Focus on Energy®
Quad V Planning Study (2027–2030)

Assessment of Energy Savings Potential

December 2025

Prepared for:

Public Service Commission of Wisconsin
4822 Madison Yards Way
North Tower—6th Floor
Madison, WI 53705-9100

CADMUS

Prepared by:
Taylor Bettine
Jeremy Eckstein
Casandra Guillen
Andrew Grant
Aquila Velonis

Table of Contents

Tables

Figures

Acronym List

Acronym	Definition
ACEEE	American Council for an Energy-Efficient Economy
AFUE	Annual Fuel Utilization Efficiency
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BBtu	Billion British thermal units
CBECS	Commercial Building Energy Consumption Survey
CFL	Compact fluorescent lamp
CHP	Combined Heat and Power
DOE	U.S. Department of Energy
EIA	Energy Information Administration
EUL	Effective useful life
EWG	Evaluation Working Group
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-emitting diode
MECS	Manufacturing Energy Consumption Survey
MMBtu	Million British Thermal Units
mTRC	Modified total resource cost
MW	Megawatt
MWh	Megawatt-hour
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
PAT	Program Administrator Test
RECS	Residential Energy Consumption Survey
SEA	Strategic Energy Assessment
SCT	Societal Cost Test
TRM	Technical reference manual
UDC	Uniform Dwelling Code

Executive Summary

Wisconsin agricultural, commercial, industrial, and residential buildings suitable for energy efficiency upgrades consume approximately 540 trillion British thermal units (Btus) of energy per year, which is approximately equivalent to 25 days of coal consumption in the United States[1] or enough gasoline to fuel every car in United States for 12 days.[2] About 65% of this building energy consumption comes from natural gas supplied by Wisconsin utilities and is used primarily in winter months for space heating.

By taking every possible opportunity to install the most efficient available technology, as well as rooftop solar, Wisconsin buildings and homes could reduce their energy consumption by 18% to 30%, depending on whether gas-heating equipment is upgraded with the most efficient gas alternative or replaced with the highest efficiency electric heat pumps. The potential lifecycle carbon emissions reduction impacts of these improvements range from 312 million to 359 million metric tons, which is roughly equivalent to 1% of annual global carbon emissions.[3]

While technically feasible, high efficiency technologies typically cost business and households more to install than market-standard alternatives. Thus, businesses and households face financial and other barriers to upgrading their buildings.

Focus on Energy provides technical assistance and financial incentives to address these barriers; its current budget and approach are expected to capture 50% of available savings due to energy efficient equipment upgrades. Other impacts of energy use reduction achieved by Focus on Energy's programs include summer and winter electric peak and gas peak demand reductions.

Given the substantial impact that Focus on Energy programs can have on energy use in the built environment, Focus on Energy and its stakeholders sought insights to inform the design of future programs over a variety of possible portfolio objectives, for the program's quadrennial planning process. Therefore, this Planning Study was developed and executed to analyze the impacts and trade-offs from six potential program design scenarios:[4]

- **Baseline:** Programs that largely maintain current offerings and budget distributions
- **Emissions Focused:** Programs emphasizing measures with maximum emissions reduction potential
- **Summer Electric Peak Focused:** Programs that focus on reducing summer electric peak demand
- **Summer Electric Peak Focused with Load-Shifting Program:** Programs that focus on reducing summer electric peak demand and introduce additional load-shifting approaches

1 U.S. Energy Information Administration. November 2025. Annual Coal Report. https://www.eia.gov/coal/annual/.

2 U.S. Energy Information Administration. Last updated March 2024. How much gasoline does the United States consume? https://www.eia.gov/tools/faqs/faq.php?id=23&t=10.

3 International Energy Agency. 2025. Global Energy Review 2025, IEA, Paris https://www.iea.org/reports/global-energy-review-2025/co2-emissions.

4 For a description of the formal study objectives and research questions, please refer to *Appendix A*.

- **Electrification Focused:** Programs focused on electrification measures added to the baseline scenario
- **Cost-Effectiveness Focused:** Programs that seek to maximize deployment of the most cost-effective measures

To evaluate these program option trade-offs, the Planning Study analyzed energy use and associated electric generation emissions for each hour of the day over 12-years, from 2027 through 2038, a period that covers three Focus on Energy quadrennial planning cycles. The study methodology combined analyses of peak impacts using Focus on Energy's peak period definitions, carbon emissions impacts using Wisconsin's utility-specific generation profiles, industrial program potential (informed by end-user interviews, historical program participation data, and utility projected industrial load growth estimates), cost-effectiveness, and interactive effects. The study used simulation modeling to estimate measure adoption, leveraging primary research on customer decision-making, project payback periods, and market maturity of Focus on Energy programs. To ensure that scenario impacts are comparable to Focus on Energy's historical performance, the study calibrated the baseline portfolio design to current offerings. Finally, to maintain fidelity with stakeholder objectives and ensure engagement and buy-in, the study engaged with Focus on Energy implementation staff and other stakeholders throughout the data collection and analysis processes.

This Planning Study developed detailed results for each sector (agriculture, commercial, industrial, and residential), building type (such as hospitals, manufacturing facilities, and single family homes), building-end use (such as water heat, space heat and cooling, plug loads), utility service area, and population segment (standard income and income-qualified). The collected data are too granular and too extensive to represent fully in a report. Thus, the Planning Study also produced a dashboard that interested parties can use to view results at their preferred level of detail.

Findings

The Planning Study developed estimates of energy, emissions, and peak energy demand impacts at the following levels:

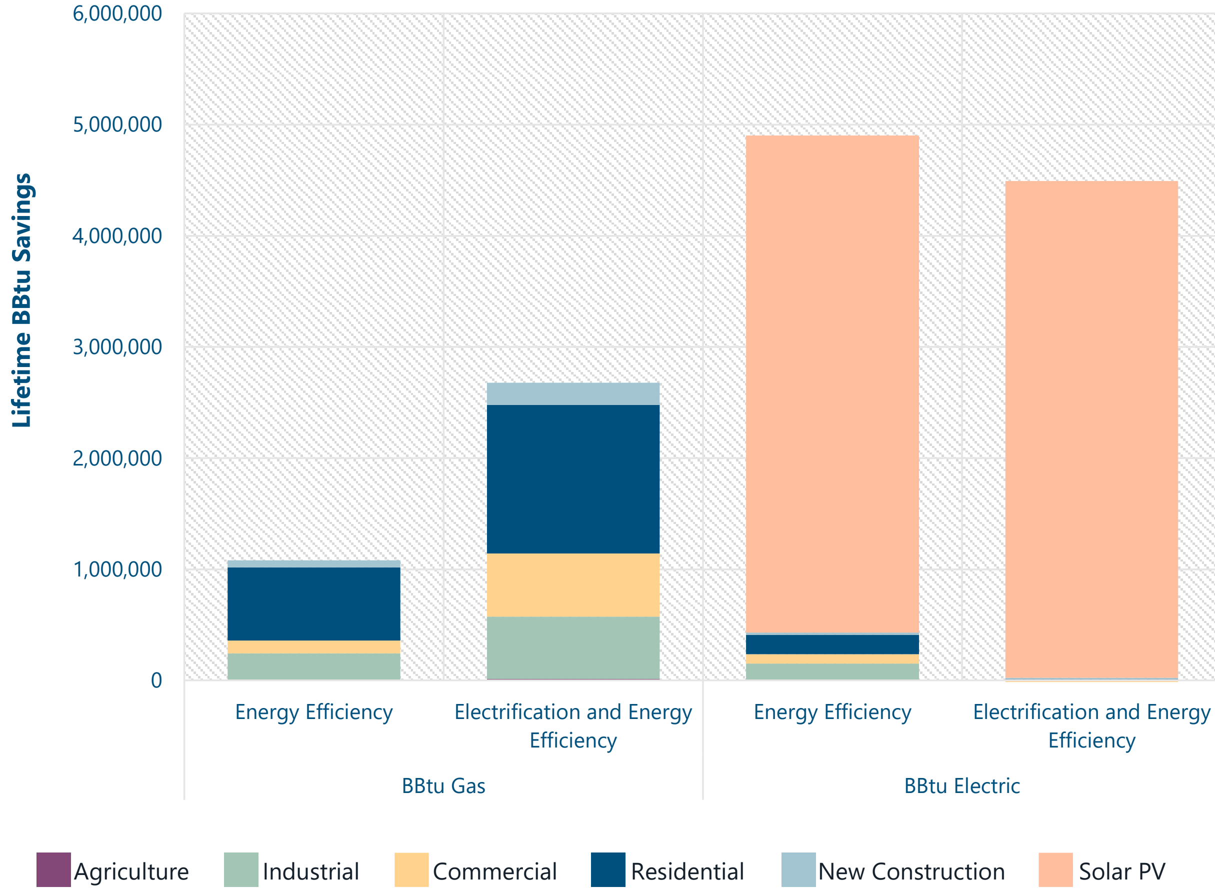
- **Technical potential**: The maximum possible impact from upgrading every building in Wisconsin to the greatest extent possible with currently available technology.
- **Economic potential**: That portion of technical potential for which the benefits of each building upgrade opportunity are greater than the associated cost. The study measured this benefit-cost ratio from three perspectives.
- **Program scenario potential:** The impacts from Focus on Energy programs, rooted in its current budget and approach for six-scenarios that align with potential program priorities.
- **Optimized potential:** The longer-term impacts of Focus on Energy, as designed in program scenario potential.

Technical Potential

The Planning Study developed technical energy savings potential for two scenarios: an energy efficiency scenario, in which the most efficient gas option replaces gas-consuming equipment, and an electrification and energy efficiency scenario, in which electric heat pumps replace this equipment. The energy efficiency scenario primarily impacts gas use, saving approximately 1 million billion British thermal units (BBtu) of gas over the full lifetime of each measure. Gas savings potential is higher than electric savings potential because statewide baseline gas consumption is nearly twice as high as electric consumption and because gas measures encompass fewer end uses than electric measures (e.g., space and water heat) that typically have a longer effective useful life (EUL).

As illustrated in Figure 1, technical energy savings potential is significantly greater for gas use under the electrification and energy efficiency scenario, because the commercial and residential electric heat pump technologies selected for these scenarios are much more efficient than even the most efficient gas-saving alternatives. When electrification measures are included, technical potential is approximately 30% of 2038 energy consumption, nearly 45% of statewide gas consumption and nearly 3% of statewide electric consumption. Additionally, while installing rooftop solar panels on every commercial and residential rooftop in Wisconsin has substantial technical potential to reduce electric demand from electric power plants, adoption of rooftop solar has been relatively moderate and makes up only a small percentage of the Focus on Energy portfolio.

Figure 1. Technical Potential Lifecycle Energy Impacts: Energy Efficiency Scenario and Energy Efficiency and Electrification Scenario



These potential energy savings are largely driven by the building upgrade opportunities shown in Table 1:

Table 1. Building Upgrades Offering the Greatest Technical Potential by Sector

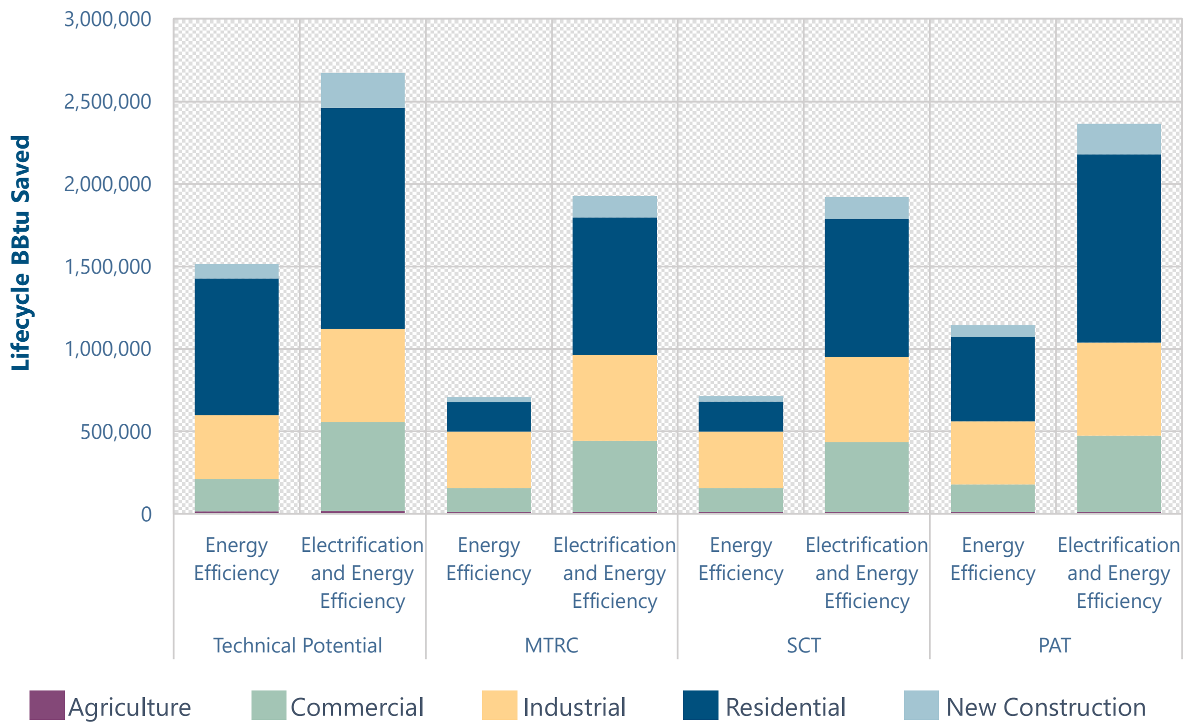
Sector	Energy Efficiency Scenario	Electrification and Energy Efficiency Scenario
Agricultural	Efficient grain dryers	Efficient grain dryers
Commercial	HVAC commissioning: advanced rooftop unit controllers, direct digital control systems, and other commissioning measures	Space heat pumps
Industrial	Process heat recovery, new construction design, and custom processes and boilers	Industrial heat pumps and resistance heating measures
Residential	Building shell upgrades including weatherization projects and window measures	Cold climate heat pumps

Economic Potential

To understand economic energy, emissions, and peak reductions potential, the Planning Study analyzed each alternative improvement measure from three perspectives: the modified total resource cost (mTRC) test, which evaluates cost-effectiveness considering incremental costs and total resource benefits, the program administrator test (PAT), which evaluates program costs and benefits from a utility perspective, and the societal cost test (SCT), which evaluates benefits and costs from the perspective of society at large.

As illustrated in Figure 2, the mTRC and the SCT screens produce very similar results; however, economic potential is considerably higher under the PAT, driven mostly by the residential sector. This is primarily because weatherization projects, which include the highest saving residential measures, are not cost-effective from the mTRC and SCT perspectives due to their high incremental costs; however, because the PAT test does not include incremental costs, weatherization becomes cost-effective from the PAT perspective. Carbon emissions are highly correlated with energy use; therefore, the distribution of carbon reduction is very similar to the distribution of energy savings for each of the sectors under each of the six economic potential scenarios.

Figure 2. Economic Potential Lifecycle Energy Savings: Energy Efficiency Scenario and Energy Efficiency and Electrification Scenario



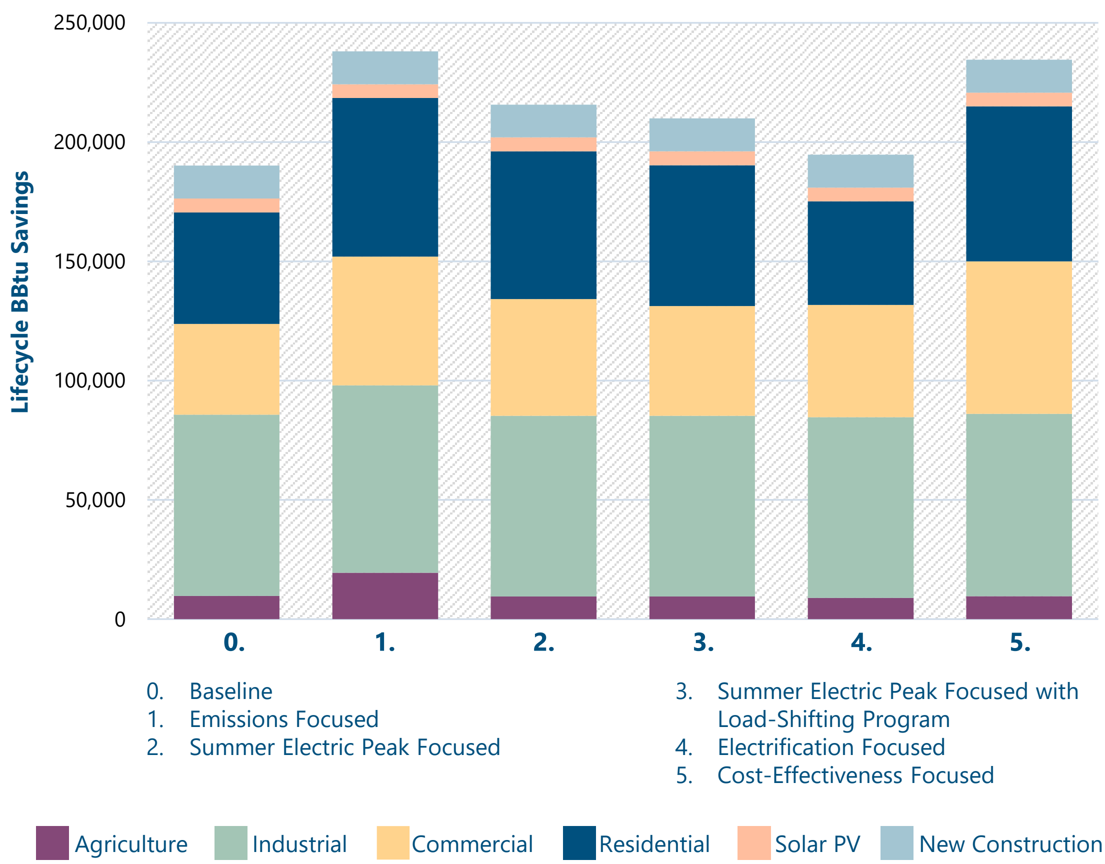
Program Scenario Potential

The Planning Study developed six program scenarios that emphasize possible future Focus on Energy priorities. Other than the baseline scenario, which reflects measure offerings that are largely aligned with current program design, the Planning Study designed each scenario to accelerate adoption through increased incentives, or removed measures based on their energy, emissions, or peak impact per incentive dollar spent. For the cost-effectiveness scenario the study accelerated measures with the highest mTRC benefit-cost ratio, and removed those with the lowest ratio.

The baseline scenario has the lowest energy savings of all the scenarios, and the emissions-focused and cost-effectiveness-focused scenarios each increase energy savings by approximately 25% relative to the baseline scenario. There is little overall change in total electric and gas BBtu savings between the electrification scenario and the baseline. This is because in some programs, overall energy savings decrease as the budgets for energy efficiency and electrification measures are used more quickly, driven by the combination of an emphasis on electrification measures and higher assumed incentive costs for electrification measures.

In the electrification scenario, total electric savings decrease by approximately 5,000 lifecycle BBtu, while total gas savings increase by 10,000 lifecycle BBtu, reflecting the high efficiency of the selected electrification measures, which are approximately twice as efficient as the gas space and water heating systems that they replace. The two summer electric peak–focused scenarios have relatively similar energy impacts. This similarity is expected given the relatively small budget allocated to load-shifting programs and the long lead time required to establish new programs. The difference between these scenarios is the addition of a load-shifting program, which has a small impact on total energy savings. Figure 3 shows the estimated total lifecycle energy savings for each program scenario

Figure 3. Quad V Program Scenario Lifecycle BBtu Savings by Scenario



As expected, the emissions-focused scenario has the largest impact on emissions reductions, saving approximately 2.3 metric tons (23%) more carbon emissions than the baseline scenario. The cost-effectiveness-focused scenario, which maximizes portfolio cost-effectiveness by removing the least cost-effective measures and increasing incentives for the most cost-effective measures, also significantly reduces carbon emissions while increasing the portfolio mTRC cost-effectiveness ratios from 1.5 to 2.2. This trend shows that reducing emissions adds substantial benefits to the mTRC cost-effectiveness calculations; however, designing a portfolio focused only on cost-effective measures substantially limits program participants' upgrade options. Table 2 shows the main metrics for each scenario.

Table 2. Quad V Scenario Impacts

Scenario	Lifecycle Energy Savings (BBtu)	Lifecycle Carbon Emissions Savings (million metric tons)	Summer PM Peak Reduction (MW)	Cost-Effectiveness mTRC Ratio	Acquisition Cost ($/MMBtu)
Baseline	190,300	9.9	227	1.5	1.4
Emissions Focused	237,900	12.2	278	1.8	1.2
Summer Peak Demand Focused	215,700	11.2	300	1.8	1.3
Summer Peak Demand Focused with Load Shifting	209,900	11.7	294	1.8	1.3
Electrification Focused	194,700	10.1	211	1.5	1.4
Cost-Effectiveness Focused	234,400	12.1	289	2.2	1.2

Considerations for Focus on Energy Program Planning

Each program scenario the Planning Study analyzed involves trade-offs. Program planning choices are heavily dependent on Focus on Energy's objectives and priorities over the next quadrennium. Whether Focus on Energy chooses to prioritize saving energy, reducing emissions, managing demand, or some combination of the three has implications for customers' measure options and available incentives, as well as for portfolio costs and delivery approach.

- The business-as-usual approach (baseline scenario) is the least advantageous in terms of energy savings, emissions reductions, and demand management, but offers the greatest diversity of measures to all customer segments.
- The emissions-focused program scenario represents the best option for both achieving overall energy savings and capturing the greatest reduction in GHG emissions. This scenario also reduces acquisition costs and increases portfolio cost-effectiveness. However, it limits customers' program options by removing a large number of measures from the portfolio across all sectors, including some measures (such as efficient air conditioners and residential and commercial appliances) that were found to be impactful for reducing summer peak demand. Additionally, this approach requires attention to the season during which a measure saves energy. Emissions in Wisconsin are lower during the summer months, making heating system upgrades (particularly electric) a key priority; however, winter electric saving measures have high relative acquisition costs. Addressing both concerns requires a nuanced balance that emphasizes heating system efficiency measures as well as measures with lower seasonal variation.

- Unlike the emissions-focused approach, maximizing summer peak demand savings requires an emphasis on measures that reduce electric energy consumption in the summer months (as well as those that reduce electric energy demand consistently over the year). This strategy also produces measurable energy and emissions reductions (though less than with either the emissions-focused or cost-effectiveness-focused scenarios) while increasing cost-effectiveness and reducing acquisition costs compared to the baseline scenario. Implementing a load-shifting program does little to support this objective on its own and is not cost-effective; however, integrating a low-cost and broadly applicable thermostat load-shifting strategy into peak demand reduction programs may have an additive overall effect on summer demand management impacts. Emerging technologies such as thermal and battery storage had high demand reduction impacts but were not found to be cost-effective and broad adoption of these technologies is likely unrealistic given Focus on Energy's budget and market dynamics. Adopting a broad set of programmatic options focused on proven summer peak electric energy reduction and demand management strategies appears to be the most beneficial in terms of both grid management and acquisition costs.
- The cost-effectiveness-focused scenario produces savings that are nearly equivalent to those of the emissions-focused scenario. This scenario substantially reduces carbon emissions while also increasing the portfolio mTRC cost-effectiveness ratio from 1.5 to 2.2 and achieving strong summer peak demand reduction. However, designing a portfolio focused on cost-effective measures limits the number of available measures, including many measures with shorter lifetimes that customers particularly value. Such measures can often serve as "door openers" for customers to engage with energy efficiency programs, so limiting them may reduce opportunities to cross-promote programs and measures within the portfolio. Alternatively, focusing on measures with the lowest incremental costs and removing those with the highest costs maximizes the budget available for high-saving measures, and could enable Focus on Energy to invest in higher incentives and more targeted and higher-touch marketing strategies.
- The electrification scenario offers very limited advantages—in terms of overall energy savings, emissions reductions, and demand management—compared to the baseline scenario. Additionally, because electricity costs are higher than gas costs on a $/Btu basis, electrification projects generally incur higher customer energy costs, and customers' willingness to adopt electrification measures is lower than their willingness to engage in traditional energy efficiency projects, making it both more difficult and more costly to spur customers to act. Finally, the electrification scenario reduces the budget available for efficiency measures. With a fixed budget, this limits Focus on Energy's ability to influence those customers who do not wish to fuel-switch and prioritize investing in higher efficiency gas measures.
- Based on the program scenario findings, the cost-effectiveness scenario, which achieves large reductions in emissions and peak demand while increasing cost-effectiveness, may appear to be the optimal choice to inform future program design. However, decades of energy efficiency program delivery experience indicate a more nuanced approach which suggests that comprehensive measures and a diversity of program options may be more likely to maximize sustained customer engagement. This engagement, regardless of program offerings, ultimately drives all benefits. Considering both findings from the program scenarios and best practices in

program design, the cost-effectiveness-focused scenario can offer a preliminary framework for the design of initial program offerings, coupled with a holistic review process to assess the value of including less cost-effective measures that generate high customer engagement and satisfaction. This approach is most likely to support a balanced portfolio that generates comprehensive long-term benefits for Focus on Energy, its stakeholders, and all Wisconsin residents.

- Households with an income of 80% or less of the area median income are eligible for increased incentives for certain measures to help offset the up-front costs of participating in the program (a known barrier to participation for income-qualified customers). Income-qualified households make up 38% of the state's households. Eligible households have not historically participated in Focus on Energy's income-qualified offerings at a rate consistent with their percentage of the overall population. This phenomenon is common among utility energy efficiency programs, and the barriers to participation for income-qualified households are well documented. The Planning Study's program scenarios include a dedicated budget for income-qualified incentives that is equivalent to 9% of the total residential budget. While a household can participate in any program, the income-qualified budget constraint likely limits adoption of energy savings measures by income-qualified households. This finding suggests that Focus on Energy may be able to achieve additional savings in the residential income-qualified sector by increasing the budget dedicated for these households. However, any budget decisions for income-qualified offerings should also consider the implications to portfolio cost-effectiveness requirements.

Study Overview

The Quadrennial V Planning Study provides Focus on Energy stakeholders with insight about how Focus on Energy programs can reduce future energy consumption, peak-time energy demand, and gas and electric emissions in Wisconsin. The study provides a view into the potential energy and emissions impacts if every building eligible for Focus on Energy incentives were upgraded to the greatest extent possible with programmatic energy efficient equipment and building envelope improvements, setting an upper limit on maximum theoretically possible impacts if Focus on Energy customers adopted all currently available interventions. The study then measures potential impacts from the Focus on Energy portfolio, considering market adoption, possible changes to measure offerings, rising costs, and evolving market conditions. While this study focuses primarily on the upcoming Quadrennial Period (2027 through 2030), it also provides potential impacts for the timespan of the next three Quadrennials (2027 through 2038).

Study Priorities and Objectives

A key objective of this study is to allow Focus on Energy stakeholders to understand the potential impacts of adapting future program designs to emphasize impacts beyond energy savings. To achieve this objective, the study's analysis centers on six potential program design scenarios. These scenarios, developed in consultation with Focus on Energy stakeholders, present the impacts and trade-offs from modifying the current program delivery approach to emphasize emissions reduction, summer electric peak reduction, electrification, and cost-effectiveness.[5] Table 3 presents these scenarios.

Table 3. Planning Study Scenarios

Scenario	Scenario Description
0. Baseline	Largely maintaining current offerings and budget distributions
1. Emissions Focused	Emphasizing measures with maximum emissions reduction potential
2. Summer Electric Peak Focused	Emphasizing measures that reduce summer electric peak demand
3. Summer Electric Peak Focused with Load Shifting Program	Adding a program to scenario 2 that specifically focuses on electric load shifting.
4. Electrification Focused	Expanding baseline offerings to include additional electrification measures.
5. Cost-Effectiveness Focused	Emphasizing the most cost-effective measures.

To inform the insights this study provides about impacts from alternative program design, Cadmus incorporated historical program context into its analysis. Based on findings from comparing forecasts from the most recent potential study (2021) to actual achievements, Cadmus took the following steps to ensure alignment with past program accomplishments.

1. Designed the approach to estimating future industrial impacts to capture the nuances of industrial program implementation

[5] For a description of the formal study objectives and research questions, please refer to *Appendix A*.

2. Calibrated program scenario results with recent program accomplishments to ensure sector and measure-level predictions were aligned in terms of energy savings, budgets, and acquisition costs (energy saved per incentive dollar spent)
3. Consulted with the Focus on Energy Program Administrator throughout the study to verify assumptions.[6]

Study Scope

The primary output of this study is an analysis of potential energy impacts in Wisconsin's building stock from the 301 intervention measures in the agricultural, commercial, industrial, and residential sectors[7]. The study measures, which Cadmus developed with input from Focus on Energy stakeholders, include current Focus on Energy offerings and additional measures that the Program may consider in the future, such as expanded electrification and technologies for shifting the timing of energy use. The study distinguishes between equipment upgrade and building retrofit measures; it assumes that equipment upgrades occur only when existing equipment fails, whereas retrofit measures can occur at any given time and do not depend on the lifetime of the equipment.

Potential future impacts from Focus on Energy programs can be shown at different levels, including a theoretical maximum or impacts constrained to program budgets. Table 4 shows the various levels at which the study calculated the potential impacts from study interventions from 2027 through 2038.

Table 4. Focus on Energy Planning Study Energy Impacts Reporting Levels

Reporting Level	Description	Scenarios
Baseline Forecast	The baseline forecast provides the statewide energy consumption forecast for each sector, building type, income, and building end use. The baseline forecast is the foundation for technical, economic, and optimized potential estimates. To calculate the baseline forecast, the study leveraged a detailed assessment of the Wisconsin building stock (including distributions and energy consumptions of various building types), characteristics of equipment in those buildings, and building counts. The baseline forecast relies on utility-provided customer and load data and is calibrated to actual utility loads in 2024. The baseline forecast shows energy consumption over the study period (2027–2038).	The study developed only a single baseline forecast.
Technical Potential	The total impacts if all technically feasible study measures were installed over the study period is called technical potential. Because the study includes measures that may compete with each other, such as multiple types of furnaces, technical potential includes the impacts from only the most efficient option.	Two scenarios: • The energy efficiency scenario assumes that the most efficient energy efficiency option is installed.

6 The Potential Study Gap Analysis conducted at the onset of the study (see *Appendix B*), provides results of the comparison of past study analysis to current trends.

7 Please see *Appendix C* for the full list of study measures.

Reporting Level	Description	Scenarios
	Technical potential considers interactions between measures (such as when a weatherization measure is installed after a furnace upgrade, which reduces the energy savings from weatherization), the energy savings impacts from changing equipment standards that change the baseline conditions, and the type of fuel savings from weatherization measures when a building switches heating fuel. Technical potential provides the theoretical maximum energy impact from Focus on Energy interventions, not accounting for budget constraints or market barriers. Technical potential shows savings over the entire study period (2027–2038).	• The electrification and energy efficiency scenario assumes that an electrification technology is installed instead of an efficiency measure, when the option exists.
Economic Potential	Economic potential includes the impacts from only measures that pass a cost-effectiveness screen. The study includes three cost-effectiveness screens: mTRC test, the PAT, or the SCT. Each test estimates cost-effectiveness from a distinct perspective. For more information on the cost and benefits considered in each test, please see the *Cost-Effectiveness Analysis* section. Economic potential calculates the same interactive effects and impacts from equipment standards described above for technical potential. Economic potential shows savings over the entire study period (2027–2038).	Six scenarios: The energy efficiency scenario and the electrification and energy efficiency scenario (similar to technical potential), with three different cost-effectiveness screens for each scenario.
Program Scenario Potential	Program scenario potential provides a detailed look at the potential performance of future Focus on Energy programs and is designed to mirror how Focus on Energy currently operates. As much as feasible, given market changes and technology offerings, program scenario potential is calibrated to current program delivery, including measure participation, acquisition costs, and cost-effectiveness. Program scenario potential provides insight into the potential performance of the future Focus on Energy portfolio and assesses how program impacts vary for each scenario. Scenario potential reflects energy savings in Quad V (2027–2030)	Six scenarios varying measure offerings and measure incentives.
Optimized Potential	Optimized potential simulates customer decisions to adopt Focus on Energy offerings using a behavioral model that combines primary research about customer preferences; project economics considering project installation costs, bill impacts, and market maturity of offerings; and Focus on Energy incentives. Like technical and economic potential, optimized potential considers measure interactions and changes to equipment standards. Unlike technical and economic potential, optimized potential considers energy efficiency and electrification equipment in the same scenario reflecting customer choices of either option. Optimized potential provides a simulation of potential market adoption trends considering customer preferences, project characteristics, and project economics. Scenario potential reflects energy savings in each quadrennium (2027–2030, 2031–2034, 2035–2038).	Six scenarios varying measure offerings and measure incentives.[8] Each scenario reflects a potential future Focus on Energy program design.

