricity system and project it into the future. The results of supply and demand convergence for the electricity market allow the model to produce a host of other outputs, allowing ATHENIA to provide insights on impacts to economic development, electricity bills and rates, public health, resource consumption (such as water), and many other variables of interest. Because of this design, the model and the research method produce highly-accurate technology-agnostic assessments of the costs and benefits of particular policy and program choices in the electricity market.

Four scenarios were evaluated in ATHENIA to provide information on a range of issues and uncertainties for various approaches to the energy future of Ohio. Each contains relevant information for policymakers to consider when evaluating which policy options represents the

---

[1] ATHENIA is a trademark of The Greenlink Group.

best path forward for the state, or what combination of approaches may provide the most benefits and opportunities for Ohio in the short- and long-run.

The first scenario represents a baseline reference case. This scenario extends the existing freeze indefinitely, as well as other existing policies. The baseline case provides information on direction of Ohio's electricity market, against which all other scenarios are compared. This scenario deploys a small amount of renewable and energy efficiency, reflecting planned developments and secular trends in adoption that persist through existing regulatory and financial barriers to market-based adoption. The remaining scenarios all have a renewable portfolio standard and the energy efficiency resource standard (RPS and EERS, respectively), with varying degrees of emphasis on the different resources.

The second scenario, the Accelerated Efficiency scenario, implements a combination of renewables and efficiency standards that puts relatively more emphasis on energy efficiency than the other scenarios. Accelerated Efficiency places Ohio on a path with efficiency being used initially to reduce energy consumption in Ohio by 1%.[2] This value gradually climbs to 1.5% by 2026, which is maintained through 2030. Renewables experience growth in this scenario as well, representing 10% of electricity generation in 2026 and 11% in 2030. Solar is responsible for 1% of generation in 2026 and 2030, alike. This scenario assumes wind setback rules would be revised to allow for expanded wind energy development.

The third scenario, the Intermediate Pathway scenario, calls for a renewables and efficiency combination that falls squarely in the middle of the three policy scenarios modeled in this research. Efficiency, as in the Accelerated Efficiency scenario, initially represents 1% of annual retail sales. Energy efficiency remains at 1% through 2026, only then growing to 1.5% for the final years of the modeling horizon. Renewables see greater deployment in this scenario, producing 12.5% of all electricity in 2026, growing to 13.5% by 2030, with solar representing 0.5% of the total. This scenario assumes wind setback rules would be revised to allow for expanded wind energy development.

The fourth and final scenario, the Expanded Renewables scenario, puts the most weight on renewables. Efficiency begins and holds at 0.5% of retail sales through 2026, after which it increases to 1%. Renewables experience consistent and steady growth in this scenario, expanding generation by an average of 1.5% per year to 19.5% of total generation in Ohio by 2026, a figure which is held constant afterwards. See Table 1.1 (below) and Appendix A for a description of the electricity demand satisfied by which resources in the three scenarios and a comparison to the original requirements of SB 221. This scenario assumes wind setback rules would be revised to allow for expanded wind energy development.

---

[2] 1% is the annual savings in retail sales not subject to an exemption

Table 1.1 Renewables and Efficiency Pathways Under Three Scenarios

Description	Accelerated Efficiency		Intermediate Pathway		Expanded Renewables	
Year						
2017	3.5%	1.0%	3.5%	1.0%	3.5%	0.5%
2020	6.5%	1.3%	6.5%	1.0%	7.5%	0.5%
2026	10.0%	1.5%	12.5%	1.0%	19.5%	0.5%
2030	11.0%	1.5%	13.5%	1.5%	19.5%	1.0%
Through 2030	11.0%	18.5%	13.5%	16.0%	19.5%	10.3%
2009-2026	10.0%	16.7%	12.5%	14.2%	19.5%	9.2%
SB 221/310	12.5%	22.0%	12.5%	22.0%	12.5%	22.0%

Had this analysis incorporated the financial and energy savings since SB221's adoption, bill savings and other financial values would be higher, as these efforts are currently yielding energy savings in Ohio. As this analysis focuses on the efforts attributable strictly to these scenarios, these benefits are not incorporated, but should be noted. The trajectories for all of these scenarios are plausible given Ohio's experience and other state's experience; more than twenty-five states have standards at or beyond the RPS/EERS targets contained within these scenarios, and more than half a dozen have already achieved these levels. Because each of them sets a target and allows the market to determine the appropriate way to meet it, they are harnessing competition and providing market certainty to drive towards least-cost outcomes. The level of those targets and their distribution between renewables and efficiency have profound impacts on the resulting landscape for Ohio. The upcoming chapters of this report investigate each scenario on its ability to drive economic development, reduce bills, improve public health, and reduce resource consumption. These chapters will also investigate the change in the cost structures for the utility sector, increased investment in the electric power market, and other potential shortcomings of the scenarios. Additionally, each scenario's implications for Clean Power Plan compliance will be evaluated and presented; should the Plan be upheld in court, this will be a key factor in assessing the additional benefits to Ohio for a given approach. Each chapter will conclude with the results of the economic development analysis and the benefit-cost analysis to summarize the primary costs and benefits of the approach for Ohioans.

2. General Scenario Methodological Summary

Demand

Energy efficiency savings were calculated as a percent of total retail sales, then disaggregated to sector and utility according to historical patterns. The distribution of sectoral savings is held constant throughout the modeling horizon. Once the annual energy savings by sector has been calculated, annual sectoral retail sales are determined, taking into account the underlying growth trajectory specific to each sector, and then summed to produce total annual retail sales. This an iterative process, as each year's annual retail sales directly lead to the savings targets established for the next year by the policy.

The same logic applies to the deployment of renewables. Historical adoption rates are used to project distributed generation adoption of photovoltaic solar panels (PV) by sector, which follow a price-response effect such that the impact of changing subsidy policies are incorporated into the analysis. If and when PV becomes broadly cost-competitive (i.e., achieves grid parity or equivalent) in a given market segment, a sector-specific growth factor is applied. This factor accounts for both price elasticity and consumer reactions to particular price thresholds and is the median value observed in other markets where grid parity has been achieved. The Ohio RPS allows for renewable energy credits (RECs) to be used to meet the targets as well; given their low cost, RECs are modeled as minimally accounting for the same historical quantity of the RPS as has been historically observed, and gap-filling for any shortfalls in renewable generation anticipated by the model, until such time that renewables have experienced cost declines to a level that RECs are no longer required in the same quantity and see a reduced role. Solar Renewable Energy Credits (SRECs) apply the same logic to solar development. Wind deployment is slow initially, with an early period allowing for the industry to ramp back to levels that existed prior to the establishment of regulatory barriers to development in Ohio. After this "rescaling" period, wind development is allowed to meet the remaining renewable energy target established by a particular scenario. As the targets are set on an annual basis, the renewable deployment trajectories are subject to the same annual adjustments as the efficiency trajectories.

The effect of savings are then broken into hourly components using industry-standard models for building simulation and renewable energy generation. Customized instances of the EnergyPlus, Wind Prospector, and PV Watts models[3] are used to develop hourly sectoral demand and production curves, which are then integrated and matched with overall balancing authority demand profiles to produce a final hourly demand signal. This exercise is repeated for all 8760 hours in each year, and replicated through 2030, representing 131,400 hours solved for in this manner. In a final step, the portions of this signal that are subject to the transmission system are treated to account for the average line losses of the system.

---

[3] Energy Plus: https://energyplus.net/;
Wind Prospector: https://mapsbeta.nrel.gov/wind-prospector;
PV Watts: http://pvwatts.nrel.gov/

Supply
Historical data on plant and unit operations is collected from the US Environmental Protection Agency, the US Energy Information Administration, the Federal Energy Regulatory Commission, SNL Financial, and Bloomberg LP. A profile is constructed for each electricity generating unit, covering aspects from generation and capacity to emissions, water usage, and financial operating data. Roughly 40,000 data points are collected for each electricity generating unit and processed through ATHENIA's machine learning algorithms, which produce information on unit availability (a simulation of each unit's probability of an outage and the probable duration of an outage for a specific unit) and unit behavior (how a particular unit responds to a shift in demand as well as a shift in the other resources that are available to meet demand in the system). This information is trained on historical data until each unit is correctly predicted with under 5% error in each hour of the hindcast. The algorithms then feed the validated and calibrated system hourly demand signals from the demand modules, and dispatch units accordingly to meet demand. Power purchases are allowed to meet demand during shortfall periods or to take advantage of market conditions to reduce overall costs; the quantity of power purchases are established from reported historical values.

Implications
Utility financial impacts as a result of supply and demand are calculated, taking into account the capital and operating costs of generation, applicable energy and capacity payments, the transmission and distribution costs, revenue requirements, and other considerations, to determine the impacts on utility financial standings as well as rates and bills for ratepayers. Pollutant emissions of NH_3, NO_x, SO_2, VOCs, PM_{10}, $PM_{2.5}$, and CO_2 are calculated and priced based on peer-reviewed econometric models of pollutant damages that are height and locationally-dependent. Water consumption and withdrawals are also calculated, based on unit-specific characteristics. Given the emissions trajectories for CO_2, the implications of a given scenario on Clean Power Plan compliance can be determined, and associated price impacts for emission rate credits or emission allowances can be incorporated into the analysis. Given the investment in various technologies provided as outputs of the Supply and Demand modules, an economic development analysis is performed, making use of the IMPLAN I/O datasets and models. This information produces net GDP, income, and employment estimates. In the final step, information from all modules is collected and processed to provide a cost-benefit analysis and economic development indicators and to summarize the impacts of a particular scenario.

For detailed model documentation, please contact the Greenlink Group or visit: http://www.thegreenlinkgroup.com/athenia

3. Accelerated Efficiency

The Accelerated Efficiency scenario places the strongest emphasis on energy efficiency as a resource, compared to the Intermediate Pathway and Expanded Renewables scenarios. Renewables play a role in the Accelerated Efficiency scenario, gradually increasing in contribution to Ohio's energy mix. As a result of the focus on efficiency, the impact on retail sales and the reduction in wear-and-tear on the grid is more pronounced. This chapter focuses on a detailed description of the Accelerated Efficiency scenario, which is followed by the results for economic development, electricity demand, electricity supply and the utilities, bill savings, public health, water resource use, and implications for the Clean Power Plan. Finally, the chapter concludes with a look at Ohio's benefit-cost analysis and the economic development indicators projected for the Accelerated Efficiency scenario.

Detailed Description

The Accelerated Efficiency scenario uses energy efficiency to meet much of the energy needs in Ohio, resulting in an 18.5% reduction in total demand by 2030 (Table 3.1). Renewables are deployed as well, with wind and solar providing a combined 11.0% of the state's electricity by 2030. Through 2026, the Accelerated Efficiency scenario models a 16.7% reduction through energy-efficiency, instead of the 22% required by SB221/SB310, and 10% total renewable energy, instead the 12.5% required by SB 221/310. For each resource, the generation targets scale over time to give the market certainty and to avoid shocks. As a result, the targets in the Accelerated Efficiency scenario do not place Ohio outside the bounds of energy policies other states have already adopted and, in many cases, achieved. For example, the 2030 annual efficiency savings called for in the scenario were already achieved by six states in 2014[4], and nearly achieved by several utilities in Ohio in the same year; the emphasis is on establishing a floor to ensure that cost-effective opportunities are not overlooked. It should also be noted that these efficiency targets are lower than called for in current Ohio law. 31 US states and territories have more aggressive renewable portfolio standards than the one called for in this scenario, with a number of them having also already exceeded these goals. As such, the

Table 3.1 Annual Contributions to Demand from Renewables and Efficiency in Accelerated Efficiency

Description	Accelerated Efficiency	
Year		
2017	3.5%	1.0%
2020	6.5%	1.3%
2026	10.0%	1.5%
2030	11.0%	1.5%
Through 2030	11.0%	18.5%
2009-2026	10.0%	16.7%
SB 221/310	12.5%	22.0%

[4] In 2014, Arizona, California, Hawaii, Massachusetts, Rhode Island, and Vermont saved more than 1.5% of retail sales through energy efficiency. For comparison, Ohio saved 1.05% in 2014.

Accelerated Efficiency scenario represents an achievable, conservative, non-arbitrary approach to addressing energy requirements for Ohio.

Annual energy efficiency savings are calculated by multiplying the target percentage of each year by the corresponding annual electricity sales. Current regulation allows industrial and large commercial customers in the state to opt out from utility-run energy efficiency programs, and the sales associated with the opted-out customers are exempted. As a result, not all retail electricity sales are subject to efficiency goals.

Energy Efficiency

The energy saving contributions from residential, commercial, and industrial players are calculated based on program level energy savings data in 2012 and 2013 collected from utility filings with the Public Utilities Commission of Ohio, the latest years where full engagement with efficiency programs under the EERS was present and the influence of the 2008 recession was muted. Historically, the commercial sector has been responsible for 43% of the total savings, followed by the residential sector at 39% and the industrial sector at 18%. This distribution of savings is extended between 2017 and 2030. As a result, the commercial and residential sectors are expected to deliver the majority of the energy efficiency savings, as shown in Figure 3.1. The step-change in the energy efficiency targets are shown as a percentage in the figure for reference.

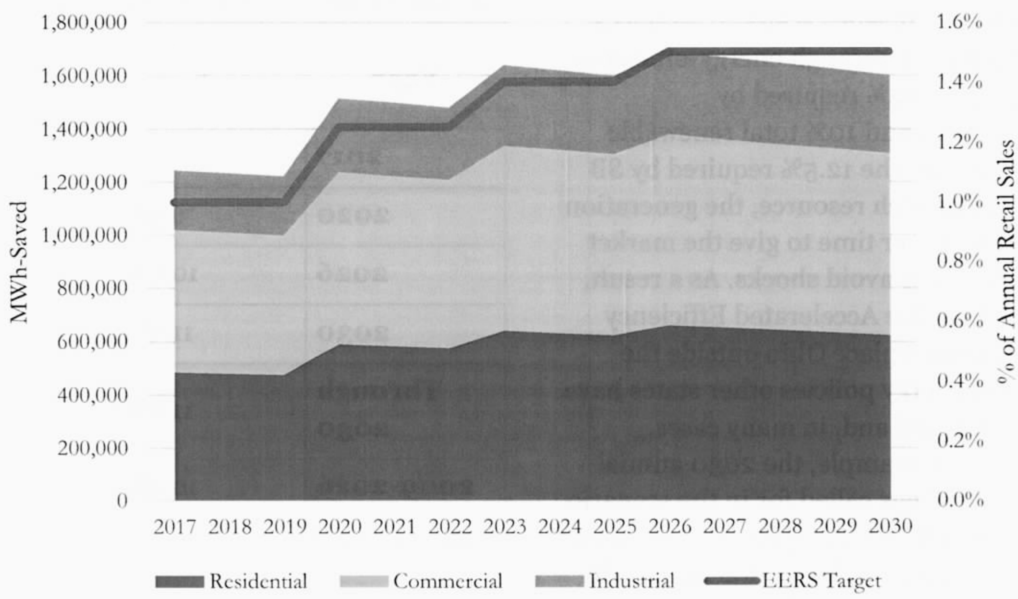


Figure 3.1 Annual Energy Efficiency Targets and Savings under Accelerated Efficiency

Renewable Energy

Assuming that wind setback rules are revised, renewable energy growth is driven by utility-scale wind and PV deployment across all sectors. Details on planned installations and existing queues are taken from EIA and the appropriate Ohio regulatory agencies and incorporated into the scenario.

The model shows residential solar installations achieving grid parity in 2018. Until then, residential adoption rates mirror the baseline case, with 15% annual growth rates, albeit from a small base of less than 12 MW initially. After grid parity is achieved, growth increases by 8.3% per year. A similar trend occurs in the Commercial sector, with grid parity occurring in 2020 and resulting in an increase in adoption of 6.25% per year.

In regards to utility-scale PV, installations are driven by load-serving entities' (LSE) demand. Utility-scale installations continue at the same rate in the baseline scenario, growing at between 10% and 20% per year depending on federal incentives until 2024 when PV is cheaper than the price of wholesale power plus the additional cost of a solar renewable energy credit (SREC). This is expected to occur when total installed costs of solar PV are under $0.70/W (corresponding to a $0.055-0.06/kWh levelized cost of electricity), at which point in-state solar development is cheaper than alternative approaches to the renewables requirements. Since the model incorporates a delay for new projects to enter the marketplace after viability is achieved, one year after this benchmark is cleared, more utility-scale projects come online to meet the demand for solar from LSEs.

After two years of competitive builds in-state, LSE demand slows due to continued growth in distributed generation, which is predominantly capitalized by residential and commercial customers. As a result, the development rate of utility scale projects slows until 2029/2030 when utility-scale PV is competitive with all resources bidding into the PJM market and becomes the lowest-cost resource to meet daytime demand. In this case, the return of utility-scale PV will be modest but productive (~50MW/year). By 2024, utility-scale PV installations overtake commercial DG deployment as the leading sector of PV installation, a position which it maintains through the remainder of the modeling horizon.

In-state wind is deployed at sufficient quantity to satisfy the remaining renewables requirements, after accounting for all other resources (including the purchase of renewable energy credits) and subject to the constraints detailed in Chapter 2. Annual installations range from 90 to 440 MW. Growth in Ohio-based wind development is strong and leads all other resources in deployed capacity, subject to annual variability based on market prices and demand. Eventually, wind grows to take the lionshare of renewable energy development in the state based on economics and resource availability. For example, total installed wind capacity in 2030 is 2.7 GW, in comparison to solar's 1.4 GW in the same year. However, wind development stalls following 2026, due to a glut in wholesale power markets and falling demand for electricity in Ohio, driven primarily by the expanded efforts in efficiency.

Renewable Energy Credits

Historically, RECs have been used to meet roughly 33% of Ohio's RPS requirements. This relationship is maintained throughout the modeling horizon. Additional REC purchases are made from 2017-2019 while wind capacity installations recover to pre-2014 levels. SRECs are used to assist in meeting solar targets whenever there is insufficient production in-state and when utility-scale PV is not cost effective against the price of wholesale purchases plus the cost of an SREC. SREC purchases are heaviest between 2019-2023. A summary of contributions by all resources driven by the Accelerated Efficiency scenario is provided in Figure 3.2. Under the Accelerated Efficiency scenario, energy from efficiency and renewables satisfy 24.4% of total system demand by 2030 making a significant contribution to the energy future of Ohio.

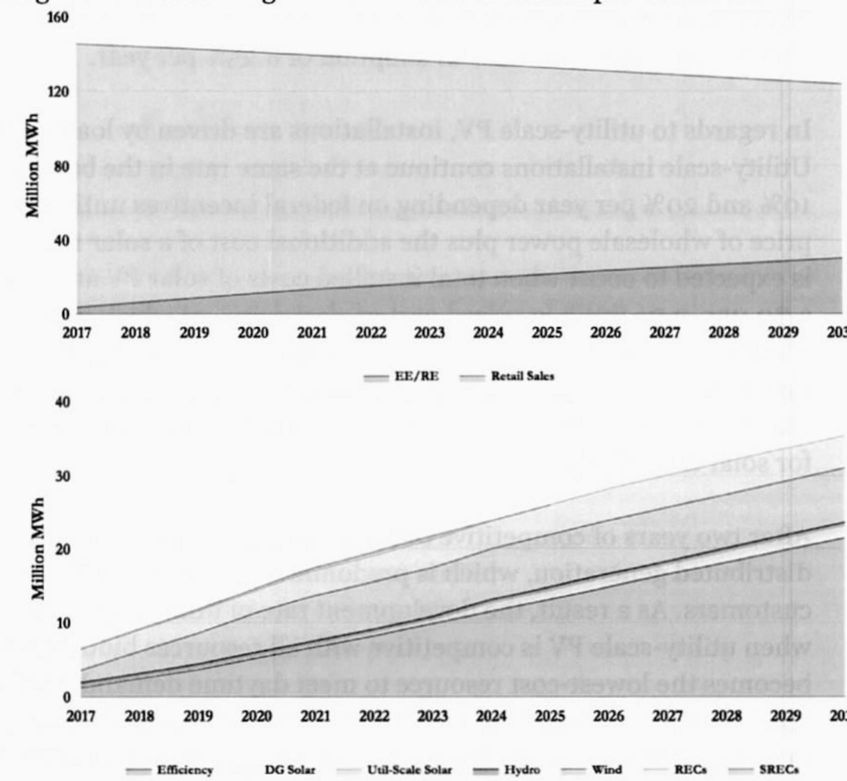


Figure 3.2 Contribution of Efficiency and Renewables to Retail Sales (Top) and Annual Composition of Efficiency and Renewables (Bottom)

Economic Development

Accelerated Efficiency spurs increased demand for energy efficiency and renewable energy, and therefore increases investments in energy efficiency and renewable energy services and technologies. Correspondingly, employment providing and producing these services and technologies is expected to increase. Additionally, as these resources drive down the consumption of electricity supplied by centralized, non-renewable merchant generation, reducing revenues and employment in that sector of the economy. Using the macroeconomic components of ATHENIA, the economic development of the Accelerated Efficiency scenario was assessed.

Employment is reported in full-time equivalent (FTE) employment for a particular year. On average, Accelerated Efficiency is expected to deliver 5,900 more jobs (net) to Ohio in each year. 2020 is projected to be the banner year for employment; while no particular resource is experiencing its best year in 2020, investment in wind and efficiency is strong and coincident in that year, resulting in high employment. 2027 is the low year in the modeled projection, resulting from a drop in new wind developments, with efficiency taking the lead for investment in that year.

The impact on Ohio's GDP is also calculated as a net value (i.e., it accounts for gains, tradeoffs losses, indirect, and induced expenditures across all of Ohio's sectors). On average, the Accelerated Efficiency scenario delivers an additional $478 million to Ohio's GDP than the Baseline case; from 2017 to 2030, Accelerated Efficiency provides an additional $6.70 billion (2014-$) to the state's GDP. The minimum and the maximum years closely correspond with the employment effects, with 2028 being the minimum and 2020 being the maximum.

The final set of economic development indicators is the impact on income derived from labor. In aggregate and on average, income from labor increases by $327 million (2014-$). If these benefits were evenly distributed across the workforce in Ohio, this would amount to an annual increase of $60 per year. In 2020, the top year for net income impacts, this value would increase to $108. Across the modeled horizon, Accelerated Efficiency produces a boost in incomes of $4.6 billion (2014-$). Figure 3.3 shows the employment, GDP, and income impacts.

