Energy Efficiency Potential in Ohio

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Abstract

This paper reviews the energy savings potential in Ohio available to meet the requirements under the state's energy efficiency standard enacted by Senate Bill 221. First, we focus on four energy efficiency studies by the investor-owned utilities (IOUs) in Ohio that were prepared between 2012 and 2014 to analyze the potential for deploying efficiency measures within their service territories. We summarize the findings of these studies regarding the cost-effective energy savings that are achievable in the state. ACEEE's review of these studies finds that they identify significant, cost-effective energy potential in the state through the next 10–20 years. In particular, the AEP study—which is the most recent available—identified sufficient cost-effective and achievable savings potential to meet the state's SB 221 targets through 2025. Still, these studies tended to underestimate the full efficiency potential in certain areas. This paper identifies several emerging technologies and best practice strategies to encourage customer participation in programs that can yield significant additional energy savings but were not fully considered in the studies. Finally, the paper examines two specific utility program portfolios from other states as an example of utilities that have consistently achieved electricity savings of 1.7–2% or more per year in recent years, a level that on average would be sufficient to meet the SB 221 targets from 2014 through 2025.

Introduction

In 2008, the Ohio legislature enacted Senate Bill 221 (SB 221)[1], which established an energy efficiency resource standard (EERS) setting annual electricity savings targets for all utilities to meet through 2025. The SB 221 standard requires annual savings of 1% from 2014 to 2018, and 2% each year thereafter, achieving a cumulative, annual electricity savings in excess of 22% by the end of 2025. This is equivalent to average incremental annual savings targets of 1.6% between 2014 and 2025. All four investor-owned utilities (IOUs) in Ohio have been running energy efficiency programs for their electricity customers since at least 2010 in accordance with this standard.

In 2014, the state enacted SB 310, which froze the energy efficiency targets at the 2014 levels for two years. The legislation created an Energy Mandates Study Committee to examine the issues and make recommendations about future legislation. To provide information to the committee and interested stakeholders about whether energy efficiency potential in Ohio is sufficient to meet the SB 221 targets, this paper analyzes the energy efficiency potential identified in the most recent studies published by the four investor-owned utilities (IOUs) in Ohio: Duke Energy,[2] FirstEnergy,[3] AEP Ohio,[4] and Dayton Power & Light (DPL).[5] Of these four, the most recent study—conducted by AEP—does identify sufficient potential to allow for compliance with SB 221 through 2025. The service territories for these utilities are similar enough that we do not see any major reasons for the potential identified by the other three utilities to be significantly less than the potential identified by AEP. We also identify several areas where all four of these studies have underestimated potential energy savings. Finally, we provide examples of program portfolios in other states that have consistently achieved savings at levels that would be sufficient to meet or exceed the SB 221 targets from 2014 through 2025.

BACKGROUND ON ENERGY EFFICIENCY POTENTIAL STUDIES

Energy efficiency potential studies estimate the amount of energy that could be saved by implementing improved technologies and behavioral changes over a certain time period. These are generally done by modeling savings opportunities using a combination of secondary data from utilities and other market sources about measure costs and savings achievements as well as primary data from customer surveys. Potential studies are a common tool for states or utilities to help set energy efficiency targets and develop programs. They typically include three types of potential:

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[1] http://www.lsc.ohio.gov/analyses127/08-sb221-127.pdf.

[2] Duke Energy, *Duke Energy Ohio: Market Assessment and Action Plan for Electric DSM Programs* (Prepared by Forefront Economics Inc. and H. Gil Peach & Associates LLC, January 7, 2013.

[3] FirstEnergy Corp., *Appendix D. Market Potential Study: Energy Savings and Demand Reduction for Ohio Edison, Toledo Edison, and the Illuminating Company* (Prepared by Black & Veatch Holding Company), June 22, 2012.

[4] AEP Ohio, *Volume 2: Appendices 2015 to 2019 Energy Efficiency/ Peak Demand Reduction (EE/PDR) Action Plan*, March 26. 2014.

[5] Dayton Power & Light, *2013–2015 Portfolio Plan Appendix A: Market Potential Update* (Prepared by Cadmus Consulting), 2013.

1. *Technical*. Maximum energy savings from full adoption of all technically feasible measures, regardless of cost.
2. *Economic.* Energy savings that are determined to be both technically feasible and cost effective.
3. *Achievable.* **E**nergy savings that are determined to be realistically achievable because the measures are technically feasible, cost effective, and likely to be adopted by customers under existing market conditions and given different levels of incentive payments.[6]

Energy efficiency potential studies therefore provide useful estimates of electricity savings potential. However, based on experience examining dozens of potential studies published between 2009 and 2013 to understand how their methodologies and assumptions influence energy efficiency potential estimates, ACEEE has identified key assumptions in such studies that often lead to underestimating savings potential (Kramer and Reed 2012; Neubauer 2014). Utilities either conduct these studies or hire the firms that do, and they often want to identify goals that will be easily achievable.

OVERVIEW OF THIS PAPER

The purpose of this analysis is to examine energy efficiency potential in Ohio by considering what the potential studies found and where they may have missed opportunities, and then drawing some comparisons to best-practice efficiency program portfolios. First, we will summarize high-level results of each of the Ohio potential studies. Second, we will review areas where the Ohio studies have likely underestimated potential savings. This is not an exhaustive review, but rather an examination of several important issue areas, based on ACEEE's independent review. In several places the studies were not transparent about key assumptions, which makes it difficult to fully characterize their findings. Finally, we will present the results of two best-practice program portfolios that have consistently achieved savings of 1.7% or more per year, which are savings levels sufficient to meet the Ohio SB 221 targets.

Summary of Ohio IOU Potential Studies

First we provide a high-level summary of the overall study findings. Table 1 shows several key results for each level of analysis (i.e., technical, economic, and achievable). These include the utilities' estimates of cumulative electricity savings potential expressed as a percentage of sales and average annual incremental savings per year over the study time period.

