REPORT

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Duke Energy Ohio DSM Market Potential Study

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1 Executive Summary

In March 2018, Duke Energy retained Nexant, Inc., to determine the potential energy and demand savings that could be achieved by demand-side management (DSM) programs in the Duke Energy Ohio (DEO) service territory. Demand-side management includes both energy efficiency (EE) and demand response (DR) approaches for reducing overall electricity consumption and peak demands. The main objectives of the study include:

- Estimating the technical, economic and realistic achievable market potential for energy and demand savings over the next ten years
- Developing savings estimates with a focus on compliance and system planning
- Estimating program costs and benefits associated with realistic achievable potential

1.1 Methodology

This study used Nexant's Microsoft Excel-based modeling tool, TEA-POT (Technical / Economic / Achievable POTential). This modeling tool was built on a platform that provides the ability to calculate multiple scenarios and recalculate potential savings based on variable inputs such as sales/load forecasts, electricity prices, discount rates, and actual program savings. The methodology for the energy efficiency potential assessment was based on a hybrid "top-down/bottom-up" approach.

Nexant disaggregated current DEO load and sales forecasts into their constituent customer-class and end use components and we examined savings from DSM measures and practices on each end use, accounting for fuel shares, current market saturations, technical feasibility, and costs. We aggregated individual measure impacts estimate potential for each end use, customer class, and for the DEO customer base.

1.2 Savings Potential

This study also incorporated provisions specified in Ohio Senate Bill 310[1] (SB 310), which was signed into law in 2014, with impacts becoming effective on January 1, 2017. SB 310 amends Senate Bill 221, which went into effect in 2008.

1.2.1 Energy Efficiency Potential

The estimated technical, economic, and achievable potential scenarios are summarized in Table 1-1, which lists cumulative energy and demand savings, as well as the levelized cost for each type of potential based on provisions specified in SB 310.

[1] State of Ohio Substitute Senate Bill 310 Section 4928.662, sections (A) through (G), pages 30 and 31.

Table 1-1: Energy Efficiency Potential[2]

Sector	Energy Efficiency Potential (2019-2028)			
	Energy (GWh)	% of 2028 Base Sales	Demand (MW)	Levelized Cost[3] ($/kWh)
Technical Potential	4,968	26%	2,186	$0.20
Economic Potential	3,082	16%	1,952	$0.03
Achievable, Base Scenario	1,192	6%	872	$0.06
Achievable, Enhanced Scenario	1,538	8%	970	$0.07

1.2.2 Demand Response Potential

Demand response opportunities were analyzed for DEO's service territory to determine the amount of summer and winter peak capacity that could be reduced through demand response initiatives from a technical, economic, and program potential perspective. While technical and economic potential are theoretical upper limits, for program-based DR, participation rates are calculated as a function of the incentives offered to each customer group. For a given incentive level and participation rate, the cost-effectiveness of each customer segment is evaluated to determine whether the aggregate DR potential from that segment should be included in the achievable potential.

Figure 1-1 and Figure 1-2 summarize the summer peak and winter peak demand response potential estimated for two program scenarios analyzed in the study.

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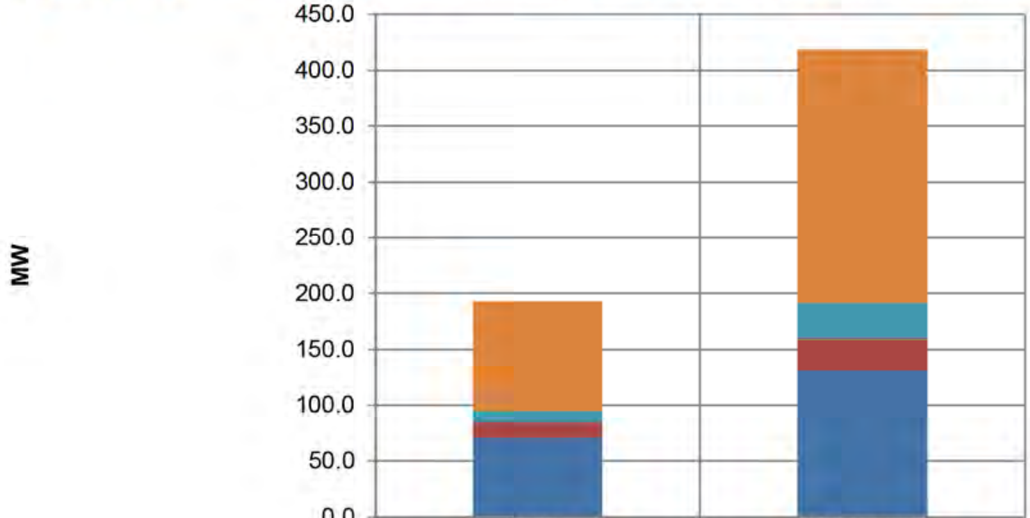
2 Current non-residential customer opt-outs are not included. Customers consuming more than 45 GWh annually are eligible to opt-out of DSM program in the DEO territory. These customers represent 8% of the non-residential baseline consumption and are not considered in this analysis. Nexant refers to these customers as "Opt-out/self-direct" customers.

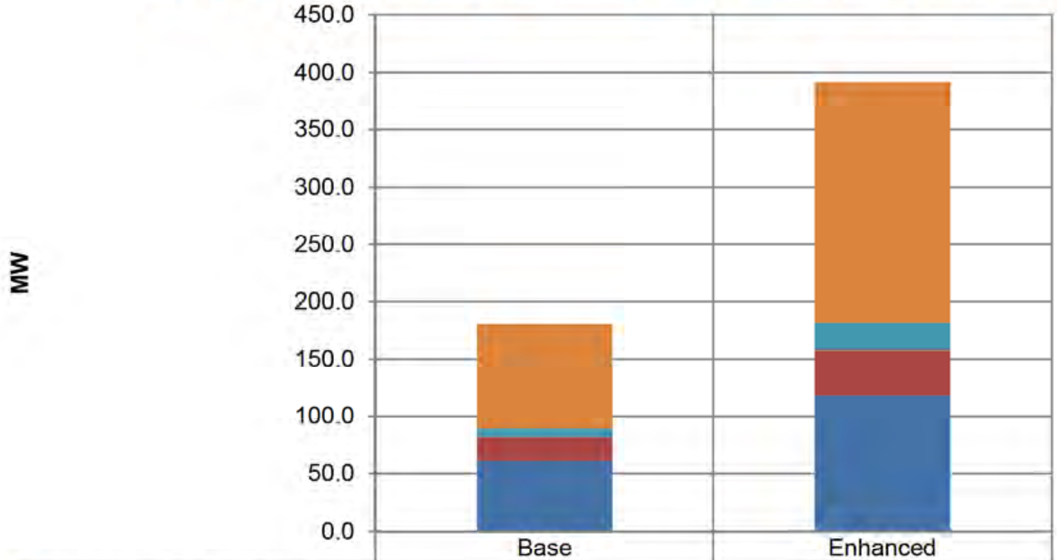
3 Levelized cost presented from the total resource cost (TRC) perspective. Technical and economic potential costs include incremental measure costs; while achievable program potential includes both incremental measure costs and program delivery and administrative costs.

Figure 1-1 Demand Response Summer Peak Capacity Program Potential



	Base	Enhanced
Large C&I - 1 MW and Up	97.9	227.4
Large C&I - 500 kW to 1 MW	10.0	30.3
Large C&I - 300 kW to 500 kW	0.5	1.5
Small and Medium Business	0.2	1.0
Residential Multi-Family	13.3	27.6
Residential Single Family	70.6	131.0

Figure 1-2 Demand Response Winter Peak Capacity Program Potential



	Base	Enhanced
Large C&I - 1 MW and Up	91.3	209.8
Large C&I - 500 kW to 1 MW	7.3	22.4
Large C&I - 300 kW to 500 kW	0.4	1.2
Small and Medium Business	0.2	0.8
Residential Multi-Family	20.3	39.2
Residential Single Family	61.1	118.2

2 Introduction

2.1 Objectives and Deliverables

In March 2018, Duke Energy retained Nexant, Inc., to determine the potential energy and demand savings that could be achieved by demand-side management (DSM) programs in the Duke Energy Ohio (DEO) service territory. The main objectives of the study include:

- Estimating the technical, economic and realistic achievable market potential for energy demand savings over the next ten years
- Developing savings estimates with a focus on compliance and system planning
- Estimating program costs and benefits associated with realistic achievable potential

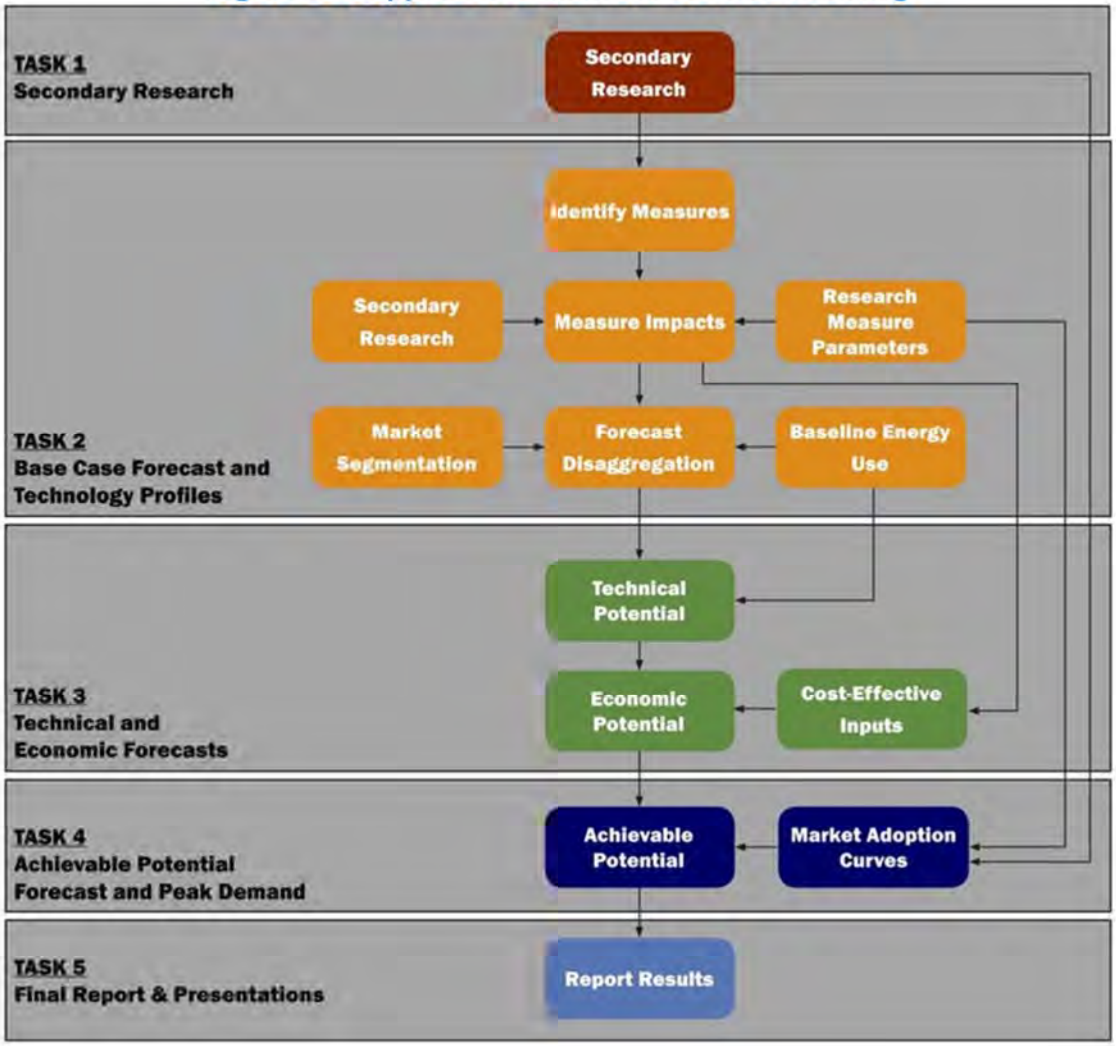
In developing the market potential for DEO, the following deliverables were developed by Nexant as part of the project and are addressed in this report:

- Project plan
- Measure list and detailed assumption workbooks
- Disaggregated baseline by year, state, sector, end use, technology saturations, and energy and demand consumptions
- List of forward looking DSM program concepts, along with the applicable markets, measures, and estimated delivery costs
- Market potential energy savings for technical, economic and realistic program achievable potential scenarios for the next ten years (2019 – 2028)
- Estimated program costs to acquire all the achievable potential
- Supporting calculation spreadsheets

2.2 Methodology

Energy efficiency and market potential studies involve a number of analytical steps to produce estimates of each type of energy efficiency potential: technical, economic, and achievable. This study utilized Nexant's Microsoft Excel-based modeling tool, TEA-POT (Technical / Economic / Achievable Potential). This modeling tool was built on a platform that provides the ability to calculate multiple scenarios and recalculate potential savings based on variable inputs such as sales/load forecasts, electricity prices, discount rates, and actual program savings. The model provides transparency into the assumptions and calculations for estimating market potential. The methodology for the energy efficiency potential assessment is based on a hybrid "top-down/bottom-up" approach.

Figure 2-1: Approach to Market Potential Modeling



As illustrated in Figure 2-1, the assessment started with current load and sales forecasts, then disaggregated it into its constituent customer-class and end use components. Nexant examined the effect of the range of energy efficiency measures and practices on each end use, taking into account fuel shares, current market saturations, technical feasibility, and costs. These unique impacts were aggregated to produce estimates of potential at the technology, end use, customer class, and system levels.

The market potential in the DEO territory can be characterized by levels of opportunity. The ceiling or theoretical maximum is based on commercialized technologies and behavior measures, whereas the realistic savings that may be achieved through DSM programs reflect real world market constraints such as utility budgets, customer perspectives, and energy efficiency policy. This analysis defines these levels of energy efficiency potential according to the Environmental Protection Agency's (EPA) National Action Plan for Energy Efficiency (NAPEE) as illustrated in Figure 2-2.

Figure 2-2: Energy Efficiency Potential

EPA – National Guide for Resource Planning

- Technical Potential is the theoretical maximum amount of energy and capacity that could be displaced by efficiency, regardless of cost and other barriers that may prevent the installation or adoption of an energy efficiency measure. Technical potential is only constrained by factors such as technical feasibility and applicability of measures.
- Economic Potential is the amount of energy and capacity that could be reduced by efficiency measures that pass a cost-effectiveness test. The Total Resource Cost (TRC) Test estimates the measure costs to both the utility and customer.
- Achievable Potential is the energy savings that can feasibly be achieved through program and policy interventions.
- Program Potential reflects the realistic quantity of energy savings the utility can realize through DSM programs during the horizon defined in the study. Potential delivered by programs is often less than achievable potential due to real-world constraints, such as utility program budgets, effectiveness of outreach, and market delays.

This study explored technical, economic, and achievable program potential over the period January, 2019 to December, 2028. The quantification of these three levels of energy efficiency potential is an iterative process reflecting assumptions on cost effectiveness that drill down the opportunity from the theoretical maximum to realistic program savings. The California Standard Practice Manual (SPM) provides the methodology for estimating cost effectiveness of energy efficiency measures, bundles, programs or portfolios based on a series of tests representing the perspectives of the utility, customers, and societal stakeholders. In this potential study, individual measures were screened for cost-effectiveness using the total resource cost (TRC) from the Standard Practice Manual.

Nexant estimated DSM program savings potential based on a combination of market research, analysis, and a review of Duke Energy's existing DSM programs, all in coordination with Duke Energy. DSM programs that Nexant examined included both energy efficiency (EE) and demand-response (DR) programs; therefore, this report is organized to offer detail on both types of programs.

The remainder of the report provides detailed methodologies and results for each step in the potential analysis process, according to the following sections:

- Market Characterization
- DSM Measure List
- Technical Potential
- Economic Potential
- Program Potential
- Conclusions and Recommendations

2.3 SB 310 Compliance

In the summer of 2014, the Ohio legislature passed Senate Bill 310[4] (SB 310) which was subsequently signed into law on June 13, 2014. SB 310 amends Senate Bill 221, which went into effect in 2008 and stipulated electric distribution utilities (EDUs) achieve a cumulative annual energy savings in excess of 22% by the end of 2025. Under SB 310, EDUs are not required to secure energy efficiency savings in 2015 or 2016 and extends the timeframe in which to exceed 22% cumulative energy savings to 2027.

In addition to revising the schedule for complying with the savings target, SB 310 also introduces new mechanisms that adjust how EDUs estimate their energy savings. Specifically, SB 310 requires that "energy efficiency savings and peak demand reduction achieved on and after the effective date of S.B. 310 of the 130th general assembly shall be measured on the higher of an as found or deemed basis, except that, solely at the option of the electric distribution utility, such savings and reduction achieved since 2006 may also be measured using this method." That is, an EDU may claim savings based on the baseline operating conditions found at the location of where the energy efficiency measure was installed, or the EDU may claim its own calculated deemed savings estimate.

In order to estimate savings consistent with this compliance rule, SB 310 methods apply the existing market baseline technology efficiency rather than the code technology efficiency. For example, the estimated savings potential under this approach would consider the incremental savings between the existing average market efficiency for central air conditioners (12.71 SEER) and a more efficient 16 SEER unit. Measures that apply to new construction will continue to use a code baseline, and non-equipment measures applied to existing premises utilize the existing technology conditions. Demand response measures also include an existing technology condition and thus SB 310 does not call for any change in approach for estimating baseline consumption.

[4] State of Ohio Substitute Senate Bill 310 Section 4928.662, sections (A) through (G), pages 30 and 31

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In addition to the prospective market potential, the Nexant team conducted a parallel analysis that addressed historical energy efficiency savings achieved in DEO's service territory from 2016 to 2017, as allowed by SB 310. The team estimated savings achieved through actions that DEO customers took that were not already claimed though DEO energy efficiency programs. This evaluation of historical savings will be incorporated into future DEO compliance filings, and is available upon request. Relevant text from SB 310 is provided in Appendix C.

3 End Use Market Characterization

The 2018 DEO sales and load forecasts provide the baseline for determining DSM savings potential for 2019 to 2028. The 2018 forecast provided to Nexant by DEO includes estimates of sales and load for the period 2018 to 2040, but the scope of this MPS covers DSM potential for the ten year period from 2019 to 2028.The baseline is also informed by other relevant DEO data, such as the 2016 Residential Appliance Saturation Survey (RASS) and DEO load research data. These baseline data provided by DEO to Nexant include end use market characterization, customer segmentation, and load forecast disaggregation. The characterization is described in this section, while the subsequent section addresses the measures and market potential energy savings scenarios.

3.1 Methodology

3.1.1 Customer Segmentation

In order to estimate energy efficiency (EE) and demand response (DR) potential, the sales forecast and peak load forecast(s) were segmented by customer characteristics. Assessing the DSM savings potential required an understanding of how DSM measures apply to electricity customers. As electricity consumption patterns vary by customer type, Nexant segmented customers into similar groups to describe how these groups may adopt specific energy efficiency technologies or provide DSM grid services.

Customer segmentation also addressed the business need to deliver cost-effective DSM programs. Significant cost efficiency can be achieved through strategic DSM program designs that recognize and address the similar DSM potential that exists within each customer group. Nexant segmented DEO customers according to the following:

1) By Sector – how much of the Duke Energy's energy sales, summer peak, and winter peak load forecast is attributable to the residential, commercial, and industrial sectors?
2) By Segment – how much electricity does each customer segment typically consume annually and during system peaking conditions?
3) By End Use – within a home or business, what equipment is using electricity during the peak? How much energy does this end use consume over the course of a year?

This analysis also identified the segments of customers ineligible for DSM, such as Opt Out/Self Direct commercial and industrial customers.

Table 3-1 presents the segmentation by sector and customer type within each sector. The analysis of the customer segmentation is discussed in Section 3.1.1. In addition to the segmentation described here for the EE analysis, the residential customer segments were further segmented by heating type (electric heat, gas heat, or unknown) and by annual consumption deciles within each sub-segment for the DR analysis. The goal of this further segmentation was to understand which customer groups were most cost-effective to recruit and allow for more targeted marketing of DR programs.

Table 3-1: Customer Segments and Sub-Sectors

Residential	Commercial		Industrial	
Single Family	Assembly	Lodging/ Hospitality	Chemicals and plastics	Primary resource industries
Multi Family	College and University	Miscellaneous	Construction	Stone, clay, glass, and concrete
	Data Center	Offices	Electrical and electronic equipment	Textiles and leather
	Grocery	Restaurant	Lumber, furniture, pulp, and paper	Transportation equipment
	Healthcare	Retail	Metal products and machinery	Water and wastewater
	Hospitals	Schools K-12	Miscellaneous manufacturing	
	Institutional	Warehouse		

From an equipment and energy use perspective, each segment may have some variations across each building type or sub-sector. For example, the energy using equipment in a convenience store will vary significantly from the equipment found in a supermarket. To account for this variation, the selected end uses describe energy savings potential that are consistent with those typically studied in national or regional surveys. These end uses are listed in Table 3-2.

Table 3-2: End Uses

Residential End Uses	Commercial End Uses	Industrial End Uses
Space heating	Space heating	Process heating
Space cooling	Space cooling	Process cooling
Domestic hot water	Domestic hot water	Compressed air
Ventilation and circulation	Ventilation and circulation	Motors, pumps
Lighting	Interior lighting	Motors, fans, blowers
Cooking	Exterior lighting	Process-specific
Refrigerators	Cooking	Lighting
Freezers	Refrigeration	HVAC
Clothes washers	Office equipment	Other
Clothes dryers	Miscellaneous	
Dishwashers		
Plug load		
Miscellaneous		

For the DR assessment, the end uses targeted were limited to end uses with controllable load for residential customers and small/medium businesses (SMB), but all load during peak hours for large commercial and industrial (large C&I) customers, who potentially would be willing to shed their load during temporary peak conditions if offered a large enough incentive. For residential customers, AC/heating loads, as well as pool pumps and electric water heaters for certain program potential scenarios were studied. For SMB customers the analysis was limited to AC/heating loads.

3.1.2 Forecast Disaggregation

Although the primary focus of the EE potential study was the electricity consumption forecast and the primary focus of the DR potential study was the peak load forecasts, the accuracy of the demand impacts and cost-effectiveness screening in the EE potential study is enhanced by a detailed approach to peak load disaggregation. Therefore, during the development of all the baselines, the energy efficiency and demand response teams coordinated with each other, to ensure consistent assumptions and to avoid potential double counting of potential.

Additionally, a common understanding of the assumptions and granularity in the baseline load forecast were developed with input with Duke Energy. Key discussion topics reviewed with Duke Energy included:

- How are Duke Energy's current DSM offerings reflected in the energy and demand forecast?
- What are the assumed weather conditions and hour(s) of the day when the system is projected to peak?
- How much of the load forecast is attributable to accounts that are not eligible for DSM programs or have opted-out of the DSM rider?

- How are projections of population increase, changes in appliance efficiency, and evolving distribution of end use load shares accounted for in the ten year peak demand forecast?
- If separate forecasts are not developed by region or sector, are there trends in the load composition that Nexant should account for in the study?

3.1.2.1 Electricity Consumption (kWh) Forecast

Nexant segmented the DEO electricity consumption forecast into electricity consumption load shares by customer class and end use. The baseline customer segmentation represents the DEO electricity market by describing how electricity was consumed within the service territory. Nexant developed these forecasts for the years 2019-2028, and based it on data provided by Duke Energy. The data addressed current baseline consumption, system load and sales forecasts.

3.1.2.2 Peak Demand (kW) Forecast

A fundamental component of DR potential was establishing a baseline forecast of what loads or operational requirements would be absent existing dispatchable DR or time varying rates. This baseline was necessary to assess how DR can assist in meeting specific planning and operational requirements. We utilized Duke's summer and winter peak demand forecast, which was developed for system planning purposes.

3.1.2.3 Estimating Consumption by End use Technology

As part of the forecast disaggregation, Nexant developed a list of electricity end uses by sector (Table 3-2). To develop this list, Nexant began with Duke Energy's estimates of average end use consumption by customer and sector. Nexant combined these data with other information, such as Duke Energy's residential appliance saturation surveys, to develop estimates of customers' baseline consumption. Nexant augmented the Duke Energy data with data available from public sources, such as the Energy Information Agency's recurring data-collection efforts that describe energy end use consumption for the residential, commercial, and manufacturing sectors.

To develop estimates of end use electricity consumption by customer segment and end use, Nexant applied estimates of end use saturation, energy fuel share, and equipment-type saturation to the average energy consumption for each sector. The following data sources and adjustments were used in developing the base year 2018 sales by end use:

Residential sector:

- The disaggregation was based on DEO rate class load shares/intensities, and adjustments were made for dwelling type.
- Adjustments were made to the baseline intensity for end use saturation, fuel source, and equipment saturation as follows:
    - Duke Energy rate class load share is based on average per customer
    - Nexant made conversions to usage data provided from individual customer accounts and the RASS

- Outcome is designed to reflect customers' opportunities to apply or adopt DSM measures

Commercial sector:

- The disaggregation was based on DEO rate class load shares, intensities, and EIA CBECS data
- Segment data from EIA, DEO
- Adjustments were made to the baseline intensity for end use saturation, fuel source, and equipment saturation as follows:
  - Duke Energy rate class load share based on EIA CBECS and end use forecasts from DEO
  - Nexant made conversions to usage data provided from individual customer accounts
  - Outcome is designed to reflect customers' opportunities to apply or adopt DSM measures

Industrial sector:

- The disaggregation was based on DEO rate class load shares, intensities, and EIA MECS data
- Segment data from EIA, DEO
- Adjustments were made to the baseline intensity for end use saturation, fuel source, and equipment saturation as follows:
  - Duke Energy rate class load share based on EIA MECS and end use forecasts from DEO
  - Nexant made conversions to usage data provided from individual customer accounts
  - Outcome is designed to reflect customers' opportunities to apply or adopt DSM measures

3.1.3 Analysis of Customer Segmentation

As noted above, breaking customer groups into segments is important to ensuring that an MPS examines DSM measure savings in a more meaningful way. Duke Energy provided Nexant with data concerning the premise type and loads characteristics for all customers for the MPS analysis. Nexant examined the received data from multiple perspectives to identify customer segments. Nexant's approach to mechanical segmentation varied slightly for commercial and residential accounts, but the overall logic was consistent with the concept of expressing the accounts in terms that were relevant to DSM opportunities.

3.1.3.1 Commercial and Industrial Accounts

Nexant segmented C&I accounts according to two approaches: North American Industry Classification System (NAICS) codes, and demand. The approach to examining DEO's C&I accounts was based on the NAICS codes, which Duke Energy provided as part of the customer data. Nexant further classified the customers in this group as *either* commercial or industrial, on the basis of DSM measure information available and applicable to each. For example, agriculture and forestry DSM measures are commonly considered industrial savings opportunities; therefore, small farms with relatively low energy demand were included in this group, regardless of their rate schedule classification. Nexant based this classification on the types of DSM measures applicable by segment, rather than on the annual energy consumption or maximum instantaneous demand from the segment as a whole.

3.1.3.2 Residential Accounts

Segmentation of residential customer accounts enabled Nexant to align DSM opportunities with appropriate DSM measures. Nexant segmented the residential sector according to two fields provided in the Duke Energy data: customer dwelling type (single family or multi-family).

3.2 Base Year 2018 Disaggregated Load

The disaggregated loads for the base year 2018 by sector and end use are summarized in Figure 3-1, Figure 3-2 and Figure 3-3.