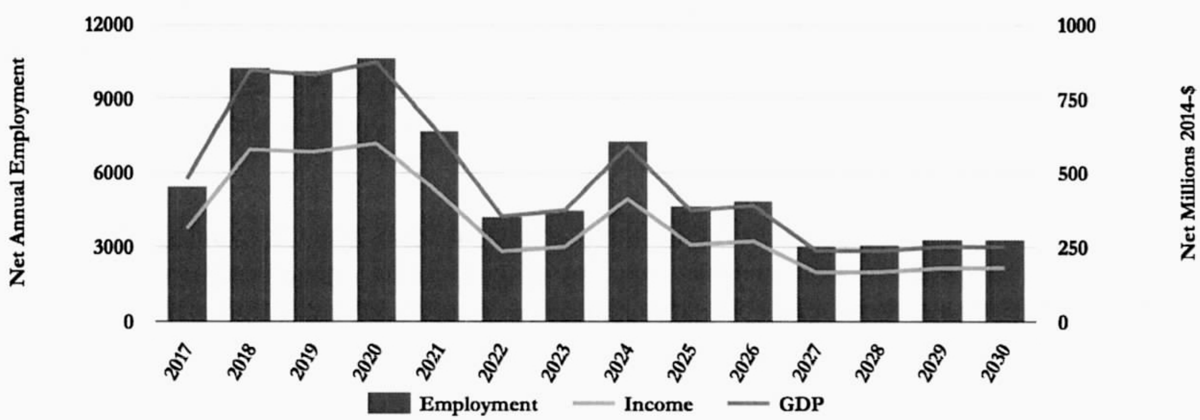


Figure 3.3 Net Jobs, GDP, and Income Impacts for Ohio under Accelerated Efficiency

As can be seen in the figure, many of these benefits for Ohio's economic development are felt most-strongly in the early years of the scenario. The remainder of the 2020s are relatively stable and continue to provide strong benefits over the baseline scenario. These benefits appear positioned for a growth trajectory into the 2030s, as the price, industry maturity, and other factors are showing greater market attractiveness in these times. However, projections of market conditions far into the future are subject to greater uncertainty than the short run implications.

Utility Implications

Besides project developers and financiers, the other major business interests affected by the Accelerated Efficiency scenario are the existing electricity market incumbents, which can be grouped into merchant generators and distributors. The following section takes a more in-depth look at the impacts to these participants in the electricity market.

Generation from large, centralized power plants is the predominant means of meeting electricity demand in Ohio, currently providing more than 80% of the electricity consumed in the state, and the Accelerated Efficiency scenario does not change that predominant status. It does, however, reduce the quantity of power demanded by distributors from generators. In-state generators do not bear the full brunt of the demand reduction, as power purchases from out-of-state suppliers decline as well. Figure 3.4 shows the difference in generation coming from centralized power plants in the Accelerated Efficiency scenario, relative to the baseline scenario. The rate of reductions in generation from centralized generating resources is slower early than in the later years. By 2030, the Accelerated Efficiency scenario shows total generation values that are 26 million MWh lower than in the baseline, a 19.8% difference.

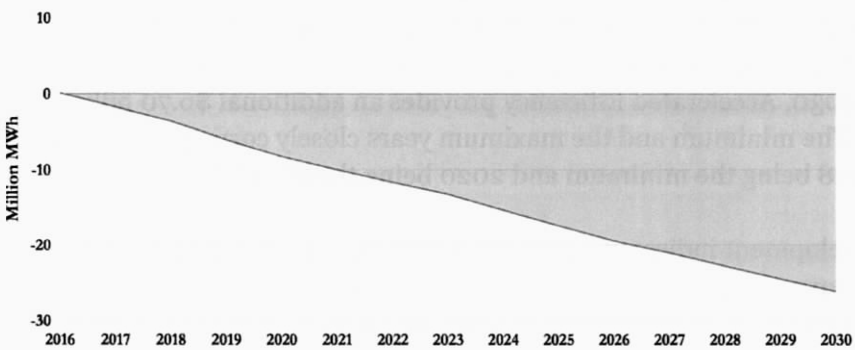


Figure 3.4 Annual Difference in Net Centralized Generation between Accelerated Efficiency and Baseline Scenarios

The reductions in generation have a financial impact for the costs, revenues, and profits collected by the companies that operate these centralized electricity generating resources. The cost and profit implications are displayed in Figure 3.5. In total, the reduction in utilization results in a significant drop in the cost of operations, shown in black. Annual costs for the centralized generation fleet runs into the several billions of dollars each year; the reduction in demand spurred by the Accelerated Efficiency scenario results in a sector-wide 16% reduction in these costs, with a value approaching $800 million. Profits are affected as well, however, due to declining sales to distributors, retailers, and other market participants. While the sector still shows profits in the billions, the Accelerated Efficiency scenario shows profits that are roughly $400 million less than in baseline, representing an 18% reduction.

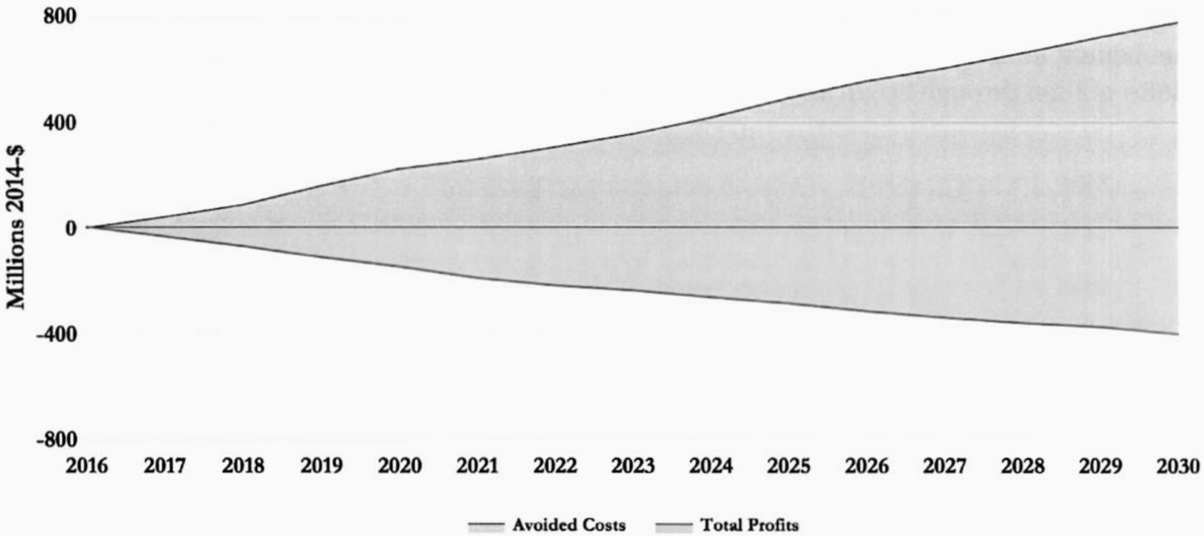


Figure 3.5 Year-to-Year Change in Overall Costs and Profits for Centralized Generation between Accelerated Efficiency and Baseline Scenarios

In total, the reduction in demand from the Accelerated Efficiency scenario has the effect of lowering costs, revenues, and profits for producers competing in this marketplace. The market becomes more economically efficient in this scenario than in the baseline, with competition for sales increasing and profit margins narrowing. Enhanced competition leads to lower prices for customers, and lower demand translates into lower maintenance costs for the electric grid as a whole.

Load Serving Entities (LSEs)

LSEs are responsible for delivering electricity to most customers in Ohio. They face a distinctly different set of challenges than the generators. These companies are involved in procuring power for resale to ultimate customers, in providing efficient power delivery, offering various energy services, and of particular relevance for this study, complying with the requirements of the energy efficiency resource and renewable portfolio standards.

The reductions in demand driven by more productive uses of electricity through efficiency and more on-site generation spur a reduction in power purchases by the LSEs, from both in-state and out-of-state generators. This, in turn, results in savings to the LSEs as power expenditures decline. While the reduction of in-state power purchases represents a transfer payment for Ohio, the reduction in out-of-state power purchases is a benefit to the state. In addition, substantial costs are avoided on the transmission and distribution system, which represent the single-largest savings category for the LSEs over the modeled horizon, with a discounted value approaching $400 million by 2030.

However, there are costs to the LSEs from the Accelerated Efficiency scenario as well. These take the form of lost revenues and program and administrative costs (including any requisite costs accrued from the procurement of RECs or SRECs). Early in the modeling period, these are substantial enough to exceed the benefits provided to the state's LSEs by the scenario, with 2022 representing a turning point. As Figure 3.6 makes clear, the Accelerated Efficiency scenario is a net benefit for the LSEs, presenting an opportunity for a discounted net present value of over $680 million through 2030, and with net benefits on a growth trajectory.

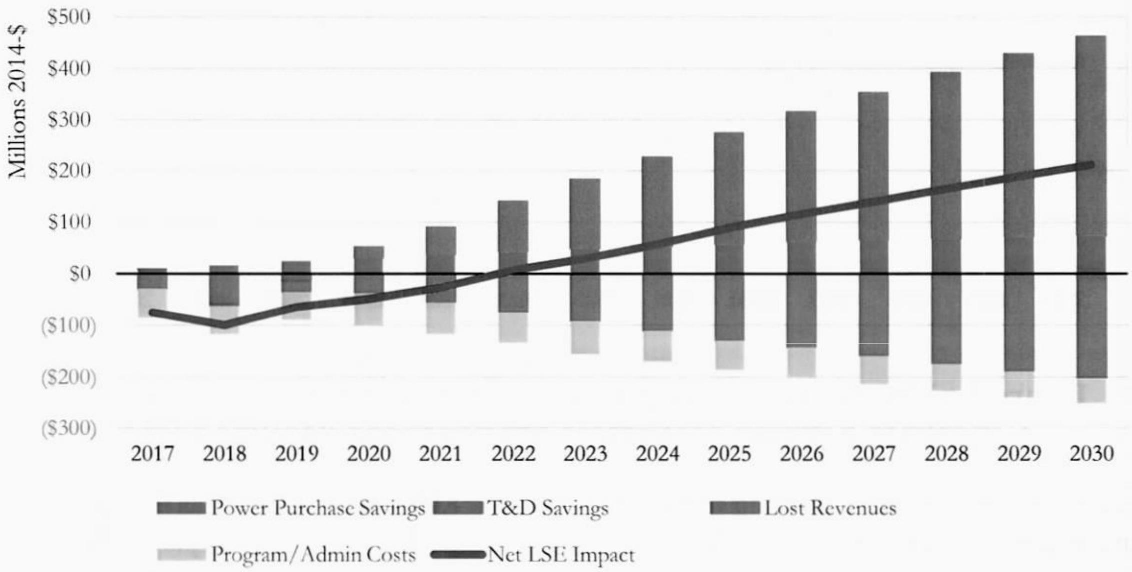


Figure 3.6 Net Present Value of Accelerated Efficiency Scenario to Ohio's LSEs

Consumer Implications

Several aspects of electricity policy options deliver significant variation from the baseline for individual residents and businesses of Ohio. The first that many think of is the impact of a policy change on electricity bills. Also important to consider is the public health implication of these policy deviations; increased emissions typically result in greater public health cost borne by citizens, and vice versa. Lastly, there are natural resources consumed as a result of producing electricity if certain technologies are used to meet market demand, including increasingly-stressed water resources, where assigning a price is not as easy.

Bill Impacts

It is common for customers to have a match requirement in order to receive energy efficiency services and benefits from utility efficiency programs. This is frequently referred to as the percent of the incentive the utility provides, with the other portion of the funding provided by the customer. Once this investment is made, the equipment is installed, where, on average, it provides savings over the other technologies that would have likely been purchased without the incentive from the utility. In Ohio, the average lifetime of the equipment installed through these programs exceeds a decade, and some studies suggest useful equipment lifetimes may reach twenty years. To account for savings that accrue beyond the first year of the investment, the savings from efficiency efforts are carried forward and evaluated in subsequent years, applying industry standard equipment-performance degradation rates.[5] This provides a good picture of the real bill impacts experienced by customers as a result of engaging with utility-provided energy efficiency programs.

Early costs in transmission and distribution (T&D) spurred by renewed wind development, incurred costs of renewable energy credits, and falling revenues from retail sales due to energy efficiency, create conditions where LSEs are expected to raise rates faster than consumption falls, resulting in a short-term increase in electricity bills. However, as more energy efficiency penetrates the market, T&D investments move from a cost to a benefit as capital investments are deferred and O&M costs decline, and the energy savings are more than capable of producing bill reductions for the average customer in the state. These savings, in contrast, are long-lived; the discounted present value of the Accelerated Efficiency scenario on electricity bills in Ohio is worth $41 million (2014-$) in 2030 alone (Figure 3.7). This means that over the lifetime of the equipment installed in the Accelerated Efficiency scenario, Ohioans electricity bills will fall.

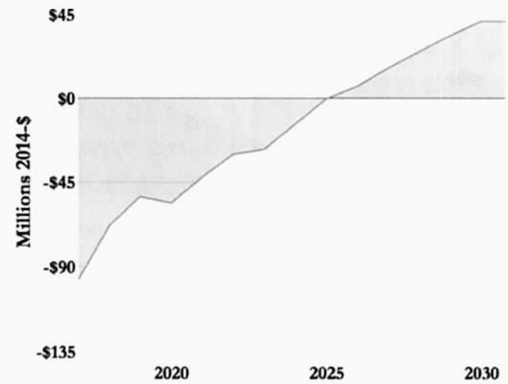


Figure 3.7 Annual Bill Impact of Accelerated Efficiency Compared to Baseline

Health Impacts

The generating characteristics, location, and stack height of power plants are critical in assessing the public health impacts of changing the way electricity is delivered to the market. An advanced public health econometrics database is utilized to assess these costs and the impacts of a change in generation choices (see Chapter 2 for more information). Ohio has a coal-intensive power supply, much of which is located near population centers. As a result, Ohio has high public health costs associated with electricity generation. This level of damages means that policies that impact these generation sources also can have a significant health impact by changing the amount of emissions caused by electricity generation in the state. In the Accelerated Efficiency case, these are substantial reductions. The annual present value of public health benefits is consistently growing over time, and exceeds $1 billion from 2024 onward. This represents thousands of avoided asthma attacks, heart attacks, pulmonary issues, and other illnesses that would have occurred otherwise under the baseline scenario. Figure 3.8 shows the trajectory of public health benefits, mapping the bill savings from Figure 3.7 alongside. While the bill savings are worthwhile, the public health benefits in most years are more significant than the cumulative value of the bill savings, as the public health savings are two orders of magnitude greater than the bill savings. The discounted present value of these savings in the Accelerated Efficiency scenario to Ohio citizens is over $1.5 billion in 2030.

[5] For example, Brown et al report 5% annual degradation rates on average. Brown M A, Wolfe A, Bordner R, Goett A, Kreitler V and Moe R. 1996. *Persistence of DSM Impacts: Methods, Applications, and Selected Findings* EPRI TR-106193 (Oak Ridge, TN: Oak Ridge National Laboratory and Synergic Resources Corporation for the Department of Energy and Electric Power Research Institute).

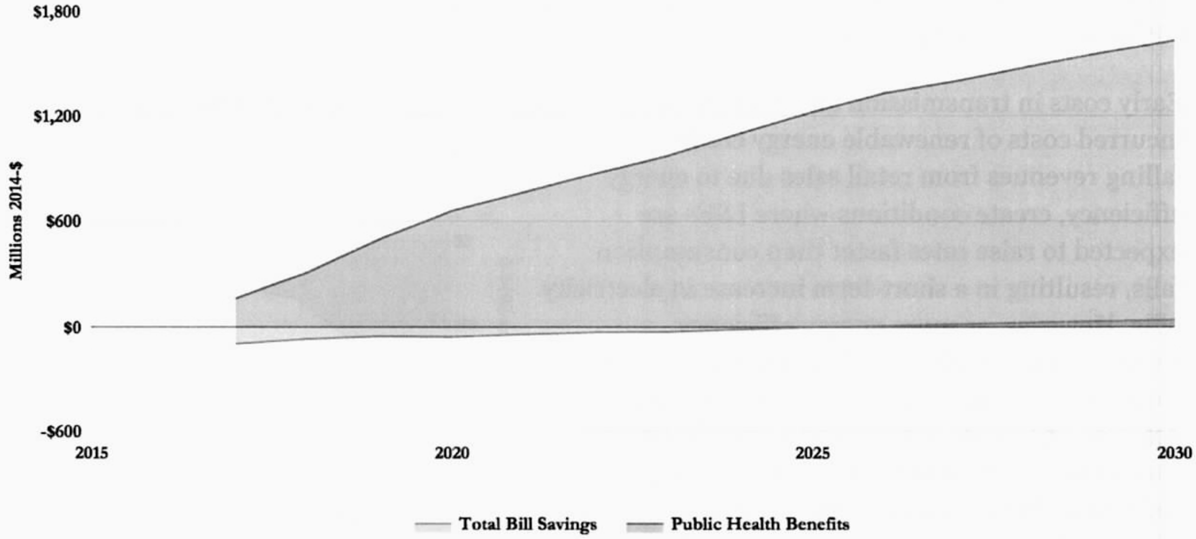


Figure 3.8 Financial Benefits of Accelerated Efficiency for Ohio Consumers

Implications for the Clean Power Plan

The Final Rule of the US Environmental Protection Agency's Clean Power Plan (CPP) allows states several ways to reduce the CO_2 emissions from their existing, covered electricity generating units (EGU) in order to achieve compliance. The major distinctions are between an approach that reduces the quantity of emissions (mass-based) and an approach that reduces the emissions per MWh (rate-based). Conditions within each state, the type of generation assets covered by the rule, policy preferences, and a host of other considerations dictate which approach each state will ultimately take.

Figure 3.11 shows the impact of Accelerated Efficiency on CPP compliance in Ohio. A value above the line represents over-achieving of the CPP target established for the state; below the line is falling short of the targets. In each year, Accelerated Efficiency performs better than the EPA targets (if only barely, as is the case in 2025), enabling Ohio EGUs to bank allowances for future years or trade them in the marketplace - in essence, Accelerated Efficiency produces a new commodity and income stream for the electricity generating sector in Ohio. On the other hand, the baseline scenario misses the target every year,

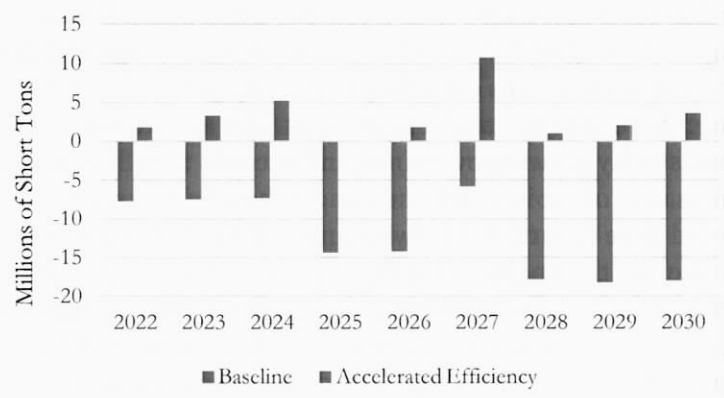


Figure 3.11 CPP Mass-Based Compliance under Accelerated Efficiency and Baseline

and would require Ohio to purchase allowances from other out-of-state actors, draining the state and the sector of resources as demand for the chief product is projected to decline.

Ohio could choose to pursue a rate-based pathway instead of a mass-based approach. Ohio appears to have a more-difficult time achieving the rate-based targets. Figure 3.12 shows the emission rates in the baseline and Accelerated Efficiency scenarios, as well as the target established by EPA for each year after 2021. In addition, the deficit in hitting the target is also shown. While the Accelerated Efficiency scenario does result in lower emission rates, neither scenario is capable of achieving annual compliance without the use of Emission Rate Credits (ERCs).

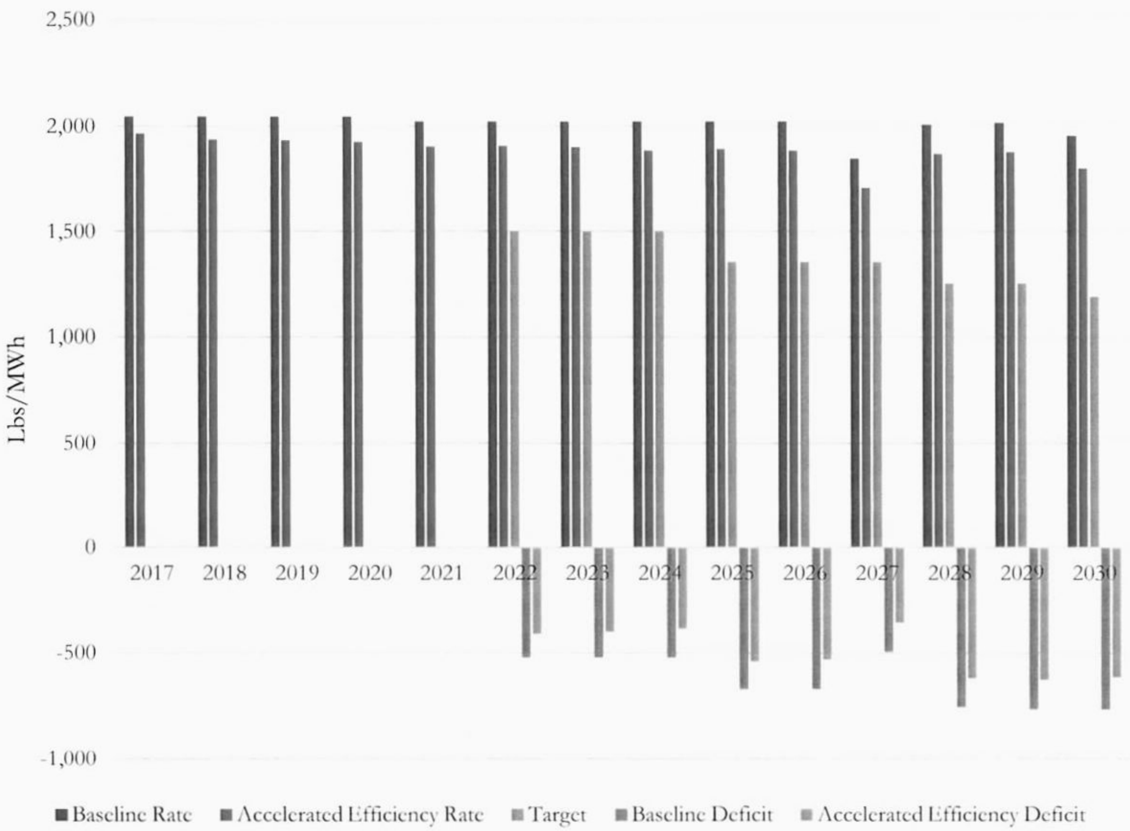


Figure 3.12 Emission Rates and Deficits in Achieving CPP Compliance without ERCs

The rate-based pathway does allow for the creation and banking of ERCs in order to reduce the effective rate of CO_2 emissions from covered units. The Accelerated Efficiency scenario results in the production of a significant number of ERCs through renewables, energy efficiency, the carbon attributes of RECs, and a small additional quantity provided through gas-shift ERCs. On the other hand, the baseline scenario generates very few ERCs that can be used to assist with the 2030 regulatory deadline. Figure 3.13 details this trajectory over time, showing the difference between the scenario and the quantity of ERCs required in order to comply with the EPA-established annual CPP targets. The figure embeds the assumption that Ohio-based EGU operators will bank ERCs for the 2030 deadline as opposed to selling them on the market. The implication of that choice is that, through the retirement of ERCs, the Accelerated Efficiency scenario will be able to meet the rate-based target in 2030, with a surplus of ERCs available for future use. The baseline scenario, even after considering the use of all ERCs produced up until 2030, will fail to meet the 2030 requirements.