Table 1 shows that average annual electricity savings potential varied widely across the studies in each level of analysis. Technical potential ranged from 1.3% per year (Duke) to 3.3% (AEP). Economic potential ranged from 0.7% per year (Duke) to 2.6% (AEP). Achievable potentials included 0.7–1.2% in the base-case scenario and 0.9–1.9% per year in

[6] The achievable potential portion often incorporates multiple scenarios, for example by varying the level of financial incentives to participants. The label of "achievable" potential can have the unintended consequence of making anything above the achievable potential forecast seem unachievable, whereas in reality factors such as effective program design and participation rates directly influence savings potential (see Kramer and Reed 2012).

the high-case scenarios involving higher incentive payments. This variation within the state demonstrates that key assumptions and methodologies have a large impact on the results of potential studies (demographics will have some influence but cannot explain such large differences). We explore some of these key differences in assumptions and methodologies, and what they mean for the savings estimates, later in the paper.

Table 1. IOU Energy efficiency potential study results summary

				Electricity savings as a percentage of sales			
IOU	Study date	Study time period (years)		Technical potential	Economic potential	Achievable potential, high case	Achievable potential, base case
AEP	March 2014	2015–2034 (20 yrs)	Annual Cumulative	3.3% 66%	2.6% 52%	1.9% 37%	1.2% 24%
Duke	January 2013	2013–2032 (20 yrs)	Annual Cumulative	1.3% 26%	0.7% 15%	N/A	1.1% 5.7% (2013–2017)
DP&L	April 2013	2013–2022 (10 yrs)	Annual Cumulative	2.2% 22%	1.2% 12%	0.9% 9%	0.7% 7%
FirstEnergy	June 2012	2012–2026 (15 yrs)	Annual Cumulative	2.2% 33%	1.9% 29%	0.9–1.1% 13–17%	0.7–0.9% 11–14%

Most of these values were reported directly in each of the studies. In some cases, we derived values, (e.g., for some studies we calculated average annual savings by dividing cumulative savings by the number of years in the study time period). Duke Energy: The study included a five-year energy efficiency Action Plan for its achievable potential scenario. FirstEnergy: achievable potential shows a range across the three utility service areas. DP&L: the study had a low, medium, and high case. Here we report the medium case as the base case.

AMERICAN ELECTRIC POWER (AEP) 2014 MARKET POTENTIAL UPDATE

This study is the most recent of the four, and therefore uses the most up-to-date information about key assumptions such as measure costs and savings. The study examined technical, economic, and achievable potential from 2015 to 2034. The study identified average economic potential savings of 2.6% per year, or 52% by 2034. The achievable potential assessment—examining, as explained above, the cost-effective savings that are realistically available—identified savings potential of 24% by 2034 with incentives at 50% of incremental measure costs (the base case) and savings potential of 37% by 2034 with incentives at 75% of incremental measure costs (the high case). These are equivalent to average annual savings potential of 1.2% in the base case and 1.9% in the high case.

In its study, AEP Ohio states that the base-case market potential savings would be sufficient to cost effectively meet the SB 221 requirements through 2019. The high-case achievable potential would cost effectively meet the full SB 221 requirements through 2025 of 22.2% cumulative savings.

DUKE ENERGY 2013 MARKET ASSESSMENT AND ACTION PLAN

Duke Energy Ohio's potential study examined technical and economic potential in the utility's service area through 2032. Overall for its economic potential assessment, the study identified average annual savings of 0.7% per year, or 15% cumulative savings in 2032.

The achievable potential assessment, which is referred to as a DSM action plan, examines only the five-year program period of 2013–2017. The recommended DSM programs are estimated to save 5.7% cumulative electricity by 2017, or incremental annual savings on average of 1.1% of sales each year.

The study finds that a five-year DSM action plan can be developed that cost effectively meets and exceeds the SB 221 targets through 2017. The study did not examine achievable potential over a longer time period. Study authors stated that their assessment of economic potential was short of the SB 221 targets for 2025. It should be noted, however, that Duke found the lowest levels of technical and economic potential of all four utilities, largely due to a more limited review of emerging technologies and strategies, as discussed in more detail later. The authors acknowledged that their estimates are based on current levels of technology and current expectations regarding avoided supply costs, and that their findings should "not [be interpreted] to say that the energy savings targets in SB 221 cannot be cost effectively achieved"(p. 5).

DAYTON POWER & LIGHT (DP&L) 2013 STUDY

This study included technical and economic potential assessments, as well as high, medium, and low estimates of achievable potential. The study identified economic potential equivalent to average annual savings of 1.2%, or cumulative savings of 12% by 2022.

For the achievable potential, analysts reviewed 50 electric energy efficiency potential studies from across the country to determine typical values for the percentage of economic potential deemed achievable. Based on this review, the study set levels of low-, medium-, and high-case achievable potential at 40%, 60%, and 80% of the economic potential, respectively. This is a simplifying but reasonable approach to estimate the portion of cost-effective potential that is achievable, and is based on a comprehensive set of studies. This led to cumulative achievable values of 5%, 7%, and 9% for the three scenarios, or 0.5%, 0.7% and 0.9% per year.

DP&L finds that its medium achievable scenario would continue to meet the SB 221 targets through 2018. Beyond 2018, however, the study's identified achievable savings would not be sufficient to meet longer-term targets. As discussed later in the paper, however, the DP&L study is conservative in its assessment of economic potential, and therefore by extension its assessment of achievable potential (which is calculated as a set percentage of economic potential). The conservative nature of the savings potential is evident from comparing DP&L's 3-year plans, which are projected to achieve an average of 71 GWh savings per year for residential programs and 86 GWh per year from business programs, and are on track to doing so (DP&L 2015). These savings levels already exceed average annual savings from the high-case achievable potential (64 GWh for residential programs and 57 GWh for commercial and industrial programs).

FIRSTENERGY 2012 MARKET POTENTIAL STUDY

This study examined technical, economic, and achievable potential in each of the three FirstEnergy utility service areas (Ohio Edison, Toledo Edison, and Cleveland Electric Illuminating) from 2012 through 2026. For economic potential, the study identified cumulative savings of 29% by 2026, which is equivalent to average annual savings of 1.9% per year.

The achievable potential assessment includes a base-case and high-case scenario using different levels of customer incentive payments. The achievable potential assessment for its high-case assumptions in 2026 finds cumulative electricity savings of 16.8% for Ohio Edison, 13.1% for Toledo Edison, and 16.3% for Cleveland Electric Illuminating. This is equivalent to a range of 0.9–1.1% incremental annual savings over the study period, or an average of 1% across the three service areas. For the base case, the range of average annual savings over the study period is 0.7–0.9%, or an average of 0.8% across the three service areas.