Figure 3-1: DEO Residential Baseline Load Shares

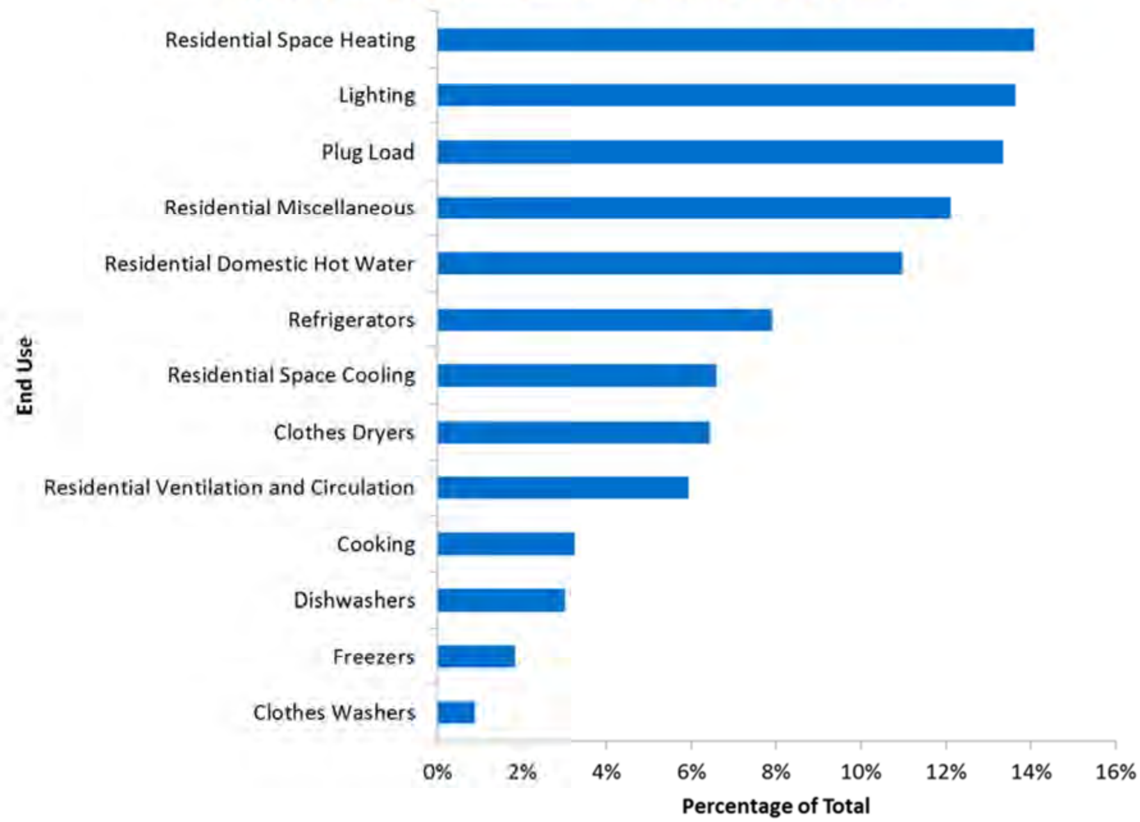


Figure 3-2: DEO Commercial Baseline Load Shares

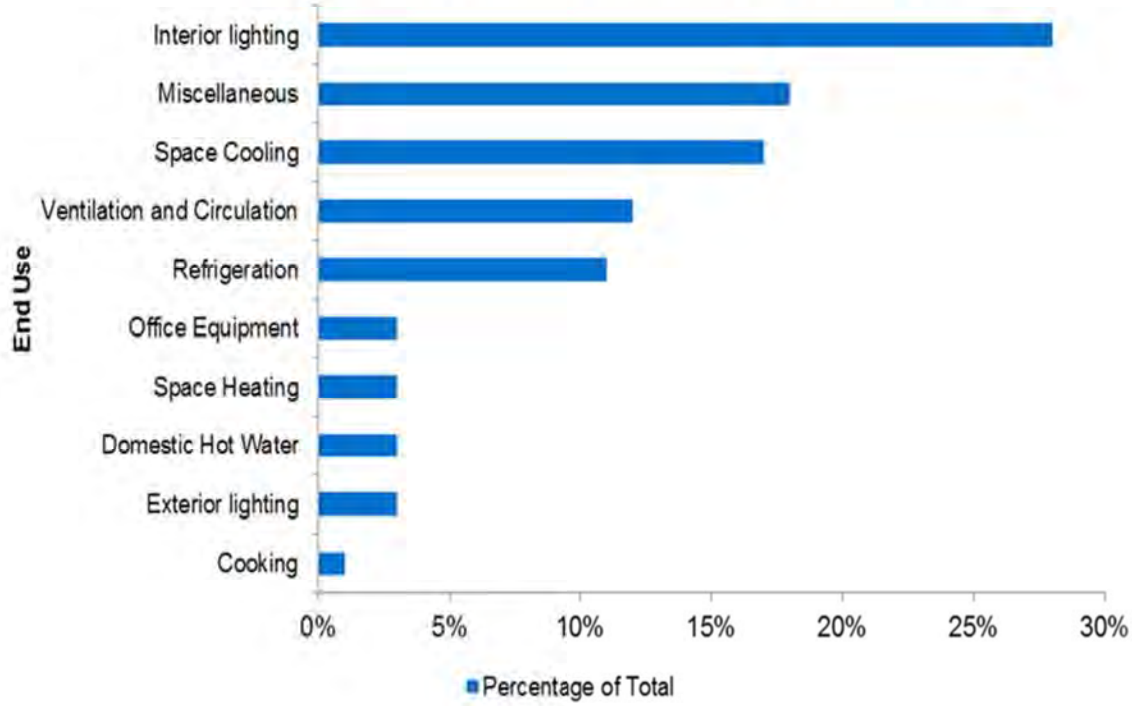
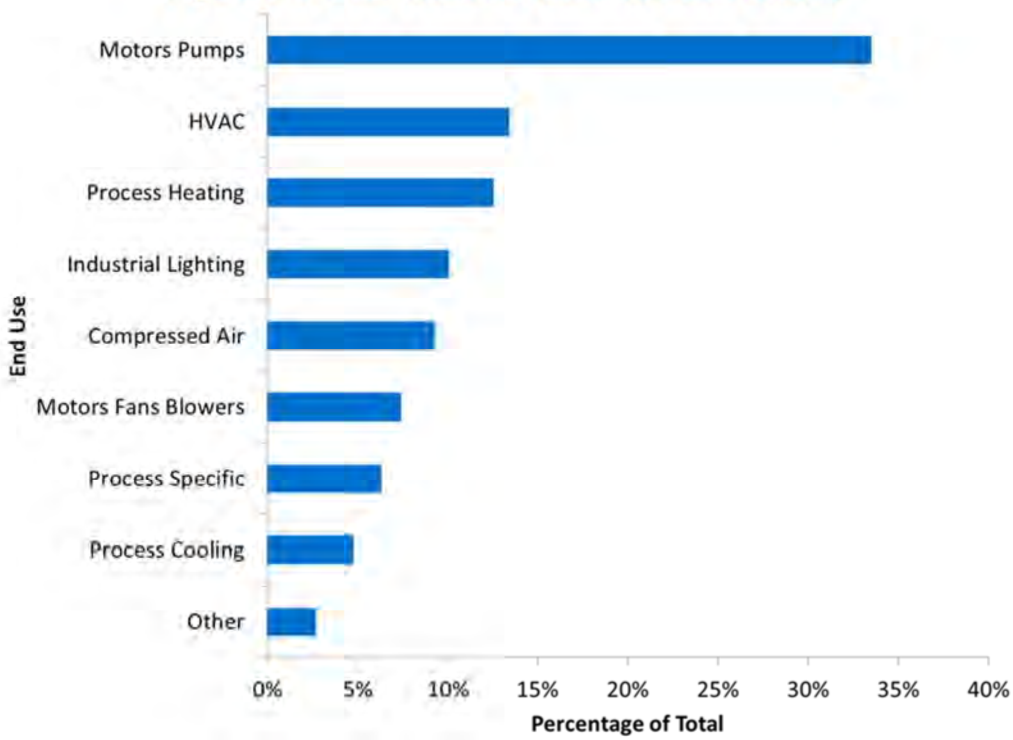


Figure 3-3: DEO Industrial Baseline Load Shares



In the base year 2018, the top load share categories are as follows:

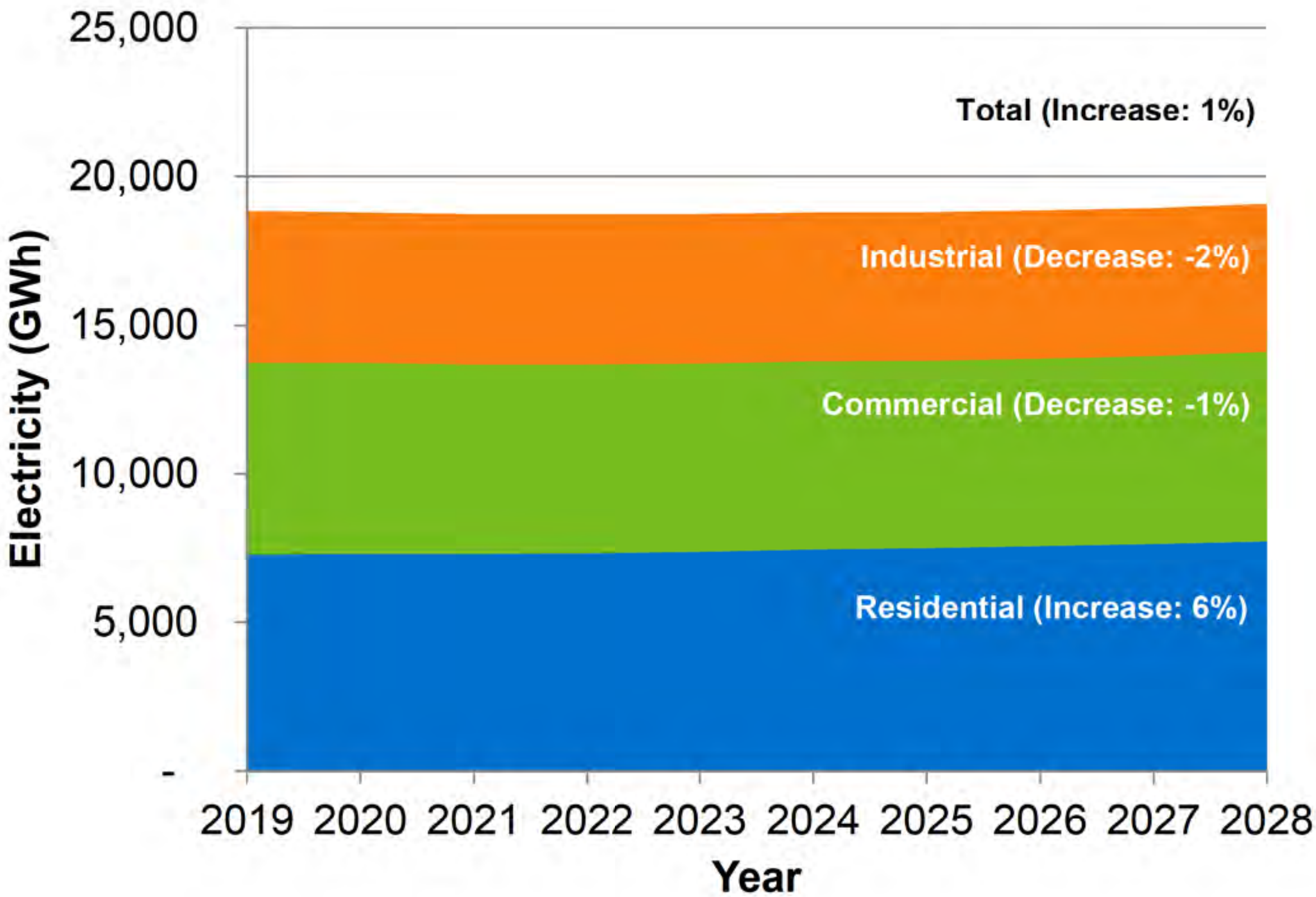
- ***Residential:*** space heating, lighting and plug loads
- ***Commercial:*** interior lighting, miscellaneous, space cooling
- ***Industrial:*** motors, HVAC, and process heating

3.3 System Load Forecast 2019 - 2028

3.3.1 System Energy Sales

Electricity use for the residential, commercial, and industrial sectors is forecasted to increase by 1% from 2019 to 2028, to a total of 19,097 GWh in 2028 (see Figure 3-4). The residential sector is expected to account for the largest share of the increase at 368 GWh over the 10 year period. In 2028 the residential sector accounts for 41% (7,737 GWh) of total electricity sales, the commercial sector 33% (6,376 GWh) and the industrial sector 26% (4,984 GWh).

Figure 3-4: Electricity Sales Forecast by Sector for 2019 - 2028[5]



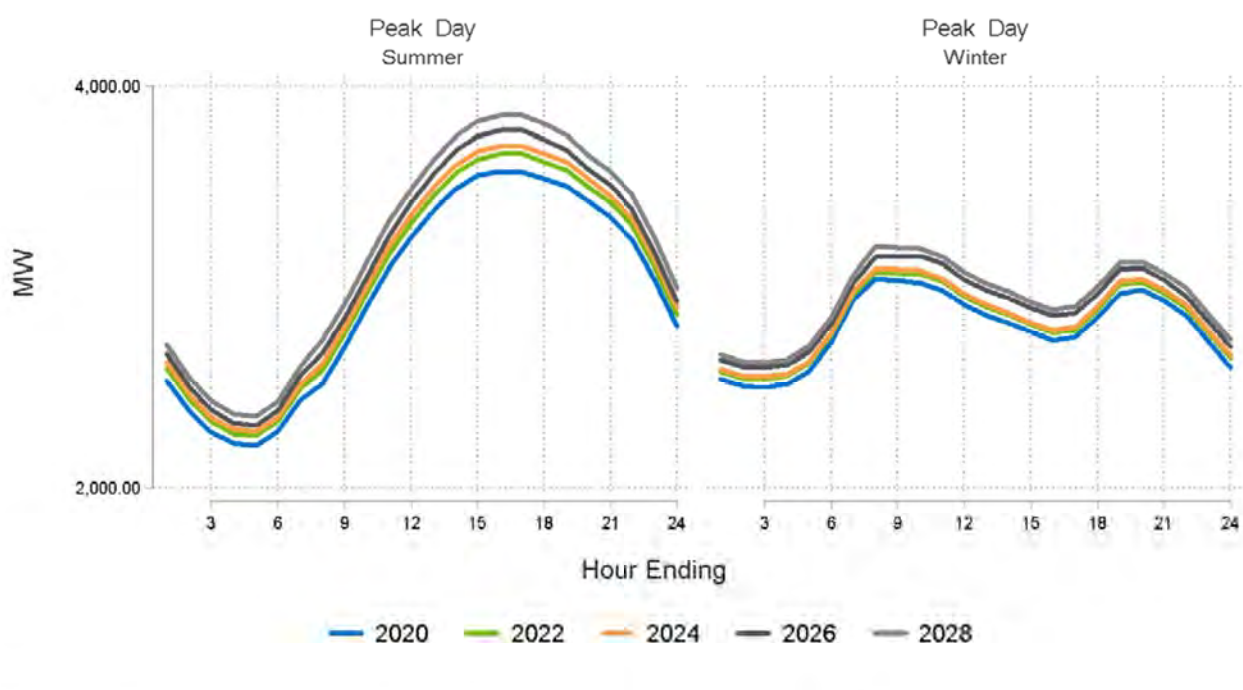
[5] Sales forecast based on DEO 2018 forecast—the current forecast at the time of Nexant's analysis.

3.3.2 System Demand

Estimating technical potential for demand response resources requires not only knowing how much load is available to be curtailed or shifted, but also understanding when it is needed. Because the benefits of demand response stem from avoiding costly investments to meet peak loads, load reductions will not have any value unless they occur during hours of peak system usage. Therefore, the first order of business in estimating the market potential for demand response is to establish when load reductions will most likely be needed throughout the year.

The primary data source used to determine when demand response resources will be needed was the system load forecast. This forecast contains forecasted loads for all 8,760 hours of each year in the study period (2019-2028). Figure 3-5 represents an initial inspection of the data. Each figure shows the expected average load profiles for two distinct types of days – peak summer days and peak winter days. Summer was defined as May-October (November through April representing winter months), while the peak days refer to days with the maximum demand during the each season.

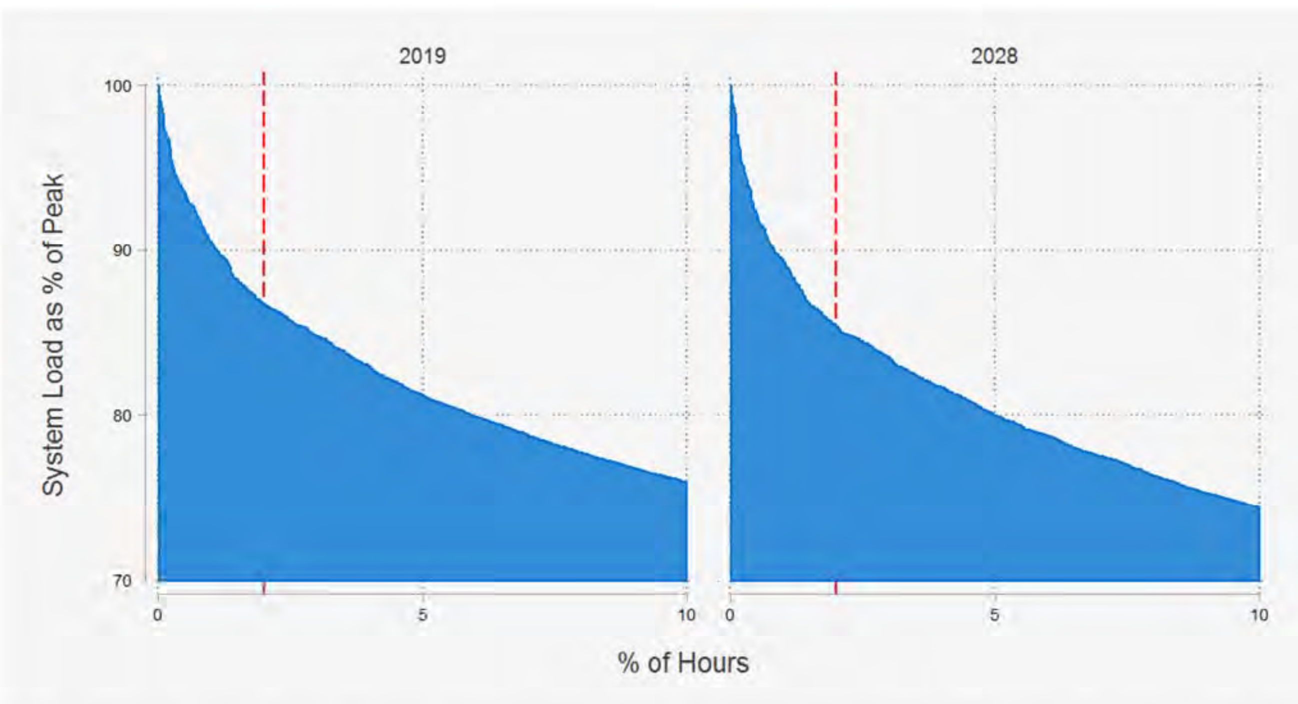
Figure 3-5: DEO System Load Forecast (2018 - 2028)



Several patterns are apparent from examining the figure above. First and foremost, forecasted loads grow over time. The summer loads are also substantially higher than winter loads. Additionally, the forecasted peak hour differs from the 2017 peak hours that we observed. In the summer, the forecasted peak shifts to the late afternoon hour of 4-5 pm, and the forecast indicates a change in winter peak timing to a morning peak of 7-8 am. However, the forecasted shifts have a high degree of uncertainty. Thus, the potential study focuses on the 2017 summer peak hour, 5-6 pm, and the winter peak hour, 6-7pm.

Though useful for assessing patterns in system loads, Figures 1 through 3 do not provide very much information about the concentration of peak loads. A useful tool to examine peak load concentration is a load duration curve, which is presented for 2019 and 2028 in Figure 3-6. This curve shows the top 10% of hourly loads as a percentage of the system's peak hourly usage, sorted from highest to lowest.

Figure 3-6: Forecasted Load Duration Curve (2019 v 2028)



The x-axis in Figure 3-6 is depicted as the cumulative percentage of hours. The red line drawn at 2% serves as a helpful reference point for interpretation by showing the amount of peak capacity needed to serve the 2% of hours with the highest usage.[6] The DEO system currently uses 13% of peak capacity to serve only 2% of hours. Peak loads, however, are projected to become more concentrated by 2028 and use 15% of peak capacity to serve the top 2% of hours.

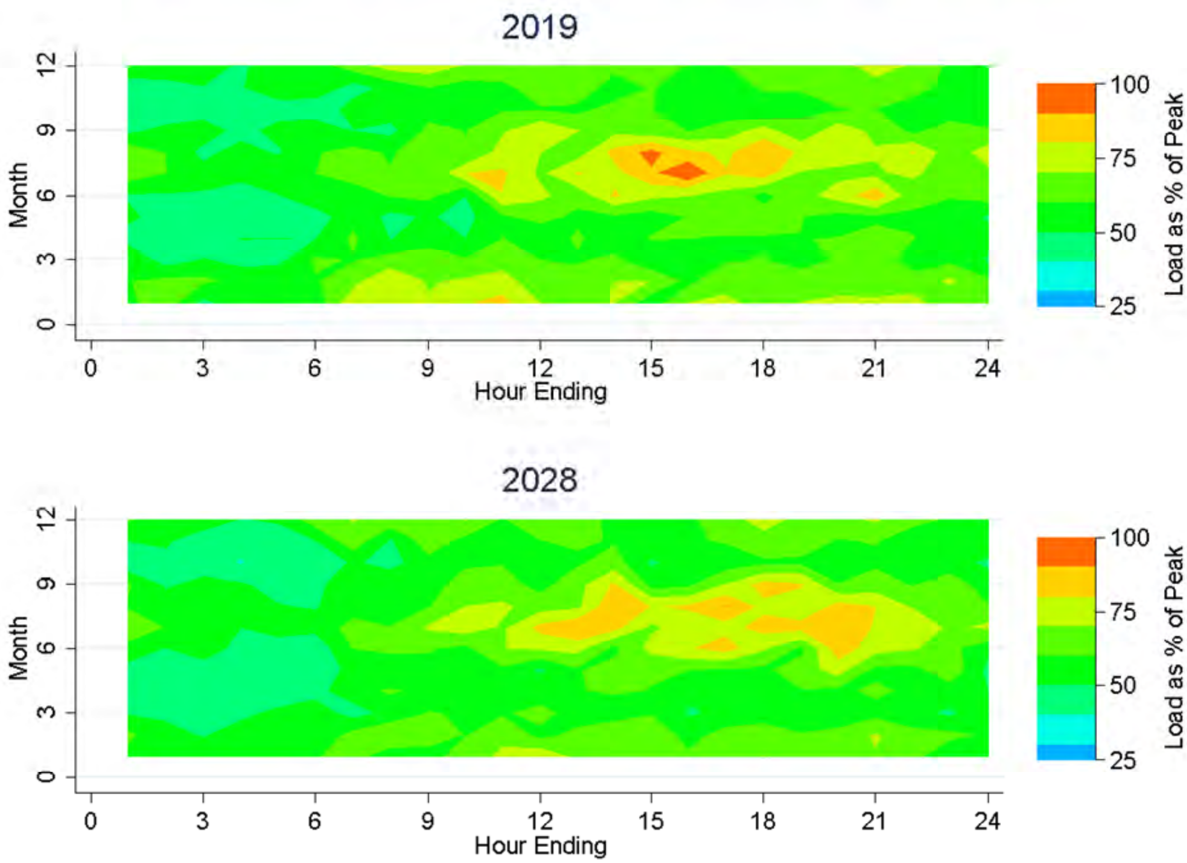
Another valuable tool for studying peak loads is a contour plot. Often referred to as "heat maps", these plots show frequencies or intensities of a particular variable for different combinations of two other variables. Figure 3-7 contains the same hourly data as a percentage of peak system load that

[6] Another interpretation of the load duration curve data would be the amount that peak load capacity could be reduced by shaving demand during 2% of the hours throughout the year.

is presented in Figure 3-6; however, it shows the months and hours when each hourly load occurs for all hours instead of only the top 10% of hours.

The results in Figure 3-7 show the highest hours of usage are concentrated in summer evening hours. Actual weather patterns reflect year to year variation in loads and, depending on the extreme temperatures for a year, winter peaks can still be of concern.

Figure 3-7: Forecasted Patterns in DEO System Load (2019 vs 2028)



4 DSM Measure List

Determining the list of demand-side management (DSM) measures to include in the MPS was a key effort in determining the market potential. This section presents the methodology to develop the measure list and discusses the energy efficiency and demand response services and products.

4.1 Methodology

Nexant identified DSM measures for consideration in the MPS by initially examining a list of proposed measures provided by Duke Energy, which included all Duke Energy measures currently offered by existing programs as well as measures that Duke Energy developed following its own gap analysis of program offerings.

Nexant reviewed the list to determine its alignment with the granularity required for the potential study analysis and to develop an initial qualitative screening for applicability in the DEO territory. Nexant also reviewed the Duke Energy program measure lists against the Nexant DSM measure library to ensure that the study covered a robust and comprehensive set of measures, and supplemented the list with Nexant-identified measures where appropriate.

The final measure list included energy efficiency technologies, as well as products that enabled DR opportunities but that focused on specific products or technologies. DR initiatives that do not rely on the installation of a specific product to implement (such as a voluntary curtailment program) are not reflected in the measure list. See Appendix A for the final measure list. Detailed assumption measure workbooks in Excel format were provided to Duke Energy.

4.2 Energy Efficiency Measures

Nexant found that many of the individual measures in the Duke Energy list of existing program measures were actually detailed permutations of general measure opportunities. For example, the Duke Energy list contained multiple instances of LED lamps with varying characteristics (candelabra base, globe base, A-line, etc.). Although these distinctions were important during program delivery, Nexant did not need this level of granularity to identify the market potential for a particular technology. In developing the final list of measures, Nexant captured the collective savings opportunities associated with specific measures by using more general measure designations.

Nexant also used a qualitative screening approach to address the applicability of proposed measures (outside of current Duke Energy program measures) to the DEO service territory. The qualitative screening criteria that Nexant used included: difficult to quantify savings, no longer current practice, better measure available, immature or unproven technology, limited applicability, poor customer acceptance, health and environmental concerns, and end use service degradation.

For each measure, a workbook was developed, which included the following information:

- Classification of measure by type, end use, and subsector
- Measure life
- Description of the base-case scenario, and the primary- and secondary-efficiency cases
- Variable inputs
- Savings algorithms and calculations per subsector, taking weather zones and subsectors into consideration
- Cost algorithms and calculations
- Sources and supporting information
- Output to be used as input in Nexant's potential-analysis model.

As shown in Table 4-1, the study included 386 unique energy-efficiency measures. Expanding the measures to account for all appropriate combinations of segments, end uses, and construction types to align with the disaggregated forecast data, customized data had to be compiled and analyzed for 11,494 measure permutations. Appendix A includes the final measure list used for the study.

Table 4-1: EE Measure Counts by Sector

Sector	Unique Measures	Permutations
Residential	99	850
Commercial	164	7,308
Industrial	123	3,336

4.3 DR Services and Products

Nexant and Duke Energy worked together to determine which DR products and services were included in the MPS, and addressed the following:

- **Direct load control.** Customers receive incentive payments for allowing the utility a degree of control over equipment, such as air conditioners or water heaters
- **Emergency load response.** Customers receive payments for committing to reduce load if called upon to do so by the grid operator, PJM
- **Economic load response:** Utilities provide customers with incentives to reduce energy consumption when marginal generation costs are higher than the incentive amount required to achieve the needed energy reduction
- **Base interruptible DR**. Customers receive a discounted rate for agreeing to reduce load to a firm service level upon request
- **Critical peak rebate.** Customers are provided a financial incentive for load reductions they voluntarily achieve during specified hours.

5 Technical Potential

In the previous sections, energy efficiency measures were identified and characterized (Section 4), and the 2018 base year load shares and reference-case load forecast for 2019 to 2028 were developed. The outputs from these tasks provided the input for estimating the technical potential scenario, which is discussed in this section.

The technical potential scenario estimates the savings potential when all technically feasible energy efficiency measures are implemented at their full market potential, while taking equipment turnover rates into account. This savings potential can be considered as a maximum potential. The subsequent sections discuss the development of the economic and program achievable potential scenarios.

5.1 Methodology

5.1.1 Energy Efficiency

Energy efficiency technical potential provides a theoretical maximum for electricity savings. Technical potential ignores all non-technical constraints on electricity savings, such as cost-effectiveness and customer willingness to adopt energy efficiency. For an electricity potential study, technical potential refers to delivering less electricity to the same end uses. In other words, technical potential might be summarized as "doing the same thing with less energy, regardless of the cost."

The potential estimate applied DSM measures to the disaggregated DEO electricity forecast to estimate technical potential. Specifically, this involved applying estimated energy savings from equipment or non-equipment measures to all electricity end uses and customers. Since technical potential does not consider the costs or time required to achieve these electricity savings, the estimates provide an upper limit on savings potential. Technical potential consists of the total electricity that can be saved in the market. Nexant reported technical potential as a single numerical value for the DEO service territory.

The core equation used in the residential sector energy efficiency technical potential analysis for each individual efficiency measure is shown in Equation 5-2 below, while the core equation utilized in the nonresidential sector technical potential analysis for each individual efficiency measure is shown in Equation 5-1 below.

Equation 5-1: Core Equation for Residential Sector Technical Potential

Technical Potential of Efficient Measures = Total Number of Households × Base Case Equipment Energy Use Intensity (kWh/unit) × Saturation Share × Remaining Factor × Applicability Factor × Savings Factor

Where:

Base Case Equipment Energy Use Intensity = the electricity used per customer per year by each base-case technology in each market segment. In other words, the base case equipment energy-use intensity is the consumption of the electrical energy using equipment that the efficient technology replaces or affects.

Saturation Share = the fraction of the end use electrical energy that is applicable for the efficient technology in a given market segment. For example, for residential water heating, the saturation share would be the fraction of all residential electric customers that have electric water heating in their household.

Remaining Factor = the fraction of equipment that is not considered to already be energy efficient. To extend the example above, the fraction of electric water heaters that is not already energy efficient.

Applicability Factor = the fraction of the applicable units that is technically feasible for conversion to the most efficient available technology from an engineering perspective (i.e., it may not be possible to install CFLs in all light sockets in a home because the CFLs may not fit in every socket).

Savings Factor = the percentage reduction in electricity consumption resulting from the application of the efficient technology.

Equation 5-2: Core Equation for Nonresidential Sector Technical Potential

Technical Potential of Efficient Measures = Total Stock Sq. Footage by Building Type by EDC × Base Case Equipment Energy Use Intensity (kWh/unit) × Equipment Saturation Share × Remaining Factor × Applicability Factor × Savings Factor

Where:

Total Stock Square Footage by Building Type = the forecasted square footage level for a given building type (e.g., office buildings).

Base Case Equipment Energy Use Intensity = the electricity used per square foot per year by each base-case equipment type in each market segment. In other words, the base case equipment energy-use intensity is the consumption of the electrical energy using equipment that the efficient technology replaces or affects.

Equipment Saturation Share = the fraction of the equipment electrical energy that is applicable for the efficient technology in a given market segment. For example, for room air conditioners, the saturation share would be the fraction of all space cooling kWh in a given market segment that is associated with room air conditioner equipment.

Remaining Factor = the fraction of equipment that is not considered to already be energy efficient. For example, the fraction of electric water heaters that is not already energy efficient.

Applicability Factor = the fraction of the equipment or practice that is technically feasible for conversion to the efficient technology from an engineering perspective (i.e., it may not be possible to install VFDs on all motors in a given market segment).

Savings Factor = the percentage reduction in electricity consumption resulting from the application of the efficient technology.

It is important to note that the technical potential estimate represents electricity savings potential at a specific point in time. In other words, the technical potential estimate is based on data describing *status quo* customer electricity use and technologies known to exist today. As technology and electricity consumption patterns evolve over time, the baseline electricity consumption will also change accordingly. For this reason, technical potential is a discrete estimate of a dynamic market. Nexant reported technical potential as a snapshot in time, based on currently known DSM measures and observed electricity consumption patterns.

Addressing Naturally-Occurring Energy Efficiency

Because the anticipated impacts of efficiency actions that may be taken even in the absence of utility intervention are included in the baseline forecast, savings due to naturally-occurring efficiency were considered separately in the potential estimates. Nexant worked with Duke Energy's forecasting group to ensure that the sales forecasts incorporated two known sources of naturally-occurring efficiency:

- **Codes and Standards:** The sales forecasts incorporated the impacts of known code changes.
- **Baseline Measure Adoption:** Sales forecasts typically exclude the projected impacts of future DSM efforts, but account for baseline efficiency penetration (this can be a delicate process given that some of these adopters are likely programmatic free-riders).

By properly accounting for these factors, the potential study estimated the net penetration rates, representing the difference between the anticipated adoption of efficiency measures as a result of DSM efforts and the "business as usual" adoption rates absent DSM intervention. This is true even in the technical and economic scenarios, where adoption was assumed to be 100%, and was particularly important in the achievable potential analysis, where Nexant estimated the measure adoption and associated savings that can be expected to occur above baseline measure adoption rates.

5.1.2 Demand Response

The concept of technical potential applies differently to demand response than for energy efficiency. Technical potential for demand response is effectively the magnitude of loads that can be managed during conditions when grid operators need peak capacity, ancillary services, or when wholesale energy prices are high. Which accounts are consuming electricity at those times? What end uses are in play? Can those end use loads be managed? Large C&I accounts generally do not provide the utility with direct control over end uses; however for enough money, businesses will forego virtually all electric demand temporarily. For residential and small C&I accounts where DR generally takes the form of direct utility control, technical potential for demand response is limited by the loads that can be controlled remotely at scale.