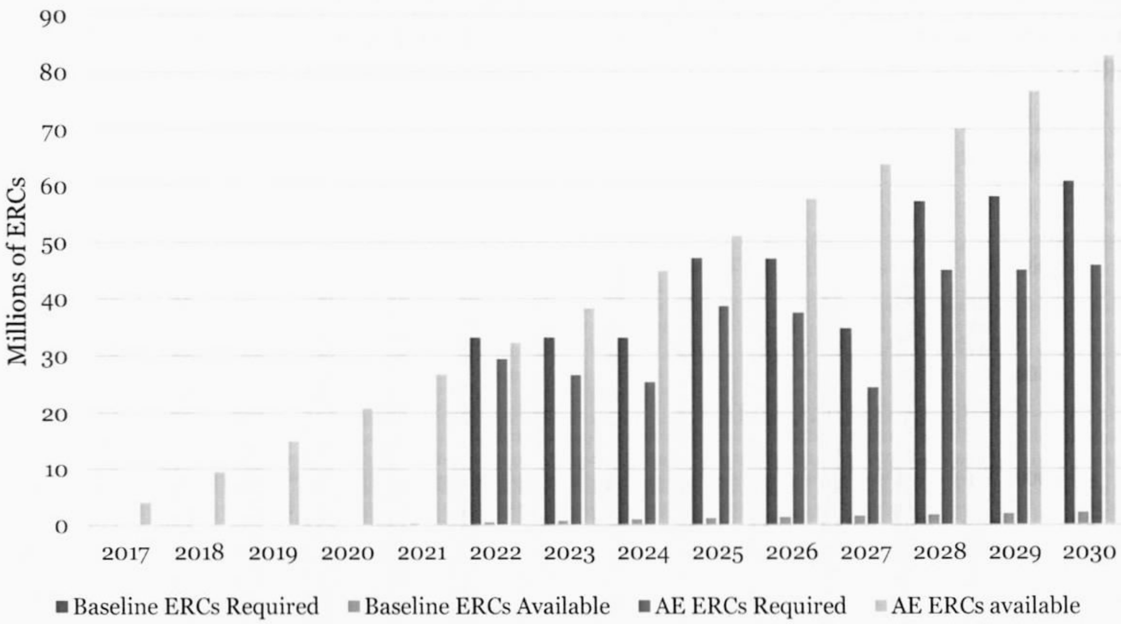


Figure 3.13 ERCs Required and Available for Rate-Based Compliance

If the Clean Power Plan is upheld and implemented, the Accelerated Efficiency scenario is poised to position Ohio for compliance. With the mass-based approach, compliance is achievable without using the banked allowances in any year, suggesting that the allowances remaining will have the opportunity to be monetized and produce an additional income stream for industry. Under a rate-based approach, compliance is also achievable with the Accelerated Efficiency scenario, but will require the state to retire some emission rate credits that had been accrued during the 2020s. The decision to sell remaining credits will not be as straightforward, given compliance requirements in and through the 2030s; banked ERCs from the 2020s would likely be exhausted in the early 2030s, suggesting that the mass-based approach represents an easier means of compliance. The baseline scenario does not approach compliance with the CPP.

Cost-Benefit Analysis

The Accelerated Efficiency scenario incurs a set of costs and provides a set of benefits relative to the baseline scenario that have been detailed in the earlier sections of this chapter. Here, these costs and benefits will be tabulated and the cost-effectiveness of the scenario will be presented.

Evaluating the cost-effectiveness of a particular policy approach requires the use of a discount rate to ensure that the time preference of money and other such interests are properly accounted for in the analysis. Per OMB Circular A-4, a 3% discount rate is appropriate for evaluating policies such as those considered under the Accelerated Efficiency scenario, so a 3% discount rate is used to assess the cost-effectiveness of the scenario.

Table 3.2 shows the benefits against the baseline scenario in 2020 and 2030 from energy bills, public health from reduced emissions, reduced power purchases, and utility costs. While all categories eventually provide benefits, not all are positive for the entire time period - for example, cumulative utility costs see a slight increase through 2020, which is offset by savings through 2030. Cumulative benefits to Ohio exceed $1 billion in 2020, and grow to over $16 billion through 2030.

Table 3.2 Societal Benefits from Accelerated Efficiency (Million $-2014)

Year	Energy Bill Savings	Public Health Savings	Lower Purchases	Net Reduced Utility Costs	Total Annual Benefits	Cumulative Benefits
2020	-$ 56.2	$ 657	$ 31.3	$ 19.9	$ 652	$ 1,360
2030	$ 41.4	$ 1,630	$ 74.5	$ 388	$ 2,130	$ 16,600

Table 3.3 shows the costs against the baseline scenario in 2020 and 2030 from investments in energy technologies, fees, charges, regulatory compliance, utility program incentive and administrative costs, and lost utility revenues. Since Accelerated Efficiency *reduces* compliance costs, so these are shown as negative costs - in effect, while compliance is typically a cost, the Accelerated Efficiency scenario changes this category to a benefit. These values are reported assuming that Ohio is utilizing a mass-based compliance strategy, which the analysis suggests would be the easiest path towards compliance. Utility revenues continue to accrue losses as the full effect of efficiency and renewables are felt. Costs exceed $4 billion through 2020, growing to $11.5 billion through 2030.

Table 3.3 Cumulative Societal Costs from Accelerated Efficiency (Million $-2014)

Year	Investment Costs	Net Compliance Costs	Program and Administrative Costs	Utility Lost Revenues	Total Annual Costs	Cumulative Costs
2020	$ 959	-	$ 63.6	$ 171	$ 1,190	$4,090
2030	$ 186	-$ 71.2	$ 49.2	$ 468	$ 632	$11,500

Having reviewed these benefit and cost streams, the cost-effectiveness of the Accelerated Efficiency scenario is presented in Table 3.4. As the renewables industry recovers and energy efficiency investments increase, economic costs outweigh benefits through 2020. Benefits grow rapidly through the 2020s as those investments begin to yield returns, public health improves, and utility operating costs decline. Overall, the scenario shows a benefit-cost ratio of 1.44, meaning that for every dollar spent, the model projection suggests a $1.44 return. Perhaps more importantly, the net benefits are $5 billion, suggesting that the Accelerated Efficiency scenario represents a significant, cost-effective improvement in the economic wellbeing of the people and businesses in Ohio when compared to the baseline, where the RPS and EERS requirements remain frozen indefinitely.

Table 3.4 Cost Effectiveness of Accelerated Efficiency

Year	B/C Ratio	Net Benefits (Million $-2014)
2020	0.33	-$ 2,730
2030	**1.44**	**$ 5,030**

The Accelerated Efficiency scenario improves the economic situation for Ohio, both in the economic sense and in the development sense. The policy is cost-effective and provides a net benefit of $5 billion dollars while also adding $6.7 billion to state GDP and providing employment opportunities to an average of 5,900 people per year. The scenario is also capable of bringing Ohio into compliance with the Clean Power Plan, and depending on the approach selected, adding value streams to the electric power sector. The standards within Accelerated Efficiency are achievable, with several states in the country already requiring, achieving, and surpassing such requirements. This analysis shows that within the Accelerated Efficiency scenario, economic development, clean energy, and a carbon-constrained future can co-exist and yield benefits to Ohioans for decades to come.

4. Intermediate Pathway

The Intermediate Pathway scenario has a similar emphasis on energy efficiency and renewable energy as resource for meeting energy demands in Ohio. This chapter will first introduce the Intermediate Pathway scenario, followed by the results for economic development, electricity demand, electricity supply and the utilities, bill savings, public health, water resource use, and implications for the Clean Power Plan. Lastly, the chapter will discuss the benefits and costs associated with the Intermediate Pathway scenario and its implications for economic development.

Detailed Description

The Intermediate Pathway scenario uses energy efficiency to provide the same service with less energy consumption in Ohio, resulting in a 16% reduction in total demand by 2030 (Table 4.1). Renewables are also used to provide 13.5% of the state's electricity by 2030. By 2026, the Intermediate Pathway scenario shows a 14.2% reduction in retail sales through energy-efficiency, about 8% less than what is required by SB221/SB310, and 12.5% of electric generation met by renewable energy, the same as required by SB 221/310. For each resource, the targets scale over time to provide market certainty and to avoid shocks. In so doing, the Intermediate Pathway scenario sets Ohio on a path that is comparable to other states with similar policies. For example, the 2030 annual efficiency savings called for in the scenario were already cost-effectively achieved by six states in 2014,[6] and nearly achieved by several utilities in Ohio in the same year; the emphasis is on establishing a floor to ensure that cost-effective opportunities are not overlooked. It should also be noted that these efficiency targets are lower than called for in current Ohio law. More than half of the country (27 US states and territories) has more aggressive renewable portfolio standards than the one called for in this scenario. As such, the Intermediate Pathway scenario represents an achievable, intelligent, non-arbitrary approach to addressing the energy requirements for Ohio.

Table 4.1 Annual Contributions to Demand from Wind, Solar, and Efficiency in Intermediate Pathway

Description	Intermediate Pathway	
Year		
2017	3.5%	1.0%
2020	6.5%	1.0%
2026	12.5%	1.0%
2030	13.5%	1.5%
Through 2030	13.5%	16.0%
2009-2026	12.5%	14.2%
SB 221/310	12.5%	22.0%

[6] In 2014, Arizona, California, Hawaii, Massachusetts, Rhode Island, and Vermont saved more than 1.5% of retail sales through energy efficiency. For comparison, Ohio saved 1.05% in 2014.

Annual energy efficiency savings are calculated by multiplying the target percentage of each year by the corresponding annual electricity sales. Industrial and large commercial customers can choose to opt out from utility-run energy efficiency programs, and the sales associated with the opted-out customers are exempted. In other word, not all retail electricity sales are subject to efficiency goals.

Energy Efficiency

Similar to the Accelerated Efficiency Scenario, energy saving contributions from residential, commercial, and industrial players in the Intermediate Pathway scenario are calculated based on program level energy savings data in 2012 and 2013 collected from utility filings with the Public Utilities Commission of Ohio. Chapter 3 contains more details about the energy efficiency contribution from all three sectors, among which the commercial and residential sectors are expected to deliver the majority of the energy efficiency savings, as shown in Figure 4.1. The step-change in the energy efficiency targets are shown as a percentage in the figure for reference.

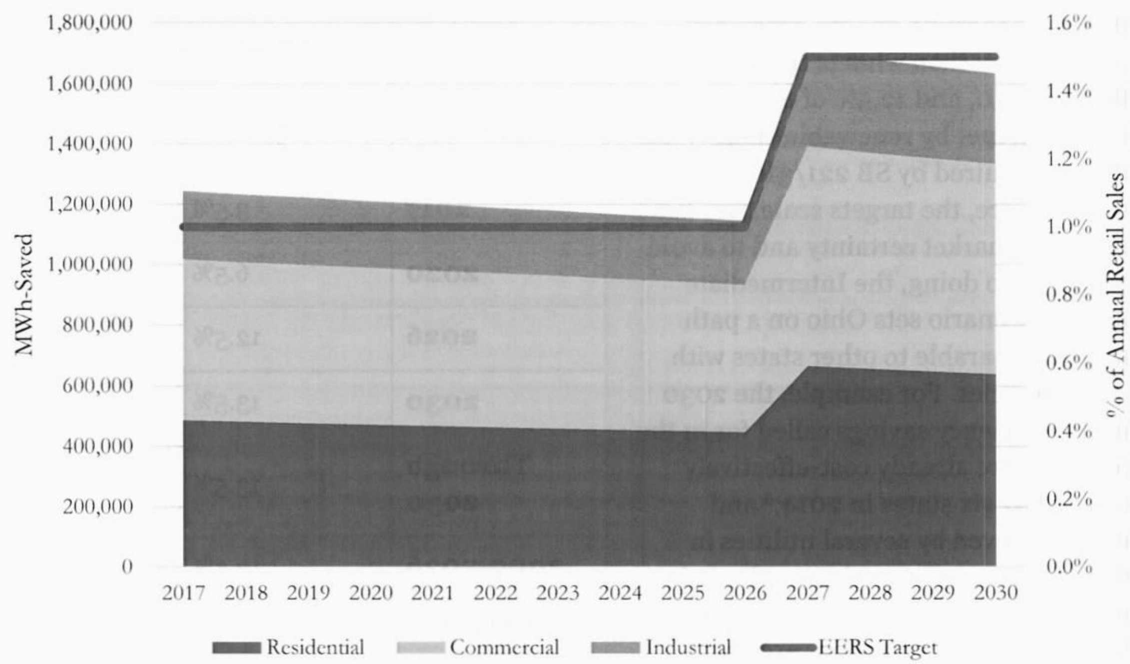


Figure 4.1 Annual Energy Efficiency Targets and Savings under Intermediate Pathway

Renewable Energy

Assuming that wind setback rules are revised, renewable energy growth is driven by utility-scale wind and PV deployment across all sectors. Details on planned installations and existing queues are taken from EIA and the appropriate Ohio regulatory agencies and incorporated into the scenario.

The model shows residential solar installations achieving grid parity in 2018. Until then, residential adoption rates mirror the baseline case, with 15% annual growth rates, albeit from a small base of less than 12 MW initially. After grid parity is achieved, growth increases by 8.3% per year. A similar trend occurs in the Commercial sector, with grid parity occurring in 2020 and resulting in an increase in adoption of 6.25% per year.

In regards to utility-scale PV, installations are driven by load-serving entities' (LSE) demand. Utility-scale installations continue at the same rate in the baseline scenario, growing at between 10% and 20% per year, depending on the level of federal incentives, until 2024 when PV is cheaper than the price of wholesale power plus the additional cost of a solar renewable energy credit (SREC). This is expected to occur when total installed costs of solar PV are under $0.70/W (corresponding to a $0.055-0.06/kWh levelized cost of electricity), at which point in-state solar development is the optimal approach to meeting the renewables requirements.

In the Intermediate Pathway scenario, LSE demand slows for PV even as competitive builds occur in-state; this is due to the continued growth in distributed generation. As a result, the development rate of utility scale projects slows until 2029/2030 when utility-scale PV may be competitive with all resources bidding into the PJM market and becomes the lowest-cost resource to meet daytime demand. In this case, the return of utility-scale PV will be more modest than in the Accelerated Efficiency scenario, at about 20 MW per year. As another difference, DG retains its position as the leading source PV deployment over the entire modeling horizon, with total installed capacity roughly three times larger in the residential and commercial sectors than utility-scale.

In-state wind is deployed at sufficient quantity to satisfy the remaining renewables requirements, after accounting for all other resources (including the purchase of renewable energy credits) and subject to the constraints detailed in Chapter 2. Annual installations range from 200 to 450 MW, averaging about 350 MW per year. Growth in Ohio-based wind development is strong and leads all other resources in deployed capacity, subject to annual variability based on market prices and demand. Given current economics and resource availability, wind represents the majority of renewable energy development in the state. For example, total installed wind capacity in 2030 is 3.9 GW, in comparison to solar's 0.8 GW in the same year. Nevertheless, wind development ceases after 2026 because of a glut in wholesale power markets and falling demand for electricity in Ohio, driven by the progress with energy efficiency and continued economic restructuring.

Renewable Energy Credits

Similar to the prior scenario, the Intermediate Pathway scenario assumes that 33% of Ohio's RPS requirements will be met by RECs. Additional REC purchases are made from 2017-2020 while wind capacity installations recover to pre-2014 levels. SRECs are used to assist in meeting solar targets whenever there is insufficient production in-state and when utility-scale PV is not cost effective against the price of wholesale purchases plus the cost of an SREC. SREC purchases are heaviest between 2018-2023. A summary of contributions by all resources driven by the Intermediate Pathway scenario is provided in Figure 4.2. Contributions from efficiency and renewables satisfy 23.8% of total system demand by 2030 under this scenario.

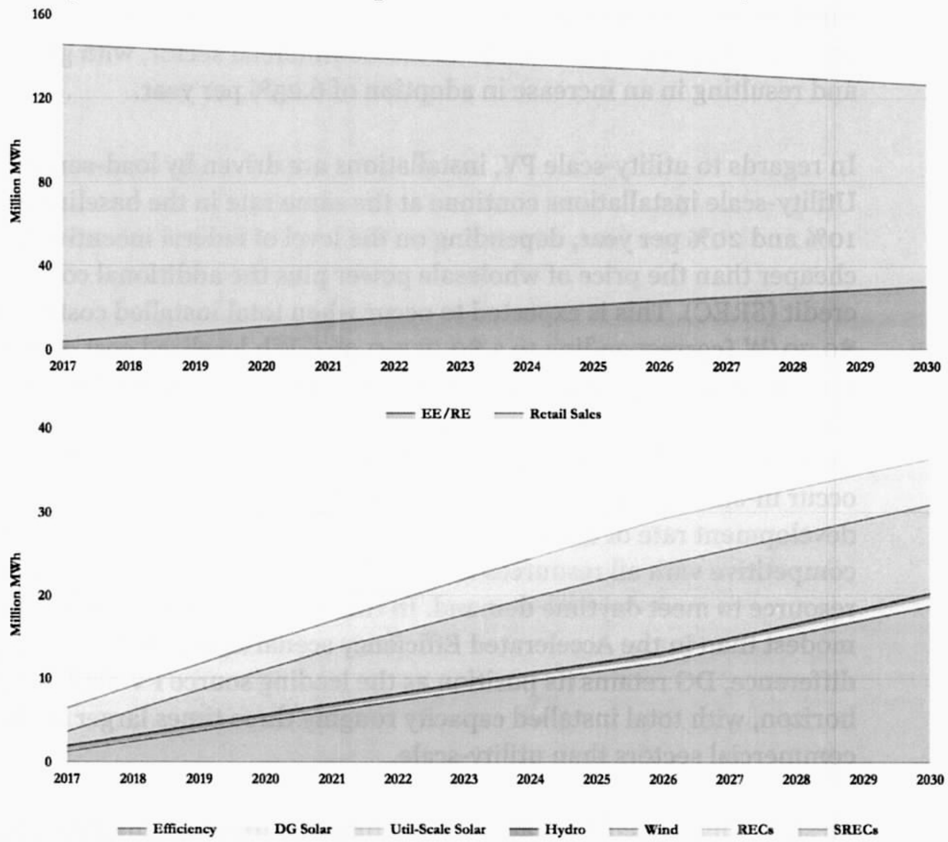


Figure 4.2 Contribution of Efficiency and Renewables to Retail Sales (Top) and Annual Composition of Efficiency and Renewables (Bottom)

Economic Development

Demand for energy efficiency and renewable energy created by the Intermediate Pathway stimulates an increase in investments in energy efficiency and renewable energy services and technologies. Correspondingly, employment providing and producing these services and technologies is expected to increase. Revenues and employment in the power generating sector decline, as efficiency and renewables drive down the consumption of electricity supplied by centralized, non-renewable merchant generation. Using the macroeconomic components of ATHENIA, the economic development impact of the Intermediate Pathway scenario was assessed.

On average, Intermediate Pathway is expected to deliver 6,800 more jobs to Ohio in each year, with the peak employment year occurring in 2018 due to high wind investment, which offsets slightly lower-than-scenario-average projected efficiency investments and a $9 million reduction in solar investment from the baseline for that year. 2027 is the low year in the modeled projection, due to a fall-off in new wind developments.

The calculated impact on Ohio's GDP accounts for gains, tradeoffs losses, indirect, and induced expenditures across all of Ohio's sectors, representing a net impact. On average, the Intermediate Pathway scenario expands Ohio economy by $555 million, compared to the Baseline case; from 2017 to 2030, Intermediate Pathway provides an additional $7.77 billion (2014-$) to the state's GDP.

The aggregate income derived from labor increases by $380 million (2014-$) on average. If these benefits were evenly distributed across the workforce in Ohio, this would amount to an annual increase of $65 per year. 2018 sees the largest increase in net labor income, a $862 million jump from the baseline scenario. Across the modeled horizon, Intermediate Pathway produces a total increase in incomes of $5.3 billion (2014-$). Figure 4.3 shows the employment, GDP, and income impacts.

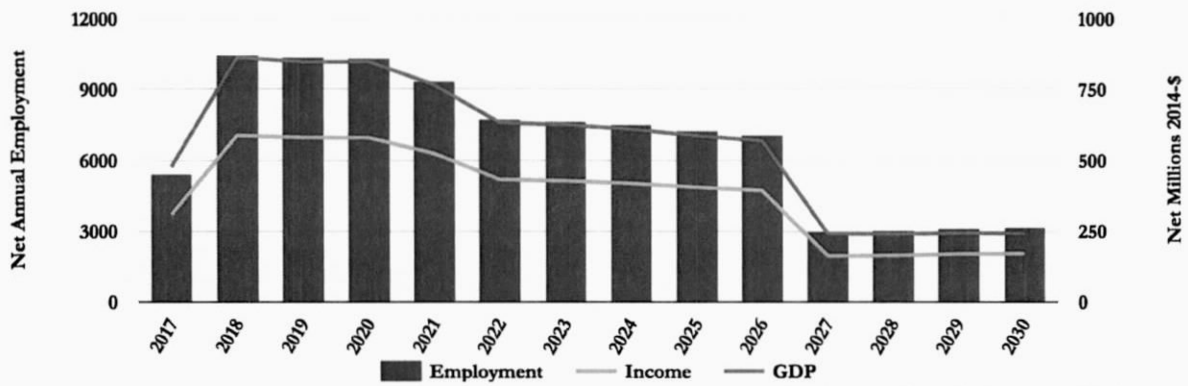


Figure 4.3 Net Jobs, GDP, and Income Impacts for Ohio under Intermediate Pathway

Many of the economic development benefits for Ohio's economic development are felt most-strongly in the early years of the scenario. The remainder of the 2020's are split between two phases, determined largely by the ongoing presence of the RPS' demands compared to only its maintenance; in either case, the scenario continues to provide strong benefits over the baseline scenario. As with the Accelerated Efficiency scenario, these benefits appear positioned for a growth trajectory into the 2030s, as the price, industry maturity, and other factors may combine to show greater market attractiveness in these years. It is worth mentioning that projections of market conditions far into the future are subject to greater uncertainty than the short run implications.