While the achievable estimates fall short of the goal of 22% by 2025 even in the high case, the potential study notes that "the analysis was intentionally developed to be conservative by limiting customer adoption of high-efficiency technologies at the end of the useful life of appliances and equipment" (p. 11). In other words, the study does not take into account replacement of appliances or equipment before the end of their useful lives. Early replacement of appliances and equipment before they wear out is a common utility energy efficiency practice and represents significant savings. Additional savings would accrue from expanding the potential study to include these retrofit measures, as well as to address a number of other gaps as identified in the next section.

Overall, of all four energy efficiency potential studies, the AEP study provides the most thorough analysis and reasonable projection that Ohio has sufficient efficiency potential to meet the targets set by SB 221. Additionally, in the section below we describe several ways in which the other three utility potential studies and even the AEP analysis underestimate Ohio's efficiency potential.

Analysis of Key Assumptions

To identify additional potential that might not be fully considered in the Ohio studies, we first analyze several key factors that have a large impact on potential study results and examine where some or all of the studies may have underestimated savings potential in these areas. We then examine a specific suite of strategies that the studies either did not consider or may not have fully captured.

FACTORS THAT COMMONLY RESULT IN UNDERESTIMATES OF POTENTIAL

This section covers three areas that have a large impact on potential study results and where studies in general tend to adopt conservative assumptions that can underestimate potential: emerging technologies, cost-effectiveness analysis, and participation rates. The Ohio studies suffer from these pitfalls to varying degrees, which in some places led to overly conservative potential estimates.

Emerging Technologies

In general, the degree to which potential studies include emerging technologies varies considerably, largely due to different perspectives on measure costs and savings potential and how those are expected to change over the study time period (Neubauer 2014). Potential studies are often conservative, only considering technologies for which there are readily available cost and savings data, and only considering measures that are cost effective today. Emerging technologies may be difficult to characterize because of limited data on costs and energy savings, but the savings potential offered by these technologies should not be ignored.[7] Failing to account for that likelihood can result in unrealistic estimates of potential savings. The consulting company McKinsey recently pointed out the trend that innovation in energy efficiency has consistently come faster than they had predicted (Nyquist 2015).

For example, the Duke Energy study states that "our estimates of technical and economic potential are based on current levels of technology . . . . Technological improvements are likely to result in new applications for saving energy and reductions in the cost of existing technologies" (p. 5). Consistent with this statement, in order to be more realistic, potential studies should estimate savings from a full suite of emerging technologies, which will generally lead to higher savings. For example, a study for Xcel Colorado in 2010 found that economic potential increased by 24% when emerging technologies were included (Neubauer 2014).

The emergence of LEDs exemplifies the importance of analyzing emerging technologies. Just a few years ago, LEDs were not regularly considered as cost-effective measures in potential studies. For example, a 2012 study for the Iowa Utility Association found cost-effective LED applications only for the commercial sector (not residential), and a 2012 study for Idaho Power assumed that residential and commercial LED measures did not become cost effective until 2020 (and not all applications become cost effective) (Neubauer 2014). Today, however, LEDs are becoming widely deployed as a cost-effective measure for both residential and business customers in numerous states (see later discussion about LED opportunities and how they are treated in the Ohio studies).

Today, other emerging technologies will offer significant savings opportunities in the near future but may not yet be cost effective. For example, advanced clothes dryers, which use heat pump technology to provide savings of about 40% over standard models, are a mature technology globally and have made significant gains in market share in Australia and Europe, yet market penetration in the US is still very low (Denkenberger et al. 2013). Advanced heat pump clothes dryers were not considered in any of the Ohio potential studies. Smart or learning thermostats are another promising technology that has been deployed in a number of pilot programs around the country. Average savings from recent pilots have been about 10–12% of total space heating energy use and about 15% of total space cooling energy use (Apex Analytics 2014; Cadmus 2015). While three of the potential studies examined the older technology of programmable thermostats, only the AEP study

[7] In some cases, emerging technologies would be well suited to pilot programs, limited-application programs (e.g. only the highest energy users), or bundled with more cost-effective measures or programs.

mentioned learning thermostats, and even then in what seemed to be a limited application. These are just two examples of technologies offering future energy savings potential that the IOUs generally excluded from their potential studies.

Of all four studies, the AEP study identifies the strongest technical potential savings opportunities of 3.3% electricity savings per year. The study appears to capture a fairly comprehensive set of measures including many emerging technologies, and notably finds sufficient cost-effective savings potential to meet the full requirements of SB 221. The other studies identify much more conservative technical potential of 1.3–2.2% savings per year. Those studies fell into this common pitfall of selecting a more limited set of technologies and practices. These overly conservative technical potential estimates can in turn lead to underestimates of economic and achievable potential.

Completeness of Cost-Effectiveness Analysis

How studies analyze the benefits from an energy efficiency measure directly affects the amount of savings potential that is considered cost effective. Unfortunately, the values, assumptions, and methodologies for quantifying these benefits in potential studies are not typically transparent, as was the case in the Ohio studies (methodology descriptions were very limited).

ACEEE recently reviewed the full range of utility system benefits of energy efficiency (Baatz 2015) (table 2). All of these benefits should be accounted for in an analysis of the overall cost effectiveness of an efficiency measure. A cost-effectiveness test that includes participant costs should also incorporate additional energy and nonenergy benefits that accrue to program participations.