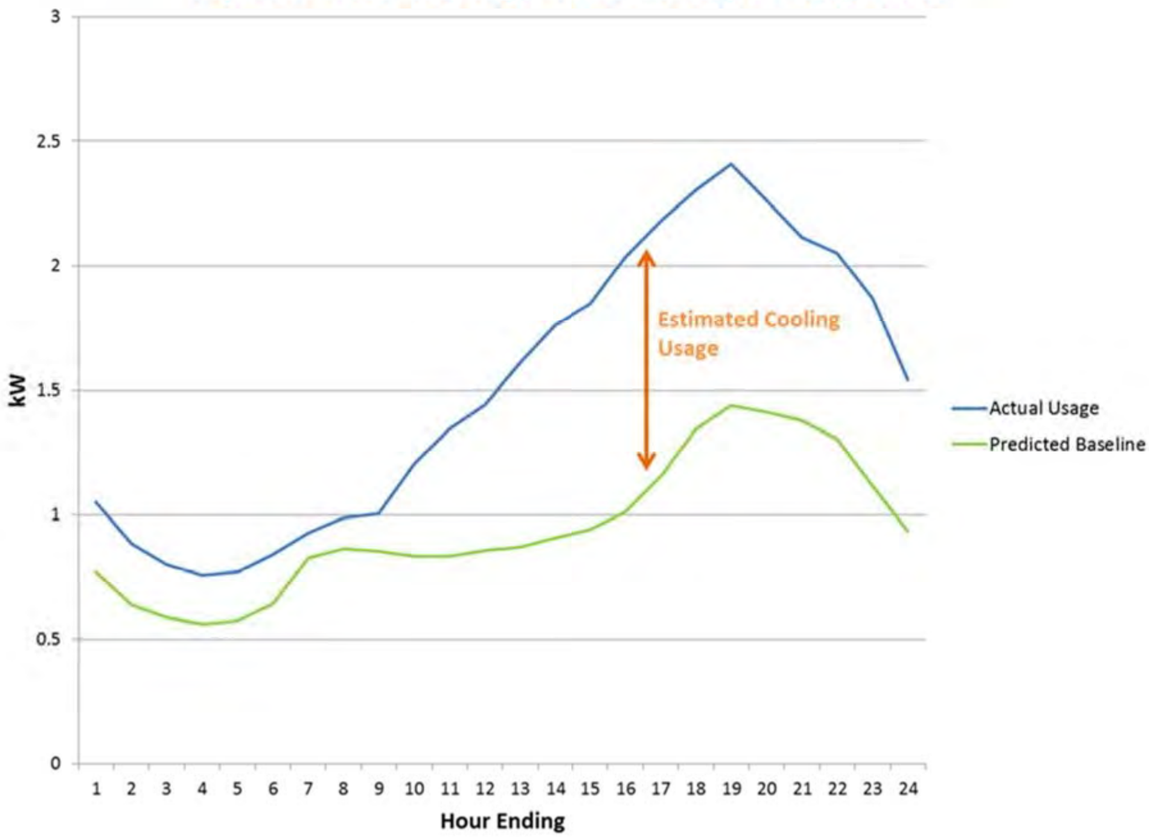
This framework makes end use disaggregation an important element for understanding DR potential, particularly in the residential and SMB sectors. As the technology to actively manage loads becomes more advanced over the study horizon, accurate end use disaggregation will be increasingly important. When done properly, end use disaggregation not only provides insights into which loads are on and off when specific grid services are needed, it also provides insight concerning how key loads and end uses, such as air conditioning use, vary across customers. The approach used for load disaggregation is more advanced than what is used for most potential studies. Instead of disaggregating annual consumption or peak demand, Nexant produced end use load disaggregation for all 8,760 hours. This was needed because the loads available at times when different grid applications are needed can vary substantially. Instead of producing disaggregated loads for the average residential customers, the study was produced for several customer segments, thereby allowing the study to identify which customers were cost-effective to recruit and which were not.

Nexant leveraged interval data for all large C&I customers and relied on average load shapes from load research samples as the starting point for analysis of residential and smaller C&I customers. Technical potential, in the context of DR, is defined as the total amount of load available for reduction that is coincident with the period of interest. In the context of this study, DR capacity is defined as the system peak hour for the summer and winter seasons. Thus, two sets of capacity values are estimated: a summer capacity and a winter capacity.

As previously mentioned, all large C&I load is considered dispatchable, while residential and SMB DR capacity is based on specific end uses. For this study, it was assumed that summer DR capacity for residential customers would be comprised of AC, pool pumps, and water heaters. For SMB customers, summer capacity would be based on AC load. For winter capacity, residential DR capacity would be based on electric heating loads and water heaters. For SMB customers, winter capacity would be based on heating load.

AC and heating load profiles were generated for residential and SMB customers using average load profiles provided by Duke. The aggregate load profile for each customer class was combined with historical weather data, and used to estimate hourly load as a function of weather conditions. AC and heating loads were estimated by first calculating the baseline load on days when cooling degree days (CDD) and heating degree days (HDD) were equal to zero, and then subtracting this baseline load. This methodology is illustrated by Figure 5-1 (a similar methodology was used to predict heating loads).

Figure 5-1: Methodology for Estimating Cooling Loads



This method was only able to produce estimates for average AC/heating load profiles for the residential and SMB sector as a whole (the load research samples provided were at an aggregate level), so billing data for 2016 and 2017 was used to scale these load profiles for more granular segmentations within each customer class. Similar to the process applied to the interval data, the billing data for each segment (building type and consumption decile for residential customers, and industry for SMB customers) was combined with historical weather data to build a regression model that estimates monthly consumption for each segment as a function of total CDD and HDD. The consumption attributable to heating and cooling loads were estimated by establishing a baseline of consumption for each segment when CDD and HDD were equal to zero, and finding the difference between the actual consumption and the baseline.

These calculations were used to estimate the relative contribution of each customer segment to the total cooling and heating load for the residential and SMB sectors. Using these relative contributions, the overall residential and SMB cooling and heating load profiles were scaled for each customer segment.

Profiles for residential water heater and pool pump loads were estimated by utilizing end use load data from CPS Energy's Home Manager Program. Consumption associated with these end uses are fairly similar across different geographic regions; so data from CPS Energy's territory in San Antonio were considered a valid proxy. The only difference was that pool pump loads were assumed to be zero in the winter season for DEO, whereas these loads are fairly constant year round for CPS Energy.

For all eligible loads, the technical potential was defined as the amount that was coincident with system peak hours for each season. System peak hours were identified using 2017 system load data. The 2017 summer peak for DEO territory occurred August 21st during hour ending 17. The 2017 winter peak for DEO territory occurred January 6th during hour ending 19.

5.2 Energy Efficiency Technical Potential

This section provides the results of the energy efficiency technical potential for each of the three segments from the SB 310 perspective, which assumes that savings for equipment turnover measures are measured against the "as found" equipment that is being replaced.

5.2.1 Summary

Table 5-1 summarizes the energy efficiency technical potential by sector and levelized cost associated with the identified potential.

Table 5-1: Energy Efficiency Technical Potential by Sector (SB 310 Provisions)

Sector	Potential (2019-2028)			
	Energy (GWh)	% of 2028 Base Sales	Demand (MW)	Levelized Cost ($/kWh)
Residential	2,189	28%	471	$0.23
Commercial	1,663	29%	1,457	$0.17
Industrial	1,116	25%	258	$0.17
Total	4,968	26%	2186	$0.20

5.2.2 Sector Details

Figure 5-2 summarizes the residential sector EE technical potential by end use.

Figure 5-2: Residential EE Technical Potential, by End use

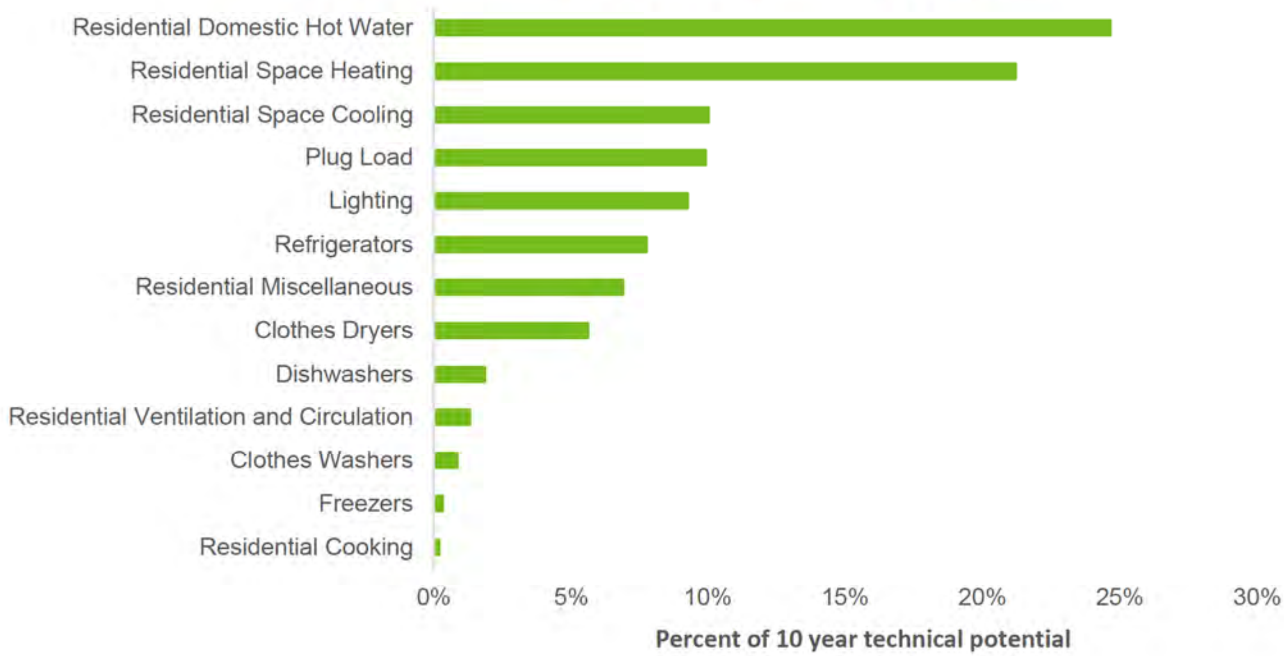


Figure 5-3 summarizes the commercial sector energy efficiency technical potential by end use.

Figure 5-3: Commercial EE Technical Potential – Cumulative 2028 by End use

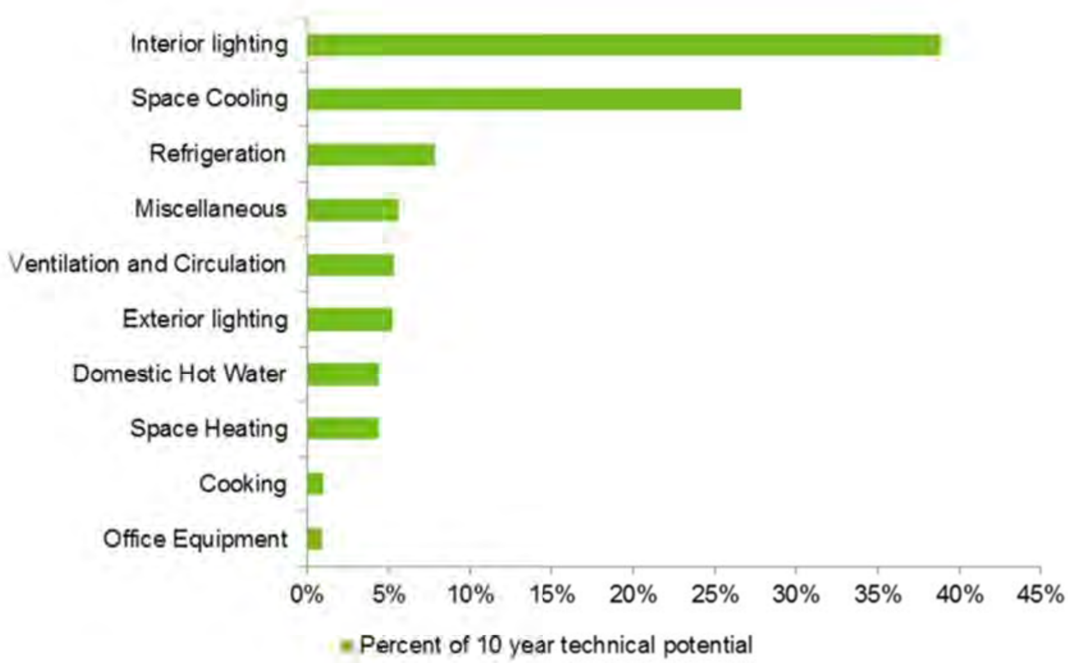


Figure 5-4 provides a summary of energy efficiency technical potential contributions by commercial facility types analyzed in this study.

Figure 5-4: Commercial EE Technical Potential Segment

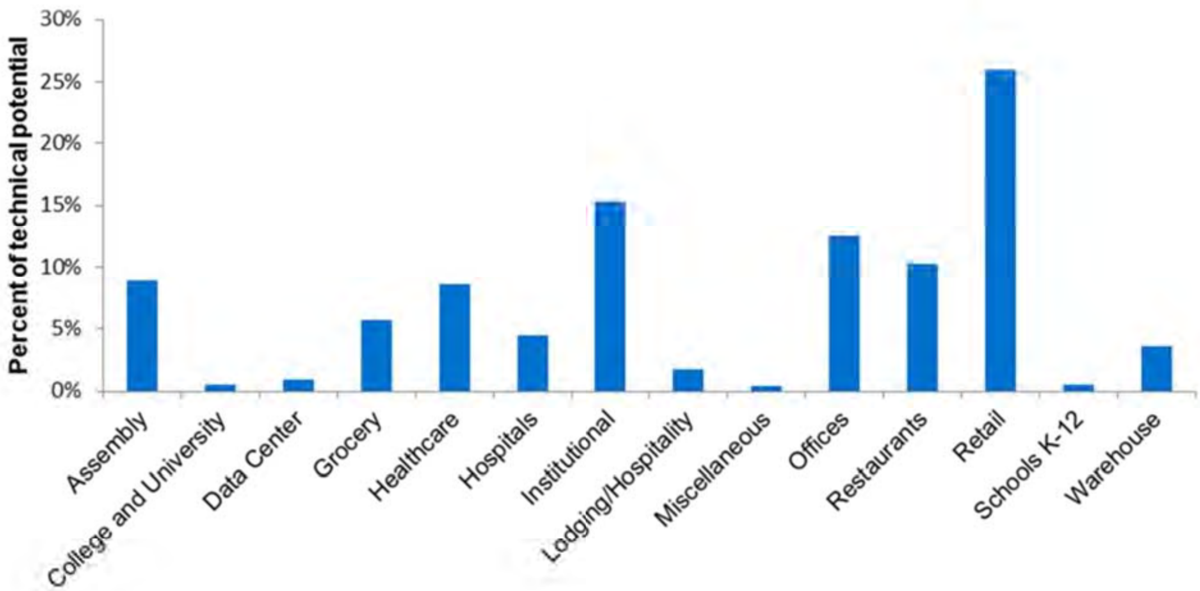


Figure 5-5 summarizes the industrial sector energy efficiency technical potential by end use.

Figure 5-5: Industrial EE Technical Potential – Cumulative 2028 by End use

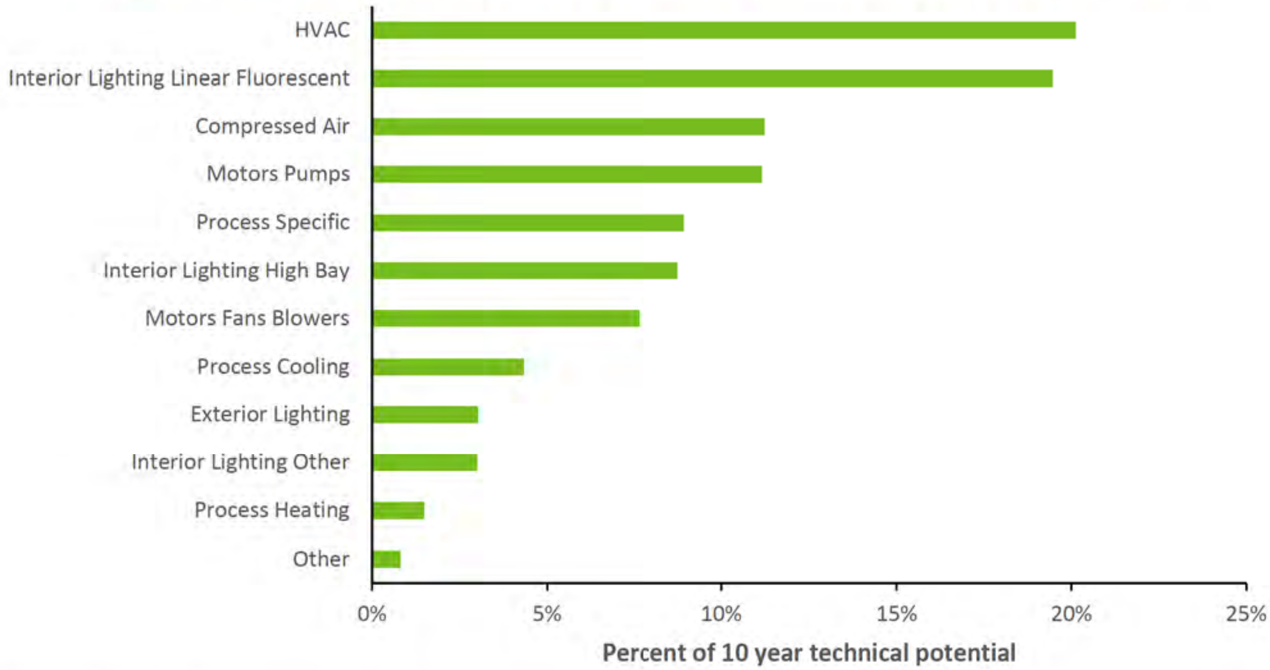
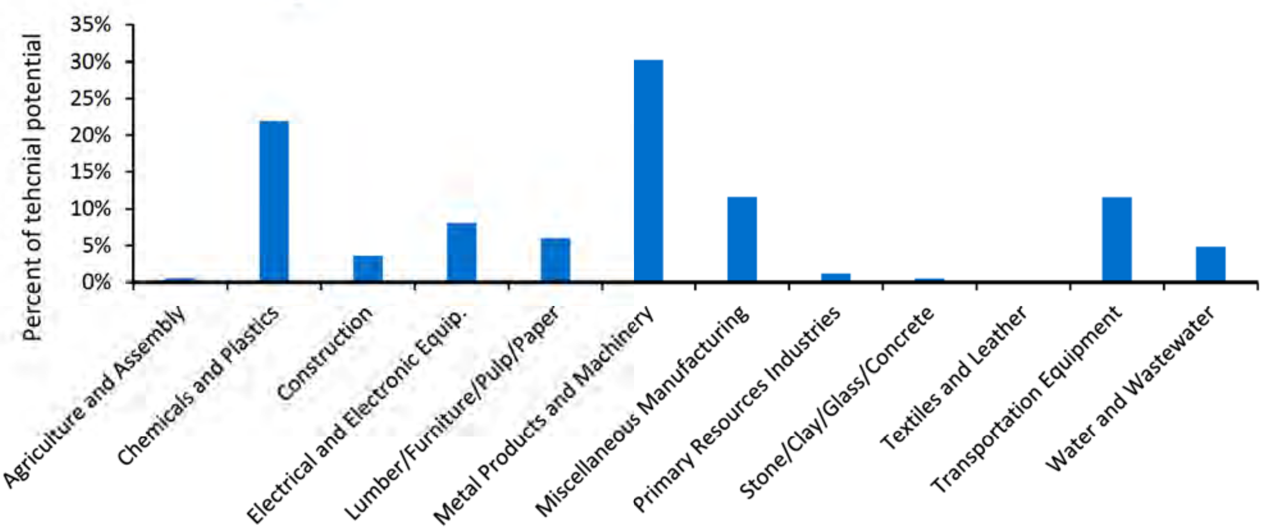


Figure 5-6 provides a summary of energy efficiency technical potential contributions by industrial facility types analyzed in this study.

Figure 5-6: Industrial EE Technical Potential Segment



5.2.3 Comparison to 2016 Study (Energy Efficiency)

Nexant previously completed an MPS for the DEO territory in 2016. The 2016 study quantified technical potential over twenty five years and included a scenario that aligned with the SB 310 baseline. Under this scenario, technical potential from the 2016 study represented 32% of end year residential sales, 28% of end year commercial sales, 26% of end year industrial sales, and 27% of total end sales for all three sectors.

Changes to start year end use consumption shares, additional primary data collection by DEO, and refined DSM measure savings estimates by Nexant all contribute a slight increase in savings potential relative to end year consumption forecasts (except for in the industrial sector, which saw a decrease). The current study estimates technical potential at 28% of end year residential sales, 29% of end year commercial sales, and 25% of industrial end year sales. The combined end year savings percentage of all economic sectors is estimated at 26% of end year sales.

5.3 Controllable Peak Load, by Customer Type

Technical potential for demand response is defined for each class of customers as follows:

- **Residential & SMB customers** – Technical potential is equal to the aggregate load for all end uses that can participate in Duke Energy's current and planned demand response programs in which the utility uses specialized devices to control loads (i.e. direct load control programs). This includes AC/heating loads for residential and SMB customers, and also water heater and pool pump loads for residential customers. Not all demand reductions are delivered via direct load control of end uses and some programs explicitly target behavior (i.e., they are not automated). The magnitude of demand reductions from behavioral programs such as time varying pricing, peak time rebates and targeted notifications is linked to cooling and heating loads. While other end uses may be curtailed, they are not well defined based on empirical studies. Because they are not well-defined, we do not include these end uses in our technical potential.
- **Large C&I customers –** Technical potential is equal to the total amount of load for each customer segment. This reflects the behavioral nature of most large C&I programs and the fact that for a large enough payment and small enough number of events, large C&I customers would be willing to reduce their usage to zero.

Table 5-2 summarizes the seasonal demand response technical potential by sector:

Table 5-2: DR Technical Potential by Sector (SB 310 Provisions)

Sector	Technical Potential (2019-2028)	
	Summer (Agg MW)	Winter (Agg MW)
Residential	937.0	887.3
SMB	29.4	23.4
Large C&I	1,025.1	876.3
Total	1,991.6	1,787.0

5.3.1 Residential and SMB Customers

Residential technical potential is summarized Table 5-3. The potential is broken down by end use and building type. A more detailed breakdown of the AC and heating loads by customer segment is provided in the economic potential section, along with the cost-effectiveness of each customer segment.

Table 5-3: Residential Demand Technical Potential (SB 310 Provisions)

Season	Peak Date	Peak Hour	End Uses	Single Family Residential		Multi Family Residential		Total
				Avg. kw	Agg. MW	Avg. kw	Agg. MW	Agg. MW
Summer	8/21/2017	17	AC Cooling	1.25	635.31	1.25	149.97	**785.28**
Winter	1/6/2017	19	Heating	3.65	667.87	3.65	211.88	**879.75**
Summer/Winter	-	-	Water Heater	0.37	73.60	0.37	28.42	**102.02**
Summer	-	-	Pool Pump	0.86	48.61	0.86	1.09	**49.71**

Small Business technical potential is provided in Table 5-4.

Table 5-4: SMB Demand Technical Potential (SB 310 Provisions)

Segment	AC Cooling		Heating	
	Avg. kw	Agg. MW	Avg. kw	Agg. MW
Assembly	0.89	2.26	23.98	1.59
Colleges and Universities	2.74	0.18	82.42	0.16
Data Centers	1.26	0.06	26.13	0.05
Grocery	1.31	0.92	32.99	0.72
Healthcare	1.17	1.86	42.43	1.63
Hospitals	2.78	0.24	181.97	0.19
Institutional	3.02	1.16	71.86	0.90
Lodging (Hospitality)	2.45	0.56	35.79	0.53
Miscellaneous	1.48	1.37	41.92	1.16
Office	0.59	6.47	14.31	5.38
Restaurants	0.95	1.86	13.12	1.30
Retail	1.05	5.61	23.03	4.23
Schools K-12	2.92	1.25	84.86	1.05
Warehouse	1.90	0.51	31.43	0.40
Agriculture & Forestry	0.21	0.11	0.17	0.09
Chemicals & Plastics	2.13	0.56	1.82	0.47
Construction	0.45	0.84	0.37	0.69
Electrical & Electronic Equipment	0.75	0.30	0.54	0.22
Lumber, Furniture, Pulp and Paper	1.76	0.32	1.31	0.24
Metal Products & Machinery	1.47	1.18	1.11	0.89
Misc. Manufacturing	1.41	0.61	1.01	0.43
Primary Resource Industries	1.57	0.08	0.80	0.04
Stone, Clay, Glass and Concrete	1.54	0.11	1.34	0.10
Textiles & Leather	0.56	0.04	0.39	0.03
Transportation Equipment	0.31	0.29	0.24	0.22
Water and Wastewater	0.89	0.67	0.87	0.65
Total		**29.43**		**23.36**

Overall the bulk of the technical potential from these two sectors comes from residential cooling and heating loads, particularly from single family homes.

5.3.2 Large C&I Customers

Technical potential for C&I customers, broken down by customer segments and three buckets of customer sizes is given in Table 5-5. The majority of the technical potential provided by large C&I customers comes from the largest class of customers. Much of the potential comes from a couple of industries, particularly chemicals/plastics and metal products/machinery.

Table 5-5: Large C&I Demand Technical Potential (SB 310 Provisions)

Segment	1 MW and Up		500 kW to 1 MW		300 kW to 500 kW	
	Summer	Winter	Summer	Winter	Summer	Winter
Agriculture & Forestry	0.0	0.0	0.0	0.0	0.0	0.0
Chemicals & Plastics	139.6	123.2	10.1	7.4	1.0	0.6
Colleges & Universities	9.8	5.6	2.6	1.9	0.0	0.0
Construction	2.9	2.3	4.8	4.4	0.9	0.4
Data Centers	0.0	0.0	2.1	0.0	0.0	0.0
Electrical & Electronic Equipment	7.9	5.1	0.0	2.0	0.0	0.0
Grocery stores / Convenience chains	14.2	9.7	20.3	14.0	2.6	1.8
Healthcare	36.6	23.2	11.5	11.3	0.7	0.7
Hospitals	38.2	24.3	2.3	1.6	0.3	0.0
Institutional	9.6	7.0	5.1	3.3	0.8	0.6
Large Public Assembly (Churches, Stadiums, Arena, & Sports Venues)	11.2	10.7	9.2	6.7	0.3	0.5
Lodging (Hospitality)	3.8	5.7	4.3	3.6	0.1	0.5
Lumber, Furniture, Pulp & Paper	29.9	29.3	5.8	4.9	0.0	0.0
Metal Products & Machinery	180.7	214.1	17.3	11.5	1.7	0.9
Misc. Manufacturing	58.2	45.9	10.9	7.7	0.7	0.4
Office	88.1	63.2	51.9	39.6	3.2	2.9
Restaurants	0.0	0.0	1.3	1.3	0.4	0.3
Retail	40.1	29.6	39.9	30.6	1.5	1.5
Miscellaneous	36.6	35.3	5.9	4.1	0.6	0.3
Primary Resource Industries	2.6	0.3	1.6	0.2	0.0	0.0
Schools K-12	2.1	1.4	10.9	7.8	3.4	2.1
Stone, Clay, Glass & Concrete	1.8	0.7	1.1	1.0	0.0	0.0
Textiles & Leather	0.0	0.0	0.0	0.0	0.0	0.0
Transportation Equipment	42.3	39.1	4.3	2.5	0.2	0.3
Warehouse	4.0	2.2	4.9	2.8	0.0	0.0
Water & Wastewater	16.6	12.6	2.1	2.1	0.0	0.1
Total	**776.8**	**690.5**	**230.2**	**172.2**	**18.1**	**13.6**

5.3.3 Comparison to 2016 Study (Demand Response)

A comparison of the technical potential from the 2016 and 2018 studies is shown in Table 5-5. For the non-res customer segments, there is less than a 5% difference between the technical potential in the previous study and the technical potential in the current study. For residential customers, the technical potential is about 11% higher in the summer for the current study, and is about 11% lower in the winter for the current study. This difference can be explained in part by updates to the percent saturation for the residential end uses, which altered the number of customers with each end use from the previous study. Remaining differences between the two studies are likely a result of different changing customer behavior between the two historical peaks that were analyzed and changes in the customer segments from the previous study.

Table 5-6: Comparison of 2016 and 2018 Technical Potential by Sector

Sector	Technical Potential			
	Summer (Agg MW)		Winter (Agg MW)	
	2016	2018	2016	2018
Residential	847.6	937.0	1,003.10	887.3
SMB	31.3	29.4	19.5	23.4
Large C&I	1,014.60	1,025.1	870.5	876.3
Total	1,893.50	1,991.6	1,893.10	1,787.0

6 Economic Potential

Nexant used the MPS to calculate economic potential by comparing the expected benefits to the expected costs of DSM measures. The project team assessed all measure permutations using established economic thresholds. The economic potential was the sum of the energy savings associated with all measure permutations passing the economic screening.

6.1 DSM Cost-Effective Screening Criteria

Based on discussions with Duke Energy, the total resource cost (TRC) test was used for the economic screening of energy efficiency measures in the MPS. The TRC is calculated by comparing the total avoided electricity production and the avoided delivery costs from installing a measure, to that measure's incremental cost. The incremental cost is relative to the cost of the measure's appropriate baseline technology. DSM program delivery and administrative costs, which are included in program-level TRC calculations, were not included in the measure-level economic screening conducted in this study.

For EE screening, the TRC test is applied to each energy efficiency measure based on installation of the measure in Year 1 of the study (i.e. avoided cost benefits begin in Year 1 and extend through the useful life of the measure; incremental costs are also incurred in Year 1). By using DSMore outputs for lifetime avoided cost benefits, the screening aligns with Duke Energy's avoided cost forecast and allows for a direct comparison of measure costs with these avoided cost benefits. The screening will include measures with a TRC ratio of 1.0 or higher for determining economic potential.

For DR screening, Nexant also used the TRC perspective, with the assumption that the incremental cost of implementing DR is equivalent to the utility program costs. However, cost-effectiveness screening for DR potential is inherently of limited usefulness. Economic potential only answers the question "Is a customer segment worth pursuing based on the marginal net benefits they provide?" However, because DR capacity is determined by participation levels, which is in turn a function of the incentive level, a full cost-effectiveness screening cannot be performed without considering incentive levels, which is a key variable for the various scenarios of the program potential. As such, cost-effectiveness screening for the economic potential only considers non-incentive costs. In other words, customer segments are screened based on whether the marginal cost-effectiveness of enrolling a customer of that segment provides positive net benefits when only considering marketing, equipment, installation, and program operation costs.

For this analysis, the non-incentive costs for each sector is detailed in Table 6-1. These values are based on the costs assumed for a similar DR potential study conducted for SMUD, and represent reasonable cost estimates in today's dollars with current technology. Another key assumption that is part of the program potential analysis is the degree to which these costs are expected to decline in future years. However, economic potential screening is conducted using today's technology costs.

Table 6-1: DR Non-Incentive Costs

	One-Time				Recurring (per year)
	Equipment	Installation	Acquisition Marketing	Other	Maintenance Marketing
Residential ($/customer)	$ 250.00	$ 200.00	$ 2.50	$ 4.50	$ 1.20
SMB ($/customer)	$ 300.00	$ 300.00	$ 20.00	$ 4.50	$ 1.20
Large C&I ($/MW)	$ 150.00		$ 10.00		

The cost of enrolling customers from each customer segment is compared to the marginal benefits provided by enrolling customers in that segment. Because DR programs are called relatively infrequently, very little benefit is derived from avoided energy costs, to the point where they are insignificant. Instead, DR derives its value from avoided generation capacity and avoided transmission and distribution capacity.