[8] For a detailed description of each scenario please see the *Program Scenario Potential* section.

This study reports the impacts from study measures for each level of potential across multiple energy, peak demand, and emissions metrics. Table 5 shows the primary metrics for which this study has calculated impacts. To compare the relative impacts on electric and gas use, this study normalized both gas and electric energy impacts to BBtu.

Table 5. Focus on Energy Planning Study Energy Impacts Reporting Metrics

Type of Impact	Reporting Metric
Energy Impacts	Electric Energy: kWh and BBtu Gas Energy: Therms and BBtu
Peak Demand Impacts	Electric Peak: Summer PM, Winter AM, Winter PM Gas Peak: Winter therm-day
Carbon Emissions	Electric Impacts: Lifecycle impacts from electric generation Gas impacts: Lifecycle impacts from on-site combustion of gas

The Planning Study analyzes the impacts of energy savings across many building types, each with a distinct energy consumption profile. These building types help to define the different facilities across the agricultural, commercial, industrial, and residential sectors in Wisconsin. Some measures are applied only to specific building types; refrigeration improvements, for example, are only applied to certain commercial segments like grocery stores. The energy impacts of a measure can also vary by the building type to which they are applied; electric boilers, for example, will have a different impact if they are installed in a large or small office building.

This building characterization allows the study to calculate a baseline energy use forecast and technical, economic, and optimized potential at a widely ranging level of granularity. Table 6 shows the Planning Study's reporting segments. Because a narrative report like this one cannot report at all segments at which data is analyzed, this study provides reporting at the statewide and sector level and has developed an online tool [9]for more detailed data exploration.

Table 6. Study Reporting Segments

Geography/ Sector	Segments
Utility Service Area	Alliant Energy, Madison Gas and Electric, We Energies, Wisconsin Public Service, Xcel Energy, Other Utilities
Agricultural	Dairy, Fruit and Vegetable Production, Grain Handling and Drying, Greenhouses, Irrigation, Poultry, Miscellaneous
Commercial	Assembly, Grocery, Health Care, Hospital, Large Office – Private, Large Office – Public, Large Retail, Lodging, Multifamily Common Area, Restaurants, School – Private, School – Public, Small Office – Private, Small Office – Public, Small Retail, University, Warehouses, Miscellaneous
Industrial	Chemicals, Electrical Equipment, Fabricated Metal Products, Food, Machinery, Nonmetallic Metal Products, Paper, Plastics and Rubber Products, Primary Metals, Printing and Related Support, Transportation Equipment, Wood Products, and Miscellaneous Industries

9 The Planning Study results dashboard can be accessed on the Planning Study's website: https://focusonenergy.com/about/quad-v-planning-study

Geography/ Sector	Segments
Residential	Single Family, Multifamily Units, Manufactured Homes Standard income customers, customers meeting Focus on Energy income eligibility criteria (income qualified)

Methodology Overview

This section summarizes the peak energy impact calculation, the carbon emissions calculation, and the measure adoption simulation. *Appendix D* provides a detailed description of the methods used to calculate hourly impacts of Focus on Energy programs.

Peak Impact Calculation

The Planning Study calculated peak energy impacts according to Focus on Energy's evaluation methodology as follows:

1. Calculated the hourly energy consumption of a building without a Focus on Energy measure (baseline).
2. Calculated the hourly energy consumption of a building with a Focus on Energy measure (measure).
3. Calculated the difference between the baseline building and measure building for each hour of the year, for each year of the measure's lifetime.
4. Calculated the average of the difference between the baseline building and measure building energy consumption for each hour that meets Focus on Energy's peak period definition.

Table 7 shows the hours of the year that meet Focus on Energy's peak period definitions. The approach this study took to calculate peak energy impacts aligns with Focus on Energy's approach but may differ from approaches other analyses use, such as those that plan for energy distribution system capacity constraints. Other studies may consider the period of maximum energy demand, such as a single hour or day in a year, to define a peak period. Because Focus on Energy calculates peak energy impacts as the average impact over many hours within a peak period, the absolute magnitude of the impact can be smaller than the impact from a calculation based on an hour of maximum energy demand.

Table 7. Focus on Energy Peak Period Definitions

Peak Period	Peak Period Definition
Summer PM Peak	Months: June, July, August, September Days: Weekdays excluding holidays Hours: 2 p.m. to 5:59 p.m.
Winter AM and PM Peak	Months: December, January, February Days: Weekdays excluding holidays Hours: 8 a.m. to 11:59 a.m. and 5 p.m. to 8:59 p.m., respectively

To calculate therm-day peak, the Planning Study summed the measure-associated hourly load shapes to a daily total. The study then averaged daily totals across December, January, and February weekdays and divided by the overall total load shape annual consumption. This approach developed a therm-day peak ratio, which the study then multiplied by measure gas savings to calculate the associated therm-day peak impact.

Carbon Emissions from Electric Generation Calculation

This study evaluates emissions impacts from electric generation using utility-specific generation profiles from Wisconsin's Strategic Energy Assessment (SEA), which provides current and planned electric generation assets and associated emissions factors (pounds of carbon emitted per kWh of energy produced) through 2030.[10]

The study classified Wisconsin utility electric generators as baseload (coal, nuclear or baseload gas), must-take (renewable energy that is unlikely to be curtailed under most circumstances), or load-following resources used to balance the energy grid within an hour (gas generation, energy storage, hydro-electric).

The study assumes that installed measures would primarily impact load-following resources used to balance the electric grid each hour. It calculated the hourly emissions factors for these load-following resources based on the hourly demand for them, accounting for the hourly utility energy demand profile and hourly generation of all resources, including baseload and must-take renewables. The study did not account for changes to Wisconsin's generation assets beyond 2030, since that data was not available in the SEA. For full details on the electric generation emissions calculation, please see *Electric Emissions Factors* in *Appendix D*.

Agricultural, Commercial, and Residential Adoption Simulation

To simulate uptake of Focus on Energy offerings over the 12-year study horizon, this study leveraged a technology market diffusion model that combines the following modeling elements:

- Primary research conducted for this study regarding agricultural, commercial, and residential decision-makers' attitudes about building and operations upgrades
- Project installation payback periods based on up-front project installation costs, including Focus on Energy incentives, and bill impacts over the project lifetime based on electric and gas rates
- Market maturity, including the speed at which Focus on Energy offerings are adopted in the market and their current level of market penetration, based on historical Focus on Energy participation data

The adoption simulations provided the study with annual rates of measure adoptions from 2027 through 2038 that informed how the study calculated changes to participation in Focus on Energy offerings in its assessment of program scenario and optimized potential.

Approach to Estimating Industrial Potential

Industrial operations vary significantly from facility to facility. Because of this, Focus on Energy industrial program offerings generate significant savings from highly customized process improvements as well as

---

10 Public Service Commission of Wisconsin Strategic Energy Assessment 2024–2030. November 2024. viewdoc.aspx

energy efficient facility expansion projects. The heterogeneity of industrial facilities and the customized industrial program offerings pose challenges to both measure and market characterization.

To best develop industrial forecasts rooted in Focus on Energy program delivery and capture the variation in industrial facilities, this study took the following steps.

1. Performed an initial end use segmentation of the industrial electric and gas load based on the Manufacturing Energy Consumption Survey (MECS) results for the given industrial sector (Wood Products, Food, and so on).[11]
2. Conducted interviews with Wisconsin industrial customers with the highest energy consumption from all key industrial sectors to understand their operations and how energy is consumed in their processes, as well as interest and barriers to implementing energy efficiency and electrification upgrades.
3. Updated the end use segmentation for the largest industrial customers interviewed to accurately reflect information collected from interviews.
4. Characterized program measure savings as a percentage of impacted end use energy. Developed these percentages by combining customer segmented energy data with program measure data.
5. Characterized program participation by analyzing historical program participation by measure compared to total industrial customers.
6. Characterized measure costs and incentives based on historical program data.
7. Modeled baseline program savings based on utility-projected industrial load growth as well as program-data based measure characterization, measure adoption, and saturation.

Cost-Effectiveness Analysis

Cost-effectiveness is expressed as the ratio of benefits divided by costs. When that ratio is greater than one, the portfolio, program, or measure is cost-effective. This study analyzed cost-effectiveness from three perspectives (calculated as tests), at both the program and portfolio levels, and for each individual measure. Certain costs and benefits apply only at the program or portfolio level while others apply to measures and are rolled into the program and portfolio calculations. Table 8 shows the tests considered in this study and the different types of benefits and costs included in each test.

Table 8. Benefits and Costs Included in Planning Study Cost-Effectiveness Analysis

Test/Perspective	Benefits	Costs
Modified Total Resource Cost (mTRC) Test	• Electric and gas avoided utility cost • Electric and gas avoided emissions • Market effects for Residential New Construction program	• Incremental measure costs[a] • Program delivery costs
Program Administrator Test (PAT)	• Electric and gas avoided utility cost	• Incentive costs • Program delivery costs

[11] U.S. Energy Information Administration. Manufacturing Energy Consumption Survey (MECS). https://www.eia.gov/consumption/manufacturing/

Test/Perspective	Benefits	Costs
Societal Cost Test (SCT)	• Electric and gas avoided utility cost • Electric and gas avoided emissions • Benefits applicable only to income-qualified customers • Market effects for Residential New Construction program • Water benefits for measures using municipal water supply • Health benefits (first five years after each measure installation) • Economic impacts analysis benefits	• Incremental measure costs • Program delivery costs

Blue: Applied at the measure level, and included in program/portfolio benefits and costs
Green: Applied at the program level
Purple: Applied at the portfolio level
[a] Incremental measure costs are calculated as the cost of the measure minus the costs of a less efficient alternative.

Approach to Interactive Effects

The Planning Study's potential study model calculates the energy savings impacts from energy efficiency and electrification measures dynamically. The study's approach to estimating technical, economic, and optimized potential accounts for future equipment standards that will raise the efficiency requirements of standard equipment. When the efficiency requirement for standard equipment increases, savings from currently offered measures can decrease or disappear.

The study also accounts for interactive effects between measures and fuels. In estimating potential, it is inappropriate to merely sum savings from individual measure installations. Significant interactive effects can result from installing complementary measures. For example, upgrading a heat pump in a home where insulation measures have already been installed can produce less savings than making energy efficiency upgrades to an uninsulated home. Our analysis of potential accounts for three types of interactions:

- **Interactions between equipment (lost opportunity) and non-equipment (discretionary or retrofit) measures.**
  Potential is based on the assumption that as equipment burns out, it will be replaced with higher-efficiency equipment, reducing average consumption across all customers. Reduced consumption causes non-equipment measures (e.g., weatherization) to save less energy than if the equipment had remained at a constant average efficiency. Similarly, savings realized by replacing equipment decrease upon installation of non-equipment measures.
- **Interactions between two or more non-equipment (discretionary or retrofit) measures.**
  Non-equipment measures that apply to the same end use may not necessarily affect each other's savings. For example, installing a low-flow showerhead does not affect savings realized from installing a faucet aerator. Insulating hot water pipes, however, causes a water heater to operate more efficiently, thus reducing savings from the water heater. Cadmus accounted for such interactions by stacking interactive measures and iteratively reducing baseline consumption as measures were installed, which lowered potential savings from subsequent measures.
- **Interactions between fuels from electrification measures**
  The replacement of a natural gas furnace with a heat pump (fuel conversion) impacts the type of

fuel the retrofit measure saves. For example, a weatherization project that saves gas space-heating fuel when installed in a home with a gas furnace will save electricity if the home's space heating system is electrified.

While the Planning Study calculated interactive effects for technical, economic, and optimized potential, it did not account for these effects in the program scenario potential. This is because the study attempted to align program scenario potential with current Focus on Energy reporting, which does not account for these interactions, given that each year's impact assessment is based on information available at the time of the assessment and does not project savings based on assumptions about the future.

Primary Differences Between Quad V Planning Study and Prior Studies

Focus on Energy conducted potential studies in 2017 and 2021. This study differs from those studies in several significant ways that limit the usefulness of comparing past results to this study's results. This study includes the following enhancements:

- Significant emphasis on developing measure-level load shapes, which are critical for determining avoided emissions and demand reduction potential for current and future Focus on Energy program measures. Prior studies did not incorporate hourly characteristics of study measures and electric grid emissions.
- Study measures that align with current and future program delivery approaches, developed in close consultation with the Focus on Energy programs implementation team. Prior studies engaged less with the Focus on Energy implementation team to develop measure characteristics.
- Program planning scenarios that demonstrate the budgetary, emissions reduction, energy, and demand savings impacts of different Focus on Energy policy scenarios. While prior studies developed policy scenarios, these were less of a priority.
- Program scenarios calibrated to current Focus on Energy offerings. Prior studies did not leverage current program design and accomplishments for scenario design.
- Enhanced measure adoption modeling to determine how changes in incentives and other measure benefits, including electrification measures, impact program participation over time. Prior studies used adoption ramp rates that did not dynamically calculate adoption rates.
- A revised approach to calculating industrial potential to align with Focus on Energy program delivery. This includes incorporating industrial expansion projects into the adoption forecast. Expansion projects were not considered in prior studies.

Stakeholder Engagement and Consultation

This study team, including Cadmus and Public Service Commission staff, engaged with Focus on Energy stakeholders throughout the study. At study inception, the study team worked with Focus on Energy's Evaluation Working Group (EWG) to inform the study scope and methodology. In parallel the study team engaged with a wider range of Wisconsin energy stakeholders to discuss study methodology, select measures, design scenarios, and review results. In total the study team held five separate meetings with the EWG and six with the broader group of stakeholders. The study's stakeholder engagement website contains meeting recordings, presentations, and related documents.[12]

In addition to formal meetings, the study team had numerous one-on-one meetings with individual stakeholders, including the Program Administrator, industry representatives, and representatives of municipal utilities and cooperatives. Input from these discussions informed the study approach.

---

12 Please see the Planning Study website for all meeting details and supporting documents: focusonenergy.com/about/quad-v-planning-study

Results

This report section provides the results of the Quad V Planning Study using the following organization:

- **Baseline End-Use Forecast:** The study's predicted load for Wisconsin electric and gas utilities at the end-use level. This forecast is rooted in current utility energy sales and customer counts and includes a residential vehicle electrification forecast.
- **Technical Potential:** Maximum energy impacts from installing all Planning Study measures in all eligible buildings. Technical potential provides the maximum energy savings that is technically feasible but does not account for installation trends or economic considerations.
- **Economic Potential:** Technical potential counting only measures that are cost-effective from the mTRC test, PAT, or SCT perspective.
- **Program Scenario Potential**: Potential future Quad V program accomplishments for six scenarios: baseline, emissions focused, summer electric peak focused, summer electric peak focused with load-shifting program, electrification focused, and cost-effectiveness focused, including the budgets, impacts, cost-effectiveness, and different outcomes of each scenario.
- **Optimized Potential:** 12-year measure adoption trends for six program scenarios that account for customer attitudes about technology options, project economics (including bill impacts), and market trends.

Baseline End-Use Forecast

As the first step of determining the energy impacts from Focus on Energy programs, the Planning Study developed a gas and electric energy use forecast based on utility sales and customer data, end-use equipment characteristics, and building characteristics. This forecast estimates yearly energy sales for each utility, sector, building type, population segment, and end use and is the foundation for potential estimates, as it allows the study to identify where most energy is used and to calculate interactive effects between Focus on Energy interventions, downstream impacts from fuel-switching, and impacts from changes in equipment standards. The study excludes energy efficiency interventions and fuel-switching of gas equipment to electric equipment from the baseline forecast.

Total predicted statewide energy consumption is approximately 56,000 GWh and 3,500 million Therms in 2038, a slight decrease of 1% in electric consumption and a slight increase of 1% in natural gas consumption compared to 2027 consumptions. The decline in electric consumption is primarily driven by future standards such as the electric water heating standard effective in 2029. This estimate relies on data provided by utilities for the Planning Study and does not include load from large-scale data centers, natural gas transport customers, or industrial customers planned for closure before the start of the study. It also does not include other non-building loads such as telecommunication towers, railway crossings, and other utility infrastructure. Table 9 shows the Planning Study's forecast of baseline energy consumption in BBtu for utilities that participate in Focus on Energy programs to enable comparisons with electric and gas consumption.

As shown in the table, the Planning Study estimates that on-site gas combustion in the absence of fuel-switching will account for approximately 65% of energy use in 2038. Residential buildings will make up

40% of total energy use, primarily using gas. The commercial and industrial sectors together make up 59% of energy use, and agricultural operations account for 1% of energy use. In the commercial sector, energy use is split relatively evenly between electricity and gas, while 66% of the industrial sector's energy use comes from on-site gas combustion.

Table 9. 2038 Annual Energy Consumption (BBtu) by Sector

Sector	Total	Electricity	Gas
Agriculture	5,900	2,400	3,500
Commercial	150,900	73,400	77,500
Industrial	167,900	56,600	111,300
Residential	217,200	59,200	158,000
Total	**541,900**	**191,600**	**350,300**

The Planning Study included Alliant Energy (Wisconsin Power and Light), Madison Gas and Electric, We Energies (Wisconsin Electric Power Company and Wisconsin Gas), Wisconsin Public Service Company, and Xcel Energy (Northern States Power Wisconsin), as well as other smaller electric utilities including cooperatives and municipal utilities. Table 10 shows the forecast electric and gas sales by Wisconsin Utility in BBtu. Electric and gas service areas for each utility do not perfectly overlap, meaning that in Wisconsin many customers do not receive electric and gas service from the same utility.

Table 10. 2038 Annual Energy Consumption (BBtu) by Utility

Utility	Total	Electricity	Gas
Alliant Energy	56,900	31,300	25,600
Madison Gas and Electric	31,900	8,800	23,100
We Energies	271,800	70,800	201,000
Wisconsin Public Service Company	115,200	36,600	78,600
Xcel Energy	37,300	21,300	16,000
Other	28,800	22,800	6,000
Total	**541,900**	**191,600**	**350,300**

As illustrated in Table 11 through Table 14, which show the end-use energy consumption for each sector, energy use is spread widely across a vast range of equipment and processes. In general, energy use is most heterogeneous in the industrial sector, as many industrial processes are highly customized. In the commercial sector, the number of end uses by themselves mask the high degree of heterogeneity of commercial building energy consumption, as energy use also varies widely by building use, with buildings of different sizes and uses having distinct energy-use patterns. This study includes 19 commercial building types including buildings as diverse as schools, hospitals, and retail stores. While energy use also varies in the residential sector, this variation is much less than in the commercial and industrial sectors because of the higher level of uniformity in size, type, and construction of single-family and multifamily homes.

Table 11 shows the agricultural sector's energy use by primary end-use group. As illustrated in the table, most of the agricultural sector's energy use comes from gas-consuming process heat, such as grain drying and other process heating uses, and from water heating. Total electric energy use, while lower than total gas use, is spread across a greater range of end uses, including pumps, process refrigeration, and cooling.

Table 11. 2038 Annual Energy Consumption for Agricultural End Uses (BBtu)

End-Use Group	Total	Electricity	Gas
Lighting	300	300	-
Other	140	140	-
Process Heat	2,600	200	2,400
Process Refrigeration and Cooling	490	490	-
Pumps	600	600	-
Ventilation	560	560	-
Water Heat	1,200	100	1,100
Total	**5,900**	**2,400**	**3,500**

As shown in Table 12, the most energy-consuming end uses in the commercial sector are packaged rooftop units, boilers and furnaces for gas space heating, and plug loads and lighting for electric use. Cooling (chillers, cooling DX, room air conditioners) makes up a moderate proportion of commercial electric consumption.

Table 12. 2038 Annual Energy Consumption for Commercial End Uses (BBtu)

End-Use Group	Total	Electricity	Gas
Chillers	630	630	-
Compressed Air	2,600	2,600	-
Cooking	6,500	1,800	4,800
Cooling DX	2,000	2,000	-
Dryers	280	190	90
Electric Room Heat	720	720	-
Electric Space Heat	2,700	2,700	-
Gas Boilers	22,500	-	22,500
Gas Furnace	15,100	-	15,100
Gas Packaged Rooftop Outdoor Unit	29,400	-	29,400
Gas Room Heat	990	-	990
Heat Pump	240	240	0
IT Equipment	750	750	0
Large Appliances	8,200	8,200	0
Lighting	16,600	16,600	0
Other Plug Load	24,500	24,500	0
Pool Heater	100	-	100
PTAC	10	10	-
PTHP	10	10	-
Room AC	130	130	-
Ventilation	11,500	11,500	-
Water Heat	5,500	840	4,600
Total	**150,900**	**73,400**	**77,500**

In the industrial sector the end uses that consume the most energy are boilers and combined heat and power, machine drives, and process heating. Table 13 shows industrial end-use electric and gas consumption in 2038.

Table 13. 2038 Annual Energy Consumption for Industrial End Uses (BBtu)

End-Use Group	Total	Electricity	Gas
Boiler/CHP	53,500	920	52,600
Conventional Electricity Generation	500	-	500
Electro-Chemical Processes	2,400	2,400	-
Facility HVAC	18,100	6,400	11,700
Facility Lighting	4,500	4,500	-
Machine Drive	31,100	28,700	2,400
On-site Transportation	400	400	-
Other Facility Support	2,600	1,300	1,300
Other Non-process Use	900	400	500
Other Process Use	4,220	1,250	2,970
Process Cooling and Refrigeration	5,490	5,300	240
Process Heating	44,220	5,120	39,100
Total	**167,900**	**56,600**	**111,300**

Table 14 shows energy consumption in residential homes by end use. As illustrated in the table, gas furnaces consume almost half of the energy used in residential buildings. Water heaters consume the second largest amount of energy, also primarily from gas usage.

Table 14. 2038 Annual Energy Consumption for Residential End Uses (BBtu)

End-Use Group	Total	Electricity	Gas
Central AC	4,800	4,800	-
Cooking	5,100	1,900	3,200
Electric Furnace	6,300	6,300	-
Electric Room Heat	910	910	-
Electronics	10,100	10,100	-
Gas Boiler	12,900	-	12,900
Gas Furnace	112,600	-	112,600
Heat Pump	1,700	1,700	-
Large Appliances	12,600	11,200	1,400
Lighting	4,400	4,400	-
Pool Heat	1,000	490	500
Pool Pump	410	410	-
Room AC	640	640	-
Small Appliances	5,200	5,200	-
Ventilation	3,900	3,900	-
Water Heat	34,700	7,200	27,500
Total	**217,300**	**59,200**	**158,100**

Baseline End-Use Forecast for Income-Qualified Households

Focus on Energy defines income-qualified households as those making 80% or less of the county median income. Households with this qualification can receive larger rebates for some measures. The Planning Study estimated the percentage of buildings occupied by income-qualified households using income data from the United States Census Bureau's American Community Survey.[13] As illustrated in Table 15, approximately 38% of households in Wisconsin qualify for higher Focus on Energy rebates, with manufactured homes and multifamily buildings having the highest proportion of income-qualified households. Additionally, income-qualified households are more likely to be renters, compared to standard income households: 46% of income-qualified households rent their homes, while only 21% of standard income households rent their homes. While renters are eligible to participate in Focus on Energy programs, renters are usually not responsible for making major building improvements. Because landlords do not generally benefit financially from reduced energy use, rented homes are less likely to have significant efficiency upgrades.

Table 15. Percentage of Residential Households that are Income Qualified

Residential Building Type	Percentage Income Qualified
Manufactured Homes	59%
Multifamily Buildings	56%
Single Family Homes	33%
All Building Types	**38%**

Technical Potential

Technical potential represents the total energy savings that would occur if every available opportunity to adopt Focus on Energy measures were taken. Because each Focus on Energy program includes a range of offerings that could be used for energy-efficient upgrades, such as various types of heat pumps, this study selects the most efficient measure within a group of similar measures to calculate technical potential. Thus, technical potential provides the upper limit of possible energy savings and does not account for customer decision-making. Because some types of gas equipment could be either upgraded to an efficient gas system or converted to efficient electric equipment, this study developed two scenarios for technical potential: one in which equipment is upgraded to the most efficient system using the same fuel and the other in which the most efficient fuel-switching option (electric) is installed. Both scenarios include efficiency measures that are not impacted by fuel-switching (such as electric appliances) and efficiency measures that are impacted by fuel switching, such as weatherization projects. For example, weatherization projects that previously saved gas when installed in buildings with gas space heating equipment save electricity when the gas space heating system is electrified.

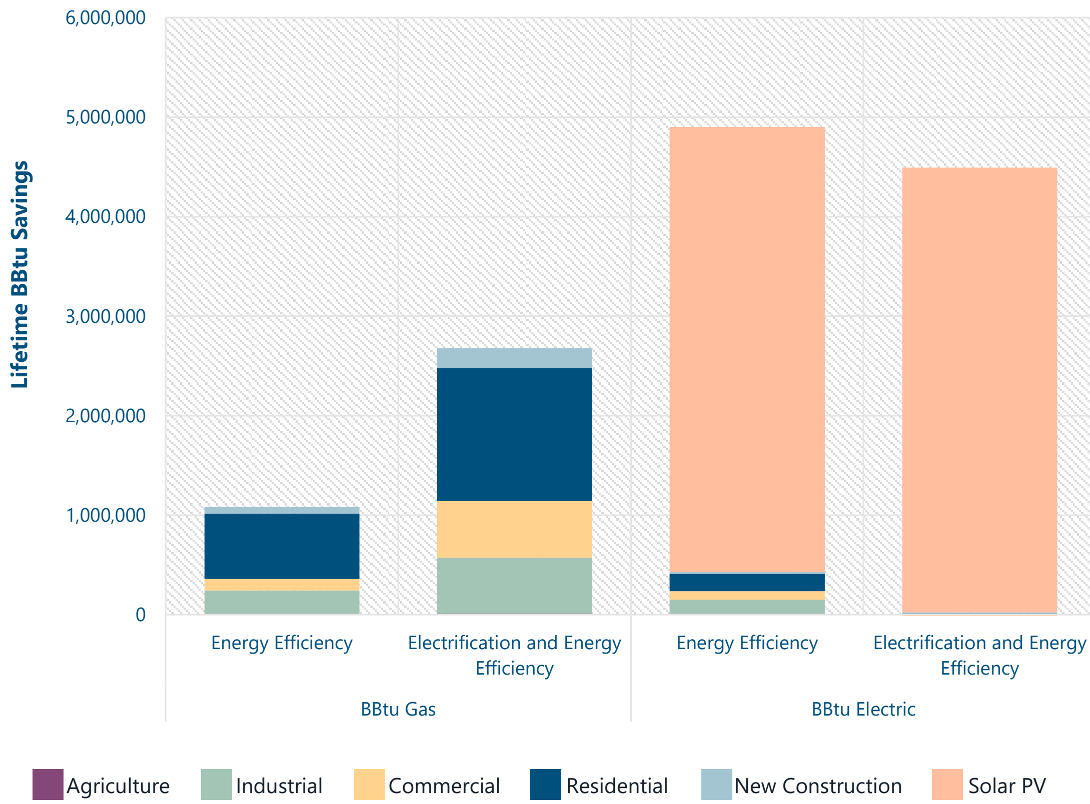
Figure 4 shows the technical potential lifecycle energy savings due to energy efficiency interventions and electrification on both electric and gas usage. The figure illustrates that energy efficiency primarily impacts

[13] United States Census Bureau American Community Survey (ACS). https://www.census.gov/programs-surveys/acs.html

gas use, saving approximately 1 million BBtu of gas over the full lifetime of each measure. Gas savings potential is higher than electric savings because statewide baseline gas consumption is about twice as high as electric consumption and because gas measures are focused on fewer end uses than electric measures, such as space and water heat, which typically have a longer EUL. This makes the lifetime impact larger for gas-saving measures. These savings account for almost 18% of the total 2038 statewide energy consumption.

Technical energy savings potential increases significantly for gas use under the electrification and energy efficiency scenario, because the commercial and residential electric heat pump technologies selected for these scenarios are much more efficient than even the most efficient gas-saving alternatives. However, electric savings almost disappear in the electrification scenario due to the added electric load from fuel-switching. Although gas use decreases when equipment switches from gas to efficient electric use, electric use increases. The combined effects of these switches across the portfolio result in a net additional electric load (negative savings) in the electrification scenario in the commercial sector and significantly reduced electric savings in the industrial and residential sectors. When electrification measures are included, technical potential is approximately 30% of 2038 energy consumption, nearly 45% of statewide gas consumption, and nearly 3% of statewide electric consumption.

Figure 4. Technical Potential Lifecycle Energy Impacts: Energy Efficiency Scenario and Electrification and Energy Efficiency Scenario



Electric peak impacts in the electrification scenario occur primarily in winter due to added electric load from heat pumps, to address space heating needs in the Wisconsin climate. As shown in Table 16, for the commercial sector, full electrification of all end uses using the most efficient heat pumps Focus on Energy offers would decrease winter AM and PM peaks by 56 MW and 18 MW respectively. In contrast, the energy efficiency scenario predicts peak reductions of 410 MW and 305 MW with full electrification. The impact of electrification on peak electric demand is most pronounced in the residential sector, in which peak load increases by 140 MW in winter mornings, compared to 500 MW in savings in the energy efficiency scenario, and 110 MW in winter evenings, compared to 480 MW in savings in the energy efficiency scenario.

The impact of the electrification scenario on winter electric peak demand is more pronounced in the residential sector than in the commercial sector because there are fewer market barriers to electrifying residential space and water heating loads. For larger commercial buildings, such as those with boilers, and sites which have periods of high usage loads, such as restaurant water heating, may not be able to fully offset all gas usage with heat pump technologies. Therefore, in specific building types and end uses in the commercial sector, the Planning Study reduced installation feasibility for heat pump electrification technologies. While these market barriers also exist in residential, such as high-rise multifamily building water heating loads, the ability to reduce or completely offset residential space and water heating is more feasible compared to the commercial sector.