Table 2. Benefits of utility energy efficiency programs to be included in best-practice cost-effectiveness analysis

Benefit	Description
Avoided cost of energy	Avoided marginal cost of energy produced
Avoided cost of capacity	Avoided cost of generating capacity
Avoided cost of transmission and distribution	Value of avoiding or deferring the construction of additional transmission and distribution assets
Avoided cost of ancillary services	Value of avoided ancillary services required to operate. A primary example would be spinning reserves.
Avoided cost of environmental compliance	Avoided cost of compliance with existing and future environmental regulations
Demand reduction induced price effects (DRIPE)	Value of energy or capacity market price mitigation or suppression resulting from reduced customer demand
Utility nonenergy benefits	Value of cost savings to a utility directly from energy efficiency programs. These benefits include reduced arrearage carry costs, reduced insurance premiums, or reduced cost of reconnections.
Avoided cost of renewable portfolio standards	Value of a reduced cost of compliance with renewable portfolio standards as electricity sales decrease

Source: Baatz 2015

Failing to consider certain types of benefits can lead to an inaccurate conclusion that an efficiency measure is not cost effective. For example, whole-house and whole-building retrofits often save significant amounts of natural gas through building shell measures like insulation. In Ohio, the majority of homes (66%) are heated by natural gas (EIA 2014a). When efficiency programs or potential studies are limited to assessing only electric savings, the combined benefits and cost effectiveness of measures are missed. (See Nowak and Kushler 2015 for a review of coordinated electric–gas program opportunities). In other words, a measure or even program may not be cost effective on the electric savings alone, but once savings of other fuels are considered, or if it is bundled with other opportunities, it becomes cost effective. At least one of the Ohio studies, conducted by Duke, specifically notes that it does not incorporate gas savings in screening for cost effectiveness:

> Measure specific estimates are typically derived by regression from a billing analysis normalized for weather. This type of analysis often does not show "crossover savings," that is, gas savings resulting from measures intended to produce electric savings. . . . This highlights a cost effectiveness issue for this analysis: the true cost effectiveness of some measures will need to include the value of both the electric and gas savings. (p. 84)

Thus, if the Duke study included gas savings benefits, then it would identify more measures as cost effective, and the electricity savings from those measures would add to the estimate of achievable potential. The other three utility studies do not expressly state whether they exclude consideration of gas savings, and to the extent they reflect the same methodology as the Duke study they are also likely to underestimate electricity savings potential. (See Nowak and Kushler 2015 for several specific examples of how to coordinate electricity and gas savings from multi-fuel programs.)

Participation Rates

Customer participation in energy efficiency programs will depend on a number of factors, including customer awareness of efficiency opportunities, benefits, and associated program offerings; their interest and willingness to participate; and the cost to participate. Program marketing and education efforts can improve customer awareness, such as by engaging trusted partners (e.g., community organizations and trade associations) to recommend the program. Program design can also enable customer participation (e.g., by making the program easy to access through one-stop-shop programs; upstream lighting programs enable point-of-purchase rebates).

While actual participation is complex, potential studies typically base participation rates primarily on customer adoption cost curves, which use the level of financial incentive as the primary basis for the results (e.g., in the AEP study, the base-case achievable scenario covers 50% of measure costs, and the high-case achievable scenario covers 75% of measure costs). Because reality is much more nuanced, this typical modeling approach may lead to inaccurate estimates of participation rates.

One way to examine participation assumptions in potential studies is to compare the achievable potential amounts to economic potential. For example, in the DP&L study, analysts examined this metric in several potential studies across the country as a way to estimate achievable potential. They came up with three values to estimate achievable potential as a percentage of economic potential for its low-, medium-, and high-case achievable potential: 40%, 60%, and 80%, respectively.

By comparison, the FirstEnergy study assumes much lower participation rates. The achievable potential (average across all three service areas) is equivalent to 43% of economic potential in the base case but only 53% in the high case. These values are based on the study's assumption that the level of participation is limited to the percentage of customers who indicated in a survey that they "would participate or install efficient equipment" (base case) and those who were "likely to participate in the program or install the equipment" (high case). Best-practice marketing, education, and other outreach strategies could expand participation beyond those who indicated on a survey their likelihood of participation. By increasing customer penetration rates to 80% of the economic potential in the achieving high case, the study's average annual electricity savings would increase from 1.0% to 1.6%. This would be a reasonable assumption, as there is ample information available regarding proven strategies to improve participation (see York et al. 2015).

In addition to marketing, education, and outreach, financing can be a complementary tool to enable participation if access to upfront capital is a barrier to adoption. For example, on-bill repayment (OBR) enables consumers to pay back energy efficiency improvements on their utility bills. Otherwise, high upfront costs for measures like heating system upgrades may discourage customer adoption even where they would provide cost-effective savings. In addition to offering affordable and accessible financing, some recent on-bill programs have specifically targeted other traditional barriers to energy efficiency, e.g., renter–owner split incentives and long project paybacks (SEEAction 2014). This may also help drive demand for energy efficiency because on-bill repayment might be more attractive and more convenient than other financing options.

GAPS IN SPECIFIC ENERGY EFFICIENCY TECHNOLOGIES AND STRATEGIES

Next, we describe several key energy efficiency measures or strategies where one or more of the potential studies either fell short in identifying the full potential or did not provide sufficient information to determine if the full potential was considered. These strategies include LED lighting, behavioral response, multifamily, combined heat and power (CHP), C&I strategic energy management, miscellaneous plug loads, and voltage optimization. This is not a comprehensive review; several other strategies and emerging technologies (e.g., learning thermostats and advanced clothes dryers) may have also been omitted or reviewed in a limited way in the studies.

LED Lighting

LED lighting offers significant savings potential because it uses about one-fifth the electricity of typical incandescent technology, and LED bulbs have much longer lifetimes. Bulb costs have been the primary barrier to customer adoption, but costs per bulb have decreased rapidly in recent years. While some of the initial LED screw-in lamps cost $40 or more as recently as 2010, costs fell to about $8–10 per bulb by 2014 (EIA 2014b). In June 2015 Philips introduced an LED lamp equivalent to a 60-watt incandescent for $5, and General Electric introduced a 3-pack of 60-watt-equivalent lamps for $10 (Business Wire 2015). Lighting industry experts expect costs to continue to decrease at least somewhat as the LED lighting market grows and matures. Also, program experience with LEDs shows that customer adoption is occurring faster than it did with CFLs. With this rapid decline in costs and increases in customer acceptance, potential studies published just a couple of years ago underestimated the potential for electricity savings from this technology.

The Ohio studies' representation of LED potential varied significantly. The FirstEnergy potential study did not appear to include LED technology for main applications in either residential or commercial sectors and therefore omitted a significant savings opportunity.[8] (The FirstEnergy energy efficiency implementation plan, however, did include LED technology in its residential and commercial programs, demonstrating its value as a cost-effective efficiency measure.)