Forecasts of these values were provided by Duke, and formed the basis for the benefit calculations. Because these values were given as annual values, while this study aims to evaluate DR capacity for summer and winter separately, the annual avoided capacity values were allocated between summer and winter. To that end, capacity values were allocated between summer and winter seasons based on weighted percentage of top load hours (i.e. hours when load was within 20% of peak load) that occurred in summer and winter of 2017. Based on this analysis, 97.9% of the avoided capacity is associated with the summer season, with the remaining 2.1% allocated to winter.

6.2 Energy Efficiency Economic Potential

This section provides the results of the energy efficiency economic potential for each of the three segments from the SB 310 Provisions perspective, which assumes that savings for equipment turnover measures are measured against the "as found" equipment that is being replaced.

6.2.1 Summary

Table 6-2 summarizes the energy efficiency economic potential by sector and levelized cost associated with the identified potential:

Table 6-2: EE Economic Potential by Sector

Sector	Economic Potential (2019-2028)			
	Energy (GWh)	% of 2028 Base Sales	Demand (MW)	Levelized Cost ($/kWh)
Residential	992	13%	408	$0.04
Commercial	1,367	23%	1,344	$0.02
Industrial	723	16%	200	$0.02
Total	3,082	16%	1,952	$0.03

6.2.2 Sector Details

Figure 6-1 summarizes the residential sector energy efficiency economic potential by end use.

Figure 6-1: Residential EE Economic Potential, by End use

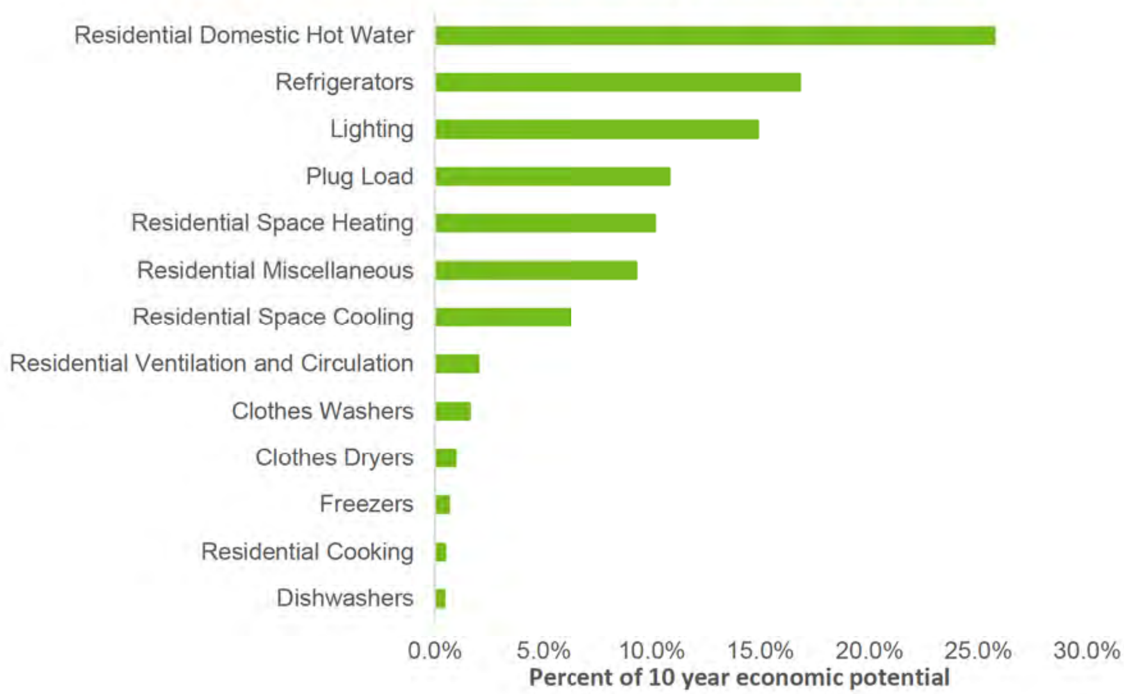


Figure 6-2 summarizes the commercial sector energy efficiency economic potential by end use.

Figure 6-2: Commercial EE Economic Potential – Cumulative 2028 by End use (SB 310)

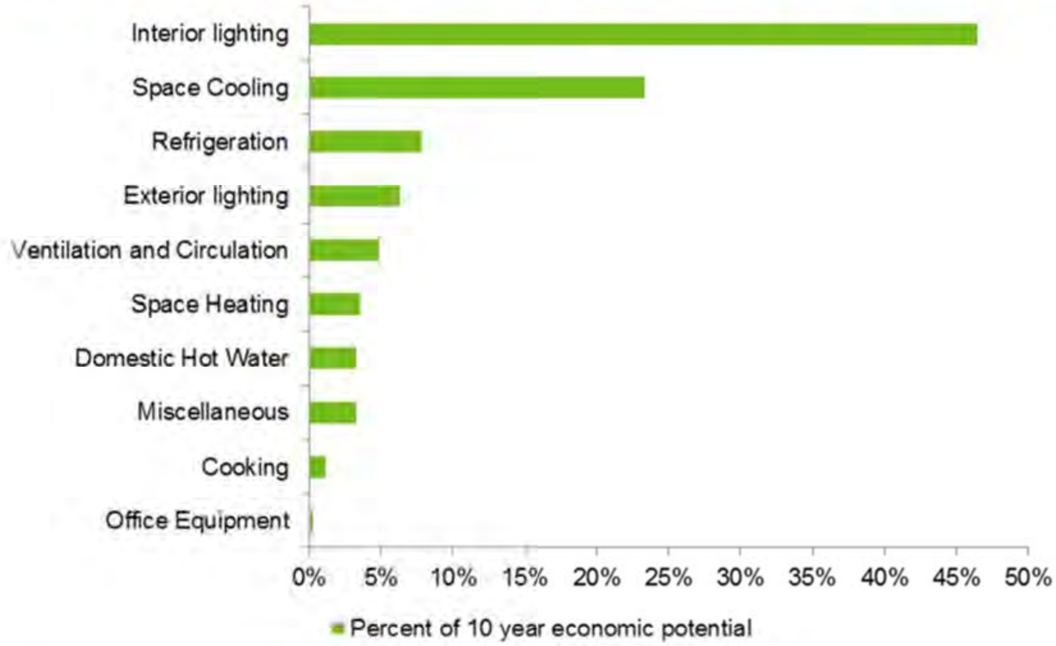


Figure 6-3 provides a summary of energy efficiency economic potential contributions by commercial facility types analyzed in this study.

Figure 6-3: Commercial EE Economic Potential by Segment (SB 310)

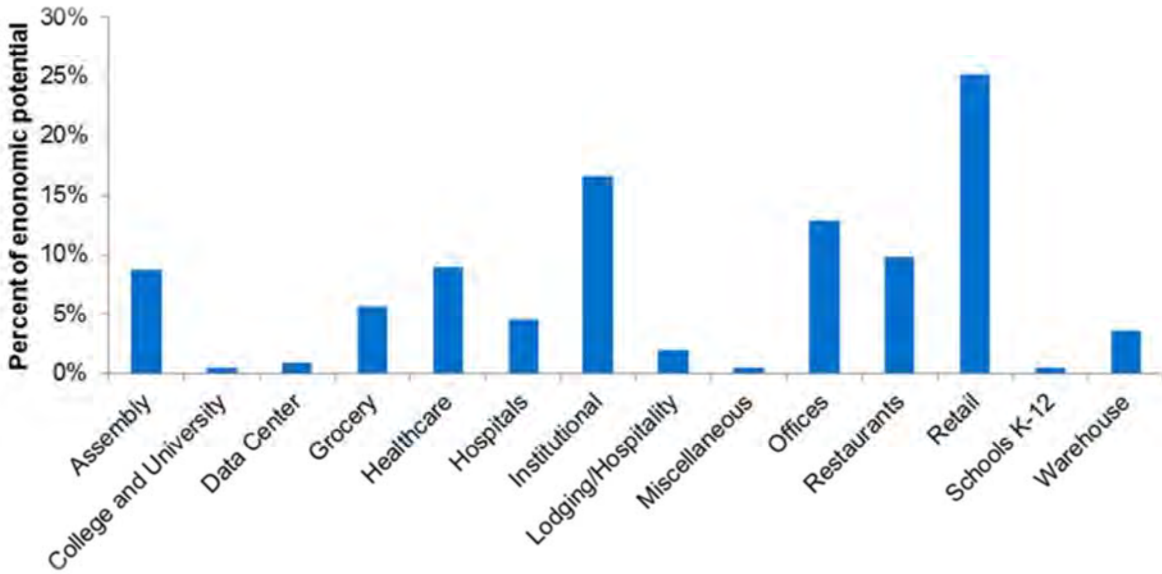


Figure 6-4 summarizes the industrial sector energy efficiency economic potential by end use.

Figure 6-4: Industrial EE Economic Potential – Cumulative 2028 by End-Use

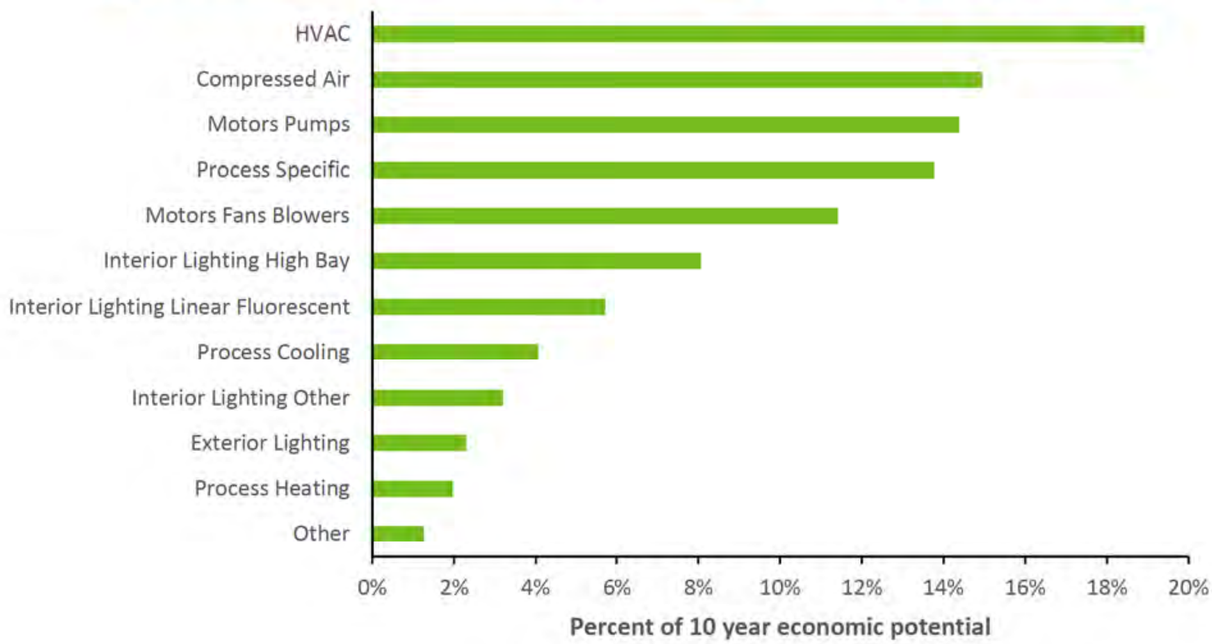
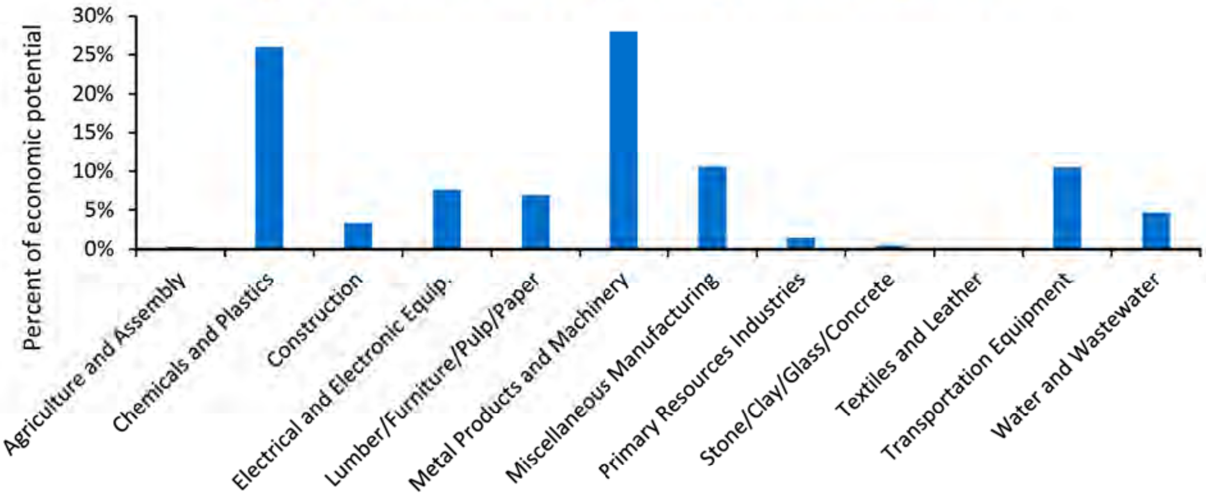


Figure 6-5 provides a summary of energy efficiency technical potential contributions by industrial facility types analyzed in this study.

Figure 6-5: Industrial EE Economic Potential Segment



6.3 Demand Response Economic Potential

Cost effectiveness screening for economic potential revealed that the vast majority of the technical potential presented in the prior chapter is cost-effective on a marginal basis. Results for single family residential customer segments are presented in Table 6-3.

Table 6-3: DR Residential Single Family Economic Potential Results

	Single Family			Summer		Winter			
	Usage_ bin	# of accounts	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Customer
Electric	1	18,104	$8,507,508	16.1	$24,042,892	25.4	$815,492	$16,350,876	$903
	2	18,104	$8,507,508	16.5	$24,722,510	33.0	$1,059,909	$17,274,911	$954
	3	18,104	$8,507,508	20.3	$30,301,958	44.5	$1,427,331	$23,221,781	$1,283
	4	18,105	$8,507,978	23.4	$35,006,526	54.6	$1,750,858	$28,249,405	$1,560
	5	18,104	$8,507,508	25.2	$37,723,770	61.1	$1,959,224	$31,175,486	$1,722
	6	18,104	$8,507,508	25.7	$38,462,985	66.0	$2,117,697	$32,073,173	$1,772
	7	18,105	$8,507,978	25.7	$38,410,029	68.6	$2,201,701	$32,103,751	$1,773
	8	18,104	$8,507,508	27.5	$41,084,180	75.4	$2,419,711	$34,996,382	$1,933
	9	18,104	$8,507,508	30.3	$45,249,955	85.5	$2,742,763	$39,485,209	$2,181
	10	18,105	$8,507,978	53.6	$80,222,991	147.9	$4,742,764	$76,457,777	$4,223
Gas	1	33,821	$15,893,308	25.3	$37,823,896	-	$-	$ 21,930,588	$648
	2	33,822	$15,893,778	19.7	$29,446,173	-	$-	$13,552,396	$401
	3	33,822	$15,893,778	21.6	$32,324,622	-	$-	$16,430,845	$486
	4	33,821	$15,893,308	23.8	$35,652,074	-	$-	$19,758,767	$584
	5	33,822	$15,893,778	26.8	$40,150,167	-	$-	$24,256,390	$717
	6	33,822	$15,893,778	29.8	$44,636,147	-	$-	$28,742,370	$850
	7	33,821	$15,893,308	33.8	$50,527,221	-	$-	$34,633,913	$1,024
	8	33,822	$15,893,778	39.3	$58,709,633	-	$-	$42,815,855	$1,266
	9	33,822	$15,893,778	48.0	$71,733,191	-	$-	$55,839,413	$1,651
	10	33,822	$15,893,778	100.6	$150,385,295	-	$-	$134,491,517	$3,976
Unknown	1	283	$132,989	-	$-	-	$-	($132,989)	($470)
	2	283	$132,989	0.0	$1,207	0.0	$60	($131,722)	($465)
	3	284	$133,458	0.0	$7,826	0.0	$871	($124,762)	($439)
	4	283	$132,989	0.0	$42,458	0.1	$2,558	($87,973)	($311)

Single Family			Summer		Winter			
Usage_ bin	# of accounts	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Customer
5	283	$132,989	0.1	$139,904	0.2	$6,402	$13,318	$47
6	284	$133,458	0.2	$261,577	0.4	$14,066	$142,185	$501
7	283	$132,989	0.3	$401,481	0.6	$19,702	$288,194	$1,018
8	284	$133,458	0.3	$491,707	0.8	$26,219	$384,468	$1,354
9	283	$132,989	0.4	$670,744	1.1	$34,351	$572,107	$2,022
10	284	$133,458	0.9	$1,415,963	2.5	$81,715	$1,364,219	$4,804
Total AC/Heating Economic Potential (only included if economic)			635.3		667.8			
Additional Potential from WH and PP			122.2		73.6			
Total Potential			**757.5**		**741.4**			

This table presents the aggregate capacity each customer segment would be able to provide during summer and winter peaks, along with the benefits associated with that capacity, based on avoided generation and T&D costs. The total cost of enrolling customers in that segment is also presented. The net benefits and net benefits per customer are presented on the right side of the table. Customer segments that do not pass the cost effectiveness screen have negative net benefits in red font. For single family residential customers, there are only segments that do not pass this screen are the three smallest deciles with unknown heating fuel source.

Similar tables are presented for multifamily residential, SMB, and large C&I customers. Nearly all of these customers pass the cost effectiveness screen.

Table 6-4: Residential Multifamily Economic Potential Results

	Multifamily			Summer		Winter			
	Usage _bin	# of accounts	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Customer
Electric	1	4,576	$2,150,373	3.1	$4,707,386	8.0	$255,800	$2,812,813	$615
	2	4,576	$2,150,373	3.8	$5,631,497	11.0	$353,605	$3,834,729	$838
	3	4,576	$2,150,373	4.4	$6,610,097	13.1	$420,343	$4,880,067	$1,066
	4	4,576	$2,150,373	5.0	$7,479,984	14.2	$456,738	$5,786,348	$1,264
	5	4,576	$2,150,373	5.1	$7,563,399	15.3	$491,574	$5,904,600	$1,290
	6	4,576	$2,150,373	5.6	$8,304,590	16.9	$541,582	$6,695,798	$1,463
	7	4,576	$2,150,373	6.1	$9,110,950	18.6	$595,502	$7,556,078	$1,651
	8	4,576	$2,150,373	6.4	$9,626,070	20.0	$640,323	$8,116,019	$1,774
	9	4,576	$2,150,373	7.9	$11,847,807	24.5	$785,167	$10,482,601	$2,291
	10	4,579	$2,151,783	11.7	$17,424,647	44.9	$1,440,630	$16,713,494	$3,650
Gas	1	7,260	$3,411,650	3.0	$4,460,223	-	$0	$1,048,573	$144
	2	7,263	$3,413,060	3.9	$5,762,230	-	$0	$2,349,170	$323
	3	7,263	$3,413,060	4.6	$6,811,468	-	$0	$3,398,409	$468
	4	7,263	$3,413,060	5.2	$7,757,742	-	$0	$4,344,682	$598
	5	7,263	$3,413,060	5.9	$8,848,619	-	$0	$5,435,559	$748
	6	7,263	$3,413,060	6.9	$10,298,432	-	$0	$6,885,372	$948
	7	7,263	$3,413,060	8.2	$12,192,721	-	$0	$8,779,661	$1,209
	8	7,263	$3,413,060	9.7	$14,491,429	-	$0	$11,078,369	$1,525
	9	7,263	$3,413,060	12.2	$18,311,904	-	$0	$14,898,844	$2,051
	10	7,265	$3,414,000	22.3	$33,341,346	-	$0	$29,927,347	$4,119
Unknown	1	764	$359,022	0.3	$417,706	0.7	$23,314	$81,997	$107
	2	764	$359,022	0.4	$582,877	0.8	$25,322	$249,177	$326
	3	764	$359,022	0.5	$764,665	1.0	$31,928	$437,571	$573
	4	764	$359,022	0.7	$1,032,632	1.7	$54,811	$728,421	$953
	5	764	$359,022	0.8	$1,190,996	2.1	$66,767	$898,742	$1,176
	6	764	$359,022	0.9	$1,399,374	2.6	$83,600	$1,123,952	$1,471
	7	764	$359,022	1.1	$1,671,844	3.2	$103,365	$1,416,186	$1,854
	8	764	$359,022	1.2	$1,841,184	3.4	$108,937	$1,591,099	$2,083
	9	764	$359,022	1.3	$1,940,875	3.7	$119,389	$1,701,243	$2,227

Multifamily			Summer		Winter			
Usage _bin	# of accounts	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Customer
10	767	$360,432	1.9	$2,846,865	6.2	$197,892	$2,684,325	$3,500
Total AC/Heating Economic Potential (only included if economic)			150.0		211.9			
Additional Potential from WH and PP			29.5		28.4			
Total Potential			**179.5**		**240.3**			

Table 6-5: SMB Economic Potential Results

SMB			Summer		Winter			
Segment	# of Accounts	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Customer
Assembly	2,535	$1,615,816	2.3	$3,385,255	1.59	$51,024	$1,820,463	$718.16
Colleges & Universities	67	$43,013	0.2	$276,240	0.16	$5,149	$238,377	$3,533
Data Centers	46	$29,333	0.1	$86,476	0.05	$1,590	$58,733	$1,276
Grocery	705	$449,083	0.9	$1,380,234	0.72	$23,078	$954,229	$1,354
Healthcare	1,592	$1,014,559	1.9	$2,779,127	1.63	$52,323	$1,816,892	$1,142
Hospitals	88	$55,889	0.2	$364,081	0.19	$6,199	$314,391	$3,586
Institutional	384	$244,827	1.2	$1,735,381	0.90	$28,887	$1,519,442	$3,956
Lodging (Hospitality)	230	$146,565	0.6	$841,572	0.53	$16,851	$711,858	$3,096
Miscellaneous	925	$589,366	1.4	$2,048,193	1.16	$37,303	$1,496,129	$1,618
Office	10,891	$6,942,247	6.5	$9,676,777	5.38	$172,618	$2,907,147	$267
Restaurants	1,958	$1,248,286	1.9	$2,779,524	1.30	$41,655	$1,572,892	$803
Retail	5,350	$3,410,330	5.6	$8,388,036	4.23	$135,737	$5,113,443	$956
Schools K-12	428	$272,541	1.2	$1,865,338	1.05	$33,594	$1,626,391	$3,804
Warehouse	269	$171,754	0.5	$766,405	0.40	$12,732	$607,383	$2,254
Agriculture & Forestry	526	$335,565	0.1	$163,843	0.09	$2,877	($168,845)	($321)
Chemicals & Plastics	261	$166,396	0.6	$832,726	0.47	$15,206	$681,536	$2,611
Construction	1,858	$1,184,185	0.8	$1,263,084	0.69	$22,158	$101,057	$54
Electrical & Electronic Equipment	399	$254,586	0.3	$446,817	0.22	$6,946	$199,177	$499
Lumber, Furniture, Pulp & Paper	183	$116,477	0.3	$481,891	0.24	$7,678	$373,093	$2,042
Metal Products & Machinery	805	$513,054	1.2	$1,769,972	0.89	$28,687	$1,285,605	$1,597

SMB			Summer		Winter			
Segment	# of Accounts	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Customer
Misc. Manufacturing	429	$273,444	0.6	$906,660	0.43	$13,908	$647,124	$1,509
Primary Resource Industries	50	$31,615	0.1	$116,534	0.04	$1,273	$86,191	$1,738
Stone, Clay, Glass & Concrete	71	$45,482	0.11	$164,679	0.10	$3,073	$122,271	$1,714
Textiles & Leather	67	$42,708	0.04	$55,627	0.03	$841	$13,759	$205
Transportation Equipment	933	$594,588	0.29	$436,959	0.22	$7,189	($150,440)	($161)
Water & Wastewater	747	$476,447	0.7	$996,877	0.65	$20,908	$541,338	$724
Total			**29.0**		**23.1**			

Table 6-6: Large C&I (1 MW and Up) Economic Potential Results

Large C&I (1 MW and Up)			Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per MW
Agriculture & Forestry	0.0	$0	-	$0	-	$0	$0	$0
Chemicals & Plastics	139.6	$22,336	139.6	$208,760,244	123.2	$3,951,934	$212,689,842	$1,523,566
Colleges & Universities	9.8	$1,568	9.8	$14,655,089	5.6	$179,633	$14,833,154	$1,513,587
Construction	2.9	$464	2.9	$4,336,710	2.3	$73,778	$4,410,024	$1,520,698
Data Centers	0.0	$0	-	$0	-	$0	$0	$0
Electrical & Electronic Equipment	7.9	$1,264	7.9	$11,813,796	5.1	$163,595	$11,976,127	$1,515,965
Grocery stores / Convenience chains	14.2	$2,272	14.2	$21,234,925	9.7	$311,151	$21,543,803	$1,517,169
Healthcare	36.6	$5,856	36.6	$54,732,270	23.2	$744,195	$55,470,610	$1,515,590
Hospitals	38.2	$6,112	38.2	$57,124,938	24.3	$779,480	$57,898,306	$1,515,662
Institutional	9.6	$1,536	9.6	$14,356,005	7.0	$224,542	$14,579,011	$1,518,647
Large Public Assembly (Churches, Stadiums, Arena, & Sports Venues)	11.2	$1,792	11.2	$16,748,673	10.7	$343,228	$17,090,109	$1,525,903
Lodging (Hospitality)	5.7	$912	3.8	$5,682,585	5.7	$182,841	$5,864,515	$1,028,862
Lumber, Furniture, Pulp & Paper	29.9	$4,784	29.9	$44,712,975	29.3	$939,867	$45,648,058	$1,526,691
Metal Products & Machinery	214.1	$34,256	180.7	$270,221,892	214.1	$6,867,769	$277,055,404	$1,294,047
Misc. Manufacturing	58.2	$9,312	58.2	$87,033,282	45.9	$1,472,352	$88,496,322	$1,520,555
Office	88.1	$14,096	88.1	$131,746,257	63.2	$2,027,291	$133,759,452	$1,518,268
Restaurants	0.0	$0	-	$0	-	$0	$0	$0
Retail	40.1	$6,416	40.1	$59,966,231	29.6	$949,491	$60,909,305	$1,518,935
Miscellaneous	36.6	$5,856	36.6	$54,732,270	35.3	$1,132,332	$55,858,746	$1,526,195
Primary Resource Industries	2.6	$416	2.6	$3,888,085	0.3	$9,623	$3,897,292	$1,498,958
Schools K-12	2.1	$336	2.1	$3,140,376	1.4	$44,908	$3,184,949	$1,516,642
Stone, Clay, Glass & Concrete	1.8	$288	1.8	$2,691,751	0.7	$22,454	$2,713,917	$1,507,732
Textiles & Leather	0.0	$0	-	$0	-	$0	$0	$0
Transportation Equipment	42.3	$6,768	42.3	$63,256,148	39.1	$1,254,226	$64,503,606	$1,524,908
Warehouse	4.0	$640	4.0	$5,981,669	2.2	$70,570	$6,051,599	$1,512,900
Water & Wastewater	16.6	$2,656	16.6	$24,823,926	12.6	$404,175	$25,225,445	$1,519,605

Large C&I (1 MW and Up)			Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per MW
Total			776.8		690.5			

Table 6-7: Large C&I (500 kW to 1 MW) Economic Potential Results

Large C&I (500 kW to 1 MW)			Summer		Winter		Total Aggregate Net Benefit	Total Net Benefit per MW
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit		
Agriculture & Forestry	0.0	$0	-	$0	-	$0	$0	$0
Chemicals & Plastics	10.1	$1,616	10.1	$15,103,714	7.4	$237,373	$15,339,471	$1,518,759
Colleges & Universities	2.6	$416	2.6	$3,888,085	1.9	$60,947	$3,948,616	$1,518,698
Construction	4.8	$768	4.8	$7,178,003	4.4	$141,141	$7,318,375	$1,524,661
Data Centers	2.1	$336	2.1	$3,140,376	-	$0	$3,140,040	$1,495,257
Electrical & Electronic Equipment	2.0	$320	-	$0	2.0	$64,155	$63,835	$31,917
Grocery stores / Convenience chains	20.3	$3,248	20.3	$30,356,970	14.0	$449,083	$30,802,805	$1,517,380
Healthcare	11.5	$1,840	11.5	$17,197,298	11.3	$362,474	$17,557,933	$1,526,777
Hospitals	2.3	$368	2.3	$3,439,460	1.6	$51,324	$3,490,415	$1,517,572
Institutional	5.1	$816	5.1	$7,626,628	3.3	$105,855	$7,731,667	$1,516,013
Large Public Assembly (Churches, Stadiums, Arena, & Sports Venues)	9.2	$1,472	9.2	$13,757,838	6.7	$214,918	$13,971,285	$1,518,618
Lodging (Hospitality)	4.3	$688	4.3	$6,430,294	3.6	$115,479	$6,545,085	$1,522,113
Lumber, Furniture, Pulp & Paper	5.8	$928	5.8	$8,673,420	4.9	$157,179	$8,829,671	$1,522,357
Metal Products & Machinery	17.3	$2,768	17.3	$25,870,718	11.5	$368,890	$26,236,840	$1,516,580
Misc. Manufacturing	10.9	$1,744	10.9	$16,300,048	7.7	$246,996	$16,545,300	$1,517,917
Office	51.9	$8,304	51.9	$77,612,154	39.6	$1,270,265	$78,874,114	$1,519,732
Restaurants	1.3	$208	1.3	$1,944,042	1.3	$41,701	$1,985,535	$1,527,335
Retail	39.9	$6,384	39.9	$59,667,147	30.6	$981,568	$60,642,331	$1,519,858
Miscellaneous	5.9	$944	5.9	$8,822,962	4.1	$131,517	$8,953,535	$1,517,548
Primary Resource Industries	1.6	$256	1.6	$2,392,668	0.2	$6,415	$2,398,827	$1,499,267

Large C&I (500 kW to 1 MW)			Summer		Winter		Total Aggregate Net Benefit	Total Net Benefit per MW
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit		
Schools K-12	10.9	$1,744	10.9	$16,300,048	7.8	$250,204	$16,548,507	$1,518,212
Stone, Clay, Glass & Concrete	1.1	$176	1.1	$1,644,959	1.0	$32,077	$1,676,860	$1,524,418
Textiles & Leather	0.0	$0	-	$0	-	$0	$0	$0
Transportation Equipment	4.3	$688	4.3	$6,430,294	2.5	$80,193	$6,509,800	$1,513,907
Warehouse	4.9	$784	4.9	$7,327,544	2.8	$89,817	$7,416,577	$1,513,587
Water & Wastewater	2.1	$336	2.1	$3,140,376	2.1	$67,363	$3,207,403	$1,527,335
Total			**230.2**		**172.3**			

Table 6-8: Large C&I (300 kW to 500 kW) Economic Potential Results

Large C&I (300 kW to 500 Kw)			Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per MW
Agriculture & Forestry	0.0	$0	-	$0	-	$0	$0	$0
Chemicals & Plastics	1.0	$160	1.0	$1,495,417	0.6	$19,246	$1,514,504	$1,514,504
Colleges & Universities	0.0	$0	-	$0	-	$0	$0	$0
Construction	0.9	$144	0.9	$1,345,875	0.4	$12,831	$1,358,562	$1,509,514
Data Centers	0.0	$0	-	$0	-	$0	$0	$0
Electrical & Electronic Equipment	0.0	$0	-	$0	-	$0	$0	$0
Grocery stores / Convenience chains	2.6	$416	2.6	$3,888,085	1.8	$57,739	$3,945,408	$1,517,465
Healthcare	0.7	$112	0.7	$1,046,792	0.7	$22,454	$1,069,134	$1,527,335
Hospitals	0.3	$48	0.3	$448,625	-	$0	$448,577	$1,495,257
Institutional	0.8	$128	0.8	$1,196,334	0.6	$19,246	$1,215,452	$1,519,315
Large Public Assembly (Churches, Stadiums, Arena, & Sports Venues)	0.5	$80	0.3	$448,625	0.5	$16,039	$464,584	$929,168
Lodging (Hospitality)	0.5	$80	0.1	$149,542	0.5	$16,039	$165,500	$331,001
Lumber, Furniture, Pulp & Paper	0.0	$0	-	$0	-	$0	$0	$0
Metal Products & Machinery	1.7	$272	1.7	$2,542,209	0.9	$28,870	$2,570,807	$1,512,239

Large C&I (300 kW to 500 Kw)			Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per MW
Misc. Manufacturing	0.7	$112	0.7	$1,046,792	0.4	$12,831	$1,059,511	$1,513,587
Office	3.2	$512	3.2	$4,785,335	2.9	$93,024	$4,877,848	$1,524,327
Restaurants	0.4	$64	0.4	$598,167	0.3	$9,623	$607,726	$1,519,315
Retail	1.5	$240	1.5	$2,243,126	1.5	$48,116	$2,291,002	$1,527,335
Miscellaneous	0.6	$96	0.6	$897,250	0.3	$9,623	$906,778	$1,511,296
Primary Resource Industries	0.0	$0	-	$0	-	$0	$0	$0
Schools K-12	3.4	$544	3.4	$5,084,419	2.1	$67,363	$5,151,237	$1,515,070
Stone, Clay, Glass & Concrete	0.0	$0	-	$0	-	$0	$0	$0
Textiles & Leather	0.0	$0	-	$0	-	$0	$0	$0
Transportation Equipment	0.3	$48	0.2	$299,083	0.3	$9,623	$308,659	$1,028,862
Warehouse	0.0	$0	-	$0	-	$0	$0	$0
Water & Wastewater	0.1	$16	-	$0	0.1	$3,208	$3,192	$31,917
Total			**18.4**		**13.9**			

7 Program Potential

7.1 DSM Program Assessment and Screening

7.1.1 Review of current and proposed programs

Nexant's development of program potential estimates began with a review of program regulatory filings, recent program evaluation reports, and publicly available program information on Duke's website or in program marketing literature.

