Commonwealth Edison Energy Efficiency Potential Study:

A Comprehensive Assessment of 2021-2030 Net Economic Opportunities

Volume I: Results

dunsky

Submitted to:

Commonwealth Edison

https://www.comed.com/

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About Dunsky

Dunsky provides strategic analysis and counsel in the areas of energy efficiency, renewable energy and clean mobility. We support our clients – governments, utilities and others – through three key services: we **assess** opportunities (technical, economic, market); **design** strategies (programs, plans, policies); and **evaluate** performance (with a view to continuous improvement).

Dunsky's 30+ experts are wholly dedicated to helping our clients accelerate the clean energy transition, effectively and responsibly.

Preface

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List of Acronyms

ASHP	Air-source Heat Pump
BAU	Business as Usual
CAC	Central Air Conditioner
CFL	Compact Fluorescent Light
CPAS	Cumulative Persisting Annual Savings
CY	Calendar Year (program period, e.g. CY2018)
DEEP Model	Demand and Energy Efficiency Potential Model
DMSHP	Ductless Mini-Split Heat Pump
EE	Energy Efficiency
EISA	Energy Independence and Security Act of 2007
EMS	Energy Management System
EUI	Energy Use Intensity
EUL	Effective Useful Life
GHG	Greenhouse Gas
GSHP	Ground-Source Heat Pump
HER	Home Energy Report
HVAC	Heating, Ventilation and Air-Conditioning
IE	Income Eligible
LED	Light Emitting Diode
NEB	Non-Energy Benefit
NLC	Networked Lighting Controls
NOMAD	Naturally-Occurring Market Adoption
NTG	Net to Gross
PY	Program Year (program period, e.g. PY7)
RCx	Recommissioning or Retro-commissioning
SCADA	Supervisory Control and Data Acquisition
SEM	Strategic Energy Management
TLED	LED Tube
TRC	Total Resource Cost
TRM	Technical Reference Manual
VFD / VSD	Variable Frequency/Speed Drive

Definitions

Technical Potential – all theoretically possible energy savings stemming from the applied measures. Technical potential is assessed by combining measure and market characterizations to determine the maximum amount of savings possible for each measure-market combination without any constraints such as cost-effectiveness screening, market barriers, or customer economics.

Economic Potential – subset of the technical potential that only includes measures that pass cost-effectiveness screening.

NOMAD – Naturally-Occurring Market Adoption, based on adoption curves and customer economics in a scenario without program incentives or enabling strategies.

Gross Savings – Total energy savings resulting from the implementation of energy conservation measures.

Net Savings – Subset of the Gross Savings after removing those that would have been achieved naturally, in the absence of programs.

Cumulative savings – Rolling sum of all new savings that will affect energy sales. Cumulative savings provide the total expected impact on energy sales and electric peak demand and are used to determine the impact of efficiency programs on long-term energy consumption and peak demand. Where applicable, cumulative savings are adjusted to account for mid-life baseline adjustments and the retirement of efficiency equipment that has reached the end of its Effective Useful Life (EUL). The model calculates cumulative potential in a similar manner to Illinois' CPAS (Cumulative Persisting Annual Savings), but the carryover or legacy savings from installations prior to the potential study period are not included in the results. Figure 5 shows legacy savings directly in order to illustrate the impact on forecasted sales.

Incremental annual savings – Expressed in terms of savings achieved in the first year.

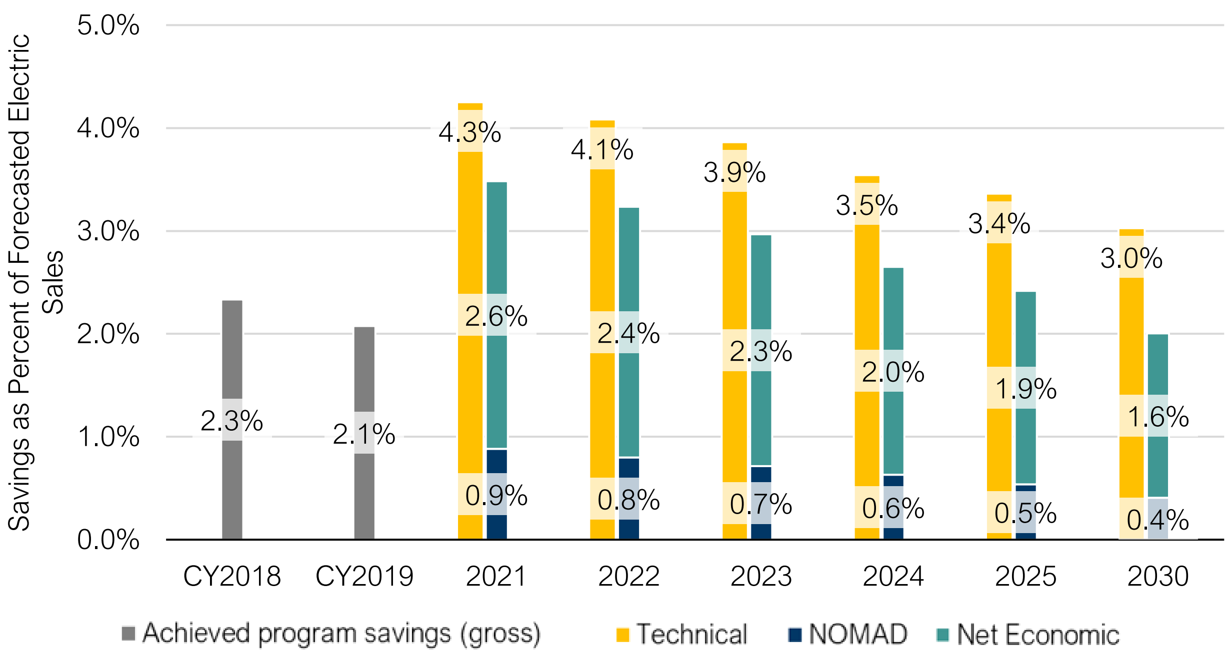
Incremental lifetime savings – Expressed in terms of expected savings over the entire useful lives.

Executive Summary

This Energy Efficiency (EE) Potential Study focusses on an assessment of the economic potential for electric efficiency savings over the ten-year period covering the years 2021 to 2030. It encompasses the eligible customers in ComEd's service territory and builds on a market baseline study conducted by Itron in 2019.

The study includes a detailed assessment of the technical and economic potentials, and while the program achievable potential is outside the scope of this study, the results from an assessment of the naturally-occurring market adoption (NOMAD) are leveraged to establish the net economic potential. The outcome is an assessment of the **economic potential net of natural adoption, based on a market evolution scenario in the absence of ComEd's DSM programs**, results of which are presented in Figure E-1 below.

Figure E-1 Cross-Sector Energy Efficiency Savings as Percent of Annual Electric Sales



Rather than assessing potentials based on the portion of each end-use that can be reduced by energy saving measures and strategies (often referred to as a "top-down" analysis), Dunsky's Demand and Energy Efficiency Potential (DEEP) model employs a **bottom-up approach which applies a highly granular calculation methodology to assess the energy savings opportunity for each measure-market segment opportunity in each year.** The assessment of industrial potential is split between the use of the DEEP model's bottom-up approach for lighting measures, and a top-down approach for all other end-uses which leverages past ComEd custom program results applied to the identified "eligible" populations and electricity consumption loads as developed by Itron and Dunsky.

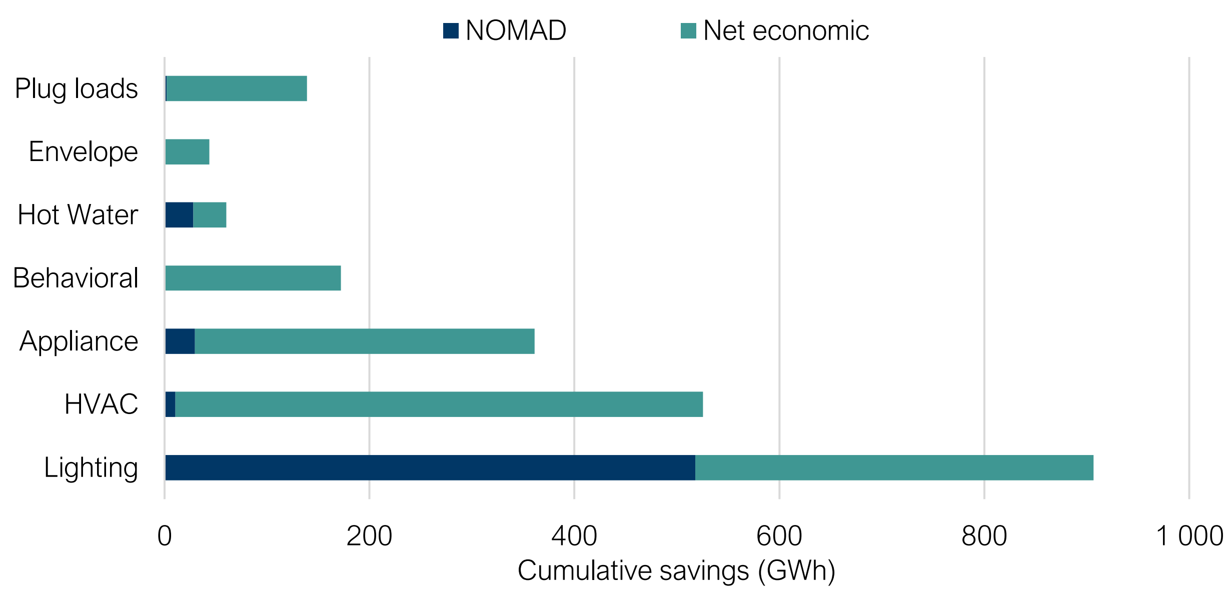
The trends in net economic opportunities assessed in this potential study offer insights for future ComEd DSM programs. First and foremost, while similar performance could be seen in the past between the residential and non-residential programs, this study's results indicate that **residential savings are declining** at an increasing rate over the study period, but that they may be partially replaced by commercial opportunities.

The current study looks at the market opportunities in the absence of the Energy Independence and Security Act (EISA) lighting standards at ComEd's request. Another key trend is that lighting savings are declining but remain the most significant opportunity in both sectors in the first 5 years (2021-2025). The rate of decline used in the current study reflects the naturally-occurring opportunity in the absence of programs, so it is likely that programs will accelerate the pace of the market transformation. To the degree that lighting programs are generous and aggressive, more savings could be realized sooner, possibly exhausting most of the opportunity by 2025.

Residential & Income-Eligible Programs

The naturally-occurring (NOMAD) and net economic potential by end-use, as determined from the cumulative potential in 2025, are presented for the residential sector in Figure E-2.

Figure E-2   Residential Savings, Cumulative in 2025 (Excluding Income-Eligible)



Focusing on lighting, while potential savings related to exterior sockets are substantial, they are linked to the Illinois Technical Reference Manual's (TRM's) hours of use assumption, which is significantly higher than for interior bulbs, and may not be fully representative of many real-world applications. Programs could focus on combined exterior fixture and controls measures in order to maximise savings.

While fuel-switching is not included in the study's scope, multiple heat pump measures are modeled in order to account for both the opportunity related to adding a standard-efficiency heat pump to replace electric resistance heating in homes, and the selection of a higher-efficiency model whenever a household chooses to replace or add a heat pump. Even if the current penetration of electric heating is low in

ComEd's service territory, heat pump savings remain a significant opportunity, especially when incorporating mini-split ductless heat pumps.

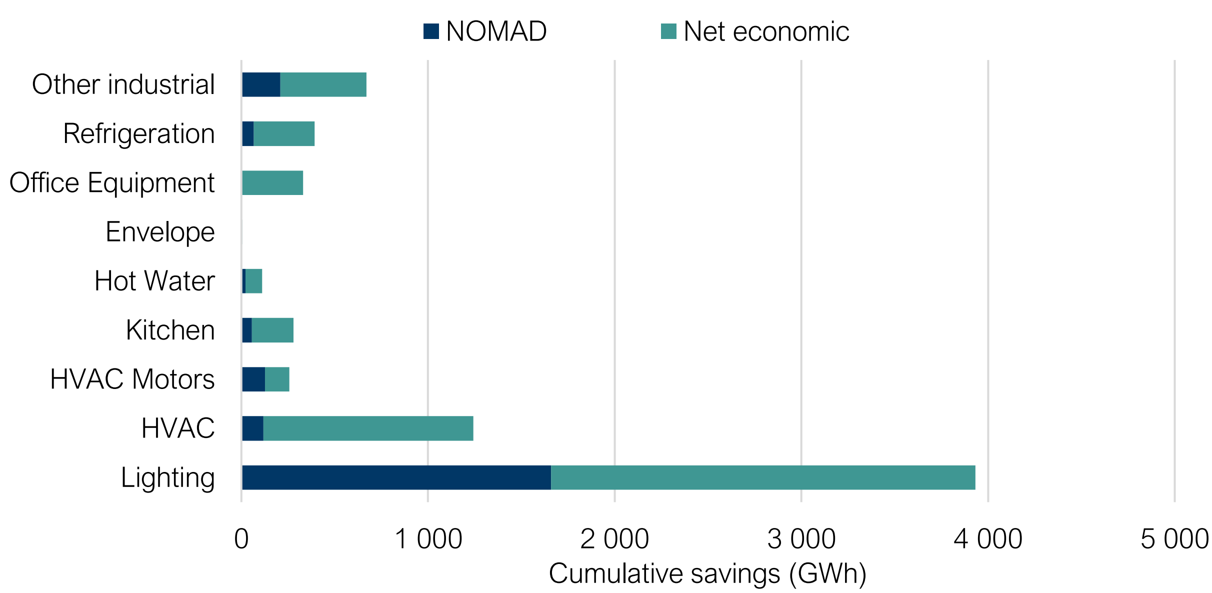
Home Energy Reports still have significant potential to deliver savings and there is an opportunity to expand their impact. However, while it remains a top residential and income-eligible measure, lifetime savings are comparatively lower than other measures and the persistence of those savings should be closely tracked. **Programs should therefore keep tracking the performance and cost-effectiveness of behavioral measures**, especially since the TRC ratio in some segments is very close to 1.0.

Finally, energy-efficient residential appliances are also a significant opportunity and should remain a focus of ComEd's residential programs.

Commercial & Industrial Programs

The naturally-occurring (NOMAD) and net economic potential by end-use, as determined from the cumulative potential in 2025, are presented for the non-residential sector in Figure E-3.

Figure E-3 Non-residential Net Economic Savings, Cumulative in 2025



In terms of commercial savings, lighting remains the largest opportunity. In a transforming market with declining opportunities, **the program's role is to encourage the adoption of state of the art LED technologies**, which are expected to continue to improve over the study period as higher efficiency linear LEDs become available, as well as reducing their operating hours through lighting control strategies. This will generate persistent savings over the long-term as LEDs have relatively long EULs and as such will remain in place for years. In addition, as the current penetration of T12 fluorescent tubes is likely linked with non-economic barriers to market adoption, **programs should consider focussing on barrier-reducing** enabling strategies, such as direct install approaches that replace the entire lighting fixture in order to prevent customers from reverting back to T12 fluorescent tubes.

As lighting opportunities decline and the market transforms, efficient HVAC technologies may offer a new program focus, with measures related to building controls and optimization providing the largest savings opportunity. These include Retro-commissioning, Strategic Energy Management and Energy Management Systems.

Future programs should also consider increasing their focus on kitchen equipment, which shows a significantly higher opportunity compared to past program performance.

As three commercial segments dominate the other nine in terms of savings opportunity, programs and strategies that are tuned to meet the need of Office, Retail, and Healthcare customers could help to improve program performance.

In terms of industrial opportunities, while participation in ComEd's Custom and Industrial Systems programs has largely been dominated by large industrial customers, a significant untapped opportunity remains in the small and medium size industrial customers, particularly for projects involving compressed air systems. While compressed air is also a significant opportunity for large customers, this segment shows a significant emerging opportunity in energy management and systems & process controls, which should be considered as a focus area in ComEd's industrial programs.

1. Introduction

1.1 – Study Overview

This report presents the results of the ComEd Energy Efficiency Potential Study. The study assesses the economic potential for electric efficiency savings over the ten-year period covering the years 2021 to 2030. It encompasses all of ComEd's service territory and builds on a market baseline study conducted by Itron in 2019.

The following provides an overview of the key aspects of the potential study, starting with some key parameters in the table below.

1.1.1 – Key Parameters

Key parameter	Details
Study Period	2021 to 2030
Geography	ComEd service territory
Sectors	Residential, Income-eligible, Commercial, Industrial
In scope	Electric Energy Efficiency
Out of scope	Non-electric Energy Efficiency, Demand response, Fuel-switching, Solar Photovoltaic, Combined Heat and Power, Transportation, Streetlighting, Voltage Optimization, Power Generation, Wastewater Customers above 10MW
EISA	Assess total LED potentials regardless of Energy Independence and Security Act (EISA) equipment and lighting standards enforcement. The study market includes remaining non-LED filled sockets.

Included in the scope of the potential study are the technical and economic potential, as well as an assessment of the naturally-occurring market adoption (NOMAD), as represented in Figure 1.

An assessment of the achievable potential is not included in the scope of this potential study. However, the naturally-occurring and net economic potential together are an indication of the opportunity available to ComEd programs – it should be expected that a portion of the NOMAD would participate in ComEd programs and be considered as free-riders, whereas the net economic potential is the incremental opportunity which programs should target.

Table 1 below provides additional detail on these four potentials.

Figure 1 Representation of the potentials included in the scope

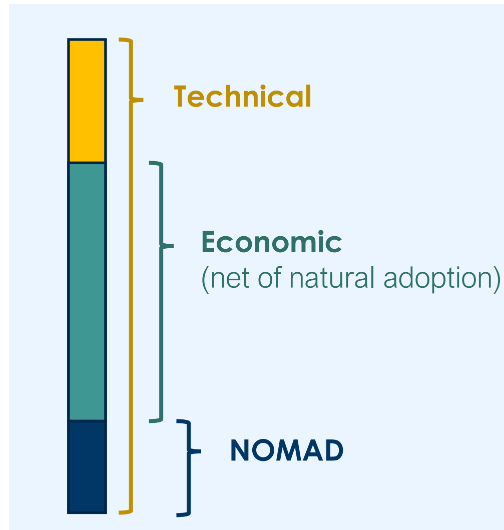


Table 1 Market Potential Opportunities

Opportunity	Details
Technical	• Includes all commercially viable opportunities, based on equipment turnover schedules, regardless of economics • Applies markets from Baseline Study findings
Economic	• Includes measures that pass the IL TRC threshold of 1.0 • Granular measure level and market segment analysis • Does not account for customer economics or market barriers • Net of natural adoption • Used for results reporting
NOMAD*	• Highlights measures with significant natural adoption potential • Applies calibrated markets and technology barriers • NOMAD assessment methodology described in Appendix C
Achievable	• *Excluded from the scope of the current Potential Study*

* Naturally Occurring Market Adoption

The Potential Study is a high-level assessment of electric savings opportunities in ComEd's service territory. The results will be a key input in ComEd's next 2022-2025 program planning process. In addition to this objective, the potential study can support resource planning and the development of state policies and strategies.

While the study provides granular information such as savings for specific measures in specific building segments, it is not a program design document meant to accurately forecast and optimize savings and spending through utility programs in a given future year. This study is meant to quantify the total potential opportunities that exist under specific parameters as defined under each scenario. Furthermore, the results of the current potential study reflect the economic opportunity net of naturally occurring market adoption, which is meant to provide trends; however, care should be taken when comparing the net economic potential to achievable forecasts or past program performance, as the economic potential does not account for customer economics or market barriers and their impact on measure adoption.

1.2 – Data Sources and Uses

The potential study leverages a pool of Illinois-specific data to populate the model used to estimate market potential. Where Illinois-specific data is not available or insufficient, data from nearby jurisdictions is leveraged to fill gaps and produce a more robust representation of market parameters in ComEd's service territory. Table 1 provides an overview of the key data sources used in the study. A more detailed description of the sources, inputs, and assumptions can be found in Appendix D.

Table 1 Study Data Sources and Uses

Data source	Application in study
ComEd customer data	Customer data is used to determine the number of customers and the average annual electricity consumption in each market segment.
ComEd baseline survey data	A recent baseline survey study conducted by Itron is used to establish the equipment penetration and saturations applied in the model.
ComEd forecasting and economic data	Projected sector-level forecasts with relevant adjustments for determining energy efficiency impacts; Average electricity retail rates by sector to determine natural adoption; Electric, natural gas and delivered fuel avoided costs for cost-effectiveness screening.
ComEd program data	Historical program data is used to characterize programs for model input (e.g. incentive levels, administrative costs) and used to calibrate the model to past performance. ComEd annual reports, evaluation reports and detailed CPAS workbooks are used to estimate historical adoption by segment as well as historical system costs, system sizes and program costs.
U.S. DOE Building Archetypes	Buildings archetypes, adjusted for ComEd's service territory climate and consumption, are used to provide end-use breakdown and for quality control purposes.
Dunsky's Market Archetype	Where Illinois specific baseline data is not available (or was based on a low number of observations), baseline data from neighboring jurisdictions in the Midwest United States is leveraged and adjusted for ComEd specific attributes wherever possible.

1.3 – Market Segmentation

The ComEd Economic Potential Assessment applies an enhanced level of market segmentation to harness the detailed baseline study data. The high market granularity reduces aggregation bias by capturing more use-cases for each technology in each market and therefore supports a more precise measure of the economic potential, giving further program insights. Additional details on the market segmentation are presented in Appendix D.

Table 2 and Table 3, below, list the Residential and Non-residential market segments used in the current Potential Study.

Table 2 Residential market segments

Sector	Building type	Level of consumption	Home size	Population	Usage (GWh, 2017)
Residential	Single family	Low	All	478,934	2,112
		Medium	<2,000 ft^2	255,056	2,069
			>2,000 ft^2	137,766	1,150
		High	<2,000 ft^2	173,232	2,326
			>2,000 ft^2	278,090	4,555
	Multifamily	Low	All	479,881	992
		Medium		137,269	617
		High		142,685	1,484
Income eligible	Single family	All	<2,000 ft^2	463,774	3,277
			>2,000 ft^2	59,512	594
	Multifamily	All	All	605,540	2,828

Table 3 Non-residential market segments

Sector	Segment	Population	Usage (GWh, 2017)
Commercial	Office	107,763	8,325
	Public admin	13,216	3,971
	Retail	55,338	4,861
	Food	22,420	2,461
	Grocery	8,167	2,080
	Health	30,716	3,510
	Colleges	1,005	2,407
	Other education	8,401	855
	Lodging	4,315	1,134
	Entertainment	6,399	1,012
	Wholesale	11,301	2,537
	Other commercial	33,387	1,474
Industrial[1]	Industrial, <100 kW	12,339	480
	Industrial, 100-400 kW	1,969	906
	Industrial, >400 kW	1,361	6,889

1.4 – Industrial Opportunity

The estimation of industrial potential is split between prescriptive measures (specifically lighting) and custom measures.

The lighting end-use is modeled through DEEP's bottom-up approach. For all other industrial end-uses, a top-down approach using the "eligible" population and load by custom project type has been developed.

Additional details on the industrial-specific top-down approach is provided in Appendix B.

[1] Note that the Industrial sector is described in Section 1.6. Only lighting was characterized in DEEP and Itron used a top down approach for all other industrial end-uses.

1.5 – Baseline Energy and Demand Forecasts

To help discern the impact of the various measures analyzed on overall energy consumption and demand in the ComEd jurisdiction, the study establishes baseline forecasts for the study period. To create these baseline forecasts, electricity consumption and peak demand forecasts provided by ComEd are adjusted to remove the projected impacts of post 2021 planned energy efficiency programs. This avoids double-counting energy efficiency impacts in the study.

Residential electricity consumption is expected to increase over the study period at annualized rates of about 1%. Commercial and industrial consumption will drop by approximately 1-2% per year and peak demand will drop by approximately 0.25% per year across all sectors. These forecasts are used to illustrate the annual and cumulative impacts of electric savings.

2. Overarching Results

2.1 – Overview

The following chapter presents overarching results across all market sectors, as well as additional insights into what portion of the energy efficiency potential might be considered naturally occurring. It also provides a deeper dive into sector-specific results.

2.1.1 – Approach

The electric energy efficiency potential is assessed using the Demand and Energy Efficiency Potential (DEEP) model. DEEP employs a multi-step process to develop a bottom-up assessment of the technical, economic and naturally-occurring potential. DEEP's bottom-up modelling approach assesses thousands of "measure-market" combinations. Rather than estimating potentials based on the portion of each end-use that can be reduced by energy saving measures and strategies (often referred to as a "top-down" analysis), the DEEP's approach applies a highly granular calculation methodology to assess the energy savings opportunity for each measure-market segment opportunity in each year.

DEEP assesses potential on an annual phased-in basis. The model assumes that most efficient measures are not eligible for deployment until the existing equipment it is replacing reaches the end of its useful life or becomes an economically viable early replacement measure. This limits the number of opportunities available for efficiency upgrades each year. For this reason, technical and economic potential will increase each year of the study as more baseline equipment is eligible to be replaced.

A more detailed description of the methodology can be found in Appendix A.

The estimation of the industrial potential is split between prescriptive measures (specifically lighting) and custom measures. The lighting end-use is modeled through DEEP's bottom-up approach. For all other industrial end-uses, a top-down approach using the "eligible" population and load by custom project type.

Additional details on the industrial-specific top-down approach is provided in Appendix B.

2.1.2 – Benchmarking Results

The first step in the potential modelling entailed loading Dunsky's DEEP model with all measure and market inputs as per the approved measure list and savings characterizations, along with baseline market data from Itron's baseline study. That yielded the technical and economic potentials, which were based on Gross savings at that point.