The Duke Energy and DP&L studies listed LED lighting as a component of its measures; however, the penetration of LEDs versus CFL or other technologies is unclear, especially in the DP&L study. However, analysts' overly conservative assumptions about LED costs in general (as discussed above) are likely to have resulted in low estimates of LED adoption rates even where the studies did deem LED measures to be cost effective. It is therefore highly probable that additional savings potential is available from higher participation rates than assumed in residential and business LED programs, a phenomenon that is already playing out in other jurisdictions (NEEP 2014). The AEP study, by comparison, included several LED measures across the residential, multifamily, commercial, and industrial sectors. Again, in including these and other measures, AEP found sufficient potential to cost effectively meet the SB 221 requirements.

Behavioral Strategies

A range of behavioral strategies can help customers save energy, as well as help spur uptake of particular measures and thereby drive participation in other programs. In the residential sector, some of these strategies include home energy reports, real-time energy feedback, and tenant engagement. These strategies have been rigorously evaluated and are becoming increasingly common as energy efficiency programs. An ACEEE study of recent (2009–2011), large scale, real-time energy feedback pilots and experiments in the United States, United Kingdom, and Ireland found incremental savings of approximately two to four percentage points over and above savings from other interventions, such as energy-saving advice and more frequent, enhanced bills (Foster and Mazur-Stommen 2012).

Both the AEP and Duke studies assessed some of these strategies but appear to have missed others. For example, the AEP study included a behavioral change measure for the commercial sector and customer energy reports for residential. The Duke Energy study also included customer energy reports, as well as in-home energy displays as measures for residential customers. The FirstEnergy study did not include behavioral change in its list of measures; however, the utility added home energy usage reports to its proposed residential portfolio in its 2012 plan. Similarly, the DP&L study did not appear to include any behavioral strategies; however, in its planning document the company indicated interest in exploring a behavioral initiative.

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[8] The list of measures (p. 84-88) did include LED exit signs and pedestrian signals.

Commercial and Industrial (C&I)

The C&I sector represents a large and diverse range of energy savings opportunities, and potential studies may fall short in mapping out the full range of possibilities, especially in the industrial sector.

For example, the DP&L study identified only 14% technical potential for the C&I sector by 2022 (1.4% per year) and only 9% economic potential (0.9% per year). The Duke Energy study similarly identified very conservative levels of technical and economic potential in the C&I sector (1.3% and 0.7%, respectively), and its list of business measures was notably short.

These are very conservative estimates that underestimate potential. By comparison, the AEP study identified 3.5% technical potential per year and 3.2% economic potential per year in this sector. The conservatism of the DP&L study is evident when examining the utility's current C&I program results, which have already achieved more savings per year (91 GWh in 2014, per DP&L 2015) than the high-case achievable potential for C&I programs (57 GWh per year 2013–2022).

Strategic energy management (SEM) or continuous energy improvement is a specific opportunity within the C&I sector that has not yet been universally adopted by efficiency programs and potential study analysts. SEM is a workforce education, training, and organizational culture change program. Customers participating in Energy Trust of Oregon's SEM program have experienced annual savings levels ranging from about 2% to 18%, and averaging about 8% (Jones et al. 2011).

The AEP study included several continuous energy improvement measures for commercial customers; however, it appeared that these measures were not considered cost effective for industrial customers (when the evidence above shows there are often cost-effective savings available). None of the other three studies explicitly listed these strategies as efficiency measure opportunities.

Multifamily

Multifamily buildings (those composed of buildings with four or more housing units) are typically an underserved market for energy efficiency programs, but represent a large share of electricity usage. A recent analysis of nine states found that multifamily programs could cost effectively reduce electricity usage by as much as 37% and natural gas by 36% over the next 20 years (Optimal Energy 2015). The high-case achievable potential ranged from 15% to 26% electricity savings over 20 years.

Residents and owners of multifamily buildings face unique challenges and as a result often do not adopt energy efficiency measures as readily as residents of single-family homes. One of the key issues is split incentives (where a resident who does not pay the electricity bill lacks the incentive to pay for an efficiency improvement, or vice versa). Therefore, programs that specifically address these obstacles may yield more cost-effective energy savings and should be considered in a potential study to provide a realistic estimate of achievable potential.

In Ohio, multifamily homes account for roughly 17% of all residential homes (US Census 2013). Several of the potential studies also estimated the share of electricity demand from multifamily homes, which is similar to the share of number of homes (for example, 14% of demand in the FirstEnergy service area and 18% of residential electricity sales in the Duke Energy area). This segment therefore offers a significant opportunity. Potential studies do not always specifically analyze the multifamily sector. While savings opportunities may be embedded in the residential sector overall, the measure screening intended for single-family homes may miss out on comprehensive cost-effective potential for multifamily homes that can be achieved through tailored programs. The following summarizes how the studies treated multifamily according to our review:

- *AEP*. It is not clear the extent to which multifamily energy efficiency savings potential is modeled. While residential measure characterization mentions multifamily, the C&I measure characterization also includes a segment on C&I Multifamily.
- *FirstEnergy*. Multifamily segment did not receive specific focus in potential study.
- *Duke Energy*. Multifamily is eligible for the company's home energy assessment program, but the sector did not receive specific focus in potential study.
- *DP&L* identifies same portion of economic potential in single-family homes as multifamily homes (15% or 1.5% per year), and the high-case achievable savings would be 80% of this, or 1.2% savings per year.

It is difficult to assess the extent to which these studies capture the full potential for the multifamily segment; however, lack of transparency suggests a possibility of additional savings potential through targeted multifamily programs. Only one of the four Ohio utilities currently offers programs specifically targeted at the multifamily sector.

Combined Heat and Power (CHP)

CHP offers significant energy savings potential. Recent national estimates indicate that an additional 130 GW of capacity is technically feasible at existing industrial, commercial, and institutional facilities (ICF International 2013). Ohio holds one of the largest technical potentials with over 5,900 MW of technical potential for projects under 100 MW (ICF International 2013). Additional potential is available in larger projects that were beyond the size limits of this study. Especially with the addition of financial incentives through utility programs, significant amounts of the technical potential in Ohio could become cost effective.