7.1.2 Development of proposed offerings

Based on existing programs and measure list developed for the study, Nexant worked with Duke Energy to identify and develop proposed program offerings to be considered in this study. Each eligible EE measure was mapped to one or more program offerings across the Residential, Commercial, and Industrial customer segments, and DR opportunities were classified into specific offerings across the customer segments.

In refining the program offerings, the cost-effectiveness of each offering was analyzed from the TRC perspective. While the measure bundles that comprised the programs may have included measures that did not pass the TRC on their own, the goal of the measure bundling into programs was to achieve programs that passed the TRC.

The following tables describe the final EE and DR program offerings included in the study.

Table 7-1: Proposed Residential EE Program Offerings

Program	Description	Targeted Segments	Delivery Approach
Smart $aver	Contractor-driven program addressing need for HVAC equipment, water heating equipment, building envelope, and pool measures	All residential building types	*Marketing strategy:* target customer segment *Customer experience:* technical assistance *Incentive type:* customer rebate
Energy Efficient Lighting	Program is designed to offer energy efficient lighting measures through different channels, such as buy-downs, giveaway, retail stores, and online store.	All residential building types	*Marketing strategy:* mass marketing and joint marketing *Customer experience:* self-directed *Incentive type:* customer rebate
Appliance Recycling	Offer rebates to the residential customers who have qualifying units for recycling. The incentives will be offered after the units are picked up by DEO's contractor.	Single Family	*Marketing strategy:* mass marketing *Customer experience:* self-directed *Incentive type:* customer rebate
Audits and EE Kits	Focuses on energy efficiency education on customers and installation of highly cost-effective measures.	All residential building types; note: decision-maker varies by building type	*Marketing strategy:* mass marketing *Customer experience:* direct install & behavior *Incentive type:* customer rebate
EE Products	Designed to deliver energy efficiency upgrades on typical residential appliances that can be self-installed by residential customers.	All residential building types	*Marketing strategy:* mass marketing & joint marketing *Customer experience:* self-directed *Incentive type:* customer rebate
Income Qualified	Addresses the approach of centralized management and existing resources for low income community to support energy efficiency.	All residential building types, demographic limitations	*Marketing strategy:* target customer segment *Customer experience:* technical assistance & direct install *Incentive type:* customer rebate
New Construction	Targets energy efficiency whole building measures and individual high cost-effective measures for new homes.	All residential building types (new construction)	*Marketing strategy:* joint marketing *Customer experience:* technical assistance *Incentive type:* customer rebate
Behavioral	Provides customers with increased information on their home energy consumption and tips to reduce energy use. Information provided through periodic usage reports as well as direct feedback with real-time usage information for their home.	All residential building types	*Marketing strategy:* target customer segment *Customer experience:* behavioral *Incentive type:* N/A

Table 7-2: Proposed Non-Residential EE Program Offerings

Program	Description	Targeted Segments	Delivery Approach
Smart $aver-Prescriptive	Addresses need to overcome cost barriers and increase efficiency of commercial and industrial equipment. Offers incentives to businesses for installing energy efficiency equipment.	All non-residential building types	*Marketing strategy:* target customer segment *Customer experience:* self-directed *Incentive type:* customer rebate
Smart $aver – Custom	Addresses need of Duke Energy customers with measures not fall in the Smart $aver prescriptive incentive program measure list. Offers incentives to businesses for installing energy efficiency equipment.	All non-residential building types	*Marketing strategy:* target customer segment *Customer experience:* technical assistance *Incentive type:* customer rebate
Small Business Energy Saver	Focuses on installing highly-cost effective measures while minimizing customers' participation burden with a direct install approach.	Non-residential small business customers (less than 100 kW demand)	*Marketing strategy:* target customer segment *Customer experience:* direct install *Incentive type:* upstream incentive/mark-down
New Construction	Influences the design and construction phase of the commercial real estate market. Offers design assistance and cash incentives for a package of whole-building energy opportunities.	All non-residential building types	*Marketing strategy:* target customer segment *Customer experience:* technical assistance *Incentive type:* customer rebate
Mercantile Self Direct	Focuses on increasing access to incentives for customers that installed Smart $aver qualified energy efficient measures but have not received incentives.	All non-residential building types	*Marketing strategy:* target customer segment *Customer experience:* self-directed *Incentive type:* customer rebate
Pay-for-Performance	Offering measures are similar to Smart $aver-Custom Program with part of the incentives paid a year later to customers.	All non-residential building types	*Marketing strategy:* target customer segment *Customer experience:* technical assistance *Incentive type:* customer rebate

Table 7-3: Proposed Demand Response Program Offerings

Type of DR	Sector	Technology	Existing Program?
Utility controlled loads	Residential	▪ Central AC switches	Y
		▪ Central Heating Switches (electric)	N
		▪ Smart thermostat	N
		▪ Water heater switches	N
		▪ Home gateway (control HVAC, water heater, pool pumps, power strips)	N
		▪ Pool pumps	N
	Non-Residential	▪ Lighting controls (EMS or lighting ballasts)	Y
		▪ HVAC controls (EMS)	Y
		▪ Pump loads	Y
		▪ Auto DR for process loads	Y
		▪ Battery storage	Y
		▪ Backup generation	Y
Contractual	Non-Residential	▪ Interruptible rates – Firm service levels	Y
		▪ Guaranteed Load Drop	Y
		▪ Emergency Load Response	Y
Voluntary	Residential	▪ Behavioral DR	N
	Non-Residential	▪ Economic Load Response	Y

7.2 EE Market Potential Methodology

7.2.1 Market Adoption Rates

Utility-sponsored DSM programs offer incentives for energy efficiency measures that are designed to lower customers' costs and increase the rate at which the market adopts energy efficiency technologies. To estimate the adoption rate of energy efficiency based on the proposed program offerings described above, Nexant incorporated Duke DSM program data as well as secondary data from other utility sponsored DSM initiatives.

Nexant used historic program participation data to derive estimates of baseline program penetration (or participation) rates. Participation in Duke Energy's most recent program year prior to the MPS is taken as the baseline cumulative penetration rate. Nexant developed estimates of future program adoption using secondary research and standard economic theories on product diffusion. Forecasting future market penetration beyond the most recent program participation rate requires assumptions about the ultimate market penetration for a given program or set of measures, and information on the expected rate of market diffusion or uptake.

Nexant considered on a number of secondary data sources to develop market adoption parameters. These sources include EPA Energy Star data on qualified product shipments, empirically-derived market penetration curves from other utility-sponsored programs, and primary research conducted in other markets. The use of secondary data for estimating market penetration is based on aligning energy efficiency measures with program concepts designed to address specific market segments and the varieties of DSM measures widely available in and suitable for the DEO market.

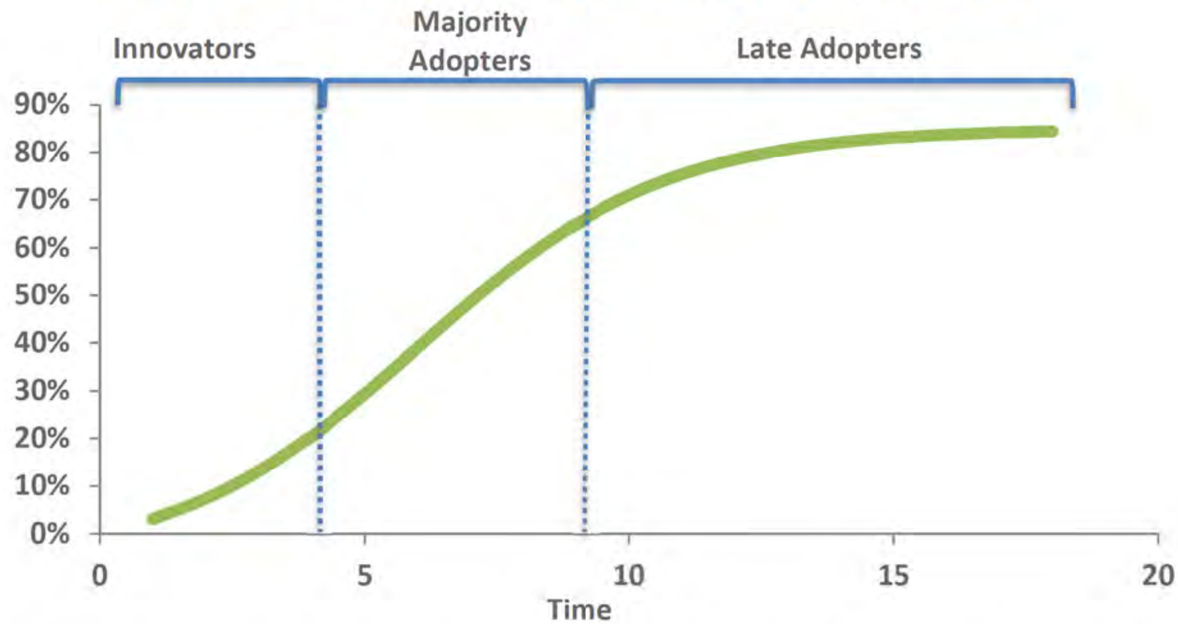
The technical and economic potential included in this study are theoretical constructs that assume 100% adoption of energy efficiency technologies over an extended period of time, including the assumption that there will be an in-kind, replacement measure to replace the transformed current measure. However, the energy efficiency market potential incorporates Nexant's market penetration estimates, which follow accepted theories of product diffusion. This theoretical model of market adoption, referred to as the Bass Diffusion Model, is a widely accepted mathematical description of how new products and innovations spread through an economy over time. The Bass Diffusion Model was originally published in 1969, and in 2004 was voted one of the top 10 most influential papers published in the 50 year history of the peer-reviewed publication *Management Science*[1]. More recent publications by Lawrence Berkeley National Laboratories have illustrated the application of this model to CDM in the energy industry[2]. Nexant applied the secondary data and research collected to develop and apply Bass Model diffusion parameters in the DEO jurisdiction.

According to product diffusion theory, the rate of market adoption for a product changes over time. When the product is introduced, there is a slow rate of adoption while customers become familiar with the product. When the market accepts a product, the adoption rate accelerates to relative stability in the middle of the product cycle. The end of the product cycle is characterized by a low adoption rate because fewer customers remain that have yet to adopt the product. This concept is illustrated in Figure 7-1.

[1] Bass, F. 2004. Comments on "A New Product Growth for Model Consumer Durables the Bass Model" (sic). *Management Science* 50 (12_supplement): 1833-1840. http://pubsonline.informs.org/doi/abs/10.1287/mnsc.1040.0300. Accessed 01/08/2016.

[2] Buskirk, R. 2014. Estimating Energy Efficiency Technology Adoption Curve Elasticity with Respect to Government and Utility Deployment Program Indicators. LBNL Paper 6542E. Sustainable Energy Systems Group, Environmental Energy Technologies Division. Ernest Orlando Lawrence Berkeley National Laboratory. http://escholarship.org/uc/item/2vp2b7cm#page-1. Accessed 01/14/2016.

Figure 7-1: Bass Model Market Penetration with Respect to Time



The Bass Diffusion model is a mathematical description of how the rate of new product diffusion in a market changes over time. Figure 1 depicts the cumulative market adoption with respect to time, $S(t)$. The rate of adoption in a discrete time period is determined by external influences on the market, internal market conditions, and the number of previous adopters. The following equation describes this relationship:

$$S(t) = \left(p + \frac{q}{m} * S(t-1)\right) * \left(m - S(t-1)\right)$$

Where:

$S(t) =$ the rate of adoption for any discrete time period, t

$p =$ external influences on market adoption

$q =$ internal influences on market adoption

$m =$ the maximum market share for the product

$S(t-1) =$ the cumulative market share of the product, from product introduction to time period *t-1*

Marketing is the quintessential external influence. The internal influences are characteristics of the product and market; for example: the underlying market demand for the product, word of mouth, product features, market structure, and other factors that determine the product's market performance. Nexant's approach applied literature reviews and analysis of secondary data sources to estimate the Bass model parameters. We then extrapolated the model to future years; the historic participation and predicted future market evolution serve as the program adoption curve applied to each proposed offering.

7.2.2 Customer Opt-Outs

Ohio Senate Bill 310 includes a provision allowing non-residential customers with annual energy consumption greater than forty-five million kWh to opt out of an EDU's portfolio plan, which exempts the customer from cost recovery mechanism but also eliminates that customer's eligibility for participation in the program. This opt-out provision took effect in 2017; since that time, 8% of eligible participants have opted out of DSM programs.

In order to incorporate the impact of opt-outs into the study, Duke provided Nexant with opt-out information in Ohio. Nexant reviewed customer characteristic data on DEO non-residential customers to identify that approximately 8% of the baseline energy sales are used by customers with annual consumption greater than 45 million kWh. 8% of non-residential DEO sales would become ineligible for the proposed programs because of customer opt-outs. Nexant incorporated this opt-out rate into the model by reducing the non-residential sales estimates by 8% and applying the applicable energy efficiency technologies and market adoption rates to the remaining sales forecast. Adding these customers back to the model would increase overall potential by 8% in the non-residential sector.

7.2.3 Scenario Analysis

The market potential for the proposed energy efficiency program offerings was developed based on two program potential scenarios, each with specific assumptions on the types of programs and eligible measures offered. The two scenarios were developed as follows:

- Base scenario – aligns with existing program portfolio, and includes existing EE programs and measures currently offered by DEO
- Enhanced scenario – includes existing EE programs with measure bundles that include current and newly proposed measures, as well as new EE programs where measures included in the study did not logically fit into an existing offering.

Table 7-4 summarizes the programs and measures considered in each scenario:

Table 7-4: EE Programs by Scenario

	Program	Included in Base Scenario?	Included in Enhanced Scenario?
Residential	Smart $aver	Yes, Existing measures only	Yes, Existing + new measures
	Energy Efficient Lighting	Yes, Existing measures only	Yes, Existing
	Appliance Recycling	No	Yes, New program and measures
	Audits and EE Kits	Yes, Existing measures only	Yes, Existing
	EE Products	No	Yes, New program and measures
	Income Qualified	Yes, Existing measures only	Yes, Existing
	New Construction	No	Yes, New program and measures
	Behavioral	Yes, Existing measures only	Yes, Existing
Non-Residential	Smart $aver - Prescriptive	Yes, Existing measures only	Yes, Existing + new measures
	Smart $aver - Custom	Yes, Existing measures only	Yes, Existing + new measures
	Pay-For-Performance	Yes, Existing measures only	Yes, Existing + new measures
	Small Business	Yes, Existing measures only	Yes, Existing + new measures
	New Construction	No	Yes, New program and measures
	Mercantile Self Direct	Yes, Existing measures only	Yes, Existing + new measures

7.3 DR Market Potential Methodology

7.3.1 Estimation of Participation Rates for DR Programs

While economic potential merely considers whether a given customer segment is worth pursuing based on the marginal net benefits provided by those customers, achievable potential takes into account the estimated participation rate and how that affects the overall cost-effectiveness of the customer segment.

The magnitude of DR resources that can be acquired is fundamentally the result of customer preferences, program or offer characteristics (including incentive levels), and how programs are marketed. How predisposed are specific customers to participate in DR? What are details of specific offers and how do they influence enrollment rates? What is the level of marketing intensity and what marketing tactics are employed?

For program-based DR, participation rates are calculated as a function of the incentives offered to each customer group. For a given incentive level and participation rate, the cost-effectiveness of each customer segment is evaluated to determine whether the aggregate DR potential from that segment should be included in the achievable potential.

The following subsections describe how marketing/incentive level, participation rates, and technology costs are handled by this study.

7.3.2 Marketing and Incentive Levels for Programs

Several underlying assumptions are used to define three different marketing levels. The number of marketing attempts and the method of outreach are varied by marketing level, as described in Table 7-5. The high scenario assumes a high marketing level for program-based DR, while the medium scenario assumes a medium marketing level and the low scenario assumes a low marketing level. Within each marketing level, the participation rate for each customer segment is a function of the incentive level.

The specific tactics included in the low, medium, and high marketing scenarios are not prescriptive but are instead designed to provide concrete details about the assumptions used in the study. There is a wide range of strategies and tactics that can attain the same enrollment levels and the best approach for a jurisdiction is best developed through testing and optimizing the mix of marketing tactics and incentives.

Table 7-5: Marketing Inputs for Residential DR Program Enrollment Model

	Input	Marketing Level			
		No Marketing	Low	Medium	High
Marketing Components	Number of marketing attempts (Direct mail)	0	3	3	5
	Outreach mode	No marketing	Direct Mail	DM + Phone	DM + Phone
	Installation required (%)	0%	70%	70%	70%

The incentive level and marketing inputs for each scenario determine the participation rate, assuming that the incentive is uniform across all customer segments within a given customer class.

7.3.3 Participation Rates

The participation models for the residential and nonresidential customer segments use a bottom up approach to estimate participation rates. These estimates have been crosschecked with mature programs in other jurisdictions to ensure that the estimated participation rates are reasonable.

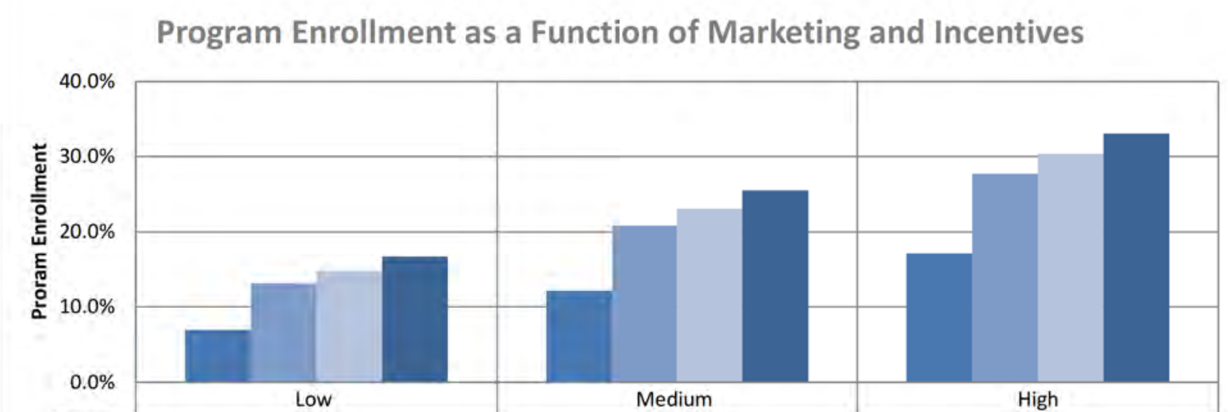
Many DR potential studies rely on top down approaches which benchmark programs against enrollment rates that have been attained by mature programs. However, aggregated program results often do not provide enough detail to calibrate achievable market potential. In many cases, programs are not marketed to all customers, either because it is not cost-effective to market to all customers or budgets are capped by regulators. Enrollment rates are a function of specific offers and the extensiveness of marketing over many years. They also vary based on the degree to which DR resources are utilized and tend to be higher when payments are high but actual events are infrequent, particularly among large C&I customers.

For residential customers, the Nexant approach to estimate participation rates involves five steps. The initial step required some modification due to the data provided (or lack thereof).

1) Estimate an econometric choice model based on who has and has not enrolled in DR programs. The goal is to estimate the pre-disposition or propensity of different customers to participate in DR based on their characteristics. Because micro-level acquisition marketing data were not provided, we relied on differences in participation rates by usage level, electric heating and income level. This information is based on prior micro-level analysis of program participation by Nexant and supplemented by outbound acquisition marketing that Nexant implements for load control programs.
2) Incorporate information about how different offer characteristics influence enrollment likelihood. What is the incremental effect of incentives? How do requirements for on-site installation affect enrollment rates? The two questions above have been analyzed using California specific data for residential customers. In each case, regression coefficients describe the incremental effect of each of the above factors on participation rates.
3) Incorporate information about how marketing tactics and intensity of marketing influence participation rates. What is the effect of incremental acquisition attempts? Is there a bump in enrollment rates when phone and/or door-to-door recruitment is added to direct mail recruitment? This relies on data from side-by-side testing designed to explicitly quantify the effect of marketing tactics on enrollment rates.
4) Calibrate the models to reflect actual enrollment rates attained with mature programs. To calibrate the models, the constant is adjusted so that the model produces exactly the enrollment rates observed by mature programs used for benchmarking.
5) Predict participation rates using specific tactics and incentive levels for programs with and without installation requirements. The enrollment estimates were produced for low, medium, and high marketing levels, where specific marketing tactics are specified for each scenario. All estimates reflect enrollment rates for eligible customers.

As a demonstration of how marketing level and incentive affects participation in DR programs, Figure 7-2 shows the range of participation rates for each marketing level for a given residential customer segment at several different incentive levels.

Figure 7-2: DR Program Enrollment for Residential Customer Segments Under Different Marketing and Incentive Levels



	Low	Medium	High
$0	7.0%	12.1%	17.2%
$25	13.1%	20.8%	27.7%
$50	14.8%	23.1%	30.3%
$100	16.7%	25.5%	33.0%

For SMB customers (300 kW or less), a similar approach was used to estimate participation levels. However, these customers tend to have lower enrollments than larger nonresidential customers, and were scaled accordingly. SMB customers tend to exhibit roughly 40% of the uptake of residential customers, based on data from California utilities, which have extensively marketed these programs.

For large nonresidential customers, enrollment levels were predicted as a function of load rather than the number of customers, since large customers tend to have relatively high participation rates and commit to relatively large demand reductions on a percentage basis. For these customers, publicly available data on DR programs offered by California utilities were used to model program participation rates. Participation data were combined with data from the utilities on customer size and industry to generate a breakdown of participation rates, which is summarized in Table 7-6.

Table 7-6: Large Nonresidential Participation Rates by Size and Industry

Industry	Annual Max Demand (Non-coincident)				Total
	100kw - 300kW*	300 - 500kW	500kW - 1MW	1 MW or more	
Agriculture, Mining & Construction	19.8%	43.2%	57.9%	60.7%	**44.6%**
Manufacturing	24.2%	44.8%	52.3%	74.0%	**64.6%**
Wholesale, Transport & Other Utilities	27.9%	50.1%	55.7%	60.8%	**49.7%**
Retail Stores	28.1%	53.0%	53.8%	48.0%	**42.7%**
Offices, Hotels, Finance, Services	13.0%	26.9%	34.3%	40.2%	**30.0%**
Schools	15.0%	30.5%	40.3%	52.5%	**35.7%**
Institutional/Government	13.7%	34.1%	42.8%	62.3%	**40.4%**
Other or Unknown	9.4%	25.3%	29.6%	29.5%	**18.6%**
Total	**19.7%**	**40.8%**	**45.6%**	**60.8%**	**45.4%**

These programs have been marketed to every large nonresidential customer in California, which is why California specific data reflect a saturated market and a good representation of the total potential. The main gap in applying these participation rates is the ability to use back-up generation for DR. California does not allow the use of backup generation for DR while Ohio does.

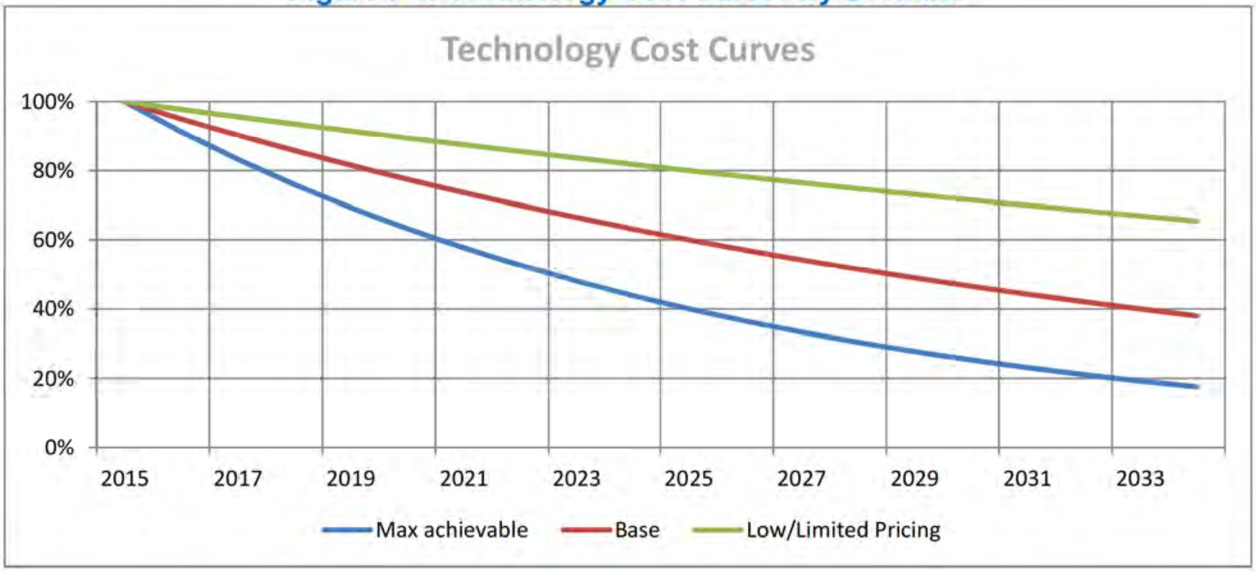
For each large nonresidential customer segment, participation was estimated as a function of incentive level and number of dispatch hours, based on publicly available information on program capacity, dispatch events, and incentive budgets.

Finally, these models were calibrated to reflect actual enrollment from DEO marketing initiatives for the Power Manager® (residential) and PowerShare® (nonresidential) programs. This helps ensure that the model reflects the incentive level that a DEO customer would respond to when modeling program participation.

7.3.4 Technology Cost Reduction

The assumed technology costs vary for the various scenarios, as illustrated by Figure 7-3, which shows the relative decrease in equipment costs for the various scenarios over time. Whereas the base scenario assumes a 40% reduction in technology costs from existing prices by 2025, the high scenario assumes a 60% reduction and the low scenario assumes a 20% reduction. A key assumption in the DR technology costs curves is that DR-ready devices and equipment will become more common, requiring utilities to purchase and install less equipment. Because of changes in code and changes in appliance/building stock, an increasing share of customers is expected to have DR-capable thermostats and energy management systems installed on their own. The utility pays an incentive to connect these customers to the Demand Response Management System (DRMS), but avoids having to pay for technology and installation, driving down program technology costs.

Figure 7-3: Technology Cost Curves by Scenario



Another relevant factor in the calculation of equipment costs is the expected penetration of smart thermostats. Customer uptake of these devices is incentivized by the energy efficiency programs described in this report in the medium and high scenarios. Customers who already have smart thermostats would not incur equipment costs, thus making them more cost effective to enroll in DR.

7.3.5 Scenario Analysis

Base and enhanced scenarios were constructed for the DR potential analysis, which align with the assumptions for the EE scenarios (notably, the penetration of smart thermostats). Other major assumptions for each scenario are listed below:

Program Potential - Base

- Continue existing programs and maintain incentives at current levels for residential and nonresidential customers
- Only target residential AC/heating (no pool pumps or water heaters)
- No incentives for purchase of smart thermostats
- Set Large C&I payments at current levels
- Existing program marketing and outreach budgets
- Target only customer segments who are cost-effective on their own
- Assume very little technology cost reduction

Program Potential - Enhanced

- Include behavioral demand response
- Maintain incentives at current levels for residential DLC participants, but include a one-time enrollment incentive

- Target pool pumps for residential customers
- Offer incentives for smart thermostats
- Higher incentives for Large C&I customers
- Aggressively increase program marketing and outreach budgets
- Target all customer segments that can be included without making the program cost-ineffective
- Assume large technology cost reductions

7.4 Energy Efficiency Program Potential

This section provides the results of the energy efficiency economic potential for each of the three segments from the SB 310 Provisions perspective, which assumes that savings for equipment turnover measures are measured against the "as found" equipment that is being replaced.

7.4.1 Summary

Table 7-7 summarizes the portfolio EE program potential for the base and enhanced scenarios. Impacts are presented as both cumulative impacts, which represent the savings that occur in the respective year based on measures installed in that year and measures installed in prior years that have not reached the end of their useful life and the sum of annual impacts, which represent the total annual incremental savings achieved over the stated time horizon.

Table 7-7: EE Program Potential (2019 – 2028)

	Base Scenario		Enhanced Scenario	
	Total Potential	% of Sales	Total Potential	% of Sales
Cumulative MWh	1,192,287	6%	1,537,786	8%
Cumulative MW	872		970	
Sum of Annual MWh	1,403,706	7%	1,797,289	10%
Sum of Annual MW	930		1,037	

The non-residential sector accounts for 76% of the energy savings potential, and 91% of the peak reduction potential. The residential sector is 24% of energy savings potential and 9% of peak reduction potential.