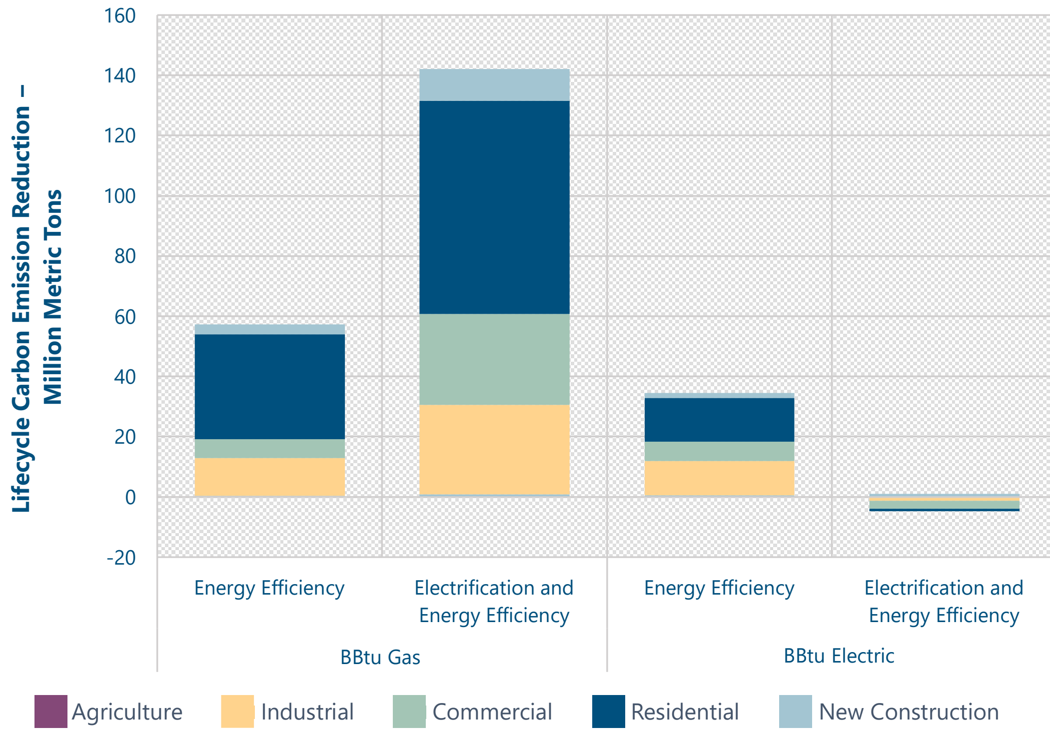
Table 16. Technical Potential Electric and Gas Peak Impacts: Energy Efficiency Scenario and Electrification and Energy Efficiency Scenario

Sector	Summer PM (MW)		Winter AM (MW)		Winter PM (MW)		Winter (Therm-Day)	
	Energy Efficiency	Electrification and Energy Efficiency	Energy Efficiency	Electrification and Energy Efficiency[a]	Energy Efficiency	Electrification and Energy Efficiency[a]	Energy Efficiency	Electrification and Energy Efficiency
Agriculture	35	-3	0	0	0	0	9	25
Commercial	430	140	410	56	305	18	771,000	1,841,000
Industrial	580	170	570	160	420	120	502,000	1,041,000
Residential	530	240	500	-140	480	-110	1,645,000	2,452,000
Solar PV	19	0	19	0	0	0	0	0
New Construction	66	32	64	34	53	22	161,000	370,000
Total	**7,000**	**5,900**	**6,900**	**5,500**	**1,300**	**100**	**3,079,300**	**5,703,800**

[a] Negative numbers reflect negative peak energy savings, or an increase in peak electric demand.

Lifetime carbon emissions savings follow a similar trend to that of the energy use impacts in the energy efficiency and electrification scenarios. As illustrated in Figure 5, reduced gas use delivers the greatest carbon reduction, particularly under the electrification scenario, which assumes installation of the most efficient heat pumps.

Figure 5. Technical Potential Lifecycle Carbon Emissions Impacts: Energy Efficiency Scenario and Electrification and Energy Efficiency Scenario



Technical Potential of Income-Qualified Households

Approximately 34% of the residential sector technical potential comes from income-qualified households, particularly in manufactured homes and multifamily buildings where over half of technical potential is found in income-qualified households. Table 17 shows the percentage of technical potential in buildings occupied by income-qualified households, as well as the total lifecycle BBtu income-qualified technical potential for each building type. The table shows income-qualified technical potential for both the energy efficiency and electrification and energy efficiency scenarios.

Table 17. Technical Potential of Income-Qualified Households as a Percentage of Residential Potential and Lifecycle BBtu Savings

Residential Building Type	Energy Efficiency Scenario		Electrification and Energy Efficiency Scenario	
	Percentage of Residential Technical Potential	Lifecyle BBtu Savings	Percentage of Residential Technical Potential	Lifecyle BBtu Savings
Manufactured Homes	61%	29,400	59%	48,700
Multifamily Buildings	56%	163,000	54%	312,900
Single Family Homes	30%	492,200	29%	792,100
All Building Types	**34%**	**684,600**	**34%**	**1,153,700**

Measure Groups with Highest Energy Savings

The Planning Study determined which measure groups have the highest lifecycle energy reducing technical potential. The study then compared this potential to that of the Quad V baseline scenario and ranked the measures in terms of gas savings, electric savings, and peak impacts. The study provided this analysis for each sector and for both the energy efficiency and electrification scenarios.

Agricultural Measure Groups with Highest Energy Savings

In the agricultural sector, the efficient grain dryers measure group has the highest technical potential for reducing energy use. This measure group uses only gas, so it is the lowest-ranked measure group for electric energy reduction. Table 18 ranks all measure groups for each electric, gas, and emissions indicator. For example, the agricultural sector includes nine measure groups that produce gas savings and 24 measure groups that produce electric savings. Thus, a rank of 9 in gas savings indicates that this measure group generates the lowest gas savings (i.e., has no gas savings), and a rank of 24 for electric savings indicates that this measure group generates the lowest electric savings (in this case, no electric savings).

As illustrated in the table, the baseline program potential scenario includes several measure groups for which program scenario potential is near technical potential. Achieving savings in future quadrenniums will become more challenging for these measure groups as the market becomes more saturated with the measures in these groups.

Table 18. Ten Top Energy-Saving Agricultural Measure Groups: Energy Efficiency Scenario

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Baseline	Technical Potential Rank			
			Gas Savings (9)	Electric Savings and Peak Impacts (24)[a]	Emissions Reduction (28)	Therm-Day (9)
Grain Dryer - Efficient	2,400	1,200	1	24	1	2
Process Heat Improvements	1,500	1,400	2	16	3	3
High Efficiency Gas Water Heat	1,200	0[b]	3	N/A	5	1
High Speed Ventilation/ Circulation Fan - VFD	1,000	160	N/A	1	2	N/A
High-Volume Low-Speed Fan	790	330	N/A	2	4	N/A
Irrigation improvements	730	710	N/A	3	6	N/A
Lighting	620	430	N/A	4	7	N/A
Plate Heat Exchanger - Dairy	550	530	N/A	5	8	N/A
Greenhouse Thermal Blanket	480	0[b]	4	N/A	12	4
VFD Process	420	280	N/A	6	9	N/A

[a] Because the rank for all electric metrics, including electric savings and winter AM, winter PM, and Summer PM peak reductions, is identical in the agricultural sector, this table combines the ranking for these metrics.
[b] A value of zero in the baseline scenario column indicates that the Quad V baseline scenario program plan does not include measures from that measure group.

Table 19 shows the ten measure groups with the highest technical potential for energy savings in the agricultural sector when electrification and energy efficiency measures are included in the analysis. In this scenario, water heater electrification becomes the highest energy saving measure group, and process heat electrification becomes the third most energy-saving measure group. While electrification measures have substantial energy savings potential, the program scenario potential electrification scenario only includes limited savings from these measures. This is because the Planning Study's adoption simulation predicts that Focus on Energy will take several years to ramp up adoption of these measures.

Table 19. Ten Top Energy Saving Agricultural Measure Groups: Electrification and Energy Efficiency Scenario

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Electrification	Technical Potential Rank			
			Gas Savings (10)	Electric Savings and Peak Impacts (38)[a]	Emissions (38)	Therm-Day (10)
High Efficiency Electric Water Heat (Electrification)	3,700	46	1	38	38	1
Grain Dryer - Efficient	2,700	1,100	2	24	1	2
Process Heat (Electrification)	1,200	300	3	37	6	3
High Speed Ventilation/ Circulation Fan - VFD	1,000	130	N/A	1	2	N/A
High-Volume Low-Speed Fan	790	290	N/A	2	3	N/A
Irrigation improvements	730	620	N/A	3	4	N/A
Process Heat Improvements	730	710	4	16	8	N/A
Lighting	620	400	N/A	4	5	N/A
Greenhouse Thermal Blanket	560	38	5	24	12	4
Plate Heat Exchanger - Dairy	550	470	N/A	5	7	N/A

[a] Because the rank for all electric metrics, including electric savings and winter AM, winter PM, and Summer PM peak reductions is identical in the agricultural sector, this table combines the ranking for these metrics.

Commercial Measure Groups with Highest Energy Savings

Advanced rooftop unit controllers, HVAC commissioning, and digital control systems have the highest technical energy efficiency savings potential of all 79 commercial measure groups included in the study. Table 20 shows the top ten measure groups with the highest technical savings potential when energy efficiency measures are applied instead of electrification measures. For these measure groups, only HVAC Commissioning shows significant savings in the Quad V baseline scenario, indicating opportunities to expand offerings for advanced rooftop unit controllers and direct digital control systems, as well as other measures with untapped potential. While advanced rooftop controller units deliver 34,500 BBtu in technical potential energy savings, the Quad V program potential scenario includes only 100 BBtu in savings for this measure group. In terms of carbon emissions reductions, the top energy-saving measure groups also deliver the highest emissions reductions.

Table 20. Ten Top Energy-Saving Commercial Measure Groups: Energy Efficiency Scenario

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Baseline	Technical Potential Rank						
			Gas Savings (35)	Electric Savings (59)	Emissions (79)	Summer AM Peak (59)	Winter AM Peak (59)	Winter PM Peak (59)	Therm-Day (35)
Advanced Rooftop Unit Controller	34,500	100	3	1	1	1	2	2	3
HVAC Commissioning	19,700	2,700	1	11	2	10	5	7	2
Direct Digital Control System	17,400	390	2	20	4	7	10	12	1
Lighting Controls	14,400	1,100	N/A	2	3	2	1	1	N/A
Automated Ventilation CO_2 Sensors	12,100	270	4	24	6	19	16	19	4
Variable Speed HVAC Pump and Fans	10,300	1,800	N/A	3	5	3	3	3	N/A
Boiler < 300 kBtuh	6,800	38	5		7	57	59	59	9
Cooking Equipment	5,700	820	6	21	8	25	22	24	13
Energy Recovery Ventilator	5,000	27	7	34	9	55	25	27	7
Water Heat LE 55 Gal	4,700	34	8	59	12	57	59	59	17

When efficient electric measures are installed instead of efficient gas measures (i.e., electrification measures), space heat pumps save the most energy, taking the place of advanced rooftop controllers and HVAC commissioning for the top ranks. These measures also reduce the most emissions; however, they save the lowest amount of electric energy because of the added electric load that they generate. Table 21 shows these trends. As illustrated in the table, while electrification measures have significant levels of technical savings potential, the program potential electrification scenario offers low savings from these measures relative to technical potential. This is because the Planning Study's adoption simulation predicts that ramping up adoption for electrification measures will take time.

Table 21. Ten Top Energy-Saving Commercial Measure Groups: Electrification and Energy Efficiency Scenario

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Electrification	Technical Potential Rank						
			Gas Savings (44)	Electric Savings (102)	Emissions (102)	Summer AM Peak (102)	Winter AM Peak (102)	Winter PM Peak (102)	Therm-Day (44)
Heat Pump - Gas Backup - Electrification	222,100	370	1	102	1	102	102	102	1

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Electrification	Technical Potential Rank						
			Gas Savings (44)	Electric Savings (102)	Emissions (102)	Summer AM Peak (102)	Winter AM Peak (102)	Winter PM Peak (102)	Therm-Day (44)
Heat Pump - Ductless - Cold Climate - Electrification	60,500	2,600	2	101	2	99	101	101	2
Heat Pump - Ductless - Gas Backup - Electrification	44,900	1,500	3	100	4	100	100	100	4
Advanced Rooftop Unit Controller	29,600	44	10	1	3	1	1	1	7
Heat Pump - Electrification	17,900	17	5	97	7	95	97	97	11
Lighting Controls	14,400	1,600	N/A	2	5	2	2	2	N/A
Cooking Equipment - Electrification	12,700	290	4	99	14	101	99	99	6
HVAC Commissioning	12,500	810	8	8	9	11	4	5	5
Heat Pump Water Heat GT 55 Gal - Electrification	12,000	2,300	6	98	11	98	98	98	8
Heat Pump[a]	10,800	45	N/A	3	6	94	3	3	N/A

[a] Heat Pumps include standard heat pump technologies and exclude cold climate, ductless, gas backup, and electrification systems.

Industrial Measure Groups with Highest Energy Savings

As shown in Table 22, in the industrial sector, process heat recovery, new construction design, and custom processes and boilers have the most technical energy savings potential of all 56 measure groups that this study analyzed. Compared to the commercial sector, the Quad V program potential baseline scenario plan for the industrial sector has a high savings forecast relative to the technical potential of the measure groups. Part of the explanation for this is that the program plan includes savings from industrial expansion projects. Because the timing and magnitude of future industrial expansion is unknown, it is not captured in technical potential.

Table 22. Ten Top Energy Saving Industrial Measure Groups: Energy Efficiency Scenario

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Baseline	Technical Potential Rank			
			Gas Savings (28)	Electric Savings and Peak Impacts (56)[a]	Emissions (67)	Therm-Day (56)
Process Heat Recovery	34,100	15,300	1	55	1	1
New Construction Design	25,700	2,100	8	2	2	8
Process - Custom	23,700	12,300	2	27	3	2
Boiler - Custom	19,200	1,600	3	54	4	3
Boiler Heat Recovery	18,300	3,900	4	48	6	4

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Baseline	Technical Potential Rank			
			Gas Savings (28)	Electric Savings and Peak Impacts (56)[a]	Emissions (67)	Therm-Day (56)
Boiler Management	18,200	180	5	56	7	5
Lime Kiln Improvements	17,200	4,400	7	56	9	7
HVAC Controls	16,300	650	9	11	5	9
Air Filtration Upgrade	14,900	2,000	6	56	11	6
Building Duct System Improvements	12,300	490	28	1	8	56

[a] Because the rank for all electric metrics, including electric savings and winter AM, winter PM, and Summer PM peak reductions is identical in the industrial sector, this table combines the ranking for these metrics.

Table 23 shows that when electrification measures are included in technical potential, industrial heat pumps and resistance heating measures become the top energy saving measures. As expected, while these measures save the most gas, they save the lowest amount of electric energy because of their added electric load. While many electrification measures have high energy savings potential, the electrification scenario of program potential includes only limited savings from these measures, due to the high barriers that facility managers identified for industrial electrification.

Table 23. Ten Top Energy Saving Industrial Measure Groups: Electrification and Energy Efficiency Scenario

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Electrification	Technical Potential Rank			
			Gas Savings (28)	Electric Savings and Peak Impacts (61)a	Emissions (67)	Therm-Day (28)
Industrial Heat Pump - Electrification	87,500	70	1	60	1	1
Resistance Heating - Electrification	52,200	240	2	61	14	2
Process Heat Recovery	34,100	15,200	5	55	2	5
New Construction Design	25,700	1,800	12	2	3	12
Process - Custom	23,700	11,900	6	27	4	6
Electric Infrared Heaters - Electrification	19,500	88	3	59	35	3
Boiler - Custom	19,200	1,600	7	54	5	7
Boiler Heat Recovery	18,300	3,870	9	48	7	9
Boiler Management	18,200	180	8	56	8	8
Electric Induction Melting - Electrification	17,700	78	4	58	49	4

[a] Because the rank for all electric metrics, including electric savings and winter AM, winter PM, and Summer PM peak reductions is identical in the industrial sector, this table combines the ranking for these metrics.

Residential Measure Groups with Highest Energy Savings

Building shell upgrades, including weatherization projects and window measures, have the highest technical potential for both gas and electric energy savings in the residential sector. Accordingly, these building shell upgrades also provide the greatest emissions reduction potential. However, both of these measures have relatively little savings in the program potential baseline scenario because of their high cost. Gas furnaces, on the other hand, have the fourth highest energy savings potential. Gas furnace measures have been a source of substantial Focus on Energy savings in the residential sector; therefore, they account for much of the program potential's baseline scenario savings.

As shown in Table 24, gas furnaces have 37,000 lifecycle BBtu of technical energy savings potential. These savings derive from replacing every gas furnace that fails through 2038 with the most efficient gas furnace. This estimate also accounts for diminishing savings from furnaces due to increasing efficiency standards. Efficient gas furnaces have been a source of a large proportion of Focus on Energy's historical residential gas savings. The program potential baseline scenario includes high savings from these measures in Quad V, approximately 40% of technical potential. This trend suggests that achieving savings from residential furnaces in after Quad V will become more challenging for Focus on Energy as much of the technical potential is exhausted.

Table 24. Ten Top Energy Saving Residential Measure Groups: Energy Efficiency Scenario

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Baseline	Technical Potential Rank						
			Gas Savings (25)	Electric Savings (40)	Emissions (49)	Summer AM Peak (40)	Winter AM Peak (40)	Winter PM Peak (40)	Therm-Day (25)
Weatherization Project	243,600	4,000	1	2	1	5	4	4	1
Insulation - Window	228,300	110	2	1	2	9	2	2	2
Water Heat LE 55 Gal	74,000	840	3	40	3	39	40	40	4
Insulation - Sill Box	34,100	1,180	4	13	4	18	22	24	7
Gas Furnace	30,700	12,400	5	40	5	39	40	40	6
Energy Recovery Ventilator	23,700	110	6	15	7	17	14	13	5
Insulation - Door	22,000	290	7	19	11	25	27	26	8
Heat Pump Water Heat LE 55 Gal	19,400	250	25	3	6	4	1	1	25
Thermostat	18,800	4,300	8	20	12	7	19	19	3
Dryer	16,500	150	23	4	10	3	3	3	23

Cold climate heat pumps become the top energy saving measure group when included in the technical potential analysis, with energy savings approximately twice as high as savings from weatherization, the measure with the highest savings in the energy efficiency scenario. As expected, furnaces are no longer a top savings measure in the electrification scenario, because their savings potential is replaced by savings potential from fuel-switching heat pumps. Savings potential from weatherization projects decreases in the electrification scenario due to reduced energy loads from efficient heat pump installations. Because efficient heat pumps use less energy than a furnace, less energy can be subsequently reduced through improved weatherization. Nonetheless, weatherization projects continue to offer high savings technical potential in the electrification scenario.

Table 25 shows the 10 residential measure groups with the highest technical potential savings in the electrification and energy efficiency scenario. While many of the electrification measures have high levels of gas savings potential, the electrification scenario of program potential includes comparatively modest savings from these measures, given historical adoption trends, high costs of the most efficient measures, and customer perception.

Table 25. Ten Top Energy Saving Residential Measure Groups: Electrification and Energy Efficiency Scenario

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Electrification	Technical Potential Rank						
			Gas Savings (27)	Electric Savings (70)	Emissions (70)	Summer AM Peak (70)	Winter AM Peak (70)	Winter PM Peak (70)	Therm-Day (27)
Heat Pump - Cold Climate - Electrification	454,300	1,700	1	70	1	69	69	69	1
Weatherization Project	168,900	3,950	3	2	2	3	2	2	3
Insulation - Window	163,000	110	4	1	3	8	1	1	4
Heat Pump Water Heat LE 55 Gal - Electrification	130,500	190	2	69	4	68	68	68	2
Heat Pump - Electrification	84,100	1,300	5	68	5	63	67	67	5
Heat Pump - Ductless - Cold Climate - Electrification	60,800	170	6	67	6	61	66	66	6
Insulation - Sill Box	23,600	1,180	10	10	8	20	20	19	12
Cooking Equipment - Electrification	22,700	6	7	65	17	67	63	64	10
Heat Pump Water Heat GT	21,100	6	8	64	18	65	64	63	8

Measure Group	Lifecycle BBtu Technical Potential	Lifecycle BBtu Savings – Quad V Program Scenario Potential - Electrification	Technical Potential Rank						
			Gas Savings (27)	Electric Savings (70)	Emissions (70)	Summer AM Peak (70)	Winter AM Peak (70)	Winter PM Peak (70)	Therm-Day (27)
55 Gal - Electrification									
Heat Pump Water Heat LE 55 Gal	19,400	150	27	3	7	5	4	3	27

Economic Potential

Economic potential represents the portion of technical potential (2027–2038) that is cost-effective, accounting for interactions between measures, such as heat pump upgrades and weatherization projects. The Planning Study estimated each energy efficiency and electrification measure's cost-effectiveness from three perspectives: mTRC, SCT, and PAT (for a description of each test, please see the *Cost-Effectiveness Analysis* section) and then subset technical potential to include only cost-effective measures in each economic potential cost effectiveness scenario. An important consideration when using these tests is that the mTRC test and SCT consider incremental measure costs and emissions impacts, whereas the PAT primarily considers incentives costs and utility-specific energy benefits. The mTRC test is the current primary test used to measure Focus on Energy's portfolio cost-effectiveness. Focus on Energy currently measures portfolio cost-effectiveness using the SCT and PAT for informational purposes.

Focus on Energy measures cost-effectiveness for each measure, each program and the portfolio. Focus on Energy can offer many measures that are not individually cost-effective, as long as the portfolio is cost-effective overall. However, economic potential as presented in the report section includes only cost-effective measures.

Economic potential represents approximately 39% of technical potential from the mTRC perspective, 87% of technical potential from the SCT perspective, and 94% from the PAT perspective in the energy efficiency scenario. The large difference between the mTRC test and both the SCT and PAT comes primarily from residential solar PV potential, which is not cost-effective from the mTRC perspective, but is cost-effective from the SCT and PAT perspectives. In the case of the SCT, residential solar PV's high incremental costs are offset by non-energy benefits that are not represented in the mTRC test. In the case of the PAT, solar PV's high incremental costs are excluded from the test altogether.

Figure 6 shows lifecycle energy savings for six economic potential scenarios: for the energy efficiency and electrification scenarios, and for each of the three cost-effectiveness screens, and compares these estimates to technical potential. The figure excludes solar, because the overall potential for solar is so high that it masks findings from other sectors. As such, the figure shows a higher percentage of technical potential remaining cost-effective than if solar were included in the representation. Figure 6 also shows that the electrification scenario has substantially higher economic potential, due to the high efficiency of top performing heat pump technologies, all of which were cost effective from the mTRC test, SCT, and PAT perspectives in the residential and commercial sectors. The high cost-effectiveness of electrification heat pumps contributes to a higher portion of technical potential being cost-effective in the electrification and energy efficiency scenario than in the energy efficiency scenario. This trend is especially apparent in the residential sector. Using the mTRC test, 21% of technical potential is cost-effective in the energy efficiency scenario, compared with 62% in the electrification and energy efficiency scenario.

While screening with the mTRC test and the SCT produces very similar results, economic potential is considerably higher under the PAT, driven mostly by increased potential in the residential sector. This is primarily because weatherization projects, which are the highest saving residential measures, are not cost-effective from the mTRC and SCT perspectives due to their high incremental costs but become cost-effective from the PAT perspective (which does not include incremental costs). Carbon emissions are highly correlated with energy use. Thus, the distribution of carbon reduction is very similar to that of energy savings for each of the sectors under each of the six economic potential scenarios.

Figure 6. Economic Potential Lifecycle Energy Savings: Energy Efficiency Scenario and Electrification and Energy Efficiency Scenario

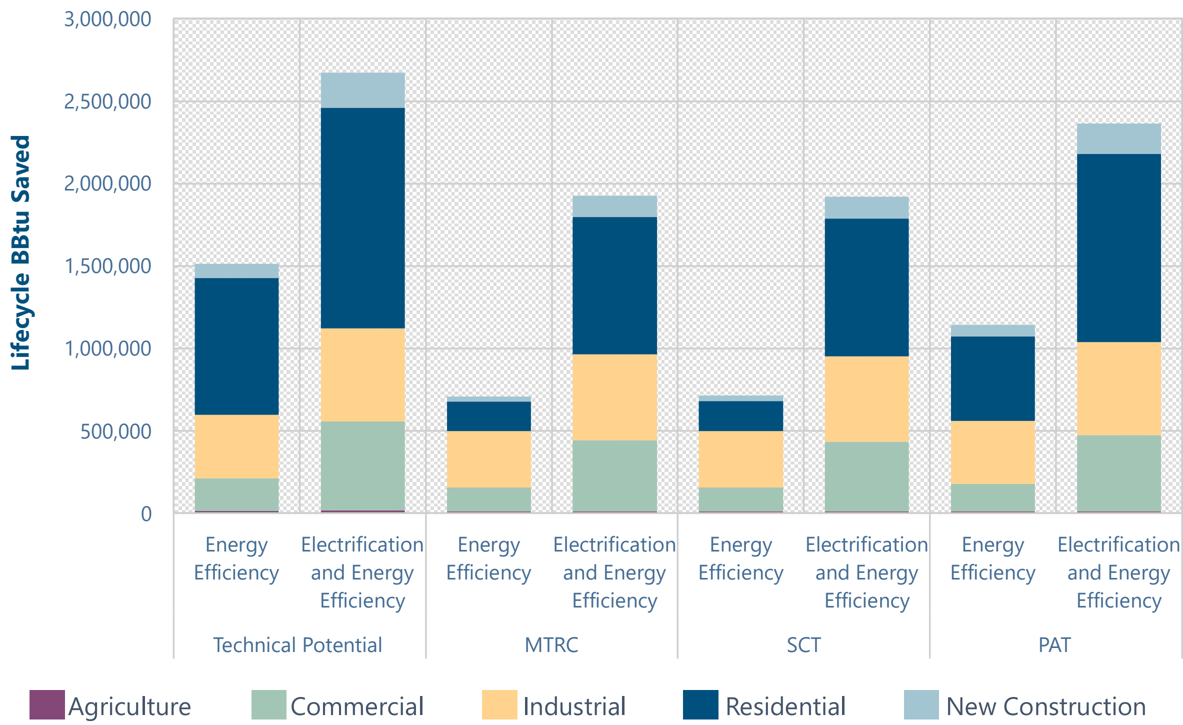


Table 26 compares the top ten technical potential measure groups in the agricultural sector with economic potential under the mTRC cost-effectiveness screen. The table shows that the agricultural high-efficiency gas water heaters measure group, which has the third highest amount of technical energy savings potential, does not pass the mTRC cost-effectiveness test, due to the high incremental cost of this equipment. For some measure groups, economic potential exceeds technical potential, because the

Planning Study's model accounts for interactions between measures.[14] The table does not provide economic potential under the SCT and PAT, because economic potential under those tests is nearly identical to economic potential under the mTRC test.

Table 26. Ten Top Agricultural Technical Potential Measure Groups with Economic Potential Comparison: Energy Efficiency Scenario

Top Technical Potential Measure Group	Lifecycle BBtu Savings	
	Technical Potential	mTRC
Grain Dryer - Efficient	2,400	2,400
Process Heat Improvements	1,500	1,500
High Efficiency Gas Water Heat	1,200	0
High Speed Ventilation/Circulation Fan - VFD	1,000	800
High-Volume Low-Speed Fan	800	1,000
Irrigation improvements	700	700
Lighting	600	700
Plate Heat Exchanger - Dairy	500	600
Greenhouse Thermal Blanket	500	500
VFD Process	400	400

The commercial sector has greater variance between economic and technical potential than that of the agricultural sector. As with the agricultural sector, economic potential is impacted by specific measures passing or not passing cost-effectiveness tests within each measure group. The largest impacts to potential energy saving opportunities result from none of the measures within the advanced rooftop unit controller measure group, the measure group with the highest technical potential, passing either the mTRC, SCT, or PAT cost-effectiveness test. Automated ventilation carbon dioxide (CO_2) sensors and water heaters, the measure groups with the fifth and tenth highest levels of technical potential, do not pass the mTRC and SCT cost-effectiveness screens, but do pass the PAT. Table 27 shows these results.

Table 27. Ten Top Commercial Technical Potential Measure Groups with Economic Potential Comparison: Energy Efficiency Scenario

Top Technical Potential Measure Group	Lifecycle BBtu Savings			
	Technical Potential	mTRC	SCT	PAT
Advanced Rooftop Unit Controller	34,500	0	0	0
HVAC Commissioning	19,700	22,500	22,400	20,800
Direct Digital Control System	17,400	19,600	19,600	18,500
Lighting Controls	14,400	11,600	12,400	14,400

[14] For example, technical potential assumes that the most efficient equipment option is installed; however, this also means retrofit measures such as home insulation will save less since the equipment is already very efficient and does not consume much energy. Under the economic potential scenario, the equipment's highest efficiency tier may not be cost-effective, therefore the next tier that is cost-effective will be selected. This results in lower equipment savings but higher retrofit (e.g., insulation) savings, because the lower efficiency equipment consumes more energy than the higher efficiency equipment.

Top Technical Potential Measure Group	Lifecycle BBtu Savings			
	Technical Potential	mTRC	SCT	PAT
Automated Ventilation CO_2 Sensors	12,100	0	0	11,300
Variable Speed HVAC Pump and Fans	10,300	13,100	13,100	13,700
Boiler < 300 kBtuh	6,800	7,000	7,000	6,900
Cooking Equipment	5,700	4,200	4,200	5,300
Energy Recovery Ventilator	5,000	5,300	5,300	5,500
Water Heat LE 55 Gal	4,700	0	0	2,700

In the industrial sector, all energy efficiency measure groups within the top ten technical potential measure groups pass the mTRC, SCT, and PAT. This is because on a measure level, industrial programs are very cost-effective from all perspectives. Industrial measures tend to be cost-effective because they typically have high net-to-gross ratios, as these projects are often planned well in advance and are evaluated from a payback perspective inclusive of incentives; long EULs, driving prolonged lifetime savings; and substantial savings without driving large outlays for administrative or implementation costs compared to other projects that might demand more spending per kWh or Therm saved.[15]

Of the five sectors that the Planning Study considers, the residential sector has the highest level of variance between technical potential and economic potential, and between the three cost-effectiveness tests. Residential weatherization project, the top saving technical potential measure group, is not cost-effective from both the mTRC because of the measure's high incremental costs; however, weatherization projects retain much of their potential after screening from the PAT perspective, given that incremental costs are not a factor in that test (the primary costs are incentives). The weatherization potential for income-qualified households is cost effective from the SCT perspective. Also, weatherization projects are cost-effective from the SCT perspective for income-qualified households, which is why approximately 50% of the measure group's technical potential is cost effective after applying the SCT screen. High-efficiency windows, the measure group with the second highest technical potential, are not cost-effective from the perspectives of any of the tests applied for this study.

Efficient conventional water heaters, the measure group with the third highest level of technical potential, lose much of their potential under the mTRC and SCT tests, given the measures' relatively high incremental cost compared to energy savings. Under the mTRC test and SCT, almost none of the efficient gas storage or tankless water heaters included in the study are cost-effective, while under the PAT the highest efficiency tankless water heaters are cost-effective, leading to a substantial jump in water heater economic potential for the PAT scenario. Heat pump water heaters, on the other hand, are cost-effective from all perspectives, given the high savings these measures generate. Table 28 shows the measure groups with highest potential in the energy efficiency scenario, as well as the economic potential of those measure groups.

---

15 Because all measures are cost-effective in the industrial sector, this report does not list them here. For a list of top-saving industrial measures refer to Table 22.

Table 28. Ten Top Residential Technical Potential Measure Groups with Economic Potential Comparison: Energy Efficiency Scenario

Top Technical Potential Measure Group	Lifecycle BBtu Savings			
	Technical Potential	mTRC	SCT	PAT
Weatherization Project	243,600	0	118,700	282,900
Insulation - Window	228,300	0	0	0
Water Heat LE 55 Gal	74,000	5,100	5,100	77,100
Insulation - Sill Box	34,100	0	0	39,600
Gas Furnace	30,700	37,600	36,300	10,200
Energy Recovery Ventilator	23,700	0	0	26,300
Insulation - Door	22,000	25,900	23,500	16,100
Heat Pump Water Heat LE 55 Gal	19,400	18,800	19,600	19,800
Thermostat	18,800	0	0	0
Dryer	16,500	0	200	8,700

The Planning Study also considered the cost-effectiveness of residential and commercial solar installations. The study found that commercial solar installations are cost-effective from all perspectives, while residential solar installations are cost-effective only from the SCT and PAT perspectives.