Several states have developed innovative approaches to increase deployment of CHP through programs by utilities and other administrators. Among the most successful is the program operated by Baltimore Gas & Electric (BGE). BGE's Smart Energy Savers CHP program provides financial incentives to commercial and industrial customers that employ CHP to reduce their energy consumption and demand usage. The first phase of BGE's program (2012–2014) resulted in five implemented projects and generated over 25,000 MWh of annualized energy savings (BGE 2015). Due to the popularity of the first phase, BGE requested approval and the Maryland Public Service Commission increased the incentive cap in the second phase (2015–2017) to $2.5 million, providing an even greater benefit to BGE's CHP program participants (MPSC 2014). Currently, 13 projects ranging in size from

60 kW to 8 MW have been approved to participate in the program, totaling over 16.5 MW of installed capacity.

Despite this potential, and even though Ohio specifically authorized the use of CHP projects to deliver energy savings as of 2012 in SB 315, the Ohio IOU studies typically did not include the potential for CHP, or its extent of penetration was unclear (see table 3).

Table 3. Treatment of CHP in Ohio IOU potential studies

AEP	Duke	DP&L	FirstEnergy
Not included in potential study	Included as measure, but extent of penetration is unclear	Not included in potential study	Potential study does not indicate whether CHP is included

This omission is particularly notable now that Ohio utilities have in fact begun to incorporate CHP projects in their energy efficiency portfolios. For example, AEP currently has two projects co-proposed with industrial customers.[9] In addition, there are several other projects that are in the final development phase awaiting final approval from the Public Utilities Commission (J. Williams, manager, energy efficiency and demand response, AEP Ohio, pers. comm., August 5, 2015). If this trajectory continues, CHP will yield significant cost-effective savings that were not considered in the utility potential studies.

Miscellaneous Energy Loads (MELs)

Energy consumed by miscellaneous energy loads (MELs) in residential and commercial buildings has been growing and is expected to grow faster than the "Energy other" category, according to EIA. MELs include consumer electronics, cable set-top boxes, computers and associated equipment, elevators, medical devices, and many other devices. These devices are often characterized as "other" loads in electricity potential studies.

These miscellaneous end-uses comprise a large share of building energy demand (estimated at about 20% of total consumption, per Kwatra, Amann, and Sachs 2013). The same is true of electricity use in Ohio. For example, in DP&L service area, plug loads account for the highest percentage of residential electricity usage (16%) and the second-highest percentage of commercial usage (25%) behind lighting.

There are significant savings opportunities from MELs. An ACEEE study identifies annual electricity savings of 285 TWh per year with full application of the highly efficient units and efficiency measures on the market, which is equivalent to 47% savings of the top 20 residential and 20 commercial MELs (Kwatra, Amann, and Sachs 2013). The AEP study similarly found significant cost-effective potential—the "Other" end-use category had the second-largest portion of economic savings in the C&I sector (figure 25). However, the study fell far short in characterizing more of these cost-effective C&I savings as achievable. Only 23% of "Other" measure savings were considered achievable in the base case and 36%

[9] See http://dis.puc.state.oh.us/CaseRecord.aspx?CaseNo=14-2296-EL-EEC and http://dis.puc.state.oh.us/CaseRecord.aspx?CaseNo=14-2304-EL-EEC.

in the high case. There are additional program opportunities to tap these cost effectively through programs and participation.

Kwatra, Amann, and Sachs recommend that program administrators motivate consumers to purchase efficient products, affect manufacturer design, and influence end-user decisions on how products are used through behavioral initiatives. Several programs complement their retail outreach with retailer, and to a lesser degree manufacturer, incentives for high-efficiency consumer electronic products. For cable set-top boxes, recent program offerings have included incentives targeted to local service providers for the purchase of more efficient boxes and incentives to customers and service providers for the replacement of non-ENERGY STAR® boxes and for upgrades to a whole-home system using thin clients (NEEP 2013).

Conservation Voltage Reduction (CVR)

Electricity distribution systems account for a large share of line losses in the United States, and one of the leading ways to reduce these losses is through conservation voltage reduction (CVR) or volt/VAR control. By analyzing voltages on distribution feeders and finding ways to reduce voltage while maintaining service requirements, CVR can save on the order of 2–3% electricity savings, with 98–99% of these savings on the customer side of the meter (Schneider et al. 2010).

CVR potential was a gap in the Ohio potential studies:

- While DP&L's planned T&D infrastructure improvements include the possibility of CVR, its potential study does not include this as a strategy.
- FirstEnergy's study notes that the savings from T&D upgrades are not included in the potential study, which would provide some additional savings. In its EE plan filed in 2012, the company noted that a new CVR study would examine the potential impacts of such a program.
- AEP does not include this strategy in its study; however, the utility has done volt/VAR optimization on 17 circuits and as a result reduced customer energy use by 2–3% (IEI 2013).
- The Duke Energy study does not include this strategy.

Best-Practice Energy Efficiency Portfolios

The following demonstrates how utilities in two states (Massachusetts and Minnesota) have used best practices in energy efficiency programs and have cost effectively achieved savings levels of at least 1.7%, and in one case over 2%, over multiple years—levels that would be sufficient to meet the SB 221 targets in Ohio.[10]

[10] Both states have rules requiring that utility efficiency programs pass cost-effectiveness tests.

Massachusetts electric utilities achieved net savings equivalent to 2.4% of electricity sales in 2014 and 2% in 2013.[11] Figure 1 shows the 2014 savings results categorized by major area. Slightly more than half of the savings came from C&I programs (57%), and slightly less than half came from residential programs (43%). Massachusetts programs are notable for their breadth in type, addressing nearly all of the strategies mentioned in this analysis (except voltage optimization, to our knowledge). For example, the C&I retrofit sector includes a substantial and successful CHP program. Residential and business programs include multiple strategies for residential and business consumer electronics, and LEDs represent a large and growing component of lighting programs.