The model then applied a high-level set of programs, with incentives and enabling strategies set to match average values across ComEd's current portfolio for each energy end-use. The results from this program potential were then used to benchmark the model outputs to recent ComEd program performance.

The model was then calibrated by adjusting the market factors and measure barriers until a satisfactory savings agreement was established between the model results and ComEd's CY2018 and CY2019 program results, as defined in the Program CPAS detailed workbooks which were provided by ComEd.

Figure 2 Residential model calibration results

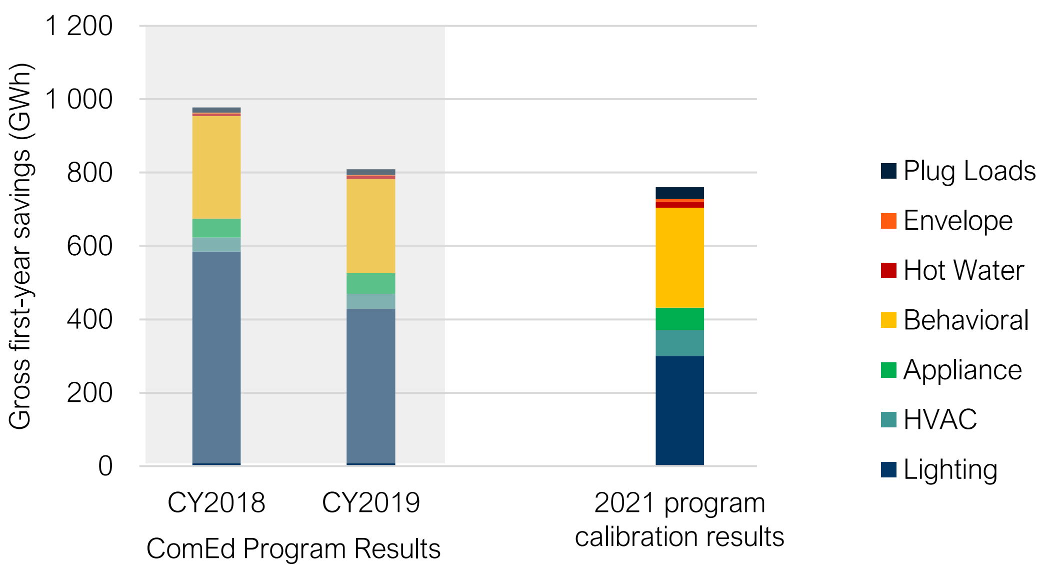
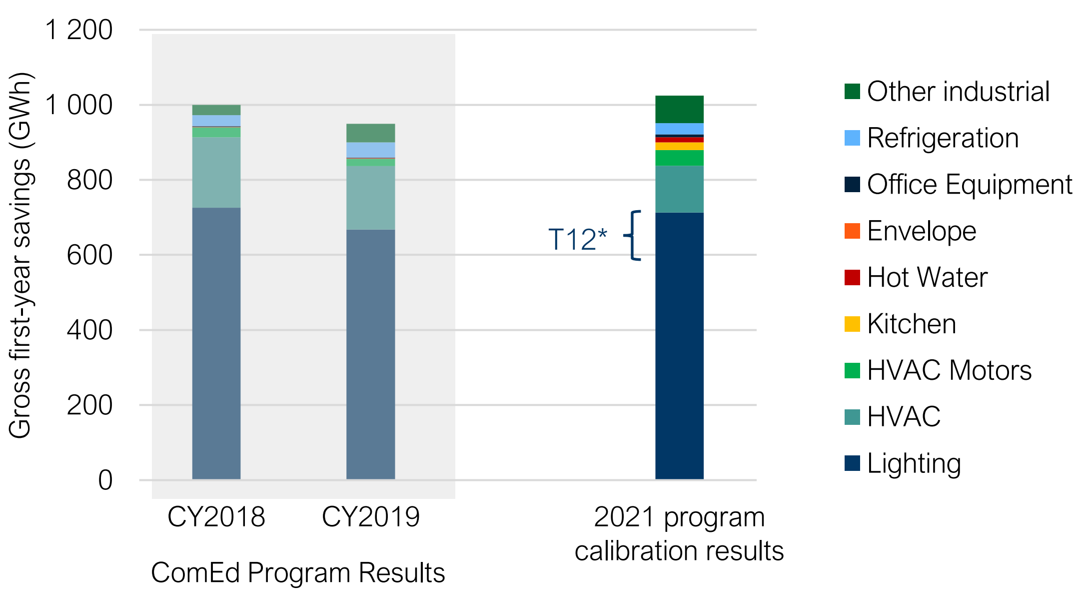


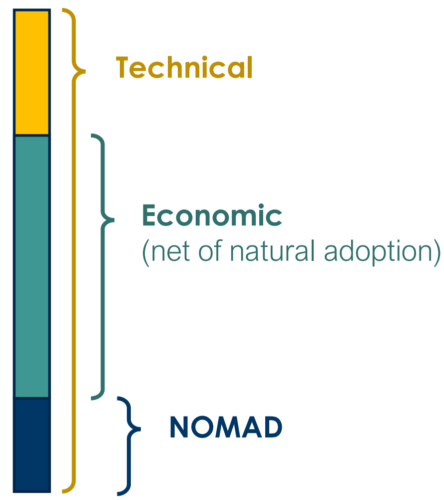
Figure 3 Non-residential model calibration results



* Lighting savings related to the T12 measures, which use a T12 baseline

2.1.3 – Savings Opportunities

The following sections describe the three types of savings opportunities assessed as part of this study. As shown in the figure on the right, the economic potential is always presented net of the Naturally Occurring Market Adoption (NOMAD).



The achievable potential is not included in the scope of this potential study. However, the naturally-occurring and net economic potential together are an indication of the opportunity available to ComEd programs – it should be expected that a portion of the NOMAD would participate in ComEd programs and be considered as free-riders, where the net economic potential is the incremental opportunity which programs should target.

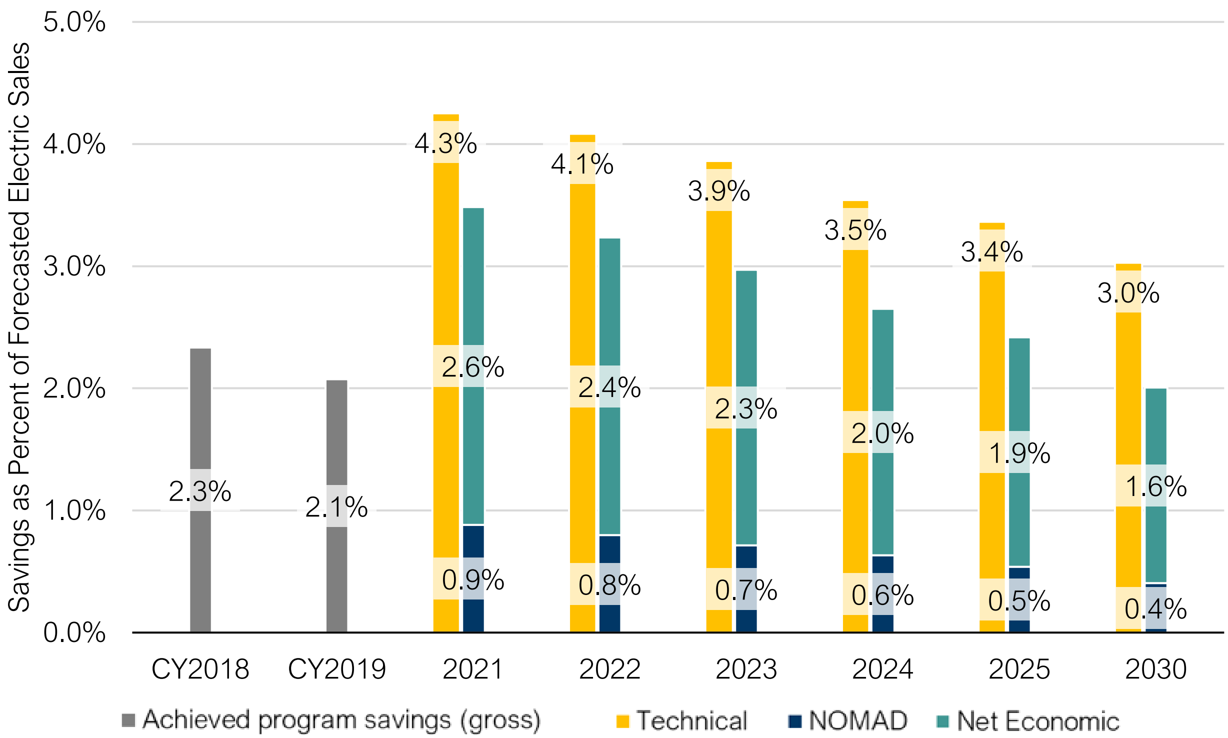
2.2 – Electric Energy Savings

The technical, economic and naturally occurring potential across all market sectors is shown in Figure 4 as a percent of the forecasted electric sales – in other words, GWh of energy efficiency savings divided by GWh of projected electricity sales in a given year. The actual savings from ComEd's program in calendar years 2018 and 2019 are also shown for comparison. To note, ComEd program savings and have been adjusted so that they are in-line with the scope of this potential study. For example, voltage optimization and streetlighting are outside the scope of this study and thus those measure savings are removed to enable an apples-to-apples comparison.

In the figure below, the achieved program savings from calendar years 2018 and 2019 as well as the technical potential are shown as gross savings. These can be compared alongside the sum of the naturally-occurring adoption plus the net economic potential.

To note, approximately 80% of the NOMAD savings would pass the TRC screening with a benefit-cost ratio of at least 1.0. Additional details on the approach to establishing net economic potential and NOMAD can be found in Appendix C.

Figure 4   Energy Efficiency Savings as Percent of Annual Electric Sales



The reader will notice that the naturally occurring potential is non-negligible and that the net economic potential is higher than the achieved CY2018 and CY2019 program results. Also, all of the potentials are on a downward trend, mostly due to the ongoing market transformation of the lighting sector, under which the saturation of LEDs increase and therefore reduces the pool of potential savings over time. A deeper dive into lighting savings over the study period can be found in Chapter 3.

The sum of the NOMAD and net economic potential is relatively close to the technical potential because the modeling focus is on commercially viable technologies, which by nature tend to be cost-effective. Around 80% of the modeled technical savings pass the cost-effectiveness screening test, as shown in Figure 8.

Figure 5 shows the cumulative potential over the study period relative to projected electricity sales. Persistent legacy savings from installations prior to 2021 are included[2] and form the basis upon which the technical, economic and NOMAD potentials are assessed.

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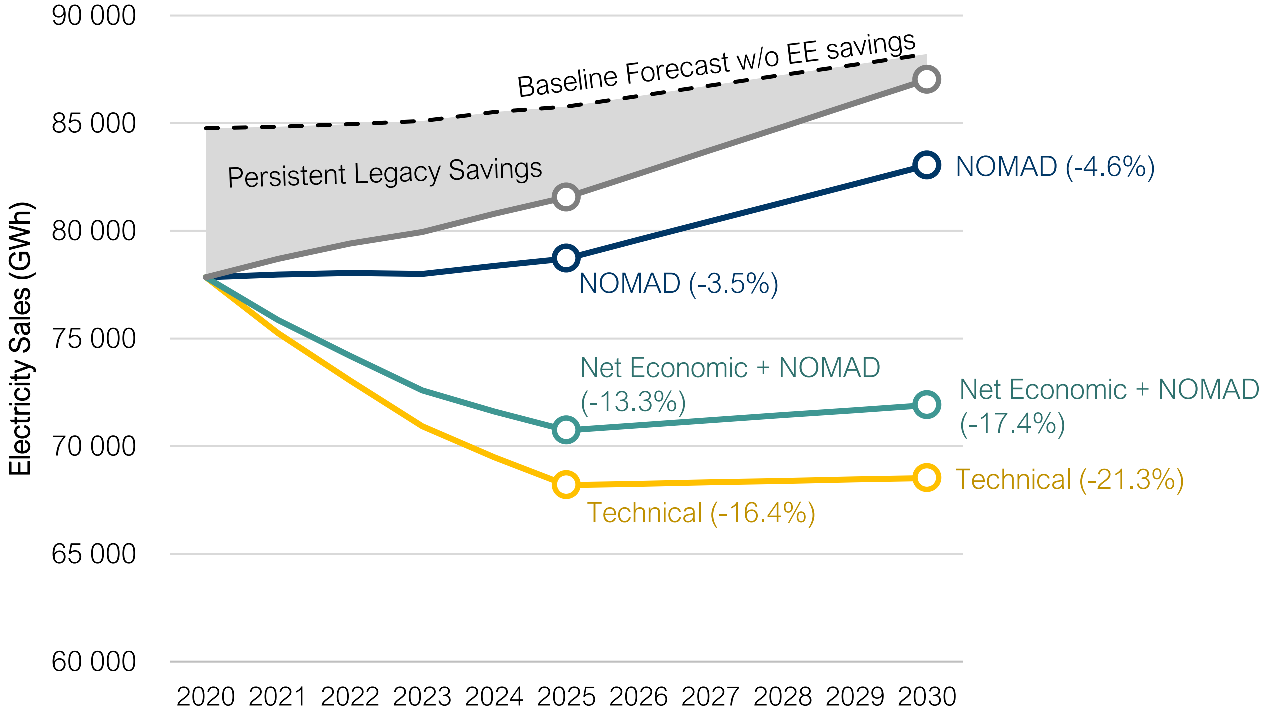
2 Estimate based on detailed 2018 and 2019 CPAS workbooks. The behavioral Home Energy Report legacy savings are excluded from the legacy savings as both the measure's legacy and incremental savings are included in the measure's net economic savings. Additional details are included in Appendix D.

Figure 5   Electric Sales under Energy Efficiency Scenarios

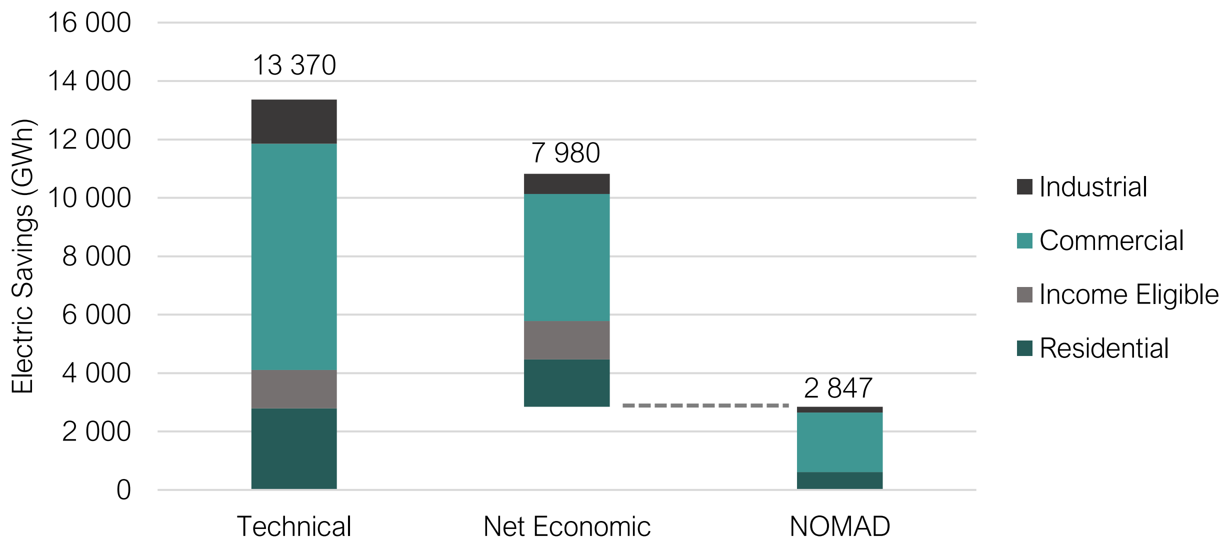


The results show that the naturally occurring potential mostly replaces the decline in legacy savings from installations prior to the study period. The addition of all net economic energy efficiency potential would lead to a reduction of electricity sales up to 2025 and then hold sales relatively flat between 2025 and 2030.

It should be noted that even though ComEd's projected energy efficiency program impacts are removed from the baseline forecast to avoid double counting, some naturally-occurring efficiency most likely remains in the baseline forecast (dotted line), since these forecasts are based on historical program trends which might not include out-of-program natural adoption. However, historical trends likely do not include a significant out-of-program natural adoption of LEDs, as that is considered to be a relatively recent trend. Figure 7 shows that the NOMAD results are largely dominated by lighting measures, both for the Residential and Commercial sectors.

Figure 6 below shows the technical, economic and NOMAD potential by sector based on the cumulative savings in 2025.

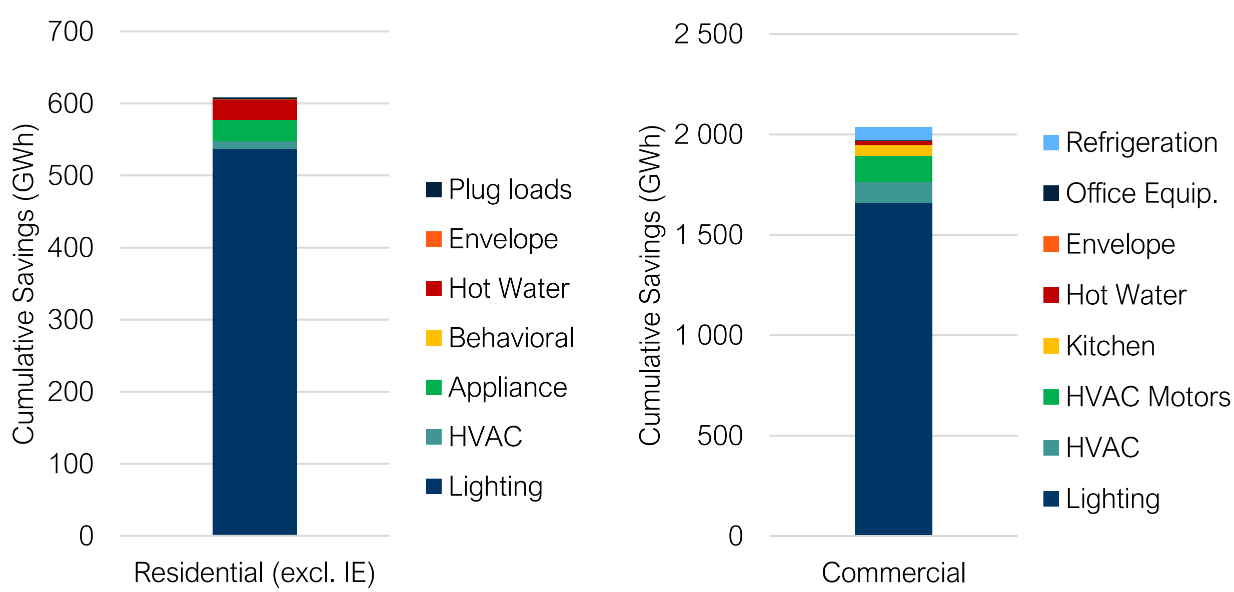
Figure 6 Cumulative Electric Energy Savings, 2025



Commercial savings largely dominate both the NOMAD and net economic potential. The astute reader will notice that the NOMAD potential for the Income-eligible sector was set at zero, as requested by ComEd (i.e. for all Income-Eligible measures, the NTG is set at 1).

Finally, Figure 7 presents the NOMAD savings by end-use, where it is clearly visible that lighting dominates for both the residential and commercial sectors' naturally occurring potential.

Figure 7 NOMAD electric savings by end use, cumulative in 2025

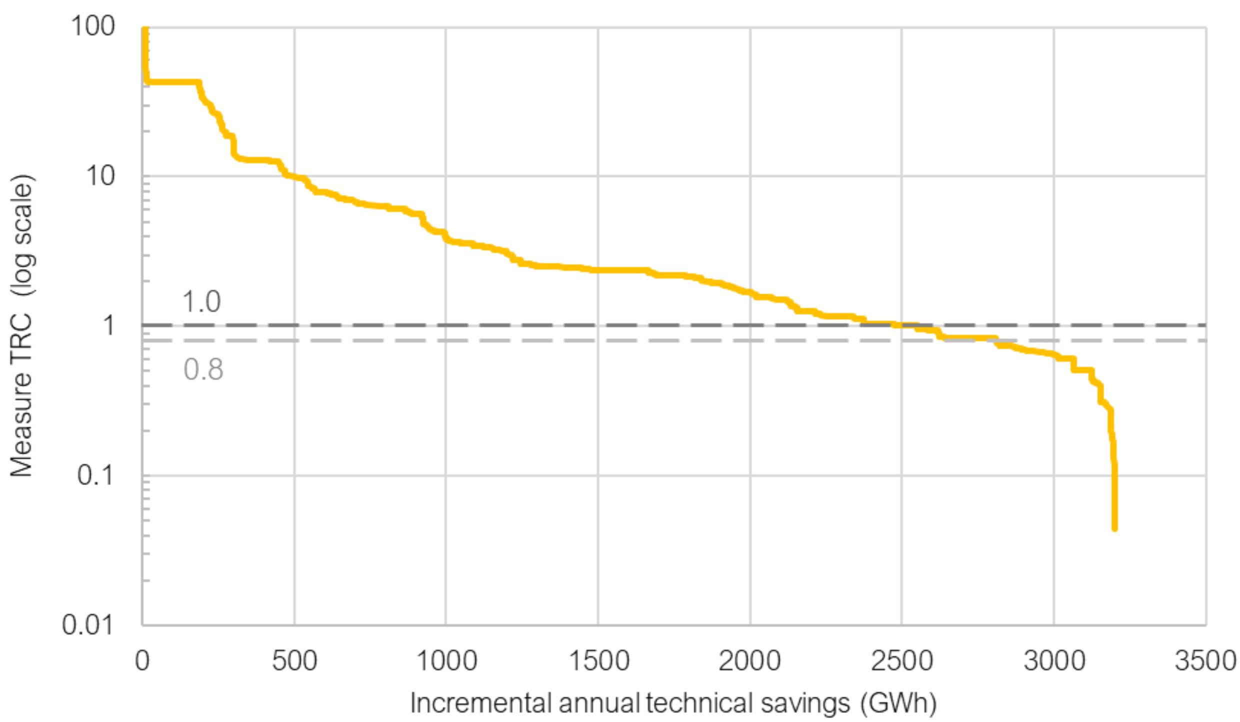


2.3 – TRC supply curve

The TRC screening test for the economic potential applies a threshold of 1.0 (except for the income-eligible sector, for which all measures are included in the economic potential, regardless of the TRC cost-effectiveness).

In order to understand the sensitivity of the results to the TRC threshold level, a TRC supply curve was produced and is presented in Figure 8 below.

Figure 8 TRC supply curve using the 2021 annual technical savings

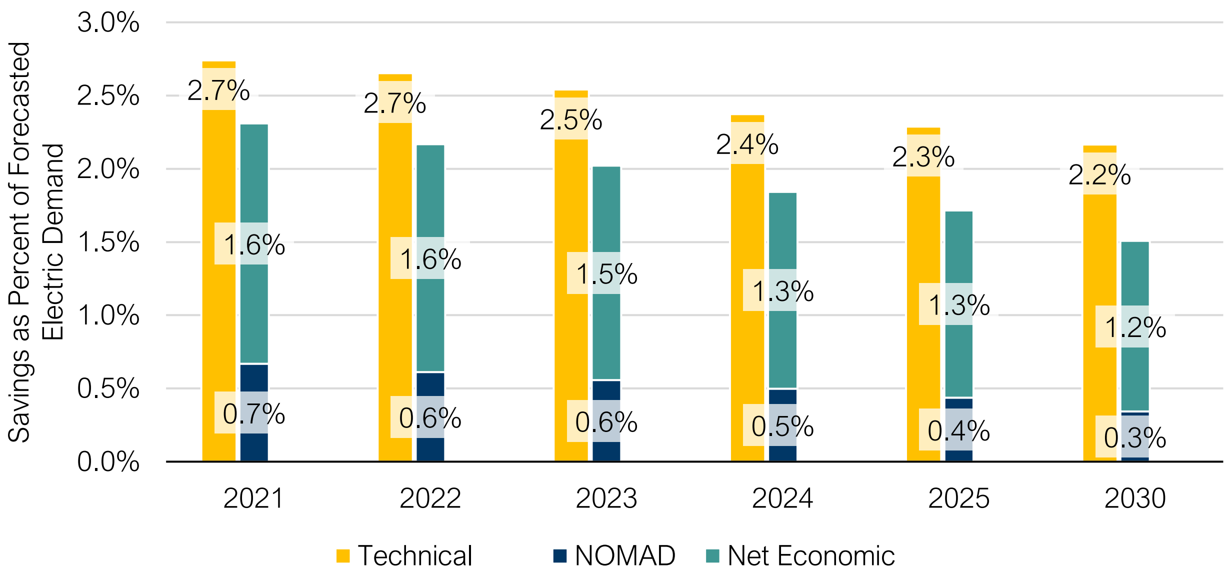


In a hypothetical scenario, should the TRC threshold be lowered from 1.0 to 0.8, an additional 260 GWh of savings would be included in the economic potential for 2021 (gap between the two dotted grey lines). ComEd programs can include some measures with a TRC slightly below 1.0 and still achieve an overall TRC above 1.0, so a part of this additional 260 GWh of savings could be available.

2.4 – Electric Demand Savings

In terms of passive demand savings (i.e. non-Demand Response), the results relative to forecasted annual electric peak demand are shown in Figure 9 below.