Economic Potential of Income-Qualified Households

Income-qualified households can take advantage of higher incentives for some measures. Participation in these additional offerings by income-qualified households impacts cost-effectiveness as follows:

- **SCT:** For each household with a major improvement, such as a weatherization project or heating and cooling system upgrade, the measure benefit-cost ratio is improved due to higher benefits associated with increased property value and reduced participant arrearages.
- **PAT**: The benefit-cost ratio is decreased for each measure receiving additional income-qualified incentives, due to higher incentive costs.

Focus on Energy Quad V may include an additional cost-effectiveness adder of 10% for income-qualified programs. This adder would increase the economic potential of income-qualified households by increasing the number of measures offered to income-qualified households that pass the cost-effectiveness screen.

As illustrated in Table 29, the economic potential for income-qualified households increases from 22% of technical potential under the mTRC test to 59% of technical potential when additional benefits are included for the SCT, which is close to the economic potential from the perspective of the PAT. Economic potential measured by the PAT is lower for income-qualified households than for standard income households because the incentives for income-qualified households are higher for many measures.

Table 29. Percentage of Cost-Effective Technical Potential for Income-Qualified and Standard Income Residential Segments

Residential Income Segment	Percentage of Technical Potential Cost Effective		
	mTRC	SCT	PAT
Income-Qualified	22%	59%	62%
Standard Income	22%	22%	71%

Program Scenario Potential

To develop a representative baseline scenario, this study first designed a Quad portfolio that included programs, associated measures, and incentive and non-incentive administrative and technical support budgets. While this design does not align perfectly with Focus on Energy's current structure or offerings, it based incentive levels and incentive-to-non-incentive budget distributions on current Focus on Energy patterns. The baseline program design includes measures currently offered by Focus on Energy as well as additional measures identified by the study team in consultation with stakeholders. The baseline scenario reflects a reasonable program design that largely aligns with current practice. The baseline scenario achieves approximately 17% less electric savings and 1% more gas savings compared to Focus on Energy performance in 2024. Portfolio cost-effectiveness based on net savings using Wisconsin's primary test (mTRC) is 1.5 in the baseline scenario, compared to 2.5 as calculated in 2024. Rising costs, changing efficiency standards, and the introduction of several new measures account for these differences.

After designing a baseline scenario, the study modified the baseline assumptions for each additional scenario by removing measures that did not contribute to meeting the scenario's priorities and adding or increasing incentives for measures aligned with the scenario's priorities to boost their adoption. The study maintained consistent budgets for the overall portfolio and by program for each scenario. Table 30 shows the design for each scenario.

Table 30. Planning Study Scenario Design

Scenario	Description	Scenario Details
0	Baseline	• Aligns Quad V with Quad IV program design as much as feasible. • Distribution of budget based on 2021–2023 budget allocations. • Incentives aligned with 2025 offerings.
1	Emissions Focused	• Remove measures with lowest emissions reduction potential within each sector program (excluding New Construction and Solar PV) • Increase incentives for measures with highest emissions reduction potential
2	Summer Electric Peak Focused	• Increase incentives for measures with highest summer peak reduction impacts
3	Summer Electric Peak Focused (with Load Shifting program)	• Increase incentives for measures with highest summer peak reduction impacts • Move $5 million from non-load-shifting program budgets to load-shifting program budgets in the residential and commercial sectors
4	Electrification Focused	• Add electrification measures that are not currently offered by Focus on Energy • Increase incentives for existing electrification measures
5	Cost-Effectiveness Focused	• Increase incentives for measures with highest cost-effectiveness from the mTRC perspective • Remove measures with lowest cost-effectiveness from the mTRC perspective

Table 31 shows the Planning Study's baseline Focus on Energy program structure, measures, and budget; customers served, and relation to current offerings.

Each Agriculture, Commercial, Industrial, and Residential program comprises a diverse mix of energy efficiency improvements. The Quad V program design offers solar PV installations and new construction projects through separate, cross-sector programs, because those measures show little variation across sectors and account for a large percentage of overall portfolio impacts.

Table 31. Planning Study Baseline Program Design

Program Name	Current Program Measures	New Measures	Population Segment	Current Offering	Four Year Incentive Budget	Four Year Program Administration and Technical Support Budget	Total Four Year Budget
Agriculture: Any buildings associated with agricultural businesses							
Agriculture	All agricultural measures (including HVAC and lighting measures for agricultural businesses)	Custom project	All agricultural customers	Agribusiness	$12,190,000	$5,560,000	$17,750,000
Commercial: All commercial buildings (including government institutions and excluding the agricultural and industrial sectors, and multifamily buildings)							
Commercial Refrigeration, Cooking, and Appliances	Commercial refrigeration, commercial cooking	Appliances	All commercial customers	Commercial cooking and refrigeration	$6,860,000	$4,890,000	$11,750,000
Commercial HVAC and Water Heat	All measures impacting HVAC and water heating end uses, including controls and building shell measures, as well as behavioral programs	Commercial custom project		Commercial HVAC and water heat	$19,240,000	$13,690,000	$32,930,000
Commercial Lighting	All commercial lighting and lighting control measures	None		Commercial Lighting	$26,960,000	$19,200,000	$46,160,000
Commercial Processes	All commercial measures impacting the process end use (as well as miscellaneous measures such as pool heat, information technology systems, and wastewater treatment)	None		Process Systems	$3,440,000	$2,450,000	$5,890,000
Industrial: All industrial buildings							
Industrial	All measures impacting buildings in the industrial sector		N/A	Small, Medium and Large Industrial Customers programs	$56,760,000	$44,310,000	$101,070,000
Residential: Multifamily units, single-family dwellings, manufactured homes							
Income Qualified	Building shell, HVAC, water heater measures, cooking electrification	None	Income qualified	Trade Ally Solutions, Instant Discount	$8,710,000	$4,010,000	$12,720,000
Multifamily	All measures impacting multifamily buildings	None	Standard and income qualified	Multifamily	$5,740,000	$3,920,000	$9,660,000
HVAC and Water Heating	HVAC, Water heating equipment (water heating and space heating electrification)	None		Trade Ally Solutions, Instant Discount, Direct to Customer	$61,231,000	$28,749,000	$89,980,000
Appliances and Lighting	Thermostats, appliances, lighting, water flow measures (aerators, etc.), pool pumps	Efficient vehicle chargers		Instant Discount and Direct to Customer	$9,909,000	$4,581,000	$14,490,000
Building Shell	Building shell measures (insulation, air sealing, windows, etc.)			Trade Ally Solutions	$13,910,000	$6,390,000	$20,300,000
Solar PV: All residential and commercial buildings							
Solar PV	Solar PV	None	Adoption data from 2020 solar potential study	Renewable Rewards	$24,280,000	$1,020,000	$25,300,000
New Construction: All residential and commercial buildings							
New Construction	All measures focused specifically on improving new construction practices via Focus on Energy	None	All residential and commercial new construction	Residential and Commercial New Construction	$27,450,000	$16,540,000	$43,990,000
Total Budget					**$276,690,000**	**$155,310,000**	**$432,000,000**

Scenario Results Overview

This section provides an overview of the Quad V energy and emissions impacts for each scenario by program (combining the Commercial and Residential programs into a single commercial and residential reporting category). The *Detailed Scenario Results* section provides further details on how each commercial and residential program differs by scenario and shows scenario impacts on cost-effectiveness and acquisition costs.

The Planning Study's scenario adjustments focused on changing incentives within individual programs but not on changing budget allocations between programs. Thus, programs with greater measure variety can present more opportunities for shifting incentives between scenarios. The Solar PV and New Construction programs have heterogeneous measure offerings, so this study did not adjust their offerings.

Figure 7 shows the estimated total lifecycle energy savings from gas and electric measures for each scenario. The study calculated lifecycle savings as the energy impacts of a measure over its EUL. An efficient furnace, for example, reduces energy use over its entire lifecycle. The baseline scenario saves 192,000 lifecycle BBtu in Quad V: 71,000 BBtu from reduced electric use and 121,000 BBtu from reduced gas use. These savings amount to approximately 0.6% of statewide electric sales and 0.5% of statewide gas sales in 2027 (on a BBtu basis, gas sales are approximately 140% of electric sales).

As illustrated in the chart, the baseline scenario has the lowest energy savings of all the scenarios, and the emissions-focused and cost-effectiveness-focused scenarios (Scenario 1 and Scenario 5, respectively) each increase energy savings by approximately 25%. There is little overall change in total electric and gas BBtu savings between the electrification scenario (Scenario 4) and the baseline scenario. This is because for some programs, overall energy savings decrease as budgets for energy efficiency and electrification measures are used more quickly, given the higher assumed incentive costs for electrification measures. The total electric and gas impacts reflect both the increased savings from removing natural gas measures and the negative electric savings (the study treats added electric load as negative savings) from adding electrification measures.

In the electrification scenario, total electric savings decrease by approximately 5,000 lifecycle BBtu, while total gas savings increase by 10,000 lifecycle BBtu, reflecting the high efficiency of electrification measures selected for the electrification options, which are approximately twice as efficient as the gas space and water heating systems that they replace. The two summer electric peak-focused scenarios have relatively similar energy impacts. This similarity is expected given the relatively small budget allocated to load-shifting programs and the long lead time to establish new programs. The difference between these scenarios is the addition in Scenario 3 of a load-shifting program, which has a small impact on total energy savings.

Figure 7. Quad V Program Scenario Lifecycle BBtu Savings by Scenario

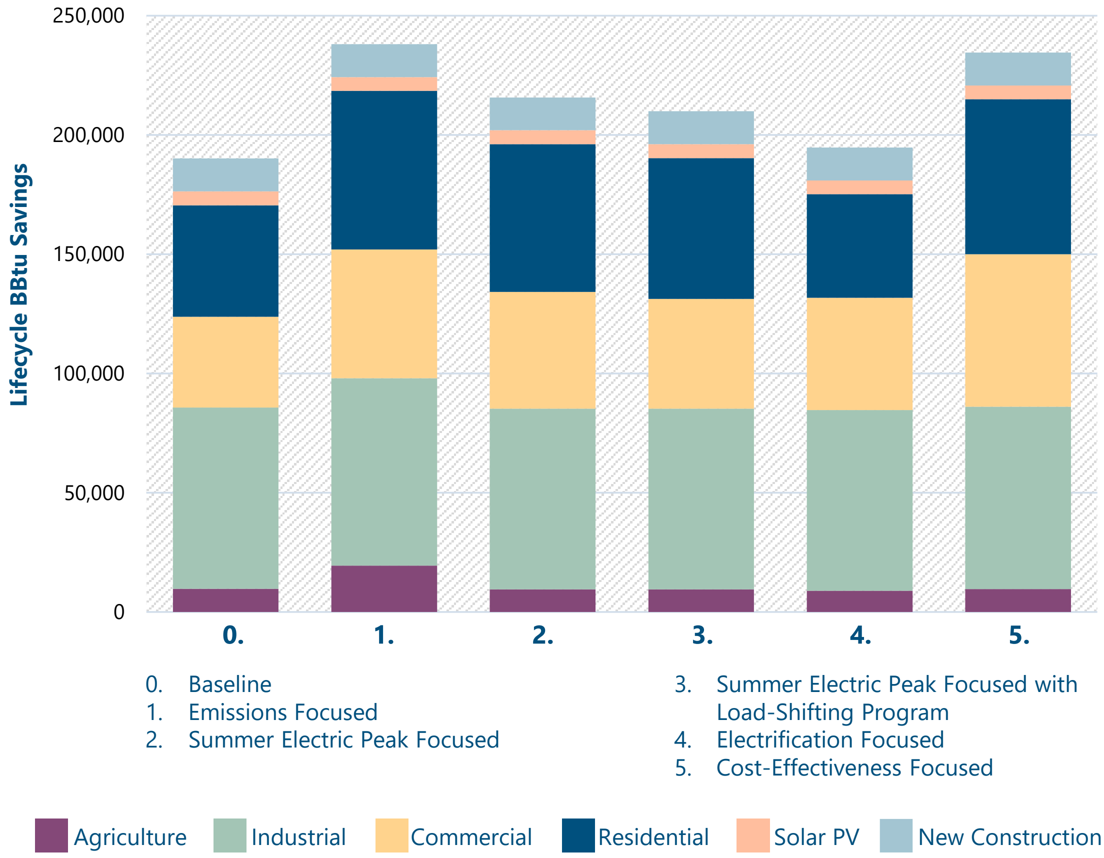


Figure 8 shows the carbon emissions savings from avoided gas and electric use for each scenario. As expected, the emissions-focused scenario has the largest impact on emissions reductions, saving approximately 2.3 metric tons (23%) more carbon emissions than the baseline scenario. The cost-effectiveness-focused scenario, which focuses on maximizing the portfolio cost-effectiveness ratio by removing the least cost-effective measures and increasing incentives for the most cost-effective measures, also significantly reduces carbon emissions while also increasing the portfolio mTRC cost-effectiveness ratios from 1.5 to 2.2. This trend shows that from the mTRC test perspective, reducing emissions adds substantial benefits to the cost-effectiveness calculations; however, designing a portfolio focused on cost-effective measures limits the number of measures available to program participants. A more detailed discussion of the differences between each scenario follows.

Figure 8. Quad V Program Scenario Lifecycle Carbon Emissions by Scenario

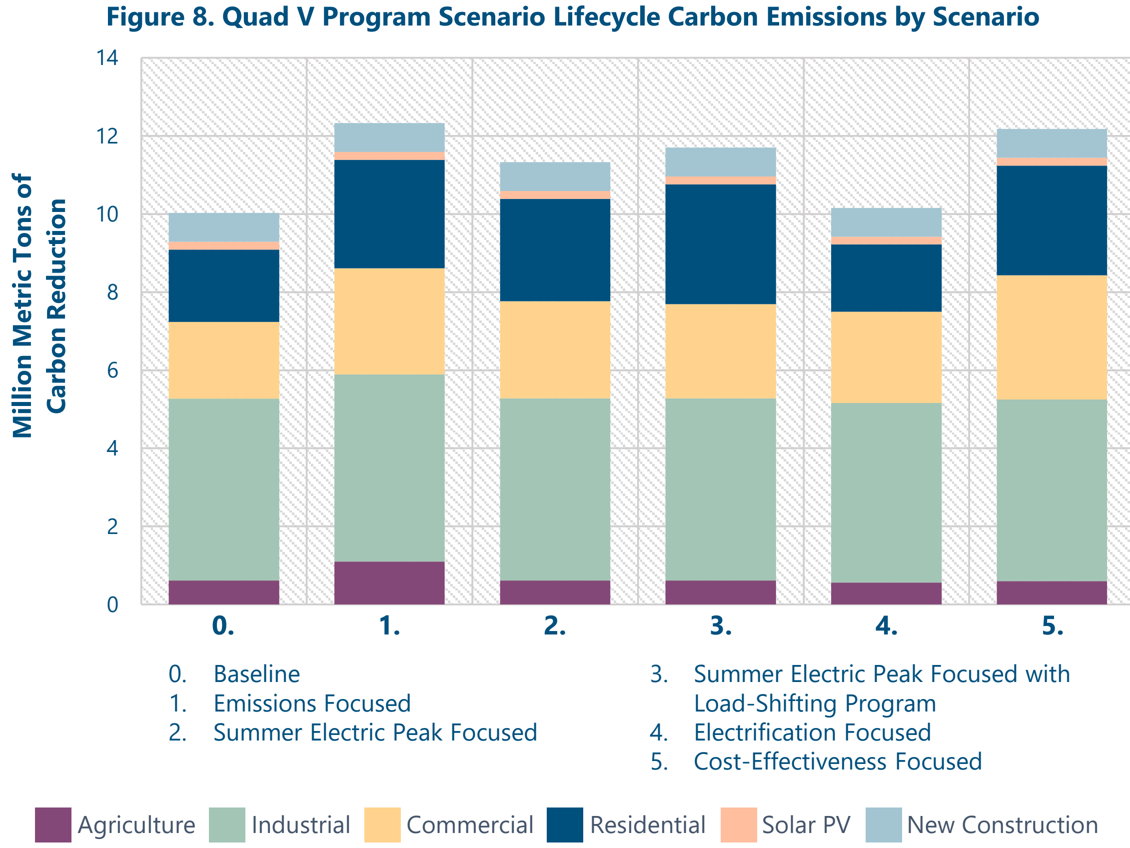


Figure 9 shows the summer peak electric demand reduction for each scenario in megawatts. The two summer peak demand reduction–focused scenarios reduce summer peak electric demand by 32% compared to the baseline, with the scenario introducing a load-shifting program having a slightly smaller impact. Both scenarios focus on measures that produce high summer electric savings per incentive dollar, including measures that impact lighting loads, industrial processes, and commercial and residential cooling loads. The electrification scenario produces the smallest reduction of electric summer peak of all the scenarios. This is because electrification measures increase peak electric demand.

Figure 9. Quad V Program Scenario Summer Peak Reduction by Scenario

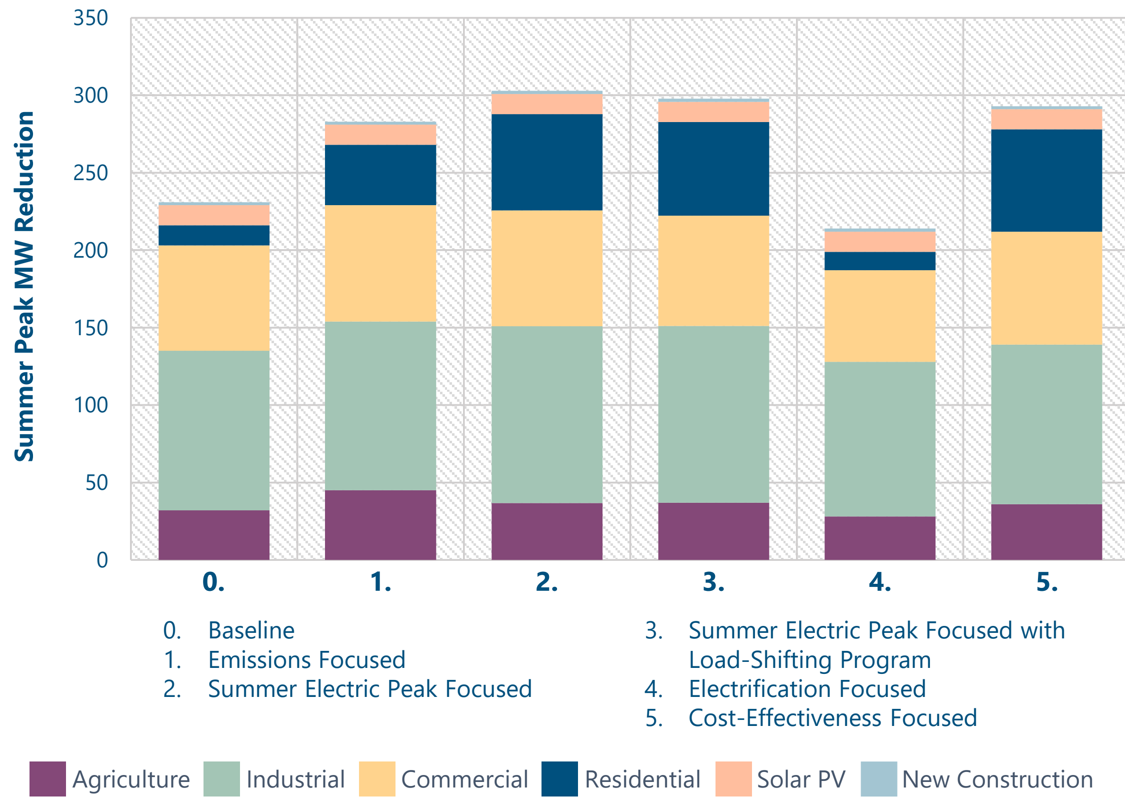


Figure 10 shows the impacts of each scenario on winter morning peak electric demand. As with summer peak demand, the electrification scenario results in less winter morning peak demand reduction relative to other scenarios, because residential heat pumps add particularly large electric loads in winter mornings.

Figure 10. Quad V Program Scenario Winter AM Peak Reduction by Scenario

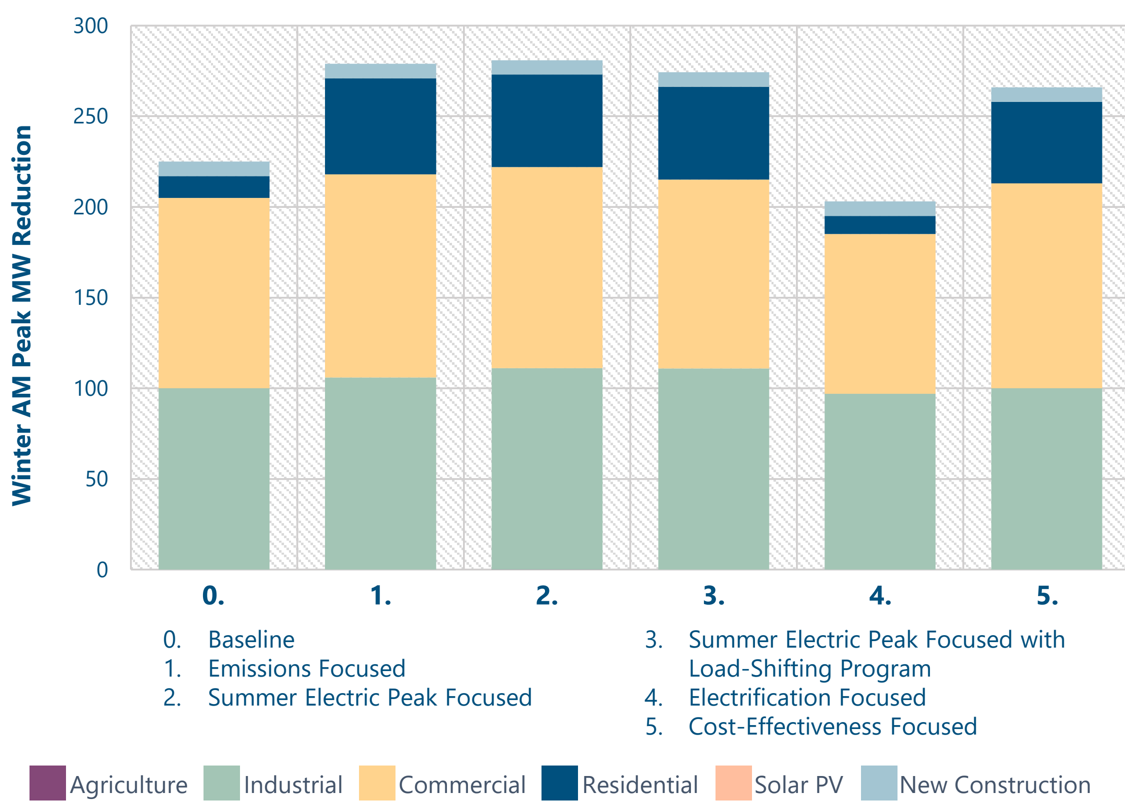


Figure 11 shows each scenario's impact on winter evening peak electric demand. As with the summer and winter morning peak demand, the electrification scenario results in less winter evening peak demand reduction than in the other scenarios, because it adds electric load for measures that operate during the winter evening peak period.

Figure 11. Quad V Program Scenario Winter PM Peak Reduction by Scenario

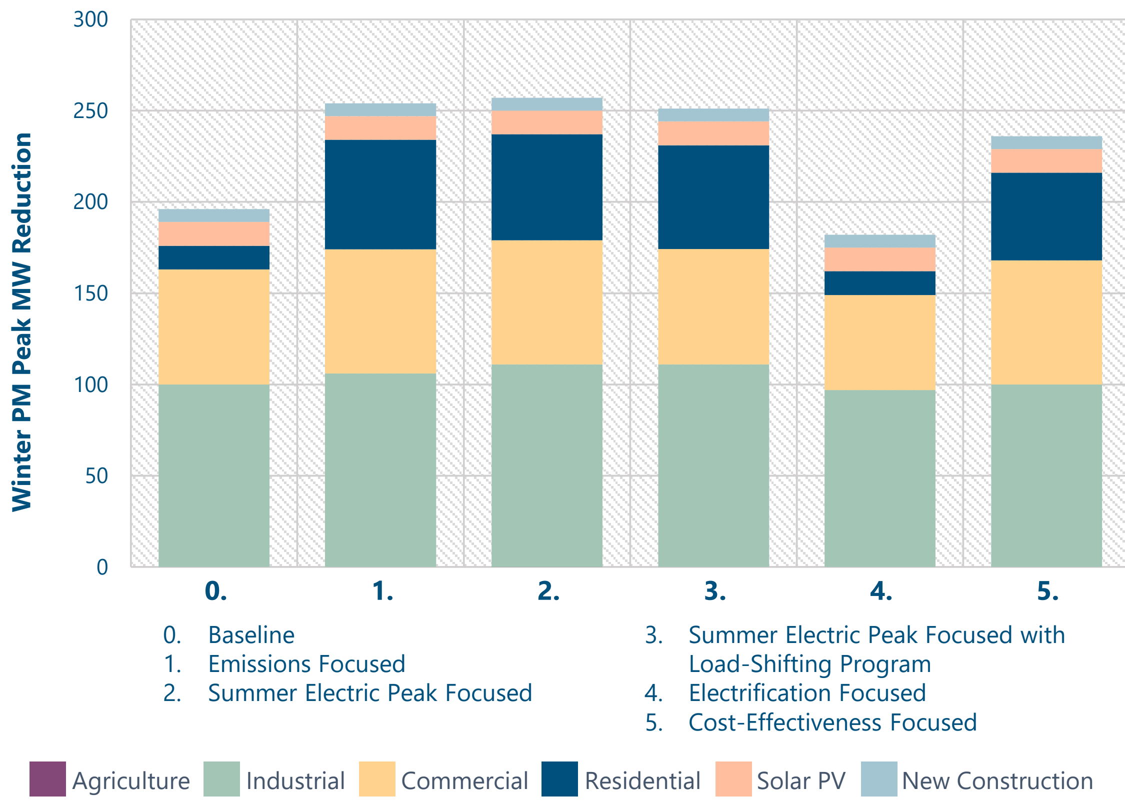
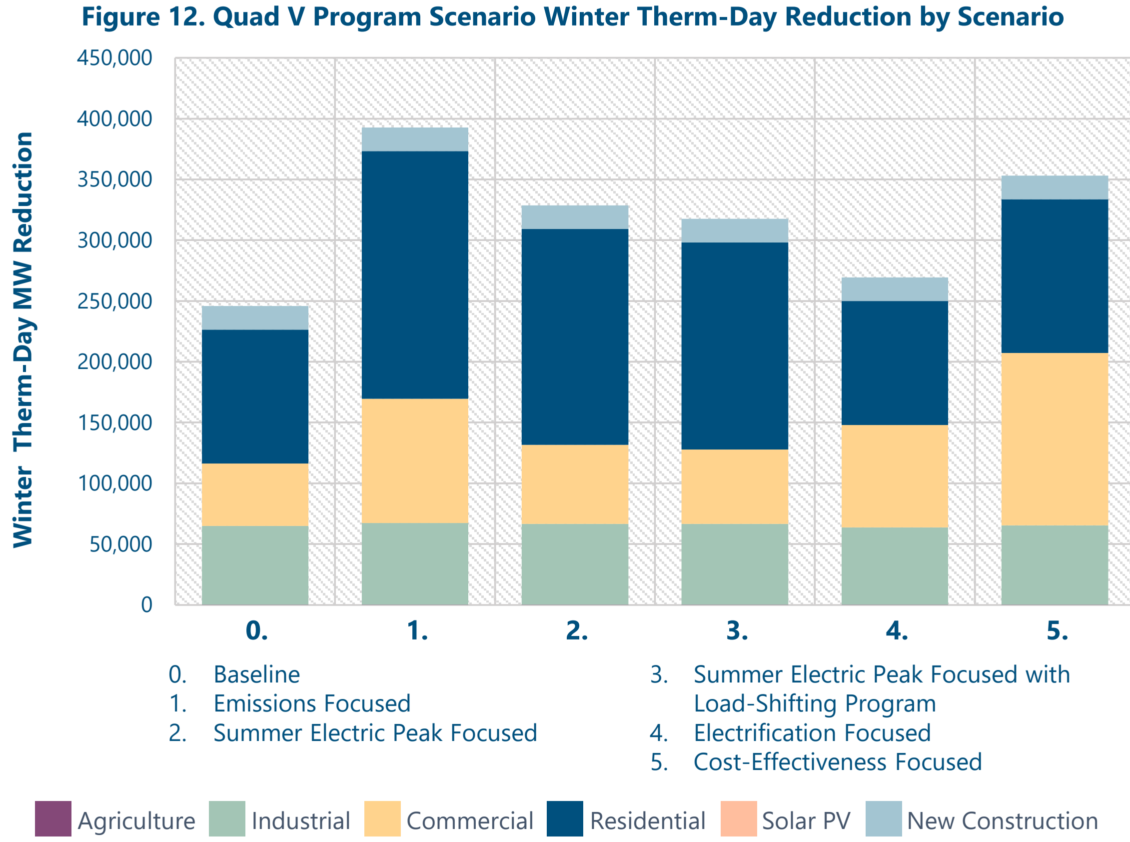


Figure 12 shows winter peak gas demand for each scenario. As illustrated in the figure, each scenario results in greater winter peak gas demand reductions compared to the baseline scenario, particularly in the emissions- and cost-effectiveness-focused scenarios. This impact is driven by residential heat pumps, which decrease gas usage considerably, in the emissions-focused scenario. In the cost-effectiveness-focused scenario, increased therm-day reductions are driven by accelerated adoption of gas space heating efficiency measures, such as efficient boilers.

Figure 12. Quad V Program Scenario Winter Therm-Day Reduction by Scenario



Detailed Scenario Results

This section provides detailed results for each of the six program potential scenarios in individual scenario-specific tables that present the Quad V impacts for the primary study reporting metrics, including gas and electric energy impacts, peak energy demand impacts, emissions impacts, cost-effectiveness ratios, and acquisition costs. The tables reflect acquisition costs as incentive dollars spent by Focus on Energy per lifecycle MMBtu of energy saved. Explanatory text prior to each table introduces the scenario, provides details about the specific changes relative to the baseline (Scenario 0), and discusses how the scenario differs from the baseline.

Scenario 0 – Baseline

The baseline scenario reflects the Planning Study's design of Focus on Energy programs that are generally consistent with current offerings. The baseline scenario achieves approximately 60% of its savings from reduced gas use, and the industrial sector makes up 40% of overall portfolio savings, followed by programs in the residential sector (24%) and the commercial sector (20%). The remainder of the portfolio's savings comes from the New Construction program (7%), the Agricultural program (6%), and the Solar PV program (3%). This study found decreasing savings from the Solar PV program in the future due to assumptions maintaining proportionality in the program incentive budget for renewables and planned increases in solar incentives, given changes to federal incentives, which have historically contributed to solar PV adoption in Wisconsin.

From the total resource cost perspective (mTRC test) the baseline scenario design achieves a net cost-effectiveness ratio of 1.5 (compared with an average of 2.3 in both 2023 and 2024) and ratios of 3.0 and 3.6 from the PAT and SCT, respectively. While acquisition costs vary greatly by program, the baseline scenario has an overall acquisition cost of $1.44 per lifecycle MMBtu saved, which is approximately $0.49 higher than recent Focus on Energy performance. The Industrial program has a relatively low acquisition cost ($0.75/lifecycle MMBtu saved), while the acquisition cost of the Residential Multifamily program is relatively high ($4.22 per lifecycle MMBtu saved). Acquisition costs for many utilities have increased over past decade, as low-cost measures such as light-emitting diodes (LEDs) have saturated more of the market. The *Benchmarking* section below highlights the general trend of increasing acquisition costs for energy efficiency programs.