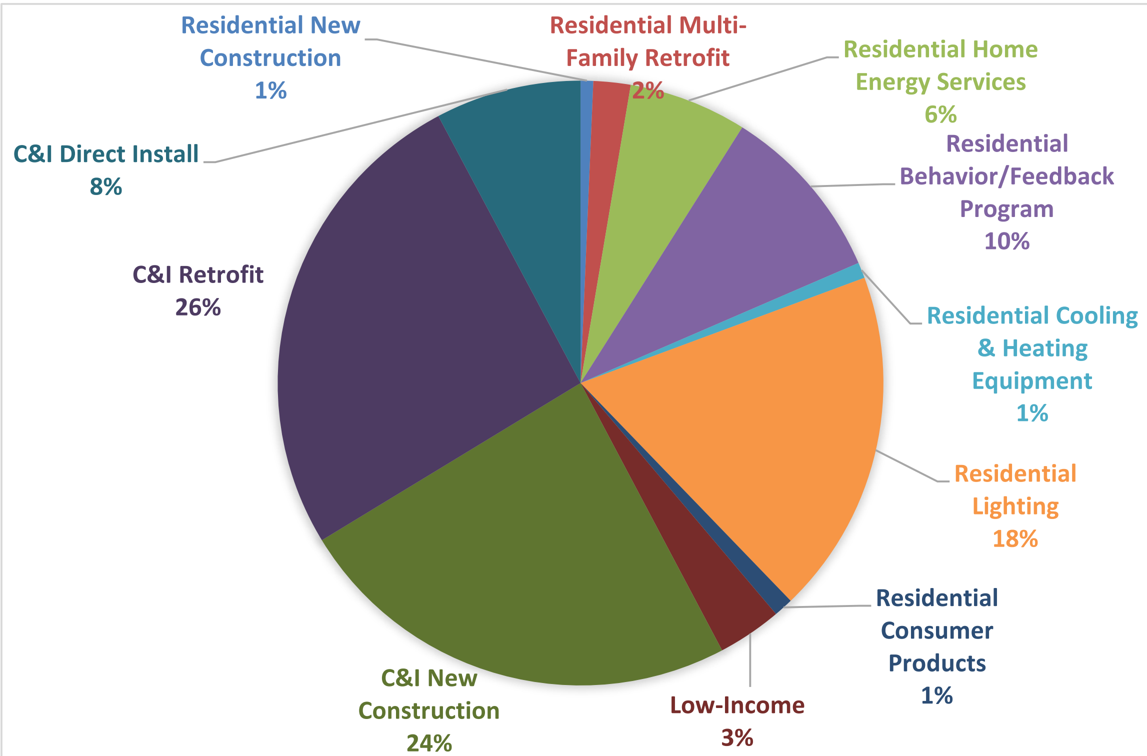

Figure 1. Share of energy efficiency savings by major area. *Source:* MA EEAC 2015.

The portfolio is also notable for its participation rates and depth of savings. For example, the cost-effective residential retrofit programs (including multifamily and home energy services) reached more than 77,000 residences, which is equivalent to 2.7% of households in Massachusetts.[12] This penetration rate is significant for one year, and demonstrates the scale that is necessary and achievable to reach large savings. These programs are also

[11] Savings are net, based on using adjustment factors to subtract savings from adoption of energy efficiency measures that would have likely occurred even without utility incentives. The state's three-year energy efficiency plan calls for savings to increase to 2.6% in 2015 (see http://database.aceee.org/state/massachusetts).

[12] Based on Census data for number of households in Massachusetts.

comprehensive, with savings of roughly 1,400 kWh per participant. The behavior program also has high participation, having reached 28% of households in 2014.

Another example of a best-practice program portfolio is Xcel Energy in Minnesota. The utility has achieved gross electricity savings of 1.8%, 1.7%, and 1.7% in 2012, 2013, and 2014, respectively (Xcel Energy 2013; 2014; 2015).[13] The utility has a diverse portfolio of programs. Notably, it addresses most of the strategies mentioned in this gap analysis (except CHP and voltage optimization, to our knowledge):

- *LED lighting.* Its upstream residential lighting program exceeded savings goals in 2014; the increased savings were the result of effective promotions and stronger-than-expected uptake of LEDs.
- *Behavior.* Energy feedback program exceeded savings goal in 2014.
- *Multifamily.* Low-income multifamily program exceeded savings goals in 2014; remaining opportunity to expand to rest of multifamily segment.
- *C&I strategic energy management.* Two programs, Commercial Efficiency and Process Efficiency, offer C&I customers customized resources to develop a holistic, sustainable energy management plan.
- *MELs,* e.g., computer efficiency program, food service program.

These are just a couple of examples of comprehensive portfolios that have consistently achieved high levels of electricity savings. While key metrics such as cost-effectiveness requirements, net or gross savings usage, and avoided costs approaches vary across jurisdictions, this demonstrates that program administrators have already achieved and sustained savings at the levels necessary to meet the SB 221 goals.

Conclusion

The four energy efficiency potential studies by Ohio investor-owned utilities document a large share of energy savings opportunities, and the most recent study by AEP indicates that it can cost effectively comply with the savings goals of SB 221. Furthermore, this analysis finds that the studies likely did not fully capture all potential. Several strategies analyzed in this gap analysis identify areas where at least some of the studies did not fully capture all achievable savings: LED lighting, behavioral response, multifamily, combined heat and power, strategic energy management, miscellaneous energy loads, and voltage optimization. Utilities in Ohio have already begun to develop programs to address many of these areas, or have at least begun planning to do so, and will be able to achieve more cost-effective savings than projected in their potential studies. Our analysis indicates that these savings will be sufficient to meet the state's energy efficiency goals as set forth in SB 221.

[13] Minnesota relies solely on gross electricity savings for its energy efficiency programs.

References

Apex Analytics, LLC. 2014. *Energy Trust of Oregon Nest Thermostat Heat Pump Control Pilot Evaluation*. October 10. Prepared for Energy Trust of Oregon. http://energytrust.org/library/reports/Nest_Pilot_Study_Evaluation_wSR.pdf.

Baatz, B. 2015. *Everyone Benefits: Practices and Recommendations for Utility System Benefits of Energy Efficiency*. Washington, DC: ACEEE. http://aceee.org/everyone-benefits-practices-and-recommendations.

BGE (Baltimore Gas & Electric). 2015. *BGE's Semi-Annual Report for Third and Fourth Quarters, July 1 through December 31, 2014 in Case No. 9154*.