Figure 9   Demand Savings as Percent of Annual Electric Sales



The trends are similar to those seen for energy savings, with a non-negligible naturally occurring potential, a larger net economic potential, and a downward trend of savings over the study period – largely due to diminishing lighting opportunities over the study period.

3. Sector-Level Findings

The detailed sector-level results are presented in this section using the following structure:

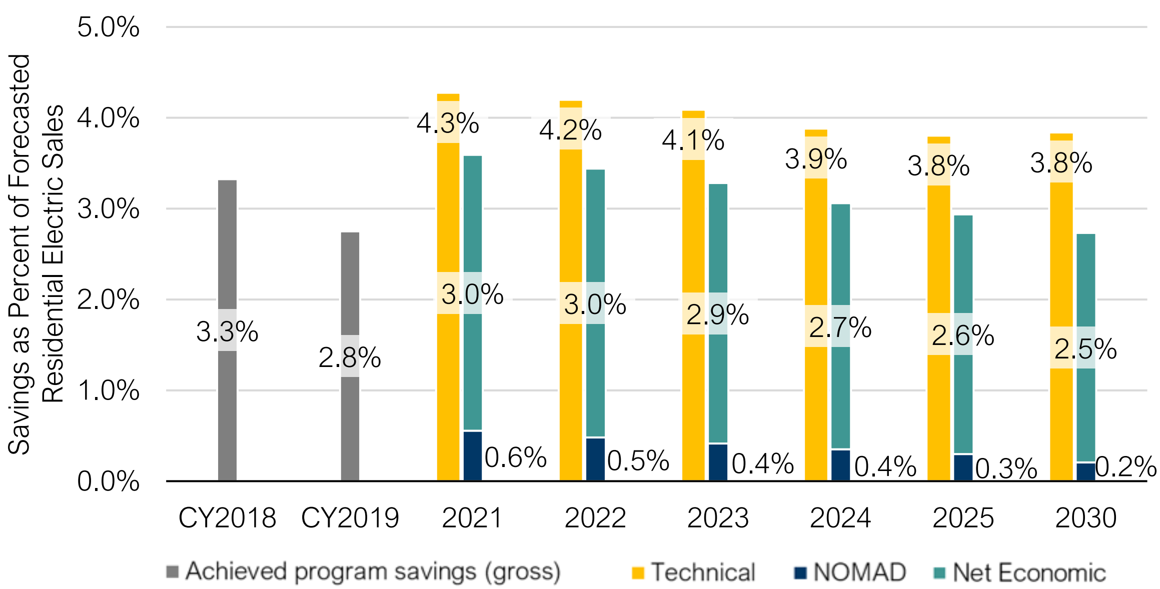
- 3.1 – Residential Market Findings
  - 3.1.1 – Residential (non income-eligible) Sector
  - 3.1.2 – Income-Eligible Sector
- 3.2 – Non-residential Market Findings
  - 3.2.1 – Commercial Sector
  - 3.2.2 – Industrial Sector

3.1 – Residential Market Findings

The residential market combines the residential and income-eligible sectors.

The technical, net economic and naturally occurring (NOMAD) potential for the residential market is shown in Figure 10 as a percent of that market's forecasted electric sales. Note that the achieved program savings from CY2018 and CY2019 and the technical potential are shown as gross savings, and compared to the sum of the naturally-occurring adoption plus the net economic potential.

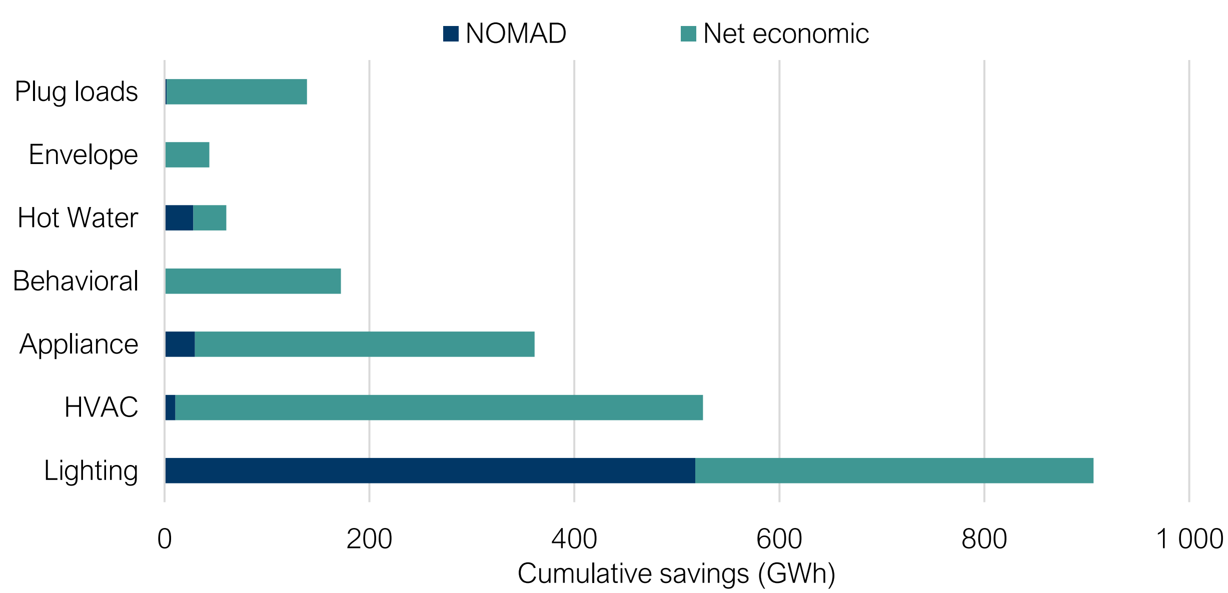
Figure 10 Residential savings as percent of annual electric sales (including income-eligible)



The naturally-occurring potential is smaller in the residential sectors compared to NOMAD in the overall results (see Figure 5). This is due to the assumption that the income-eligible customers would not adopt any energy-conservation measures in the absence of programs. For this same reason, the decline in energy savings potential in later is relatively lower in the Residential Sector compared to the overall results (Figure 5) – the decline is mostly related to the reduction of the annual bulb turnover rate as bulbs get replaced with longer-lasting LEDs. This dynamic is captured in market reduction factors which are discussed in Appendix C.

The residential sector NOMAD results are presented by end-use in Figure 11, excluding the income eligible sector because, as discussed above, natural adoption or NOMAD is assumed to be negligible and is thus set at zero at ComEd's request.

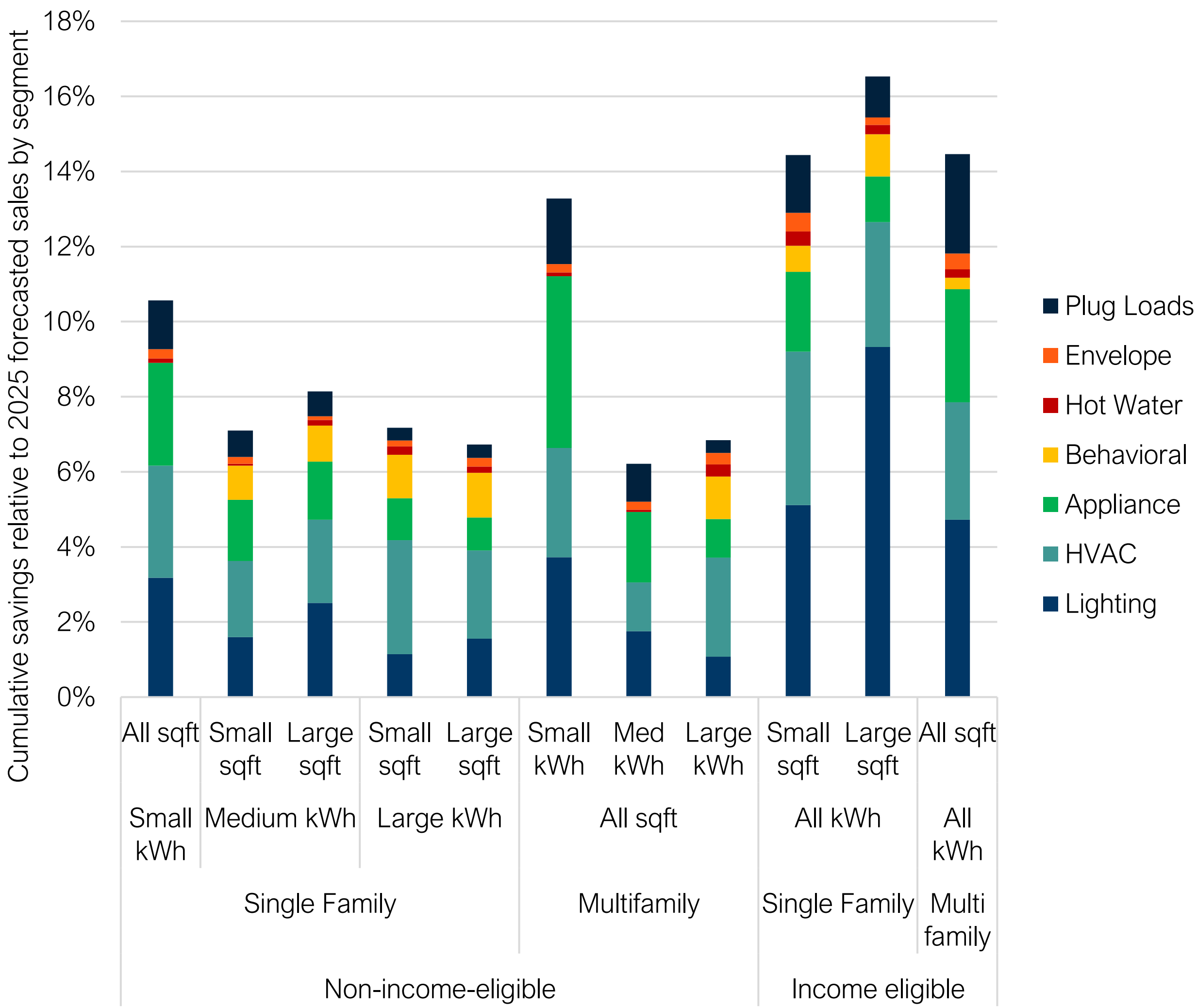
Figure 11   Residential savings, cumulative in 2025 (excluding income-eligible)



The results show that the lighting end-use offers the most savings, but over half of the savings are from natural adoption, reflecting the current pace of market transformation in the lighting sector. Other end-uses show a relatively small portion of naturally-occurring potential in the absence of programs, with the exception of hot water measures (low-flow faucet aerators and shower heads). Plug load savings are largely dominated by advanced power strips, which are not expected to be adopted in the absence of programs.

Diving further into the results of the residential market, Figure 12 show the savings by end-use for each market segment. As with most figures in this chapter, the results are shown in terms of economic potential net of natural adoption.

Figure 12   Residential net economic savings by segment and end-use, relative to each segment's forecasted sales



The ComEd potential study applies an enhanced level of market segmentation to harness the detailed baseline study data. The high market granularity reduces aggregation bias by capturing more use-cases for each technology in each market and therefore supports a more precise measure of the economic potential, as can be seen in the figure above.

When expressed relative to forecasted sales by segment (Figure 12 above), homes that have lower consumption or are smaller in size show more relative potential compared to homes that currently use more energy and/or are larger. That trend is likely linked with appliance consumption, which is relatively similar across segments, unlike other end-uses like lighting and HVAC which is linked to the size of the home. A similar trend is seen for multifamily homes, though in the case of the high-consuming multifamily segment, the Home Energy Report measure passes the TRC screen - which is not the case for the other two non-income-eligible multifamily segments – driving the higher savings level.

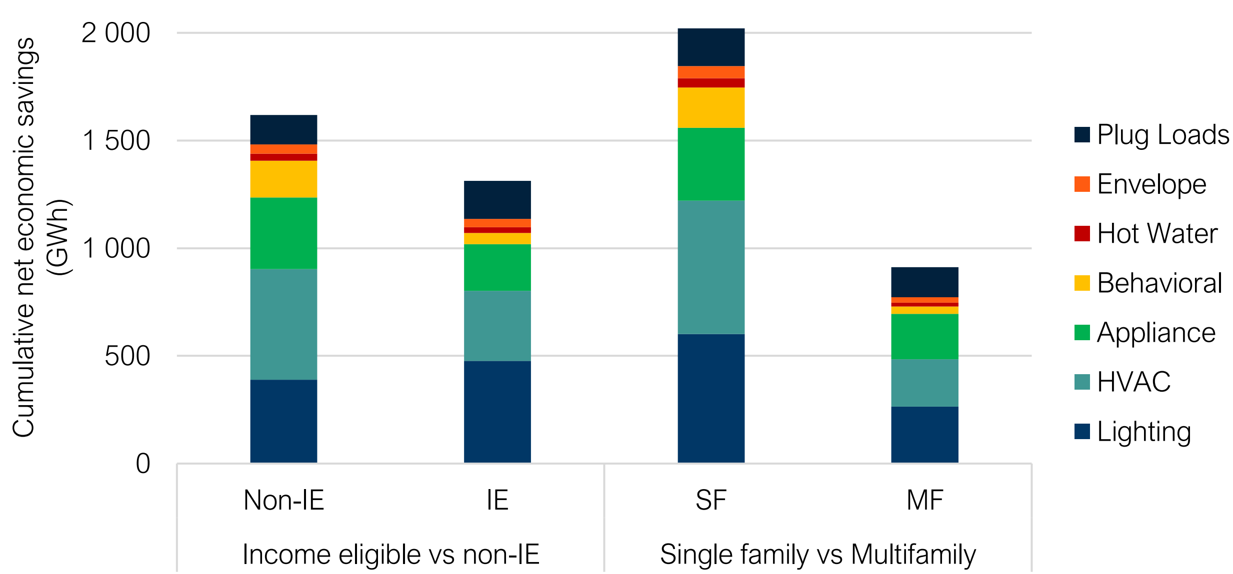
The segment representing multifamily dwellings in the small consumption bucket (6th bar from the left) shows a relatively large savings potential due to a significant central air conditioning efficiency opportunity, including whole house fans.

While fuel-switching is not included in the study's scope, multiple heat pump measures are modeled in order to account for both the opportunity related to adding a standard-efficiency heat pump in electrically-heated homes, and the selection of a higher-efficiency model whenever a household chooses to replace or add a heat pump. Even though the penetration of electric heating is relatively low in ComEd's service territory, the addition of mini-split ductless heat pumps in homes heated with electric baseboards shows a significant net economic energy savings opportunity. It should also be noted that all residential heat pump measures show negligible natural adoption in the absence of programs.

Finally, Figure 12 shows the high savings potential in the income-eligible sector, where its three segments have the highest relative savings opportunity across the residential sector. This can be explained in part by the higher penetration of inefficient technologies, and also by the fact that no TRC screening was applied to the income eligible sector.

Figure 13 shows a comparison of absolute savings per segment type.

Figure 13   Residential net economic savings by segment type and end-use



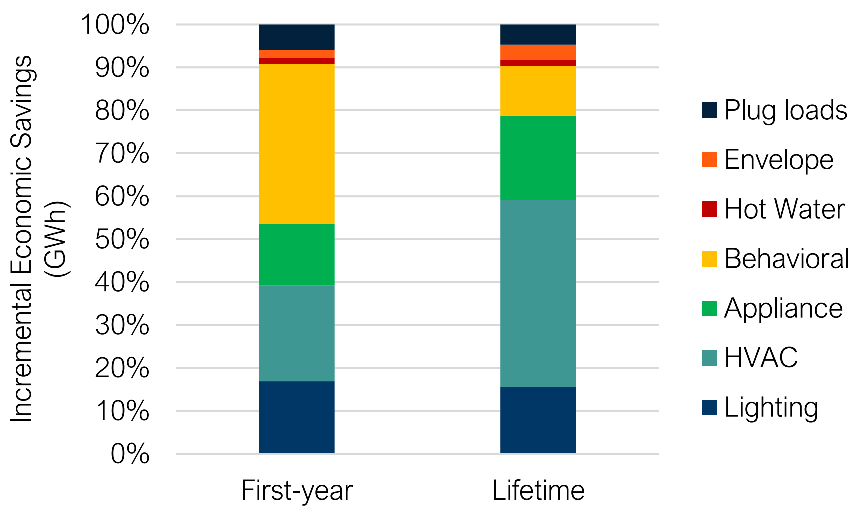
Results show a slightly lower savings potential in the income eligible sector vs non-income eligible segments, which highlights the significant opportunity in the income-eligible sector. Likewise, single-family households provide more potential savings than multifamily segments.

3.1.1 – Residential (non income-eligible) Sector

The residential sector savings shows the highest rate of decline over the study period, driven primarily by the lighting end-use.

Before diving into the lighting savings, Figure 14 presents average annual incremental economic savings (2021-2025) by end-use, comparing the breakdown by measure between first-year savings and lifetime savings.

Figure 14 Residential (excluding income-eligible) net economic savings by end-use, 2021-2025 average



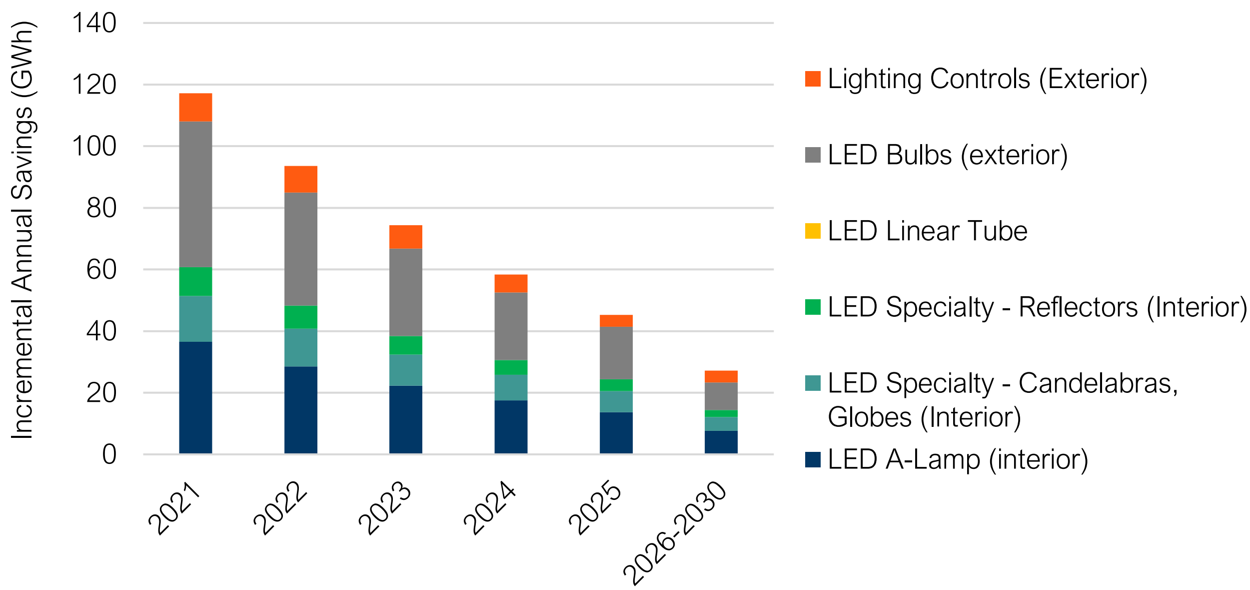
Results show that HVAC, Appliance and Envelope measure lifetime savings grow relative to first-year savings, as they have longer EULs. On the contrary, the Home Energy Report (HER) measure – which constitutes the Behavioral end-use – has a declining share relative to first-year savings due to declining persistence factors, which reduce the long-term potential of behavioral measures.[3]

The significant portion of first-year savings from the behavioral end-use is due to the inclusion of both legacy and incremental savings, as well as the applicability of the measure in up to 80% of all homes – more details on the modeling approach of the HER measure is provided in Appendix D.

A deeper dive into the lighting end-use is presented in Figure 15. As a reminder, the current potential study assesses total LED potential regardless of EISA.

[3] The lifetime savings of the Home Energy Report measure include persistent savings for a 5-year period, in line with the Illinois TRM. First-year savings combine both legacy and incremental savings in order to model total behavioral savings for a specific year.

Figure 15 Residential (excluding income-eligible) net economic lighting savings over study period



Lighting savings for the residential sector visibly declines over the course of the potential study as the lighting market transforms. This is primarily due to the declining market, as the market turnover rate declines due to the replacement of short-EUL sockets with longer-EUL LEDs. The rate of market decline used in the current study reflects the naturally-occurring opportunity in the absence of programs, so it is likely that programs would accelerate the pace of the market transformation, bringing more savings sooner and possibly exhausting most of the lighting opportunity by 2025. A portion of the decline in net economic savings can also be explained by the declining NTG ratios due to the projected increase in natural adoption over the course of the potential study. Additional details on the characterization of the lighting measures can be found in Appendix C.

To note, exterior bulbs have a relatively high share of lighting savings for three reasons:

1. the hours of use in the Illinois TRM (2,475 hours vs 1,089 for interior bulbs);
2. the baseline study found a negligible CFL penetration in exterior sockets, while it is around 35% for non-LED interior sockets; and, 3) the average wattage which is higher for exterior bulbs.

In addition, two key factors from the baseline study limit overall lighting savings:

1. the baseline study found a relatively low saturation of reflectors (2.3 per home on average), and
2. the high CFL saturation in interior sockets[4], as the savings from a CFL to LED conversion are minimal compared conversions from halogens or incandescent bulbs.

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[4] The relatively high CFL saturation is consistent with the 2017 baseline study, as seen in the Commonwealth Edison Residential Lighting Study and Illinois Statewide LED Hours of Use Study Results by Opinion Dynamics. https://ilsag.s3.amazonaws.com/ComEd-Residential-Lighting-Discounts-PY9-Combined-Report-2019-02-14.pdf

Table 4 presents the top-20 measures in the residential sector (the equivalent top-20 table for the income-eligible sector is presented in Table 5). It should be noted that as with most results in the current potential study, this list is based on the net economic potential, which excludes market barriers and customer adoption curves. Moreover, in the case of measures which compete for the same market, the economic potential by definition assumes that the highest-saving measure captures the whole market (i.e. if two tiers of advanced power strips are competing for the same market, the one with the highest unit savings (highest tier) will capture the entire market, for example).

Table 4 Top-20 Residential sector measures, as defined from the cumulative net economic potential in 2025

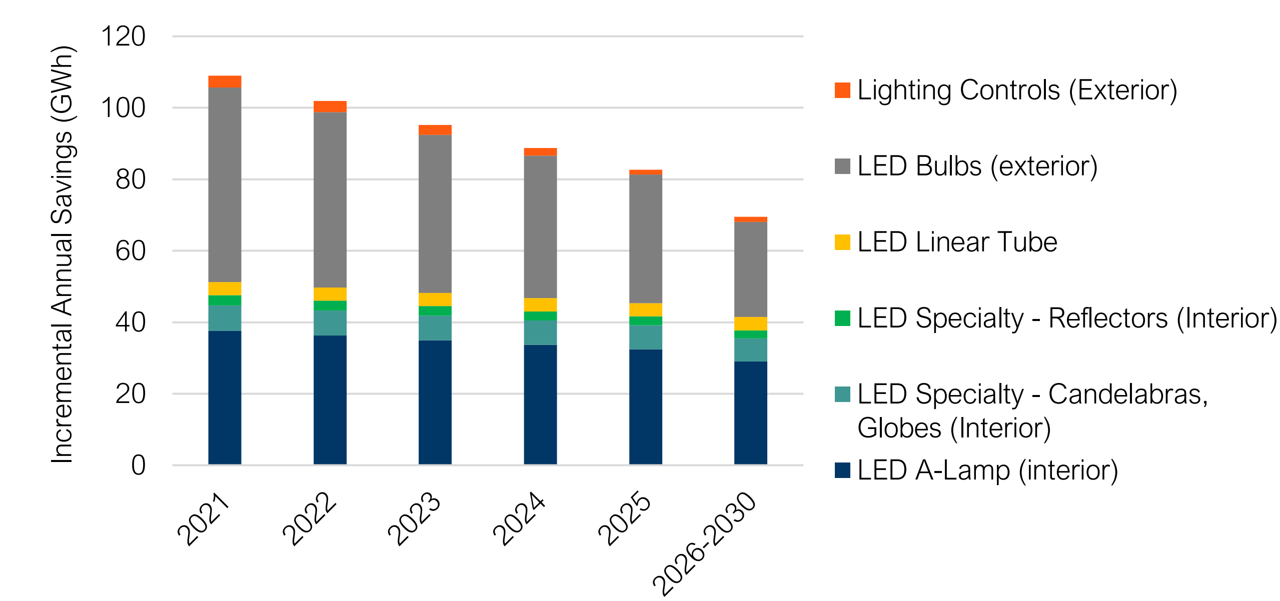
Rank	Residential measure	GWh
1	Home Energy Report	172
2	LED Bulbs (exterior)	151
3	Thermostat Wi-Fi	146
4	Advanced Power Strips[5]	134
5	LED A-Lamp (interior)	119
6	Energy Star Clothes Dryer	106
7	Electric Resistance to DMSHP	93
8	Energy Star Clothes Washer	92
9	Central Air Conditioning (CAC)	81
10	Whole House Fan	78
11	LED Specialty - Candelabras, Globes (Interior)	52
12	Freezer Recycle	38
13	Energy Star Refrigerator	37
14	Lighting Controls (Exterior)	35
15	LED Specialty - Reflectors (Interior)	32
16	Electric furnace to ASHP	31
17	Air Source Heat Pump (ASHP)	29
18	Energy Star Air Purifier	26
19	Air Sealing	24
20	Energy Star Bathroom Exhaust Fan	23

[5] On-device energy management has likely improved since the pre-2010 studies which form the basis of the deemed savings in the Illinois TRM, and is expected to keep improving. Lower per-unit savings could be seen, which is not accounted for in the current study.