Utility Implications

Besides project developers and financiers, the other major business interests affected by the Intermediate Pathway scenario are the existing electricity market incumbents, which can be grouped into merchant generators and distributors. The following section takes a more in-depth look at the impacts to these participants in the electricity market.

In the Intermediate Pathway scenario, centralized power plants are still the predominant means of electricity generation although the quantity of power demanded by distributors from generators declines. In-state generators do not bear the entirety of the demand reduction, as power purchases from out-of-state suppliers decline as well. Figure 4.4 shows the change in generation coming from centralized power plants in the Intermediate Pathway scenario, relative to the baseline scenario. The rate of reductions in generation from centralized generating resources is relatively constant throughout. By 2030, the Intermediate Pathway scenario shows total net generation values that are 26.4 million MWh lower than in the baseline, a 19.8% difference.

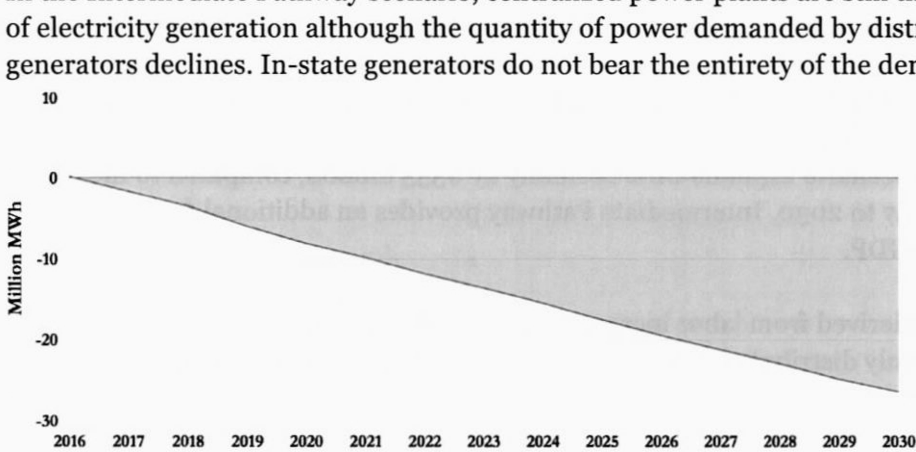


Figure 4.4 Annual Difference in Net Centralized Generation between Intermediate Pathway and Baseline Scenarios

The reductions in centralized power generation have a financial impact in terms of the costs, revenues, and profits collected by the generating companies, as shown in Figure 4.5. In total, the reduction in power plants' utilization results in a significant drop in the cost of operations, shown in black. Annual costs for the centralized generation fleet runs into the several billions of dollars each year; the reduction in demand spurred by the Intermediate Pathway scenario results in a sector-wide 16.5% reduction in these costs, with a value approaching $800 million. Profits are affected as well, however, due to declining sales to distributors, retailers, and other market participants. While the sector still shows profits in the billions, the Intermediate Pathway scenario shows profits that are roughly $400 million less than in baseline, representing an 18.4% reduction.

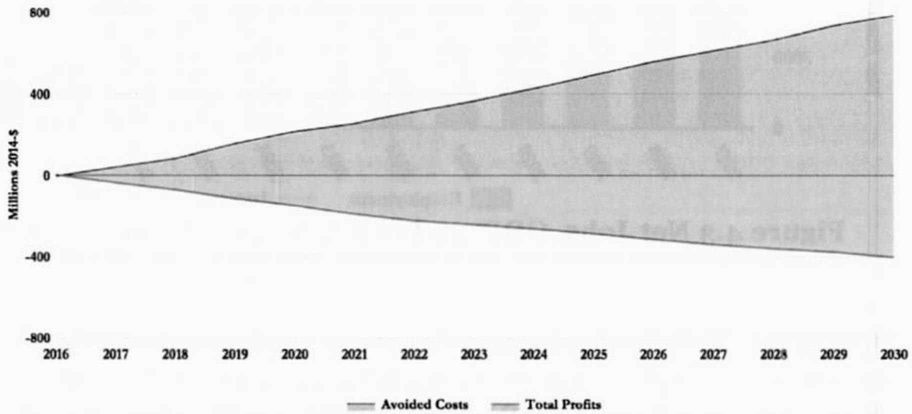


Figure 4.5 Year-to-Year Change in Overall Costs and Profits for Centralized Generation between Intermediate Pathway and Baseline Scenarios

In total, the reduction in demand from the Intermediate Pathway scenario has the effect of lowering costs, revenues, and profits for producers competing in this marketplace. Similar to the prior scenario, the market becomes more economically efficient in this scenario than in the baseline, producing generally-better average outcomes.

Load Serving Entities (LSEs)

More productive uses of electricity through efficiency and more on-site generation spurs a reduction in power purchases for the LSEs, from both in-state and out-of-state generators. This, in turn, results in savings to the LSEs as power expenditures decline. While the reduction of in-state power purchases represents a transfer payment for Ohio, the reduction in out-of-state power purchases is a benefit to the state. In addition, substantial transmission and distribution costs are avoided, which represent the single-largest savings category for the LSEs over the modeled horizon, with a discounted value of about $320 million in 2030.

As Figure 4.6 makes clear, the Intermediate Pathway scenario is a net benefit for the LSEs, presenting an opportunity for a discounted net present value of $729 million through 2030, and with net benefits showing continue room for upward growth, despite the costs to the LSEs. The costs include lost revenues and program and administrative costs (including any costs from the purchase of RECs or SRECs). Early in the modeling period, these are substantial enough to exceed the benefits provided to the state's LSEs by the scenario, with 2022 representing a turning point.

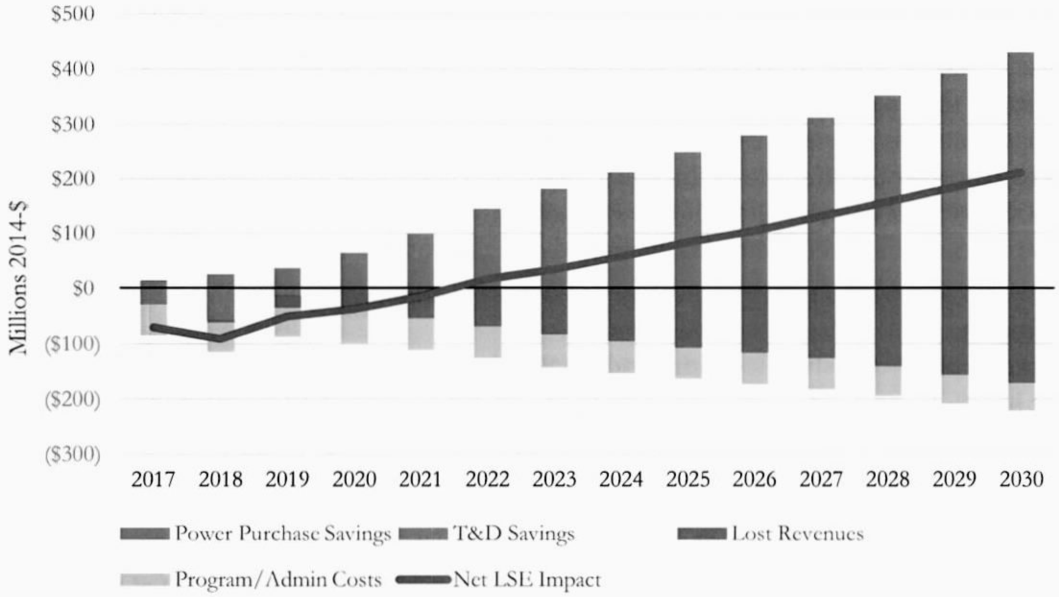


Figure 4.6 Net Present Value of Intermediate Pathway Scenario to Ohio's LSEs

Consumer Implications

The previous chapter articulated important consumer implications of the scenario, such as electricity bills, public health, water consumption, etc. This section unpacks the Intermediate Pathway Scenario's impact on these indicators.

A typical utility-run energy efficiency program usually requires investment from both the utility and consumers in order to install energy-efficient equipment. In Ohio, the average lifetime of the equipment installed through these programs exceeds a decade, and can be as long as two decades in some cases. To account for savings that accrue beyond the first year of the investment, the savings from efficiency efforts are carried forward, applying industry standard equipment-performance degradation rates.[7] This provides a good picture of the real bill impacts experienced by customers as a result of engaging with utility-provided energy efficiency programs.

Bill Impacts

Early costs in transmission and distribution (T&D) spurred by renewed wind development, incurred costs of renewable energy credits, and falling revenues from retail sales due to energy efficiency, create conditions where LSEs are expected to raise rates faster than consumption falls, resulting in a short-term increase in electricity bills. However, as more energy efficiency penetrates the market, T&D investments move from a cost to a benefit as capital investments are deferred and O&M costs decline, and the energy savings are more than capable of producing bill reductions for the average customer in the state. These savings, in contrast, are long-lived; by 2030, the discounted present value of the Intermediate Pathway scenario on electricity bills in Ohio is $28.8 million (2014-$) (Figure 4.7). This means that over the lifetime of the equipment installed in the Intermediate Pathway scenario, Ohioan's electricity bills will fall. However, the Intermediate Pathway represents the least bill savings of the three scenarios evaluated as a part of this report.

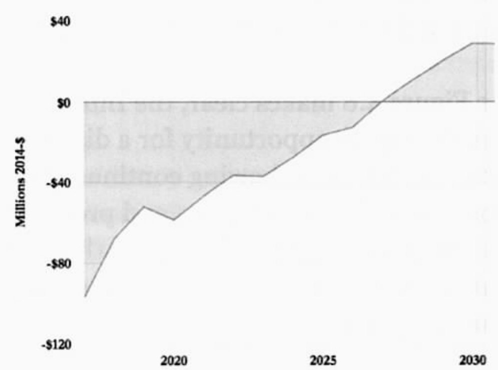


Figure 4.7 Annual Bill Impact of Intermediate Pathway Compared to Baseline

Health Impacts

The generating characteristics, location, and stack height of power plants are critical in assessing the public health impacts of electricity generation. An advanced public health econometrics database is utilized to assess these costs and the impacts of a change in generation choices (see Chapter 2 for more information). Ohio's coal-heavy generating fleet creates billions in public health costs that are borne by citizens. This level of damages means that policies that impact these generation sources also can have a significant health impact by changing the amount of emissions caused by electricity generation in the state. The annual present value of public health benefits derived from the Intermediate Pathway scenario is consistently growing over time, and exceeds $1 billion from 2023 onward. This represents thousands of avoided asthma attacks,

---

[7] For example, Brown et al report 5% annual degradation rates on average. Brown M A, Wolfe A, Bordner R, Goett A, Kreitler V and Moe R. 1996. *Persistence of DSM Impacts: Methods, Applications, and Selected Findings* EPRI TR-106193 (Oak Ridge, TN: Oak Ridge National Laboratory and Synergic Resources Corporation for the Department of Energy and Electric Power Research Institute).

heart attacks, pulmonary issues, and other illnesses that would have occurred under the baseline scenario. Figure 3.8 shows the trajectory of public health benefits, mapping the bill savings from Figure 3.7 alongside. While the bill savings are worthwhile, the public health benefits in each year is more significant than the cumulative value of the bill savings, as the public health savings are more than three orders of magnitude greater than the bill savings. The combined net present value of Intermediate Pathway to Ohio consumers is over $14 billion by 2030.

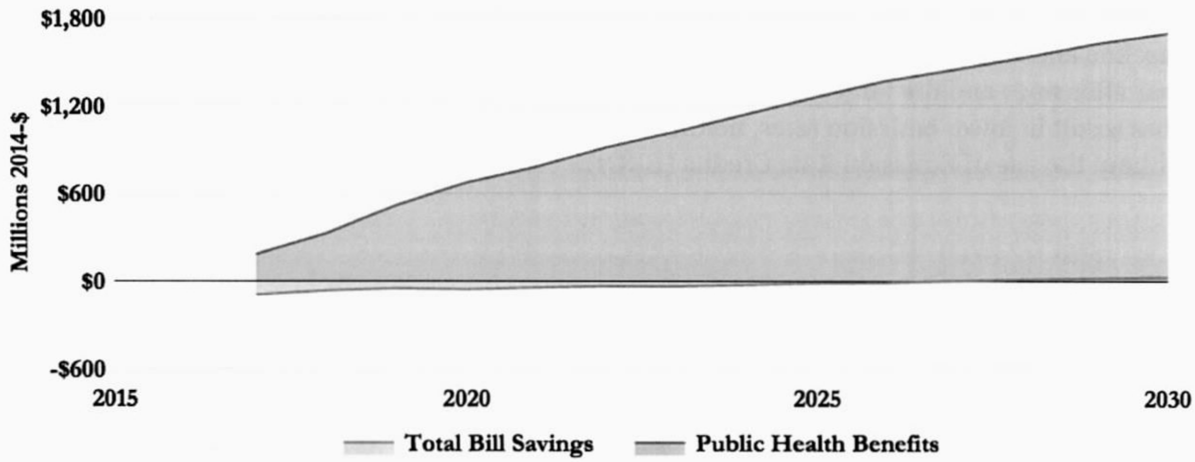


Figure 4.8 Financial Benefits of Intermediate Pathway on Ohio Consumers

Implications for the Clean Power Plan

The Final Rule of the US Environmental Protection Agency's Clean Power Plan (CPP) gives states several ways to reduce the CO_2 emissions from their existing, covered electricity generating units (EGU) in order to achieve compliance. The major distinctions are between an approach that reduces the quantity of emissions (mass-based) and an approach that reduces the emissions per MWh (rate-based). Conditions within each state, the type of generation assets covered by the rule, policy preferences, and a host of other considerations dictate which approach each state will ultimately take.

Figure 4.11 shows the impact of Intermediate Pathway on CPP compliance in a mass-based system. A value above the line represents over-achieving of the CPP target established for the state; below the line is falling short of the targets. In each year, Intermediate Pathway performs

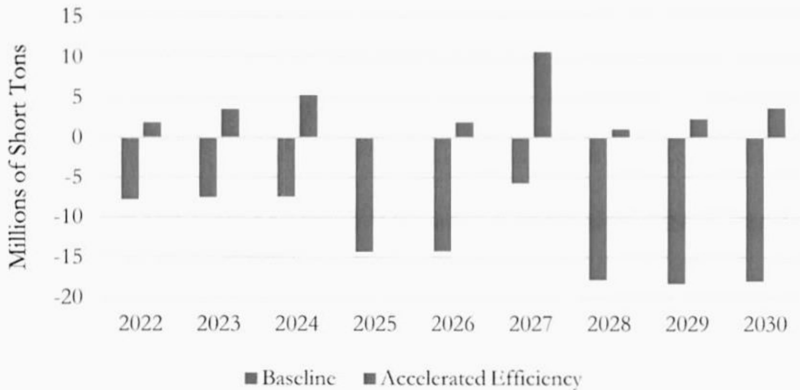


Figure 4.11 CPP Mass-Based Compliance under Intermediate Pathway and Baseline

better than the EPA targets, enabling Ohio EGUs to bank allowances for future years or trade them; allowances become a new commodity and potential income stream for the electricity generating sector in Ohio. On the other hand, the baseline scenario misses the target every year, and would require Ohio to purchase allowances from out-of-state entities, increasing costs at the same time sales decline.

An alternative to the mass-based approach is the rate-based approach. Ohio appears to have a more-difficult time achieving the rate-based targets. Figure 4.12 shows the emission rates in the baseline and Intermediate Pathway scenarios, as well as the target established by EPA for each year after 2021 and the target deficit for each scenario. While the Intermediate Pathway scenario does result in lower emission rates, neither scenario is capable of achieving annual compliance without the use of Emission Rate Credits (ERCs).

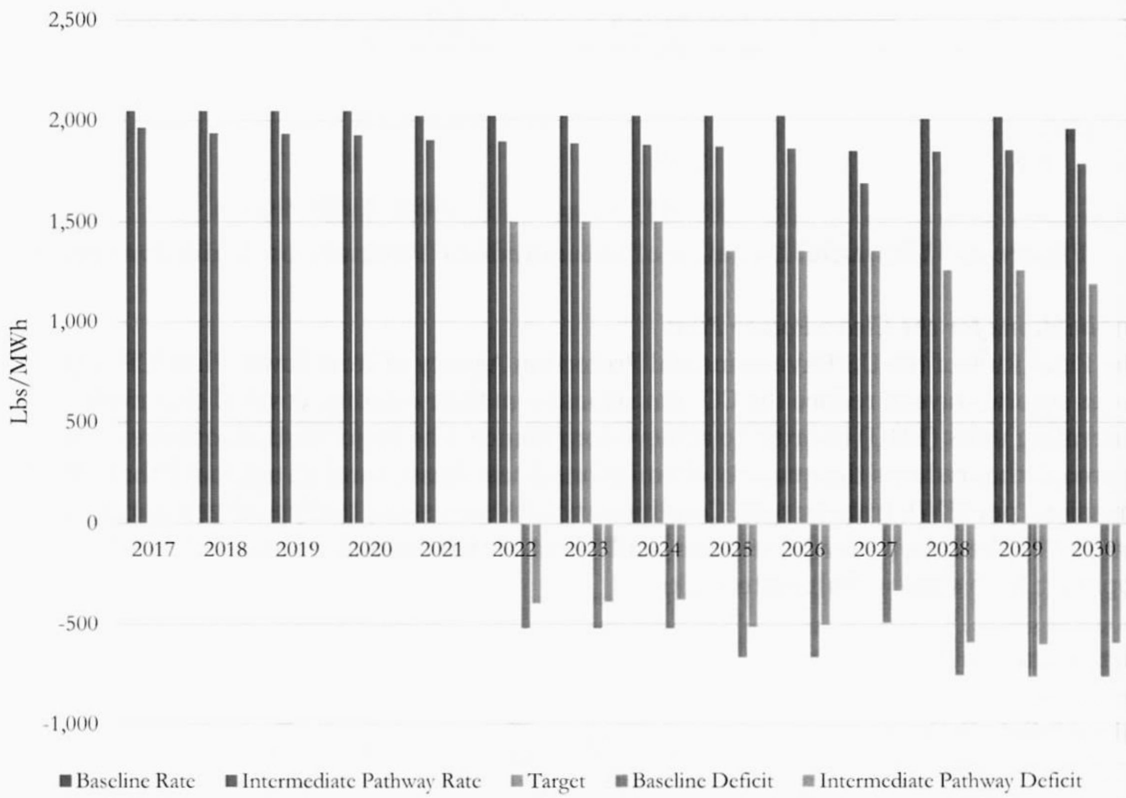


Figure 4.12 Emission Rates and Deficits in Achieving CPP Compliance without ERCs

Similar to the production of allowances in the mass-based approach, the rate-based pathway allows companies to create and bank ERCs in order to reduce the effective rate of CO_2 emissions from covered units. The Intermediate Pathway scenario results in the production of a significant number of ERCs through renewables, energy efficiency, the carbon attributes of RECs, and a small additional quantity provided through gas-shift ERCs. On the other hand, the baseline scenario generates very few ERCs that can be used to assist with the 2030 deadline. The quantity of ERCs required for the annual targets along with those banked and available for use is detailed in Figure 4.13. The figure includes the assumption that Ohio-based EGU operators will bank ERCs for the 2030 deadline as opposed to selling them on the market. Through the retirement of ERCs, the Intermediate Pathway scenario will be able to meet the rate-based target in 2030, with a surplus of ERCs available for future use. The baseline scenario, even after considering the use of all ERCs produced up until 2030, will fail to meet the 2030 requirements.

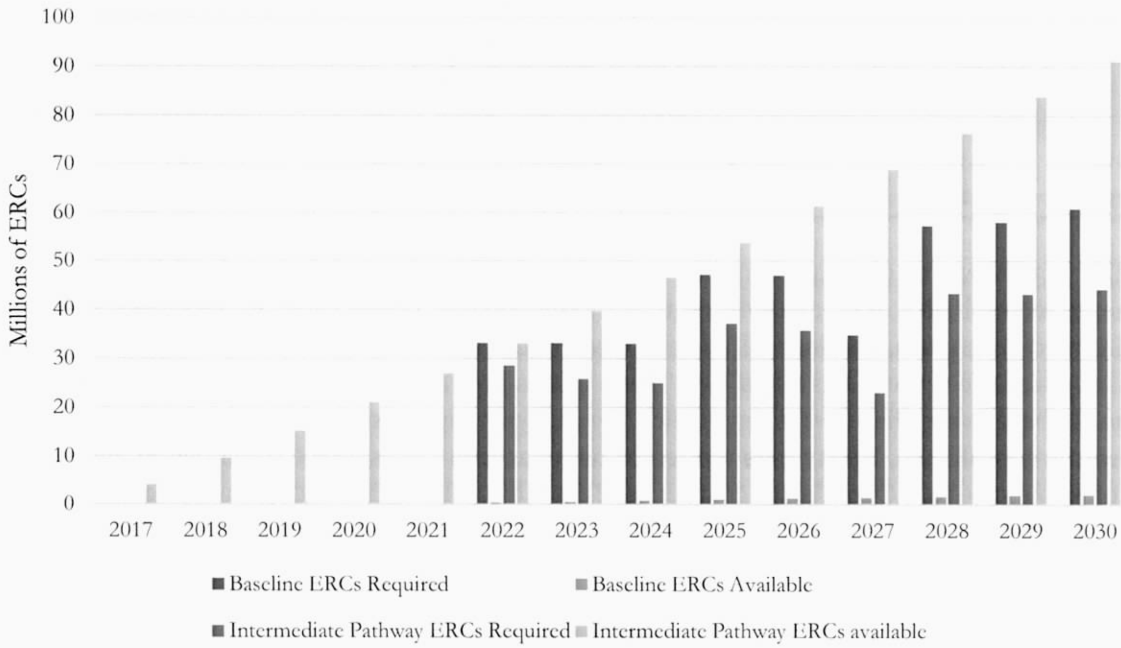


Figure 4.13 ERCs Required and Available for Rate-Based Compliance

If the Clean Power Plan is upheld and implemented, the Intermediate Pathway scenario is poised to position Ohio for compliance. With the mass-based approach, compliance is achievable without using the banked allowances in any year, with remaining allowances becoming monetizable and producing income for industry. Under a rate-based approach, compliance is also achievable with the Intermediate Pathway scenario, but will require the state to retire some emission rate credits that accrued during the 2020s. The decision to sell remaining credits will not be straightforward, given compliance requirements through the 2030s; banked ERCs from the 2020s would likely be exhausted in the early 2030s, suggesting that the mass-based approach represents an easier means of compliance. Regardless of approach, the baseline scenario is consistently non-compliant with the CPP.