Business Wire. 2015. "GE Launches Bright Stik™, a CFL Replacement LED Light Bulb Available in an LED 3-pack for under $10 Every Day at the Home Depot." The Street. June 3. http://www.thestreet.com/story/13173819/1/ge-launches-bright-stik-a-cfl-replacement-led-light-bulb-available-in-an-led-3-pack-for-under-10-every-day-at-the-home-depot-photo-general-electric.html.

Cadmus. 2015. *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program*. Prepared by Cadmus for Vectren Corporation. http://www.cadmusgroup.com/papers-reports/evaluation-2013-2014-programmable-smart-thermostat-program/.

Denkenberger, D., C. Calwell, N. Beck, B. Trimboli, D. Driscoll, and C. Wold. 2013. *Analysis of Potential Energy Savings from Heat Pump Clothes Dryers in North America*. Ecova, CLASP, SEDI. http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2013/Clothes-Dryer-Heat-Pump-Technology-Offers-Substantial-Cost-and-Energy-Savings-for-North-America.aspx.

DP&L (Dayton Power and Light). 2015. *2014 Energy Efficiency and Demand Reduction/Response Portfolio Status Report*. May 15. http://dis.puc.state.oh.us/TiffToPDf/A1001001A15E15B50040G41339.pdf.

EIA (Energy Information Administration). 2014a. "Ohio State Profile and Energy Estimates." http://www.eia.gov/state/data.cfm?sid=OH#ConsumptionExpenditures.

———. 2014b. "LED Bulb Efficiency Expected to Continue Improving as Cost Declines." March 19. http://www.eia.gov/todayinenergy/detail.cfm?id=15471.

Foster, B., and S. Mazur-Stommen. 2012. *Results from Recent-Real-Time Feedback Studies*. Washington, DC: ACEEE.

Hayes, S., G. Herndon, J. Barrett, J. Mauer, M. Molina, M. Neubauer, D. Trombley, and L. Ungar. 2014. *Change Is in the Air: How States Can Harness Energy Efficiency to Strengthen the Economy and Reduce Pollution*. Washington, DC: ACEEE. http://aceee.org/research-report/e1401.

ICF International. 2013. *The Opportunity for CHP in the United States.* Prepared for the American Gas Association. Washington, DC: ICF International. https://www.aga.org/opportunity-chp-us.

IEI (Institute for Electric Innovation). 2013. *Innovations across the Grid: Partnerships Transforming the Power Sector.* Washington, DC: Institute for Electric Innovation. http://www.edisonfoundation.net/iei/Documents/InnovationsAcrosstheGrid_LoRes_InstElcInnv.pdf.

Jones, T., K. Crossman, J. Eskil, and J. Wallner. 2011. "The Evolution of Continuous Energy Improvement Programs in the Northwest: An Example of Regional Collaboration." In *Proceedings of the 2011 ACEEE Summer Study on Energy Efficiency in Industry.* Washington, DC: ACEEE.

Kramer, C., and G. Reed. 2012. *Ten Pitfalls of Potential Studies.* November 12. Regulatory Assistance Project and Energy Futures Group. http://www.raponline.org/document/download/id/6214.

Kwatra, S., J. Amann, and H. Sachs. 2013. *Miscellaneous Energy Loads in Buildings.* Washington, DC: ACEEE. http://aceee.org/research-report/a133.

MA EEAC (MA Energy Efficiency Advisory Council). 2015. *Electric Statewide Summary*. June 5. http://ma-eeac.org/results-reporting/.

MPSC (Maryland Public Service Commission). 2014. Order No. 86785. http://webapp.psc.state.md.us/Intranet/sitesearch/Whats_new/Order%20No.%2086785%20-%20Cases%20Nos.%209153-9157,%209362%20-%20EmPOWER%20MD%202015%20-%202017%20Program%20Cycle.pdf.

NEEP (Northeast Energy Efficiency Partnerships). 2013. *Business & Consumer Electronics: A Strategy for the Northeast*. August. Lexington, MA: NEEP.

———. 2014. *Northeast Residential Lighting Strategy: 2014-15 Update.* December. Lexington, MA: NEEP.

Neubauer, M. 2014. *Cracking the TEAPOT: Technical, Economic, and Achievable Potential Studies.* Washington, DC: ACEEE. http://aceee.org/research-report/u1407.

Nowak, S., and M. Kushler. 2015. *Successful Practices in Combined Gas and Electric Utility Energy Efficiency Programs.* Washington, DC: ACEEE.

Nyquist, S. 2015. "Peering into Energy's Crystal Ball." McKinsey & Company. July. http://www.mckinsey.com/insights/energy_resources_materials/peering_into_energys_crystal_ball.

Optimal Energy. 2015. *Potential for Energy Savings in Affordable Multifamily Housing.* Prepared for Natural Resources Defense Council. May.

http://www.energyefficiencyforall.org/sites/default/files/EEFA%20Potential%20Study.pdf.

Schneider, K., F. Tuffner, J. Fuller, and R. Singh. 2010. *Evaluation of Conservation Voltage Reduction (CVR) on a National Level*. PNNL-19596. Richland, WA: Pacific Northwest National Laboratory. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19596.pdf

SEEAction (State and Local Energy Efficiency Action Network). 2014. *Financing Energy Improvements on Utility Bills: Market Updates and Key Program Design Considerations for Policymakers and Administrators*. Prepared by Lawrence Berkeley National Laboratory.

US Census. 2013. *American Community Survey.* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

Xcel Energy. 2013. *2012 Status Report & Associated Compliance Filings: Minnesota Electric and Natural Gas Conservation Improvement Program.* April 1. Minneapolis.

——. 2014. *Errata – 2013 Status Report & Associated Compliance Filings: Minnesota Electric and Natural Gas Conservation Improvement Program.* May 21. Minneapolis.

——. 2015. *2014 Status Report & Associated Compliance Filings: Minnesota Electric and Natural Gas Conservation Improvement Program.* April 1. Minneapolis.

York, D., M. Neubauer, S. Nowak, and M. Molina. 2015. *Expanding the Energy Efficiency Pie: Serving More Customers, Saving More Energy through High Program Participation.* Washington, DC: ACEEE.