3.1.2 – Income-Eligible Sector

Focussing on the income-eligible residential sector, Figure 16 presents the evolution of lighting savings over the potential study period.

Figure 16 Income-eligible net economic lighting savings over study period



Compared to Figure 15 for the residential sector, the above results show a slower decline of lighting savings over the study period. That is caused by the fact that the NOMAD results are leveraged to define the market reduction factors. Since the natural adoption of energy conservation measures is lower for the income-eligible sector, the annual market reduction factors are smaller. In other words, the rate of market decline reflects the naturally-occurring opportunity in the absence of programs, thus it is likely that programs would accelerate the pace of the market transformation, bringing more savings sooner. The approach to defining the market reduction factors is discussed in Appendix C. The decline in income-eligible lighting savings seen in Figure 16 is largely related to the exterior LED bulbs, which have a faster stock turnover rate because of their higher annual hours of use, which shortens their EUL. Finally, the smaller decline in lighting savings compared to the non-income-eligible residential sector is related to the fact that NTGs are set at 1 for the income eligible sector and do not decline over the potential study period.

Compared to the non-income-eligible residential sector, the smaller relative potential from specialty bulbs and lighting controls, as well as the larger relative potential from exterior bulbs, reflects the baseline study results for the three income-eligible segments. In particular, the income-eligible segments have more exterior bulbs which are already controlled (which *reduces* lighting controls potential), however they have proportionally more exterior halogen bulbs per home (which *increases* exterior bulb potential).

Table 5 presents the top-20 income-eligible measures. One notable difference in these results in comparison to the same table for the non-income-eligible residential-sector (Table 4) is that the Home Energy Report measure is the 9th ranked measure (while it was 1st in the non IE segments), which reflects both the smaller savings opportunity due to the lower average kWh consumption of income-eligible homes, and the additional savings opportunities from other measures and end-uses linked with the higher penetration of low-efficiency technologies currently deployed.

Table 5 Top-20 Income-eligible sector measures, as defined from the cumulative net economic potential in 2025

Rank	Income Eligible measure	GWh
1	LED Bulbs (exterior)	224
2	Advanced Power Strips[6]	176
3	LED A-Lamp (interior)	175
4	Electric Resistance to DMSHP	99
5	Thermostat Wi-Fi	84
6	Energy Star Clothes Dryer	60
7	Energy Star Refrigerator	55
8	Energy Star Clothes Washer	54
9	Home Energy Report	50
10	Whole House Fan	39
11	LED Specialty - Candelabras, Globes (Interior)	34
12	Electric furnace to ASHP	33
13	Central Air Conditioning Tune Up	27
14	Central Air Conditioning (CAC)	26
15	Freezer Recycle	19
16	Energy Star Air Purifier	19
17	LED Linear Tube	19
18	Low Flow Shower Head	15
19	Air Sealing	14
20	LED Specialty - Reflectors (Interior)	13

[6] On-device energy management has likely improved since the pre-2010 studies which form the basis of the deemed savings in the Illinois TRM, and is expected to keep improving. Lower per-unit savings could be seen, which is not accounted for in the current study.

3.2 – Non-residential Market Findings

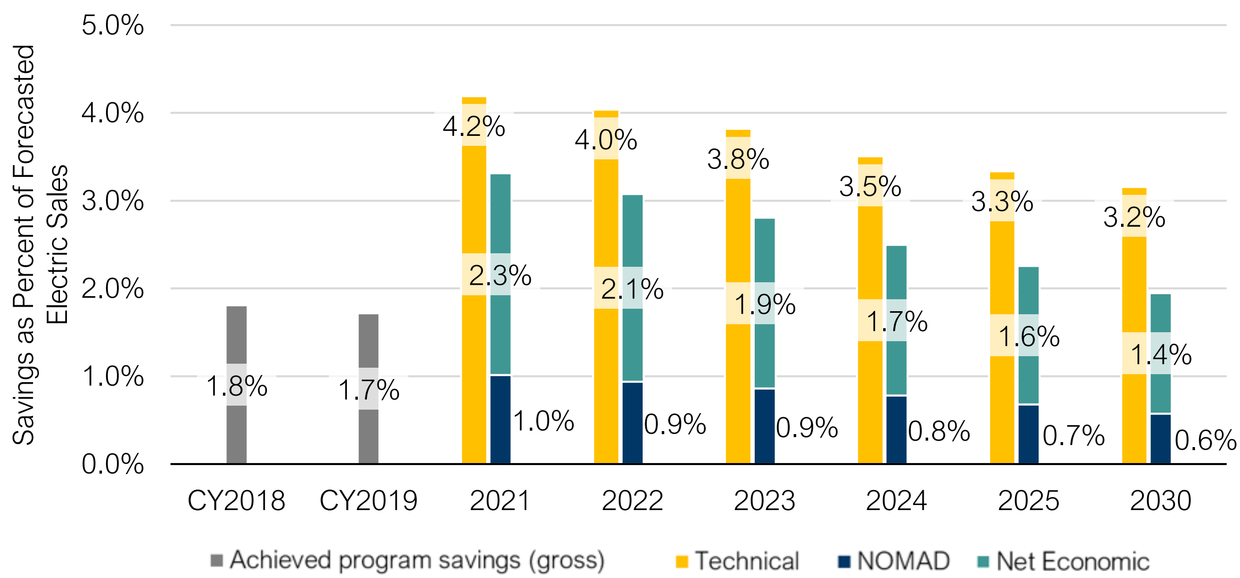
The non-residential market, which combines the commercial and industrial sectors, shows significant savings opportunities in multiple end-uses. While lighting dominates savings in the short term, the opportunity declines as LED saturation increases and HVAC becomes a close second in terms of savings opportunity in the second half of the potential study period.

Note that the industrial sector uses a different modeling approach for the current potential study, where lighting measures are characterized in Dunsky's bottom-up DEEP model, and all other industrial end-uses are modeled trough a top-down approach which is outlined in the first section of the report and explained in detail in Appendix B.

The technical, net economic and naturally occurring (NOMAD) potential for the non-residential market is shown in Figure 17 as a percent of that market's forecasted electric sales.

As in the residential sector, the actual program savings from calendar years 2018 and 2019 as well as the technical potential are shown as gross savings, and compared to the sum of the naturally-occurring adoption and the net economic potential.

Figure 17 Non-residential energy efficiency savings as percent of forecasted annual electric sales

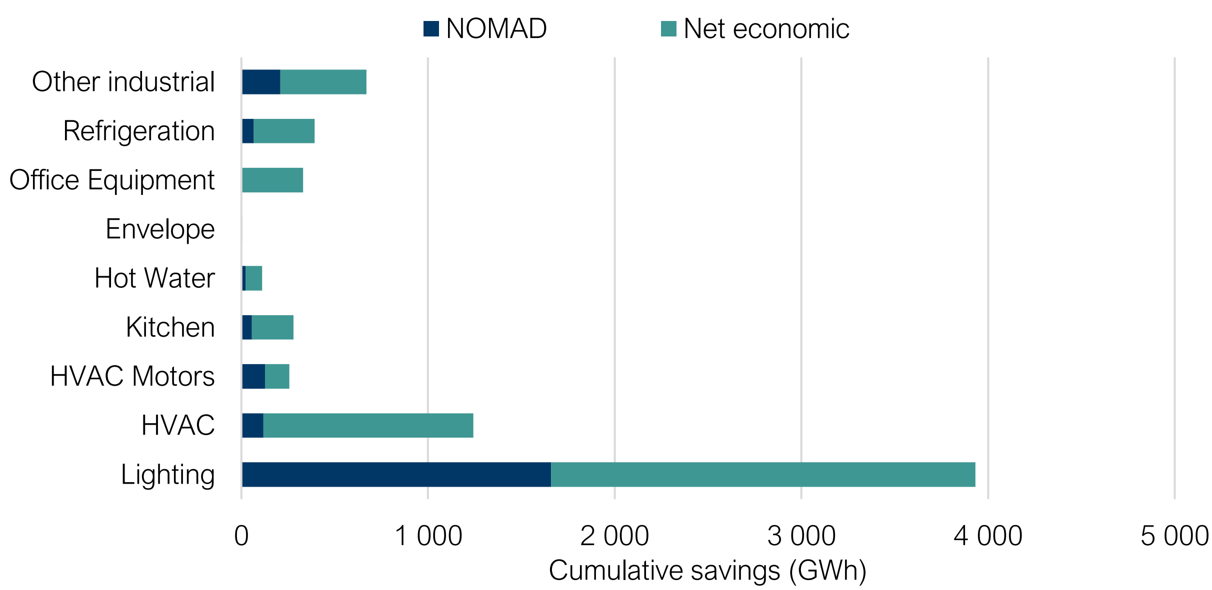


Compared to the residential sector (see Figure 10), the non-residential results show a slightly higher relative savings from CY2018 and CY2019 programs, but a similar overall technical potential. In terms of naturally-occurring and net economic potentials, the sum is somewhat comparable, as is the decline throughout the potential study period; however, natural adoption savings make up a larger portion of these savings.

Most of the natural adoption – as well as the decline in relative savings potential throughout the potential study – can be explained by the lighting end-use, as shown in the next two figures.

Figure 18 presents the NOMAD and net economic savings by end-use.

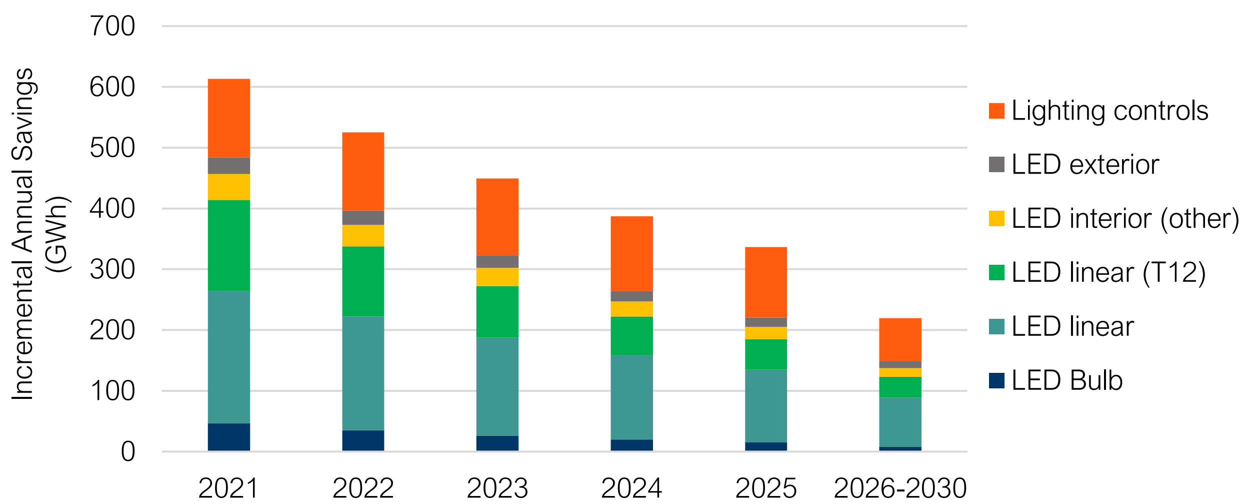
Figure 18   Non-residential net economic savings, cumulative in 2025



After lighting, HVAC motors (Variable Frequency Drives on pumps and fans) also have a high share of NOMAD savings, but they are less significant in absolute terms. All other end-uses show a smaller natural adoption, especially in the 2nd and 3rd largest end-uses in terms of economic potential, respectively the HVAC and other industrial (compressed air equipment and air leaks, industrial motors, process cooling, etc.) end-uses. These are therefore opportunities where ComEd programs can have significant impact.

Diving deeper into the lighting end-use, Figure 19 presents the non-residential lighting savings opportunities by measure type over the course of the potential study period. The results include the industrial sector, for which the lighting measures are modeled in the same bottom-up approach used for the residential and commercial sectors, though industrial segments yield less than 5% of non-residential lighting savings.

Figure 19 Non-residential net economic lighting savings over study period



The large decline in lighting savings over the course of the potential study are due to three factors:

1. The modeled decline of the market turnover rate as low-EUL bulbs and fixtures get replaced with longer-EUL variants. The decline rate for each measure-segment combination is based on the naturally-occurring adoption – in other words a no program scenario (a scenario with programs would lead to a faster pace of adoption and thus a faster market decline rate).
2. The modeled decline of the NTG ratios, which is also based on the NOMAD.
3. While bulb replacement measures are based on stock turnover rates, lighting control measures are based on a diffusion curve to smooth the opportunity over a few years, which presents a larger opportunity in the initial years and decline with time.

Additional details on these items are provided in Appendix C.

Since T12 fluorescent tube saturation is non-negligible in northern Illinois[7], T12 measures are included in the current potential study. T12s are used as the baseline for the tube "replace on burnout" measure and a dual baseline is applied for the fixture "early replacement" measure, which assumes that the fixture would be upgraded to a T8 or TLED at the end of its life, as is supported by the baseline study findings[8]. As a result, this study identifies a significant remaining savings opportunity for T12 replacements in the early years of the study.

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[7] According to the baseline study, close to 25% of all linear lighting are T12 fluorescent fixtures on average, ranging between 3 and 41% depending on segment.

[8] According to the baseline study, upon T12 ballast burnout, more than 60% would upgrade to a T5, T8 or LED fixture, with only 33% who would replace with an equivalent T12 ballast.

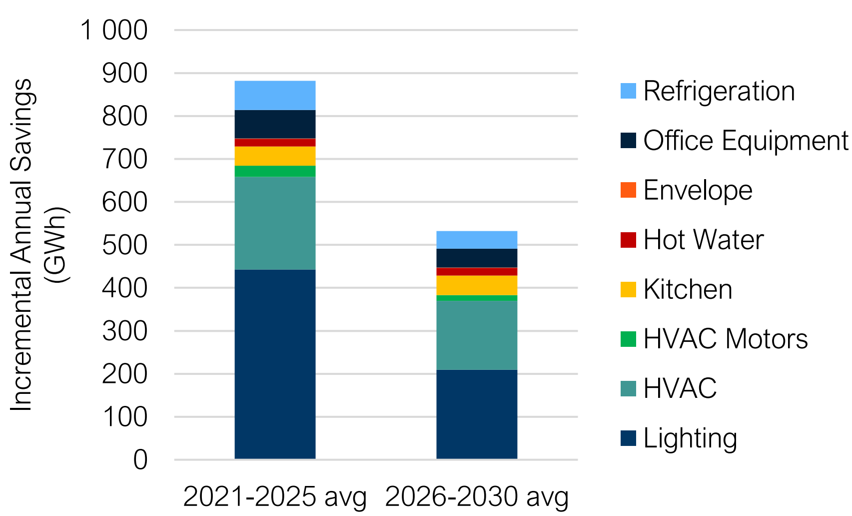
Upon closer observation, the reduction in TLED opportunities in Figure 19 slows in 2025, as compared to the rate of decline from 2021-2024. This is explained by the introduction of the high-efficiency TLED measure in the model in 2025, which carries 15% more savings per bulb than the TLED measures applied in 2021-2024.

In terms of lighting controls, the large majority of savings are related to occupancy-based controls, though Networked Lighting Controls (NLC) produce about a tenth of the economic savings opportunity. With the exception of avoided costs of water and GHGs, the Illinois TRC does not account for Non-Energy Benefits (NEB) which may constrain the NLC's cost effectiveness, considering that they carry significant NEBs, such as enhanced WIFI connectivity. Furthermore, the model considers measure chaining so that that as LED saturations increase, the lighting fixtures connected to a lighting control device have a lower connected wattage, which means that the reduction of hours of use from implementing lighting controls leads to a less significant savings opportunity. Additional detail on measure chaining is provided in Appendix A and D.

3.2.1 – Commercial Sector

In order to illustrate the market transformation around lighting in the commercial sector, Figure 20 presents the average annual incremental economic savings and compares the first half and the second half of the potential study period.

Figure 20 Commercial net economic savings by end-use

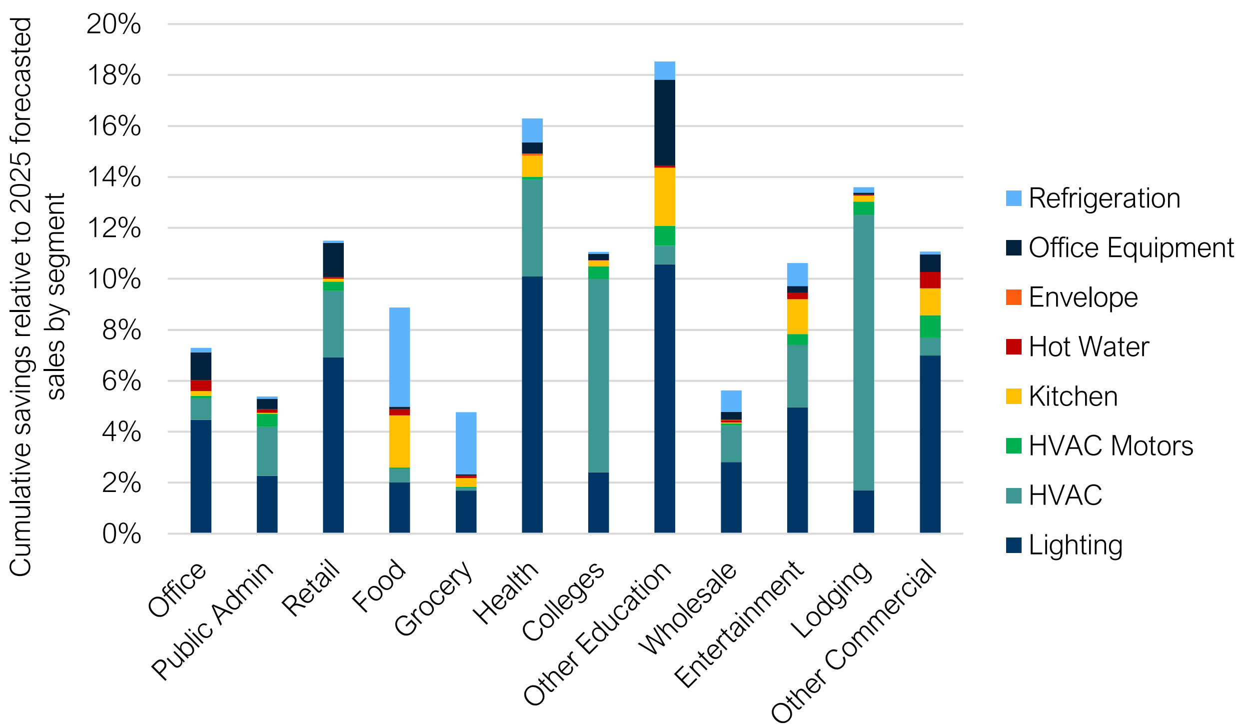


While savings are dominated by the lighting end-use in the first half, the lighting opportunity's decline (shown in Figure 19) leads to a different share in the second half of the potential study with HVAC now a close second - even considering the addition of a high-efficiency TLED measure in 2025. In addition, the commercial kitchen savings are significantly higher than in current ComEd programs.

The annual and lifetime breakdowns are not shown here as they would look almost identical due to the relatively long EUL of commercial LED tubes and fixtures as well as the absence of short-EUL behavioral savings (compared to Figure 14 for the residential sector).

Figure 21 dives deeper into the end-use breakdown by presenting savings by commercial segment relative to the 2025 baseline forecast sales by segment.

Figure 21   Commercial net economic savings by segment and end-use, relative to each segment's forecasted sales



The results show a significant difference between segments in terms of the net economic impact relative to each segment's forecasted electric sales, as well each end-use's share. These depend primarily on the segment's composition, which is reflected by the detailed baseline study data and TRM inputs (general building characteristics and equipment used, hours of use, energy conservation measures already implemented, etc.). In terms of absolute savings opportunity by segment shown in Figure 22 below, the results are different in that they reflect each segment's total number of buildings, average square feet of conditioned space and energy use intensity.

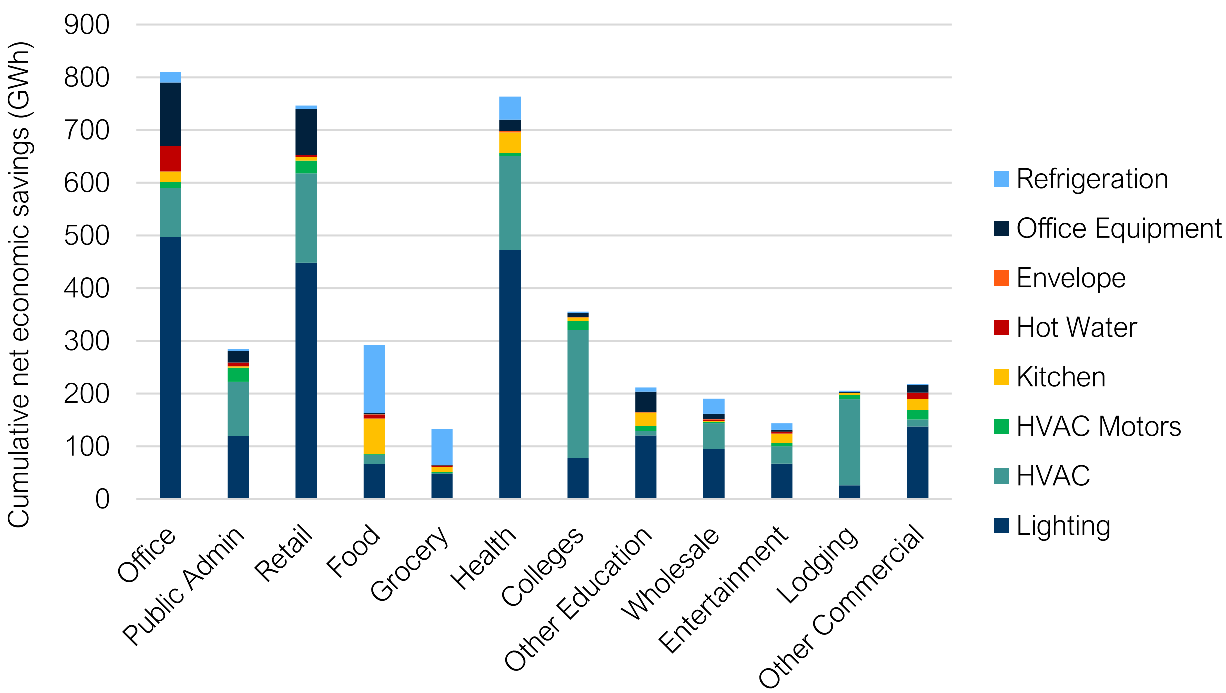
There is a significant lighting opportunity in some segments, especially in the Retail, Health, Other education (elementary and high schools) and Other commercial segments. These reflect the combined impact of the LED saturations, the lighting densities from baseline study results as well as the hours of use from the TRM inputs.

HVAC savings are largely related to the portion of electric heating in each segment, especially in the lodging sector where baseline study results show a 92% electricity fuel share of space heating – other segments are below 5% except for the Health and Wholesale segments at 24% and 8% respectively. The high HVAC savings in the College segment can be explained by its comparatively large number of sites above 250,000 ft^2, which makes it a unique opportunity for retro-commissioning (RCx) and Strategic Energy Management (SEM).

Comparing the Office and Public Administration segments, which are both office buildings but for private businesses and government services respectively, the difference in lighting opportunities (significantly higher in Office than in Public Administration) can be explained by the fixture density, which is about twice as high in Public Administration buildings compared to Office buildings. In terms of HVAC savings, the higher Energy Use Intensity (EUI) of Public Administration buildings leads to a significant RCx and SEM opportunity, whereas that measure does not pass the TRC economic screening for the Office segment.[9]

Figure 22 presents the absolute savings in each commercial segment, which shows that three segments dominate the net economic potential: Office, Retail and Health.

Figure 22   Commercial net economic savings in 2025 by segment and end-use



[9] While the electric energy use intensities from the baseline study prevents this measure from passing the cost-effectiveness screening for some segments, it should be noted that such a measure should be cost-effective for most segments. The baseline study results were not altered in order to keep consistency.

Table 6 below lists the top-20 measures for the commercial sector. It should be noted that as with most results in the current potential study, this list is based on the net economic potential, which excludes market barriers and customer adoption curves. Moreover, in the case of measures which compete for the same market, the economic potential by definition assumes that the highest-saving measure captures the whole market (i.e. if LED luminaires are competing with LED linear tubes for the same market, the one with the highest unit savings will capture the entire market, for example).