Cost-Benefit Analysis

The Intermediate Pathway scenario incurs costs and provides benefits relative to the baseline scenario that have been detailed in the earlier sections of this chapter. Here, these costs and benefits will be tabulated and the cost-effectiveness of the scenario will be presented, following the procedure laid out in Chapters 2 and 3.

Table 4.2 shows the benefits against the baseline scenario in 2020 and 2030 from energy bills, public health from reduced emissions, reduced power purchases, and utility costs. While all categories provide benefits eventually, not all are positive at all times - for example, utility costs see a slight increase through 2020, which is offset by savings through 2030 and beyond. Benefits to Ohio exceed $1 billion in 2020, and grow to about $17 billion through 2030.

Table 4.2 Societal Benefits from Intermediate Pathway (Million $-2014)

Year	Energy Bill Savings	Public Health Savings	Lower Purchases	Net Reduced Utility Costs	Total Annual Benefits	Cumulative Benefits
2020	-$ 58.6	$ 671	$ 46.6	$ 18.3	$ 677	$ 1,470
2030	$ 28.8	$ 1,700	$ 108	$ 323	$ 2,160	$ 16,800

Table 4.3 shows the costs against the baseline scenario in 2020 and 2030 from investments in energy technologies, fees, charges, regulatory compliance, utility program incentive and administrative costs, and lost utility revenues. Since Intermediate Pathway reduces compliance costs, these are reported as negatives. These values are reported assuming that Ohio is utilizing a mass-based compliance strategy, which the analysis suggests would be the easiest path towards compliance. Utility revenues continue to accrue losses as the full effect of efficiency and renewables are felt. Cumulative costs exceed $4 billion through 2020, growing to $12.5 billion through 2030.

Table 4.3 Cumulative Societal Cost from Intermediate Pathway (Million $-2014)

Year	Investment Costs	Net Compliance Costs	Program and Administrative Costs	Utility Lost Revenues	Total Annual Costs	Cumulative Costs
2020	$ 933	-	$ 61.4	$ 172	$ 1,170	$ 4,100
2030	$ 182	$ (71.4)	$ 49.4	$ 438	$ 598	$ 12,500

The total cost-effectiveness of the Intermediate Pathway scenario is presented in Table 4.4. As the renewables industry recovers and energy efficiency investments increase, economic costs outweigh benefits through 2020. Benefits grow rapidly through the 2020s as those investments begin to yield returns, public health improves, and utility operating costs decline. Bill savings and reduced compliance costs also begin to contribute significantly to the impacts of the Intermediate Pathway scenario in later years. Overall, the scenario shows a benefit-cost ratio of 1.35, meaning that for every dollar spent, the model projection suggests a $1.35 return, with net benefits rising to $4.4 billion, suggesting that the Intermediate Pathway scenario represents a significant, cost-effective improvement in the economic wellbeing of the people and businesses in Ohio when compared to the baseline, where the RPS and EERS requirements remain frozen indefinitely.

Table 4.4 Cost Effectiveness of Intermediate Pathway

Year	B/C Ratio	Net Benefits (Million $-2014)
2020	0.36	-$ 2,630
2030	**1.35**	**$ 4,370**

The Intermediate Pathway scenario improves the economic situation for Ohio, both in the economic sense and in the development sense. The policy is cost-effective and provides a net benefit of $4.4 billion dollars while also adding $7.8 billion to state GDP and providing employment opportunities to an average of 6,800 people per year. The scenario is also capable of bringing Ohio into compliance with the Clean Power Plan, and depending on the approach selected, adding value streams to the state. The standards within Intermediate Pathway are achievable, with several states in the country already requiring, achieving, and surpassing such requirements. This analysis shows that within the Intermediate Pathway scenario, economic development, clean energy, and a carbon-constrained future can co-exist and yield benefits to Ohioans for decades to come.

5. Expanded Renewables

The Expanded Renewables scenario has a greater emphasis on the use of renewable energy as resource for meeting energy demands in Ohio. This chapter begins with a detailed description of the Expanded Renewables scenario, which is followed by the impacts on economic development, electricity demand, electricity supply and the utilities, bill savings, public health, water resource use, and implications for the Clean Power Plan. Finally, the chapter concludes with a look at Ohio's benefit-cost analysis and the economic development indicators projected for the Expanded Renewables scenario.

Detailed Description

The Expanded Renewables scenario models the deployment of renewables as growing to provide 19.5% of the state's electricity by 2030. The scenario also uses energy efficiency to provide the same service with less energy consumption in Ohio, resulting in a 10.3% reduction in total demand by 2030 (Table 4.1). Through 2026, 19.5% of electric generation is met by renewable energy, instead of the 12.5% required by SB221/SB310, and electricity sales are reduced by 9.2% as a result of increased energy-efficiency. As with the previous scenarios, the resource targets scale over time to provide market certainty and to avoid shocks. As a result, the targets in the Expanded Renewables scenario place Ohio firmly in the mainstream of energy policies other states have already adopted and, in many cases, achieved. For example, the 2030 annual efficiency savings called for in the scenario were already achieved by sixteen states in 2014[8], including Ohio. It should also be noted that these efficiency targets are lower than called for in current Ohio law. Twenty-one US states and territories have more aggressive renewable portfolio standards than the one called for in this scenario, with a number of them having also already exceeded these goals. As such, the Expanded Renewables scenario represents an achievable, moderate, non-arbitrary approach to meeting Ohio's energy needs.

Table 5.1 Annual Contributions to Demand from Wind, Solar, and Efficiency in Expanded Renewables

Description	Expanded Renewables	
Year		
2017	3.5%	0.5%
2020	7.5%	0.5%
2026	19.5%	0.5%
2030	19.5%	1.0%
Through 2030	19.5%	10.3%
2009-2026	19.5%	9.2%
SB 221/310	12.5%	22.0%

[8] In 2014, Arizona, California, Connecticut, Hawaii, Illinois, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Ohio, Oregon, Rhode Island, Vermont, and Washington saved more than 1.0% of retail sales through energy efficiency. Ohio saved 1.05% in 2014.

Annual energy efficiency savings are calculated by multiplying the target percentage of each year by the corresponding annual electricity sales. As with the other scenarios, not all retail electricity sales are subject to efficiency goals due to existing opt-out provisions in efficiency programs.

Energy Efficiency

The energy saving contributions from each sector are calculated using the same methodologies detailed in Chapters 2 and 3. As a result, the commercial and residential sectors are expected to deliver the majority of the energy efficiency savings, as shown in Figure 5.1. The step-change in the energy efficiency targets are shown as a percentage in the figure for reference.

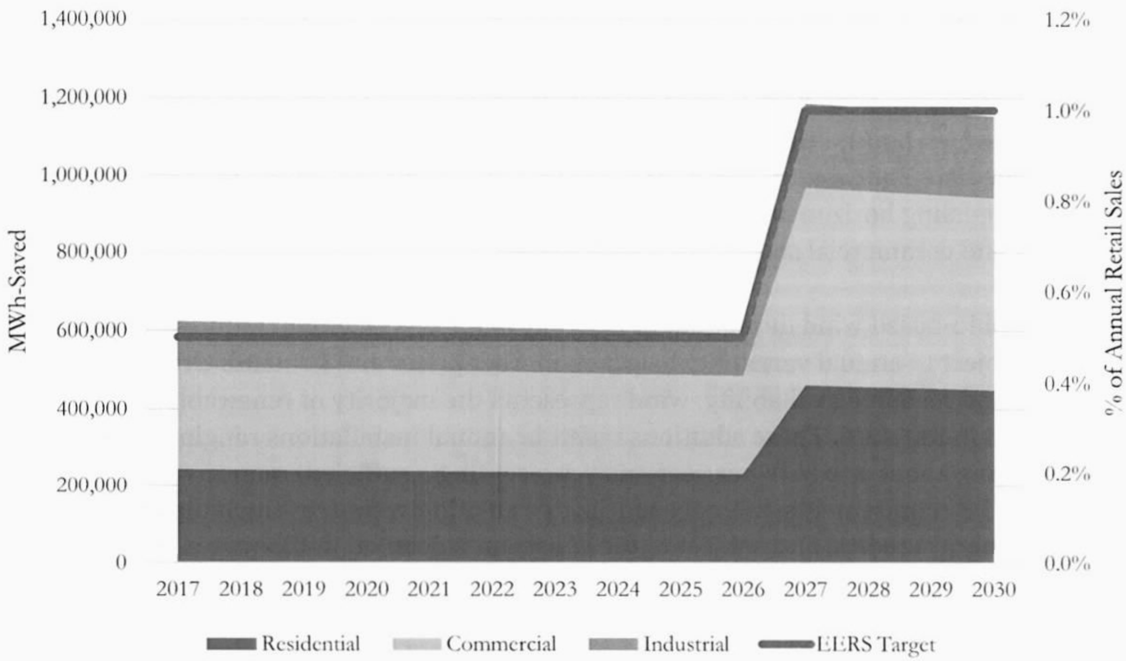


Figure 5.1 Energy Efficiency Targets and Savings under Expanded Renewables Scenario

Renewable Energy

Assuming that wind setback rules are revised, renewable energy growth is driven primarily by utility-scale wind. Details on planned installations and existing queues are taken from EIA 923, EIA 860 and the appropriate Ohio regulatory agencies and incorporated into the scenario.

The model shows residential solar installations achieving grid parity in 2018. Until then, residential adoption rates mirror the baseline case, with 15% annual growth rates, starting from a relatively small base of less than 12 MW. After grid parity is achieved, growth increases by 8.3% per year. A similar trend occurs in the Commercial sector, with grid parity occurring in 2020 and resulting in an increase in adoption of 6.25% per year.

In regards to utility-scale PV, installations are driven by load-serving entities' (LSE) demand. Utility-scale installations continue at the same rate in the baseline scenario, growing between 10% and 20% per year, depending on the level of federal incentives, until 2024 when PV is cheaper than the price of wholesale power plus the additional cost of a solar renewable energy credit (SREC). This is expected to occur when total installed costs of solar PV are under $0.70/W (corresponding to a $0.055-0.06/kWh levelized cost of electricity), at which point in-state solar development is cheaper than alternative approaches to the solar requirements. Since the model incorporates a delay for new projects to enter the marketplace after viability is achieved, one year after this benchmark is cleared, more utility-scale projects can be brought online to meet the demand for solar from LSEs.

Due to continued growth in distributed resources, LSE demand falls despite in-state utility-scale PV becoming the least-cost non-DG solar resource. As a result, the development rate of utility scale projects slows until 2029/2030 when utility-scale PV may be competitive with all resources bidding into the PJM market and becomes the lowest-cost resource to meet daytime demand. At which point, utility-scale PV installations will increase at about 40 MW per year. As with Intermediate Pathway, DG retains its position as the leading source PV deployment over the entire modeling horizon, with total installed capacity roughly 2.5 times larger in the residential and commercial sectors than utility-scale.

Growth in Ohio-based wind development is strong and leads all other resources in deployed capacity, subject to annual variability based on market prices and demand. Given current economics and resource availability, wind represents the majority of renewable energy development in the state. These additions result in annual installations ranging from 200 to 750 MW, averaging about 450 MW per year and representing a sufficient quantity to satisfy the remaining RPS requirements, after accounting for all other resources (including the purchase of renewable energy credits) and subject to the constraints detailed in Chapter 2. The final total installed wind capacity in 2030 is 6.6 GW, in comparison to solar's 0.9 GW in the same year. Despite the large disparity, wind's growth trajectory is the opposite of solar's - wind development stalls following 2026, due to a glut in wholesale power markets and falling demand for electricity in Ohio, driven primarily by the expanded efforts in efficiency.

Renewable Energy Credits

The scenario assumes that RECs will be used to meet 33% of the requirements in each year, as shown by historical behaviors. Additional REC purchases are made from 2017-2020 while wind capacity installations recover to pre-2014 levels. SREC purchases are heaviest between 2018-2023. A summary of contributions by all resources driven by the Expanded Renewables scenario is provided in Figure 5.2. Under the Expanded Renewables scenario, energy from efficiency and renewables satisfy 22.1% of total system demand by 2030 making a significant contribution to the energy future of Ohio.

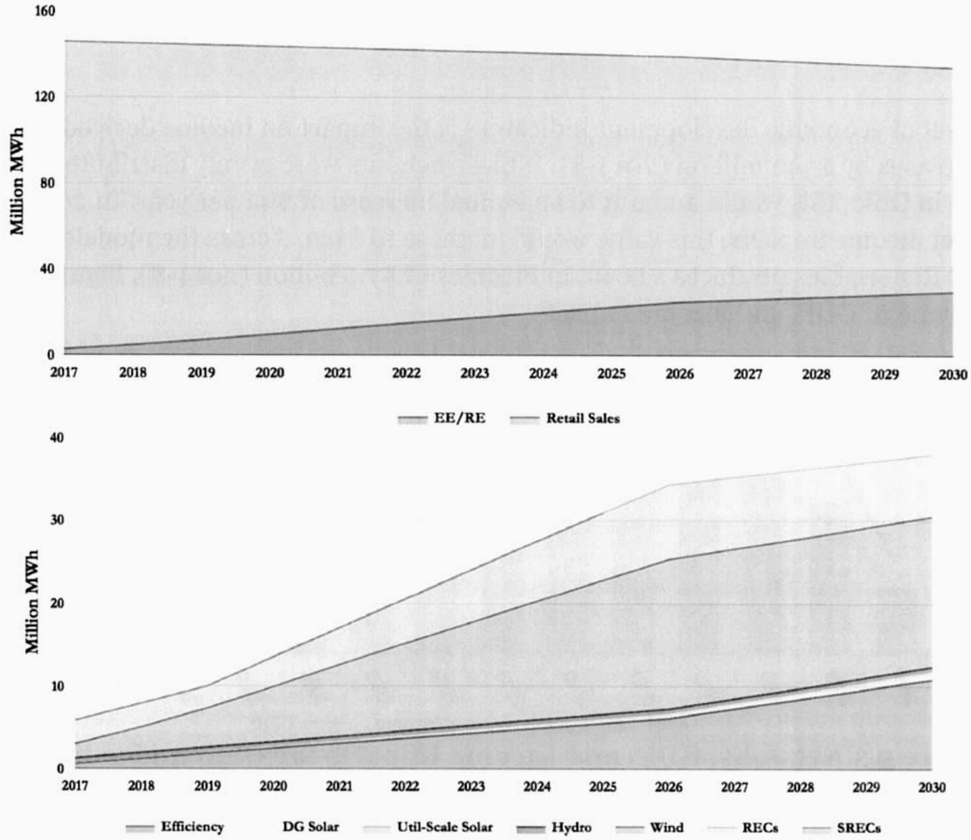


Figure 5.2 Contribution of Efficiency and Renewables to Retail Sales (Top) and Annual Composition of Efficiency and Renewables (Bottom)

Economic Development

Expanded Renewables increases demand for energy efficiency and renewable energy. Correspondingly, employment providing and producing these services and technologies is expected to increase. With falling consumption of non-renewable merchant generation, revenues and employment in that sector of the economy decline. Using the macroeconomic components of ATHENIA, the economic development of the Expanded Renewables scenario was assessed.

On average, Expanded Renewables is expected to deliver an increase in 9,700 jobs in Ohio in each year over the modeling horizon. In 2021, employment peaks, corresponding with a peak in wind investments. Increased employment is lowest in 2027 resulting from an achievement of the RPS goals and a drop-off in wind development due to sufficiently-supplied wholesale markets.

Ohio's GDP is also affected, both positively and negatively, by these changes in electricity generation. On average, the Expanded Renewables scenario delivers a net gain of $767 million to Ohio's GDP than the Baseline case; from 2017 to 2030, Expanded Renewables provides an additional $10.7 billion (2014-$) to the state's GDP. The minimum and the maximum years closely correspond with the employment effects, with 2027 being the minimum and 2021 being the maximum.

The final set of economic development indicators is the impact on income derived from labor, which increases by $542 million (2014-$). If these benefits were evenly distributed across the workforce in Ohio, this would amount to an annual increase of $92 per year. In 2021, the top year for net income impacts, this value would increase to $143. Across the modeled horizon, Expanded Renewables produces a boost in incomes of $7.6 billion (2014-$). Figure 5.3 shows the employment, GDP, and income impacts.

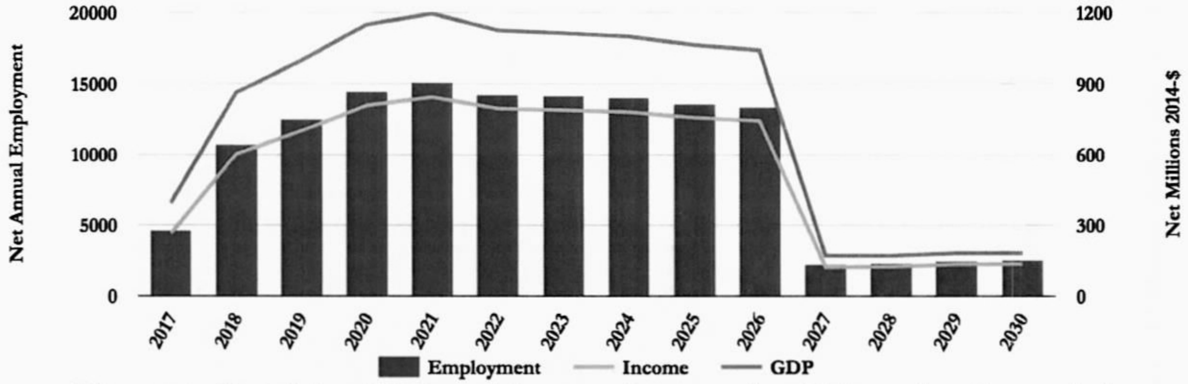


Figure 5.3 Net Jobs, GDP, and Income Impacts for Ohio under Expanded Renewables

As shown in figure 5.3, many of the benefits for Ohio's economic development are felt most-strongly during the years that the RPS is growing. The remainder of the 2020s are relatively stable and continue to provide strong benefits over the baseline scenario; the effect of the RPS targets being achieved and then only maintained is clearly visible. Despite this slowdown in the late 2020s, the market appears poised for a resurgence in the 2030s, as price, industry maturity, and other factors may combine to show greater market attractiveness in these years. However, projections of market conditions far into the future are subject to greater uncertainty than the short run implications.

Utility Implications

In addition to gains made by project developers and financiers, the other major sector affected by the Expanded Renewables scenario is the existing electricity market incumbents, which can be grouped into merchant generators and distributors. The following section takes an in-depth look at the impacts to these participants in the electricity market.

Generation from large, centralized power plants remain the predominant means of meeting electricity demand in Ohio in the Expanded Renewables scenarios. It does, however, reduce the quantity of power demanded by distributors from generators and from out-of-state suppliers.

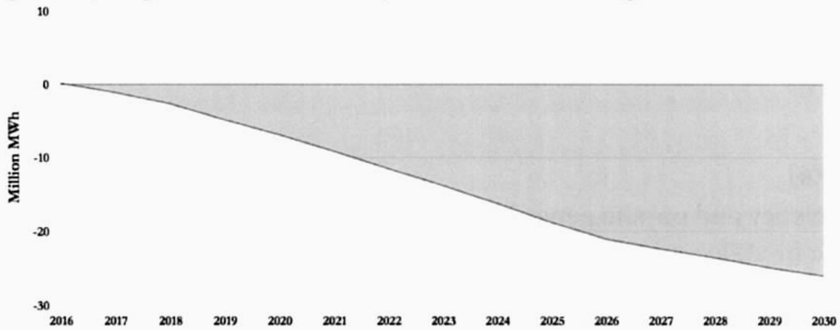


Figure 5.4 Annual Difference in Net Centralized Generation between Expanded Renewables and Baseline Scenarios

Figure 5.4 shows the difference in generation flowing from centralized power plants in the Expanded Renewables scenario, relative to the baseline scenario. The rate of reductions in generation from centralized generating resources is relatively constant throughout. By 2030, the Expanded Renewables scenario shows total net generation values that are 26 million MWh lower than in the baseline, a 19.7% difference.

The reductions in generation have a financial impact for the costs, revenues, and profits collected by the companies that operate these centralized electricity generating resources. The cost and profit implications are displayed in Figure 5.5. In total, the reduction in utilization results in a significant drop in the cost of operations, shown in black. Annual costs for the centralized generation fleet runs into the several billions of dollars each year; the reduction in demand spurred by the Expanded Renewables scenario results in a sector-wide 16.4% reduction in these costs, with a value approaching $800 million. Profits are affected as well, however, due to declining sales to distributors, retailers, and other market participants. While the sector still shows profits in the billions, the Expanded Renewables scenario shows profits that are roughly $390 million less than in baseline, representing an 17.9% reduction.

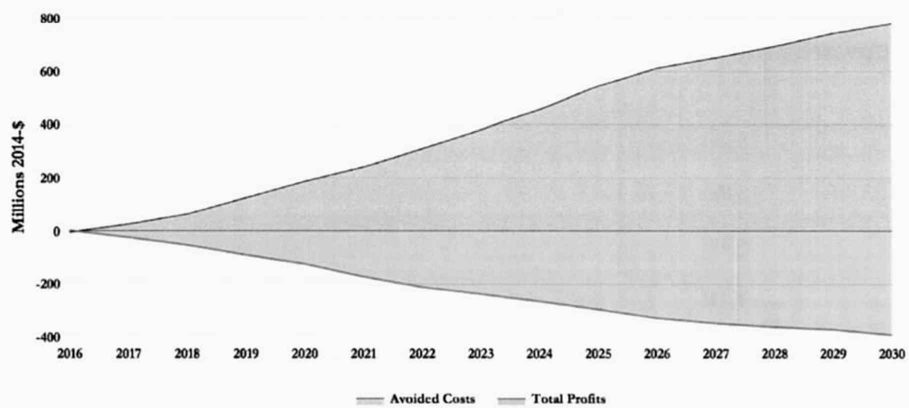


Figure 5.5 Year-to-Year Change in Overall Costs and Profits for Centralized Generation between Expanded Renewables and Baseline Scenarios

In total, the reduction in demand from the Expanded Renewables scenario has the effect of lowering costs, revenues, and profits for producers competing in this marketplace. The market becomes more economically efficient in this scenario than in the baseline, with competition for sales increasing and profit margins narrowing. Enhanced competition leads to lower prices for customers, and lower demand translates into lower maintenance costs for the electric grid as a whole.

Load Serving Entities (LSEs)

The greater use of energy efficiency and on-site generation results in a reduction in power purchases for LSEs, from both in-state and out-of-state generators. This, in turn, results in savings to the LSEs as power expenditures decline. While the reduction of in-state power purchases represents a transfer payment for Ohio, the reduction in out-of-state power purchases is a benefit to the state. In addition, substantial transmission and distribution costs are avoided, which represent the single-largest savings category for the LSEs over the modeled horizon, with a discounted value of about $350 million in 2030.