Participant and program costs associated with achievable program potential scenarios include the following:

- **Program incentives:** Financial incentives paid by energy-efficiency programs to subsidize purchases of energy-efficiency measures.
- **Program administration costs:** Administrative, marketing, promotional, and other costs associated with managing programs designed to achieve energy-efficiency savings.

- **Total program acquisition costs:** Total incentive and non-incentive program costs per sum of annual incremental energy savings achieved.
- **Participant costs:** Incremental costs to purchase, install, and maintain energy-efficiency measures.

Table 7-8 lists estimated participant and program costs associated with the theoretically achievable scenarios.

Table 7-8: EE Participation and Program Costs by Scenario (cumulative through 2028)

Program Sector	Program Incentives ($M)	Program Admin ($M)	Participant Costs ($M)	Levelized Cost ($/kWh)
Base Scenario				
Residential	$23.83	$72.59	$43.36	$0.058
Non-Residential	$129.12	$51.94	$144.10	$0.061
Total	$152.95	$124.53	$187.46	$0.06
Enhanced Scenario				
Residential	$38.94	$92.72	$59.29	$0.088
Non-Residential	$188.39	$72.57	$196.95	$0.066
Total	$227.33	$165.29	$256.24	$0.072

7.4.2 Residential Program Details

Table 7-9 summarizes the ten year cumulative residential energy efficiency program potential for the base and enhanced scenarios.

Table 7-9: EE Residential Program Potential (2019 – 2028)

	Base Scenario		Enhanced Scenario	
	Total Potential	% of Residential Load[3]	Total Potential	% of Residential LoadError! Bookmark not defined.
Cumulative MWh	283,281	4%	401,373	6%
Cumulative MW	80		125	
Sum of Annual MWh	292,041	4%	427,725	6%
Sum of Annual MW	81		128	

Figure 7-4 and Figure 7-5 illustrate the relative contributions to the overall residential program potential by program for the base and enhanced scenarios.

[3] Based on baseline sales forecast in 2028 for a 10-yr impact.

Figure 7-4: Residential Cumulative Potential by Program – Base Scenario

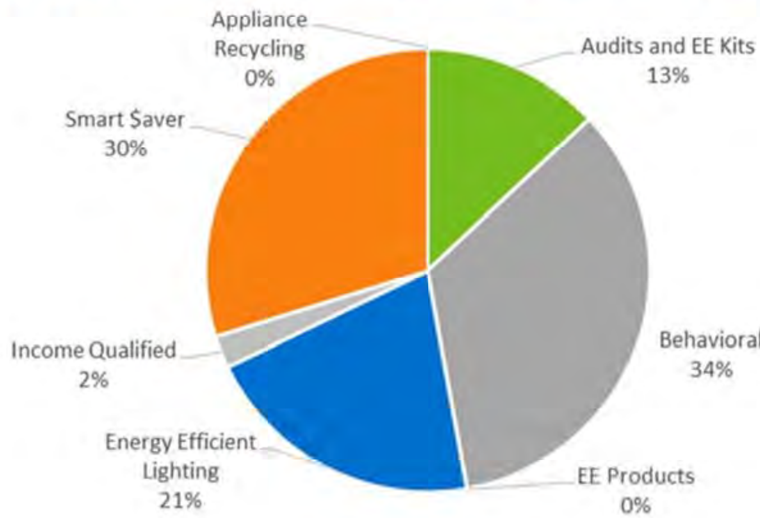
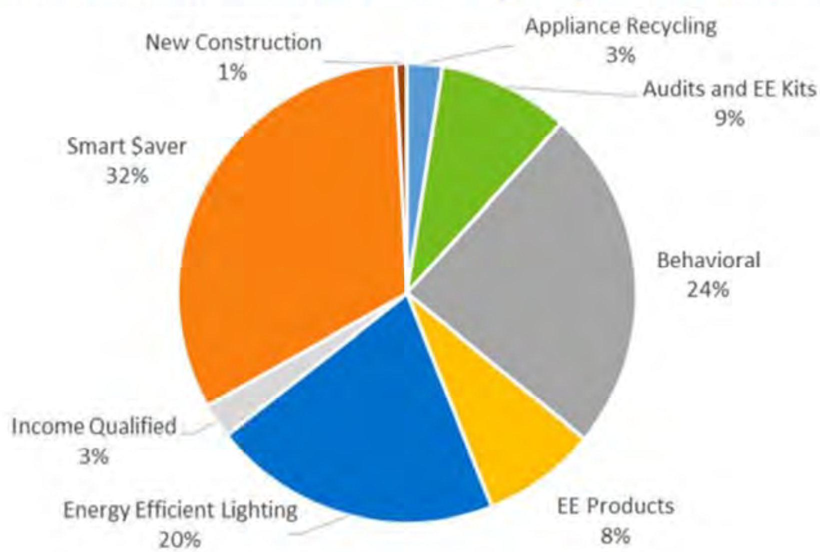


Figure 7-5: Residential Cumulative Potential by Program – Enhanced Scenario



Detailed program results for the short-term residential energy efficiency programs are provided in Table 7-10.

Table 7-10: EE Residential Program Potential (cumulative through 2028)

	Audits & EE Kits	Smart $aver	EE Products	Appliance Recycling	Energy Efficient Lighting	Behavioral	Income Qualified	New Const.
2028 impacts – Base scenario								
MWh savings (cumulative)	37,323	81,832	-	-	59,524	98,206	6,961	-
MW savings (cumulative)	27	34.9	-	-	4.5	11.2	2.8	-
Program costs (cumulative) ($M)	$12.7	$31.9	-	-	$8.2	$40.1	$3.5	-
TRC Net Benefits ($M)	$16.1	$87.7	-	-	$24.05	$601	$4.00	-
TRC benefit-cost ratio	2.3	2.2	-	-	4.0	16.0	2.1	-
Levelized Cost ($/kWh)	$0.04	$0.12	-	-	$0.02	$0.04	$0.05	-
2028 impacts – Enhanced scenario								
MWh savings (cumulative)	37,417	127,201	32,486	10,136	82,748	98,086	9,860	3,438
MW savings (cumulative)	26.6	61.0	14.1	1.4	6.5	11.2	3.9	1
Program costs (cumulative) ($M)	$12.78	$44.21	$8.34	$3.19	$17.32	$40.1	$4.79	$0.97
TRC Net Benefits ($M)	$16.08	$119.64	$26.77	$0.24	$24.78	$601	$5.93	$4.29
TRC benefit-cost ratio	2.3	2.4	3.0	1.1	2.4	16.0	2.2	4.1
Levelized Cost ($/kWh)	$0.04	$0.10	$0.40	$0.05	$0.03	$0.04	$0.05	$0.06

7.4.3 Non-Residential Program Details

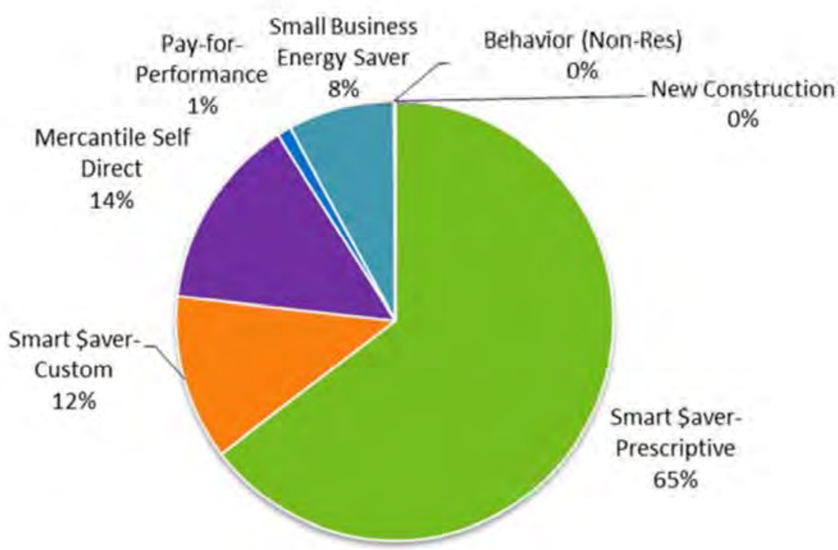
Table 7-11 summarizes cumulative residential energy efficiency program potential for the base and enhanced scenarios.

Table 7-11: EE Non-Residential Program Potential

	Base Scenario		Enhanced Scenario	
	Total Potential	% of Non-Res Load[4]	Total Potential	% of Non-Res Load[Error! Bookmark not defined.]
10-yr (2028) impacts				
Cumulative MWh	909,006	8%	1,136,413	11%
Cumulative MW	792		845	
Sum of Annual MWh	1,111,665	10%	1,369,564	13%
Sum of Annual MW	849		909	

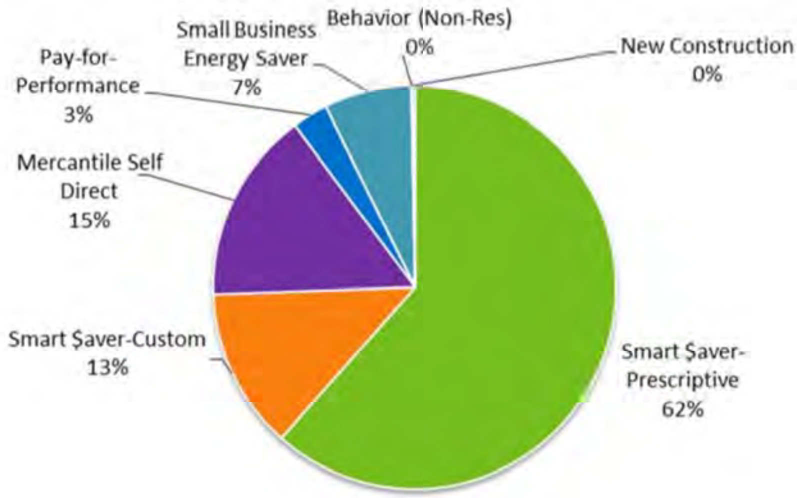
Figure 7-6 and Figure 7-7 illustrate the relative contributions to the overall non-residential program potential by program for the base and enhanced scenarios

Figure 7-6: EE Non-Residential 10-Yr Cumulative Potential by Program – Base Scenario (SB 310)



[4] Based on baseline sales forecast in 2028 for 10-yr impacts.

Figure 7-7: EE Non-Residential 10-Yr Cumulative Potential by Program – Enhanced Scenario (SB 310)



Detailed program results for the short-term non-residential EE programs are provided in Table 7-12:

Table 7-12: EE Non-Residential Program Potential (cumulative through 2028)

	Prescriptive	Custom	Pay-for-Performance	Mercantile Self Direct	Small Business Energy Saver	Behavioral	New Construction
10-yr (2028) impacts – Base scenario							
MWh savings	587,867	110,344	9,429	129,739	71,628		
MW savings	557.6	8.0	1.6	203.1	21.2		
Program costs ($M)	$98.70	$26.44	$13.48	$14.52	$27.91		
TRC Net Benefits ($M)	$1,028.79	$17.22	$7.10	$456.97	$107.22		
TRC benefit-cost ratio	6.6	1.4	1.3	10.5	4.5		
Levelized Cost ($/kWh)	$0.04	$0.03	$0.17	$0.13	$0.17		
10-yr (2028) impacts – Enhanced scenario							
MWh savings	699,166	146,809	32,424	175,117	79,447	701	2,750
MW savings (cumulative)	587.1	16.4	5.5	212.2	22.8	0.06	0.6
Program costs ($M)	$133.65	$37.28	$19.17	$19.58	$48.33	$0.81	$2.15
TRC Net Benefits ($M)	$1,096.62	$37.78	$14.21	$495.20	$91.34	$0.36	$0.04
TRC benefit-cost ratio	5.4	1.7	1.5	8.8	2.7	6.2	1.0
Levelized Cost ($/kWh)	$0.04	$0.03	$0.10	$0.12	$0.20	$0.10	$0.08

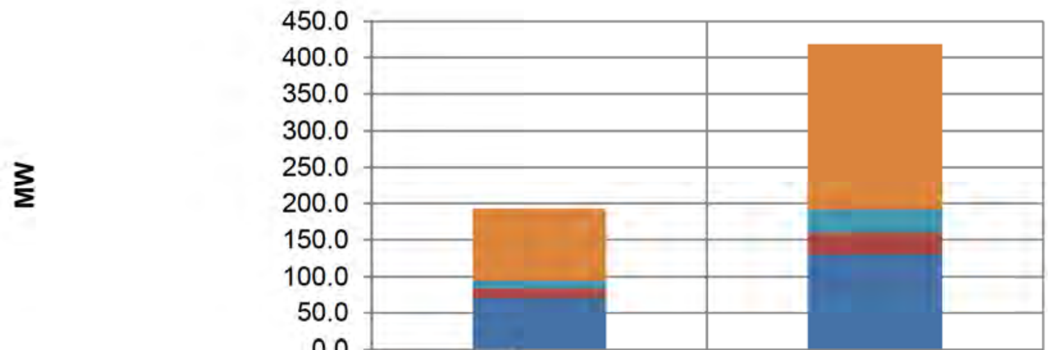
7.5 Demand Response Program Potential

This section presents the estimated overall potential for the baseline and enhanced scenarios. The results are provided separately for summer and winter peaking capacity. The results are further broken down by customer segment and presented in the form of supply curves. All results presented reflect the projected achievable DR potential by 2028.

7.5.1 Summer Peak Reduction Capacity

Figure 7-8 presents the overall summer peak capacity results for each scenario, broken down by customer class. The capacity is what is expected to be available during the peak hour of system demand. Overall, the estimated magnitude of peak capacity ranges from 192 MW to 419 MW across the two scenarios considered. This equates to 13-29% of Duke Ohio's peak load. Most of the peak capacity potential comes from the large C&I sector, which is not surprising given that it makes up a large portion of the overall system demand. Variation in the peak capacity across the various scenarios can be attributed to differences in incentive levels, the degree of marketing, and technology cost forecasts.

Figure 7-8: DR Summer Peak Reduction Capacity Program Potential

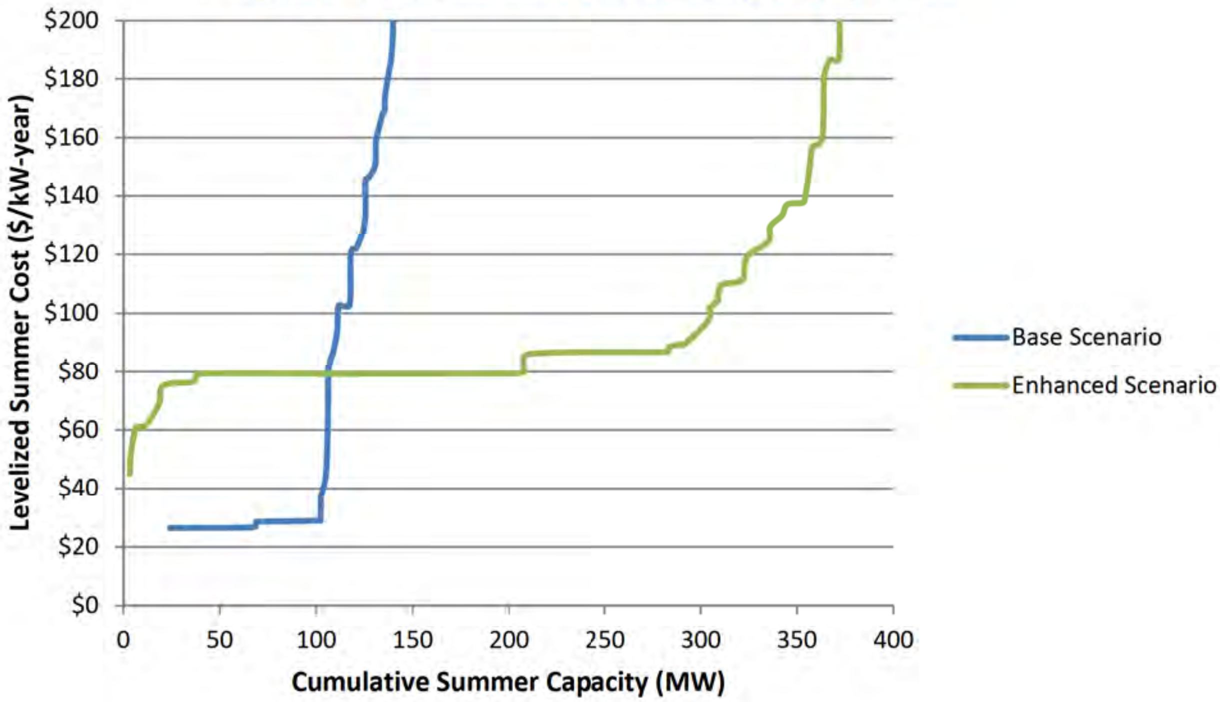


	Base	Enhanced
Large C&I - 1 MW and Up	97.9	227.4
Large C&I - 500 kW to 1 MW	10.0	30.3
Large C&I - 300 kW to 500 kW	0.5	1.5
Small and Medium Business	0.2	1.0
Residential Multi-Family	13.3	27.6
Residential Single Family	70.6	131.0

Figure 7-9 shows the amount of peak capacity that can be attained based on levelized capacity costs. The supply curve is constructed by stacking all 164 granular customer segments starting with the least expensive resources. The supply cost curve is a useful metric because it allows

DR resources to be compared with the full spectrum of resource options. Supply curves allow planners to rank different DR options and customer segments based on levelized costs, comparable resources, and the optimization of the resource mix. Because the base scenario has lower incentive levels, the initial DR resources are less costly but the potential is lower. In contrast, under the enhanced scenario, initial resources cost more but the potential is higher.

Figure 7-9: DR Summer Peak Capacity Supply Curve



Because the achievable potential is driven by marketing intensity, incentive levels, and technology costs, it is possible to yield non-linear changes in participation level. This can be seen in the program participation results in Table 7-13 DR Program Participation Rates by Scenario and Customer Class.

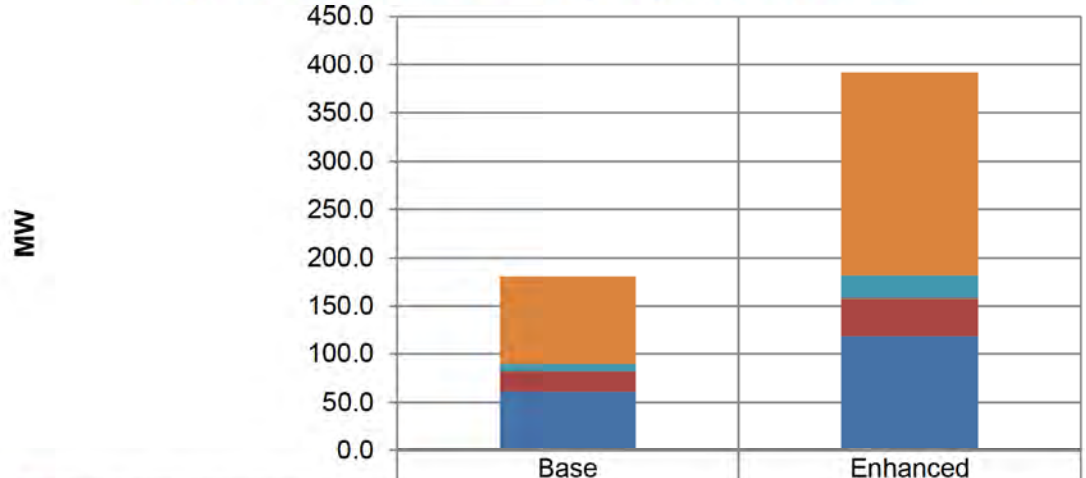
Table 7-13 DR Program Participation Rates by Scenario and Customer Class

Customer Class	Base	Enhanced	Units
Residential Single Family	10.9%	18.0%	% of Customers
Residential Multi-Family	9.3%	15.8%	% of Customers
Small and Medium Business	1.1%	3.4%	% of Customers
Large C&I - 300 kW to 500 kW	2.6%	8.1%	% of Load
Large C&I - 500 kW to 1 MW	4.4%	13.2%	% of Load
Large C&I - 1 MW and Up	12.8%	29.6%	% of Load

7.5.2 Winter Peak Reduction Capacity

Figure 7-10 presents the overall winter peak capacity results for each scenario, broken down by customer class. The capacity is what is expected to be available during the peak hour of system demand. Overall, the estimated magnitude of peak capacity ranges from 181 MW to 392 MW across the two scenarios considered. This equates to 13-29% of Duke Ohio's winter peak load. Most of the peak capacity potential comes from the large C&I sector, which is not surprising given that it makes up a large portion of the overall system demand. Variation in the peak capacity across the various scenarios can be attributed to differences in incentive levels, the degree of marketing, and technology cost forecasts.

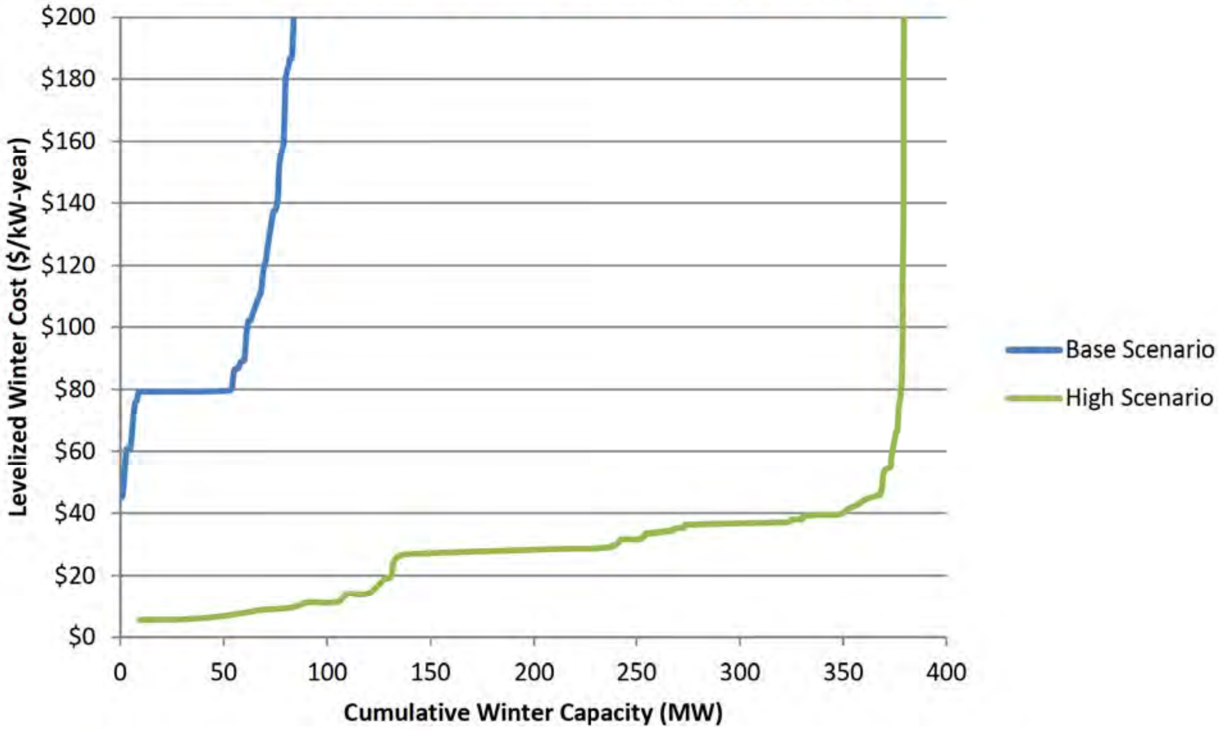
Figure 7-10 DR Winter Peak Capacity Program Potential



	Base	Enhanced
Large C&I - 1 MW and Up	91.3	209.8
Large C&I - 500 kW to 1 MW	7.3	22.4
Large C&I - 300 kW to 500 kW	0.4	1.2
Small and Medium Business	0.2	0.8
Residential Multi-Family	20.3	39.2
Residential Single Family	61.1	118.2

Figure 7-11 shows the amount of peak capacity that can be attained based on levelized capacity costs. The supply curve is constructed by stacking all 164 granular customer segments starting with the least expensive resources.

Figure 7-11 DR Winter Peak Capacity Supply Curve



7.5.3 Segment specific results

A total of 172 different customer segments were individually analyzed. This includes 30 segments each for residential single family and multi-family homes (60) and 23 industry types for four distinct commercial and industrial customer size categories (112). The section presents the segment-level results, focusing on the customer segments that are most attractive to pursue, allowing for prioritization and targeted marketing of those customer segments.

These results are fairly similar across the various scenarios that were studied, with only the absolute magnitude of the results changing. For the sake of simplicity, only the results for the base scenario are presented in this section.

Table 7-14 shows residential single family customer segments, ranked in terms of the benefit/cost ratio of their achievable peak capacity. Residential customers who rank in the top decile of consumption provide the greatest benefit/cost ratio. This is not surprising since they tend to have the greatest load available for load reduction, making it possible to enroll significant capacity per marginal dollar spent on acquisition marketing, equipment, and installation costs.

Table 7-15 through Table 7-18 show the segment specific program potential results for each non-residential customer class.

Table 7-14: Residential Single Family Segment Specific DR Program Potential

	Single Family				Summer		Winter		Total Aggregate Net Benefit	Net Benefit per Enrollee	Marginal Benefit Cost Ratio
	Usage bin	# of accounts	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit			
Electric	1	18,104	9.28%	$797,633	1.5	$2,230,590	2.4	$75,658	$1,508,615	$898	2.89
	2	18,104	9.28%	$797,633	1.5	$2,293,641	3.1	$98,334	$1,594,342	$949	3.00
	3	18,104	8.30%	$718,377	1.7	$2,515,135	3.7	$118,472	$1,915,229	$1,275	3.67
	4	18,105	8.30%	$718,417	1.9	$2,905,625	4.5	$145,325	$2,332,534	$1,552	4.25
	5	18,104	8.30%	$718,377	2.1	$3,131,163	5.1	$162,620	$2,575,406	$1,714	4.59
	6	18,104	7.99%	$693,445	2.1	$3,074,269	5.3	$169,263	$2,550,088	$1,762	4.68
	7	18,105	7.99%	$693,483	2.1	$3,070,037	5.5	$175,978	$2,552,531	$1,764	4.68
	8	18,104	7.99%	$693,445	2.2	$3,283,776	6.0	$193,403	$2,783,734	$1,924	5.01
	9	18,104	10.65%	$908,937	3.2	$4,819,141	9.1	$292,105	$4,202,309	$2,180	5.62
	10	18,105	10.65%	$908,987	5.7	$8,543,785	15.7	$505,107	$8,139,904	$4,222	9.95
Gas	1	33,821	12.50%	$1,978,590	3.2	$4,728,714	-	$0	$2,750,123	$650	2.39
	2	33,822	12.50%	$1,978,649	2.5	$3,681,337	-	$0	$1,702,689	$403	1.86
	3	33,822	9.06%	$1,457,381	2.0	$2,929,033	-	$0	$1,471,652	$480	2.01
	4	33,821	9.06%	$1,457,338	2.2	$3,230,543	-	$0	$1,773,205	$579	2.22
	5	33,822	9.06%	$1,457,381	2.4	$3,638,129	-	$0	$2,180,748	$712	2.50
	6	33,822	12.96%	$2,048,566	3.9	$5,786,364	-	$0	$3,737,799	$853	2.82
	7	33,821	12.96%	$2,048,505	4.4	$6,550,048	-	$0	$4,501,543	$1,027	3.20
	8	33,822	12.96%	$2,048,566	5.1	$7,610,767	-	$0	$5,562,202	$1,269	3.72
	9	33,822	14.02%	$2,208,189	6.7	$10,054,838	-	$0	$7,846,649	$1,655	4.55
	10	33,822	14.02%	$2,208,189	14.1	$21,079,501	-	$0	$18,871,312	$3,981	9.55
Unknown	1	283	12.50%	$0	-	$0	-	$0	$0	$0	-
	2	283	12.50%	$0	-	$0	-	$0	$0	$0	-
	3	284	9.06%	$0	-	$0	-	$0	$0	$0	-
	4	283	9.06%	$0	-	$0	-	$0	$0	$0	-
	5	283	9.06%	$12,194	0.0	$12,677	0.0	$580	$1,063	$41	1.09
	6	284	12.96%	$17,202	0.0	$33,909	0.1	$1,823	$18,531	$503	2.08
	7	283	12.96%	$17,141	0.0	$52,046	0.1	$2,554	$37,459	$1,021	3.19

Single Family				Summer		Winter		Total Aggregate Net Benefit	Net Benefit per Enrollee	Marginal Benefit Cost Ratio
Usage bin	# of accounts	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit			
8	284	12.96%	$17,202	0.0	$63,742	0.1	$3,399	$49,939	$1,356	3.90
9	283	14.02%	$18,477	0.1	$94,018	0.2	$4,815	$80,357	$2,026	5.35
10	284	14.02%	$18,542	0.1	$198,475	0.4	$11,454	$191,388	$4,808	11.32
Total AC/Heating Program Potential				70.6		61.1				
Additional Potential from WH and PP				-		-				
Total Potential				**70.6**		**61.19**				

Table 7-15: SMB Segment Specific DR Program Potential

SMB				Summer		Winter				
Segment	# of Accounts	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Net Benefit per Enrollee	Marginal Benefit Cost Ratio
Assembly	2,535	0.20%	$52,471	0.0	$6,773	0.0	$102	($45,596)	($8,991)	0.13
Colleges & Universities	67	0.20%	$1,406	0.0	$553	0.0	$10	($843)	($6,243)	0.40
Data Centers	46	1.57%	$1,182	0.0	$1,358	0.0	$25	$201	$278	1.17
Grocery	705	3.56%	$23,238	0.0	$49,156	0.0	$822	$26,739	$1,066	2.15
Healthcare	1,592	0.23%	$33,148	0.0	$6,388	0.0	$120	($26,640)	($7,282)	0.20
Hospitals	88	0.20%	$1,827	0.0	$728	0.0	$12	($1,086)	($6,191)	0.41
Institutional	384	0.20%	$8,009	0.0	$3,472	0.0	$58	($4,480)	($5,830)	0.44
Lodging (Hospitality)	230	0.23%	$4,813	0.0	$1,934	0.0	$39	($2,840)	($5,374)	0.41
Miscellaneous	925	0.22%	$19,245	0.0	$4,500	0.0	$82	($14,663)	($7,218)	0.24
Office	10,891	0.23%	$226,303	0.0	$22,242	0.0	$397	($203,665)	($8,136)	0.10
Restaurants	1,958	0.23%	$40,749	0.0	$6,389	0.0	$96	($34,265)	($7,612)	0.16
Retail	5,350	3.56%	$174,678	0.2	$298,734	0.2	$4,834	$128,890	$676	1.74
Schools K-12	428	0.13%	$8,791	0.0	$2,472	0.0	$45	($6,274)	($11,070)	0.29
Warehouse	269	1.57%	$7,022	0.0	$12,036	0.0	$200	$5,214	$1,232	1.74
Agriculture & Forestry	526	1.69%	$0	-	$0	-	$0	$0	$0	-
Chemicals & Plastics	261	0.81%	$6,054	0.0	$6,740	0.0	$123	$809	$383	1.13
Construction	1,858	1.69%	$47,608	0.0	$21,291	0.0	$373	($25,944)	($828)	0.46