Table 6 Top-20 Commercial sector measures, as defined from the cumulative net economic potential in 2025

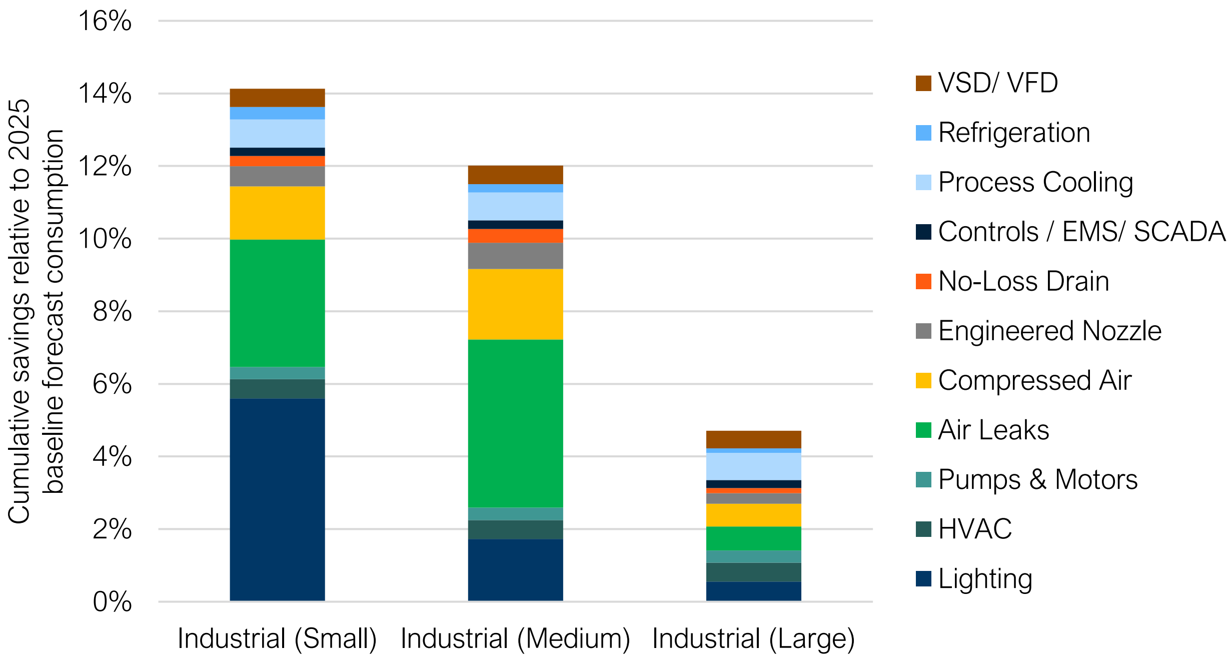
Rank	Commercial measure	GWh
1	LED Linear Luminaire	788
2	Retro-commissioning Strategic Energy Manager (RCx SEM)	511
3	Lighting Controls (Occupancy)	364
4	Advanced Power Strips	318
5	LED T12 Linear Tube	307
6	Refrigeration Economizers	219
7	Lighting Controls (Dual Occupancy & Daylight Sensors)	173
8	Energy Management System (EMS)	164
9	LED T12 Linear Luminaire	149
10	Air Source Heat Pumps (ASHP)	130
11	Hot Food Holding Cabinet	90
12	Absorbent Air Cleaner	85
13	LED Parking Garage (Exterior)	85
14	HVAC VFD - Fan	84
15	Water Heater - Heat Pump Water Heater (HPWH)	75
16	LED High Bay	74
17	LED A-Lamp (Interior)	72
18	LED Exit Sign	71
19	Lighting Controls (Network)	60
20	Steamer	54

3.2.2 – Industrial Sector

As discussed in the Chapter 1, the industrial sector's economic savings opportunity is established by bundling together lighting end-use results from the DEEP model (assessed via a bottom-up approach, as per the results in other sectors) and the results of a top-down analysis conducted outside of the model for all other industrial segment end-uses (approach described in Appendix B).

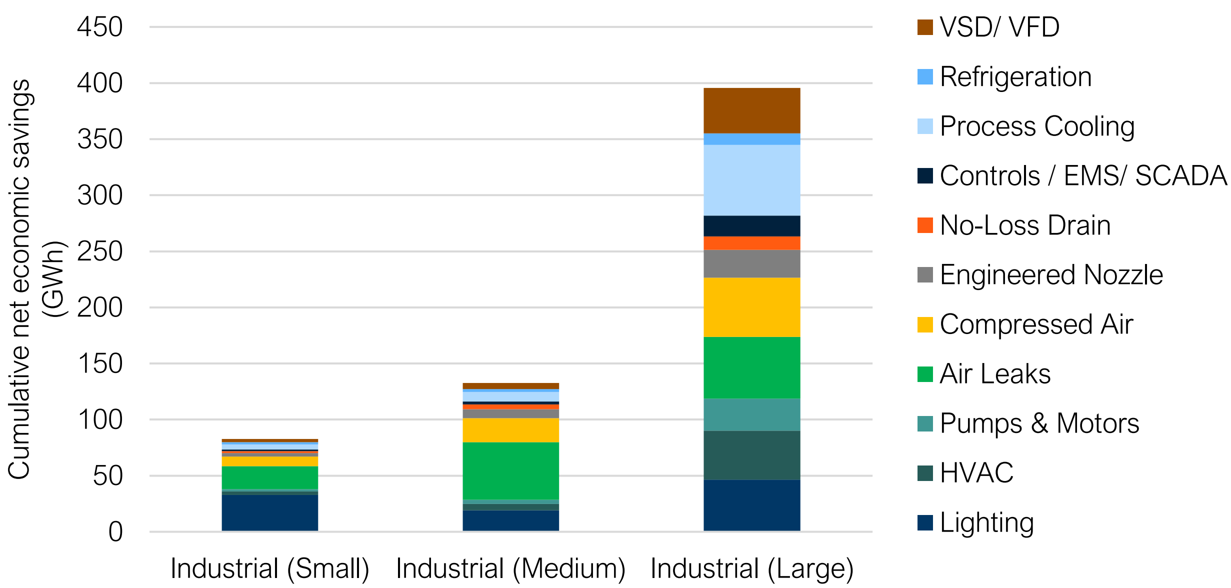
The resulting cumulative net economic savings potential is provided in Figure 23. Similar to the commercial sector, savings are presented by industrial segment relative to the 2025 forecasted sales by segment.

Figure 23 Industrial net economic savings in 2025 by segment and end-use, relative to each segment's forecasted sales



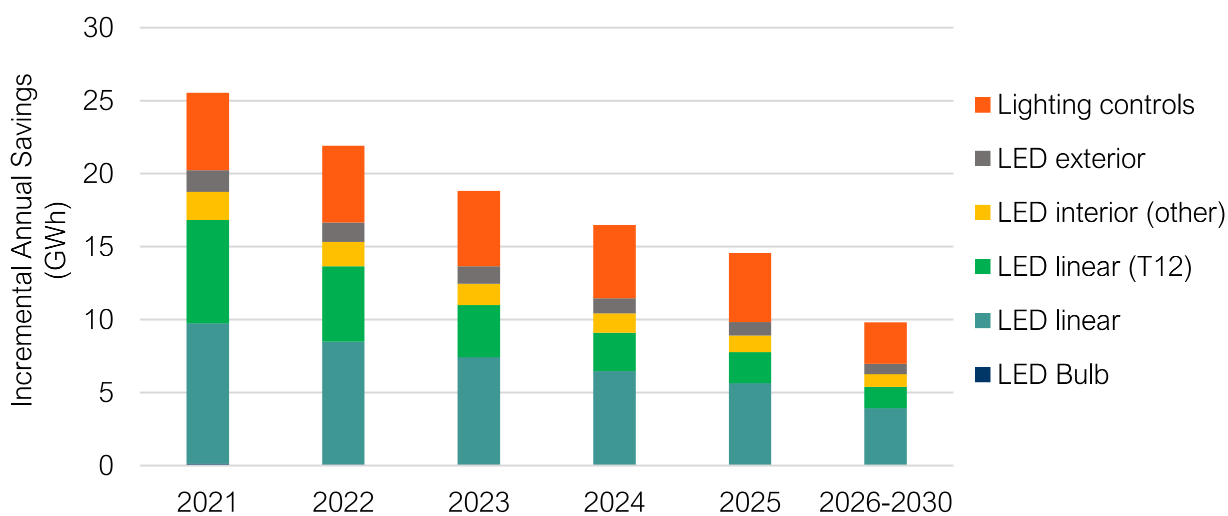
The results show that while the absolute savings opportunity is larger for the high-consumption industrial segment (Figure 24), the opportunity relative to each segment's forecasted sales (Figure 23) is higher for the smaller-consumption segments. For the Small and Medium industrial segments, that is largely due to the lighting opportunity, while the relative portion of savings from the Compressed Air and Air Leaks end-uses are larger for the Medium segment, which reflects the composition of the segments by type of industrial facility.

Figure 24   Industrial net economic savings in 2025 by segment and end-use



Diving deeper into the lighting end-use, Figure 25 presents the non-residential lighting savings opportunities by measure type over the course of the potential study period.

Figure 25   Industrial net economic lighting savings over study period



Compared to the equivalent representation for all non-residential segments (Figure 19), trends look fairly similar, with the exception of LED bulbs for which there is a negligible savings opportunity in industrial sites.

Detailed results for all other end-uses are presented in the next sub-section.

3.2.2.1 – Detailed Top-down Results

In this sub-section, the results of the top-down modeling of industrial custom potential are summarized and benchmarked against total industrial load and recent program accomplishments.

Table 7 shows the total estimate of max cumulative program business as usual (BAU) and gross economic potential, in GWh, by project type as well as by customer size. That potential is a snapshot estimate that does not yet take into account the annualization of that potential to determine the annual potential. While the achievable potential is not in the scope of the current potential study, program BAU potential is shown in this section as it is used to define the economic potential. The top-down approach is described in detail in Appendix B.

Table 7 Max cumulative Business as Usual and Gross Economic Potential by Project Type and Customer Size

Analysis Segmentation	Max Cumulative Gross Economic Potential (GWh)	Max Cumulative Program BAU Potential (GWh)
Custom Project Type:		
Air Leaks	190	95
Compressed Air	322	161
Engineered Nozzle	161	81
No-Loss Drain	53	27
Controls	134	67
Process Cooling	342	171
HVAC	314	157
Pumps & Motors	256	128
Refrigeration	88	44
VSD/VFD	220	110
Customer Size:		
<100 kW	170	85
100-400 kW	365	182
>400 kW	1,545	772
Total (GWh)	**2,080**	**1,040**
Total (as % of total industrial load)	*25%*	*13%*
Total (as % of PY4-PY9 verified gross savings)	*622%*	*311%*

As Table 7 shows, the max cumulative program BAU potential for ComEd's industrial custom programs (excluding lighting) is estimated to be 1,040 GWh, with max cumulative economic potential estimated to be 2,080 GWh. To provide a frame of reference to better interpret these results, Table 7 also expresses these total potential savings as a percentage of total industrial load and the cumulative verified gross savings from ComEd's Custom and Industrial Systems programs since Program Year 4 (PY4).

Projects involving compressed air systems (Air Leaks, Compressed Air, Engineered Nozzle, and No-Loss Drain) account for just over a third of max cumulative program BAU and economic potential, followed by Process Cooling, HVAC, Pumps & Motors, and Variable Speed/Frequency Drives (VSD/VFD) projects.

By customer size, max cumulative program BAU and economic potential are heavily concentrated among large customers (>400 kW). However, it is worth pointing out that small (<100 kW) and medium (100-400 kW) size customers account for larger shares of max cumulative program BAU and economic potential relative to their respective shares of total industrial load – 8.5% vs 5.8% for small customers, and 18.2% vs 10.9% for medium customers. This result is consistent with the fact that participation in ComEd's Custom and Industrial Systems programs to date has been dominated by large industrial customers, with very little participation from small and medium size industrial customers.

Table 8 shows the annualized estimates of max program BAU potential by project type and customer size. Results are shown in gross savings and then split between *free-riders* and *net savings* terms. Again, net savings (identified at the bottom of the table) are estimated by applying the historical average NTG ratio from ComEd's custom and Industrial Systems programs (0.67). To provide a frame of reference to better interpret these results, the table also expresses these annualized results as a percentage of total industrial load and the PY9 verified gross savings from ComEd's custom and Industrial Systems programs.

The estimated annual max program BAU gross savings potential is equivalent to just over 1% of total industrial load and 120% of PY9 verified gross savings – a result that is consistent with the "program max BAU" framing. However, it is important to point out that Table 8 also shows that annual max BAU potential is much more uniformly distributed than cumulative max BAU potential and past program history, with small industrial customers accounting for just over 10%, medium size customers 25%, and large customers 65%. In turn, this result implies that ComEd will need to target and capture significantly more program savings from small and medium size industrial customers than in years past.

Table 8 Annualized Max BAU Potential by Project Type and Customer Size

Analysis Segmentation	Annual Economic Potential (GWh)	Annual Program Max BAU Potential (GWh)
Custom Project Type:		
Air Leaks	63.3	31.6
Compressed Air	24.8	12.4
Engineered Nozzle	10.8	5.4
No-Loss Drain	5.3	2.7
Controls	6.7	3.3
Process Cooling	22.8	11.4
HVAC	15.7	7.9
Pumps & Motors	10.2	5.1
Refrigeration	4.4	2.2
VSD/VFD	14.7	7.3
Customer Size:		
<100 kW	19.0	9.5
100-400 kW	44.2	22.1
>400 kW	115.4	57.7
Total Gross Savings (GWh)	178.6	89.3
Total Free Riders (GWh)	59.2	29.6
Total Net Savings (GWh)	119.4	59.7
Total Gross Savings (as % of PY9 verified gross savings)	*240%*	*120%*
Total Gross Savings (as % of total industrial load)	*2.16%*	*1.08%*

4. Conclusion and Implications for ComEd Programs

The trends in net economic opportunities assessed in this potential study offer insights for future ComEd DSM programs. First and foremost, while similar performance could be seen in the past between the residential and non-residential programs, this study's results indicate that **residential savings are declining at a increasing rate over the study period, but that they may be partially replaced growing by commercial opportunities.**

The current study looks at the market opportunities in the absence of the Energy Independence and Security Act (EISA) lighting standards at ComEd's request. Another key trend is that lighting savings are declining but remain the most significant opportunity in both sectors in the first 5 years (2021-2025). The rate of decline used in the current study reflects the naturally-occurring opportunity in the absence of programs, so it is likely that programs will accelerate the pace of the market transformation. **To the degree that lighting programs are generous and aggressive, more savings could be realized sooner, possibly exhausting most of the opportunity by 2025.**

4.1 – Residential & Income-Eligible Programs

Focusing on lighting, while potential savings related to exterior sockets are substantial, they are linked to the Illinois Technical Reference Manual's (TRM's) hours of use assumption, which is significantly higher than for interior bulbs, and may not be fully representative of many real-world applications. **Programs could focus on combined exterior fixture and controls measures in order to maximise savings.**

While fuel-switching is not included in the study's scope, multiple heat pump measures are modeled in order to account for both the opportunity related to adding a standard-efficiency heat pump to replace electric resistance heating in homes, and the selection of a higher-efficiency model whenever a household chooses to replace or add a heat pump. **Even if the current penetration of electric heating is low in ComEd's service territory, heat pump savings remain a significant opportunity, especially when incorporating mini-split ductless heat pumps.**

Home Energy Reports still have significant potential to deliver savings and there is an opportunity to expand their impact. However, while it remains a top residential and income-eligible measure, lifetime savings are comparatively lower than other measures and the persistence of those savings should be closely tracked. **Programs should therefore keep tracking the performance and cost effectiveness of behavioral measures**, especially since the TRC ratio in some segments is very close to 1.0.

Finally, energy-efficient residential appliances are also a significant opportunity and should remain a focus of ComEd's residential programs.

4.2 – Commercial & Industrial Programs

In terms of commercial savings, lighting remains the largest opportunity. In a transforming market with declining opportunities, **the program's role is to encourage the adoption of state of the art LED technologies**, which are expected to continue to improve over the study period as higher efficiency linear LEDs become available, as well as reducing their operating hours through lighting control strategies. This will generate persistent savings over the long-term as LEDs have relatively long EULs and as such will remain in place for years. In addition, as the current penetration of T12 fluorescent tubes is likely linked with non-economic barriers to market adoption, **programs should consider focussing on barrier-reducing enabling strategies, such as direct install approaches that replace the entire lighting fixture in order to prevent customers from reverting back to T12 fluorescent tubes**.

As lighting opportunities decline and the market transforms, **efficient HVAC technologies may offer a new program focus, with measures related to building controls and optimization providing the largest savings opportunity**. These include Retro-commissioning, Strategic Energy Management and Energy Management Systems.

Future programs should also consider increasing their focus on kitchen equipment, which shows a significantly higher opportunity compared to past program performance.

As three commercial segments dominate the other nine in terms of savings opportunity, **programs and strategies that are tuned to meet the need of Office, Retail, and Healthcare customers could help to improve program performance**.

In terms of industrial opportunities, while participation in ComEd's Custom and Industrial Systems programs has largely been dominated by large industrial customers, **a significant untapped opportunity remains in the small and medium size industrial customers**, particularly for **projects involving compressed air systems**. While compressed air is also a significant opportunity for large customers, this segment shows a significant **emerging opportunity in energy management and systems & process controls, which should be considered as a focus area in ComEd's industrial programs**.

Commonwealth Edison Energy Efficiency Potential Study:

A Comprehensive Assessment of 2021-2030 Net Economic Opportunities

Volume II: Appendices

Submitted to:

Commonwealth Edison

https://www.comed.com/

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About Dunsky

Dunsky provides strategic analysis and counsel in the areas of energy efficiency, renewable energy and clean mobility. We support our clients – governments, utilities and others – through three key services: we **assess** opportunities (technical, economic, market); **design** strategies (programs, plans, policies); and **evaluate** performance (with a view to continuous improvement).

Dunsky's 30+ experts are wholly dedicated to helping our clients accelerate the clean energy transition, effectively and responsibly.

EXPERTISE

Efficiency — Renewables — Mobility

SERVICES

Assess Opportunities — Design Strategies — Evaluate Performance

Preface

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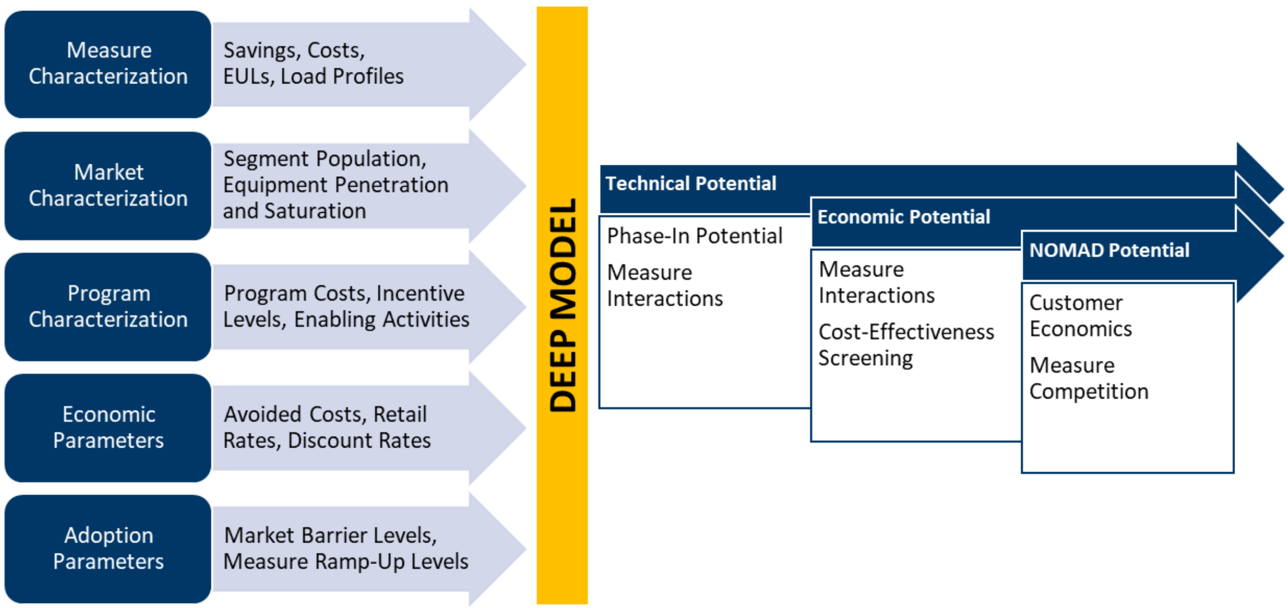
Appendix A – DEEP Modelling Methodology

1 Overview

The Economic potential for energy efficiency was estimated using the Demand and Energy Efficiency Potential (DEEP) model. DEEP employs a multi-step process to develop a bottom-up assessment of the technical, economic and naturally occurring potentials. This appendix describes DEEP's modeling approach, the process of developing DEEP model inputs and the underlying calculations employed to assess energy efficiency potential.

Figure A-1. DEEP Model



2 The Demand and Energy Efficiency Potential Model

DEEP's bottom-up modelling approach assesses thousands of "measure-market" combinations to assess energy savings potentials across multiple scenarios. Rather than estimating potentials based on the portion of each end-use that can be reduced by energy saving measures and strategies (often referred to as a "top-down" analysis), the DEEP's approach applies a highly granular calculation methodology to assess the energy savings opportunity for each measure-market segment opportunity in each year. Key features of this assessment include:

- Measure-Market Combinations: Energy saving measures are applied on a segment-by-segment basis using segment-specific equipment saturations, utility customer counts, and demographic data to create unique segment-specific "markets" for each individual measure. The measure's impact and market size are unique for each measure-market segment combination, which increases the accuracy of the results.

- **Phase-In Potential:** DEEP assesses the phase-in technical, economic, and naturally occurring potential by applying a measure's expected useful life (EUL) and market growth factors to determine the number of energy savings opportunities for each measure-market combination each year. This provides an important time series for each energy savings measure upon which estimated phase-in technical and economic potentials can be calculated in the model, as well as the naturally occurring annual measure uptake volumes (measure counts and savings).

- **Annual and Cumulative Savings:** For each measure-market combination in each year, DEEP calculates the annual and cumulative potential savings accounting for mid-life baseline adjustments and measure lifespans where appropriate.[1] This provides a read on the cumulative technical, economic and naturally occurring savings potential, as well as the annual technical and economic opportunities that could be available to pass through DSM portfolios.

3 DEEP Model Inputs

DEEP requires an extensive set of model inputs related to energy savings measures, markets, economic factors, and adoption parameters to accurately assess energy efficiency potential. These inputs are developed through several concurrent processes that include measure characterization, market characterization, economic parameter development and adoption parameter development. The remainder of this section outlines each process.

3.1 – Measure Characterization

Measure characterization is the process of determining the costs, savings, and lifetimes of potential energy-saving technologies and services and their baseline equivalents that will then be used as inputs to the DEEP model. The measure characterization process begins by developing a comprehensive list of energy saving measures.

In this study, an initial measure list was proposed based on the full range of existing measures in ComEd's programs as well as a number of emerging opportunities. Measures were limited to currently commercially viable options, and those that may become commercially viable over the study period (based on Dunsky's professional experience). In some cases, Dunsky excluded measures that were highly unlikely to pass the Technical Resource Cost (TRC) test over the study period due to relatively low savings and/or high incremental costs or extremely low market penetration due to existing baselines. The measure list was vetted and approved by ComEd and finalized prior to measure characterization. The final measure list represents more than 1,900 measure-market combinations, representing the full range of commercially available technologies – current and emerging. Appendix D provides the full measure list.

[1] Mid-life baseline adjustments are required for early retirement measures after the useful life of the existing equipment expires and new equipment (at a more efficient baseline) would have been purchased. Measure lives are also taken into account to determine when an efficient measure is adopted to replace a previously installed efficient measure at the end of its life, which results in *annual* savings but no additional *cumulative* savings.

Measure characterization is accomplished by compiling primary and secondary data (as available) on the efficient and baseline (e.g. non-efficient) energy-consuming equipment available in a given jurisdiction. Measures are characterized using segment-specific inputs, where available, yielding segment specific characterizations for each measure-market combination.

Measures are characterized in terms of their **market unit** such as savings per widget, savings per square foot, or savings per ton of cooling capacity. Each measure in the measure list was characterized by defining a range of specific parameters. Table A-1 describes these parameters.

Table A-1. DEEP Measure Characterization Parameters

Parameter	Description
Market unit	The unit in which the measure is characterized and applied to the market (e.g. per widget, per building, per square foot, etc.)
Measure type	The measure type, which can be at least one of the following: • Replace on Burnout • Early Replacement • Additional Measures • New Construction/Installation
Annual gross savings	The annual gross savings of the measure per market unit in terms of both energy (kWh), demand (kW) and other factors (e.g. water, secondary fuels etc.) as applicable
Measure costs	The incremental cost of the measure (e.g. the difference in cost between the baseline technology and the efficient technology)
Measure life	The effective useful life (EUL) and/or remaining useful life (RUL) of both the efficient measure and the baseline technology
Impact factors	Any factors affecting the attribution of gross savings including net-to-gross adjustments, in-service factors, persistence factors and realization rates.
Load factors	Any factors affecting modulating gross savings, includes summer and winter peak coincidence factors as well as seasonal savings distributions.

This study characterized measures using inputs from the Illinois Technical Resource Manual (TRM)[2] when supporting entries were present and deemed applicable to the study. In cases where IL TRM entries were not available, judged to be less accurate than alternative approaches, or did not account for segment by segment variations, measures were characterized using other best in class TRMs from other jurisdictions.

[2] The 2020 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 8.0 was applied to characterize the majority of measures in this study. A detailed list of the assumptions applied for each measure is provided in Appendix D.

Measure Diffusion

DEEP incorporates four measure diffusion schedules – replace on burnout, early replacement, equipment additions, and new construction/installation. DEEP treats each of these measure types differently in determining the maximum annual market available for phase-in potential. Table A-2 provides a guide as to how each measure type is defined and how the replacement or installation schedule is applied within the study to assess the phase-in potentials each year.