As with the previous scenarios, there are costs to the LSEs as well. These costs take the form of lost revenues as well as program and administrative costs (including any costs from the purchase of RECs or SRECs). Early in the modeling period, these costs are substantial enough to exceed the benefits provided by greater adoption of energy efficiency and renewables for LSEs. However, by 2019, the benefits outweigh the costs. As shown in Figure 5.6, the Expanded Renewables scenario is a net benefit for the LSEs, presenting an opportunity for a discounted net present value of $1.8 billion through 2030, and with net benefits showing continue room for upward growth.

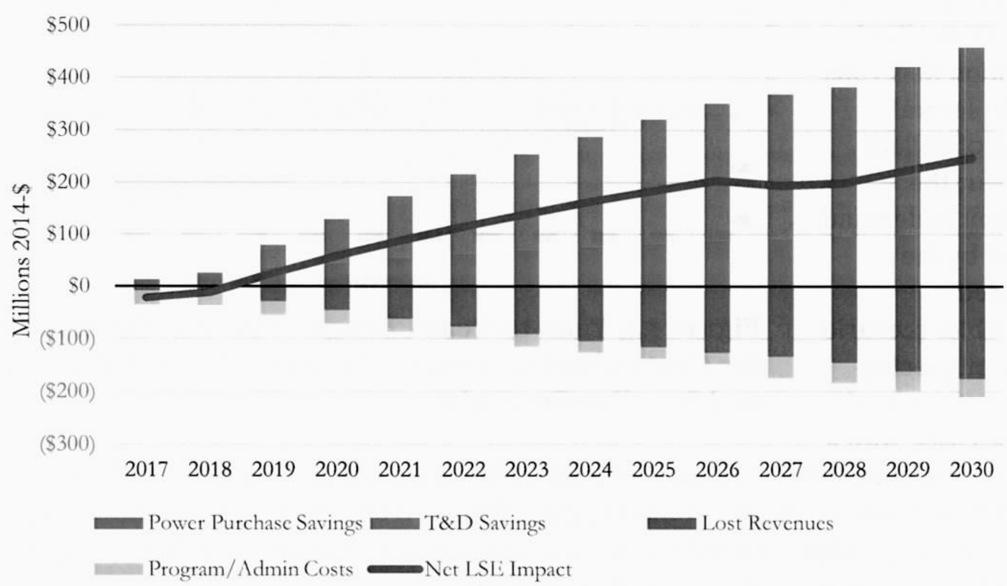


Figure 5.6 Net Present Value of Expanded Renewables Scenario to Ohio's LSEs

Consumer Implications

Several aspects of electricity policy options deliver significant variation from the baseline for individual residents and businesses of Ohio. One area of particular importance is the impact on electricity bills. Another is the public health implication of these policy options; increased emissions typically result in greater public health cost borne by citizens, and vice versa. Lastly, natural resources are consumed as a result of producing electricity if certain technologies are used to meet market demand, including increasingly-stressed water resources, where assigning a price is not as easy.

Bill Impacts

When modeling the long-term impacts of energy efficiency investments, it is important to capture the both the short and long-term impacts of customer investments. It is common for customers to have a match requirement in order to receive energy efficiency services and benefits from utility efficiency programs. This is typically the inverse of the percentage of the incentive the utility provides. Once this investment is made, the equipment is installed, where, on average, it provides savings over the other technologies that would have likely been purchased without the incentive from the utility. In Ohio, the average lifetime of the equipment installed through these programs exceeds a decade, and some studies suggest useful equipment lifetimes may reach twenty years. To account for the long-term savings that accrue beyond the first year of the investment, efficiency efforts carried forward, applying industry standard equipment-performance degradation rates.[9] By doing so, the model provides a clearer picture of the real bill impacts experienced by customers as a result of engaging with utility-provided energy efficiency programs.

While investments in energy efficiency equipment will decrease customer consumption, this must be measured against projections in customer rates. Early costs in transmission and distribution (T&D) spurred by renewed wind development, incurred costs of renewable energy credits, and falling revenues from retail sales due to energy efficiency, create conditions where LSEs are expected to raise rates faster than consumption falls, resulting in a short-term increase in electricity bills. As more energy efficiency penetrates the market, T&D investments move from a cost to a benefit as capital investments are deferred and O&M costs decline, and the energy savings are more than capable of producing bill reductions for the average customer in the state. These savings are long-lived; the discounted present value of the Expanded Renewables scenario on electricity bills in Ohio is $51 million (2014-$) (Figure 5.7). This means that over the lifetime of the equipment

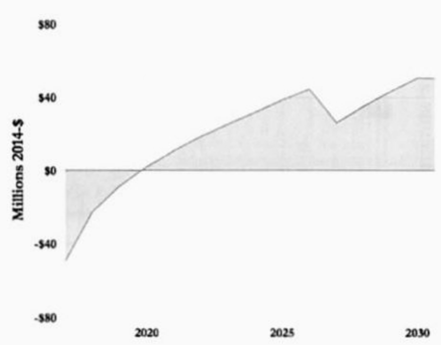


Figure 5.7 Annual Bill Impact Expanded Renewables Compared to Baseline

[9] For example, Brown et al report 5% annual degradation rates on average. Brown M A, Wolfe A, Bordner R, Goett A, Kreitler V and Moe R. 1996. *Persistence of DSM Impacts: Methods, Applications, and Selected Findings* EPRI TR-106193 (Oak Ridge, TN: Oak Ridge National Laboratory and Synergic Resources Corporation for the Department of Energy and Electric Power Research Institute).

installed in the Expanded Renewables scenario, Ohioans' electricity bills will decline. Expanded Renewables represents the largest bill savings opportunity of any scenario in this report.

Health Impacts

The generating characteristics, location, and stack height of power plants are critical in assessing the public health impacts of changes in electricity generation. An advanced public health econometrics database is utilized to assess the costs and the impacts of a change in generation choices (see Chapter 2 for more information). Ohio has a coal-intensive power supply, much of which is located near population centers. As a result, Ohio currently has high public health costs associated with electricity generation. This level of damages means that policies that impact these generation sources also can have a significant positive health impact by decreasing the amount of emissions generated by power plants in the state. The annual present value of public health benefits derived from the Expanded Renewables scenario consistently grows over time, and exceeds $1 billion from 2023 onward. This $1 billion benefit is comprised of thousands of avoided asthma attacks, heart attacks, pulmonary issues, and other illnesses that would have occurred otherwise under the baseline scenario. Figure 5.8 shows the trajectory of public health benefits, mapping the bill savings from Figure 5.7 alongside. While the bill savings are worthwhile, the public health benefits in half of the years are more significant than the cumulative value of the bill savings, as the public health savings are much greater than the bill savings. The cumulative net present value of Expanded Renewables to Ohio consumers is over $14 billion by 2030.

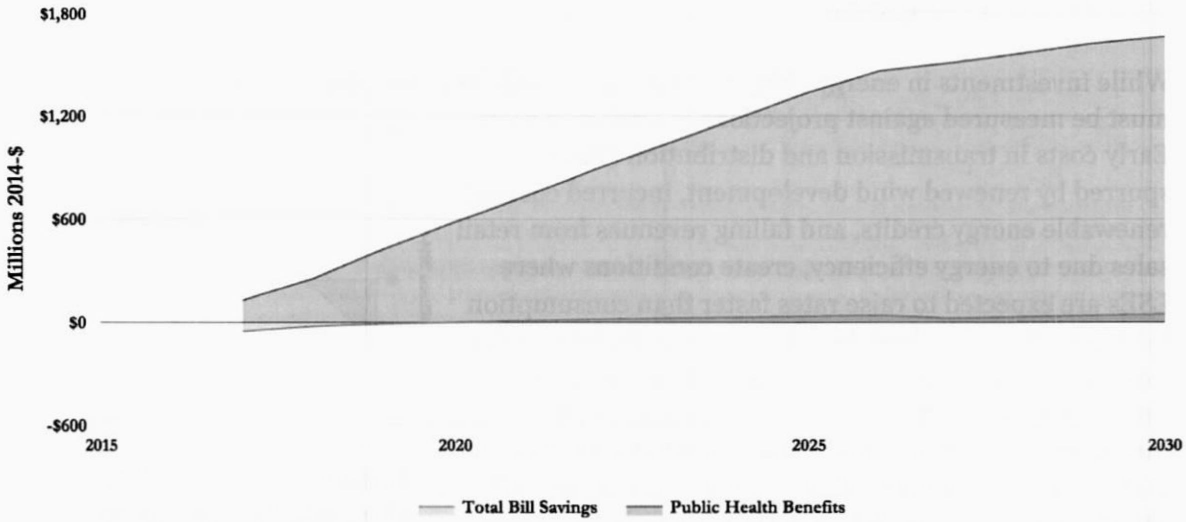


Figure 5.8 Financial Benefits of Expanded Renewables on Ohio Consumers

Implications for the Clean Power Plan

The Final Rule of the US Environmental Protection Agency's Clean Power Plan (CPP) allows states several options to reduce the CO_2 emissions from their existing, covered electricity generating units (EGU) in order to achieve compliance. The major distinction is between an approach that reduces the quantity of emissions (mass-based) and an approach that reduces the emissions per MWh (rate-based). Conditions within each state, the type of generation assets covered by the rule, policy preferences, and a host of other considerations dictate which approach each state will ultimately take.

Figure 5.11 shows the impact of Expanded Renewables on CPP compliance in Ohio under a mass-based approach. A value above the line represents over-achieving of the CPP target established for the state; below the line is falling short of the targets. In each year, Expanded Renewables performs better than the EPA targets (if only barely, as is the case in 2025), enabling Ohio EGUs to bank allowances for future years or trade them in the marketplace. The Expanded Renewables scenario produces a new commodity and income stream for the electricity generating sector in Ohio. In contrast, the baseline scenario misses the target every year, and would require Ohio to purchase allowances from other out-of-state actors, draining the state and the sector of resources as demand for electricity is projected to decline.

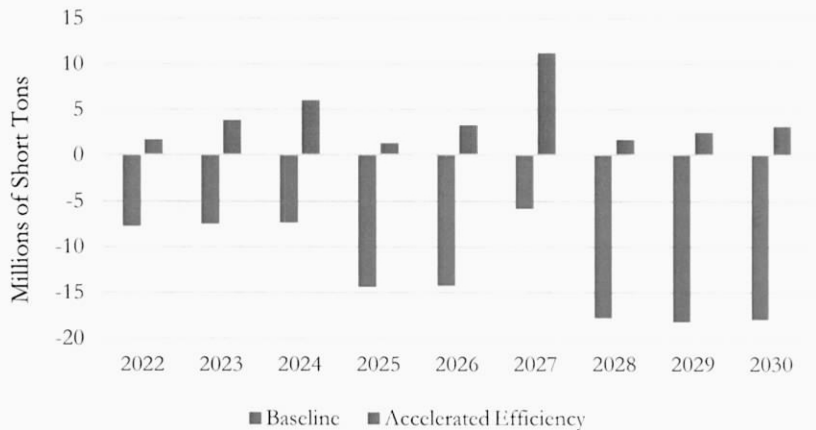


Figure 5.11 CPP Mass-Based Compliance under Expanded Renewables and Baseline

Ohio could choose to pursue a rate-based pathway instead of a mass-based approach. Figure 5.12 shows the emission rates in the baseline and Expanded Renewables scenarios, as well as the target established by EPA for each year after 2021. In addition, the deficit in hitting the target is also shown. Ohio appears to have a more-difficult time achieving the rate-based targets. While the Expanded Renewables scenario does result in lower emission rates, neither scenario is capable of achieving annual compliance without the use of Emission Rate Credits (ERCs).

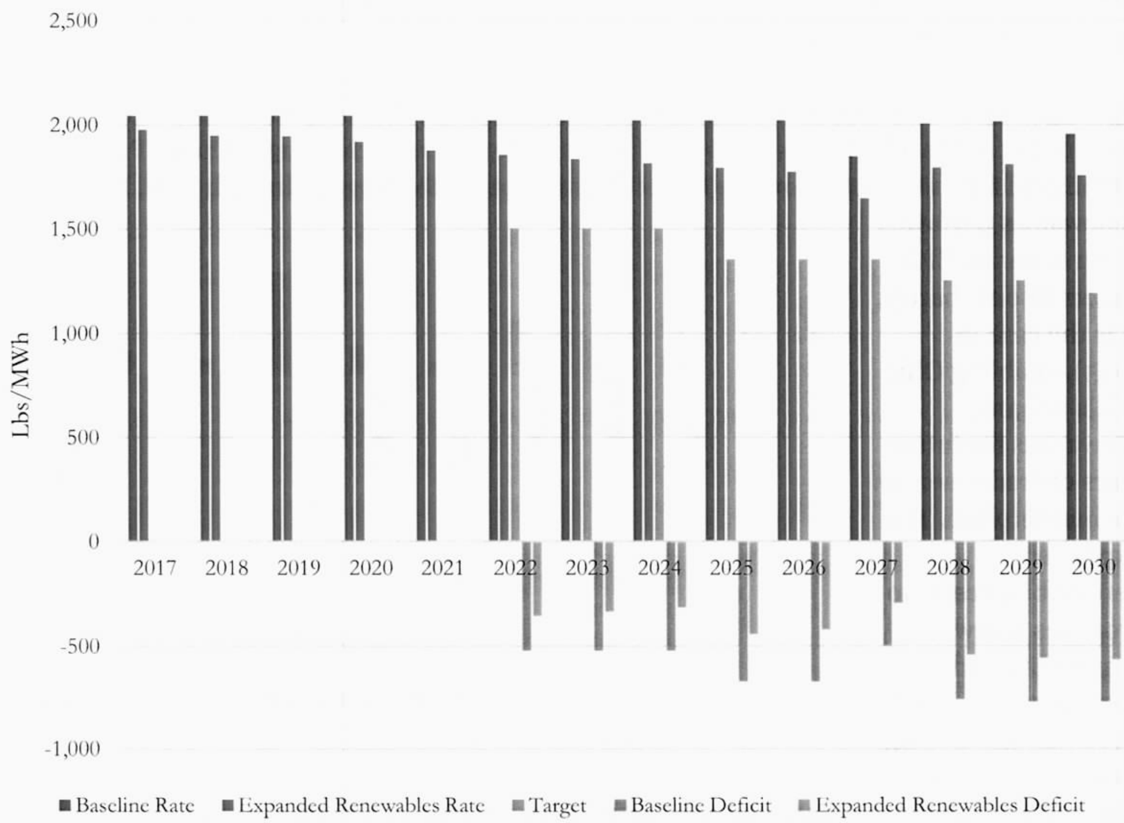


Figure 5.12 Emission Rates and Deficits in Achieving CPP Compliance without ERCs

The rate-based pathway does allow for the creation and banking of ERCs in order to reduce the effective rate of CO_2 emissions from covered units. The Expanded Renewables scenario results in the production of a significant number of ERCs through renewables, energy efficiency, the carbon attributes of RECs, and a small additional quantity provided through gas-shift ERCs. On the other hand, the baseline scenario generates very few ERCs that can be used to assist with the 2030 regulatory deadline. Figure 5.13 details this trajectory over time, showing the difference between the scenario and the quantity of ERCs required in order to comply with the EPA-established annual CPP targets. The figure embeds the assumption that Ohio-based EGU operators will bank ERCs for the 2030 deadline as opposed to selling them on the market. The implication of that choice is that, through the retirement of ERCs, the Expanded Renewables scenario will be able to meet the rate-based target in 2030, with a surplus of ERCs available for future use. The baseline scenario, even after considering the use of all ERCs produced up until 2030, will fail to meet the 2030 requirements.

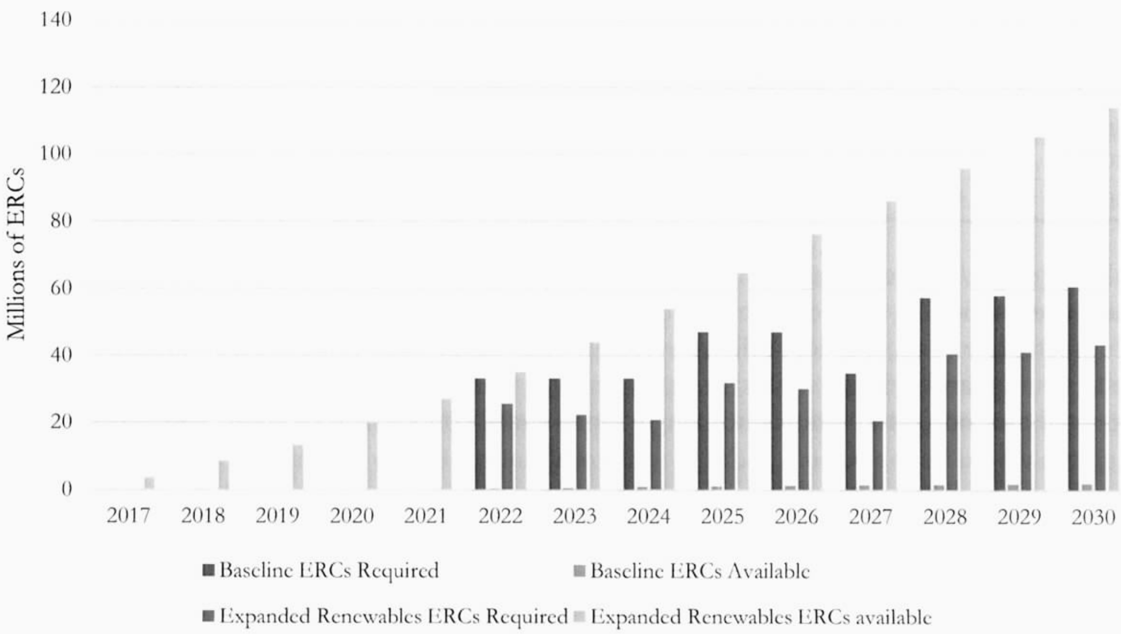


Figure 5.13 ERCs Required and Available for Rate-Based Compliance

If the Clean Power Plan is upheld and implemented, the Expanded Renewables scenario is poised to position Ohio for compliance. With the mass-based approach, compliance is achievable without using the banked allowances in any year, suggesting that the allowances remaining will have the opportunity to be monetized and produce an additional income stream for industry. Under a rate-based approach, compliance is also achievable with the Expanded Renewables scenario, but will require the state to retire some emission rate credits that accrued during the 2020s. The decision to sell remaining credits will not be straightforward, given compliance requirements through the 2030s; banked ERCs from the 2020s would likely be exhausted in the early 2030s, suggesting that the mass-based approach represents an easier means of compliance. The baseline scenario does not approach compliance with the CPP.

Cost-Benefit Analysis

The Expanded Renewables scenario incurs a set of costs and provides a set of benefits relative to the baseline scenario that have been detailed in the earlier sections of this chapter. Here, these costs and benefits will be tabulated and the cost-effectiveness of the scenario will be presented, using a 3% discount rate, as in the other scenarios.

Table 5.2 shows the benefits against the baseline scenario in 2020 and 2030 from energy bills, public health from reduced emissions, reduced power purchases, and utility costs. Benefits to Ohio exceed $1.5 billion in 2020, and grow to more than $18 billion through the lifetime of the energy efficiency equipment installed as a result of the policy.

Table 5.2 Societal Benefits from Expanded Renewables (Million $-2014)

Year	Energy Bill Savings	Public Health Savings	Lower Purchases	Net Reduced Utility Costs	Total Annual Benefits	Cumulative Benefits
2020	$ 1.96	$ 583	$ 45.1	$ 83.4	$ 713	$ 1,580
2030	$ 50.9	$ 1,670	$ 105	$ 354	$ 2,180	$ 18,200

Table 5.3 shows the costs against the baseline scenario in 2020 and 2030 from investments in energy technologies, fees, charges, regulatory compliance, utility program incentive and administrative costs, and lost utility revenues. Since Expanded Renewables *reduces* compliance costs, the Expanded Renewables scenario changes this category to a benefit. These values are reported assuming that Ohio is utilizing a mass-based compliance strategy, which the analysis suggests would be the easiest path towards compliance. Utility revenues continue to accrue losses as the full effect of efficiency and renewables are felt. Costs approach $4.5 billion through 2020, growing to $15.3 billion through 2030.

Table 5.3 Societal Cost from Expanded Renewables (Million $-2014)

Year	Investment Costs	Net Compliance Costs	Program and Administrative Costs	Utility Lost Revenues	Total Annual Costs	Cumulative Costs
2020	$ 1,270	-	$ 25.7	$ 180	$ 1,480	$ 4,430
2030	$ 134	-$ 69.8	$ 35.7	$ 442	$ 542	$ 15,300

Having reviewed these benefit and cost streams, the cost-effectiveness of the Expanded Renewables scenario is presented in Table 5.4. As the renewables industry recovers and energy efficiency investments increase, economic costs outweigh benefits through 2020. Benefits grow rapidly through the 2020s as those investments begin to yield returns, public health improves, and utility operating costs decline. Overall, the scenario shows a benefit-cost ratio of 1.19, meaning that for every dollar spent, the model projection suggests a $1.19 return. Perhaps more importantly, the net benefits are $2.9 billion, suggesting that the Expanded Renewables scenario represents a significant, cost-effective improvement in the economic well being of the people and businesses in Ohio when compared to the baseline, where the RPS and EERS requirements remain frozen indefinitely.

Table 5.4 Cost Effectiveness of Expanded Renewables

Year	B/C Ratio	Net Benefits (Million $-2014)
2020	0.36	-$ 2,850
2030	**1.19**	**$ 2,890**

The Expanded Renewables scenario improves the economic situation for Ohio, both in the economic sense and in the development sense. The policy is cost-effective and provides a net benefit of $2.9 billion dollars while also adding $10.7 billion to state GDP and providing employment opportunities to an average of 9,700 people per year. The scenario is also capable of bringing Ohio into compliance with the Clean Power Plan, and depending on the approach selected, adding value streams to the electric power sector. The standards within Expanded Renewables are achievable, with several states in the country already requiring, achieving, and surpassing such requirements. As with the other scenarios, this analysis shows that the Expanded Renewables scenario presents yet another way that economic development, clean energy, and a carbon-constrained future can co-exist and yield benefits to Ohioans for decades to come.

6. Comparative Analysis and Conclusions

Scenario Comparisons

The three scenarios evaluated through the previous chapters have shown variations and convergence in several areas of interest for policymakers by emphasizing different approaches to meeting the electricity demands of Ohio's businesses and residents. Each of these scenarios deviate from the prescriptions of SB 221/310, although all are more conservative in the pursuit of energy efficiency, as summarized in the table below. Efficiency is producing savings that range from 9.2% (Expanded Renewables) to 16.7% (Accelerated Efficiency) in 2026; renewables range from 10% (Accelerated Efficiency) to 19.5% (Expanded Renewables), with the Intermediate Pathway falling in-between on both counts.