Table 32 shows the detailed impacts and cost metrics of the baseline scenario. While there are differences between the baseline scenario and Focus on Energy's current program performance, the trends in the study's baseline scenario are generally consistent with, though somewhat lower than, Focus on Energy's performance in 2023 and 2024. Electric savings in the first year of the Quad V baseline scenario are approximately 22% lower than the average Focus on Energy electric savings in 2023 and 2024, and gas savings in the first year of the Quad V baseline scenario are approximately 4% higher than the average gas savings in 2023 and 2024.

Table 32. Detailed Quad V Scenario 0 Baseline Results

Sector/Program		Lifecycle Energy Savings				Emissions	Peak Demand Reductions				Cost-Effectiveness Ratios			Incentive
		Electric BBtu	Gas BBtu	GWh	Million Therms	Million Metric Tons CO2	Summer MW	Winter AM MW	Winter PM MW	Winter Therm-Day	MTRC	PAT	SCT	$/Lifecycle MMBtu
Agriculture		5,500	4,200	1,621	42	0.5	32	-	-	10	3.2	6.6	3.7	1.1
Commercial	Refrigeration, Cooking, and Appliances	2,400	900	713	9	0.2	10	8	8	2,000	1.3	2.4	5.7	2.3
Commercial	HVAC and Water Heat	3,200	13,200	947	132	0.8	10	12	9	49,200	1.8	2.5	1.9	1.3
Commercial	Lighting	17,800	-	5,215	-	1.0	47	83	45	-	1.6	3.9	2.0	1.5
Commercial	Processes	500	-	151	-	0.0	1	2	1	-	1.0	1.3	1.3	2.5
Commercial	Load Shifting	-	-	-	-	-	-	-	-	-				0.0
Industrial		28,800	47,200	8,449	472	4.7	103	100	100	65,000	2.3	6.1	2.6	0.8
Residential	Income Qualified	(13)	2,800	(4)	28	0.1	-	-	-	7,000	0.4	0.7	4.2	3.2
Residential	HVAC and Water Heating	(800)	28,700	(244)	287	0.9	4	(3)	(3)	54,600	0.8	1.1	0.8	1.5
Residential	Appliances and Lighting	2,800	7,600	835	76	0.5	9	13	14	37,400	0.9	1.6	2.4	2.9
Residential	Building Shell	400	4,000	112	40	0.2	-	1	1	8,500	0.4	0.9	0.4	3.2
Residential	Multifamily	200	1,100	63	11	0.1	-	1	1	2,800	0.3	0.4	0.3	4.2
Residential	Residential Load Shifting	-	-	-	-	-	-	-	-	-				0.0
Solar PV		5,800	-	1,698	-	0.2	13	0	13	-	1.1	2.5	1.3	4.2
New Construction		3,200	10,600	944	106	0.7	2	8	7	19,400	1.7	1.3	1.9	2.0
Portfolio		**69,900**	**120,400**	**20,499**	**1,203**	**9.9**	**231**	**225**	**196**	**246,000**	**1.5**	**3.0**	**3.6**	**1.4**

Solar PV Program

The Planning Study assumed that the Solar PV program would have a Quad V budget of $25.3 million, of which 96% would be devoted to incentives. However, significant uncertainty remained during the study about how recent changes to federal solar incentives will impact installations of solar PV systems on Wisconsin homes and business facilities in the future. Thus, after consulting with the Focus on Energy Program Administrator, this study assumed that Focus on Energy incentives for solar systems would be increased from current offerings in future Quads to make up for reduced solar incentives at the federal level. This increase in incentives resulted in lower projected solar program participation than participation and adoption levels forecast in the 2021 Focus on Energy solar potential study.[16], because Focus on Energy would meet its solar budget cap more quickly with increased incentives.

Table 33 shows the incentives that this study assumed for the Solar PV program. This study assumed that relative participation in the Solar PV program by agricultural, commercial, and industrial buildings would be consistent with past trends.

Table 33. Planning Study Solar PV Incentive Assumptions

Sector	Unit	Current	Planning Study Assumption
Nonresidential	$/system (kW)	$50	$160
Residential	$/project	$300	$2,400

New Construction Program

The Planning Study assumed that the New Construction program, which offers financial incentives to construction companies to build efficient new homes and commercial buildings, would continue to operate in future Quads as it currently operates. The Planning Study assumed that the New Construction program would spend its entire $6,862,500 incentive budget each year, incentivizing the construction of 1,754 single family homes, 54 manufactured homes, 53 multifamily buildings, and 21 commercial buildings annually. While this does not reflect the year-to-year variances that have occurred in actual program delivery, it reflects a reasonable assumption that the New Construction program will largely maintain consistency with current delivery.

Income-Qualified Program

The Income-Qualified program is designed specifically to encourage adoption of Focus on Energy measures in households that earn 80% or less than the area median income by offering these customers higher incentives compared to standard income customers. The baseline scenario allocates 9% of the residential Quad V budget to the Income-Qualified program, which generates 6% of the Quad V energy savings. This budget allocation and the associated savings are disproportionately low compared to the overall percentage of income-qualified households and technical potential, which account for 38% and 34% of total residential households and technical potential respectively.

Income-qualified customers may also opt into offerings from other programs, both for measures that are offered in the Income-Qualified Program (such as heating and cooling systems), and for measures that are not targeted to income-qualified populations in that program (such efficient appliances). However, specific additional incentives and attention are necessary to increase adoption of energy efficiency and electrification measures in income-qualified households for the following reasons:

- Income-qualified customers expressed that they are less likely to adopt efficiency and electrification measures, even when these measures pay for themselves very quickly (see *Develop Maximum Adoption Percentage through Hurdle Rates* in *Appendix D*), especially for projects with higher capital costs.
- A greater proportion of income-qualified customers are renters, compared to standard income customers, which is an additional barrier to adopting energy efficiency measures. A greater proportion of renter-occupied households are likely to adopt Focus on Energy measures, especially those requiring high capital investment, compared to owner-occupied households.

---

[16] Cadmus. October 4, 2021. *2021 Rooftop Solar Potential Study Report*. Prepared for Public Service Commission of Wisconsin for the 2021 solar study. focusonenergy.com/about/2021-potential-study-documents.

The baseline budget allocation suggests that Focus on Energy may be able to achieve additional savings by increasing the budget for income-qualified households, which represents a large fraction of the population with barriers to adopting measures. In 2024 Focus on Energy received 952 applications for rebates from income-qualified household, representing approximately 0.5% of all residential customer rebates that Focus on Energy processed that year.

The cost-effectiveness ratio for the Income-Qualified program is 0.4 under the mTRC test due to the high incremental costs of many measures such as weatherization. However, the cost-effectiveness ratio improves under the PAT to 0.7, despite the higher incentives the Income-Qualified program provides. Under the SCT, the cost-effectiveness ratio improves further to 4.2, due to additional benefits for measures that improve property values and reduce arrearages. These benefits amount to approximately $9,500 per participant making a major upgrade to their home.[17] Potential future changes to how cost-effectiveness is calculated for income-qualified measures could improve the Income-Qualified program's benefit-to-cost ratios (see: *Economic Potential of Income-Qualified Households*).

Scenario 1 – Emissions Focused

To estimate savings from the emissions-focused program design, this study increased incentives to accelerate adoption for intervention measures with the highest lifecycle emissions reductions per incentive dollar and removed measures for which lifecycle emissions reduction per incentive dollar were lowest. The Planning Study made these changes within each program and did not shift budgets between programs, under the assumption that Focus on Energy would continue to offer a diverse set of options to Wisconsin energy consumers, regardless of whether the program shifted its focus.

Key takeaways from the emissions-focused scenario design include the following:

- Emissions from gas-fueled space and water heating equipment (equipment that combusts gas inside a building) are lower per unit of energy consumed than emissions associated with using electric energy, even when accounting for lower carbon intensity of the electric grid in the future. Thus, if selected purely on emissions intensity without considering costs, a portfolio designed to emphasize emissions reductions is likely to prioritize electric energy savings over natural gas energy saving.
- While the emissions associated with gas-consuming equipment do not vary by hour, hourly emissions from electric equipment depend on the time of year in which the equipment is used. While the generation sources of Wisconsin's electric utilities are diverse, the grid is generally less carbon intensive in the summer due to contributions from renewable sources such as solar. Thus, measures that result in winter electric savings have more favorable emissions impacts than measures that save electricity in the summer.
- It is not realistic to expect to design a portfolio that optimizes emissions reductions only on the basis of maximizing winter electric savings. Optimizing the portfolio also needs to account for the relative cost of achieving emissions reductions, as the Focus on Energy budget is limited. Allocating more budget to expensive, high-winter-electric saving measures could leave less budget available for measures that have a lower cost of acquisition and a high overall emissions impact relative to their cost.
- Optimizing the Focus on Energy portfolio for emissions impacts based on cost per emissions reduction yields a nuanced picture. Both gas-saving and electric-saving measures are impactful. High-efficiency heat pumps, for example, reduce emissions both by minimizing gas use (and adding electric load) and by reducing winter electric use due to their high efficiency relative to existing equipment.

---

[17] While economic potential, which calculates potential on the basis of whether or not a measure is cost-effective, is higher from the PAT perspective than from the SCT perspective, the Income-Qualified program SCT ratio is higher than the PAT ratio. This trend occurs because the Planning Study considers the magnitude of measure benefits and costs when evaluating the cost-effectiveness ratio of a program, while economic potential only considers whether the measure is cost-effective. Property value benefits under the SCT have a substantial impact on the magnitude of the benefits of many measures offered in the Income-Qualified program.

Table 34 shows the measures for which this study accelerated adoption for the emissions-focused scenario, and measures that it removed for this scenario.

Table 34. Study Measures Maximized or Removed for Emissions-Focused Scenario

Accelerate Adoption	Removed
Agriculture Program	
Greenhouse climate controls (e, g) Greenhouse perimeter insulation (e, g) Process heat improvements (e, g)	Circulation fans and ventilation (e) Custom dairy projects (e) Custom lighting improvements (e) High efficiency water heat (e, g) Irrigation pressure reduction (e)
Commercial Programs	
Air source heat pump (e) ECM evaporator fans, insulation (e) Efficient boilers (g) LED lighting and controls (e)	Advanced rooftop units (e, g) Building automation (e, g) Heat pump water heaters (e) Chillers (e) Cooking equipment (e, g) Commissioning DX Package (e) Equipment tune-ups and maintenance (e, g) Ground source heat pumps (e) Package terminal air conditioner (e) Tankless water heaters (g) Variable refrigerant flow systems (e)
Industrial Program	
Boiler controls (g) Boiler draft fan variable frequency drives (e) Compressed air leak reduction (e) Cooling tower fan upgrade (e) Pump upgrades and drives (e, g) Fan upgrades and drives (e) Steam traps (g) Strategic energy management and operations and maintenance (e, g)	Advanced lighting controls (e) Advanced rooftop unit upgrades (e) Air conditioners (e) Commissioning (e, g) Compressed air mist eliminator, heat pump and economizer upgrades (e) Radiant heat (g)
Residential Programs	
Advanced cold climate and enhanced efficiency heat pumps (including electrification systems) (e, g) Boiler reset controls (g) Building shell insulation (e, g) Efficient furnaces (g) Low-flow water fixtures (e, g) Water pipe insulation (g)	Advanced condensing water heat (g) Advanced efficient air conditioner (e) Condensing water heaters (g) Efficient appliances (e, g) Efficient electric vehicle charger (e) Efficient windows (e, g) Heat pump water heaters (e) LED connected lighting (e) Tune-ups (e, g)

e = measures that save electricity, g = measures that save gas

Table 35 shows detailed energy impacts and cost metrics of the emissions-focused scenario. The table shows that by applying the changes listed in Table 34, Quad V lifecycle carbon emissions savings increase by 2.3 million tons (23%) relative to the baseline scenario, and overall energy savings increase by 25%, particularly from reduced gas use, which shows a 30% increase in savings (electric savings increase by 16%). The acquisition cost in this scenario decreases by $0.28 per lifecycle MMBtu saved, and cost-effectiveness increases under all three tests.

As shown in Table 34, emissions-reducing measures include many measures that primarily save gas, such as industrial boiler controls and residential enhanced efficiency heat pumps (for energy efficiency and electrification applications). At the same time, measures that are less effective at reducing emissions include many electricity-saving measures such as air conditioners and connected LED lighting. However, it is not a universal pattern that an emissions-focused scenario will favor reducing gas use. The Planning Study selected measures for scenarios based on their impact per incentive dollar; both cost savings and emissions savings matter. Therefore, if a measure has a high acquisition cost per energy unit saved, it may also have a high cost per pound of carbon avoided. Connected LED lighting, for example, has a relatively high ratio of emissions savings to electric energy savings, given its hourly savings profile but has relatively high cost of energy savings, and is therefore removed in the emissions-focused program scenario.

The comparative impact of gas- and electricity-savings measures on emissions reductions depends on a variety of factors, including the individual measure efficiency, the relative impact per incentive dollar, and the lifetime of the measure. The study also considered that electric emissions factors vary by hour of the year, by year within the study period, by utility service territory, and by measure load profile (as the coincidence of hourly savings with grid emissions intensity varies each hour). For example, average carbon emissions savings per kWh of electricity saved for a heat pump water heater is approximately 0.55 pounds of carbon per kWh in 2027, compared to 0.74 for a heat pump. Solar energy, which is coincident with solar energy production, has the lowest emissions factor in 2027 of 0.50 pounds of carbon per kWh, reaching 0.37 in 2030. This pattern is observed because Wisconsin's electric grid is generally cleaner in the summer than in the winter as some Wisconsin utilities produce more solar energy in the summer. Thus, solar systems, which produce energy in the summer, have a relatively low ratio of emissions savings to energy savings, while heat pumps, which save space heating energy in the winter have higher emissions savings per kWh saved. Water heaters, which save energy consistently over seasons, fall between solar and heat pumps in terms of carbon emissions reduction impact per kWh saved.

On average, statewide emissions factors are projected to decrease from 0.65 pounds of carbon emitted per kWh in 2027 (191,000 pounds per BBtu) to 0.54 (158,000 pounds per BBtu) in 2030. The rate of decrease in statewide emissions factors is informed by Wisconsin utility planned capacity additions and retirements reported in the SEA. Additional information on the methodology used by the study to calculate emissions impacts can be found in *Appendix D* (*Electric Emissions Factors*).

This study assumes that gas combusted on site for space and water heating and commercial processes emits 11.7 pounds of carbon per Therm (117,000 pounds per BBtu) of energy consumed. One of the reasons emissions factors from electricity are higher than those from on-site gas use is that fossil fuel power plants have significant efficiency losses when converting fuel to electric energy. Thus, while average carbon emissions impacts from electricity are greater than those from gas in the near term, emissions impacts vary according to each measure's load profile.

Table 35. Detailed Quad V Scenario 1 Emissions-Focused Results

Sector/Program		Lifecycle Energy Savings				Emissions - Million Metric Tons CO2	Peak Demand Reductions				Cost-Effectiveness Ratios			Incentive $/Lifecycle MMBtu
		Electric BBtu	Gas BBtu	GWh	Million Therms		Summer MW	Winter AM MW	Winter PM MW	Winter Therm-Day	MTRC	PAT	SCT	
Agriculture		7,600	11,900	2,234	119	1.0	45	-	-	20	4.2	10.4	4.7	0.6
Commercial	Refrigeration, Cooking, and Appliances	4,400	1,600	1,275	16	0.3	17	14	13	3,300	1.8	4.3	10.5	1.3
	HVAC and Water Heat	3,100	26,400	897	264	1.4	9	12	9	98,800	3.0	3.9	3.2	0.7
	Lighting	17,900	-	5,258	-	1.0	48	84	45	-	1.6	3.9	2.0	1.5
	Processes	600	-	161	-	0.0	1	2	1	-	1.0	1.4	1.4	2.3
	Load Shifting	-	-	-	-	-	-	-	-	-				0.0
Industrial		30,600	47,900	8,976	479	4.8	109	106	106	67,400	2.4	6.4	2.7	0.7
Residential	Income Qualified	(100)	3,000	(15)	30	0.1	-	-	-	7,100	0.4	0.8	2.9	2.9
	HVAC and Water Heating	300	29,200	73	292	1.0	4	-	1	54,000	0.9	1.4	0.9	1.2
	Appliances and Lighting	7,100	19,700	2,088	197	1.3	35	51	57	129,200	1.9	3.7	3.5	1.3
	Building Shell	400	4,600	107	46	0.3	-	1	1	9,300	0.4	1.0	0.4	2.8
	Multifamily	200	2,000	58	20	0.1	-	1	1	4,200	0.5	0.7	0.5	2.6
	Residential Load Shifting	-	-	-	-	-	-	-	-	-				0.0
Solar PV		5,800	-	1,698	-	0.2	13	0	13	-	1.1	2.5	1.3	4.2
New Construction		3,200	10,600	944	106	0.7	2	8	7	19,400	1.7	1.3	1.9	2.0
Portfolio		**81,100**	**156,800**	**23,755**	**1,568**	**12.2**	**283**	**279**	**254**	**393,000**	**1.8**	**3.7**	**4.1**	**1.2**

Scenarios 2 and 3 – Summer Electric Peak Focused

The summer electric peak–focused scenarios emphasize reducing summer electric peak demand. The study originally designed these scenarios to reduce demand during all peak periods, but found that when attempting to achieve reductions in four peak periods concurrently, the program was challenged to achieve meaningful savings in any of the periods. This outcome is not unexpected; a statewide portfolio with a diverse set of energy efficiency and renewable offerings would likely face challenges achieving meaningful reduction in peak period usage across multiple time periods and fuels. For the first summer electric peak–focused scenario, the study focused on accelerating measures with highest summer electric peak reduction per incentive dollar spent, but did not remove any measures from the portfolio, as doing so would have required removing measures that only save gas, which is an unrealistic scenario.

The other summer electric peak–focused scenario added a load-shifting program in the commercial and residential sectors. This program included technologies and approaches specifically designed to encourage customers to move electric load from peak to off-peak periods, but not to save energy.

Key takeaways from the summer electric peak–focused scenario designs include the following:

- Focus on Energy can substantially reduce summer peak electric demand by accelerating the adoption of measures that reduce electric energy consumption in summer months or measures that reduce electric energy demand consistently over the year.
- To maximize summer electric peak reductions, the program should be optimized to consider not only the net summer peak demand reduction of a measure, but also its incentive cost relative to peak reduction.
- Allocating funding to commercial and residential programs focused specifically on load-shifting measures does not reduce overall summer peak impacts relative to a portfolio that emphasizes summer peak reductions without these specific programs. This is because the load-shifting programs use budget that could be more effectively spent in the near term on more established interventions for the following reasons:
- Focus on Energy currently evaluates summer peak impacts based on average reductions over many summer hours, whereas many load-shifting interventions such as battery or thermal storage systems are designed to reduce maximum peak impacts during fewer hours of maximum peak. This evaluation approach favors measures that have impacts over many hours, such as efficiency measures.
    - The Planning Study assumed that ramping up load-shifting programs would take several years and that a substantial amount of funding would be allocated to program administration in the early years of the program. This budget allocation reduces the budget available for other impactful efficiency measures.

Table 36 shows the measures for which this study accelerated adoption for the summer electric peak–focused scenarios and the intervention measures added for the load-shifting programs. Measures with the highest summer peak impact include those that effectively reduce summer load, such as efficient air conditioners, or measures that distribute load evenly across the year, such as commercial and residential appliances.

Table 36. Baseline Study and Load-Shifting Measures Accelerated and Added for the Summer Electric Peak–Focused Scenario

Accelerate Adoption	Load-Shifting Measures Added
Agriculture Program	
Engine block timer Greenhouse climate controls High-volume low-speed fan Irrigation improvements Linear LED packages Variable frequency drives	None

Accelerate Adoption	Load-Shifting Measures Added
Commercial Programs	
Cooling tower fan Daylighting controls Dishwashers and dryers ECM evaporator fans IT system efficient rectifier Variable speed control on HVAC pump system	Electric vehicle load shift Thermal storage Thermostat load control
Industrial Program	
Boiler draft fan variable frequency drive (process) Building duct system improvements Compressed air leakage reduction and nozzles Cooling tower fan upgrade High efficiency injection mold machines Lighting controls Operations and maintenance Pump and fan upgrades and drives Variable speed pump for HVAC recirculation	None
Residential Programs	
Efficient air conditioners Efficient dehumidifiers and air purifiers Heat pump pool heaters Water flow measures	Battery storage Electric vehicle load shift Thermal storage Thermostat load control

Table 37 shows the detailed results from the summer electric peak–focused scenarios. Because in many instances the differences between these scenarios are minor, the table presents results from both scenarios together, includes values for each scenario when these values differ, and shades the cells that have differing values. As shown in the table, focusing on summer peak–reducing measures by themselves reduces summer peak electric demand by 66 MW, which is approximately 32% compared to the baseline. The scenario also decreases lifecycle carbon emissions by 1.3 million tons, increases electric savings by 19%, and increases gas savings by 10% relative to the baseline. The portfolio cost-effectiveness also increases, and acquisition cost decreases.

Table 37. Detailed Quad V Scenarios 2 and 3 Summer Electric Peak–Focused Results without and with Load-Shifting Program

Sector/Program		Lifecycle Energy Savings				Emissions - Million Metric Tons CO2	Peak Demand Reductions				Cost-Effectiveness Ratios			Incentive $/Lifecycle MMBtu
		Electric BBtu	Gas BBtu	GWh	Million Therms		Summer MW	Winter AM MW	Winter PM MW	Winter Therm-Day	MTRC	PAT	SCT	
Agriculture		6,500	3,000	1,891	30	0.5	37	0	0	10	4.4	7.2	4.9	1.2
Commercial	Refrigeration, Cooking, and Appliances	3,200 3,100	800	927 914	8	0.2	13	11 10	10	1,800	1.7	2.9 3.1	6.5 6.6	2.1 1.9
	HVAC and Water Heat	3,600 3,500	22,300 21,100	1,055 1,033	223 211	1.2	11	13	10 9	63,300 59,600	2.5	3.6	2.7	0.8
	Lighting	18,600 17,100	-	5,441 5,020	-	1.0 0.9	49 46	86 80	47 43	-	1.6	4.1 3.9	2.0	1.4
	Processes	400	-	128	-	0.0	1	1	1	-	0.9	1.2	1.2	2.4
	Load Shifting	- 0	-	-	-	- 0.1	- 0.3	- 0.1	- 0.2	-	- 0.0	- 0.0	- 0.0	- 0.0
Industrial		31,800	44,000	9,315	440	4.7	114	111	111	66,500	2.4	6.4	2.8	0.8
Residential	Income Qualified	100	2,800 2,600	43	28 26	0.1	2	(0)	0	6,400 6,000	0.4	0.9	2.9 2.8	3.0
	HVAC and Water Heating	(500)	26,300 26,900	(144) (135)	263 249	0.9 0.8	5	(3) (92)	(2)	48,600 45,900	0.8	1.3	0.8	1.2 1.1
	Appliances and Lighting	10,100 9,800	16,600 16,000	2,972 2,874	166 160	1.3 1.2	54 53	52 50	58 56	110,500 106,900	2.2 2.3	4.0	3.6 3.7	1.6 1.5
	Building Shell	400	4,600 4,300	116 110	46 43	0.3	-	1	1	9,200 8,800	0.4	1.0	0.5 0.4	2.8
	Multifamily	300	1,200 1,100	88 84	12 11	0.1	1	1	1	2,900 2,700	0.3	0.7	0.3	3.9
	Residential Load Shifting	-	-	-	-	- 0.6	- 0.5	- 1.3	- 0.9	-	- 0.1	- 0.1	- 0.1	- 0.0
Solar PV		5,800	-	1,698	-	0.2	13	0	13	-	1.1	2.5	1.3	4.2
New Construction		3,200	10,600	944	106	0.7	2	8	7	19,400	1.7	1.3	1.9	2.0
Portfolio		**83,500 81,700**	**132,200 128,500**	**24,474 23,916**	**1,322**	**11.3 11.1**	**303 298**	**281 274**	**255 251**	**329,000 318,000**	**1.8**	**3.5**	**3.9**	**1.3**

Highlighted cells show the Scenario 2 value (top) followed by the Scenario 3 value (bottom). Cells with no highlighting and only one value indicate that the value is the same in both scenarios.

Load-Shifting Programs

The Planning Study developed a potential load-shifting program that could begin in the first year of Quad V (2027) and continue in Quad VI and Quad VII. The study assumed that participation would slowly ramp up as the offering matured. Additionally, the analysis assumed that in Quad V approximately 75% of the program budgets would be dedicated to program administration and technical support, with the budget gradually shifting toward incentives as the load-shifting program matured in later years.

Table 38 shows the predicted Summer PM electric peak reductions from the commercial and residential load-shifting program in Quad V. Note that whereas other tables in the study express peak demand reduction impacts in MW, Table 38 reports in kW to better reflect the scale of the demand reduction impacts estimated for the load-shifting program. The Planning Study design analyzed impacts from a residential thermal storage technology focused on reducing winter electric peak from space heating but did not include this technology in the load-shifting program, as the design of the peak reduction scenario was revised following review of draft results to focus solely on summer electric peak reduction.

Table 38. Summer Peak Electric Demand Reduction Impacts from Load-Shifting Measures in kW

Sector	Load-Shifting Measure	2027	2028	2029	2030
Commercial	Electric Vehicle Load Shift	0	8	23	54
	Thermal Storage	0	11	11	18
	Thermostat Load Shift	0	28	57	101
Residential	Battery Storage	0	51	51	79
	Electric Vehicle Load Shift	0	6	18	44
	Thermal Storage	0	0		0
	Thermostat Load Shift	0	39	78	139
Total		**0**	**144**	**238**	**434**

As illustrated in Table 38, thermostat load-shifting measures in the commercial and residential sectors can have the highest impact on reducing summer peak reduction. These measures are relatively low cost and can be applied to a large portion of residential and commercial buildings (i.e., buildings with cooling systems and smart thermostats installed). While electric vehicle load-shifting measures are also low cost, the relatively low saturation of electric vehicles (EVs) makes these measures less widely applicable than thermostat load-shifting measures, which limits their market adoption.

While commercial thermal storage and residential battery storage systems have relatively high impacts per system deployed, the Planning Study found that the high cost of these measures limits their widespread market adoption.

The Planning Study cost-effectiveness analysis indicated that the load-shifting program was not cost-effective under any of the calculated testing frameworks for several reasons:

- The administration and technical support budget for the load-shifting program was assumed to be relatively high, especially in Quad V when the program would be starting up. However, the load-shifting program did not become cost-effective in later years as the administrative proportion of the program's budget decreased and demand reductions increased.
- The residential battery storage system generated negative electric savings due to efficiency losses associated with operating the systems.
- Focus on Energy calculates average impacts over many peak hours, whereas technologies included in this analysis are often deployed to reduce peak electric demand during a small number of extreme events. Thus the current Focus on Energy peak period definition may not be appropriate for estimating the impacts of measures designed to reduce demand for short-duration peaks such as those commonly corresponding to utility demand response programs.
- The current Wisconsin cost-effectiveness testing framework has been designed to primarily assess energy efficiency programming investments and therefore may not capture other benefits associated with load-shifting measures such as grid resilience.

Scenario 4 – Electrification Focused

The Planning Study added several electrification measures to the Focus on Energy Agricultural, Commercial, Industrial, and Residential programs for the electrification scenario. The study also increased incentives for residential electrification equipment for which Focus on Energy already offers incentives (which are included in the baseline scenario).

Key takeaways from the electrification-focused scenario designs include the following:

- The Planning Study indicates that adding and accelerating electrification measures to the Focus on Energy portfolio has relatively modest impacts on portfolio emissions reductions and energy savings relative to the baseline scenario. The electrification scenario's primary impact is to shift savings between electric and gas fuels.
- The relatively modest impacts of the electrification scenario on energy and emissions savings relative to the baseline occur because the Planning Study's adoption model predicts relatively low electrification adoption for two reasons: primary research shows customer attitudes about electrification projects are less positive than their attitudes about energy efficiency projects, and normalized energy prices (expressed as $/Btu) are lower for gas than for electricity, making gas heating more economical than electric heating for customers.
- The Planning Study assumed that electrification projects require higher incentives than energy efficiency projects to spur adoption, given customer attitudes and relative fuel prices. This reduced the budget available for other measures, which reduced savings from those measures.

Table 39 shows the measures added to the electrification scenario, as well as the currently offered residential electrification measures accelerated in this scenario. While the electrification scenario added fuel-switching measures to all sectors, consistent with current Focus on Energy offerings, only the residential sector included electrification measures in the baseline scenario. Therefore, the electrification scenario only simulated accelerated adoption of electrification measures in the residential sector through increased incentives.

Table 39. Electrification Measures Accelerated and Added for the Electrification Scenario

Accelerate Adoption	Electrification Measures Added
Agriculture Program	
No existing electrification offerings	High efficiency water heat electrification Process heat electrification
Commercial Programs	
No existing electrification offerings	Space and water heating heat pumps Cooking equipment
Industrial Programs	
No existing electrification offerings	Infrared heaters Electric induction melting Heat pumps for space heating Radio frequency heating Resistance heating
Residential Programs	
Heat pumps for space heating electrification	Clothes dryers High efficiency cooking equipment Heat pump water heaters

Electrification in the Agricultural, Commercial and Residential Sectors

This study collected data on agricultural, commercial, and residential attitudes to electrification projects. While many survey respondents expressed positive attitudes about electrification projects, across the population willingness to install an electrification project is lower compared to a same-fuel alternative, even when the payback period is lowered through incentives. For example, 54% of residential standard income households would consider electrifying space heating if the system paid for itself within a year, while 95% of respondents would consider upgrading the efficiency of their existing system under the same financial circumstances. Commercial customer respondents reflected less enthusiasm about efficiency projects than did residential customers, but generally viewed electrification projects more favorably than residential households (66% said they would install an electrification project if it had a very low payback period).

Another challenge to electrification in the commercial and residential sectors is the relative cost of electric fuel. For example, based on current Wisconsin energy rates, the cost per BBtu for electricity is approximately four times the cost of gas (4.6 times higher in the commercial sector, 5.9 times higher in the industrial sector, and 3.6 times higher in the residential sector)..[18] Current electric and gas fuel costs combined with customer attitudes about electrification requires both relatively high incentives and high-efficiency electrification projects to spur significant market adoption, which would require reallocating budget from other energy efficiency measures. However, relative fuel costs and population attitudes may change in the future.

Electrification in the Industrial Sector

Large industrial facility managers interviewed for this study agreed that the current incentives are very influential in their decisions to pursue energy efficiency projects. Customers agreed that incentives for electrification would increase their likelihood to electrify certain end uses; however, most noted that the incentives would need to offset the higher equipment and energy costs for electrification projects to make them competitive with energy efficient gas-saving projects. Many facility managers interviewed said that the challenges to electrification were greater than only high equipment costs, noting that electrifying energy-intensive systems like process heating or boilers would require additional substation capacity to meet the power demand. Facility managers said they were worried about this additional cost. They also commented that if they needed to replace equipment due to failure and the electric equipment alternative required additional time and an increase in substation capacity, that option would not be feasible due to long downtimes. Based on industrial facility manager feedback about equipment costs, energy costs, and power supply barriers, this study modeled limited adoption of electric equipment in competition with energy efficient natural gas options for the industrial sector. The main opportunities for electrification were for industrial heat pumps in sectors with low heat hot water applications in the food and beverage sector. According to interview respondents, in terms of electrification of process heat, the most likely pathway is resistance heating.

Multiple facility managers mentioned an awareness of and interest in using hydrogen as an alternative fuel to natural gas for some hard-to-electrify processes, though this is not a study measure. However, these managers also acknowledged the challenges of transitioning to hydrogen. One large facility manager mentioned their missed opportunity to reduce peak demand with on-site solar, saying that they have the capital to pursue the project but are limited by Wisconsin's distributed energy interconnection limit of 15 MW.