Table A-2. DEEP Measure Type Descriptions

Measure Type	Description	Yearly Units Calculation
Replace on Burnout (ROB)	An existing unit is replaced by an efficient unit after the existing unit fails. *Example: Replacing burned out bulbs with LEDs*	The eligible market is the number of existing units divided by EUL.[3]
Early Replacement (ER)[4]	An existing unit is replaced by an efficient unit before the existing unit fails. These measures are generally limited to measures where savings are sufficient enough to motivate a customer to replace existing equipment earlier than its expected lifespan. *Example: Replacing a functional, but inefficient, furnace*	The eligible market is assumed to be a subset of the number of existing units based on a function of the equipment's EUL and remaining useful life (RUL), and applying a diffusion S-curve.
Equipment Addition (ADD)	A measure is applied to existing equipment or structures and treated as a discretionary decision that can be implemented at any moment in time. *Example: Adding controls to existing lighting systems, adding insulation to existing buildings*	The eligible market is distributed over the estimated useful life of the measure using a diffusion S-curve function.
New Construction/ Installation (NEW)	A measure that is not related to existing equipment. *Example: Installing a heat-pump in a newly constructed building.*	The eligible market is measure-specific and defined as new units per year.

In this study, only a small number of measures were characterized as early replacement measures. In general, early replacement measures are limited to those where energy savings are sufficient to motivate a customer to replace existing equipment significantly before the end of its expected useful life. This is generally limited to measures with long EULs and a large difference between existing installed efficiency

[3] The EUL is set at a minimum of 3 years to spread installations over the potential study period. Note: Home Energy Reports are a special case with an EUL of one year (further discussion of this measure can be found in Appendix D)

[4] Early replacement measures are limited to measures where energy savings are sufficient enough to motivate a customer to replace existing equipment prior to the end of its expected lifespan.

and baseline efficiencies for new equipment (e.g. T12 linear lights) as the early replacement of these measures will create significant additional savings through the early retirement of particularly inefficient equipment. While current ComEd programs may incentivize customers to replace equipment before it actually ceases to function or maintenance costs become excessive, the exclusion of these measures in the model will not impact overall savings estimates as the model is calibrated to the savings currently procured through the existing market turnover.

3.2 – Market Characterization

Market characterization is the process of defining the size of the **market** available for each characterized measure. Primary and secondary data are compiled to establish a **market multiplier**, which is an assessment of the market baseline that details the current penetration (e.g. the number of lightbulbs) of energy-using equipment and saturation of energy efficiency equipment (e.g. the percentage of lightbulbs that are LEDs) in each market sector and segment. The market multiplier is applied to each market segment's **population** to establish each measure's market. The market multiplier can be understood as the average number of opportunities per customer within the market segment in terms of the measure's market unit.

This study characterized markets by leveraging anonymized ComEd customer data and the 2019 baseline study data gathered across ComEd's customer base in conjunction with this assessment of economic potential. When ComEd-specific baseline data was not available (or was based on a low number of observations), baseline data from neighbouring jurisdictions in the Midwest United States were leveraged and adjusted for Illinois specific attributes wherever possible.

3.3 – Economic Parameter Development

DEEP harnesses key economic parameters such as avoided costs, retail energy rates, and discount rates to assess measure cost-effectiveness and customer adoption. Appendix D outlines the development of these inputs.

3.4 – Program Inputs for Model Calibration

Recent program results are used to calibrate the model and ensure that the model settings are reflective of the local market conditions. To accomplish this, a set of program inputs were characterized to represent the DSM strategies applied in ComEd programs. Program inputs generated for the calibration process include:

- **Incentives** are the portion of the measure's incremental costs that are covered by the program. Incentive levels vary by program scenario.
- **Enabling activities** are strategies employed by programs to reduce market barriers (e.g. effective marketing and delivery processes, contractor training, etc.).

This study characterized programs through an extensive review of ComEd's 2020 Energy Efficiency Plan, and the 2018 and 2019 program year impacts, as well as through conversations with ComEd's program specialists to develop initial estimates of program costs, incentives, and enabling activities. Appendix D provides more information on the specific program inputs applied for the model calibration.

4 Assess Potential

Using the comprehensive set of model inputs for this study, DEEP assesses three levels of energy savings potential: technical, economic, and naturally occurring market adoption (NOMAD). In each case, these levels are defined based on the governing regulations and practice in the modeled jurisdiction, such as applying the appropriate cost-effectiveness tests, and applying the relevant benefit streams. Table A-3 provides a summary of how DEEP treats each potential type.

Table A-3. DEEP Treatment of Technical, Economic, and Achievable Potential

	Technical Potential	Economic Potential	NOMAD*
Measure Interactions	Chaining	Chaining	Chaining
Economic Screening	n/a	TRC cost-effectiveness	No screening
Market Barriers	No Barriers	No Barriers	Adoption Curves
Competing Measures	Winner takes all (most efficient)	Winner takes all (most efficient)	Competition Groups
Net Savings	Gross	Net of free-ridership	Gross

* Naturally Occurring Market Adoption

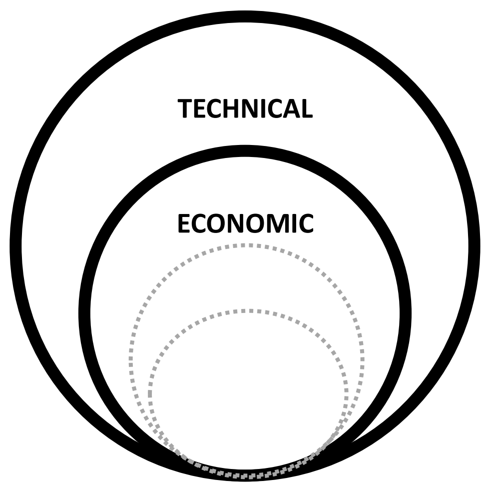
For each level of potential, DEEP calculates annual and cumulative potential:

- **Annual potential** is the incremental savings attributable to program activities in the study year. It includes the re-installation of measures (e.g. when a new LED lightbulb is needed to replace a burnt-out LED lightbulb previously counted in the cumulative potential). This is the most appropriate measure for annual DSM program planning.

- **Cumulative potential** is the total savings from the beginning of the study period to the relevant study year. It accounts for mid-life baseline adjustments to measures implemented in previous years, as well as the retirement of savings for measures reaching their end of life. As such it does not include new savings for re-installed measures that had been accounted for earlier in the study period, thereby providing an assessment of the cumulative potential impact of the measures (e.g. the reduction in energy sales). This is the most appropriate measure for resource planning and is similar to Illinois' Cumulative Persisting Annual Savings (CPAS).

4.1 – Technical and Economic Potential

Technical potential is all theoretically possible energy savings stemming from the applied measures. Technical potential is assessed by combining measure and market characterizations to determine the maximum amount of savings possible for each measure-market combination without any constraints such as cost-effectiveness screening, market barriers, or customer economics. The Phase-in technical potential is calculated for each year in the study period.



DEEP's calculation of technical potential accounts for markets where multiple measures compete. In these instances, the measure procuring the greatest energy savings is selected while all other measures are excluded to avoid double counting energy savings while maximizing overall technical energy savings (see description of measure competition below for additional detail).

Additionally, the calculation of technical potential also accounts for measures that interact and impact the savings potential of other measures (see description of measure interactions below for additional detail).

Mid-Life Baseline Adjustments

Where a new standard may alter the baseline of a measure before the end of its EUL, the model removes a portion of the savings for previously installed measures from the cumulative savings for that measure. The amount removed is equivalent to the difference between the baselines, which may represent all or just a portion of the previously installed measure's cumulative savings.

Economic potential is a subset of technical potential that only includes measures that pass cost-effectiveness screening. Economic screening is performed at the measure level and only includes costs related to the measure. All benefits and costs applied in the cost-effectiveness screening are multiplied by their corresponding cumulative discounted avoided costs to derive a present value ($) of lifetime benefits. All benefits and costs are adjusted to real dollars expressed in the first year of the study. Economic screening does not include general program costs.

Like technical potential, the calculation of economic potential also accounts for measure competition and interaction. However, in this study, the Economic potential includes only the savings that are net of NOMAD, and thus represent the portion of the cost-effective savings that are available to ComEd DSM programs.

This study screened measures based on the Illinois TRC test as defined in the Illinois Power Agency Act (see 20 ILCS 3855/1-10)[5] as follows:

> *'Total resource cost test' or 'TRC test' means a standard that is met if, for an investment in energy efficiency or demand-response measures, the benefit-cost ratio is greater than one. The benefit-cost ratio is the ratio of the net present value of the total benefits of the program to the net present value of the total costs as calculated over the lifetime of the measures. A total resource cost test compares the sum of avoided electric utility costs, representing the benefits that accrue to the system and the participant in the delivery of those efficiency measures, as well as other quantifiable societal benefits, including avoided natural gas utility costs, to the sum of all incremental costs of end-use measures that are implemented due to the program (including both utility and participant contributions), plus costs to administer, deliver, and evaluate each demand-side program, to quantify the net savings obtained by substituting the demand-side program for supply resources. In calculating avoided costs of power and energy that an electric utility would otherwise have had to acquire, reasonable estimates shall be included of financial costs likely to be imposed by future regulations and legislation on emissions of greenhouse gases.*

The IL TRC test consists of multiple benefit and cost streams, which were treated and aggregated for use in the DEEP model. The description of these inputs can be found in Appendix D. Measures that did not pass the IL TRC test were excluded from economic potential.

[5] Section 1-10 Definitions of the Illinois Power Agency Act: http://www.ilga.gov/legislation/ilcs/fulltext.asp?DocName=002038550K1-10

DEEP's Phase-In Potential

DEEP assesses potential on an annual phased-in basis. The model assumes that the most efficient measures are not eligible for deployment until the existing equipment it replaces reaches the end of its useful life or becomes a viable early replacement measure. This limits the number of opportunities available for efficiency upgrades each year. For this reason, technical and economic potential will increase each year of the study as more baseline equipment is eligible for replacement.

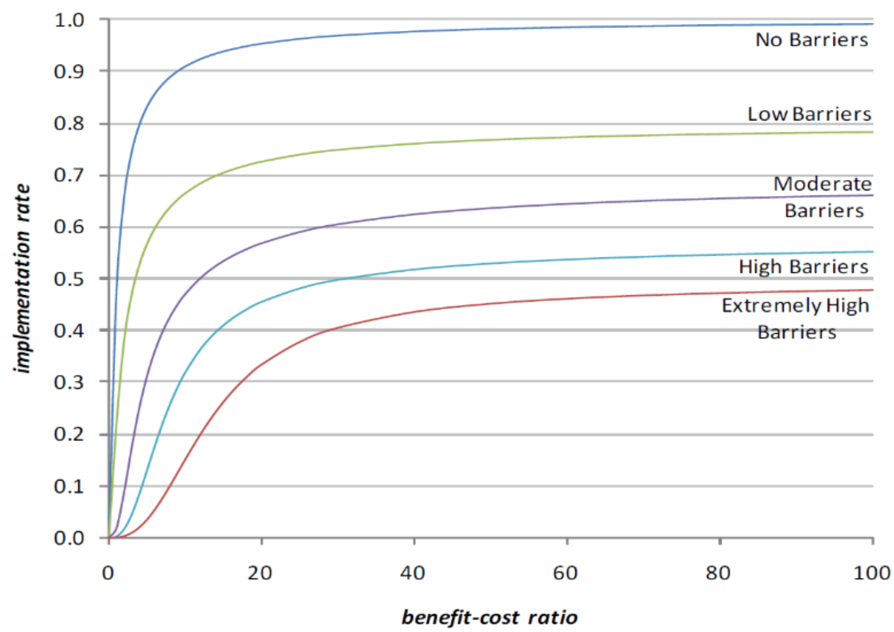
4.2 – Naturally Occurring Market Adoption Potential (NOMAD)

NOMAD represents the energy savings stemming from the customer adoption of energy-savings measures in the absence of utility programs. Rooted in the United States' Department of Energy (U.S. DOE) adoption curves,[6] DEEP defines annual adoption rates based on a combination of customer cost-effectiveness and market barrier levels. Customer cost-effectiveness is calculated within the model based on inputs from measure and program characterization as well as economic and adoption parameters. Figure A-2 displays a representative example of the resulting adoption curves.

While this methodology is rooted in the U.S. DOE's extensive work on adoption curves, it applies an important refinement related to the **choice of the cost-benefit criteria.** The DOE model assumes that participants make their decisions based on a benefit-cost ratio calculated using discounted values. While this may be true for a select number of large, more sophisticated customers, experience shows that most consumers use simpler estimates, including simple payback periods. This has implications for the choice and adoption of measures since payback period ignores the time value of money as well as savings after the break-even point. The model converts DOE's discount rate-driven curves to equivalent curves for payback periods and applies simple and discounted payback periods based on sector. Generally, DEEP assumes residential customers assess cost-effectiveness by considering a measure's simple payback period, while commercial customers assess cost-effectiveness by considering a discounted payback period.

[6] The USDOE uses this model in several regulatory impact analyses. An example can be found in https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217 , section 17-A.4.

Figure A-2. Representative Example of Adoption Curves



Market barrier levels are assigned for each measure-market combination based on market research and professional experience. Barrier levels were set based on consideration of technology factors (i.e. ease of installation), and market factors (i.e. the investment decision-making processes and thresholds in various market segments). Different end-uses and segments exhibit different barriers, and barrier levels may change over time if market transformation effects are anticipated. The market barrier levels determine the adoption curve applied in the NOMAD assessment for a given measure.

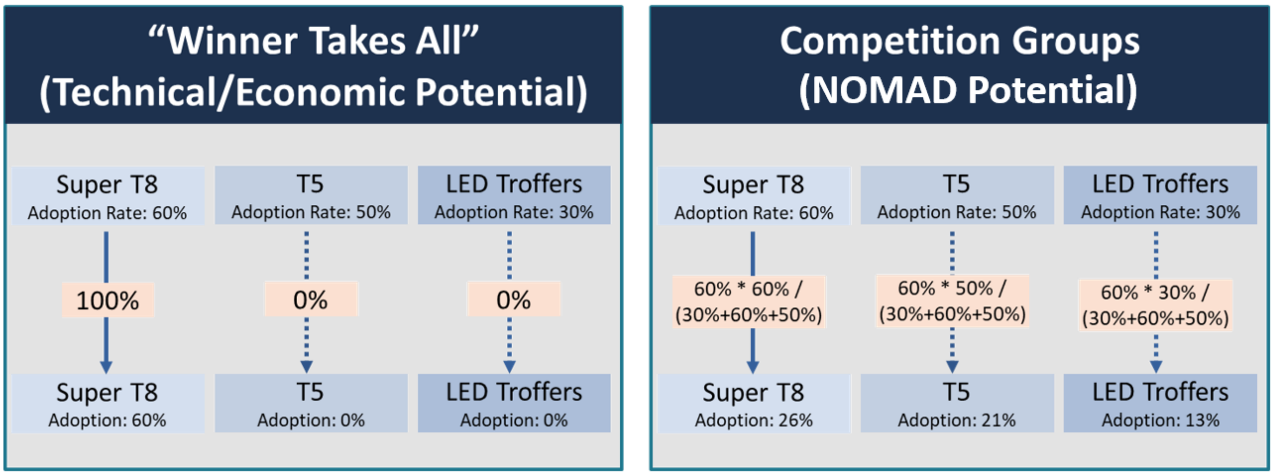
4.3 – Measure Competition

Measure competition occurs when measures share the same market opportunity but are mutually exclusive. For example, LED troffers, T5 lamps and Super T8 lamps can all serve the same market opportunity but will not be simultaneously adopted. In these cases, DEEP assesses the market potential for each measure as follows:

- **Technical Potential**: 100% of the market is applied to the measure with the highest savings.
- **Economic Potential:** 100% of the market is applied to the measure with the highest savings that passes cost-effectiveness screening.
- **NOMAD**: The market is split between all cost-effective measures by pro-rating the adoption rate based on the maximum adoption rate and each of the measures' respective adoption rates.

Figure A-3 presents an example where three measures compete: LED troffers, Super T8 and T5 lamps. First, the adoption rate is calculated for each measure independent of any competing measures, as outlined in the figure below. Based on this assessment, the maximum adoption rate is 60%, corresponding to the measure with the highest potential adoption. Next, the adoption of each measure is pro-rated based on their relative adoption rates to arrive at each measure's share of the 60% total adoption rate. As a result, the total adoption rate is still 60%, but it is shared by three different measures.

Figure A-3. Example of DEEP Measure Competition

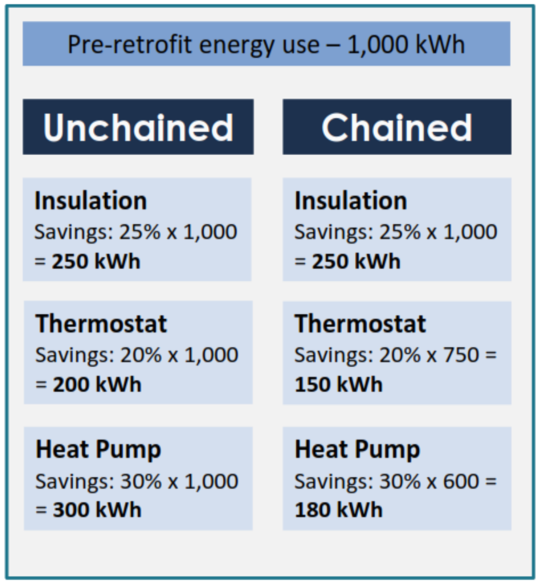


4.4 – Measure Interactions (Chaining)

Measure interactions occur when the installation of one measure will impact the savings of another measure. For example, the installation of more efficient insulation will reduce the savings potential of subsequently installing a smart thermostat. In DEEP, measures that interact are "chained" together and their savings are adjusted when other chained measures are adopted in the same segment. Chaining is applied at all potential levels and these interactive effects are automatically calculated according to measure screening and uptake at each potential level.

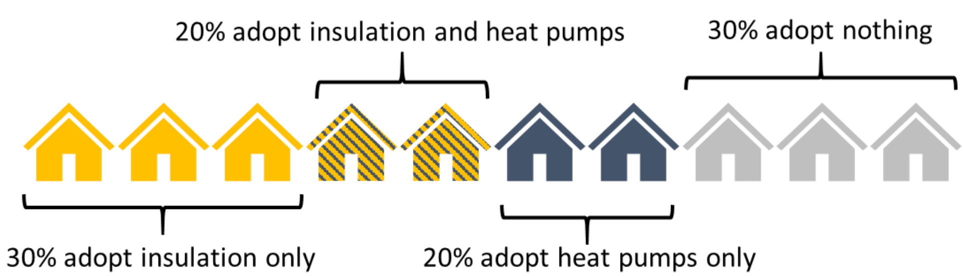
DEEP applies a hierarchy of measures in the chain reducing the savings from each measure that is lower down the chain. The model adjusts the chained measures' savings for each individual measure, with the final adjustment calculated based on the likelihood that measures will be chained together (determined by their respective adoption rates) and the collective interactive effects of all measures higher in the chain. Figure A-4 provides an example of the calculations used to determine the interactive savings effects for a customer where insulation is added in addition to a smart thermostat and a heat pump.

Figure A-4. Example of Savings Calculation for DEEP Chained Measures



The model estimates the number of customers adopting chained measures based on the relative adoption rates of each measure. In an example where insulation has a 50% adoption rate and heat pumps have a 40% adoption rate in isolation, when chaining is considered, the model might assume 40% of customers adopting insulation will also install a heat pump, which means 50% of customers adopting a heat pump will also improve their installation levels. This segments the market into customers adopting only one of the measures, customers adopting both measures, and customers adopting none of the measures as shown in Figure A-5.

Figure A-5. Example of Adoption for DEEP Chained Measures



Appendix B – Industrial top-down approach

In Itron's experience, industrial customer on-site surveys can be significantly riskier (compared to on-site surveys at commercial or residential premises). This is due to the high costs associated with on-site data collection and the limited value of those data for developing a representative characterization of end-use consumption and energy-efficiency opportunities for the industrial sector as a whole. This dynamic is a result of the heterogeneity of industrial processes and equipment compared to commercial businesses, even within a given industrial subsector (e.g. fabricated metals). Moreover, these cost/value tradeoffs are exacerbated when samples are limited in size (e.g. 3-10 points per segment).

At the same time, Itron had access to two rich primary data sets:

- End-use and measure-level results from the 2012 Baseline Study, which included 527 telephone surveys and 121 on-site surveys of industrial customers
- Customer-level program tracking and evaluation data from ComEd's Custom and Industrial Systems (IS) programs from PY4 (2011) through PY9 (2017)[1]

Given the availability of these two primary data sets, Itron proposed (and ComEd approved) supplementing those data with:

1. a small set of in-depth interviews with industrial plant managers and energy efficiency investment decision-makers in ComEd's territory; and,
2. national-level data from the 2014 Manufacturing Energy Consumption Survey (MECS) – in lieu of conducting new primary data collection for this study.

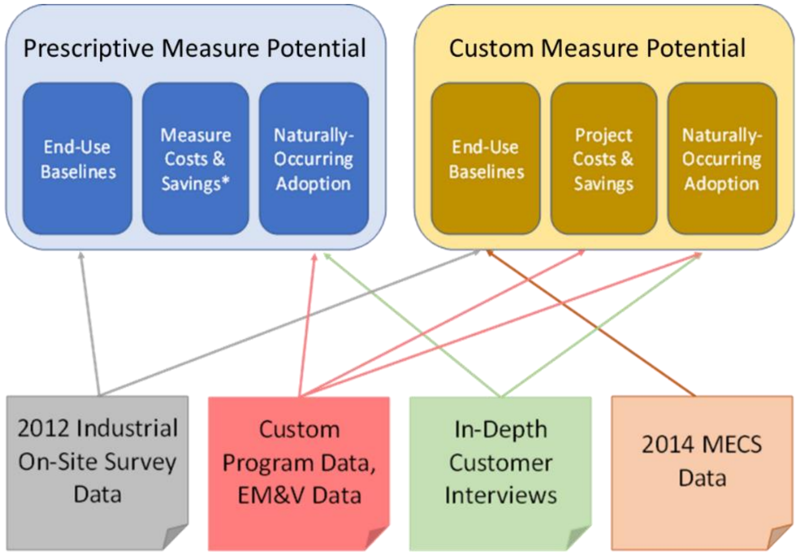
1 Overall Industrial Potential Modeling Approach

After assembling the data above and reviewing them in detail, Itron then developed a potential modeling approach that provided meaningful and grounded estimates of savings potential from industrial programs in the near term. At the highest level, Itron and Dunsky bifurcated the estimation of industrial potential between that from prescriptive measures (specifically lighting) and that from custom measures. For custom measures, a top-down approach was developed to estimate potential. This overall modeling approach is summarized in Figure B-1 below and presented in more detail in the remainder of this Appendix.

For industrial lighting measures, significant detailed stock data were available from the 2012 Baseline Study to support using the same bottom-up modeling methodology that the Dunsky team applied to other deemed measures in the residential and commercial sectors (i.e. using Dunsky's DEEP model). To account for changes in the lighting market since 2012, the Dunsky team adjusted the 2012 technology shares to account for growth in TLED and T8 penetration based on recent industrial lighting data that Dunsky has available from other jurisdictions.

[1] PY9 was a 19-month program as part of FEJA-mandated transition to calendar year program cycles.

Figure B-1. Overall Potential Modeling Approach for Industrial Customers



The output from the bottom-up modeling of industrial lighting measures are estimates of technical, economic, and naturally occurring potential for industrial lighting in the same form as those for deemed residential and commercial measures.

For all other custom measures, Itron developed and implemented a top-down approach that leveraged the detailed program tracking, evaluation, and billing data available to the study team. The benefits of this approach are that it is highly grounded in a large volume of actual custom project costs and savings, directly reflective of ComEd's specific industrial customer base, particularly in terms of program eligibility going forward due to the Future Energy Jobs Act (FEJA), and highly transparent and reproducible.

2 Top-Down Modeling Approach

This top-down modeling approach for the custom measures consisted of three main steps. Note that each of these steps were applied to three industrial customer segments based on size (as measured by peak kW demand), consistent with the industrial segments defined in Dunsky's DEEP model: <100 kW, 100-400 kW, >400 kW.

Step 1: Calculate the "eligible" population and load by high-level custom project type

To do this, the historical program tracking data available was used to identify all industrial customers who have yet to participate in ComEd's Custom or Industrial Systems programs, i.e. the "non-participant" load. Then the non-participant population was further narrowed by the share with the given end-use or efficiency opportunity based on data from the 2012 Baseline Study or the 2014 MECS (e.g. the share of industrial customers with compressed air). Finally, customer billing data was used to calculate the total kWh consumption associated with that "eligible" customer population.

Step 2: Calculate the average percent savings by custom project type

Itron first categorized each custom project rebated by ComEd from PY4 (2011) through PY9 (2017) into one of 13 higher-level custom project types (see table below).[2] The project-specific ex-ante savings for each project was then normalized against the total annual consumption for that customer. Then the average of these percent savings across each high-level project type was calculated. Transforming the project-level savings claims into savings as a percent of total load creates a metric that can be reasonably applied to the eligible customer population regardless of size.

Note that this overall top-down methodology was applied to 10 of the 13 high-level custom project types listed in Table B-1 below. In the case of Lighting, the potential associated with those project types will be included in the deemed measure estimate derived using Dunsky's DEEP model. For the Injection Molding and Other project types, there was not sufficient data available from the 2012 Baseline Study or the 2014 MECS to reliably estimate the share of the non-participant population with those efficiency opportunities. However, the "in scope" custom project types account for over 83% of total ex ante claims from ComEd's industrial custom programs to date (as shown in the table below).

[2] "Compressed Air" is largely compressor upgrades or other compressed air system upgrades. "Air Leaks", "Engineered Nozzle", and "No-Loss Drain" are all specific types of compressed air system improvements that are not included in the "Compressed Air" category but were common enough to merit their own category.