Table 6.1 Electricity Demand Met by Resource and Scenario

Description	Accelerated Efficiency		Intermediate Pathway		Expanded Renewables	
Year						
2017	3.5%	1.0%	3.5%	1.0%	3.5%	0.5%
2020	6.5%	1.3%	6.5%	1.0%	7.5%	0.5%
2026	10.0%	1.5%	12.5%	1.0%	19.5%	0.5%
2030	11.0%	1.5%	13.5%	1.5%	19.5%	1.0%
Through 2030	11.0%	18.5%	13.5%	16.0%	19.5%	10.3%
2009-2026	10.0%	16.7%	12.5%	14.2%	19.5%	9.2%
SB 221/310	12.5%	22.0%	12.5%	22.0%	12.5%	22.0%

Policymakers have interests in the quantity of renewable energy and energy-efficiency established by the standards, both annually and cumulatively. The three scenarios evaluate a range of reasonable approaches in the service of providing data and information for policymakers to consider towards the goal of designing a set of non-arbitrary benchmarks. To this end, policymakers could draw several conclusions from the study:

- Maximize Long-Term Economic Benefits – All three scenarios meet the traditional policy goals of improving the economic position of Ohioans over a baseline case. A policymaker might then pick the option that creates the largest economic benefit for the state. The Accelerated Efficiency scenario is the winner here, producing $5.0 billion in net benefits by 2030, compared to $4.3 billion and $2.9 billion for Intermediate Pathway and Expanded Renewables scenarios, respectively. Accelerated Efficiency also has the best benefit-cost ratio of the three, making it the most cost-effective scenario. The primary reason for the Accelerated Efficiency scenario having larger lifetime economic benefits is a higher investment in energy efficiency.
- Maximize Economic Development in Ohio – All three scenarios also increase employment, payroll, and GDP over the baseline case. However, the Expanded

Renewables scenario produces the most near-term economic impact, with about 132,000 new jobs through 2030 and a $10 billion cumulative addition to GDP. In comparison, while Accelerated Efficiency has the best overall long-term benefits, its short term employment impact is less at about 78,000 new jobs through 2030, and a cumulative GDP impact of $6.4 billion.

- Maximize Short-Term Economic Benefits, Minimize Short-Term Bill Impacts – Taking the same policy goals, but with a shorter time horizon, the Expanded Renewables scenario may appeal to some policymakers. By 2020 and 2030, the Intermediate Pathway and Expanded Renewables have comparable total net benefits as Accelerated Efficiency. However, Expanded Renewables shows the lowest near-term bill impacts due to the private sector's willingness to invest in renewables.
- CPP Compliance Achieved in Mass-Based Method - Cumulative amounts of renewable energy and energy-efficiency should put Ohio on a path to compliance with the CPP. Each of the tested scenarios puts Ohio on a path towards achieving CPP compliance in 2030. However, there is little room for further reduction in energy efficiency or renewable energy deployment. For this reason, policymakers should be wary of additional reductions without careful testing of the impact on CPP compliance.

The annual pathways for each scenario reveal that Accelerated Efficiency is, on average, delivering slightly more clean energy to Ohio than the other two scenarios. Intermediate Pathway is the second-most productive on this front, despite outright leading the state in clean energy delivery in 2022. Expanded Renewables is strongest relative to the other scenarios between 2023 and 2028, peaking in 2026 with a 1.5 million MWh lead driven by wind generation. When credit purchases are factored in, Expanded Renewables shows the greatest amount of clean energy production originating from anywhere in the country, accounting for 338 million MWh over the modeling horizon (Figure 6.1).

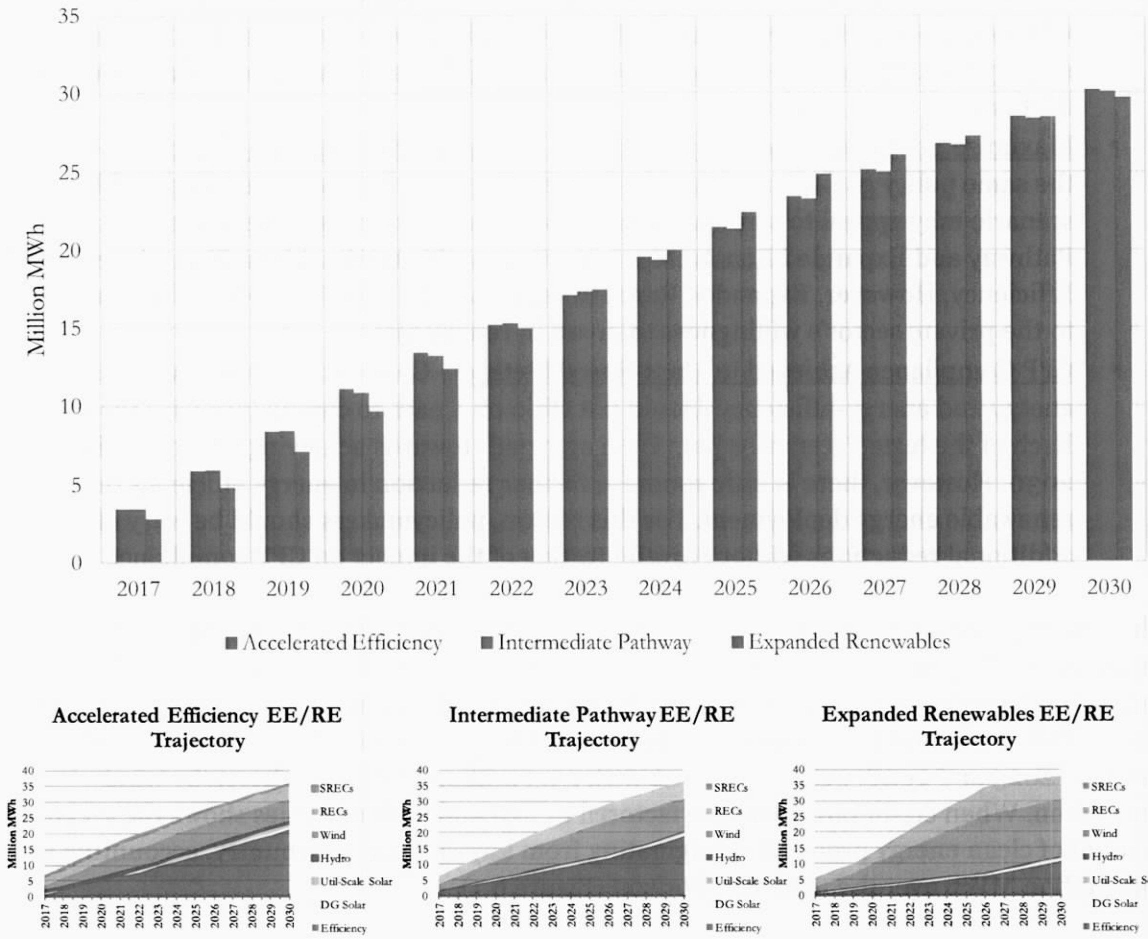


Figure 6.1 Clean Energy Production in Ohio (top) and in Total (Bottom)

Employment effects are more stable and similar for the Accelerated Efficiency and Intermediate Pathway scenarios than for Expanded Renewables. Net employment effects are positive in each year for all scenarios, indicating that all three scenarios would increase employment in the state above and beyond the baseline scenario. Renewable energy and energy-efficiency implementation serves as a significant driver of employment, most notably in the Expanded Renewables scenario, where employment increases by 12,700 per year. After 2026, when the standards are no longer serving to drive economic development in the state forward, energy efficiency investments become the primary source of employment. As a result, Accelerated Efficiency shows greater employment effects in the post-2026 time frame. Income and GDP effects, as related measures to employment, show similar trends, with all scenarios outperforming the baseline that lacks the EERS/RPS components. Expanded Renewables shows the potential to increase state GDP by more than $750 million per year, on average (Figure 6.2).

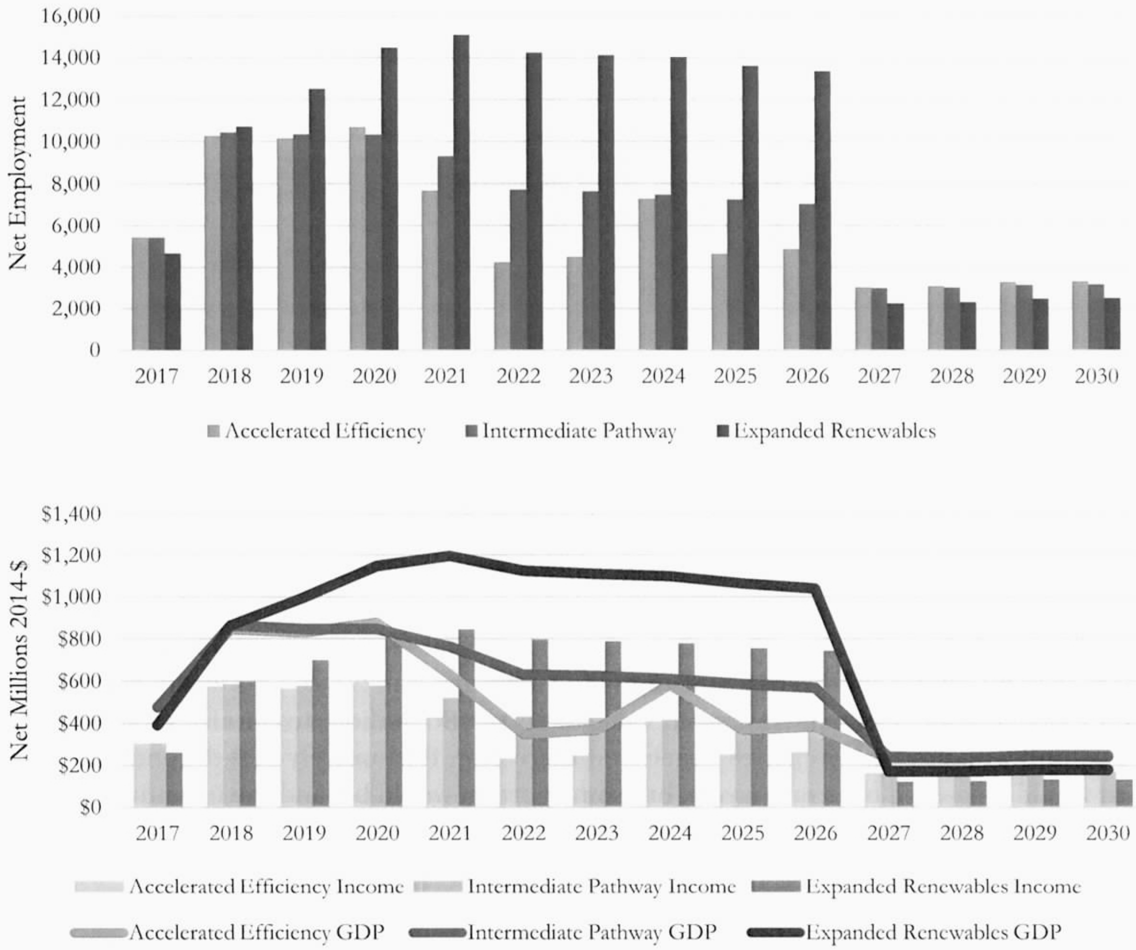


Figure 6.2 Full-Time Equivalent Jobs, GDP, and Income Effects

Public health impacts are a significant source of benefits for Ohioans from these scenarios, valued at $14 - $14.5 billion in total. The Intermediate Pathway maximizes the public health benefit overall, and leads from 2017-2022 and 2029-2030. Expanded Renewables leads in all other years (Figure 6.3). All three scenarios yield public health savings that vary based on the timing and location of the clean-energy resource deployed, but the source of the savings remains strikingly similar. The map in Figure 6.3 shows the location and the source of public health benefits, which are predominantly derived from reductions in generation at the largest coal plants in the state (as noted on the map). On the other hand, these are also the largest sources of public health damages; note that the map is showing the net benefit, not an outright benefit to public health, of having these electricity generating units in these locations.

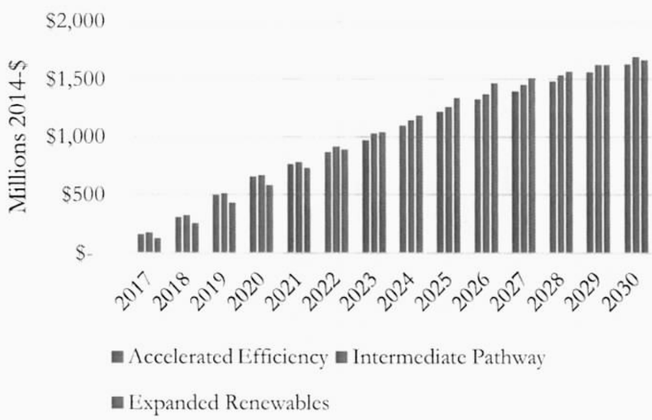


Figure 6.3 Annual Public Health Benefits (Left) and the Sources of Net Public Health Benefits in Ohio (Right)

Unlike the previous economic development and resource deployment projections, each scenario shows similar implications for compliance with the Clean Power Plan. In all cases, the baseline scenario would leave Ohio in the position of a net importer of credits or allowances, requiring more than 60 million credits or about 18 million allowances in 2030. This would add costs of $90 - $120 million (discounted present value of $60 - $80 million) to the electricity system in 2030, and without further changes, each year thereafter. It is unlikely that the entirety of this cost would be passed onto ratepayers, but some portion would be, and the incentives facing the industry would be to pass on as much as possible.

While the three scenarios modeled and detailed in this report are not the only ways to achieve compliance with the Clean Power Plan, all three would enable Ohio to do so under any approaches to compliance that the US EPA has declared presumptively approvable. Under the rate-based approach, no scenario will lower Ohio's unadjusted emissions rate to low enough levels that the targets are outright achieved. However, each scenario deploys significant quantities of renewables and energy efficiency, producing a bank of emission rate credits that can be drawn from for compliance purposes. All three scenarios produce a bank sufficient to allow for several years of compliance beyond 2030 without incurring additional costs.

The most successful pathway for Clean Power Plan compliance would come from a mass-based approach. All scenarios also put Ohio on a trajectory to meeting the 2030 targets, as with the rate-based approach. Unlike the rate-based approach, all of these scenarios are capable of meeting the 2030 goals outright, without the need of any banked allowances, and appear capable of doing so indefinitely into the future. The implication is that these scenarios can place Ohio on a glidepath to compliance. Additionally, and significantly, choosing the mass-based pathway with any of these scenarios enables Ohio to become a net exporter of allowances, producing an additional income stream for industry valued at $130 to $250 million per year, reducing revenue requirements from electricity generation, and potentially producing downward pressure on rates. Accelerated Efficiency and Intermediate Pathway perform slightly better than Expanded Renewables on this front, but these general conclusions would hold across all scenarios (Figure 6.4).

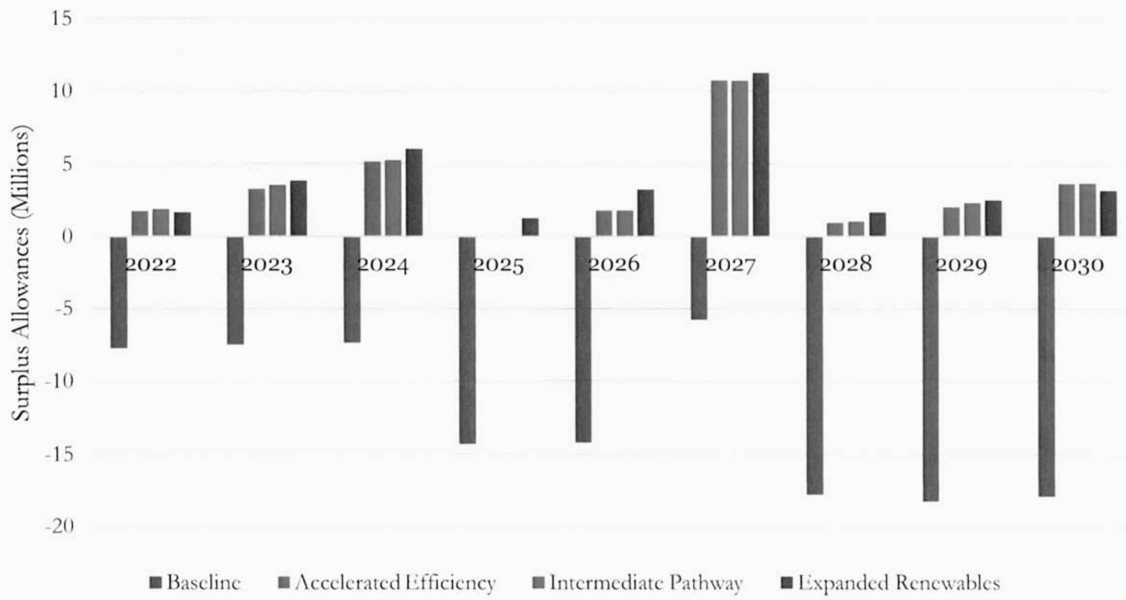


Figure 6.4 Clean Power Plan Implications across Scenarios with a Mass-Based Compliance Approach

The benefits and costs reach into the tens of billions, but the benefits of each scenario significantly outweighs the costs. Accelerated Efficiency leads all scenarios, with a benefit/cost ratio of 1.44 and net benefits of $5.0 billion. Intermediate Pathway is slightly less cost-effective, with a benefit/cost ratio of 1.35 and net benefits of $4.3 billion. Expanded Renewables performs the least-well in these tests, with a benefit/cost ratio of 1.19 and net benefits of $2.9 billion (Figure 6.5).

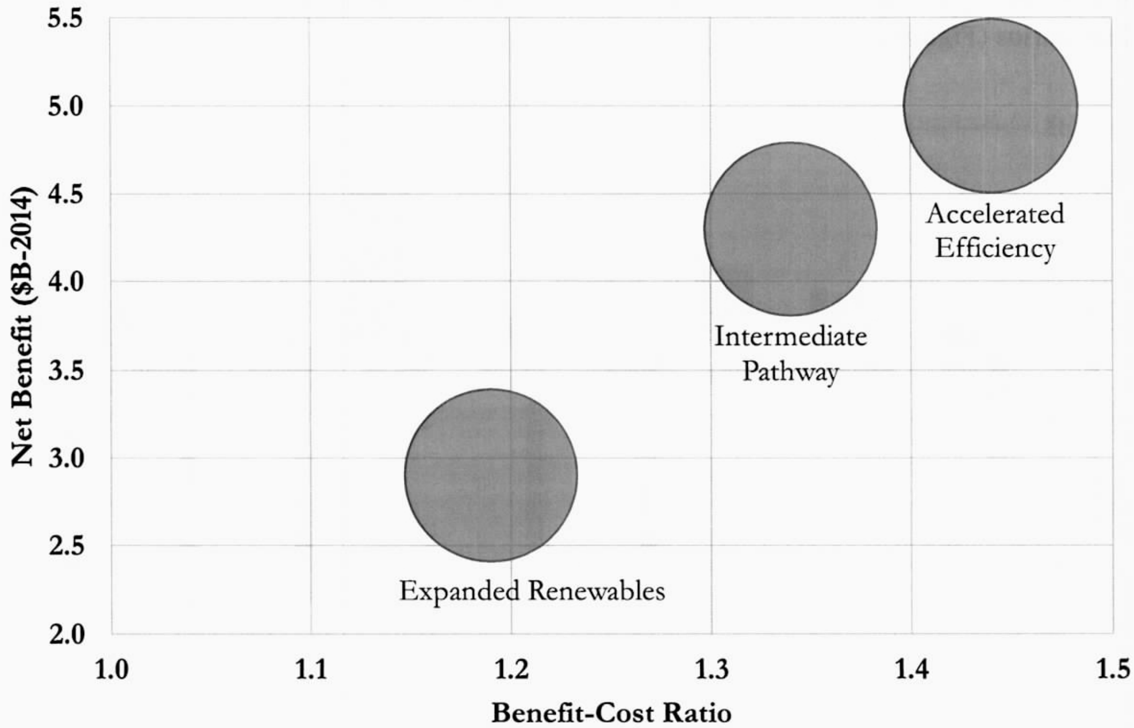


Figure 6.5 Net Impacts and Cost-Effectiveness of All Scenarios

Any of these scenarios would place Ohio on a more cost-effective, more economically-beneficial future. The Accelerated Efficiency scenario maximizes economic benefits and represents the most cost-effective scenario. The Intermediate Pathway scenario provides the greatest public health benefit. The Expanded Renewables scenario maximizes job creation and GDP growth. All scenarios show an ability to comply with the Clean Power Plan under multiple approaches, if or when it is implemented. Which of these impacts represent the best planning for Ohio's future will be soon debated. Policymakers can use these results to evaluate which of these scenarios is the most-preferable path for Ohio.

Market-Based Policy Concepts

Greenlink's ATHENIA model results show billions of dollars of positive economic impact of renewable energy and energy efficiency deployment on Ohio's economy in the coming years. Of interest to Ohio policymakers, then, is what market-based policy options are available to achieve these goals.

When is a policy market based? Market-based policies produce a target and allow the market to determine the most efficient way to achieve the target, or adjust prices to help the market operate efficiently; market-based policies prioritize desirable outcomes over the selection of "winners and losers". Market-based policies reduce barriers to participation, allowing buyers and sellers to experience gains from trade in the market for a particular commodity, product, or service, and therefore, give consumers greater freedom to choose products and services. Inherently, market-based policies do not favor incumbents, or create barriers to market entry. A market-based policy favors transparency for the commodity, product, or service, such that sellers engage in a fair competition for business and buyers can reliably purchase goods that meet their demands.

Market-Based Policy Features

- Competition for business and market share
- Does not pick winners and losers
- Removes barriers to entry
- Establishes transparent pricing for a good

Market-Based Policy Potential Benefits

- Freedom to choose products and services
- Accurate prices
- Lower prices
- Higher efficiency
- Reliable quality
- Innovation

Why should policymakers consider market-based policies? Markets are good at synthesizing complicated information and allocating resources efficiently. By leveraging the features of markets, policy goals can be achieved efficiently, at low cost, with minimal bureaucratic engagement. If government establishes appropriate incentives, market competition between buyers and sellers can establish the value of a good or service, reward market innovations, and produce widespread social benefits, at lower cost and more rapidly than regulatory processes. Markets can be a powerful tool to realizing the public interest when the primary aim of a policy involves the quantity or price of a good or service.

ATHENIA Analysis Insights & Market-Based Policy Recommendations

The simulations yield several insights of interest to policymakers. Renewable energy deployment results in billions of dollars in economic development and public health benefits for Ohio. Additionally, renewable energy has a minimal impact on customer bills in the short-term, with long-term customer bill benefits. A key reason for the minimal bill impact is that the RPS creates a competitive marketplace for private capital investment.