Scenario Results

Table 40 shows the detailed results from the electrification scenario. The table shows that adding and accelerating electrification measures to the portfolio reduces electric savings by 8%, increases gas savings by 8%, and increases overall energy savings and emissions reductions by 2% relative to the baseline scenario.

In most programs, adding electrification measures causes electric savings to decrease and gas savings to increase. However, in the residential HVAC and Water Heating program, adding electrification measures has the opposite effect: increasing electric savings and decreasing gas savings. In the residential Appliances and Lighting program, both electric and gas savings decrease compared to the baseline scenario. This is because the HVAC and Water Heating program already included electrification measures. Increasing incentives for these measures reduces the budget for other energy-saving measures. The additional savings from accelerated electrification measures do not outpace reduced savings from other, lower-cost measures. In the Appliances and Lighting program, moving incentive budget to electrification measures reduced the number of energy efficiency measures incentivized, reducing the program's overall impact.

---

[18] The Planning Study used the following 2025 Wisconsin energy retail rates from the U.S. Energy Information Administration for this rate comparison:
For gas, the cost per Mcf was $8.86 for the commercial sector, $4.86 for the industrial sector, and $15.99 for the residential sector (seehttps://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PIN_DMcf_m.htm).
For electric, the cost per kWh was $0.13 for the commercial sector, 0.09 for the industrial sector, and $0.16 for the residential sector (see https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a)

In terms of economic performance, cost-effectiveness decreases in the electrification scenario from the mTRC test perspective. Acquisition costs decrease by $0.03 per lifetime MMBtu saved, primarily due to a decrease of $0.44 per MMBtu saved in the Commercial HVAC and Water Heating program.

Table 40. Detailed Quad V Scenario 4 Electrification Program Results

Sector/Program		Lifecycle Energy Savings				Emissions - Million Metric Tons CO2	Peak Demand Reductions				Cost-Effectiveness Ratios			Incentive $/Lifecycle MMBtu
		Electric BBtu	Gas BBtu	GWh	Million Therms		Summer MW	Winter AM MW	Winter PM MW	Winter Therm-Day	MTRC	PAT	SCT	
Agriculture		4,700	4,200	1,377	42	0.5	24	-	-	10	3.1	5.8	3.5	1.2
Commercial	Refrigeration, Cooking, and Appliances	800	2,600	241	26	0.2	4	1	3	7,100	1.0	1.7	6.5	2.3
	HVAC and Water Heat	1,500	23,800	454	238	1.2	7	2	3	77,000	2.6	3.2	2.7	0.8
	Lighting	17,800	-	5,215	-	1.0	47	83	45	-	1.6	3.9	2.0	1.5
	Processes	500	-	151	-	0.0	1	2	1	-	1.0	1.3	1.3	2.5
	Load Shifting	-	-	-	-	-	-	-	-	-				0.0
Industrial		27,800	48,000	8,157	480	4.6	100	97	97	63,800	2.2	6.0	2.5	0.8
Residential	Income Qualified	(100)	2,800	(24)	28	0.1	-	-	-	7,000	0.4	0.7	3.4	3.3
	HVAC and Water Heating	(600)	26,200	(180)	262	0.9	4	(3)	(2)	50,300	0.8	1.0	0.8	1.6
	Appliances and Lighting	2,500	6,800	739	68	0.4	8	11	13	33,200	0.9	1.5	2.4	3.1
	Building Shell	400	4,100	112	41	0.2	-	1	1	8,600	0.4	0.9	0.4	3.1
	Multifamily	200	1,100	54	11	0.1	-	1	1	2,900	0.3	0.4	0.3	4.4
	Residential Load Shifting	-	-	-	-	-	-	-	-	-				0.0
Solar PV		5,800	-	1,698	-	0.2	13	0	13	-	1.1	2.5	1.3	4.2
New Construction		3,200	10,600	944	106	0.7	2	8	7	19,400	1.7	1.3	1.9	2.0
Portfolio		**64,600**	**130,100**	**18,937**	**1,300**	**10.1**	**211**	**203**	**182**	**269,000**	**1.5**	**3.0**	**3.7**	**1.4**

Scenario 5 – Cost-Effectiveness Focused

The Planning Study designed Scenario 5 to maximize cost-effectiveness of the Focus on Energy portfolio from the mTRC test perspective, in which benefits from reduced utility costs and reduced emissions are compared with incremental costs of building upgrades and the costs of running the Focus on Energy program, excluding incentives. Incentives are considered both a cost and a benefit from the mTRC test perspective and thus are treated as transfer payments excluded from both the cost and benefit sides of the equation. This study accelerated adoption of some measures with the highest mTRC ratios and removed those with the lowest mTRC ratios.

Key takeaways from the cost-effectiveness-focused scenario design include the following:

- Prioritizing measures with high mTRC ratios over those with low mTRC ratios has substantial impacts on the cost-effectiveness, emissions reductions, energy savings, and summer peak reduction of the Quad V Focus on Energy program scenario.
- The significant energy and emissions impacts of the cost-effectiveness-focused scenario occur because measures with high mTRC ratios generally have the lowest incremental cost per lifecycle energy unit saved, and measures with low mTRC ratios have high incremental costs per lifecycle energy unit saved. As incentive costs and incremental costs are generally linked, prioritizing low-incremental cost measures also prioritizes measures with lower incentive levels per lifecycle energy unit saved. This increases the number of units that can be incentivized with a fixed budget, and leads to increased savings relative to the baseline scenario.
- The level to which cost-effectiveness and savings increase in the cost-effectiveness-focused scenario depends on the cost-effectiveness of measures in the baseline scenario. If a program such as the Industrial program comprises mostly cost effective measures, this leaves little room to increase performance. On the other hand, if a program, such as the residential appliances and lighting program, includes many measures that are not cost-effective, changing the measure mix can have substantial impacts on cost-effectiveness and savings.

Table 41 shows the measures for which this study accelerated adoption and the measures that it removed for the cost-effectiveness-focused scenario. The primary drivers for deciding whether to accelerate, remove, or minimize a measure were its relative incremental cost to savings and its EUL. In the agricultural sector, cost-effectiveness from the mTRC perspective was highly correlated with incremental cost per BBtu saved. The measures selected for acceleration had the lowest ratio of incremental cost to BBtu saved, while those that were removed had the highest ratio.

In the commercial sector, accelerated measures with the highest mTRC cost-effectiveness ratios were primarily in the HVAC and Water Heating program. While these measures did not necessarily have the lowest incremental cost per BBtu saved, their incremental costs were low. The selected measures had EULs between 15 years (such as pipe insulation) and 25 years (such as high efficiency boilers). The air source heat pumps selected for acceleration had relatively modest incremental costs per BBtu saved and a relatively long EUL of 18 years. These measures also generated benefits from reduced emissions given their savings impacts in winter months. The cost-effectiveness scenario minimized or removed many commercial measures with shorter EULs, such as equipment tune-ups, and with high incremental costs relative to savings, such as advanced rooftop units.

Industrial measures are typically highly cost-effective; thus, the Planning Study did not accelerate any specific measures for the cost-effectiveness-focused scenario. However, the study minimized several measures with the highest incremental cost per BBtu saved, as shown in Table 41.

For the residential sector, the cost-effectiveness-focused scenario accelerated adoption of measures with low incremental costs per BBtu saved and relatively long measure lives, such as small appliances and low-cost water savings measures (pipe insulation and low-flow shower heads and faucet aerators). The cost-effectiveness-focused scenario also accelerated more expensive measures, such as efficient furnaces, pool heaters, and some heat pump water heaters, based on incremental costs and EULs. Importantly, the study did not accelerate all measures within a measure category. For example, cost-effectiveness of heat pump water heaters varies between efficiency tiers, and while the study found advanced tier-heat pump water heaters to be very cost-effective, this was not the case for geothermal heat pump water heaters (which are more efficient).

Table 41. Study Measures Maximized or Removed for Cost-Effectiveness-Focused Scenario

Accelerate Adoption	Remove or Minimize Adoption
Agriculture Program	
Engine block heater timer Greenhouse climate controls Greenhouse unit heater High-volume low speed fan Irrigation improvements LED lighting Low energy livestock waterer Variable frequency drive for processes Variable speed control vacuum pump for dairy fans	Level 1 circulation fan High efficiency gas water heat
Commercial Programs	
Air source heat pumps Boilers: efficient / economizer / reset temperature controls/linklageless controls / variable speed draft fan Efficient evaporator fans Energy management systems IT System efficient rectifier Variable speed cooling tower fan Package terminal heat pumps Premium ductless air conditioner Variable speed control for HVAC heating pump Water pipe insulation	Advanced rooftop units Building automation Heat pump water heaters Chillers Cooking equipment Commissioning DX package Equipment tune-ups and maintenance Ground source heat pumps Package terminal air conditioner Tankless water heaters Variable refrigerant flow systems
Industrial Programs	
No specific measures accelerated due to the high cost-effectiveness of most industrial measures	Air conditioning upgrade Air source heat pump Cooling chiller upgrades Electric induction melting Electric infrared heaters HVAC commissioning Industrial heat pumps Radio frequency heating Resistance heating
Residential Programs	
Efficient small appliances Efficient furnaces Heat pump pool heaters Heat pump water heaters Water flow measures and pipe insulation	Advanced efficiency dishwashers Advanced efficiency heat pumps Advanced tier clothes washers Efficient windows Most efficient bathroom fans Energy recovery ventilators Induction cooking range LED connected lighting Smart WIFI water heater controller Tier 2 electric vehicle chargers Tune-ups Whole home weatherization projects

Table 42 shows the detailed results of the cost-effectiveness-focused scenario. The table shows that by focusing on the most cost-effective measures from the mTRC perspective the portfolio increases emissions reductions by 22%, overall energy savings by 23%, and summer peak reductions by 26%, relative to the baseline scenario. At the same time, the mTRC cost-effectiveness ratio for the Quad V portfolio increases by 47%. This trend occurs because incentive levels are usually highly correlated to incremental cost. Focusing on measures with the lowest incremental costs and removing those with the highest costs maximizes the budget available for measures with high savings, which expands the total savings of the portfolio.

Table 42. Detailed Quad V Scenario 4 Cost-Effectiveness-Focused Program Results

Sector/Program		Lifecycle Energy Savings				Emissions - Million Metric Tons CO2	Peak Demand Reductions				Cost-Effectiveness Ratios			Incentive $/Lifecycle MMBtu
		Electric BBtu	Gas BBtu	GWh	Million Therms		Summer MW	Winter AM MW	Winter PM MW	Winter Therm-Day	MTRC	PAT	SCT	
Agriculture		6,400	3,200	1,180	32	0.5	33	-	-	10	4.7	7.0	5.4	1.1
Commercial	Commercial Refrigeration, Cooking, and Appliances	3,900	1,200	1,132	12	0.3	15	12	12	2,700	1.8	3.7	7.4	1.6
Commercial	Commercial HVAC and Water Heat	2,300	36,800	682	368	1.8	6	10	7	139,300	4.4	4.7	4.6	0.5
Commercial	Commercial Lighting	19,100	-	5,588	-	1.0	51	89	48	-	1.6	4.1	2.1	1.4
Commercial	Commercial Processes	600	-	162	-	0.0	1	2	1	-	1.0	1.4	1.4	2.3
Commercial	Commercial Load Shifting	-	-	-	-	-	-	-	-	-				0.0
Industrial		28,800	47,700	8,438	477	4.7	103	100	100	65,300	2.6	6.2	2.9	0.7
Residential	Income Qualified	100	2,600	28	26	0.1	-	1	1	4,300	1.0	0.6	13.5	3.3
Residential	HVAC and Water Heating	(500)	24,500	(148)	245	0.8	3	(2)	(1)	42,400	1.0	1.2	1.0	1.1
Residential	Appliances and Lighting	12,600	18,700	3,679	187	1.6	63	40	43	66,400	4.4	4.8	12.9	1.4
Residential	Building Shell	400	4,300	108	43	0.2	-	1	1	8,500	0.5	0.9	0.5	3.0
Residential	Multifamily	300	1,900	101	19	0.1	-	5	4	4,800	0.7	0.8	0.8	2.5
Residential	Residential Load Shifting	-	-	-	-	-	-	-	-	-				0.0
Solar PV		5,800	-	1,698	-	0.2	13	0	13	-	1.1	2.5	1.3	4.2
New Construction		3,200	10,600	944	106	0.7	2	8	7	19,400	1.7	1.3	1.9	2.0
Portfolio		**82,900**	**151,500**	**24,293**	**1,515**	**12.21**	**289**	**265**	**234**	**353,000**	**2.2**	**3.7**	**5.2**	**1.2**

Optimized Potential

Optimized potential shows the Planning Study's predictions of measure adoption trends over the twelve-year study horizon, accounting for current market conditions, implementation approaches, and measure offerings. These estimates show the long-term energy impacts from adopted Focus on Energy measures. While assumptions about Focus on Energy incentives and program budgets for optimized potential scenarios align with the assumptions of program scenario potential, the two types of potential differ in a number of ways:

- Optimized potential accounts for interactive effects between measures, while program scenario potential does not.
- Optimized potential adjusts measure savings based on future changes to equipment standards, while program scenario potential does not.
- Program scenario potential calibrates the program and measure mix to 2023 and 2024 program achievements. This requires a view into measure performance using current assumptions that impact measure performance (such as assumptions from a technical reference manual [TRM]). Optimized potential developed historical adoption rates based on program data, but did not calibrate baseline adoption to 2023 and 2024 program achievements.
- Both optimized and program scenario potential use the same measure and adoption assumptions to estimate measure adoption over time.
- Optimized potential includes measures adopted without program incentives, while program scenario potential includes only measures for which Focus on Energy provided an incentive.
- Optimized potential analyzes measure adoption at the sector, segment and utility service area-level, while program scenario potential analyzes program participation for each Focus on Energy program.

Because optimized potential incorporates long-term changes to the built environment and equipment market, optimized potential provides a longer-term outlook for energy savings including from residential electrification measures in the baseline scenario. Optimized potential predicts changes to measure performance based on known factors, such as changes to equipment standards. Similarly, program evaluation and the Wisconsin TRM take these factors into account, but apply these on a yearly basis.

Figure 13 shows the cumulative lifecycle BBtu savings for Focus on Energy measures over each of three Focus on Energy Quad periods in this study's time horizon, using assumptions from the Planning Study baseline scenario. The figure compares these trends to the technical potential energy efficiency and energy efficiency and electrification scenarios. Based on current known factors that impact performance and adoption of the Focus on Energy measures included in this study, the Focus on Energy savings from 2027 through 2038 will account for nearly 50% of technical potential in the energy efficiency scenario and nearly 20% of technical potential in the electrification and energy efficiency scenario.

Figure 13. Optimized Potential Energy Savings Projections

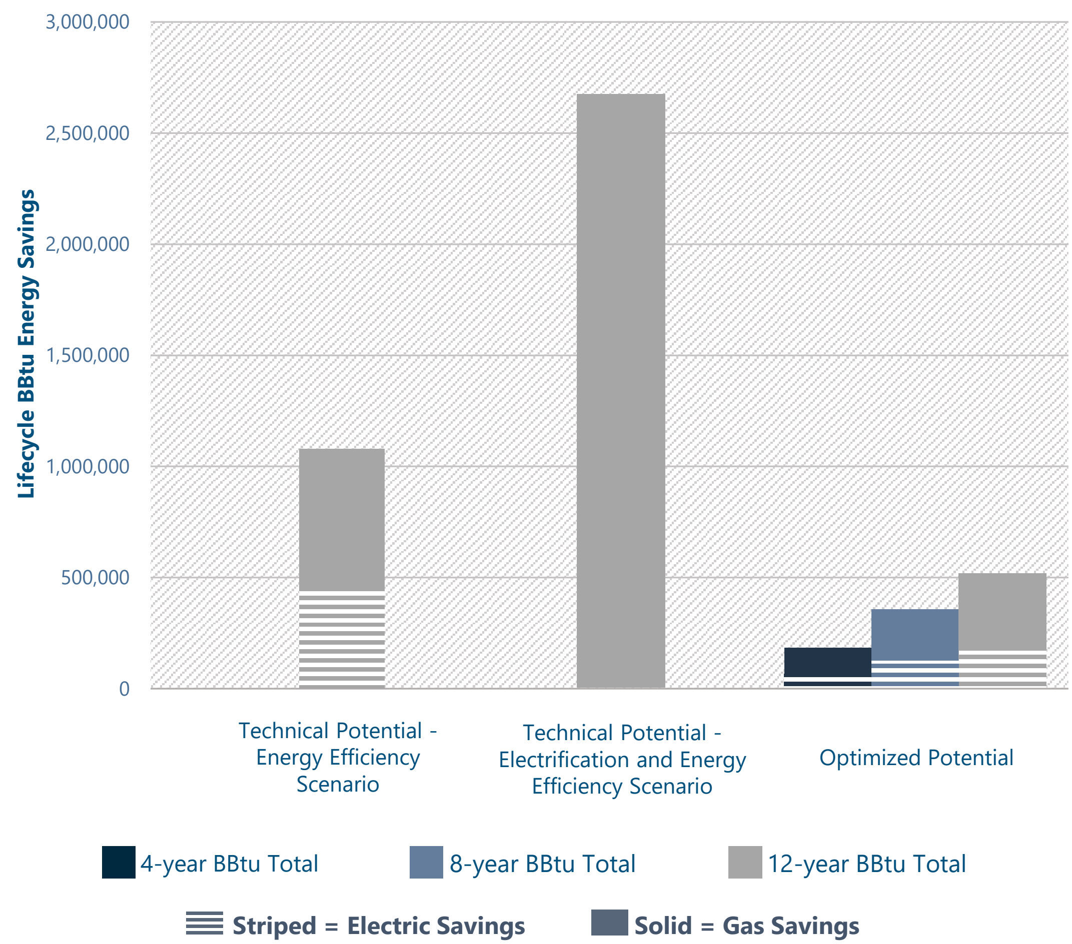


Table 43 shows optimized potential lifecycle BBtu savings by sector and by year. The industrial sector has the highest amount of energy savings, followed by the residential and commercial sectors. The proportion of energy savings in each of the sectors stays roughly equivalent across Quad periods, as the Planning Study assumed that the variables affecting measure adoption would stay consistent over the study horizon.

Table 43. Optimized Potential Energy Savings by Sector

Sector	Lifecycle BBtu Savings		
	4-year	8-year	12-year
Agriculture	1,700	3,200	4,400
Commercial	27,200	57,600	84,400
Industrial	91,300	173,000	246,700
Residential	49,900	94,200	138,200
Solar PV	5,800	10,900	15,700
New Construction	7,500	17,300	28,500

Predicted Focus on Energy savings relative to technical potential are substantial. However, neither technical potential nor optimized potential are static estimates. Predictions for both types of potential change as new technologies are introduced into the market, the composition of the building stock changes, and costs impact adoption. For this reason, Focus on Energy conducts cyclical, four-year planning processes.

Benchmarking

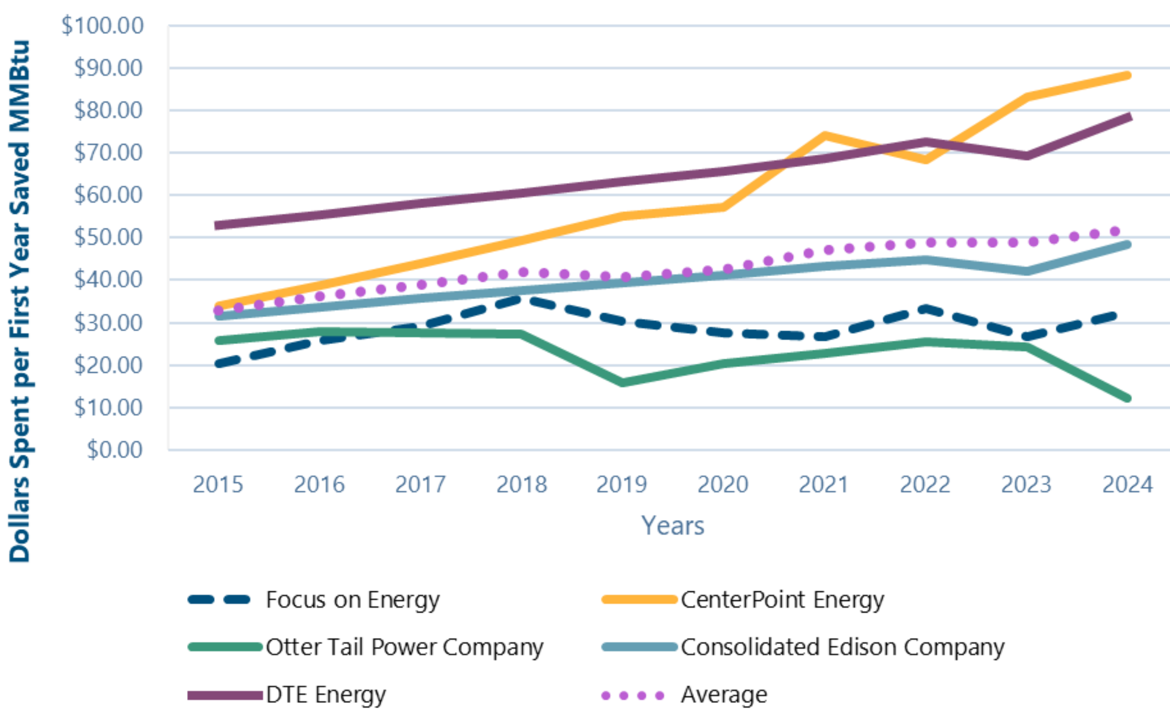
To contextualize acquisition costs (energy saved per incentive dollar spent), the Planning Study compared Focus on Energy's portfolio acquisition costs to those of five utility programs. This analysis measures energy savings generated by the utilities' energy efficiency programs, primarily in the Midwest, relative to their portfolio energy efficiency incentive expenditures.

To collect data for this benchmark analysis, the Planning Study reviewed various publicly available annual energy efficiency reports and documented total portfolio energy efficiency incentive investments to provide a high-level understanding of overall trends. Due to the non-standardized reporting structure of acquisition costs, there were substantial differences among and gaps in the publicly available data from the selected utilities, with both the reporting metrics and the timeline of available data varying across the reports.

To normalize reporting metrics, the Planning Study standardized the data based on dollars per first year saved MMBtu, as not all utilities report lifecycle savings. The study includes all available data from the last ten years and applied trend assumptions to fill data gaps. Additional factors including utilities' diverse climate zones and varying energy efficiency measure compositions and measure lifetimes limit the comparability of benchmark data.

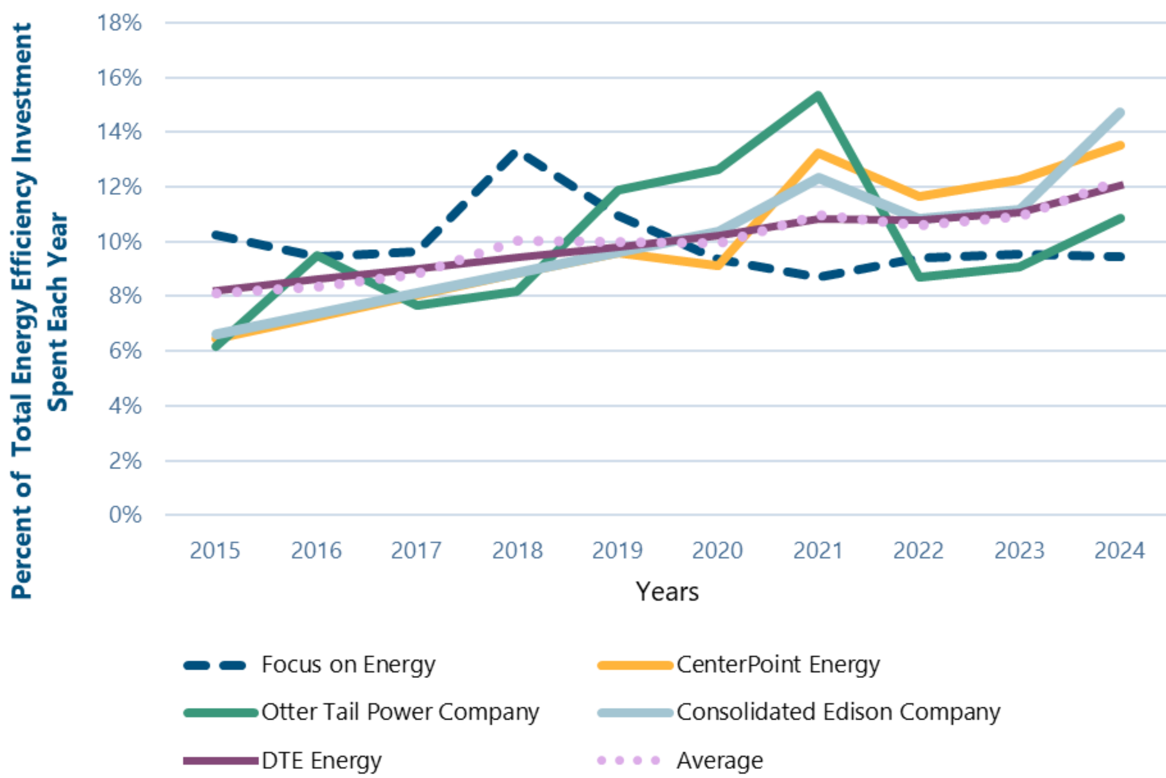
Figure 14 shows the incentive dollar amounts that utilities spent to save one MMBtu each year, for the last ten years. The study shows that, on average, the costs of achieving energy savings are increasing. Notably, Focus on Energy's acquisition costs have been relatively stable and are at the lower end of utility costs in the comparison analysis.

Figure 14. Ten-Year Comparison of Dollar per First Year MMBtu Saved



To address the differences in scale between the five comparison utilities' energy efficiency investments, the Planning Study converted their expenditures into percentages, which allowed the study to compare the utilities' energy efficiency portfolio spending throughout the ten years (Figure 15). That is, for each utility, the study divided first year spending by the total investment over the ten-year period. The figure shows different spending peaks throughout the ten years, such as Focus on Energy spending the most during 2018 and Otter Tail Power sharply increasing spending between 2019 and 2021 before dipping in 2022. On average, the analysis shows that energy efficiency portfolio spending has increased over time. This trend is also echoed in a recent American Council for an Energy-Efficient Economy (ACEEE) report that said in studying state policies and program efforts to advance energy efficiency, one of the most notable trends in the last 30 years across the United States has been an increase in energy efficiency program spending.[19]

Figure 15. Ten-Year Comparison of Energy Efficiency Program Investments



This study did not analyze the specific drivers impacting each utility's cost of acquisition or total spending patterns, but instead looked at common factors across the industry that influence energy efficiency programs' ability to achieve cost-effective energy savings and the investment needed to sustain savings. The increasing spending, shown in Figure 15, correlates with broader economic factors impacting

[19] State Energy Efficiency Scorecard. ACEEE. 2025. https://www.aceee.org/state-policy/scorecard

customers' ability to invest in high-efficiency equipment and the phasing out of many cost-effective lighting programs.

In the past few years, many unforeseen economic challenges have impacted utilities' ability to reliably deliver energy efficiency programs to customers. Influences such as inflation, tariffs, labor shortages, supply chain disruptions (including the lingering effects of COVID-19) have increased the overall cost of goods and services and negatively impacted consumer confidence and willingness to pay for high-efficiency equipment. As a result, energy-efficient technologies and services are becoming less accessible for price-sensitive buyers. Labor shortages and supply chain constraints have led to regular project delays and increased costs, which are often passed on to consumers.

There are also fewer opportunities for lighting initiatives that historically have provided cost-effective energy savings. LED lighting has been widely adopted and the market is approaching LED saturation. Energy efficiency portfolios have needed to adjust to rely less on lighting as a relatively affordable, easy, and effective way to reduce energy usage. Additionally, the quantity of energy-efficient measures available to customers through utilities has declined due to increasing federal standards.

The utilities' costs, consumers' ability to invest in energy efficiency, and market saturation of cost-effective LED programs are all affected by nearer-term economic impacts and a changing regulatory landscape. The potential effect on Focus on Energy's ability to accomplish its goals remains unknown, as the longer-term impacts from these obstacles continue to evolve. These and other exogenous factors will require Focus on Energy to remain adaptable as it establishes priorities during the Quad V Planning Process and beyond. The scenarios examined by this study that focus on reducing emissions and maximizing summer peak demand reductions have acquisition cost benefits. Focus on Energy may wish to consider adopting elements of these scenarios that support managing acquisition costs to help achieve its energy saving goals as cost-effectively as possible.

Appendix A. Research Questions

The Planning Study addresses objectives and research questions developed at the onset of the project.

Objective 1

Estimating avoided emissions potential.

The PSC wishes to better understand the impacts of Focus on Energy's programmatic interventions (such as different technologies and time-of-day usage) on avoided emissions. **The Planning Study should provide insight into how focusing on emissions could impact potential savings.** Avoided emissions analysis will require consideration of forecasted changes in Wisconsin's generation mix.

Research Question	Approach
• What are the 4- and 12-year emissions impacts of Focus on Energy program design scenarios?	• Use measure and utility generation hourly profiles to estimate emissions impacts. • Consult EWG and stakeholders to inform measure selection/configuration and program scenario design. • Use program design scenarios, which can shift incentives between different measures or fuel switching applications, remove or add measures from programs, or fund/defund programs. • Develop program scenarios and estimate 4- and 12-year emissions, energy, and demand impacts for each scenario. • Use program scenario potential for 4-year impacts and optimized potential for 12-year impacts.
• How cost-effective are potential market interventions designed to achieve emissions impacts?	• Estimate 4-year program scenario budgets and cost-effectiveness using the mTRC. • Estimate 12-year economic potential using the mTRC for two scenarios: energy efficiency and fuel switching.
• How do future program designs compare to past program achievements?	• Compare last full quadrennial program accomplishments for savings, demand reduction and emission, and budgets to program scenarios.
• Which measures have the greatest potential for achieving emissions reductions?	• Estimate technical potential and sort measures by emissions, energy, and demand potential to identify measures with highest savings potential. • Estimate economic potential and sort measures by emissions, energy, and demand potential to identify measures with highest savings potential. • Estimate optimized and program potential and sort measures with highest impacts (although potential impacts will also depend on program scenario design).

Objective 2

Incorporating load shapes to improve peak demand impacts (from electrification and energy efficiency).

An increasing interest in capturing demand savings for both summer and winter peak demands warrants an investigation into opportunities for peak demand reduction by applying (and developing as necessary) end-use load shapes to the estimate of potential. **This will allow the Wisconsin PSC to assess the value of and trade-offs between programmatic interventions that emphasize demand reduction versus energy savings.**

Research Question	Approach
1. What are the 4- and 12-year demand reduction impacts of Focus on Energy program design scenarios?	Research Questions 1 through 4 with focus on demand impacts
2. What measures and/or program intervention approaches achieve the highest levels of demand reduction?	
3. Which sectors/segments have the greatest potential for achieving demand reductions?	

Objective 3

Understanding implications by customer segment.

The PSC is interested in **understanding the implications of potential energy, demand, and emissions reduction potential for various customer segments in its territory, particularly income-qualified customers.** This analysis will build on prior customer segmentation research conducted between 2020 and 2021 for the Quad IV Energy Efficiency study.

Research Question	Approach
1. What is the energy, demand, and emissions reduction potential for specific customer segments?	• Provide energy and emissions impacts for the following segments: a. Residential: single family, multifamily, and manufactured homes b. Residential: Income qualified, standard income c. Commercial: office, retail, restaurant, hospitals, lodging, grocery, schools, government, nonprofit organizations, and miscellaneous building d. Agricultural e. Industrial • Show results by utility service territory

Objective 4

Assessing opportunities for expanded program electrification.