Table B-1. Share of Total Claimed Savings in ComEd's Custom and IS Programs (PY4-PY9) by Project Type

Custom Project Type	Ex Ante kWh Savings	% of Total Ex Ante kWh Savings
Air Leaks	40,168,982	16%
Compressed Air	61,838,931	25%
Engineered Nozzle	2,133,567	1%
No-Loss Drain	1,613,998	1%
Controls	19,768,593	8%
Process Cooling	25,603,443	10%
HVAC	6,630,199	3%
Lighting	8,078,158	3%
Pumps & Motors	6,025,888	2%
Refrigeration	11,917,013	5%
VSD/ VFD	21,264,383	9%
~~Injection Molding~~*	~~2,055,035~~	~~1%~~
~~Other~~*	~~38,508,577~~	~~16%~~
Total	*245,606,769*	*100%*
In Scope	*205,043,156*	*83%*

**The values that have been crossed out indicate the project types that were not included in the analysis, as indicated above.*

Step 3: Multiply eligible load by the average percent savings by project type

The product of this calculation is an estimate of the maximum achievable savings potential that can be expected from a continuation of ComEd's current industrial custom programs in terms of incentives, program design, and overall program budget. As such, this estimate is referred to as the "max BAU" savings potential. Note that this approach produces max BAU savings potential estimates by both project type and customer size.

An example calculation of max BAU potential for compressed air is provided in Figure B-2 below. In this example, the lack of any previous compressed air projects for small industrial customers (<100 kW) required an assumption for average percent project savings. In this particular case, the average percent project savings from the 100-400 kW cohort was applied. A complete list of the specific assumptions required to implement this approach is provided in the subsequent sections of this chapter.

Figure B-2. Example Calculation of max BAU Potential for Compressed Air

Segment	Total Population (GWh)	Program Participants (GWh)	Non-Participants (GWh)	Share with Opportunity (%)	Eligible Load (GWh)	Average Project Savings (%)	Max BAU Potential Savings (GWh)	Max BAU Potential Savings (% of total load)
<100 kW	480	0	480	75%	358	4.7%	17	3.5%
100-400 kW	906	3	903	99%	894	4.7%	42	4.6%
>400 kW	6,889	688	6,201	96%	5,965	1.7%	103	1.5%
Total	**8,275**	**691**	**7,584**	-	**7,217**	-	**161**	**1.9%**

Billing
Billing + Program Tracking
2012 Baseline Study

Total PY4-PY9 Ex Ante Claims = 61.8 GWh

No compressed air projects in this segment yet; need to assume value (example uses 100-400 kW value)

Share of businesses with compressed air

2.1 – Naturally Occurring Potential

To complement the estimate of max BAU potential for custom programs, an estimate of naturally occurring potential was also developed. This estimate was based on the following three steps:

1. Remove >10 MW customers from program tracking data
2. Calculate the historical average evaluated NTG ratio
3. Multiply forecasted Max BAU program savings by "1-NTG"

Technically speaking, the resulting estimate is a forecast of program free ridership and would be less than the true naturally occurring potential (which includes adoption by non-participants). However, the estimate is internally consistent with observed customer adoption behavior in ComEd's territory and provides a meaningful benchmark against which to evaluate and interpret the max BAU achievable potential results.

2.2 – Economic Potential

It is important to note that the top-down approach does not *explicitly* consider measure cost-effectiveness in the traditional potential modeling sense. As such, it does not produce direct estimates of economic potential. However, the max BAU estimates generated were leveraged to produce indirect estimates of economic potential.

It has been widely observed, both in ComEd and in other jurisdictions across the US, that industrial customers tend to pursue only a fraction of all identified cost-effective energy savings opportunities. Indeed, an impact evaluation of the 9,000+ audits conducted through the U.S. DOE's Industrial Assessment Center program (1997-2013) found that only one-third of all cost-effective energy savings measures had actually been implemented (SRI International, 2015). Similarly, an impact evaluation of the 700+ audits conduced through the U.S. DOE's Save Energy Now program (2006-2008) found that just over half of all cost-effective measures had actually been implemented (Oak Ridge National Laboratory, 2010).

Since the top-down modeling approach used in this study produces estimates of max BAU savings potential, *Itron believes that multiplying this estimate by a factor of two produces an reasonable estimate of economic potential* that is consistent with the empirical findings from the two audit impact studies cited above. It should be understood that the resulting estimate of economic potential is best considered and interpreted in aggregate, rather than at the project-type or customer-size level, since the empirical findings from two audit program evaluations referenced above were not developed with the same project type definitions as each other or relative to those in this top-down modeling approach.

2.3 – Annualizing Estimates of Max BAU and Economic Potential

The top-down modeling approach described above produces cumulative or "snapshot" estimates of max BAU and economic potential. To make the resulting potential estimates more useful for ComEd's portfolio planning, these snapshot estimates must be transformed into annualized values.

To do this, a simple annualization approach was used whereby each snapshot estimate (by project type) was multiplied by a ratio of one over the average effective useful life (EUL) of that project type (i.e. 1/EUL). To implement this annualization approach, EULs for each project type were developed. See the section below for documentation of the data sources and assumptions used to develop the EULs applied to the snapshot estimates of max BAU and economic potential.

3 Key Assumptions and Data Sources

The three elements of the top-down potential estimation that are not universally derived from billing data or program tracking data are as follows:

1. The share of the industrial population with a given energy efficiency opportunity;
2. The average savings as a percent of total load by custom project type; and,
3. The effective useful life for each custom project type.

This section documents the specific data sources and assumptions used by Itron to support these elements. These sources and assumptions represent the "best available" estimates in the context of the study.

3.1 – Share of Population with Energy Efficiency Opportunity

Table B-2 below presents the specific values and data sources that describe the share of ComEd's industrial population with a given custom project opportunity.

Table B-2.Metrics and Data Sources Used to Quantify Share of Eligible Population with a Given Efficiency Opportunity

Custom Project Type	Estimate	Source
Air Leaks	Share of premises that do not actively detect and control compressed air leaks (2014 MECS) * share of premises with compressed air (2012 BL)	2014 MECS Table 8.4, 2012 Baseline Study
Compressed Air	Share of premises with compressed air (%)	2012 Baseline Study
Engineered Nozzle	Share of premises with compressed air (%)	2012 Baseline Study
No-Loss Drain	Share of premises with compressed air (%)	2012 Baseline Study
Controls	Share of premises that do not use process controls (%)	2014 MECS Table 8.2
Process Cooling	All premises	Assumption
HVAC	All premises	Assumption
Pumps & Motors	All premises	Assumption
Refrigeration	Share of premises in Food sub-segment (%)	ComEd Billing
VSD/ VFD	Share of premises that do not use adjustable speed motors (%)	2014 MECS 8.2

As Table B-2 shows, the 2014 MECS and the 2012 Baseline Study provide direct estimates of the shares of the industrial population with the opportunity to apply 6 of the 10 in-scope custom project types – air leaks, compressed air, engineered nozzle, no-loss drains, controls, and VSDs/VFDs. Since the data available from the 2012 Baseline are based exclusively on ComEd's industrial customer base, these estimates were not transformed in any way.

In contrast, the data from the 2014 MECS are reported at the industrial sub-segment level (e.g. Fabricated Metals vs. Food Processing vs. Nonmetallic Minerals). In order to apply those data in the top-down framework, aggregate estimates that properly reflect ComEd's specific mix of industrial sub-segments were developed. To do so, weighted sub-segment levels based on the distribution of annual kWh consumption were developed, as shown in Table B-3 below.

Table B-3. Weights Applied to Sub-Segment Level MECS Estimates

Sub-Segment	2017 kWh	kWh Share	Detect & Control Compressed Air Leaks [1]	Process Controls [2]	Adjustable Speed Motors [2]
Fabricated Metals	1,520,670,064	20%	49%	78%	60%
Food Processing	1,602,486,394	21%	46%	50%	25%
Apparel	76,623,003	1%	40%	68%	65%
Pulp & Paper	757,805,216	10%	35%	43%	28%
Printing	373,895,109	5%	55%	78%	59%
Chemical	465,452,356	6%	44%	48%	27%
Rubber	907,348,820	12%	27%	53%	23%
Nonmetallic Minerals	322,981,466	4%	43%	61%	56%
Primary Metals	334,168,813	4%	45%	52%	35%
Machinery	631,511,403	8%	49%	78%	59%
Transportation Equipment	308,734,022	4%	51%	64%	47%
Miscellaneous Industrial	459,658,397	6%	62%	69%	68%
Weighted Values			*45%*	*61%*	*42%*

[1] MECS Table 8.4 (Share of establishments that do not participate)
[2] MECS Table 8.2 (Share of establishments with measure not in use)

For the four remaining in-scope project types – Process Cooling, HVAC, Pumps & Motors, and Refrigeration – neither the 2014 MECS or the 2012 Baseline Study provided related population estimates. However, the following assumptions were used to fill these data gaps:

- **For Process Cooling, HVAC, and Pumps & Motors, assume that the associated efficiency opportunities exist in all industrial sub-segments in ComEd's territory.** For perspective, the end-use energy consumption estimates in the 2014 MECS Table 5.3 indicate that all the industrial sub-segments present in ComEd's territory use process cooling, facility HVAC, and machine drives to varying degrees. Additionally, ComEd's custom program data also indicate that Process Cooling, HVAC, and Pumps & Motors projects have occurred across a wide range of industrial sub-segments.
- **For Refrigeration, assume that these opportunities only exist in the Food Processing sub-segment.** For perspective, ComEd's custom program data indicate that refrigeration projects have only occurred in ComEd's Food Processing sub-segment.

The complete set of values derived from the specific data sources, weighting, and assumptions described above that quantify the shares of ComEd's industrial population with a given custom project opportunity are summarized in Table B-4 below.

Table B-4. Final Values Used to Quantify Eligible Population with Given Efficiency Opportunity

Project Type	Share of Industrial Population with Opportunity			Source
	<100 kW	100-400 kW	>400 kW	
Air Leaks	34%	44%	43%	2014 MECS, 2012 BL Study
Compressed Air	75%	99%	96%	2012 BL Study
Engineered Nozzle	75%	99%	96%	2012 BL Study
No-Loss Drain	75%	99%	96%	2012 BL Study
Controls	61%	61%	61%	2014 MECS
Process Cooling	100%	100%	100%	Assumption
HVAC	100%	100%	100%	Assumption
Pumps & Motors	100%	100%	100%	Assumption
Refrigeration	20%	13%	20%	ComEd Billing
VSD/ VFD	42%	42%	42%	2014 MECS

3.2 – Average Project Savings as Percent of Total Load

All data for average project savings come from customer-level program tracking data from ComEd's Custom and Industrial Systems programs from PY4 (2011) through PY9 (2017). However, past industrial custom projects have been concentrated almost exclusively among 100-400 kW and >400 kW customers. In this respect, percent savings values for the <100 kW customer segment for all custom project types, as well as for 100-400 kW customers for some project types were assumed. To do this, the average percent savings values available for the next larger customer segment were applied. The ***bolded*** cells in Table B-5 below show where these assumptions are necessary and the associated assumed values.

Table B-5. Average Project Savings as Percent of Customer Load

Project Type	Average Project Savings as % of Customer Load				
	<100 kW		100-400 kW		>400 kW
Air Leaks	***9.5%***	←	9.5%		1.7%
Compressed Air	***4.7%***	←	4.7%		1.7%
Engineered Nozzle	***2.0%***	←	2.0%		0.9%
No-Loss Drain	***0.7%***	←	0.7%		0.3%
Controls	***1.4%***	←	***1.4%***	←	1.4%
Process Cooling	***2.1%***	←	***2.1%***	←	2.1%
HVAC	***1.9%***	←	***1.9%***	←	1.9%
Pumps & Motors	***1.5%***	←	***1.5%***	←	1.5%
Refrigeration	***6.4%***	←	6.4%		2.3%
VSD/VFD	***3.3%***	←	***3.3%***	←	3.3%

3.3 – Effective Useful Life

The EUL values applied for each project type are shown below in Table B-6. EUL estimates are sourced from the latest version of the Illinois Technical Resource Manual (v8) for three of the ten custom project types (Compressed Air, Engineered Nozzle, and No-Loss Drain). For Process Cooling and VSD/VFD, EUL estimates came from the latest version of the Michigan Energy Measures Database (2020).

Table B-6. Effective Useful Life Values Used to Annualize Cumulative Potential Estimates

Custom Project Type	EUL Estimate (years)	Source
Air Leaks	3	Assumption
Compressed Air	13	Illinois TRM v8
Engineered Nozzle	15	Illinois TRM v8
No-Loss Drain	10	Illinois TRM v8
Controls	20	Assumption
Process Cooling	15	Michigan Energy Measures Database
HVAC	20	Assumption
Pumps & Motors	25	Assumption
Refrigeration	20	Assumption
VSD/ VFD	15	Michigan Energy Measures Database

For the remaining project types (Air Leaks, Controls, HVAC, Pumps & Motors, and Refrigeration), EULs from TRMs in the Midwest or elsewhere were not available. Therefore, for these project types, EUL values were assumed based on the following logic:

- For **HVAC**, the assumed EUL (20 years) is between the EULs for packaged HVAC and chillers in IL TRM v8 (15 and 23 years, respectively).
- For **Pumps & Motors**, the assumed EUL is consistent with the expected life for large motors (e.g. 50+ HP) and strong evidence from the IDIs that industrial customers always seek to extend the useful life of large motors through systematic rewinding of large motors, rather than replacement.
- For **Air Leaks**, many TRMs used an EUL of 1 year for air leak repair. But while, this project type includes many simple one-time leak repair projects, this project type also includes leak monitoring systems and other longer-lived interventions designed to address air leaks.
- For **Controls**, the assumed EUL is consistent with the expected life for EMS, BMS, and other plant- or building-level control systems based on software and a network of sensors.
- For **Refrigeration**, the assumed EUL is consistent with the expected life of compressor upgrades and other comprehensive system retrofits/upgrades that make up the bulk of the interventions within this project type.

Appendix C – Calibration and NOMAD Methodology

The following describes Dunsky's methodology related to the DEEP model calibration of results and how the Naturally-Occurring Market Adoption (NOMAD) results are assessed to establish the net economic potential.

At a high level, the approach applies a theoretical Net-to-Gross (NTG) ratio at the overall economic potential level. This accounts for the portion of the economic and technical potentials that are expected to occur via natural market adoption, and would likely be counted as free-riders should they participate in ComEd programs.

The assessment takes into account market factors (i.e. market transformation in areas such as LED lighting) but because the study does not include an assessment of the program achievable potential, the net economic assessment does not account for the potential impact of program delivery factors (e.g. providing incentives, program design features and enabling strategies).

The result is an estimate of economic potential net of natural adoption that is based on a market evolution scenario in the absence of programs.

Additional detail with respect to Dunsky's four-step approach is provided after relevant definitions.

Definitions

Technical Potential – all theoretically possible energy savings stemming from the applied measures. Technical potential is assessed by combining measure and market characterizations to determine the maximum amount of savings possible for each measure-market combination without any constraints such as cost-effectiveness screening, market barriers, or customer economics.

Economic Potential – subset of the technical potential that only includes measures that pass cost-effectiveness screening.

NOMAD – Naturally-Occurring Market Adoption, based on adoption curves and customer economics in a scenario without program incentives or enabling strategies.

Gross Savings – Total energy savings resulting from the implementation of energy conservation measures.

Net Savings – Subset of the Gross Savings after removing those that would have been achieved naturally, in the absence of programs.

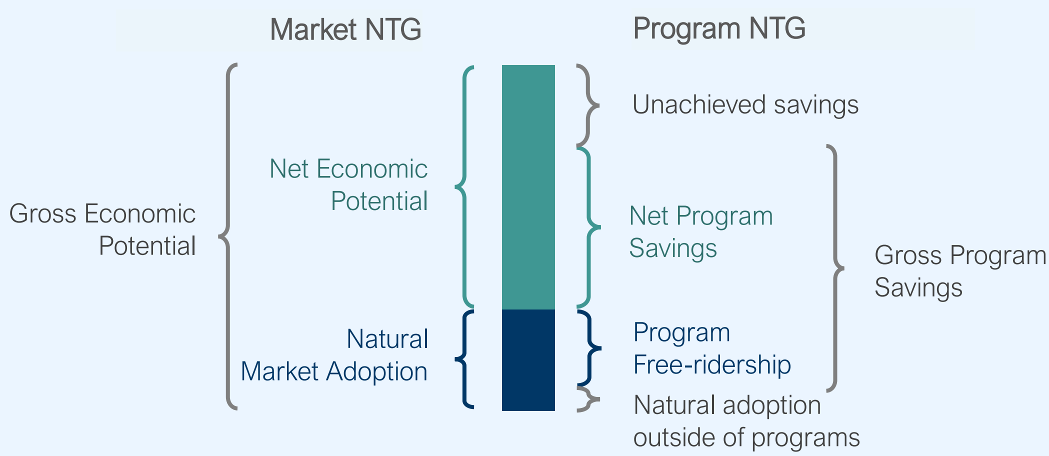
Net to Gross Ratio – or NTG ratio, is a factor applied to the Gross Savings which yields the Net Savings. See Box 1.

Box 1: Market NTG vs Program NTG

This study applies NTG ratios that account for naturally-occurring market adoption (NOMAD) as projected in the absence of programs, but do not take account for program factors such as in service rates, rebound effects or spillover.

As shown below, it is expected that Market NTG ratios will differ from Program NTG ratios, as their numerator (green) and denominator (green + blue) differ:

- only a portion of the natural market adoption would participle in programs and would therefore be considered as free-ridership,
- programs aim to achieve as much of the economic potential as possible



Step 1: DEEP Model Calibration

As a first step, Dunsky's DEEP model is populated with all measure and market inputs as per the approved measure list and characterization process as well as baseline market data from Itron's baseline study. This yields the technical and economic potentials for the first year of the potential study (2021), which are based on gross savings.

The model then incorporates high-level ComEd program design elements, where each sector is assigned a set of program settings to reflect current ComEd incentive levels and enabling strategies that help overcome non-economic barriers (*see Box 2*, below, for additional background on non-economic barriers). This allows Dunsky to calibrate program results for 2021 to recent DSM program results. Through an iterative process, market factors and barriers are adjusted until the sector-level modeling results are reasonably in-line with ComEd's CY2018 and CY2019 gross program results, as defined in the Program CPAS detailed workbooks provided by ComEd.

The results of this step are shown in section 2.1.2 of the report (Volume 1).

Step 2: Initial NOMAD Assessment

Once the model is calibrated for the first year of the potential study, the next step is to remove ComEd's existing programs from the model. To do this, incentive levels are set at zero and enabling strategies are excluded in order to remove their impact on market barriers (see Box 2). The model is then run for the complete study period (2021-2030) and generates the initial NOMAD assessment, which equates to the expected adoption of energy conservation measures in a scenario in the absence of ComEd programs. Those results are leveraged in the market NTG ratio determination next step.

Box 2: Market Barrier Setting

Baseline barrier levels and barrier reductions from programs have been refined over the course of Dunsky's 30+ potential studies and reflect the following factors:

- Technology-specific barriers: insulation is more difficult to install than a new LED bulb;
- Market segment barriers: energy investment decisions and capacity to implement an efficiency upgrade differs for each market segment;
- Non-economic barriers: energy efficiency programs go beyond incentives to address other non-economic barriers to customer participation. Barrier reductions can be achieved through enabling activities such as upstream programs, contractor training and financing programs;
- Calibration: where there is a large discrepancy between past program savings and the 2021 program calibration savings that cannot be explained through an identified change in the market conditions, market barriers can be adjusted in the model to reflect the specific conditions in ComEd's service territory.

Step 3: Market NTG and Growth Factors

The initial NOMAD results are leveraged in three ways to arrive at: 1) first-year NTG ratios; 2) NTG decline factors; and, 3) market reduction factors. These elements, described below, are then used to assess the net economic potential in Step 4 of the process.

1. **First-year NTG ratios**: Net-to-Gross ratios are set at the measure-sector level using the following formula.

$$NTG_{market} = \frac{kWh\ savings_{technical} - kWh\ savings_{NOMAD}}{kWh\ savings_{technical}}$$

   The resulting theoretical NOMAD-based NTG ratios are compared to the NTG ratios from ComEd's programs as well as secondary research reports from neighboring jurisdictions,[1] and combined using professional judgement to arrive at new market-based NTG ratios.

   Depending on the measure, ComEd program NTG ratios are used as the basis of comparison, while other measures use NTG ratios from secondary sources. This depends on whether the expected adoption of energy conservation measures or equipment would or would not be affected by non-economic factors. For example, commercial kitchen measures and residential behavioral measures are rarely adopted in the absence of programs, and their NTG ratios are therefore set at a higher level than the theoretical NTG ratios. Overall, approximately 70% of the technical potential uses theoretical NTG ratios developed from the NOMAD assessment.

   At ComEd's request, the income-eligible sector uses an of 1.0, assuming there would be no naturally-occurring potential outside of programs.

2. **NTG decline factors:** To reflect the current pace of market transformation in lighting, the incremental cost of LED lighting measures in the DEEP model is set to decline by 3.0% per year, based on a recent DOE study.[2] Moreover, the market barriers are reduced with time in the DEEP model over the 10-year study period to reflect the increasing acceptance of LED lighting. These two factors result in increased natural adoption of lighting measures over the study period. The NTG ratio formula from the previous step is used to calculate the NTG ratio for the last period of the potential study and is compared to the first-year NTG ratio to yield a compound annual rate of NTG decline. This decline rate – between 3-5%, depending on the measure – is comparable to ComEd's own decline assumptions.

[1] Opinion Dynamics, June 2017. Iowa Gas and Electricity Potential Study, Net-to-Gross Research, Final Report.
[2] U.S. DOE, Office of Energy Efficiency & Renewable Energy, Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, December 2019.
https://www.energy.gov/sites/prod/files/2020/02/f72/2019_ssl-energy-savings-forecast.pdf

3. **Market reduction factors:** Lighting replacements have the benefit of both saving energy and increasing the Expected Useful Life (EUL) of the equipment. As the non-LED sockets get replaced with LED variants, the annual stock turnover therefore declines every year, following the steady increase of the average EUL associated with the longer-lasting LED bulbs.

   The NOMAD results are used to define market decline factors at the measure-segment level. For example, the residential A-lamp measures yielded a market decline of around 16% annually as the non-LED bulbs – with an average EUL of 4 years – are replaced with longer-lasting 10-year EUL LED bulbs. That decline would be even faster in a program scenario as the rate of adoption would be even higher.

   The initial NOMAD results show some adoption in the income-eligible sector, which are leveraged to define market reduction factors in that sector. However, as requested by ComEd, the final NOMAD in step 4 is set at 0 and the NTG ratios set at 1 in the income-eligible sector.

Step 4: Net Economic Potential

The first-year NTG ratios for all measures, the lighting-specific NTG decline factors, and the market reduction factors from step 3 are then loaded as inputs into the DEEP model. The final run yields the resulting technical, net economic, and NOMAD potentials for the complete potential study period (2021-2030).

The main report sections include some sector- and end-use-level insights from the NOMAD results, but the net economic potential is presented in most figures throughout the report.

Appendix D - Study Inputs and Assumptions

The following appendix describes the key inputs used in this study and how they were derived.

1 Measure Characterization

1.1 – Energy Efficiency Measure List

The following tables list the energy efficiency measures and characterization sources used in this study. Table D-1 lists the various Technical Resource Manuals (TRM) and other sources used to characterize measures.

Table D-1. Measure Characterization Sources

Key	Source
CA	California Municipal Utilities Association (CMUA), Savings Estimation Technical Reference Manual – Third Edition
IA	Iowa Statewide Technical Reference Manual - Version 2.0
IL-1	2020 Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 8.0
MA-1	Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 - Plan Version.
MA-2	Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2019-2021 - Plan Version.
MA-3	MA RES21, Energy Optimization Study
ME	Efficiency Maine Technical Resource Manual - Version 2018.3
MN	State of Minnesota Technical Resource Manual for Energy Conservation Improvement Programs - Version 3.0
NB	Energie NB Power Technical Resource Manual - September 2017
NEEP	Mid-Atlantic Technical Reference Manual - Version 8
PSEG-LI	PSEG Long Island - Technical Reference Manual - 2019
RI-1	Rhode Island Technical Reference Manual, 2020 Program Year, Electronic Version
WI	Wisconsin Focus on Energy - 2018 Technical Reference Manual

Table D-2 and Table D-3 list each residential and non-residential energy efficiency measure included in this study, along with the TRM from which the measure was characterized and some additional details for custom measures. These typically reference the source of the algorithms used to determine the measures' savings and impacts, which were then applied to the ComEd specific market, equipment saturations, climate, and customer consumption data used as inputs to the study. TRMs from other jurisdictions were used in order to obtain more granular and segment specific savings estimates. However, in most cases, ComEd specific jurisdictional data was used to populate algorithms sourced from other jurisdictions' TRMs.