SMB				Summer		Winter				
Segment	# of Accounts	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Net Benefit per Enrollee	Marginal Benefit Cost Ratio
Electrical & Electronic Equipment	399	0.81%	$9,101	0.0	$3,617	0.0	$56	($5,428)	($1,679)	0.40
Lumber, Furniture, Pulp & Paper	183	0.81%	$4,218	0.0	$3,901	0.0	$62	($255)	($173)	0.94
Metal Products & Machinery	805	0.81%	$18,511	0.0	$14,327	0.0	$232	($3,952)	($607)	0.79
Misc. Manufacturing	429	0.81%	$9,859	0.0	$7,339	0.0	$113	($2,407)	($693)	0.76
Primary Resource Industries	50	1.69%	$1,305	0.0	$1,964	0.0	$21	$681	$815	1.52
Stone, Clay, Glass & Concrete	71	0.81%	$1,642	0.0	$1,333	0.0	$25	($285)	($493)	0.83
Textiles & Leather	67	0.81%	$1,523	0.0	$450	0.0	$7	($1,066)	($1,966)	0.30
Transportation Equipment	933	1.57%	$0	-	$0	-	$0	$0	$0	-
Water & Wastewater	747	1.57%	$19,052	0.0	$15,656	0.0	$328	($3,068)	($261)	0.84

Table 7-16: Large C&I (300-500 kW) Segment Specific DR Program Potential

Large C&I - 300 kW to 500 kW				Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Enrolled MW
Agriculture & Forestry	0.0	4.21%	$0	-	$0	-	$0	$0	$0
Chemicals & Plastics	1.0	2.02%	$741	0.0	$30,261	0.0	$389	$29,909	$1,478,047
Colleges & Universities	0.0	4.21%	$0	-	$0	-	$0	$0	$0
Construction	0.9	0.50%	$172	0.0	$6,732	0.0	$64	$6,624	$1,471,552
Data Centers	0.0	3.93%	$0	-	$0	-	$0	$0	$0
Electrical & Electronic Equipment	0.0	2.02%	$0	-	$0	-	$0	$0	$0
Grocery stores / Convenience chains	2.6	8.90%	$8,388	0.2	$346,178	0.2	$5,141	$342,931	$1,481,390
Healthcare	0.7	0.57%	$152	0.0	$6,015	0.0	$129	$5,992	$1,489,632
Hospitals	0.3	0.50%	$57	0.0	$2,244	-	$0	$2,187	$1,457,295
Institutional	0.8	0.50%	$153	0.0	$5,984	0.0	$96	$5,927	$1,481,353
Large Public Assembly (Churches, Stadiums, Arena, & Sports Venues)	0.5	0.50%	$95	0.0	$2,244	0.0	$80	$2,229	$891,206
Lodging (Hospitality)	0.5	0.57%	$109	0.0	$859	0.0	$92	$843	$293,298
Lumber, Furniture, Pulp & Paper	0.0	2.02%	$0	-	$0	-	$0	$0	$0
Metal Products & Machinery	1.7	2.02%	$1,260	0.0	$51,443	0.0	$584	$50,767	$1,475,782
Misc. Manufacturing	0.7	2.02%	$519	0.0	$21,182	0.0	$260	$20,923	$1,477,130
Office	3.2	0.57%	$696	0.0	$27,497	0.0	$535	$27,336	$1,486,624
Restaurants	0.4	0.57%	$87	0.0	$3,437	0.0	$55	$3,405	$1,481,612
Retail	1.5	8.90%	$4,839	0.1	$199,718	0.1	$4,284	$199,163	$1,491,260
Miscellaneous	0.6	0.55%	$125	0.0	$4,928	0.0	$53	$4,856	$1,473,513
Primary Resource Industries	0.0	4.21%	$0	-	$0	-	$0	$0	$0
Schools K-12	3.4	0.33%	$441	0.0	$16,848	0.0	$223	$16,630	$1,476,089
Stone, Clay, Glass & Concrete	0.0	2.02%	$0	-	$0	-	$0	$0	$0
Textiles & Leather	0.0	2.02%	$0	-	$0	-	$0	$0	$0
Transportation Equipment	0.3	3.93%	$428	0.0	$11,743	0.0	$378	$11,692	$992,645
Warehouse	0.0	3.93%	$0	-	$0	-	$0	$0	$0
Water & Wastewater	0.1	3.93%	$143	-	$0	0.0	$126	($17)	($4,300)
Total				**0.5**		**0.4**			

Table 7-17: Large C&I (500 kW – 1 MW) Segment Specific DR Program Potential

Large C&I - 500 kW to 1 MW				Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Enrolled MW
Agriculture & Forestry	0.0	6.32%	$0	-	$0	-	$0	$0	$0
Chemicals & Plastics	10.1	4.57%	$16,759	0.5	$689,616	0.3	$10,838	$683,695	$1,482,578
Colleges & Universities	2.6	1.45%	$1,388	0.0	$56,371	0.0	$884	$55,867	$1,482,046
Construction	4.8	6.32%	$10,999	0.3	$453,368	0.3	$8,915	$451,283	$1,488,540
Data Centers	2.1	4.67%	$3,563	0.1	$146,644	-	$0	$143,081	$1,459,080
Electrical & Electronic Equipment	2.0	4.57%	$3,319	-	$0	0.1	$2,929	($389)	($4,264)
Grocery stores / Convenience chains	20.3	8.90%	$65,492	1.8	$2,702,854	1.2	$39,984	$2,677,347	$1,481,305
Healthcare	11.5	1.73%	$7,307	0.2	$297,750	0.2	$6,276	$296,718	$1,490,236
Hospitals	2.3	1.45%	$1,228	0.0	$49,867	0.0	$744	$49,384	$1,480,919
Institutional	5.1	1.45%	$2,722	0.1	$110,575	0.0	$1,535	$109,387	$1,479,361
Large Public Assembly (Churches, Stadiums, Arena, & Sports Venues)	9.2	1.45%	$4,910	0.1	$199,468	0.1	$3,116	$197,674	$1,481,965
Lodging (Hospitality)	4.3	1.73%	$2,732	0.1	$111,332	0.1	$1,999	$110,600	$1,485,572
Lumber, Furniture, Pulp & Paper	5.8	4.57%	$9,624	0.3	$396,017	0.2	$7,177	$393,570	$1,486,175
Metal Products & Machinery	17.3	4.57%	$28,706	0.8	$1,181,223	0.5	$16,843	$1,169,360	$1,480,399
Misc. Manufacturing	10.9	4.57%	$18,087	0.5	$744,239	0.4	$11,278	$737,430	$1,481,736
Office	51.9	1.73%	$32,978	0.9	$1,343,757	0.7	$21,993	$1,332,771	$1,483,192
Restaurants	1.3	1.73%	$826	0.0	$33,659	0.0	$722	$33,555	$1,490,794
Retail	39.9	8.90%	$128,726	3.6	$5,312,507	2.7	$87,395	$5,271,175	$1,483,783
Miscellaneous	5.9	0.37%	$838	0.0	$32,242	0.0	$481	$31,885	$1,478,849
Primary Resource Industries	1.6	6.32%	$3,666	0.1	$151,123	0.0	$405	$147,861	$1,463,146
Schools K-12	10.9	0.79%	$3,206	0.1	$128,207	0.1	$1,968	$126,969	$1,480,978
Stone, Clay, Glass & Concrete	1.1	4.57%	$1,825	0.1	$75,107	0.0	$1,465	$74,746	$1,488,237
Textiles & Leather	0.0	4.57%	$0	-	$0	-	$0	$0	$0
Transportation Equipment	4.3	4.67%	$7,296	0.2	$300,272	0.1	$3,745	$296,720	$1,477,730
Warehouse	4.9	4.67%	$8,314	0.2	$342,170	0.1	$4,194	$338,050	$1,477,410

Large C&I - 500 kW to 1 MW				Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Enrolled MW
Water & Wastewater	2.1	4.67%	$3,563	0.1	$146,644	0.1	$3,146	$146,227	$1,491,158
Total				**10.0**		**7.3**			

Table 7-18: Large C&I (≥1 MW) Segment Specific DR Program Potential

Large C&I – 1 MW and Up				Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Enrolled MW
Agriculture & Forestry	0.0	10.86%	$0	-	$0	-	$0	$0	$0
Chemicals & Plastics	139.6	17.10%	$863,802	23.9	$35,702,104	21.1	$675,858	$35,514,160	$1,487,545
Colleges & Universities	9.8	13.58%	$48,173	1.3	$1,990,225	0.8	$24,395	$1,966,446	$1,477,551
Construction	2.9	10.86%	$11,409	0.3	$471,119	0.2	$8,015	$467,725	$1,484,643
Data Centers	0.0	10.86%	$0	-	$0	-	$0	$0	$0
Electrical & Electronic Equipment	7.9	17.10%	$48,883	1.4	$2,020,391	0.9	$27,978	$1,999,486	$1,479,944
Grocery stores / Convenience chains	14.2	5.79%	$29,846	0.8	$1,229,700	0.6	$18,019	$1,217,872	$1,481,034
Healthcare	36.6	4.04%	$53,840	1.5	$2,213,732	0.9	$30,100	$2,189,992	$1,479,380
Hospitals	38.2	13.58%	$187,777	5.2	$7,757,814	3.3	$105,857	$7,675,894	$1,479,626
Institutional	9.6	13.58%	$47,190	1.3	$1,949,608	1.0	$30,494	$1,932,911	$1,482,611
Large Public Assembly (Churches, Stadiums, Arena, & Sports Venues)	11.2	13.58%	$55,055	1.5	$2,274,542	1.5	$46,612	$2,266,099	$1,489,866
Lodging (Hospitality)	5.7	4.04%	$8,385	0.2	$229,841	0.2	$7,395	$228,851	$992,652
Lumber, Furniture, Pulp & Paper	29.9	17.10%	$185,012	5.1	$7,646,797	5.0	$160,736	$7,622,521	$1,490,670
Metal Products & Machinery	214.1	17.10%	$1,324,785	30.9	$46,213,254	36.6	$1,174,523	$46,062,992	$1,258,026
Misc. Manufacturing	58.2	17.10%	$360,124	10.0	$14,884,402	7.8	$251,801	$14,776,079	$1,484,534
Office	88.1	4.04%	$129,599	3.6	$5,328,682	2.6	$81,997	$5,281,081	$1,482,059
Restaurants	0.0	4.04%	$0	-	$0	-	$0	$0	$0
Retail	40.1	5.79%	$84,284	2.3	$3,472,603	1.7	$54,984	$3,443,303	$1,482,800
Miscellaneous	36.6	3.11%	$41,546	1.1	$1,704,796	1.1	$35,270	$1,698,520	$1,489,911
Primary Resource Industries	2.6	10.86%	$10,229	0.3	$422,382	0.0	$1,045	$413,199	$1,462,904
Schools K-12	2.1	7.50%	$5,708	0.2	$235,423	0.1	$3,367	$233,082	$1,480,546
Stone, Clay, Glass & Concrete	1.8	17.10%	$11,138	0.3	$460,342	0.1	$3,840	$453,045	$1,471,711
Textiles & Leather	0.0	17.10%	$0	-	$0	-	$0	$0	$0
Transportation Equipment	42.3	10.86%	$166,416	4.6	$6,871,836	4.2	$136,253	$6,841,673	$1,488,853

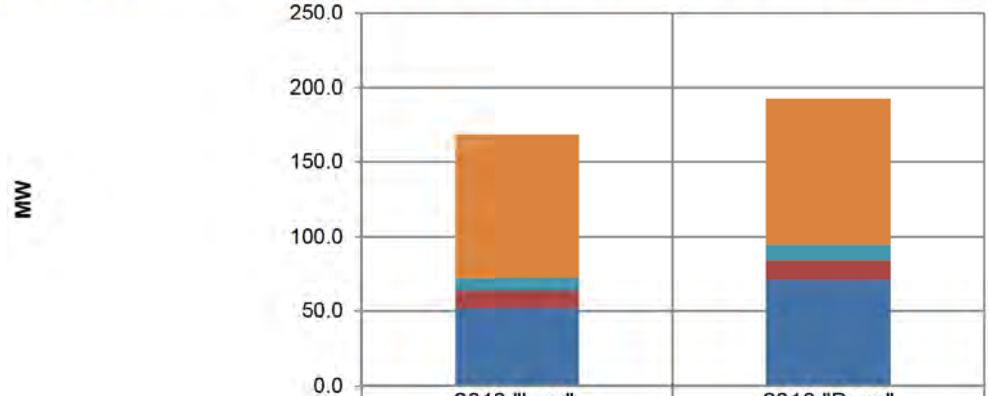
Large C&I – 1 MW and Up				Summer		Winter			
Segment	MW of Tech Potential for cost calc (max of winter and summer)	Participation	Total Cost	Agg. MW	Total Benefit	Agg. MW	Total Benefit	Total Aggregate Net Benefit	Total Net Benefit per Enrolled MW
Warehouse	4.0	10.86%	$15,737	0.4	$649,819	0.2	$7,666	$641,749	$1,476,845
Water & Wastewater	16.6	10.86%	$65,308	1.8	$2,696,749	1.4	$43,908	$2,675,349	$1,483,550
Total				**97.9**		**91.3**			

7.5.4 Comparison to 2016 Study

In the 2016 study, Nexant examined three different marketing and enrollment scenarios. For the 2018 study, only two scenarios were considered in order to be consistent with the number of scenarios considered for energy efficiency. The "Base" scenario considered for the 2018 study is most similar to the "Low" scenario considered in 2016 and the "Enhanced" scenario considered for the 2018 study is most similar to the "High" scenario considered in 2016. We will be comparing these two scenarios. However, it should be noted that some of the differences between the two years will be due to differences in marketing levels and incentives used for the new respective scenarios. For the "Base" scenario, existing marketing budgets were used compared to the minimum marketing budget used for the "Low" scenario, and for the "Enhanced" scenario, an additional sign-up incentive was considered rather than tripling the existing incentive. Therefore, we would expect the "Base" scenario potential would be higher than the "Low" scenario due to higher marketing levels and we would expect the "Enhanced" scenario potential would be lower than the "High" scenario due to the lower incentive levels.

The summer program potential for the Low/Base scenarios is compared in Figure 7-12. The residential program potential is higher for the 2018 study due to the higher marketing levels and the up-front differences observed in the residential technical potential, but the other sectors changed very little from the previous study. The patterns we see for summer are similar to those seen when comparing winter program potential for 2016 and 2018.

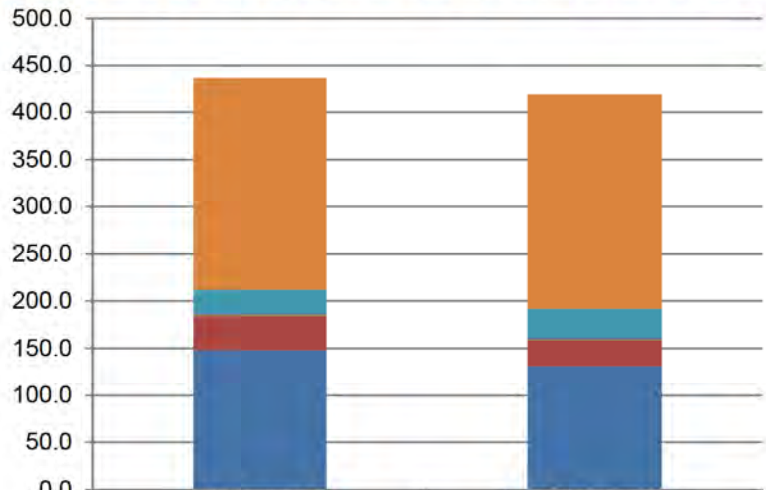
Figure 7-12 Comparison of 2016 and 2018 Low/Base DR Scenarios for Summer



	2016 "Low"	2018 "Base"
Large C&I - 1 MW and Up	96.1	97.9
Large C&I - 500 kW to 1 MW	8.6	10.0
Large C&I - 300 kW to 500 kW	0.3	0.5
Small and Medium Business	0.0	0.2
Residential Multi-Family	11.7	13.3
Residential Single Family	51.8	70.6

The summer program potential for High/Enhanced scenarios is compared in Figure 7-13. The residential program potential is lower for the 2018 study due to the lower incentives, but the other sectors changed very little from the previous study.

Figure 7-13 Comparison of 2016 and 2018 High/Enhanced DR Scenarios for Summer



	2016 "High"	2018 "Enhanced"
Large C&I - 1 MW and Up	224.4	227.4
Large C&I - 500 kW to 1 MW	25.4	30.3
Large C&I - 300 kW to 500 kW	1.1	1.5
Small and Medium Business	1.3	1.0
Residential Multi-Family	36.1	27.6
Residential Single Family	147.9	131.0

7.5.5 Customer Opt-Outs

Ohio Senate Bill 310 includes a provision allowing non-residential customers with annual energy consumption greater than forty-five million kWh to opt out of an EDU's portfolio plan, which exempts the customer from cost recovery mechanism but also eliminates that customer's eligibility for participation in the program.

Using the interval data and billing data for DEO's large C&I customers, Nexant identified 19 customers that were eligible to opt out of the portfolio plan. During DEO's summer system peak the collective peak demand for these customers was about 400 MW, or 10.5% of the system peak load. Half of the eligible opt-out customers have elected to opt-out of the portfolio plan, which means that 200 MW of the technical potential for large C&I customers is not available for the program potential.

7.5.6 Key Findings

The overall DR potential is estimated to be 193 MW of peak capacity in the base scenario, and is as high as 419 MW under the assumption of aggressive marketing strategies and substantial reductions in technology costs. These estimates are based on an in-depth, bottom-up assessment of load reduction potential of all customer segments, and includes an analysis of pricing and program-based DR.

The extent to whether these potential figures can be attained in a cost-effective manner by 2028 depends on the ability to implement programs that target all possible end uses and cost-effective customer segments. These predictions also rely upon certain assumptions around the future value of capacity, as well as technology cost reductions.

The customer segment-level analysis of the program- and pricing-based DR potential sheds light on which customer segments can provide the greatest magnitude of capacity, as well as which customer segments are most cost-effective to pursue. Unsurprisingly, the most attractive customer segments from a benefit/cost perspective are customers who have more load available for reduction during peak hours: larger residential customers who live in single-family homes, as well as large C&I customers, particularly industrial, wholesale, and manufacturing customers. In general, these customers are more capable of shifting load with little inconvenience/cost, and therefore tend to have higher participation levels in DR programs as well as greater willingness to shed a higher percentage of their load.

8 Appendices

Appendix A Glossary

Within the body of this report, there are several technical terms that require explanation. Additionally, some of the terms may appear to be similar at first review; however, have very different means. Terms such as "reported" and "verified" can easily be confused by the reader and are thus defined as following:

Baseline The expected energy usage level of a specific measure or project before improvements are implemented. This becomes the comparison value for all energy savings calculations.

Deemed Savings Amount of savings for a particular measure provided by documented and validated sources or reference materials. Often used when confidence is high for a specific measure, databases lack sufficient information, or costs of measurement and verification greatly outweigh the benefits.

Early Replacement Refers to an efficiency measure or efficiency program that seeks to encourage the replacement of functional equipment before the end of its operating life with higher-efficiency units.

Freerider A participant who, on some level, would have acquired in the energy efficiency measure regardless of the program influence. Determining freeridership values is a large component in calculating the Net-to-Gross ratio.

Gross Savings Total amount of a parameter of interest (kWh or kW) saved by a project/program.

Levelized Cost The cost of the energy efficiency investment on a per kilowatt hour basis levelized over the life of the program.

Net-to-Gross Ratio A ratio value determined through the process of surveying decision makers who implemented projects in order to account for freeridership and other attribution effects. The net-to-gross (NTG) ratio is multiplied by gross verified savings to produce net savings. (NTG is typically calculated for a statistically significant sample of projects and then extrapolated to the population as a whole)

Net Savings Total amount of a parameter of interest (kWh, kW) saved by a program that is directly related to the program. It takes into account the realization rate, as well as results of the attribution analysis (freeriders), to provide a value of energy savings directly related to the program influence. Net Savings is calculated by multiplying the gross verified savings by the net-to-gross (NTG) ratio.

Participant Cost The cost to the participant to participate in an energy efficiency program.

Program A group of projects with similar technology characteristics that are installed in similar applications.

Replace-on-burnout: A DSM measure is not implemented until the existing technology it is replacing fails or burns out. An example would be a unitary air conditioning rooftop unit being purchased after the failure of the existing rooftop unit at the end of its useful life.

Reported Savings Savings calculated and reported by GPC. This also referred to as Ex-Ante savings.

Stratify The process of breaking down a population of projects into groups with similar characteristics (technical, financial, size, location, etc.). This is used during population sampling and allows projects with greater uncertainty or higher budgets to be accurately weighted to assess their impact on a program.

Sub-Strata The individual groups remaining once a population has been stratified.

Stipulated Savings Same as *Deemed Savings*

Verified Savings Savings determined by the evaluation team through the collection of data at on-site inspections, phone surveys, and engineering analysis. This also referred to as Ex-Post savings.

Appendix B MPS Measure List

For information on how Nexant developed this list, please see Section 4.

B.1 Residential Measures

Residential Measure Workbooks	
1.5 GPM Bathroom Faucet Aerators	Energy Star Qualified Dimmable CFL
1.5 GPM Kitchen Faucet Aerators	Energy Star Qualified LED, Recessed Lighting
1.60 GPM Low-Flow Showerhead	Energy Star Qualified LED, Screw-In, 10 W
Air Sealing	Energy Star Qualified LED, Screw-In, 14 W
Air Source Heat Pump Maintenance	Energy Star Qualified LED, Screw-In, 25 W
ASHP from Electric Resistance	Energy Star Qualified LED, Screw-In, 6 W
ASHP, 2 Tons, 18 SEER, 9 HSPF	Energy Star Refrigerator
Basement or Crawlspace Wall Insulation R-15	Energy Star Room AC - 12 SEER
Behavior Modification Home Energy Reports	Energy Star Set-Top Receiver
Behavior Modification Home Energy Reports - Active Engagement	Energy Star Television
CEE Tier 2 Clothes Washer	Energy Star Windows
Ceiling Insulation R-49	Exterior Wall Insulation on Wall Above Grade R-13
Central AC Maintenance	Floor Insulation R-30
Conventional Water Heater	Freezer Recycling
Dehumidifier Recycling	Green Roof
Drain Water Heat Recovery	Heat Pump Clothes Dryer
Dual Speed Pool Pump Motors	Heat Pump Pool Heater
Duct Insulation	Heat Pump Water Heater 50 Gallons
Duct Sealing	Heat Pump Water Heater 80 Gallons
Ductless Mini-Split HP, 2 Tons 15 SEER, 9 HSPF	High Efficiency Bathroom Exhaust Fan
ECM Motor	Holiday Lights
Energy Efficiency Education	Home Energy Assessment
Energy Star Air Purifier	Hot Water Pipe Insulation
Energy Star ASHP, 2 Tons, 15 SEER, 8.5 HSPF	Indoor Daylight Sensor
Energy Star ASHP, 2 Tons, 16 SEER, 9.0 HSPF	Insulating Tank Wrap on Water Heater
Energy Star Ceiling Fan	Interior Lighting Controls
Energy Star Central AC - 15 SEER	LED Nightlight
Energy Star Central AC - 16 SEER	OUTDOOR LIGHTING TIMER
Energy Star Central AC - 18 SEER	OUTDOOR MOTION SENSOR

Energy Star Central AC - 20 SEER	Pre-Pay Program
Energy Star Clothes Dryer	Programmable Thermostat
Energy Star Clothes Washer	Properly Sized AC System
Energy Star Dehumidifier	RealTime Information Monitoring
Energy Star Desktop Computer	Refrigerator Recycling
Energy Star Dishwasher (Electric Water Heating)	Residential New Construction Tier 1 (10% more efficient)
Energy Star Dishwasher (Gas Water Heating)	Residential New Construction Tier 2 (20% more efficient)
Energy Star Doors	Residential New Construction Tier 3 (30% more efficient)
Energy Star DVD Blu-Ray Player	Residential Whole House Fan
Energy Star GSHP, 2 Tons, 17.1 SEER, 3.60 COP	Room AC Recycling
Energy Star Manufactured Home	Smart Strip Plug (Entertainment Center)
Energy Star Monitor	Smart Strip Plug (Home Office)
Energy Star Qualified 3-Way CFL	Smart Thermostat
Energy Star Qualified Airtight Can Lights	Solar Attic Fan
Energy Star Qualified CFL, Light Fixture, 1 or 2 Sockets	Solar Electric Water Heater
Energy Star Qualified CFL, Light Fixture, 3 or More Sockets	Tankless Water Heater
Energy Star Qualified CFL, Outdoor Use, 26 W	Thermostatic Shower Restriction Valve
Energy Star Qualified CFL, Screw-In, 14 W	Variable Speed Pool Pump Motors
Energy Star Qualified CFL, Screw-In, 24 W	Water Heater Thermostat Setback
Energy Star Qualified CFL, Screw-In, 40 W	Window Shade Film
Energy Star Qualified CFL, Screw-In, 9 W	

B.2 Commercial Measures

Commercial Measure Workbooks	
1.5 GPM Faucet Aerators	Hand-Man Crosswalk Sign
1.5HP Open Drip-Proof(ODP) Motor	HE Air Cooled Chiller - All Compressor Types - 100 Tons
1.75 GPM Low-Flow Showerhead	HE DX 11.25-20.0 Tons Elect Heat
10HP Open Drip-Proof(ODP) Motor	HE DX 11.25-20.0 Tons Other Heat
20HP Open Drip-Proof(ODP) Motor	HE DX 20.0-63.33 Tons Elect Heat
2x4 LED Troffer	HE DX 20.0-63.33 Tons Other Heat
4' 4-Lamp High Bay T5 Fixture (28W)	HE DX 5.4-11.25 Tons Elect Heat
4' 4-Lamp High Bay T5 Fixture (28W) HID Baseline	HE DX 5.4-11.25 Tons Other Heat
42W 6 Lamp High Bay Compact Fluorescent	HE DX Less than 5.4 Tons Elect Heat
42W 6 Lamp High Bay Compact Fluorescent HID Baseline	HE DX Less than 5.4 Tons Other Heat
Advanced Rooftop Controller	HE DX more than 63.33 Tons Elect Heat
Air Compressor Optimization	HE DX more than 63.33 Tons Other Heat
Anti-Sweat Heater Controls (Cooler)	HE Water Cooled Chiller - Centrifugal Compressor - 200 Tons
Auto Closer on Refrigerator Door	HE Water Cooled Chiller - Centrifugal Compressor - 500 Tons
Auto Off Time Switch	HE Water Cooled Chiller - Rotary or Screw Compressor - 175 Tons
Beverage Vending Machine Controls	HE Water Cooled Chiller - Rotary or Screw Compressor - 50 Tons
Bi-Level Lighting Control	Heat Pump Water Heater 50 Gallons
Business Energy Report	High Efficiency Air Compressor
Business Energy Report - Active Engagement	High Efficiency CRAC Unit
Ceiling Insulation R40	High Efficiency Refrigeration Compressor - Discus
Ceramic Metal Halide Lamp	High Efficiency Refrigeration Compressor - Scroll
Ceramic Metal Halide Lamp HID Baseline	High Performance Medium Bay T8 Fixture
Ceramic Metal Halide, 20 - 100W	High Speed Fans
Ceramic Metal Halide, 20 - 100W HID Baseline	Hot Water Pipe Insulation
Ceramic Metal Halide, 350W+	Hotel Key Card Room Energy Control System
Ceramic Metal Halide, 350W+ HID Baseline	Indoor Daylight Sensor
Chilled Water Reset	Induction High Bay Lighting
CO Sensors for Parking Garage Exhaust	Insulating Tank Wrap on Water Heater
Data Center Server Consolidation	LED Canopy Lighting
Demand Controlled Circulating Systems	LED Exit Sign
Demand Controlled Ventilation	LED Exterior Area Lights
Demand Defrost	LED Exterior Wall Packs
Door Gasket (Cooler)	LED High Bay

Door Gasket (Freezer)	LED or Equivalent Sign Lighting
Drain Water Heat Recovery	LEED New Construction Whole Building
Dual Entropy Economizer	Light Tube
Ductless Mini-Split AC, 4 Ton, 16 SEER	Linear LED replacing T8
Ductless Mini-Split HP, 4 Ton, 16 SEER, 9 HSPF	Low-Flow Pre-Rinse Sprayers
DX Coil Cleaning	Network PC Power Management
Efficient New Construction Lighting	Occupancy Sensors, Ceiling Mounted
Electric Resistance Water Heater	Occupancy Sensors, Switch Mounted
Energy Recovery Ventilation System	Outdoor Motion Sensor
Energy Star Clothes Dryer	Packaged Terminal AC
Energy Star Combination Oven	Packaged Terminal HP
Energy Star Commercial Clothes Washer	Photocell Dimming Control (Exterior)
Energy Star Convection Oven	Photocell Dimming Control (Interior)
Energy Star Copiers	Programmable Thermostat
Energy Star Dishwasher	PSC to ECM Evaporator Fan Motor (Reach-In)
Energy Star Fax	PSC to ECM Evaporator Fan Motor (Walk-In, Refrigerator)
Energy Star Fryer	Pulse Start Metal Halide, 320 - 400W
Energy Star Glass-Door Freezer	Pulse Start Metal Halide, 320 - 400W HID Baseline
Energy Star Glass-Door Refrigerator	RealTime Information Monitoring
Energy Star Griddle	Red LED Traffic Light
Energy Star Hot Food Holding Cabinet	Reduced Wattage (25W) T8 Fixture
Energy Star Ice Machines (Self Contained Units)	Reduced Wattage (28W) T8 Fixture
Energy Star Monitors	Reduced Wattage (28W) T8 Relamping
Energy Star PCs-Desktop	Reflective Roof Treatment
Energy Star Printers	Refrigerated Display Case LED Lighting
Energy Star Qualified 3-Way CFL	Refrigerated Display Case Lighting Controls
Energy Star Qualified CFL, Light Fixture, 1 or 2 Sockets	Refrigeration Commissioning
Energy Star Qualified CFL, Outdoor Use, 26 W	Retro-Commissioning
Energy Star Qualified CFL, Screw-In, 15 W	Small Buildings Retro-Commissioning
Energy Star Qualified LED Lamp, All Shapes and Directions	Smart Strip Plug Outlet
Energy Star Qualified LED Shelf-Mounted Task Lighting	Smart Thermostat
Energy Star Qualified LED, Recessed Lighting	Solar Electric Water Heater
Energy Star Room AC - 12 SEER	Solid State Cooking Hood Controls
Energy Star Scanners	SP to ECM Evaporator Fan Motor (Walk-In, Refrigerator)
Energy Star Servers	Strip Curtains - Freezers
Energy Star Solid-Door Freezer	Strip Curtains - Refrigerators
Energy Star Solid-Door Refrigerator	Suction Pipe Insulation - Freezers
Energy Star Steamer	Suction Pipe Insulation - Refrigerators