As building electrification gains market acceptance, the PSC is interested in **understanding the options for and potential benefits of policy and programmatic changes that promote further fuel switching.**

Research Question	Approach
1. What is the technical, economic, optimized, and program scenario potential for fuel switching measures?	• Estimate technical and economic potential for energy efficiency and fuel-switching scenarios. • Include fuel-switching measures that compete for participation/ installations with energy efficiency measures in optimized and program scenario potential. • Estimate impacts from participation / adoption of electrification measures in optimized and program scenario potential.
2. What are the relative emissions, demand, and energy impacts from measures when used in fuel-switching versus energy efficiency applications.	• Estimate technical and economic potential for energy efficiency and fuel-switching scenarios and compare results for measures with a fuel-switching option (e.g., heat pumps, heat pump water heaters).
3. How does the cost-benefit profile of a program scenario emphasizing fuel switching compare to scenario emphasizing energy efficiency?	• Design electrification and energy efficiency programs. • Compare cost-effectiveness (mTRC) of programs.

Objective 5

Study Note: Cadmus and the PSC developed objective 5 and associated research questions in 2024, when the Inflation Reduction Act (IRA) was in place. Over the course of the study a federal policy changed regarding the IRA, resulting in adjustments to the federal tax credit. Due to these changes and challenges related to the lack of information on federal rebates to inform modeling assumptions, the Planning Study did not address Objective 5.

Understanding how energy efficiency and electrification incentives offered through the Inflation Reduction Act (IRA) could impact the remaining potential in Wisconsin.

The tax credits and rebate programs offered through the IRA are expected be to fully operational in 2024; this could have significant implications for the uptake of efficient technologies, especially electric water and space heating equipment. **The PSC wishes to better understand how the IRA could impact programmatic uptake for Focus on Energy programs and what the best path will be to complement its implementation**.

Research Question	Approach
1. How much of Wisconsin's technical and economic energy efficiency, electrification, and distributed solar potential do federal programs incentivize?	• Identify measures that receive federal tax credits and incentives. • Estimate technical and economic potential from measures with federal incentives (do not apply caps to tax credits).
2. What are the emissions, demand, and energy impact of different program configurations considering allocation of federal and Focus on energy incentives?	• Design program scenarios considering allocation of federal and Focus incentives. • Compare 4- and 12-year emissions, peak demand, and energy program design and optimized potential results.

Objective 6

Contextualizing study findings to inform program goals.

Focus on Energy is subject to budget constraints that have implications for program goals. As efficient equipment saturation and baseline efficiency levels increase, acquisition costs also increase. To help contextualize study findings and consider appropriate and realistic program goals, the PSC is interested in understanding costs and savings metrics from jurisdictions in other states:

- Energy savings acquisition costs ($/kWh and $/Therm saved) and trends
- Demand reduction acquisition costs ($/kW)
- Overall investment in energy and demand savings and related efforts

Research Question	Approach
1) What are trends in energy efficiency program cost of acquisition of savings?	• Select six utilities or state programs (including programs in the Midwest and programs that emphasize electrification) to gather data on. • Gather cost and savings metrics for selected utilities and estimate energy efficiency acquisition costs for the past five years.
2) How does Focus on Energy cost of acquisition trends compare to that of other programs, nationally and in the Midwest?	• Compare Focus on Energy acquisition cost trends to six selected utilities.
3) What are the savings acquisition cost trends by sector?	• Conduct analysis from RQ 14 and 15 by sector.
4) For states that have increased their emphasis on electrification, how has the cost of acquiring savings changed?	• Estimate acquisition cost trends for utilities with electrification focus (identified as part of RQ 14).

Appendix B. September 2024 Gap Analysis Memorandum

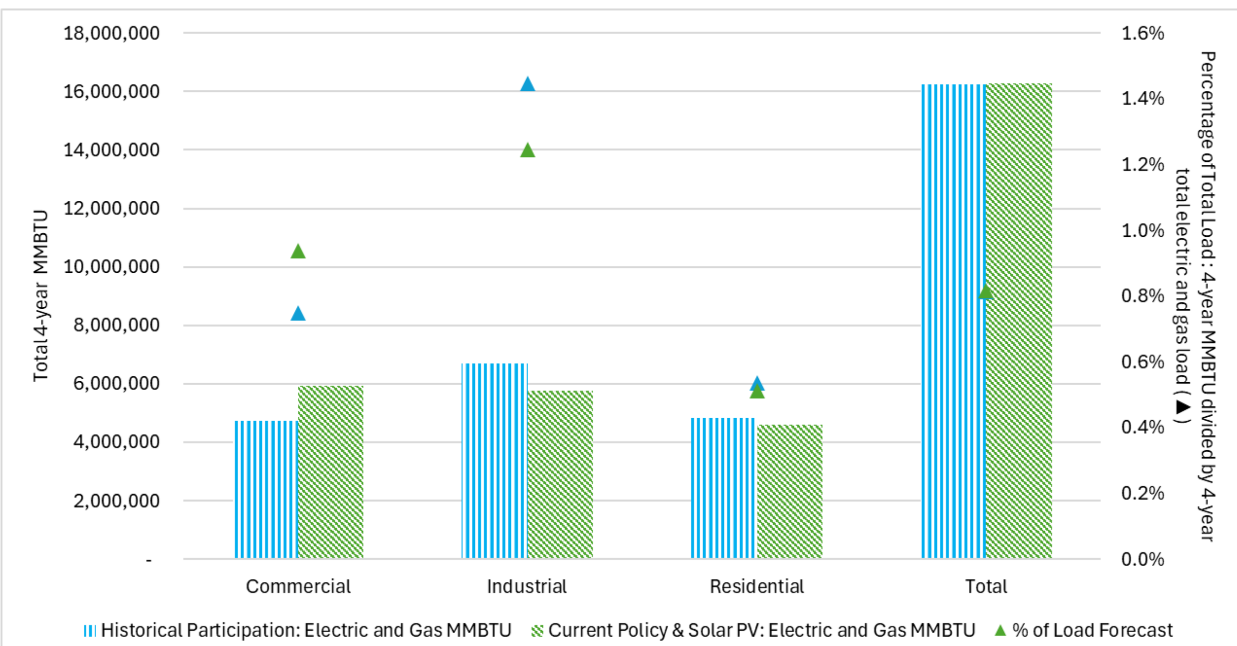
This memo provides a comparison of historical savings from the Wisconsin Focus on Energy program portfolio for 2020 through 2023 with the 2021 potential study's four-year (2023–2026) current policy potential estimates. We conducted this gap analysis to understand how closely the 2021 potential study approximated program behavior. We compare current policy potential to actual adoption because current policy potential was developed to simulate measure uptake with current Focus on Energy budgets. The potential estimates include both energy efficiency and solar PV installations. Due to the timing of the potential projection, only one year of the analysis periods (2023) overlaps.

This memo also includes an appendix with a long-term view of Focus on Energy savings by end use. We included this analysis to provide context for how the program has changed over the years.

The gap analysis covers savings by sector, fuel type, and end-use group. We normalized all energy use and potential estimates to MMBtu to allow for a standard comparison between gas and electric savings.

As illustrated in Figure B-1, overall estimated electric and gas savings closely approximate overall historical savings. For the commercial and industrial sectors, there is approximately a 20% difference between the historical savings and the estimates from the potential study, which overestimates commercial adoption and underestimates industrial adoption. In contrast, the residential sector shows only about a 5% difference. Overall, the total historical and potential study savings estimates align closely, with almost 100% correspondence.

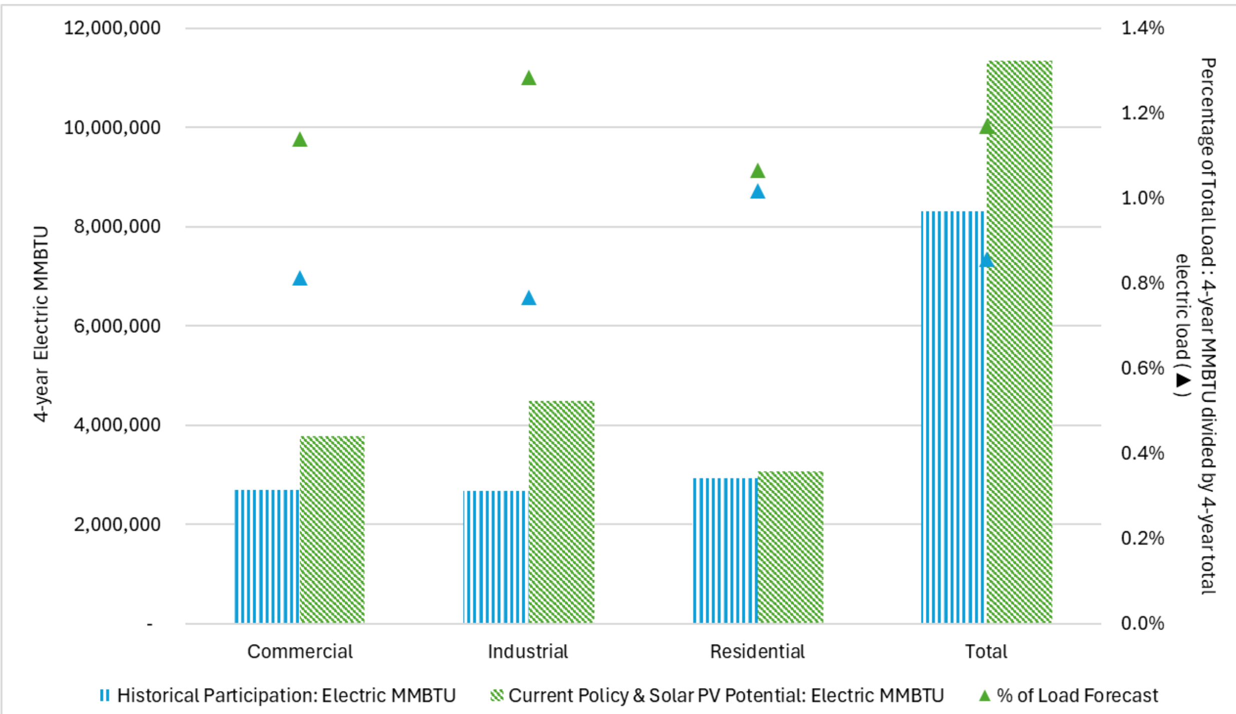
Figure B-1. Total Combined Gas and Electric Actual Savings and Optimized Potential Estimates in MMBtu and Percentage of Load Reduced



We also compared historical adoption and potential estimates by sector and fuel type. In general, the total historical electric adoption is about 30% lower than the potential study estimates, while the total historical natural gas adoption is about 30% higher than the potential estimates (Figure B-2).

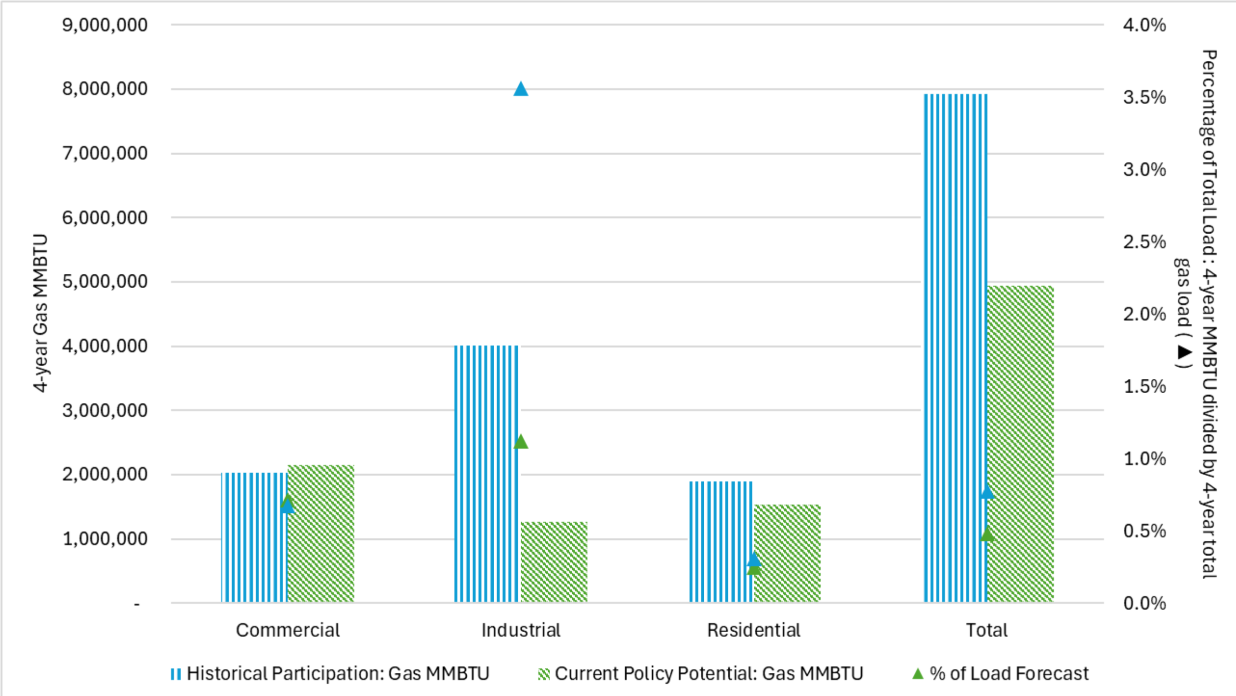
The residential potential study electric savings estimates align almost exactly with historical data, but there is about a 30% difference between commercial electric historical and potential study estimates. The industrial sector shows the largest discrepancy, with historical electric savings that are only 60% of the potential study estimates.

Figure B-2. Electric Actual Savings and Optimized Potential Estimates in MMBtu and Percentage of Load Reduced



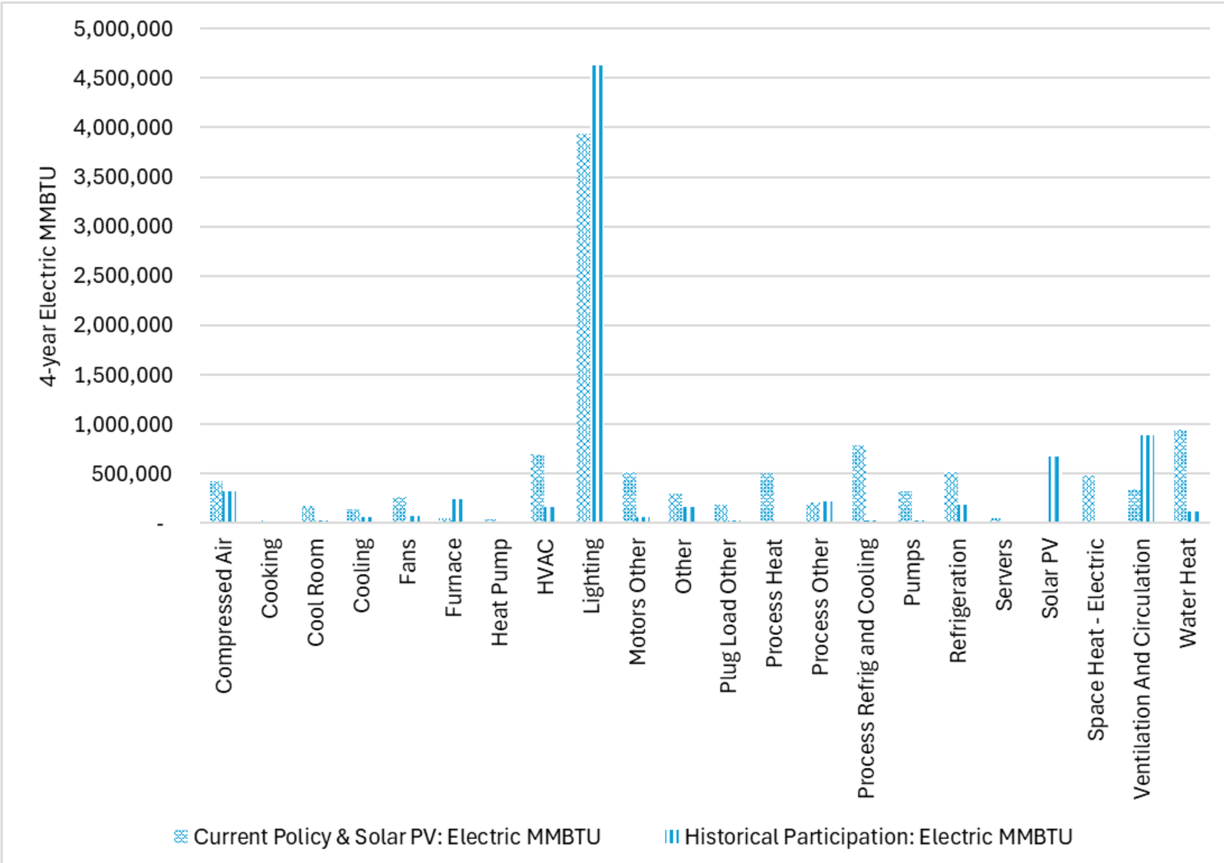
The trend for each sector's natural gas savings is similar to that of electric savings; however, the commercial sector's potential study natural gas adoption estimates align best with historical savings. The residential sector also shows good alignment, but in the industrial sector, the potential study's natural gas savings are only around 30% of the historical savings (Figure B-3).

Figure B-3. Gas Actual Savings and Optimized Potential Estimates in MMBtu and Percentage of Load Reduced



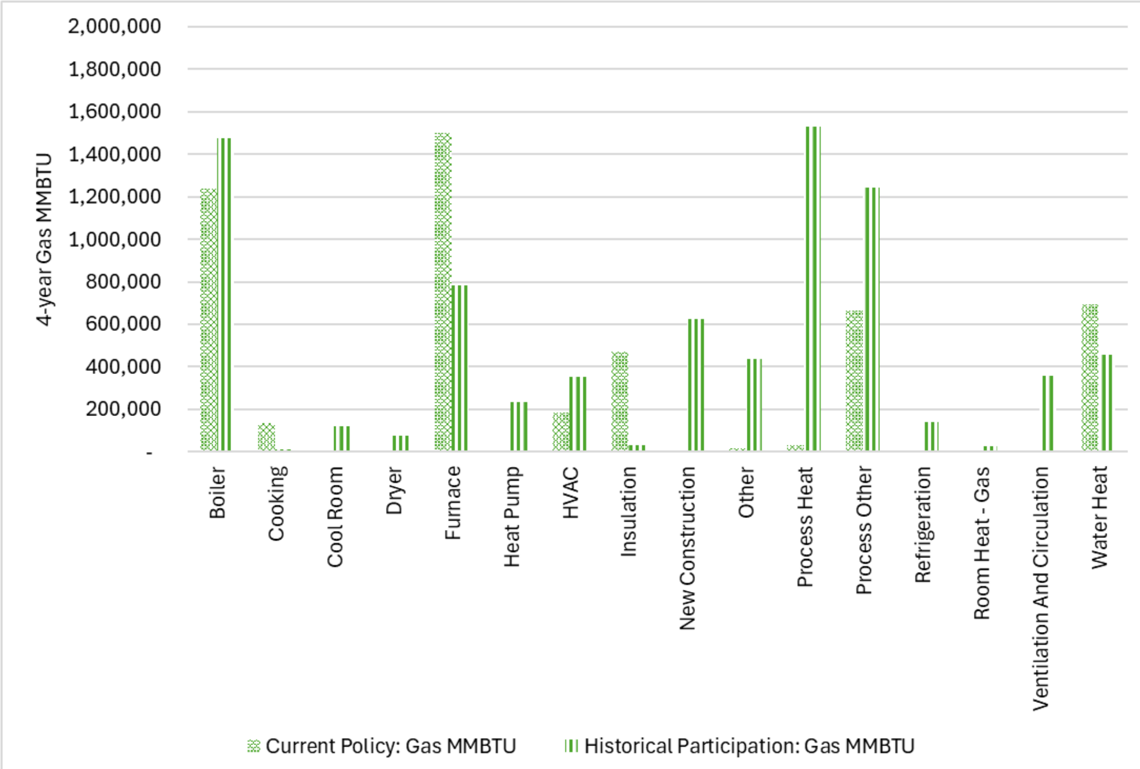
We mapped potential study and program measure categories to end uses and compared current policy potential to historical participation fuel type. For electric fuel, lighting made up the largest current policy potential and actual historical adoption. The biggest gaps between potential and historical adoption are for the following end uses: water heat, process refrigeration and cooling, and lighting. The end use that shows the smallest gap between the potential study estimates and historical savings is the Process Other end use, which is an industrial end use that consists of measures such as efficient agitators, equipment maintenance, equipment scheduling upgrades, process improvements, and strategic energy management in the potential study (Figure B-4).

Figure B-4. Electric Actual Savings and Optimized Potential Estimates by End Use



For natural gas historical savings and current policy potential, there are fewer end uses. The largest gaps between potential estimates and historical savings are for the industrial processes end uses, for which the potential study significantly underestimated potential (Figure B-5).

Figure B-5. Gas Actual Savings and Optimized Potential Estimates by End Use



Key Takeaways

- In general, the potential study savings estimates align well with historical program savings. Specifically, the residential sector's potential study MMBtu savings nearly match the historical program's MMBtu savings.
- Among all sectors, the industrial sector shows the most significant discrepancy between electric or gas potential study savings estimates and historical savings, primarily because most industrial savings are from custom projects. Industrial savings are very difficult to model and forecast, as the Focus on Energy team conducts very targeted outreach to the largest industrial users and includes facility upgrades that cannot be predicted in potential study models.
- The substantial gap between the program and potential study electric water heat end-use savings occur because the potential study's aerator and showerhead electric MMBtu savings are ten times greater than historical program savings. Additionally, the potential study includes clothes washers and heat pump water heaters under water heat end use, whereas these measures are not present in the historical program data as individual measures (the new homes program includes heat pump water heaters in a “whole home” measure.
- There are also considerable discrepancies between potential study and program savings in the new construction end-use group for both electric and gas. This is because Cadmus does not model new construction as a separate end use in the potential study, but rather differentiates new and existing construction vintage across individual measures.

Further Details

This section provides a historical perspective from 2015 through 2023 on the end uses from which Focus on Energy has achieved savings in the residential, commercial, industrial, and agricultural sectors. Program savings for each sector, categorized by measure, are presented through figures, followed by tables detailing the specific savings values.

Figure B-6 illustrates the measure savings trends in the residential sector from 2015 to 2023. On the electric side, the lighting measures (LED and CFL) consistently contributed the highest annual savings, accounting for approximately 80% of annual residential electric MMBtu savings from 2015 to 2022. However, in 2023, lighting savings saw a significant decline due to a change in lighting standards, which established LEDs as the baseline for lighting energy efficiency. Meanwhile, solar PV savings have steadily increased since 2015, with a notable 40% increase from 2022 to 2023. On the gas side, furnace measure savings have been on the rise, while electric furnace savings have declined. Insulation gas measure savings increased from 2016 to 2022 but experienced a sharp drop in 2023.

Figure B-6 Residential Electric and Gas Annual Program Savings by Measure Category

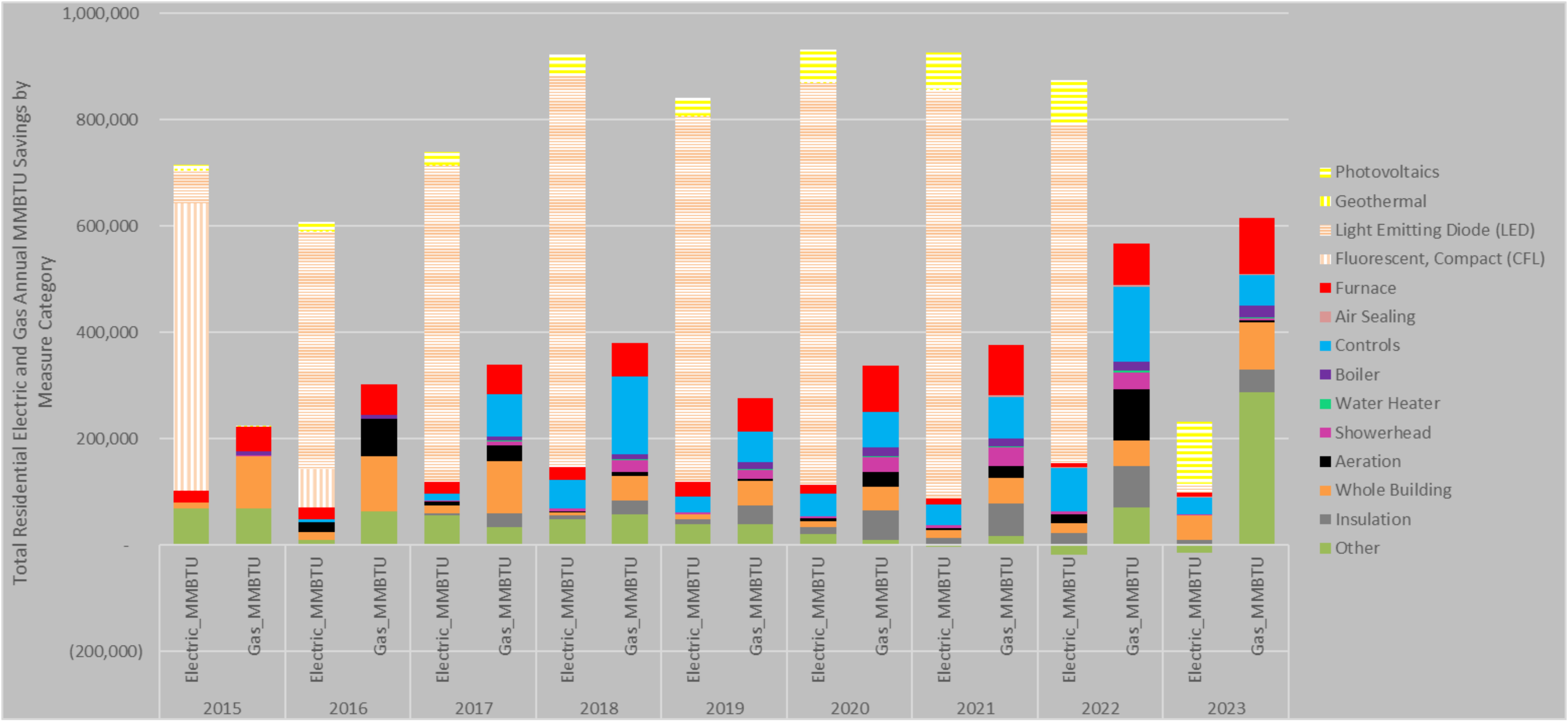


Table B-1. Residential Electric and Gas Annual MMBtu Program Savings by Measure Category

	2015		2016		2017		2018		2019		2020		2021		2022		2023	
Measure Category	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas
Aeration	102	311	19,551	68,895	7,053	29,967	1,790	8,012	862	3,687	4,745	27,347	3,689	21,297	16,666	96,168	911	4,100
Air Sealing	-	-	-	-	-	-	-	-	-	-	337	698	500	2,773	772	3,799	470	1,757
Boiler	-	6,175	-	6,230	-	7,418	-	10,235	-	13,573	-	15,884	-	15,763	-	16,550	-	21,728
CFL	540,042	-	73,507	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Controls	18	148	4,943	1,058	13,210	79,126	53,882	145,423	30,834	57,088	41,799	66,317	38,737	77,469	81,612	140,167	32,801	57,321
Furnace	22,686	47,369	21,730	56,630	22,282	56,559	24,467	62,226	26,171	61,824	17,374	86,446	10,065	95,112	8,173	77,315	7,778	104,549
Geothermal	2,475	19	2,505	-	505	-	1,184	-	1,159	-	1,758	-	1,202	-	-	-	-	-
Insulation	51	735	5	101	3,728	26,162	7,445	25,043	7,760	34,513	13,200	56,772	12,744	60,796	22,185	77,470	9,147	43,641
LED	61,082	-	445,524	-	595,104	-	736,112	-	688,011	-	755,203	-	769,579	-	633,917	-	16,480	-
Other	68,583	68,033	8,881	63,062	55,803	33,006	48,019	58,421	39,924	39,510	21,028	9,217	(2,624)	16,915	(17,407)	71,380	(14,372)	286,968
Photovoltaics	8,974	-	16,440	-	25,276	-	38,251	-	33,575	-	60,550	-	68,620	-	85,622	-	116,188	-
Showerhead	232	585	31	88	1,698	7,521	4,722	22,388	2,922	17,097	4,833	28,328	6,168	35,751	5,491	31,415	701	3,297
Water Heater	(2)	1,045	(3)	1,391	165	975	68	1,510	16	1,520	-	1,776	-	1,990	-	3,608	-	2,266
Whole Building	11,448	98,723	14,958	104,544	14,808	98,583	6,132	45,924	9,757	46,658	10,629	44,453	14,674	48,621	19,609	48,482	46,568	88,599

Figure B-7 shows the heat pump measure savings trends in the residential sector from 2015 through 2023. Overall, the boiler, furnace, and heat pump measures have shown an increasing trend in total MMBtu savings. Both the furnace and heat pump experienced a significant jump in savings from 2022 to 2023. Notably, since the introduction of fuel-switching heat pump savings in 2021, the 2022 savings were approximately five times higher than in 2021, and the 2023 savings tripled compared to 2022—an exceptionally rapid growth rate.

Figure B-7. Residential Heat Pumps Annual Savings

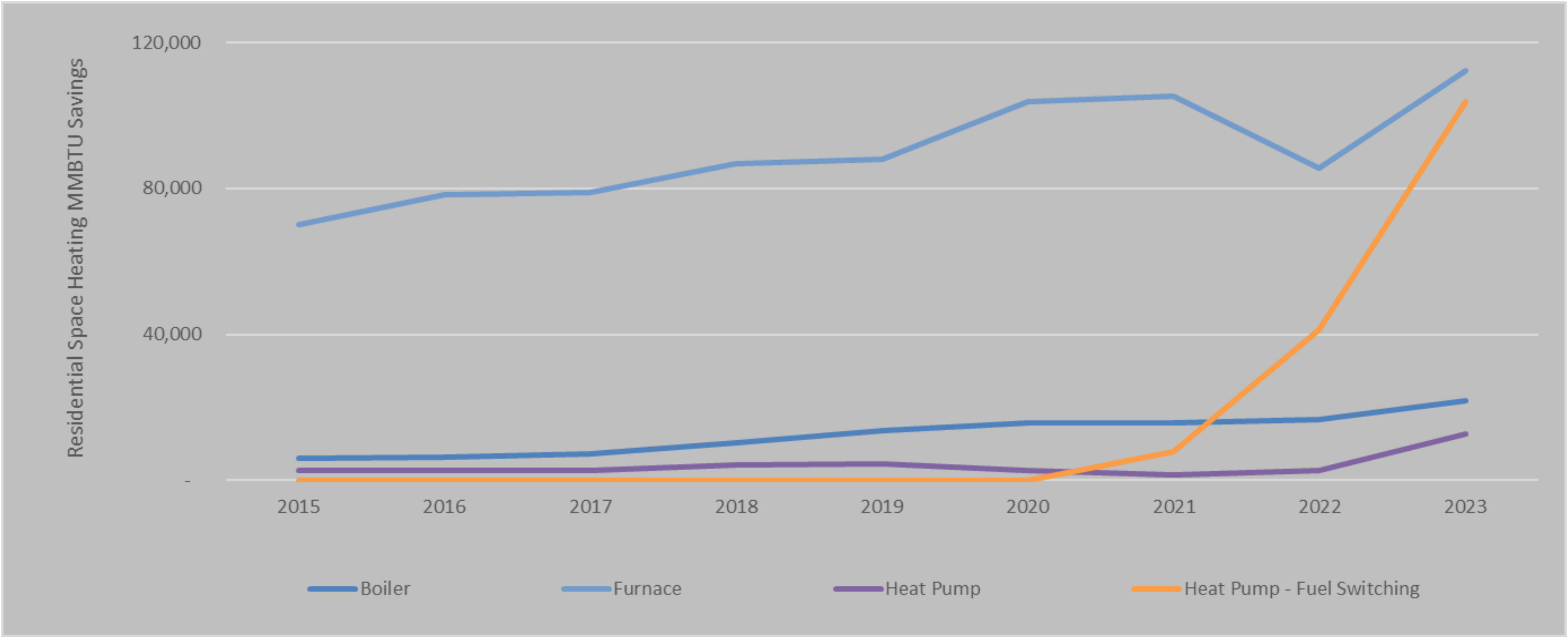


Table B-2. Residential Heat Pumps Annual Savings

Measure Category	2015	2016	2017	2018	2019	2020	2021	2022	2023
Boiler	6,175	6,230	7,418	10,235	13,573	15,884	15,763	16,550	21,728
Furnace	70,054	78,360	78,841	86,692	87,995	103,821	105,177	85,487	112,327
Heat Pump	2,675	2,735	2,632	4,225	4,420	2,638	1,616	2,738	12,603
Heat Pump - Fuel Switching	-	-	-	-	-	-	8,015	41,306	103,696

Figure B-8 shows measure savings trends in the commercial sector from 2015 through 2023. On the electric side, LED savings grew steadily from 2015, peaking in 2019 before beginning to decline due to changes in lighting standards. Solar PV savings have increased consistently since 2015, with the most significant leap occurring between 2022 and 2023, where 2023 savings were approximately 3.5 times those of 2022. On the gas side, boiler measure savings have been more volatile, with a major drop in 2017 followed by a rebound in 2018, though savings have steadily declined since then. The commercial new construction design measure accounted for 10% of electric and gas MMBtu savings, but has been on a downward trend since 2020. In contrast, commercial new construction whole building measure savings have continued to grow since 2020.