Table D-2. Residential Energy Efficiency Measures

End-use	Residential Measure	Source	Additional details
Appliance	Air Purifier	RI-1	
Appliance	Clothes Dryer	IL-1	
Appliance	Clothes Washer	NEEP	
Appliance	Dehumidifier	IL-1	
Appliance	Dishwasher	IL-1	
Appliance	Freezer	NEEP	
Appliance	Freezer Recycle	IL-1	
Appliance	Refrigerator Recycle	IL-1	
Appliance	Refrigerator	NEEP	
Behavioral	Home Energy Report	Custom	Refer to section 1.6 – page D-9
Envelope	Air Sealing	IA	
Envelope	Attic Insulation	IL-1	
Envelope	Basement Insulation	IL-1	
Envelope	Wall Insulation	IL-1	
Envelope	Efficient Windows	IA	
Hot Water	Faucet Aerator	IL-1	
Hot Water	Low Flow Shower Head	IL-1	
HVAC	Air Source Heat Pump (ASHP) Tune Up	IA	
HVAC	Central Air Conditioning Tune Up	IA	
HVAC	Duct Sealing	IA	
HVAC	Whole House Fan	IA	The relative savings which are at the source of the deemed savings provided in the TRM are used
HVAC	Bathroom Fan	IL-1	
HVAC	Thermostat Programmable	IL-1	
HVAC	Thermostat Wi-Fi	IL-1	
HVAC	Air Source Heat Pump (ASHP)	MA-2	Refer to section 1.3 – page D-7
HVAC	Mini-split Ductless Heat Pump (DMSHP)	MA-2	Refer to section 1.3 – page D-7
HVAC	Central Air Conditioning (CAC)	NEEP	

End-use	Residential Measure	Source	Additional details
HVAC	Ground Source Heat Pump (GSHP)	NEEP	Refer to section 1.3 – page D-7
HVAC	Electric Resistance to DMSHP	MA-3	Refer to section 1.3 – page D-7
HVAC	Electric furnace to ASHP	Custom	Refer to section 1.3 – page D-7
HVAC	Room Air Conditioner (RAC)	RI-1	
Lighting	LED Linear Tube	NEEP	
Lighting	LED Specialty - Candelabras, Globes (Interior)	IL-1	
Lighting	LED Specialty - Reflectors (Exterior)	IL-1	
Lighting	LED Specialty - Reflectors (Interior)	IL-1	
Plug Loads	Advanced Smart Strips	IL-1	
Plug Loads	Pool Pump	IL-1	

Table D-3. Non-Residential Energy Efficiency Measures

End-use	Non-Residential Measure	Source	Additional details
Envelope	LEED Certified	Custom	Assumed that half of the Energy Performance credits are achieved – 10% savings vs IECC
Hot Water	Circulator Pump EC Motor	ME	
Hot Water	Low Flow Faucet Aerator	IL-1	
Hot Water	Water Heater - Heat Pump Water Heater (HPWH)	NEEP	
Hot Water	Low Flow Shower Head	IL-1	
Hot Water	Low Flow Pre-Rinse Spray Valve	IL-1	
Hot Water	Water Heater - Storage	IL-1	
HVAC	Absorbent Air Cleaner	IL-1	
HVAC	Thermostat Wi-Fi	MA	
HVAC	Air Conditioner Tune-up	IL-1	
HVAC	Air Source Heat Pumps (ASHP)	NEEP	Refer to section 1.3 – page D-7
HVAC	Chiller, Air Cooled	IL-1	
HVAC	Chiller, Water Cooler, Centrifugal	IL-1	

End-use	Non-Residential Measure	Source	Additional details
HVAC	Computer Room Air Conditioner (CRAC)	MN	
HVAC	Demand Control Ventilation (DCV)	Custom	PNNL study, 2013. https://www.pnnl.gov/main/publications/external/technical_reports/pnnl-22072.pdf
HVAC	Energy Management System (EMS)	Custom	15-20% HVAC motor, 10% heating savings
HVAC	Energy Recovery Ventilator (ERV)	IL-1	
HVAC	Ground Source Heat Pump (GSHP)	IL-1	Refer to section 1.3 – page D-7
HVAC	Guest Room Energy Management	IA	
HVAC	Kitchen Demand Control Ventilation	IL-1	
HVAC	Mini-split Ductless Air Conditioner	PSEGLI	
HVAC	Mini-split Ductless Heat Pump (DMSHP)	NEEP	Refer to section 1.3 – page D-7
HVAC	Package Terminal Air Conditioner (PTAC)	IL-1	
HVAC	Package Terminal Heat Pump (PTHP)	IL-1	Refer to section 1.3 – page D-7
HVAC	Thermostat Programmable	MA -1	
HVAC	Retro-commissioning Strategic Energy Manager (RCx SEM)	Custom	US EPA rule of thumb, scaled down as an average (9% of kWh and 6% of Btu) https://19january2017snapshot.epa.gov/statelocalclimate/rules-thumb_.html
HVAC	Room/Wall-Mounted Air Conditioner (RAC)	IL	
HVAC	Unitary Air Conditioner	NEEP	
HVAC	Unitary Equipment Economizer	MN	
HVAC	Ventilation Hoods	Custom	Online LBNL calculator: http://fumehoodcalculator.lbl.gov/
HVAC Motors	HVAC EC Motor	MA-1	
HVAC Motors	HVAC VFD - Cooling Tower	NB	
HVAC Motors	HVAC VFD - Fan	NB	
HVAC Motors	HVAC VFD - Pump	NB	
Kitchen	Dishwasher	IL-1	
Kitchen	Fryer	IL-1	
Kitchen	Griddle	IL-1	

End-use	Non-Residential Measure	Source	Additional details
Kitchen	Hot Food Holding Cabinet	IL-1	
Kitchen	Oven	IL-1	
Kitchen	Steamer	IL-1	
Lighting	Lighting Controls (Network)	WI	
Lighting	Lighting Controls (Bi-Level)	IL-1	
Lighting	LED Linear Tube, High Efficiency	IL-1	
Lighting	LED A-Lamp (Interior)	IL-1	
Lighting	LED Exit Sign	IL-1	
Lighting	LED High Bay	IL-1	
Lighting	LED Linear Luminaire	IL-1	
Lighting	LED Parking Garage (Exterior)	ME	
Lighting	LED Pole Mounted (Exterior)	IL-1	
Lighting	LED Specialty - Reflectors (Interior)	IL-1	
Lighting	Lighting Controls (Dual Occupancy & Daylight Sensors)	IL-1	
Lighting	Lighting Controls (Daylighting)	IL-1	
Lighting	Lighting Controls (Occupancy)	IL-1	
Lighting	LED Linear Tube	IL-1	
Lighting	LED T12 Linear Tube	IL-1	
Lighting	LED T12 Linear Luminaire	IL-1	
Office Equipment	Advanced Power Strips	IL-1	Tier 2 from MN TRM
Office Equipment	Computers	IL-1	
Office Equipment	ENERGY STAR Uninterruptable Power Supply	CA	
Refrigeration	LED Refrigerated Case Lighting	PSEGLI	
Refrigeration	Door Closers	IL-1	
Refrigeration	ENERGY STAR Ice Maker	MA-2	
Refrigeration	Refrigerated Case Anti-Sweat Door Heaters	IL-1	
Refrigeration	Refrigerated Case Door Gaskets	NEEP	
Refrigeration	Refrigerated Case EC Motor	IL-1	

1.2 – Lighting and EISA

At the time of this study, federal efficiency standards for lighting were in flux due to uncertainty regarding the triggering of the "backstop" mechanism for specialty lighting in the 2007 Energy Independence and Security Act (EISA). To understand the impact of this uncertainty, ComEd has decided to assess total LED potentials regardless of EISA enforcement. The market therefore focusses on remaining non-LED sockets.

The following items are worth being raised:

- **Bulbs** – Since the baseline study shows a significant penetration of CFLs, which is in line with previous market study in ComEd's service territory[1], a blended baseline approach is used in terms of delta Watts and baseline EUL.

- **EUL** – As non-LED sockets get replaced with longer-EUL LED variants, a reduced market turnover is modeled through an annual market decline factor. More details are provided in Appendix C.

- **NTG** – The net to gross ratios for lighting measures are expected to drop over the course of the potential study as the market transforms and natural adoption of LED increase. An NTG decline factor is therefore set for each lighting measure and described in Appendix C.

- **T12** – Since T12 fluorescent linear tubes still account for around 25% of ComEd's market[2], two measures are included in the current potential study: a T12 to TLED tube replace-on-burnout (T12 as baseline) and an early replacement of the luminaire (dual baseline)

- **TLED** – An emerging high-efficiency TLED measure is applied starting in 2025.

- **NLC** – Advanced lighting controls, namely networked lighting controls (NLC), are applied as a measure throughout the potential study period. Note however that the Illinois TRC does not account for non-energy benefits, but that it is expected that NLC adoption will be driven by non-economic factors.[3] Furthermore, the model takes into account the reduction of the connected kW as LEDs get adopted, which reduces the savings potential of lighting controls measures.

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[1] Opinion Dynamics, December 2017. "Commonwealth Edison Residential Lighting Study and Illinois Statewide LED Hours of Use Study Results" https://s3.amazonaws.com/ilsag/ComEd-Residential-Lighting-Discounts-PY9-Combined-Report-2019-02-14.pdf

[2] *Northern Illinois Lighting Supply Chain Characterization*, October 2019, by NMR Group and Apex Analytics.

[3] *Lighting Market Analysis*, October 2019, by Peter Brown, Lighting Transitions, and *C&I Networked Lighting Controls Technology Overview*, by Energy Futures Group, September 2019

1.3 – Heat Pumps

Multiple heat pump measures were modeled in order to account for both the opportunity related to adding a standard-efficiency heat pump in electrically-heated homes, and the selection of a higher-efficiency model whenever a household or business chooses to replace or add a heat pump.

While fuel-switching is not included in the study's scope, the incremental savings opportunity related to higher-efficiency models for any installed heat pump – whether in electrically or gas-heated buildings – is assessed in the model. A market growth rate derived from heat pump shipment forecasts for North America and scaled to ComEd's service territory - provided by Itron - is used in the modelling.

Table D-4 outlines the heat pump technologies being considered in the study.

Table D-4 List of residential and non-residential heat pump measures

Market	Measure	Additional details
Residential	Air Source Heat Pump (ASHP)	Central ASHP replacement on burnout upgrade to a cold-climate model (2 tiers)
	Mini-split Ductless Heat Pump (DMSHP)	DMSHP replacement on burnout DMSHP in new construction upgrade to a cold-climate model (2 tiers)
	Ground Source Heat Pump (GSHP)	Central GSHP replacement on burnout upgrade to a higher-efficiency model
	Electric Resistance to DMSHP	Addition of a standard-efficiency DMSHP in homes heated with electric baseboards
	Electric furnace & CAC to ASHP	Ducted central AC unit replacement by an ASHP upon the central AC's burnout
Non-residential	Air Source Heat Pumps (ASHP)	Central ASHP replacement on burnout upgrade to a high-efficiency (2 tiers) or cold-climate model (2 tiers)
	Mini-split Ductless Heat Pump (DMSHP)	DMSHP replacement on burnout DMSHP in new construction upgrade to a high-efficiency (2 tiers) or cold-climate model (2 tiers)
	Ground Source Heat Pump (GSHP)	GSHP replacement on burnout upgrade to a higher-efficiency model GSHP addition in new construction
	Package Terminal Heat Pump (PTHP)	PTHP replacement on burnout upgrade to a higher-efficiency model
	Water Heater - Heat Pump Water Heater (HPWH)	Electric storage unit replacement on burnout upgrade to a Heat Pump Water Heater

1.4 – Appliance and Equipment Standards

Updates to US Federal appliance and equipment standards will impact the claimable savings for measures that incorporate the relevant appliances and equipment. This study accounts for updates to standards that will occur during the study period. The study only considers published final standards updates with compliance dates within the study period as draft standards are subject to revisions and revocations. Standards that will be updated before the study period are applied for entire study period – impacting the baseline efficiency of the applicable efficiency measures.

Updates to state standards in the ComEd service areas were not considered in this study as there were no finalized updates at the time of the study's initiation. While proposed state legislation existed to increase efficiency standards beyond federal regulations, there was too much uncertainty in whether and when standards would come into force to include in the study.

Table D-5 lists the final published updates to federal U.S. standards with compliance dates within the study period.

Table D-5. Federal U.S. standard updates within study period

Product	Compliance Date
Residential – Central Air Conditioners and Heat Pumps	2023
Commercial – Unitary Air Conditioners and Air Source Heat Pumps	2023
Commercial – Ductless Mini-split Heat Pumps	2023

1.5 – Building Codes

Updates to applicable building codes – to the extent they increase the energy efficiency of buildings built to code – will impact the claimable savings for new construction energy efficiency measures.

It was understood that the State of Illinois typically adopts the most recent version of the IECC building codes shortly after they are released. Based on this, the baseline energy efficiency for residential and commercial buildings corresponding to each IECC update, as well as the incremental costs and savings associated with the NC measures in the model were updated. To account for this, the following assumptions were applied:

- Assume a 3-year delay between IECC release date, and it being reflected in new buildings. This accounts for time required to update the state building code as well as the time lag before new buildings which meet the updated code requirements are completed.
- Assume that the 2024 IECC update accounts for the entire 2026-2030 modeling period. This is necessary because the model does not perform discrete yearly calculations over the second half of the study. Given the high degree of uncertainty over future IECC updates, this is not expected to impact the study accuracy.

Table D-6. Assumed New Building Energy Codes in Study

IECC Building Code Release	Date of Application to new construction Baseline	Residential EUI Improvement	Commercial EUI Improvement
2018	2021-2023	2%[4] over 2015	8%[5] over 2015
2021[6]	2024-2030	8% over 2018	7% over 2018

1.6 – Behavioral Home Energy Report Measure

The presence of persistence factors for behavioral measures in the Illinois TRM required some analysis. The approach to the Home Energy Report behavioral measure is explained in this sub-section.

1.6.1 – Persistence of behavioral savings

The Home Energy Report measure is not included as a measure in the Illinois TRM, but the TRM does include persistence factors specific to behavior savings over a 5-year period under *Volume 4: Cross-cutting Measures and Attachments*. However, the 5-year persistence of savings in the TRM are different from a regular EUL in that the persisting savings decline over that 5-year period. For example, the persistence factor of 80% for year 2 equates to a 20% drop in behavioral savings should customers stop receiving Home Energy Reports in year 2.

ComEd's residential behavioral program's evaluation reports were studied to define the approach to the Home Energy Report behavioral measure for the current potential study. As reported in the evaluation reports, total savings in a given year are split into two buckets: Legacy Savings and Incremental savings. Table D-7 shows a hypothetical scenario where the same customers are reached under previous Home Energy Reports programs and the 2021 program. The following are presented:

- Total Persisting Savings which align with the persistence factors from the TRM
- Legacy savings from HER programs up to 2020 (same persistence factors with a 1-year delay); and,
- Incremental savings from the 2021 program, which prevents the decline in savings.

[4] 2% improvement noted for Climate zone 6. Source: https://www.energycodes.gov/sites/default/files/documents/2018_IECC_PreliminaryDetermination_TSD.pdf#page=8

[5] 8% improvement on average nation wide. Source : https://www.energycodes.gov/sites/default/files/documents/02202018_Standard_90.1-2016_Determination_TSD.pdf#page=10

[6] Stated target is 10%-15% improvement by 2021 codes. We assume that is net of the current baseline and applied 10% for residential and 15% for commercial. Source: https://www.greenbuildingadvisor.com/article/2019-year-energy-codes

Table D-7. Sample savings from a 2021 Home Energy Report Program

	2021	2022	2023	2024	2025	*Total*
Legacy Savings	80%	54%	31%	15%	-	-
Incremental 2021 savings	20%	26%	23%	16%	15%	*100%*
Total Persisting Savings	*100%*	*80%*	*54%*	*31%*	*15%*	-

The reader will notice that both the total persisting savings for the current year (2021), and the sum of the 2021 incremental savings, are 100%.

Therefore, since it is assumed that the Home Energy Report program will remain throughout the potential study period, the approach for this study is to assess the *total persisting savings* for every year of the potential study, instead of separating the *legacy savings* from the *incremental savings*, in order to compare apples with apples with the other measures.

In the DEEP model, in general, the EUL is used to define the portion of the total market which is eligible for a replacement (for example, 1/16th of ASHPs would reach their end of life in a single year), as well as the cumulative potential. Therefore, using the 1-year EUL for the HER measure enables the whole market to be reached every year, and prevents the same savings from being counted more than once in the cumulative savings.

This approach aligns with the Illinois TRM and the program evaluation reports in that 100% of savings are characterized in a single year (same as the sum of the incremental savings), and 100% of the total persisting savings are included in the cumulative savings (same as the sum of the legacy savings and incremental savings, avoiding double-counting).

1.6.2 – Measure and market characterizations

In order to reflect the economic potential of Home Energy Reports, the measure was split in two:

1. The first measure aligns with ComEd's current program, using the CY2018 evaluation report (1.52% average savings). Leveraging the granular market segmentation in the current potential study, it has been assumed that the high-consumption segments are included first, until the number of participants from the CY2018 eval report is reached.

2. The second measure is designed to model the potential from reaching up to 80% of residential customers. The savings percentage per segment uses a linear regression from the 2018 evaluation report based on the kWh consumption per home from the different HER waves. On average, the savings are lower than the first measures, at 0.82%, which is expected as most high-consumption customers are already considered to have been reached in the first measure.

Table D-8 details the market applicability of both HER measures by residential market segment.

Table D-8   Home Energy Report behavioral measure market applicability by segment

Sector	Building type	Whole-home kWh	Home size	Population	Avg kWh	Reached by 1st measure	Reached by 2nd measure
Residential	Single family	Low	All	478 934	4 410	24%	52%
		Medium	<2,000 ft^2	255 056	8 111	80%	20%
			>2,000 ft^2	137 766	8 345	84%	16%
		High	<2,000 ft^2	173 232	13 428	90%	10%
			>2,000 ft^2	278 090	16 380	90%	10%
	Multifamily	Low	All	479 881	2 067	5%	11%
		Medium		137 269	4 493	24%	54%
		High		142 685	10 399	90%	10%
Income eligible	Single family	All	<2,000 ft^2	463 774	7 067	61%	39%
			>2,000 ft^2	59 512	9 989	90%	10%
	Multifamily	All	All	605 540	4 671	26%	58%

The cost assumption is $8.65 per HER, using data from the Rhode Island TRM.

2 Market Characterization

2.1 – Customer Population Counts

Customer population counts are a key parameter for defining market opportunities. They are presented for each sector and segment in Table D-9 and Table D-10.

2.1.1 – Residential segmentation

For this study, ComEd expressed a strong interest in using data collection and analysis approaches designed to minimize aggregation bias wherever possible. For most of the major residential end-uses, Itron's multi-modal data collection approach for the baseline study allows the distribution of end-use energy consumption to be characterized based on large samples of equipment-specific rated capacity and efficiency data.

Itron augmented this rich primary data set with a dedicated analysis designed to characterize the distribution of space cooling energy consumption in ComEd's service territory. This analysis was composed of two main steps – site-specific load disaggregation followed by a cluster analysis – the output of which is a segmentation scheme designed to minimize aggregation bias for space cooling measures that is then applied during the estimation of economic potential.

In total, the following were identified as the variables that most differentiated each main cluster (and were available for this study):

- Building type (single family vs multi-family)
- Whole-home kWh consumption (low, medium, high)
- Home size (less than 2,000 ft^2, greater than or equal to 2,000 ft^2)
- Low-income program eligibility (Income-eligible, non-income-eligible)

These variables combine to produce 24 segments. However, after examining the average space cooling consumption in each of the segments defined by these variables, several segments with either very small customer populations, similar average space cooling consumption, and/or similar market adoption barriers can be collapsed. The final set of 11 modeling segments that are defined for the potential study phase of this project are presented in Table D-9:

Table D-9. Residential customer sector and segment population counts

Sector	Building type	Whole-home consumption	Home size	Population	2017 GWh
Residential	Single family	Low	All	478,934	2,112
		Medium	<2,000 ft^2	255,056	2,069
			>2,000 ft^2	137,766	1,150
		High	<2,000 ft^2	173,232	2,326
			>2,000 ft^2	278,090	4,555
	Multifamily	Low	All	479,881	992
		Medium		137,269	617
		High		142,685	1,484
Income eligible	Single family	All	<2,000 ft^2	463,774	3,277
			>2,000 ft^2	59,512	594
	Multifamily	All	All	605,540	2,828

2.1.2 – Non-residential segmentation

As with the residential sector, ComEd expressed a strong interest in using data collection and analysis approaches designed to minimize aggregation bias wherever possible. For the commercial sector, Itron explored a range of different segmentation schemes (e.g. various combinations of building type, size, and public vs. private) that would minimize aggregation bias, align with prevailing program designs, and address ComEd's highest priority research objectives. This exercise yielded a segmentation scheme based primarily on building type (based on NAICS code). This segmentation was the most well-distributed in terms of the relative shares of total commercial consumption (and by proxy, energy savings potential).

The main aspects of this segmentation scheme that help address aggregation bias are: 1) separating Education into Colleges and Other Education, and 2) separating Offices from Public Administration (which are often grouped together). This segmentation approach also aligns well with prevailing segment-specific program designs and market barriers.

The final set of 11 modeling segments that are defined for the potential study phase of this project are presented in Table D-10.

Table D-10. Non-residential customer sector and segment population counts

Sector	Segment	Population	2017 GWh
Commercial	Office	107,763	8,325
	Public admin	13,216	3,971
	Retail	55,338	4,861
	Food	22,420	2,461
	Grocery	8,167	2,080
	Health	30,716	3,510
	Colleges	1,005	2,407
	Other education	8,401	855
	Lodging	4,315	1,134
	Entertainment	6,399	1,012
	Wholesale	11,301	2,537
	Other commercial	33,387	1,474
Industrial[7]	Industrial, <100 kW	12,339	480
	Industrial, 100-400 kW	1,969	906
	Industrial, >400 kW	1,361	6,889

[7] Note that the Industrial sector uses a different modeling approach in the current potential study, which is described in detail in Appendix B.

3 Program Characterization

Program characterization is performed by reviewing past energy efficiency program investments and savings, as well as the 2018-2021 EE Plan investments and savings. These are then compared to Dunsky's internal database of program incentive levels from other potential studies and program design work and the program costs, incentive levels and measure barrier reductions resulting from enabling activities in each program are set for each of the programs.

The programs are used for the calibration of the results, as described in Appendix C. For simplicity and to facilitate that high-level calibration to ComEd's CY2018 and CY2019 program results, programs are bundled by end-use, with additional granularity for some specific C&I lighting measures like TLEDs.

Program costs are not included in the scope of the current potential study.

Table D-11. Program Inputs

Program	Average Incentive Level	Barrier Level Impact
Residential Appliance	48%	-1
Residential Behavioral	100%	-1
Residential Envelope	34%	-1
Residential Hot Water	100%	-1
Residential HVAC	33%	-1
Residential Lighting	55%	-1.5
Residential Other	38%	-1
Income eligible	100%	-1.5
Business Envelope	50%	-1
Business Hot Water	47%	-1
Business HVAC	35%	-1
Business HVAC Motors	67%	-1
Business Kitchen	34%	-1
Business Lighting	44%	-1
Business Office Equipment	36%	-1
Business Refrigeration	27%	-1
Industrial	44%	-1

Note: Incentives are expressed as the portion of efficient equipment incremental costs covered by the program.

4 Economic and other parameters

4.1 – Discount Rates and Line Losses

Discount and inflation rates are used throughout the model to forecast future values and value future dollar amounts in the present day. Transmission and Distribution line loss factors capture the energy and peak demand loss in the transport of electricity from the generator to the meter.

The discount rates are sourced from the 2020 Illinois Technical Reference Manual. The inflation rate and generator-to-meter line losses are sourced from the internal company document '2020 Energy Supply Escalators. The rate values as shown in Table D-12 and Table D-13 are used across the study as necessary.

Table D-12. Discount and inflation rates

Rate Name	Rate Value
Nominal Discount	2.380%
Real Discount	0.460%
Inflation	1.809%

Table D-13. Transmission and Distribution Line Losses Factors

Rate Name	Rate Value
Energy	11.28%
Peak Demand	14.48%

4.2 – Avoided Costs

Avoided Costs are used principally to determine the cost savings from the energy and demand savings. This study calculated the avoided costs for electric energy and demand, natural gas, propane, and water.

2020 electric energy avoided costs are derived from NYMEX future markets. This price is calibrated using the selected electric price scenario within the DSMore analytics package. All years from 2021-2045 track the EIA's Annual Energy Outlook (AEO) price forecasts from the 'Electricity Supply, Disposition, Prices, and Emissions' table under the 'Energy Prices' section of the AEO datasets. For years beyond (i.e. 2046-2060), avoided costs are calculated using a linear forecast.

Electric capacity prices for 2020 are based on PJM Base and transition auction results and reflect the clearing prices for the ComEd zone. All years from 2021 onward escalate prices using the same methodology that is used to determine electric energy avoided costs.

2020 gas avoided costs were provided by ComEd. Years 2021-2045 use the AEO 2018 forecasts – which includes the Clean Power Plant adder - to track cost escalation. For years beyond those covered by the AEO forecasts (2046-2060), avoided costs are calculated using a linear forecast.

Propane values are based on the EIA wholesale weekly average for 2019. Years 2021-2045 escalate using the EIA's residential propane price forecast considering the Clean Power Plan. For years beyond (i.e. 2046-2060), avoided costs are calculated using a linear forecast.

For water avoided costs, the study sources the current City of Chicago Water rates. According to the source, water rates escalate at inflation, so we assume the avoided costs in real dollars will stay constant over the project period.

The avoided cost inputs used in this study are available in a separate workbook accompanying this report. The values are reported in 2021 real-dollar terms.

4.3 – Retail Rates

The study uses marginal retail rates to estimate customer bill impacts – one component of calculating achievable potential – for energy savings measures. Average 2019 marginal electric and gas retail consumption and demand rates were developed by ComEd on March 21st, 2020 and delivered to Dunsky. The rates are delivered in three classes: residential, small C&I and large C&I. In the C&I sector, using consumption data by size and segment, Dunsky blended the rates by size to create C&I rates by segment. All rates are inflated to 2021 dollars - the first year of the study – and are assumed to escalate at the model inflation rate.

The retail rate inputs used in this study are available in a separate workbook accompanying this report. The values are reported in 2021 real-dollar terms.