- <u>An RPS attracts private capital</u> – The competition and demand created by the RPS attracts private investors to carry the risk and up-front cost of capital for development of renewable generation assets, including wind and solar farms.
- <u>Many resources are nearly economically competitive in the wholesale electric market</u> - Wind energy has achieved a levelized cost of electricity that makes it attractive for new capacity investments where regulatory environments are amenable to market forces. Solar power's ongoing rapid price declines will allow it to compete for market share in the coming years.

- Ohio's wind zoning is an impediment to market-driven investment - Ohio's existing restrictive wind zoning setback has limited, and continues to limit, private investment. Without changes to Ohio's wind zoning rules, billions of dollars of economic benefits are at risk.
- The RPS creates additional benefits beyond fixing wind zoning - The RPS annual benchmarks drive renewable energy development above the baseline scenario. In the event the wind zoning setback is corrected to allow the market to function, the RPS annual benchmarks will provide market certainty and drive greater levels of investment in wind and other renewable energy, leading to higher economic development for Ohioans.
- To encourage the role of markets, policy and regulators should adopt a "no favorites" position – When regulators or policymakers choose companies or technologies, especially incumbents, in a developing market, private investment may be deterred and innovation can stall. The utility sector already lags in innovating compared to almost any other sector in the country. Therefore, it is recommended that specific companies are not given special regulatory development rights to renewable energy. State-directed benefits to incumbents may send a strong signal to dissuade non-incumbent businesses from investing and competing in Ohio.

Renewable Energy

- RPS attracts private capital
- RPS attracts competition
- Wind zoning a barrier to development
- Wind nearly economically competitive
- Favoring incumbents inhibits market development

Renewable Energy Market-Based Policy Concepts

Ohio already has a market-based renewable energy development policy – the Renewable Portfolio Standard. The RPS sets a development goal, and then allows multiple sellers and buyers to compete to achieve the goal. The cost is established through market competition and is reflected in the price of a renewable energy credit (REC). The RPS has attracted private capital. While some may not consider the RPS a market-based policy, the alternative to renewable energy development being proposed in Ohio is monopolistic. Ohio is currently debating whether the competitive affiliates of regulated electric distribution utilities can own renewable energy with the costs recovered by a non-bypassable charge on the ratepayer base. Additionally, increasingly discussions have turned to whether electric generation should be re-regulated fully. Consider the differences between the approaches. With an RPS, private investors carry the risk of investment and provide the capital. In a monopolistic approach, the ratepayers carry the risk and provide the capital. In an RPS, a market of buyers and sellers determines the cost, reflected through a transparent REC price. In a monopolistic approach, costs are set through regulatory proceedings. An RPS encourages fair play, and allows for new entrants into the market. In a monopolistic approach, the incumbent is favored.

There are, however, clear anti-market policies to renewable energy development in Ohio. The most prominent is the restrictive zoning for new wind farms. Ohio currently has approximately 400 megawatts of utility scale wind farms. This amount does not include any projects that are below 5 megawatts in power as they are not subject to the jurisdiction of the Ohio Power Siting Board (OPSB). The OPSB has approved an additional 1,300MW, however these turbines have been put on hold by their owners due to the passage of a provision in House Bill 483 that specified a minimum setback of 1,125 feet "measured from the tip of the turbine's nearest blade at 90 degrees to the property line of the nearest adjacent property." This is in contrast to the previous standards that required a similar setback but from the edge of the "nearest, habitable, residential structure on adjacent property." One cause for the stall in development is due to improved turbine technology that would require them to get new approval from the OPSB. The changed statue has resulted in the hiatus of already approved installations.

When siting regulations were originally drafted into law in 2008, Ohio had a 750-foot setback from the "nearest, habitable, residential structure" as well as a distance from the base of the turbine to the edge of the property line of 1.1 times the total height of the turbine (inclusive of the blade radius). In 2013, House Bill 59 increased the wind farm setback distance to from 750 feet to 1,125 feet for "economically significant wind farms." This includes all farms between 5-50 megawatts of nameplate capacity. When HB 483 was passed it was only applied on a prospective basis but it effectively stymied further large wind development in Ohio. This is despite significant wind resources available in Northwest Ohio and in general throughout the state of Ohio if hubs are allowed to achieve 140 meters in height. Such siting regulations create barriers to enter the wind development market and discourage market participation.

Ohio will benefit from the development of renewable energy. A market-based policy for renewable energy development could set a goal, and then harness competition to meet that goal. Incumbents would not receive special status, barriers to development would be reduced or removed, and prices and costs would be determined by the market, not by regulatory proceedings. We identified the following market-based policy concepts as promising for Ohio:

1. Maintain a Robust Renewable Portfolio Standard
2. Modify the Wind Farm Zoning Rules to Reduce Development Barriers
3. Do Not Favor Incumbents in Regulation or Policy

Energy Efficiency Market-Based Policy Concepts

Energy efficiency creates long-term customer bill savings, while attracting investment from customers and private companies. Ohioans are expected to realize a $4.1 return for every dollar invested in efficiency programs. Thus, Ohio policymakers should maintain a robust Energy Efficiency Resource Standard (EERS). However, unlike renewable energy investment, in Ohio's current energy-efficiency financing system, up-front capital costs and risk is partially borne by ratepayers. Also, unlike most customer-based capital investments, up-front capital costs are not easily spread-out over multiple years of equipment lifetime, but instead all costs occur up front.

Policymakers could consider several market-based actions which would keep the cumulative long-term savings produced by efficiency programs while better controlling costs, shifting capital costs and risks to private investment and away from the ratepayer base, and aligning the timing of costs to the benefit of customers and investors alike:

- Maintain a Robust EERS – An EERS sets the efficiency goal that yields significant lifetime cost savings for customers. Historically, markets have developed around these goals, as efficiency project incentives attract matching investment from customers, and private companies compete with efficient products and services.
- Leverage the Electric Distribution Utility Experience and Brand to Expand Market – The Electric Distribution Utility (EDU) could play a significant role in an expanded efficiency market, and Ohio has several exemplary EDU efficiency programs. For example, AEP Ohio has taken several steps which illustrate this role. One is the BidforEfficiency auction AEP Ohio has initiated and operated. The auction procures efficiency project savings competitively. Such a system could be used to procure energy efficiency credits.
- On-bill Repayment – On-bill repayment is a mechanism by which customer-sited efficiency projects can be financed, and repaid through a line item on a utility bill. The intent is that the additional cost of repayment would be offset by the electricity bill savings to produce positive cash flow for the customer. On-bill repayment allows energy efficiency service provider, such as energy service companies or utilities to access capital through banks, instead of using ratepayer funds. On-bill repayment could shift efficiency program costs, risk, and financial return from the ratepayer base to private investment. The EDU can play an important role in On-bill Repayment.
- Expand efficiency market participation through energy-efficiency credits – Currently, the "cost" of energy efficiency programs varies between utilities, and is determined through regulatory proceedings. An efficiency credit ("white credits") registry would create a market for efficiency, attract more private investment and participants, reduce program costs, and encourage innovation. Energy efficiency credit markets are under intense development nationally. Some ways white credits could be used include:
    - Trading between Electric Distribution Utilities – The performance of EDUs on delivering energy efficiency savings is inconsistent across the sector, with some over-performing and others failing. Regulatory processes constrain over-performance and do not provide many options for under-performers, hampering current EDU efforts and reducing the benefits for Ohioans. Efficiency credits would create competition and market incentives for utilities to leverage their programmatic strengths and maximize the savings for Ohioans.
    - Mercantile Self-Direct with Credits – Mercantile customers (mid-sized businesses and larger) can already self-direct, financing their own efficiency programs, and receive an exemption from paying into a utility efficiency program. However, in practice the exemption process is constrained to each individual utility account. This often results in customers achieving many years of

Energy Efficiency

- EERS creates a market for goods, services
- Leverage Utility to Expand Market
- On-Bill Repayment Attracts Private Capital
- Energy Efficiency Credits Expand Market Participation
- Avoid Fixed Charges

rider exemptions which they are unable to monetize, while other customers do not have projects to invest in and thus cannot receive an exemption. A credit system could allow a business to manage its energy finances effectively, through the production and trade of energy efficiency credits signifying energy savings. In effect, this expands the market for energy-efficiency by harnessing the expertise of businesses and allowing the entirety of the private sector to participate in the energy efficiency marketplace.

  - Aggregation providers – There is currently no mechanism for small businesses or residences to self-direct on energy-efficiency. However, a host of businesses have market-tested models to aggregate the individual demand of small businesses and residences and pursue efficiency actions similar to their larger mercantile counterparts. By allowing aggregation providers the same self-direct exemption process, small business and homeowners could also engage with the efficiency market and establish themselves as market participants. This could include existing community aggregation providers.
  - Certified Retail Electric Suppliers, Energy Service Companies – Private companies already provide efficiency products and services, and continue to invest in innovation and delivery. Examples include some certified retail electric suppliers (CRES), energy service companies (ESCOs), and traditional engineering design and consulting companies. An efficiency credit system would expand Ohio's efficiency market by allowing these companies to contribute and stretch efficiency dollars further.
- Avoid Fixed Charges in Electric Rate Structures – Recently, Ohio's electric utilities have increasingly sought to change the rates at which they bill customers from volumetric pricing to constant, fixed charges on customer bills. This can result in inefficient homes and businesses paying the same for electricity as efficient homes and businesses. In addition, it can seriously impair the incentive for customers to invest in efficiency. Fixed costs are an anti-market move in the opposite direction to the long-term interest of ratepayers. They hinder the market signal and disincentivize individuals and businesses from managing or changing their electricity usage patterns. To promote market-based efficiency, policymakers would want to direct Ohio's utilities to increase the strength of the price signal in rate structures, not weaken it.

States without an Energy Efficiency Resource Standard see about a 0.3% increase in energy-efficiency each year, as a matter of course.[10] However, many have observed that even greater levels of energy efficiency exist to be tapped. A number of market-barriers prevent investment in energy efficiency, including split incentives (landlord/tenant), lack of capital, lack of knowledge, etc. The result is that most businesses and ratepayers are either unaware, or forgo, economical investments in energy efficiency with short payback periods, while continuing to pay for traditional generation assets that take many decades to payback – if ever. An EERS that is implemented well overcomes these market barriers, and creates a market for energy efficiency goods, services, allowing energy-efficiency to be used as a resource and compete with other traditional electricity resources. As a result, states with an EERS see a four-fold expansion of

[10] http://aceee.org/sites/default/files/eers-052016.pdf

energy-efficiency, to about 1.2% of retail electricity sales per year, on average. Twenty-five states have an electric EERS while 15 states of a natural gas EERS.[11]

While an EERS creates a market for energy-efficient goods and services, a typical utility-operated EERS requires funds from the ratepayer base to share in the program costs. Additionally, the costs are set through the regulatory process, instead of being determined by a market.

On-Bill Repayment (OBR) could be a key complement to an EERS. On-Bill Repayment addresses the lack-of-capital market barrier to increased energy-efficiency deployment. OBR can utilize third-party capital to finance an energy-efficiency project. Repayment for the project is made through a line-item on the utility bill. The idea is to link the savings from the efficiency project, which occur on the utility bill, to the repayment of the project, such that consumers and businesses can realize positive cash flows. Importantly, this also shifts capital costs and risk to the private sector, and away from the ratepayers. It also allows the collection of project costs over time, as with most customer-based capital investment (currently, most energy-efficiency project costs are paid in full, up-front). OBR is already successfully implemented by a number of investor-owned utilities and electric cooperatives in the US.

Another complement to the EERS would be the inclusion of energy-efficiency credits, or white credits, as an allowable compliance strategy for both utilities and customers. Currently, the cost of energy-efficiency programs in Ohio varies by utility, and is determined through regulatory proceedings. Unlike with renewable energy, there is no energy efficiency marketplace for participants to understand competitive or non-competitive efficiency offerings. This results in several problems. First, costs can vary significantly by utility territory and rate class. Second, there is little liquidity for utilities creating energy efficiency. While utilities can "bank" extra energy savings for later compliance, they cannot buy or sell efficiency credits, forgoing the benefit of trade. Highly successfully utilities face the perverse incentive to slow down efficiency programs in good years. Thirdly, decisions on who creates energy efficiency, and what that efficiency is worth, are primarily determined by each utility. As a result, there is a disparity of efficiency program types amongst Ohio's utilities. For example, only DP&L and AEP incentivize combined heat and power (CHP) projects, even though CHP is one of Governor Kasich's energy pillars, and was allowed as an efficiency project by law over four years ago.

Energy efficiency credits can clearly facilitate the expansion of an energy-efficiency market. An energy efficiency credit system would require a registry to catalogue kWh savings attributes of projects which can be tracked and purchased by entities seeking compliance with an energy efficiency standard. Such a system requires high levels of measurement and verification and typically a system of tracking in order to avoid double counting resources. Such standards are currently in-development, and Ohio can position itself for participation with these programs. It would be necessary for energy efficiency projects to be certified with quality assurance to ensure that the credits transparently communicate the value they provide. The following are examples for developing and fostering an energy efficiency credit system.

[11] Ibid

National Energy Efficiency Registry

The most promising system is the National Energy Efficiency Registry (NEER). NEER is a collaborative effort which includes the involvement of Tennessee, Minnesota, Georgia, Pennsylvania, Michigan, and Oregon.[12] In addition to these states, NEER also includes the National Association of State Energy Officials (NASEO), APX Inc., and The Climate Registry. The aim of NEER is to provide a national framework for registration of energy efficiency projects that is both policy neutral and will aid in Clean Power Plan compliance. They identify six roles in the creation of a robust tracking system: Accounts (Providers), Assets (Eligible Projects), Production (Issuance Application), Certificates (MWh/Tons), Transactions (tracking), and Retirement. The end goal for this project is to launch the registry in 2018 for general use. While the collaborative team for NEER has already been set, Ohio's Environmental Protection Agency (EPA) and PUCO could request to become observers of the NEER process now. In this way, Ohio would be able to consider joining NEER in the near-term, when utility portfolio programs will be expiring and need revision and reapproval by the PUCO.

Connecticut Energy Efficiency Component of the Renewable Portfolio Standard

In 1998, Connecticut created its RPS and has revised it several times since. Energy efficiency savings, including benefits from combined heat and power, are included as a class for the RPS, and are able to produce and trade credits to assist in complying with the RPS. The efficiency class is required to meet 4% of load in each year after 2010. Recent regulatory findings of the Public Utilities Regulatory Authority show that the electric suppliers made use of the market to procure over 3,500 efficiency credits, which comprised a portion of the $18.5 million (net) certificate market.[13] Banking is allowed in the Connecticut RPS market, and suppliers have banked nearly 150,000 efficiency credits for use in future years. Across the state, utilities operate efficiency programs that save 1.3-1.5% of retail sales, and rely on the efficiency market and banked credits to meet remaining needs.

PJM Generation Attribute Tracking Systems (GATS)

A system that is currently operating is the PJM Generation Attribute Tracking System (GATS) system. While primarily used for the monitoring and evaluation of renewable energy assets, Pennsylvania has included "demand-side management" in their goals and those resources are tracked along with alternative energy generation. This is a potential opportunity for Ohio to increase the value of energy efficiency products by having an independent third party such as PJM track the investments. And while there are many examples of energy efficiency tracking, there is still space within the demand-side management marketplace to innovate and create new products that result in benefits for businesses, residential customers, and utilities by allowing for competition and encouraging the investment in low-cost/no-cost energy efficiency opportunities. This will create value for Ohioans and reduce power prices.

---

[12] Tennessee Office of Energy Programs, Tennessee Department of Environment & Conservation, Georgia Finance Authority, Michigan Economic Development Office, Minnesota Pollution Control Agency, Oregon Department of Energy, Pennsylvania Department of Environmental Protection.

[13] Public Utilities Regulatory Authority of Connecticut, Docket 12-09-02 (Annual Review of Connecticut Electric Suppliers' and Electric Distribution Companies' Compliance with Connecticut's Renewable Energy Portfolio Standards in the Year 2011).

Finally, just like wind farm development faces development barriers because of restrictive zoning, energy efficiency is increasingly facing investment barriers because of changes to utility-proposed rate schedules. Increasingly, electric utilities are seeking to assess fixed charges to customers, instead of allowing for volumetric pricing, especially in the residential sector. As a result, when a customer invests in energy efficiency, they are increasingly not accruing the full savings from the investment. In the long term, price signals will likely be needed increasingly to allow consumers and businesses to change their electricity usage patterns. Fixed costs are an anti-market move in the opposite direction to the long-term interest of ratepayers. This hinders the market signal and disincentivizes individuals and businesses from managing or changing their electricity usage patterns.

Ohio will benefit from increased investment in energy efficiency. A market-based policy for renewable energy development would set a goal, and then harness competition to meet that goal. Market-based policies would seek to shift investment and risk from the captive rate-base to the private sector, and with costs of efficiency programs determined by the market through an energy efficiency credit system. We identified the following market-based policy concepts as promising for Ohio:

1. Maintain a Robust Energy Efficiency Resource Standard
2. Implement On-Bill Repayment
3. Adopt Use of Energy-Efficiency Credits
4. Maintain and Promote Electric Rate Structures that Incorporate Price Signals

These scenarios and recommendations would direct Ohio towards a more cost-effective, more economically-beneficial future. They would facilitate compliance with the Clean Power Plan under multiple approaches, if or when it is implemented. Which of these impacts represent the best planning for Ohio's future will be soon debated. What can be said with certainty from these results is that any of these scenarios represent a significant improvement in the quality of life of Ohioans over the repeal or instatement of a permanent freeze on the RPS/EERS, and thus bear consideration as the current freeze expires.

Appendix A: Annual Trajectories for All Scenarios

Table A.1 Energy Resource Trajectory by Scenario

Description	Accelerated Efficiency		Intermediate Pathway		Expanded Renewables	
Year						
2017	3.50%	1.00%	3.50%	1.00%	3.50%	0.50%
2018	4.50%	1.00%	4.50%	1.00%	4.50%	0.50%
2019	5.50%	1.00%	5.50%	1.00%	5.50%	0.50%
2020	6.50%	1.25%	6.50%	1.00%	7.50%	0.50%
2021	7.50%	1.25%	7.50%	1.00%	9.50%	0.50%
2022	8.00%	1.25%	8.50%	1.00%	11.50%	0.50%
2023	8.50%	1.40%	9.50%	1.00%	13.50%	0.50%
2024	9.00%	1.40%	10.50%	1.00%	15.50%	0.50%
2025	9.50%	1.40%	11.50%	1.00%	17.50%	0.50%
2026	10.00%	1.50%	12.50%	1.00%	19.50%	0.50%
2027	10.25%	1.50%	12.75%	1.50%	19.50%	1.00%
2028	10.50%	1.50%	13.00%	1.50%	19.50%	1.00%
2029	10.75%	1.50%	13.25%	1.50%	19.50%	1.00%
2030	11.00%	1.50%	13.50%	1.50%	19.50%	1.00%
Through 2030	11.0%	18.5%	13.5%	16.0%	19.5%	10.3%
2009-2026	10.0%	16.7%	12.5%	14.2%	19.5%	9.2%
SB 221/310	12.5%	22.0%	12.5%	22.0%	12.5%	22.0%

Learn / Energy 101 / Solar Job Growth

SOLAR JOB GROWTH

Read Time: 4 minutes

The solar industry has seen tremendous growth over the past few decades and there are no signs it's slowing down. Rapid growth for the solar industry means exciting opportunities for solar job growth. Last year alone, the industry added 51,000 jobs, bringing the total number of Americans working in the solar industry to more than 260,000.

Falling installation costs can be accredited for solar job growth over the past couple years. With the positive environmental and financial opportunities, and lower installation costs, both residential and commercial consumers are more likely to choose solar. In fact, new data shows that solar installers will be the fastest-growing job in America over the next decade. But installation jobs are not the only ones available. There are many different types of solar jobs available to suit different individuals.

Solar Job Timeline

EXHIBIT
PENGAD 800-631-6989
25
AEP

Solar workers, according to The Solar Fc IGS n, are those who spend at least 50 percent of their time supporting solar-related activi e number of workers who meet that definition has increased drastically since 2010. Check out The Solar Job Census' numbers for 2017 here.

The job growth is tremendous. However, the industry did experience a slight decline in job growth, dropping 3.8 percent from 2016 to 2017. Even with the overall decline, in 2017, 29 states saw solar job growth. States with significant job gains include Utah, Minnesota, Arizona, Colorado, Pennsylvania, New York, New Jersey, and Tennessee. California remains the state with the largest number of solar jobs nationwide.

Solar industry growth can be largely be accredited to the falling prices of installation. The cost to install solar has fallen by more than 70 percent since 2010.

Types of Solar Jobs

Generally, there are two types of solar projects and thus two large groupings of solar jobs: utility scale and rooftop solar. The categories are driven by different policies and have different cost structures and job outcomes.

1. Utility Scale

- Large utility-scale (>20 MW) solar farms that sell wholesale electricity to energy providers.
- Utility scale jobs will have more versatility with their skills, according to research done by the University of California Berkeley – "we also note that workers whose skills are limited to rooftop solar installation are subject to the large fluctuations in the solar segment of the construction market, with little to fall back on, whereas utility-scale workers generally gain a much broader skill set through apprenticeship and can work on many types of green and other constructions projects."

2. Rooftop Solar

- These are often smaller projects where the electricity generated is first used on site with the excess energy sold in the grid through a net metering mechanism.

- The increase in residential solar ha IGS an increase in need for rooftop solar jobs.

The solar industry also creates jobs for:

- Electricians
- Roof technicians
- Administrative
- Warehouse workers
- Sales
- Marketing
- Accounting
- And more! Learn about them here.

Looking Forward

While 2017 saw a slight decrease in solar jobs compared to 2016, the future is bright for jobs in the industry. As the U.S. economy adds a projected 11.5 million jobs over the next decade, solar installer jobs will grow by 105 percent – more than any other occupation. Wind turbine technician jobs followed at number two on the list, showing that clean energy jobs are driving the U.S. economy forward. The solar industry is already adding jobs 17 times faster than the rest of the nation's economy, and as the U.S. Solar Market Insight report has said, the industry is expected to triple in size by 2022. Solar photovoltaic installers are also projected to surge in importance and offer expanded employment opportunities.

Find a Job in Solar

Are you interested in a job in the renewable energy industry? There are plenty of resources available to help you learn about and find opportunities:

- Energy.gov has resources to help find jobs, internships, training, and careers.

- Solar Energy International is founc IGS he mission of providing "industry-leading technical training and expertise in ble energy to empower people, communities and businesses worldwide."
- American Solar Energy Society also provides solar training.

CHECK OUT OUR CURRENT SOLAR JOB OPENINGS