Energy Star Uninterruptable Power Supply	Time Clock Control
Energy Star Vending Machine	VAV System
Energy Star Water Coolers	Vertical Night Covers
Energy Star Windows	VFD on Chilled Water Pumps
Escalator Motor Efficiency Controller	VFD on HVAC Fan
Exterior Bi-Level Lighting Control	VFD on HVAC Pump
Facility Commissioning	VSD Controlled Compressor
Fan Thermostat Controller	Water Heater Setback
Floating Head Pressure Controller	Water Source Heat Pump
Green LED Traffic Light	Window Shade Film
Green Roof	Yellow LED Traffic Light

B.3 Industrial Measures

Industrial Measure Workbooks	
1.5HP Open Drip-Proof(ODP) Motor	HE Water Cooled Chiller - Centrifugal Compressor - 200 Tons
10HP Open Drip-Proof(ODP) Motor	HE Water Cooled Chiller - Centrifugal Compressor - 500 Tons
20HP Open Drip-Proof(ODP) Motor	HE Water Cooled Chiller - Rotary or Screw Compressor - 175 Tons
2x4 LED Troffer	HE Water Cooled Chiller - Rotary or Screw Compressor - 50 Tons
3-phase High Frequency Battery Charger - 1 shift	Heat Reclaimer
4' 4-Lamp High Bay T5 Fixture (28W)	High Bay Occupancy Sensors, Ceiling Mounted
4' 4-Lamp High Bay T5 Fixture (28W)-HID Baseline	High Efficiency Refrigeration Compressor - Discus
42W 6 Lamp High Bay Compact Fluorescent	High Efficiency Refrigeration Compressor - Scroll
42W 6 Lamp High Bay Compact Fluorescent-HID Baseline	High Efficiency Welder
Air Compressor Optimization	High Performance Medium Bay T8 Fixture
Auto Closer on Refrigerator Door	High Speed Fans
Auto Off Time Switch	High Volume Low Speed Fan (HVLS)
Automated Controls System	Indoor Daylight Sensor
Bi-Level Lighting Control	Induction High Bay Lighting
Block Heater Timer	Injection Mold and Extruder Barrel Wraps
Ceiling Insulation R40	Insulated 3" Pellet tank and duct
Central Lighting Control System	LED Canopy Lighting
Ceramic Metal Halide Lamp	LED Exit Sign
Ceramic Metal Halide Lamp-HID Baseline	LED Exterior Area Lights
Ceramic Metal Halide, 20 - 100W	LED Exterior Wall Packs
Chilled Water Reset	LED or Equivalent Sign Lighting
Cogged Belt on 15HP ODP Motor	LEED New Construction Whole Building
Cogged Belt on 40HP ODP Motor	Linear LED replacing T8
Compressed Air Storage Tank	Low Energy Livestock Waterer
Demand Controlled Ventilation	Low Pressure Sprinkler Nozzles
Demand Defrost	Low Pressure-drop Filters
Dew Point Sensor Control for Desicant CA Dryer	Milk Precooler - Dairy Plate Cooler
Drip Irrigation Nozzles	Occupancy Sensors, Ceiling Mounted
Dual Entropy Economizer	Outdoor Motion Sensor
DX Coil Cleaning	Packaged Terminal AC
Efficient Compressed Air Nozzles	Photocell Dimming Control (Exterior)
Efficient New Construction Lighting	Photocell Dimming Control (Interior)
Electric Actuators	Process Cooling Ventilation Reduction

Energy Efficient Laboratory Fume Hood	Programmable Thermostat
Energy Efficient Transformers	Pulse Start Metal Halide, 320 - 400W
Energy Recovery Ventilation System	Pulse Start Metal Halide, 320 - 400W-HID Baseline
ENERGY STAR Qualified 3-Way CFL	Pulse Start Metal Halide, 400 - 750W
Energy Star Qualified CFL, Light Fixture, 1 or 2 Sockets	Pulse Start Metal Halide, 400 - 750W-HID Baseline
ENERGY STAR Qualified CFL, Outdoor Use, 26 W	Reduced Wattage (25W) T8 Fixture
ENERGY STAR Qualified CFL, Screw-In, 15 W	Reduced Wattage (28W) T8 Fixture
ENERGY STAR Qualified LED Lamp, All Shapes and Directions	Reduced Wattage (28W) T8 Relamping
Energy Star Qualified LED Shelf-Mounted Task Lighting	Reflective Roof Treatment
ENERGY STAR Qualified LED, Recessed Lighting	Refrigeration Commissioning
Energy Star Room AC - 12 SEER	Retro-Commissioning
Energy Star Windows	Single Creep Pad
Exterior Bi-Level Lighting Control	Small Buildings Retro-Commissioning
Facility Commissioning	Smart Thermostat
Facility Energy Management System	Synchronous Belt on 15HP ODP Motor
Fan Thermostat Controller	Synchronous Belt on 5HP ODP Motor
Floating Head Pressure Controller	Synchronous Belt on 75HP ODP Motor
Grain Bin Aeration Control System	Time Clock Control
HE Air Cooled Chiller - All Compressor Types - 100 Tons	VAV System
HE Air Cooled Chiller - All Compressor Types - 300 Tons	VFD on Air Compressor
HE DX 11.25-20.0 Tons Elect Heat	VFD on Chilled Water Pumps
HE DX 11.25-20.0 Tons Other Heat	VFD on HVAC Fan
HE DX 20.0-63.33 Tons Elect Heat	VFD on HVAC Pump
HE DX 20.0-63.33 Tons Other Heat	VFD on Process Pump
HE DX 5.4-11.25 Tons Elect Heat	VSD Controlled Compressor
HE DX 5.4-11.25 Tons Other Heat	Water Source Heat Pump
HE DX Less than 5.4 Tons Elect Heat	Window Shade Film
HE DX Less than 5.4 Tons Other Heat	Zero Loss Condensate Drain
HE DX more than 63.33 Tons Other Heat	

Appendix C Customer Demand Characteristics

Customer demand on peak days was analyzed by rate classes within each sector. Outputs presentation includes load shapes on peak days and average days, along with the estimates of technical potential by end uses. The two end uses, Air Conditioning and Heating, were studied for both residential and large C&I customers; however, in residential sector, another two end uses were also incorporated into the analyses, which are Water Heaters and Pool Pumps.

Residential

Air Conditioning

The cooling load shapes on the summer peak weekday and average weekdays were generated from hourly load research sample in DEO territory for the years 2016 and 2017. A regression model was built to estimate relationship between load values and cooling degree days (CDD) (shown as *Equation (1)*). The p-values of the model and coefficient are both less than 0.05, which means that they are of statistically significance. The product of actual hourly CDD values and coefficient would be used as cooling load during that hour in terms of per customer.

Equation (1):

$$Load_t = CDD_t * \beta_1 + i.month + \varepsilon$$

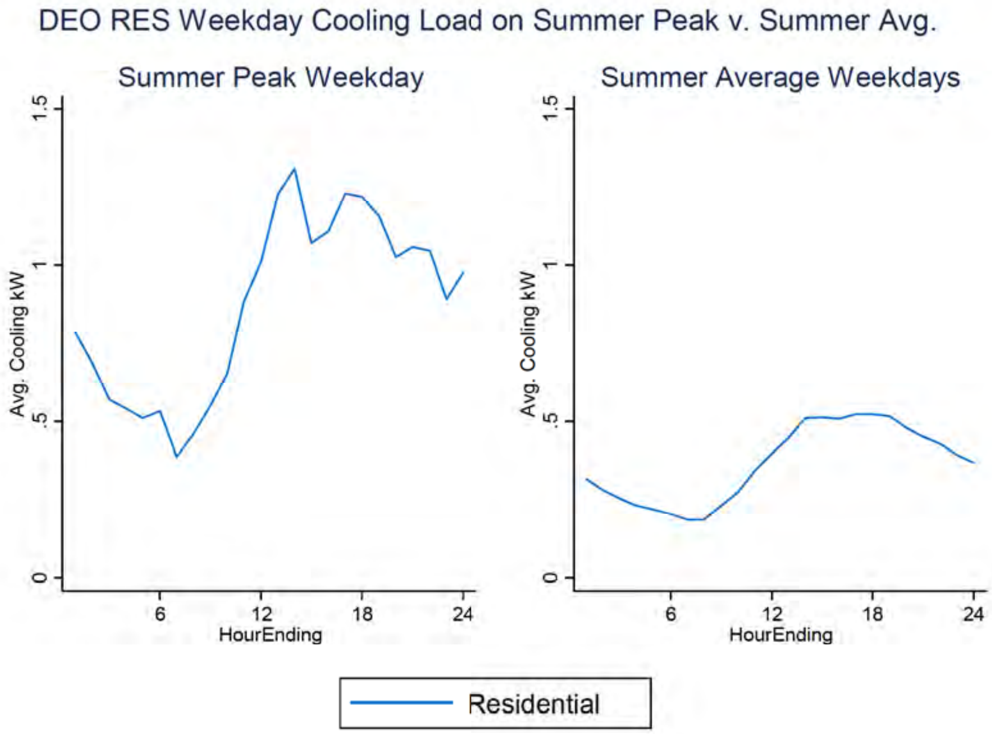
Where:

t	Hours in each day in year 2016 and 2017
$Load_t$	Load occurred in each hour
CDD_t	Cooling Degree Day value associated with each hour
β_1	Change in average load per CDD
$i.month$	Nominal variable, month
ε	The error term

To study the peak technical potential, a peak day was selected if it has the hour with system peak load during summer period (among May to September). Technical potential for residential customers was then calculated as the aggregate consumption during that summer peak hour.

The Figure 8-1 displays the comparison of cooling load shape on summer peak weekday and average weekdays in DEO territory. By comparing these two load shapes, peak hours could be identified as around 4:00 pm to 8:00 pm in summer time. As cooling load is highly sensitive to weather, the maximum usage per customer during summer peaks exceeds 1 kW, more than 2 times greater than average usage in the same time on normal days. The least consumption occurs between 6:00 am to 8:00 am in the morning, when houses are cooled down over night and before heated by direct sunshine.

Figure 8-1: Average Cooling Load Shapes for DEO Customers



Estimates of technical potential are listed in Table 8-1, which was derived by multiplying average usage by customer (showed in load shapes), number of residential customers and saturation of air conditioning in Ohio territory.

Table 8-1: Technical DR Potential for Residential Cooling

DEO - Residential			
Hour Ending	MW	Hour Ending	MW
1	492.88	13	771.63
2	432.20	14	823.06
3	358.05	15	671.73
4	340.64	16	696.49
5	320.78	17	772.42
6	335.58	18	766.17
7	243.69	19	725.52
8	288.79	20	644.26
9	346.15	21	664.00
10	411.06	22	656.26
11	556.74	23	560.05

12	636.41	24	614.61

Space Heating

Similar to the analyses for air conditioning, the heating load shapes on peak day and average days were obtained from the same hourly load research profile in 2013 and 2014, and the peak day was defined as the day with system peak load during winter period. The regression model was modified to evaluate relationship between energy consumption and heating degree days (HDD) (shown as Equation (2)), but the technical potential was calculated in the same way as illustrated earlier.

Equation (2):

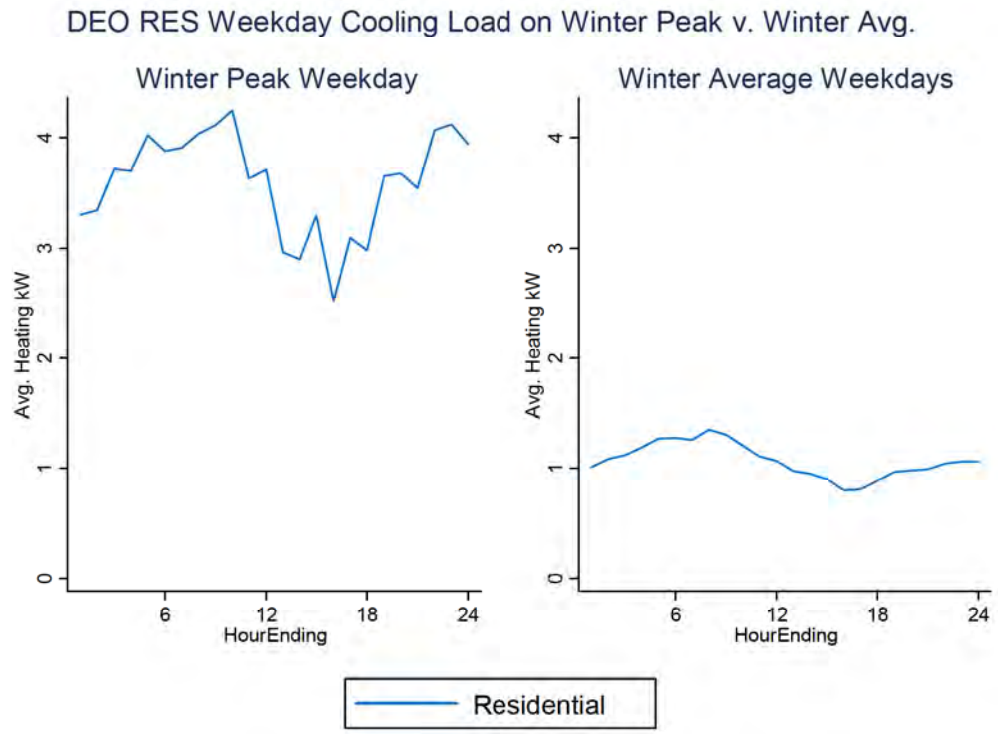
$$Load_t = HDD_t * \beta_1 + i.month + \varepsilon$$

Where:

t	Hours in each day in year 2013 and 2014
$Load_t$	Load occurred in each hour
HDD_t	Heating Degree Day value associated with each hour
β_1	Change in average load per HDD
$i.month$	Nominal variable, month
ε	The error term

The Figure 8-2 captures hourly peak usage and average usage. The load shape on winter average weekdays shows that space heating consumes more energy after midnight to early morning. However, the historical data reveals a somewhat abnormality of peak usage. Observed from the usage curve on a winter peak day, the average energy consumption continues increasing along with the time to the end of the day. The starting point is 3.3 kW per customer, which is greater than the highest consumption level that occurs on average weekdays. The load is high in the morning and evenings, and decreases in the middle of the day when the outdoor temperature is warmer and houses require less heating.

Figure 8-2: Average Heating Load Shapes for DEO Customers



Shown in the Table 8-2, there is a dual peak for winter technical potential. The results hit a trough at 4:00 pm which is equivalent to 605 MW, but is over 900 MWin the morning and evening hours.

Table 8-2: Technical DR Potential for Residential Heating

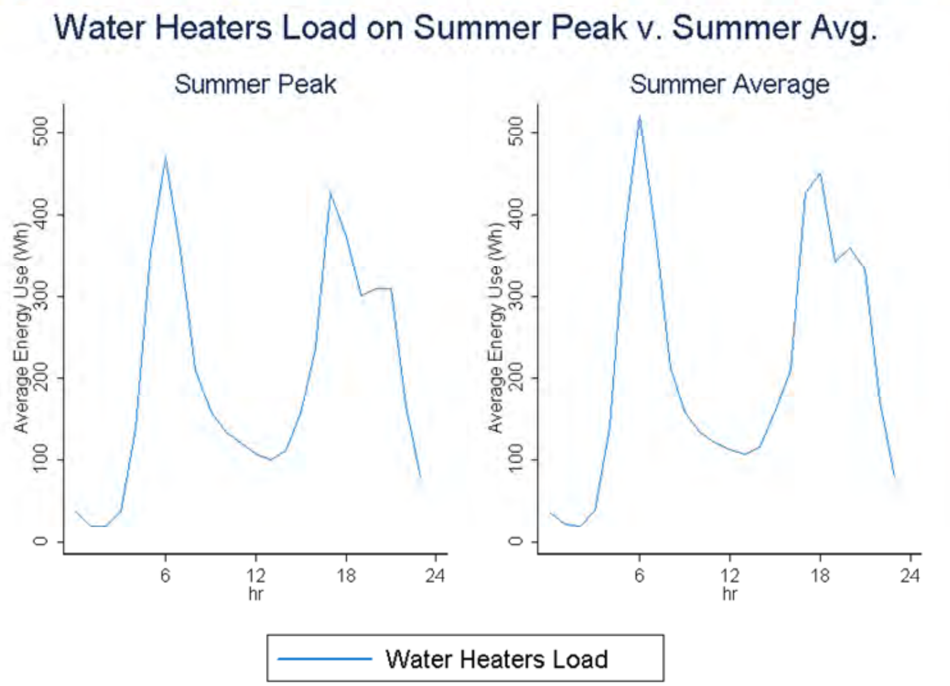
DEO - Residential			
Hour Ending	MW	Hour Ending	MW
1	794.2	13	714.3
2	804.6	14	698.1
3	894.9	15	793.0
4	890.8	16	605.9
5	968.9	17	746.4
6	934.0	18	718.0
7	941.5	19	879.7
8	972.6	20	885.3

9	991.9	21	853.9
10	1023.5	22	980.5
11	874.5	23	992.7
12	894.2	24	950.3

Water Heaters

Interval load data by end use are not available for individual customers in Duke territory, so the analyses of water heaters was completed based on end use metered data from CPS (San Antonio) Home Manager Program. As water heater loads were assumed to be relatively constant throughout the year (used for summer and winter), average load profiles for water heaters on CPS's 2013 system peak were assumed to be representative for residential customers in Duke jurisdictions.

Figure 8-3: Average Water Heaters Load Shapes for DEO Customers

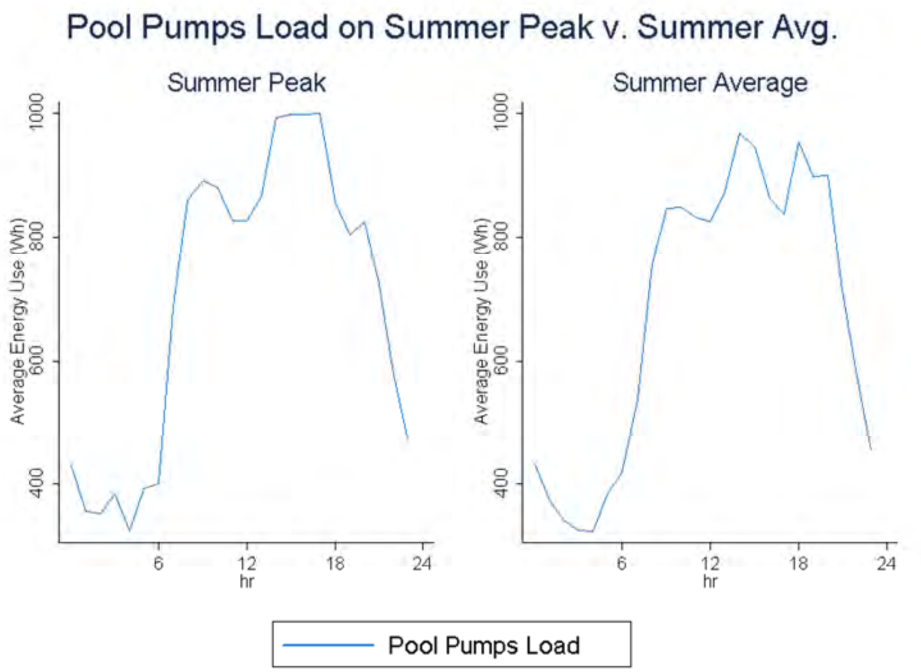


It is apparent from the Figure 8-3 that there is not much difference from peak usage and average usage, which proves that water heater loads has low sensitivity to weather. There are two spikes in a day, indicating two shifts when people would be likely to take showers. The time periods with highest consumption are 5:00 am – 7:00 am and 5:00 pm – 8:00 pm.

Pool Pumps

Likewise, pool pump loads were assumed to be fairly constant throughout the summer time as well, so the average load profiles for pool pumps from CPS's project were also used to represent for residential customers in Duke jurisdictions.

Figure 8-4: Average Pool Pumps Load Shapes for DEO Customers



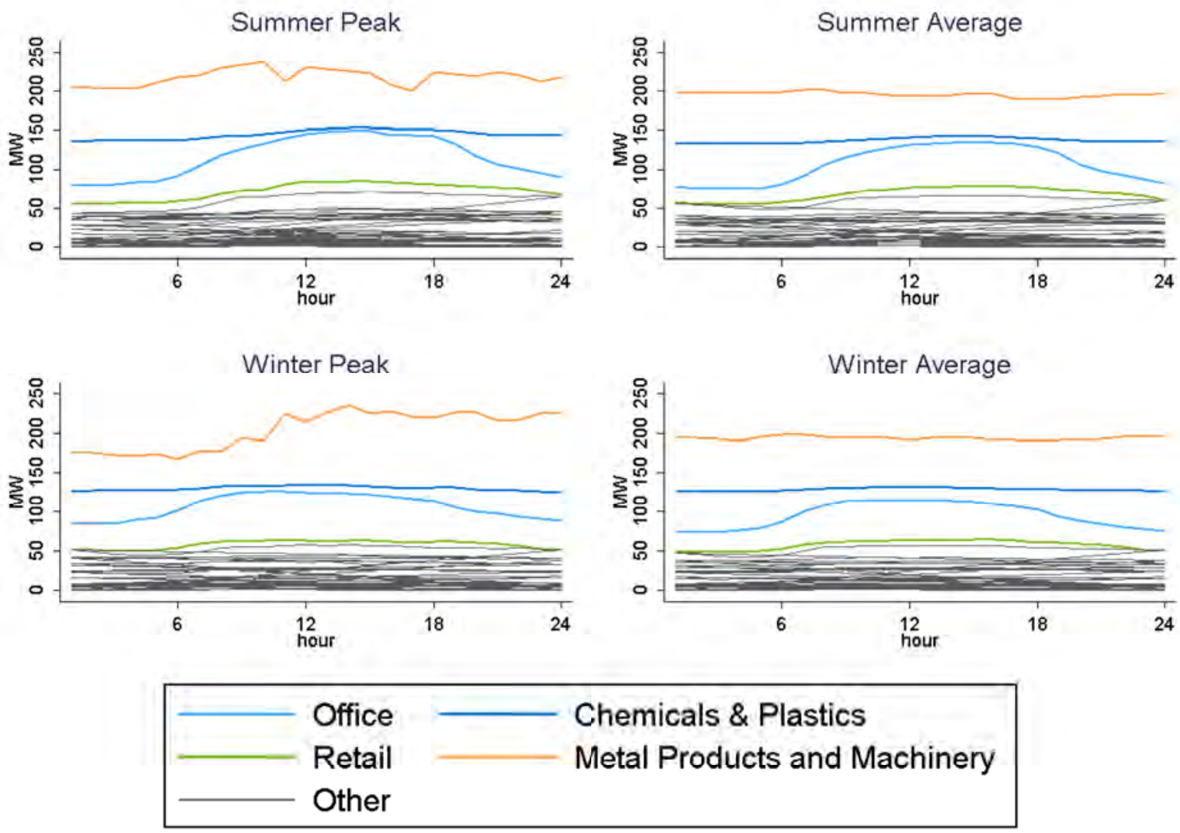
According to the Figure 8-4, the peak hours for pool pumps are 3:00 pm to 6:00 pm, and there is minor sensitivity with weather observed by comparing peak loads and average loads.

Large C&I Customers

Estimates of technical potential were based on one year of interval data (2017) for all non-residential customers in three categories based on maximum loads: 300-500 kW, 500kW-1MW, and over 1 MW. Customers were categorized into one of 23 industry segments for the purpose of analysis. Technical potential for these customers was defined as the aggregate usage within each segment during summer and winter peak system hours.

Visual presentations of the results are shown below. These graphs are useful to identify the segments with the highest potential as well as examine the weather-sensitivity of each segment by comparing peak usage to the average usage in each season. For example, the segments with the highest technical potential are metal products & machinery, the chemicals and plastics, and the office segment. In contrast to the office segment that shows a modest amount of weather sensitivity year-around, the other two segments show almost no weather sensitivity in either season.

Figure 8-5: Aggregate Load Shapes for DEO Large C&I Customers



More precise estimates of technical potential are shown in Table 8-3, which focuses on peak period potential in each season. The specific hours included in the peak period were informed by the analysis of system loads presented earlier in this memo. For DEO, the summer peak period was defined as 4:00 pm to 8:00 pm, while the winter peak period was defined as 6:00 pm to 9:00 pm.

Table 8-3: Technical DR Potential for Large C&I Customers

Segment	Summer Peak	Winter Peak
Agriculture & Forestry	0.0	0.0
Chemicals & Plastics	150.6	131.2
Colleges & Universities	12.4	7.5
Construction	8.6	7.1
Data Centers	2.1	0.0
Electrical & Electronic Equipment	7.9	7.1
Grocery stores / Convenience chains	37.0	25.6
Healthcare	48.8	35.2
Hospitals	40.8	25.9
Institutional	15.5	10.8
Large Public Assembly (Churches, Stadiums, Arena, & Sports Venues)	20.7	17.9
Lodging (Hospitality)	8.2	9.7
Lumber, Furniture, Pulp & Paper	35.7	34.2
Metal Products & Machinery	199.6	226.5
Misc. Manufacturing	69.8	54.0
Office	143.2	105.7
Restaurants	1.6	1.5
Retail	81.4	61.7
Miscellaneous	43.1	39.7
Primary Resource Industries	4.2	0.5
Schools K-12	16.4	11.3
Stone, Clay, Glass & Concrete	2.9	1.7
Textiles & Leather	0.0	0.0
Transportation Equipment	46.8	41.8
Warehouse	8.9	5.0
Water & Wastewater	18.7	14.8

Appendix D Senate Bill 310 Legislation

Energy Efficiency Accounting

130th General Assembly Senate Bill Number 310

Sec. 4928.662. For the purpose of measuring and determining compliance with the energy efficiency and peak demand reduction requirements under section 4928.66 of the Revised Code, the public utilities commission shall count and recognize compliance as follows:

(A) Energy efficiency savings and peak demand reduction achieved through actions taken by customers or through electric distribution utility programs that comply with federal standards for either or both energy efficiency and peak demand reduction requirements, including resources associated with such savings or reduction that are recognized as capacity resources by the regional transmission organization operating in Ohio in compliance with section 4928.12 of the Revised Code, shall count toward compliance with the energy efficiency and peak demand reduction requirements.

(B) Energy efficiency savings and peak demand reduction achieved on and after the effective date of S.B. 310 of the 130th general assembly shall be measured on the higher of an as found or deemed basis, except that, solely at the option of the electric distribution utility, such savings and reduction achieved since 2006 may also be measured using this method. For new construction, the energy efficiency savings and peak demand reduction shall be counted based on 2008 federal standards, provided that when new construction replaces an existing facility, the difference in energy consumed, energy intensity, and peak demand between the new and replaced facility shall be counted toward meeting the energy efficiency and peak demand reduction requirements.

(C) The commission shall count both the energy efficiency savings and peak demand reduction on an annualized basis.

(D) The commission shall count both the energy efficiency savings and peak demand reduction on a gross savings basis.

(E) The commission shall count energy efficiency savings and peak demand reductions associated with transmission and distribution infrastructure improvements that reduce line losses. No energy efficiency or peak demand reduction achieved under division (E) of this section shall qualify for shared savings.

(F) Energy efficiency savings and peak demand reduction amounts approved by the commission shall continue to be counted toward achieving the energy efficiency and peak demand reduction requirements as long as the requirements remain in effect.

Customer Opt-out

130th General Assembly Senate Bill Number 310

Sec. 4928.6611. Beginning January 1, 2017, a customer of an electric distribution utility may opt out of the opportunity and ability to obtain direct benefits from the utility's portfolio plan. Such an opt out shall extend to all of the customer's accounts, irrespective of the size or service voltage level that are associated with the activities performed by the customer and that are located on or adjacent to the customer's premises.

Sec. 4928.6612. Any customer electing to opt out under section 4928.6611 of the Revised Code shall do so by providing a verified written notice of intent to opt out to the electric distribution utility from which it receives service and submitting a complete copy of the opt-out notice to the secretary of the public utilities commission. The notice provided to the utility shall include all of the following:

(A) A statement indicating that the customer has elected to opt out;

(B) The effective date of the election to opt out;

(C) The account number for each customer account to which the opt out shall apply;

(D) The physical location of the customer's load center;

(E) The date upon which the customer established, or plans to establish a process and implement, cost-effective measures to improve its energy efficiency savings and peak demand reductions.

Sec. 4928.6613. Upon a customer's election to opt out under section 4928.6611 of the Revised Code and commencing on the effective date of the election to opt out, no account properly identified in the customer's verified notice under division (C) of section 4928.6612 of the Revised Code shall be subject to any cost recovery mechanism under section 4928.66 of the Revised Code or eligible to participate in, or directly benefit from, programs arising from electric distribution utility portfolio plans approved by the public utilities commission.

Sec. 4928.6614. (A) A customer subsequently may opt in to an electric distribution utility's portfolio plan after a previous election to opt out under section 4928.6611of the Revised Code if both of the following apply:

(1) The customer has previously opted out for a period of at least three consecutive calendar years.

(2) The customer gives twelve months' advance notice of its intent to opt in to the public utilities commission and the electric distribution utility from which it receives service.

(B) A customer that opts in under this section shall maintain its opt-in status for three consecutive calendar years before being eligible subsequently to exercise its right to opt out after giving the utility twelve months' advance notice.

Sec. 4928.6615. Any customer electing to opt in under section 4928.6614 of the Revised Code shall do so by providing a written notice of intent to opt in to the electric distribution utility from which it receives service and submitting a complete copy of the opt-in notice to the secretary of the public utilities commission. The notice shall include all of the following:

(A) A statement indicating that the customer has elected to opt in;

(B) The effective date of the election to opt in;

(C) The account number for each customer account to which the opt in shall apply;

(D) The physical location of the customer's load center.

Sec. 4928.6616. (A) Not later than sixty days after the effective date at a customer's election to opt out under section 4928.6611of the Revised Code, the customer shall prepare and submit an initial report to the staff of the public utilities commission. The report shall summarize the projects, actions, policies, or practices that the customer may consider implementing, based on the customer's cost-effectiveness criteria, for the purpose of reducing energy intensity.

(B) For as long as the opt out is in effect, the customer shall, at least once every twenty-four months, commencing with the effective date of the election to opt out, prepare and submit, to the staff of the commission, an updated report. The updated report shall include a general description of any cumulative amount of energy-intensity reductions achieved by the customer during the period beginning on the effective date of the election to opt out and ending not later than sixty days prior to the date that the updated report is submitted.

(C) All reports filed under this section shall be verified by the customer.

(D) Upon submission of any updated report under division (B) of this section, the staff of the commission may request the customer to provide additional information on the energy-intensity-reducing projects, actions, policies, or practices implemented by the customer and the amount of energy-intensity reductions achieved during the period covered by the updated report.

(E) Any information contained in any report submitted under this section and any customer responses to requests for additional information shall be deemed to be confidential, proprietary, and a trade secret. No such information or response shall be publicly divulged without written authorization by the customer or used for any purpose other than to identify the amount of energy-intensity reductions achieved by the customer.

(F) If the commission finds, after notice and a hearing, that the customer has failed to achieve any substantial cumulative reduction in energy intensity identified by the customer in an updated report submitted under division (B) of this section, and if the failure is not excusable for good cause shown by the customer, the commission may suspend the opt out for the period of time that it may take the customer to achieve the cumulative reduction in energy intensity identified by the customer but no longer.

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