Figure B-8. Commercial Electric and Gas Annual Program Savings by Measure Category

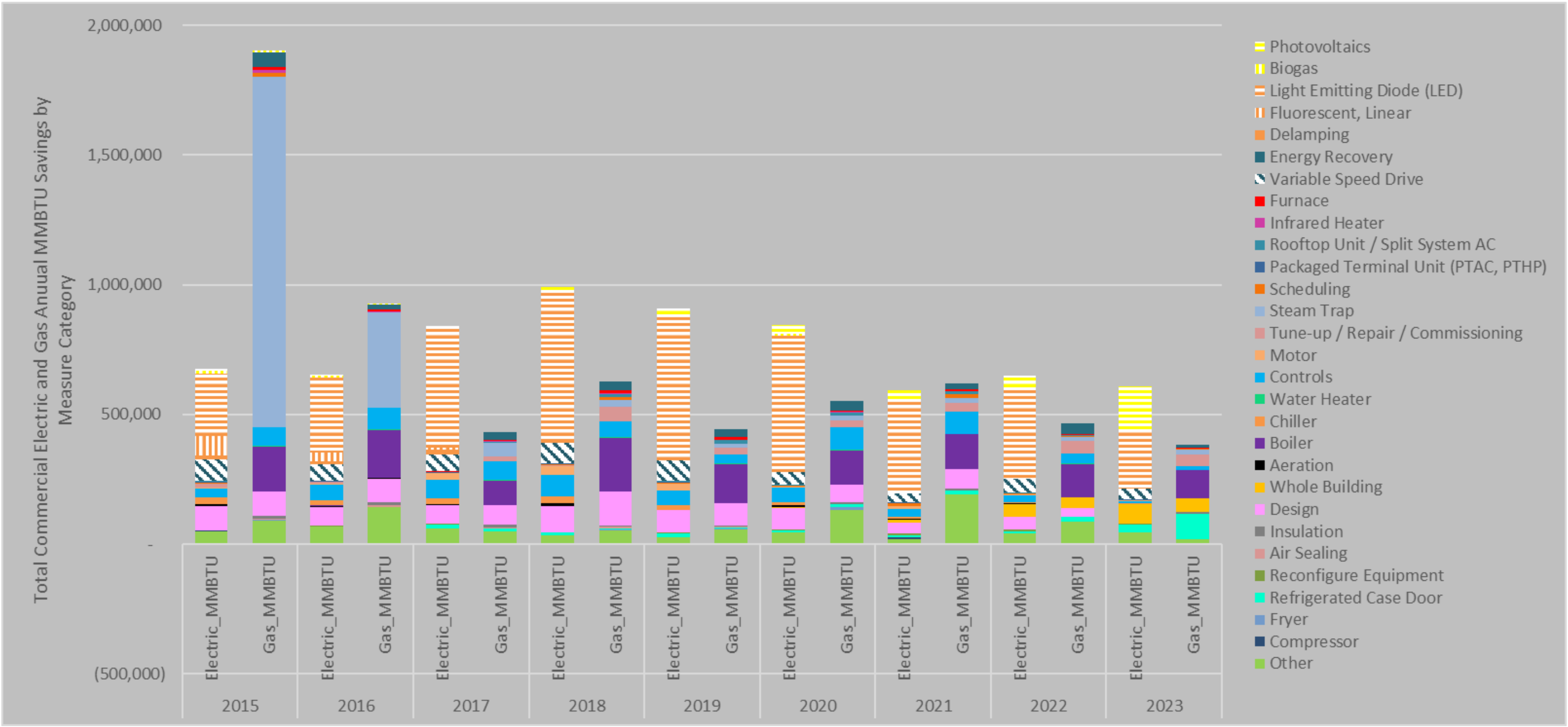


Table B-3. Commercial Electric and Gas Annual MMBtu Savings by Measure Category

Measure Category	2015		2016		2017		2018		2019		2020		2021		2022		2023	
	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas
Aeration	7,793	1,434	5,460	1,758	1,832	-	9,156	962	2,248	227	10,644	-	4,688	-	658	-	925	-
Air Sealing	17	6,382	104	7,023	36	5,533	13	7,837	110	3,652	-	1,258	-	176	-	95	30	2,112
Biogas	10,874	10,614	6,824	918	-	-	-	-	-	-	6,677	-	-	-	-	-	-	-
Boiler	432	170,605	765	185,146	-	91,124	245	206,814	-	152,706	-	131,024	-	132,277	-	127,645	-	107,070
Chiller	27,735	-	20,729	-	22,299	-	28,030	-	17,854	-	8,509	-	6,639	-	4,657	-	3,632	-
Compressor	3,684	-	1,217	-	250	-	1,053	-	52	-	310	-	8,132	-	891	-	836	-
Controls	31,921	74,090	61,227	81,126	71,064	74,631	80,865	62,659	57,205	34,941	56,321	86,394	29,063	84,119	27,733	40,984	8,963	14,482
Delamping	15,391	-	11,285	-	18,409	-	8,720	-	5,465	-	3,698	-	-	-	605	-	-	-
Design	90,879	93,928	71,474	92,237	70,966	75,927	101,473	130,030	85,465	84,469	85,171	66,772	42,454	74,846	48,707	31,749	-	-
Energy Recovery	1,030	55,864	1,152	20,058	6	26,755	729	35,208	(6)	27,730	49	35,650	528	22,928	596	41,138	324	11,975
Fluorescent, Linear	73,227	-	32,291	-	7,722	-	986	-	-	-	-	-	-	-	-	-	-	-
Fryer	-	1,345	-	542	60	309	265	3,160	21	4,584	97	12,381	-	-	-	-	-	-
Furnace	786	9,748	588	7,180	596	6,166	813	10,473	686	10,808	182	6,883	43	5,279	37	4,264	28	3,515
Infrared Heater	-	10,798	-	1,837	-	2,966	-	4,267	-	2,118	-	1,076	-	620	-	49	-	-
Insulation	1,084	9,033	520	10,467	24	11,358	57	2,300	15	2,455	4	8,661	2	5,475	-	552	-	7,372
LED	240,893	-	290,839	-	460,133	-	571,648	-	551,800	-	520,537	-	360,577	-	347,192	-	219,971	-
Motor	5,549	-	3,480	-	26,201	-	32,677	-	26,633	-	3,901	-	12,251	-	2,559	-	950	-
Other	49,353	91,269	67,437	141,784	59,568	49,094	34,945	54,088	28,042	56,606	45,140	130,603	19,101	192,883	40,452	87,198	44,403	18,775
Packaged Terminal Unit (PTAC, PTHP)	4,158	-	3,516	-	2,051	-	2,752	-	3,795	-	2,841	-	2,823	-	2,151	-	1,519	-
Photovoltaics	5,328	-	1,549	-	9,219	-	17,200	-	28,630	-	33,105	-	36,662	-	49,479	-	171,605	-
Reconfigure Equipment	-	-	1,126	-	5,908	-	2,708	-	2,203	-	2,980	-	7,437	-	7,340	-	4,900	-
Refrigerated Case Door	482	811	926	1,264	14,735	10,139	7,866	4,348	14,432	4,611	7,472	10,755	6,533	14,884	8,196	19,366	31,148	97,280
Rooftop Unit/ Split System AC	871	2,342	1,310	2,294	1,561	4,957	2,589	10,180	3,650	12,965	3,711	12,283	2,061	12,296	2,737	5,187	1,092	1,589
Scheduling	6,204	12,441	260	211	26	56	4,510	10,392	1,063	130	1,386	1,430	10,600	14,821	3,467	3,921	2,886	1,750
Steam Trap	-	1,350,269	-	365,867	-	52,066	-	27,080	-	15,061	-	19,204	-	20,703	-	13,600	-	20,400
Tune-up /Repair/ Commissioning	12,839	-	5,738	-	3,235	16,609	3,449	55,471	871	27,549	1,846	23,696	-	32,783	-	47,613	-	44,890
Variable Speed Drive	83,641	-	62,628	357	66,741	-	77,346	-	79,671	-	48,071	-	34,326	-	51,922	-	41,470	-
Water Heater	87	3,470	51	4,682	152	2,962	330	2,912	(1)	1,890	18	3,209	-	3,288	45	1,556	-	775
Whole Building	-	-	-	-	-	-	-	-	-	-	703	617	10,737	2,244	50,548	42,230	72,679	52,873

Figure B-9 shows measure savings trends in the industrial sector from 2015 through 2023. On the electric side, lighting savings follow the same trend as in the residential and commercial sectors, with savings declining due to changes in lighting standards. On the gas side, energy recovery savings peaked in 2019 and have been declining since. The Other measure category, which is 80% comprised of Process Other measure savings, has remained robust from 2015 to 2023, with gas savings typically 2 to 10 times greater than electric savings.

Figure B-9. Industrial Electric and Gas Annual Program Savings by Measure Category

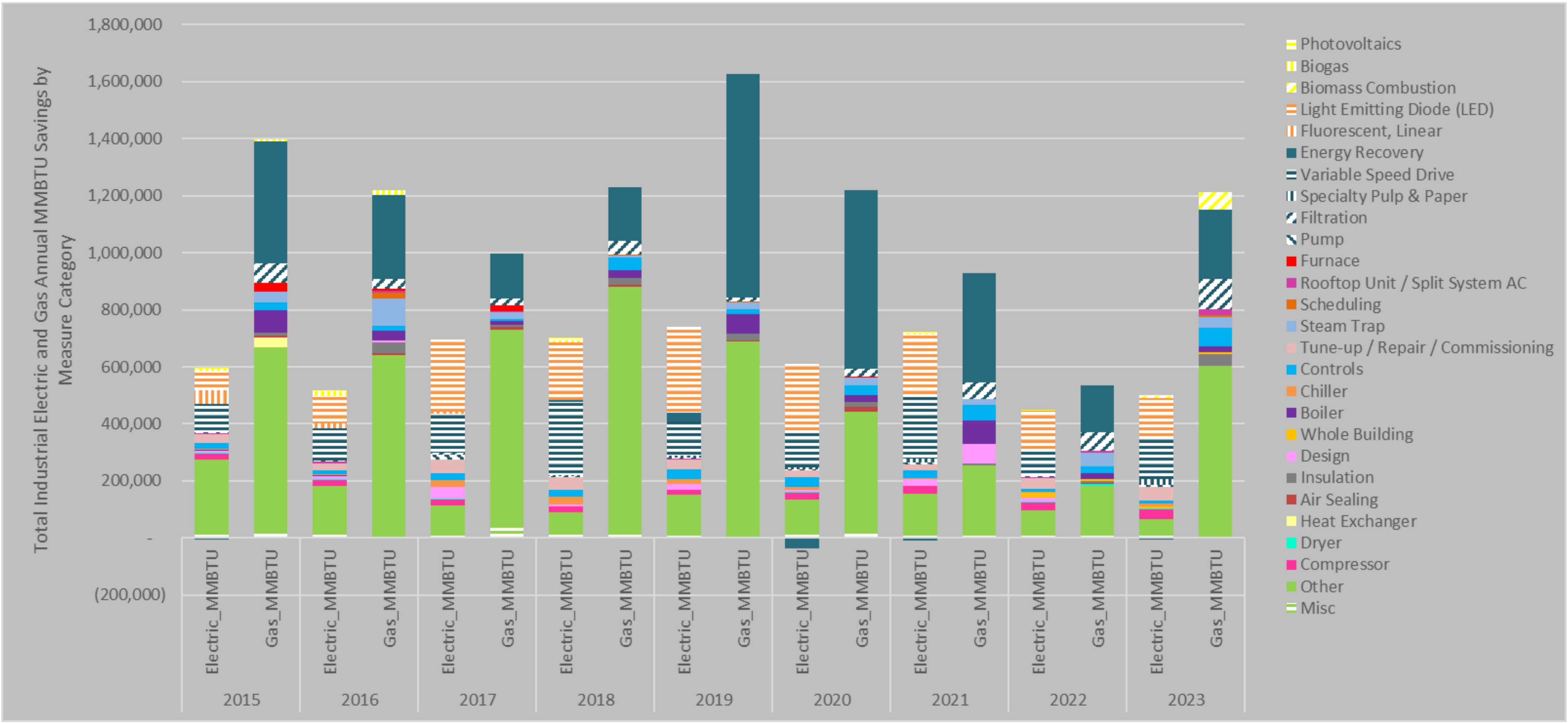


Table B-4. Industrial Electric and Gas Annual MMBtu Program Savings by Measure Category

Measure Category	2015		2016		2017		2018		2019		2020		2021		2022		2023	
	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas
Air Sealing	(0)	8,873	118	5,692	-	9,920	(9)	6,991	-	5,977	-	14,927	-	723	-	1,187	-	426
Biogas	6,847	7,573	15,318	19,267	-	-	8,674	-	-	-	-	-	2,142	-	-	-	-	-
Biomass Combustion	-	1,178	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,631	63,104
Boiler	3,711	77,193	1,204	35,249	93	15,678	1	26,807	318	69,260	(73)	23,493	(836)	82,655	-	21,287	-	19,609
Chiller	6,188	-	5,897	-	23,671	-	29,411	-	16,465	-	10,179	-	3,604	-	1,395	-	10,323	-
Compressor	21,641	-	21,330	-	20,268	-	18,596	-	16,875	-	23,793	-	26,255	-	27,507	-	34,959	-
Controls	18,773	28,625	11,045	17,580	26,398	5,858	24,248	45,465	36,723	18,723	34,176	35,691	26,373	53,864	11,104	25,456	11,704	64,257
Design	4,475	335	12,178	4,989	41,834	(1,219)	5,139	1,220	18,044	(2,920)	9,476	(777)	22,786	69,041	12,084	(611)	-	-
Dryer	2,346	-	3,195	-	1,882	-	1,653	-	1,901	-	1,575	-	1,115	-	4,601	9,791	3,687	-
Energy Recovery	(5,973)	425,364	(3,905)	292,746	(2,375)	157,512	5,916	187,813	32,221	784,709	(37,054)	626,302	(7,108)	382,118	(394)	165,112	(1,686)	242,949
Filtration	2,430	68,351	1,992	34,484	4,055	26,595	(681)	48,978	1,286	13,592	1,076	27,990	(659)	58,079	852	62,583	(2,523)	104,404
Fluorescent, Linear	50,010	-	19,450	-	6,531	-	716	-	-	-	-	-	-	-	-	-	-	-
Furnace	(121)	31,982	39	8,150	(162)	20,358	59	776	29	421	10	316	1	181	2	198	1	176
Heat Exchanger	10	32,531	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Insulation	1,051	9,005	100	37,817	-	6,199	352	22,668	2	21,523	-	17,636	-	6,587	-	8,310	-	42,998
LED	66,956	-	95,143	-	246,961	-	202,566	-	292,852	-	232,596	-	217,831	-	144,499	-	136,657	-
Miscellaneous	10,604	19,829	12,490	5,261	8,308	37,585	10,157	12,714	6,958	1,346	12,986	18,304	8,091	7,237	7,641	7,678	6,233	4,724
Other	263,930	649,921	168,572	637,260	105,846	692,122	80,388	867,777	144,577	686,514	122,185	425,240	147,336	246,017	88,137	173,242	60,161	597,275
Photovoltaics	5,051	-	5,539	-	7,104	-	9,307	-	7,967	-	8,864	-	7,625	-	857	-	3,034	-
Pump	1,070	-	2,033	-	19,578	-	1,510	-	4,560	-	2,757	-	6,119	-	1,891	-	4,983	-
Rooftop Unit/ Split System AC	2,270	35	3,718	6,504	356	724	935	(374)	695	642	579	78	241	26	3,494	7,912	256	22,138
Scheduling	290	121	1,139	18,386	178	387	1,186	1,568	-	3,306	-	-	-	-	-	1,080	109	6,713
Specialty Pulp & Paper	1,317	-	1,213	-	-	-	4,986	-	4,687	-	7,639	-	13,903	-	2,568	-	21,794	-
Steam Trap	-	36,900	-	97,451	-	25,398	-	6,899	-	22,613	-	28,619	-	21,116	-	46,054	-	37,425
Tune-up/ Repair/ Commissioning	30,324	-	25,406	-	45,020	-	42,508	-	34,453	-	22,468	-	22,037	-	37,166	-	47,182	-
Variable Speed Drive	98,322	740	112,106	-	137,315	-	254,952	-	119,157	-	120,970	-	217,084	-	84,659	-	148,624	-
Whole Building	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19,299	4,829	5,557	7,291

Appendix C. Measure Lists

Residential Measures

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	IRA Impacted Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing and New Construction	HVAC	Heat Pump - Air Source	Program Measure	Yes	Yes	Yes
Electric Only	Existing and New Construction	HVAC	Heat Pump - Cold Climate	2021 Focus Study	Yes	Yes	Yes
Electric Only	Existing and New Construction	HVAC	Heat Pump - Ground Source	Program Measure	Yes	Yes	Yes
Electric Only	Existing and New Construction	HVAC	Air Conditioner - Central	Program Measure		Yes	Yes
Electric and Natural Gas	Existing and New Construction	Cooking	Cooking Oven	2021 Focus Study	Yes	Yes - Electric Only	
Electric and Natural Gas	Existing and New Construction	Cooking	Cooking Range	2021 Focus Study	Yes	Yes - Electric Only	
Electric Only	Existing and New Construction	Appliance	Dehumidifier	Program Measure			Yes
Electric and Natural Gas	Existing and New Construction	Appliance	Clothes Dryer	Program Measure	Yes		
Electric Only	Existing and New Construction	Appliance	Heat Pump - Clothes Dryer	2021 Focus Study	Yes	Yes	Yes
Electric Only	Existing and New Construction	Appliance	Refrigerator	Focus Homes Offerings		Yes	
Electric and Natural Gas	Existing and New Construction	Appliance	Dishwasher	Focus Homes Offerings		Yes	
Electric Only	Existing and New Construction	Appliance	Freezer	2021 Focus Study		Yes	
Electric and Natural Gas	Existing and New Construction	Appliance	Clothes Washer	Focus Homes Offerings		Yes	
Electric Only	Existing and New Construction	HVAC	Air Conditioner - Ductless Mini-Split	2021 Focus Study			Yes

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	IRA Impacted Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing and New Construction	Water Heat	Heat Pump Water Heater	2021 Focus Study	Yes	Yes	Yes
Electric and Natural Gas	Existing and New Construction	Water Heat	Storage Water Heater	Program Measure	Yes	Yes - Gas Only	
Electric Only	Existing and New Construction	Appliance	Air Purifier	2021 Focus Study			
Electric Only	Existing and New Construction	HVAC	Heat Pump - Ductless Mini-Split	Program Measure		Yes	Yes
Electric Only	Existing and New Construction	Plug Load	Soundbar	2021 Focus Study			
Electric Only	Existing and New Construction	Lighting	Lighting Interior Linear LED	2021 Focus Study			
Electric Only	Existing and New Construction	Other	Electric Vehicle Charger	2021 Focus Study			Yes
Natural Gas Only	Existing and New Construction	HVAC	Boiler - Efficient	Program Measure		Yes	
Electric Only	Existing and New Construction	HVAC	Ventilation Fans	Focus Homes Offerings		Yes	
Natural Gas Only	Existing and New Construction	HVAC	Furnace - Efficient	Program Measure		Yes	
Natural Gas Only	Existing and New Construction	Other	Pool Heater	2021 Focus Study	Yes		
Electric Only	Existing and New Construction	Other	Pool Pumps	Focus Homes Offerings		Yes	
Natural Gas Only	Existing and New Construction	Water Heat	Tankless Water Heater	Program Measure		Yes	
Electric and Natural Gas	Existing and New Construction	HVAC	Efficient Door	2021 Focus Study		Yes	Yes
Electric and Natural Gas	Existing Construction Only	HVAC	Insulation - Sill Box	2021 Focus Study		Yes	Yes
Electric and Natural Gas	Existing and New Construction	HVAC	Window - Efficient	2021 Focus Study		Yes	Yes
Electric and Natural Gas	Existing and New Construction	HVAC	Smart Thermostat	Program Measure			

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	IRA Impacted Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing Construction Only	HVAC	Air Conditioner Tune-up	2021 Focus Study			Yes
Electric Only	Existing Construction Only	HVAC	Heat Pump Tune-up	2021 Focus Study			Yes
Electric and Natural Gas	Existing and New Construction	Other	Water Heat Temperature Setback	2021 Focus Study			
Electric Only	Existing and New Construction	Plug Load	Advanced Power Strip	2021 Focus Study			
Electric and Natural Gas	Existing and New Construction	Water Heat	Faucet Aerator	Program Measure			
Electric and Natural Gas	Existing and New Construction	Water Heat	Showerhead	Program Measure			
Electric and Natural Gas	Existing and New Construction	Water Heat	Insulation - DWH Pipe	Program Measure			
Electric and Natural Gas	Existing and New Construction	Water Heat	Smart Water Heater Controller	Program Measure			Yes
Natural Gas Only	Existing Construction Only	HVAC	Boiler Controls - Reset Temperature Control	2021 Focus Study			
Natural Gas Only	Existing and New Construction	HVAC	Boiler - Pipe Insulation	2021 Focus Study			
Natural Gas Only	Existing Construction Only	HVAC	Boiler Tune-up	Program Measure			
Natural Gas Only	Existing Construction Only	HVAC	Furnace Tune-up	Program Measure			
Natural Gas Only	Existing and New Construction	Water Heat	Indirect Water Heater	Program Measure			
Electric and Natural Gas	New Construction Only	HVAC	New Construction Home - Advanced	Program Measure			Yes
Electric and Natural Gas	Existing and New Construction	HVAC	Thermostat Load Shift	Cadmus Suggestion			Yes
Electric Only	Existing and New Construction	Other	Electric Vehicle Charging Load Shift	Cadmus Suggestion			Yes
Electric and Natural Gas	Existing and New Construction	Other	Energy / Demand Feedback - Installed Device	Cadmus Suggestion			Yes

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	IRA Impacted Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing and New Construction	Other	Solar PV	2021 Focus Study			
Electric Only	Existing and New Construction	HVAC	Smart Thermostat, Line Voltage	Program Measure			
Electric and Natural Gas	Existing Construction Only	HVAC	Weatherization Project Completion - Tier 1	Program Measure		Yes	Yes
Electric and Natural Gas	Existing Construction Only	HVAC	Weatherization Project Completion - Tier 2	Program Measure		Yes	Yes
Electric Only	Existing and New Construction	HVAC	Air Conditioner Cover	Proposed Future WI TRM			
Electric Only	Existing and New Construction	HVAC	Window Heat Pump	Proposed Future WI TRM	Yes		
Electric Only	Existing and New Construction	Cooking	Induction Cooktop	Proposed Future WI TRM	Yes	Yes	
Electric and Natural Gas	Existing and New Construction	HVAC	Energy Recovery Ventilator	Proposed Future WI TRM			
Electric and Natural Gas	Existing and New Construction	Water Heat	Showerhead Thermostatic Shut-off Valves	2024 WI TRM			
Electric and Natural Gas	Existing and New Construction	Water Heat	Tub Spout Thermostatic Shut-off Valves	2024 WI TRM			
Electric and Natural Gas	Existing and New Construction	Water Heat	DHW Temperature Turndown	2024 WI TRM			
Natural Gas Only	Existing and New Construction	HVAC	Thermostatic Radiator Valve (TRV)	2024 WI TRM			
Electric Only	Existing and New Construction	Lighting	LED Connected Lighting	2024 WI TRM			
Electric Only	Existing and New Construction	HVAC	Thermal Storage - Electric Space Heating	Stakeholder Suggestion			Yes
Electric Only	Existing and New Construction	All	Battery Storage	Stakeholder Suggestion			Yes

Commercial Measures

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing and New Construction	HVAC	Heat Pump - Air Source	Program Measure	Yes	Yes
Electric Only	Existing and New Construction	HVAC	Heat Pump - Cold Climate	2021 Focus Study	Yes	Yes
Electric Only	Existing and New Construction	HVAC	Heat Pump - Ground Source	2022 Focus Study	Yes	Yes
Electric Only	Existing and New Construction	HVAC	Cooling Chillers	Program Measure		Yes
Electric Only	Existing and New Construction	HVAC	Air Conditioner - Central	Program Measure		Yes
Electric Only	Existing and New Construction	HVAC	Air Conditioner - Split or Packaged System	Program Measure		Yes
Electric Only	Existing and New Construction	HVAC	Air Conditioner - Package Terminal	2021 Focus Study		Yes
Electric Only	Existing and New Construction	HVAC	Heat Pump - Package Terminal	Program Measure	Yes	Yes
Electric Only	Existing Construction Only	Lighting	Lighting Interior Linear LED	Program Measure		Yes
Electric Only	Existing Construction Only	Lighting	Lighting Interior High Bay LED	Program Measure		Yes
Electric Only	New Construction Only	Lighting	New Construction Lighting	Program Measure		Yes
Electric Only	Existing and New Construction	Other	Pool Pump VSD	Program Measure		
Electric Only	Existing and New Construction	Water Heat	Heat Pump Water Heater	2021 Focus Study	Yes	
Electric Only	Existing and New Construction	Appliance	Heat Pump - Clothes Dryer	2021 Focus Study	Yes	
Natural Gas Only	Existing and New Construction	HVAC	Unit Heater - Infrared Heater	Stakeholder Suggestion		
Natural Gas Only	Existing and New Construction	HVAC	Boiler - Efficient	Program Measure		
Natural Gas Only	Existing and New Construction	HVAC	Furnace - Efficient	Program Measure		
Electric and Natural Gas	Existing and New Construction	Other	Pool Heat	2021 Focus Study	Yes	
Electric and Natural Gas	Existing and New Construction	Water Heat	Storage Water Heater	Program Measure	Yes	
Natural Gas Only	Existing and New Construction	Water Heat	Tankless Water Heater	Program Measure		
Electric and Natural Gas	Existing and New Construction	HVAC	Advanced Rooftop Unit Controller	Program Measure		
Electric Only	Existing and New Construction	Air Compressor	Air Compressor - VFD	Program Measure		
Electric Only	Existing and New Construction	Air Compressor	Air Compressor - Leakage Reduction	Program Measure		Yes

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric and Natural Gas	Existing and New Construction	Cooking	Fryers	Program Measure	Yes	
Electric and Natural Gas	Existing and New Construction	Cooking	Griddle	Program Measure	Yes	
Electric Only	Existing and New Construction	Cooking	Hot Food Holding Cabinet	2021 Focus Study		
Electric and Natural Gas	Existing and New Construction	Cooking	Convection Oven	Program Measure	Yes	
Electric and Natural Gas	Existing and New Construction	Cooking	Combination Oven	2021 Focus Study	Yes	
Electric and Natural Gas	Existing and New Construction	Cooking	Steam Cooker	Program Measure	Yes	
Electric Only	Existing Construction Only	Plug Load	Advanced Power Strip	2021 Focus Study		
Electric Only	Existing and New Construction	Embedded Data Center	IT Systems - Uninterruptible Power Supply Upgrade	Program Measure		
Electric Only	Existing and New Construction	Embedded Data Center	IT Systems - Hot or Cold Aisle Configuration	Program Measure		
Electric Only	Existing Construction Only	Water Heat	Variable Speed ECM Pump - Domestic Hot Water Recirculation	Program Measure		
Electric Only	Existing Construction Only	HVAC	Variable Speed ECM Pump - HVAC Space Heating Recirculation	Program Measure		
Electric Only	Existing Construction Only	HVAC	Variable Speed ECM Pump - HVAC Space Cooling Recirculation	Program Measure		
Electric Only	Existing Construction Only	HVAC	Variable Speed ECM Pump - HVAC Heat Pump Recirculation	2021 Focus Study		
Electric Only	Existing Construction Only	HVAC	Cooling Tower Fan - Variable Speed Control	Program Measure		
Electric and Natural Gas	Existing Construction Only	HVAC	Exhaust Air to Ventilation Air Heat Recovery	2021 Focus Study		
Electric and Natural Gas	Existing Construction Only	HVAC	Automated Ventilation CO2 Sensors	Program Measure		

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing and New Construction	HVAC and Lighting	Hotel Key Card Control System	Program Measure		
Electric and Natural Gas	Existing and New Construction	HVAC	HVAC Commissioning	Program Measure		Yes
Electric and Natural Gas	Existing and New Construction	HVAC	Strategic Energy Management	Program Measure		Yes
Electric and Natural Gas	Existing and New Construction	HVAC	Smart Thermostat	Program Measure		
Electric and Natural Gas	Existing and New Construction	HVAC	Energy Management System	Program Measure		
Electric Only	Existing and New Construction	HVAC	Heat Pump - Ductless Mini-Split	2021 Focus Study	Yes	Yes
Electric Only	Existing Construction Only	HVAC	Chilled Water Side Economizer	2021 Focus Study		
Electric Only	Existing Construction Only	HVAC	Air Side Economizer	Program Measure		
Electric Only	Existing Construction Only	HVAC	Economizer Optimization	Program Measure		
Electric Only	Existing and New Construction	HVAC	Cooking Hood Controls	Program Measure		
Electric Only	Existing Construction Only	HVAC	Air Conditioner Tune-up	2021 Focus Study		Yes
Electric Only	Existing Construction Only	HVAC	Chiller Tune-up	2021 Focus Study		Yes
Electric Only	Existing Construction Only	HVAC	Heat Pump Tune-up	2021 Focus Study		Yes
Electric Only	Existing Construction Only	Lighting	Lighting Occupancy Sensor	Program Measure		
Electric Only	Existing Construction Only	Lighting	Bi-Level Control - Stairwell Lighting	Program Measure		
Electric Only	Existing Construction Only	Lighting	Bi-Level Control - Parking Garage Lighting	Program Measure		
Electric Only	Existing Construction Only	Lighting	Daylighting Controls	Program Measure		
Electric Only	Existing and New Construction	Lighting	Display Case LEDs	Program Measure		
Electric Only	Existing Construction Only	Lighting	Exit Sign - LED	2021 Focus Study		
Electric Only	Existing and New Construction	Lighting	Lighting Exterior	Program Measure		
Electric Only	Existing and New Construction	Lighting	LED Signage	Program Measure		
Electric Only	Existing and New Construction	Appliance	Ice Maker	Program Measure		
Electric Only	Existing and New Construction	Refrigeration	Refrigeration Economizer	Program Measure		

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing and New Construction	Refrigeration	Night Covers for Display Cases	Program Measure		
Electric Only	Existing Construction Only	Refrigeration	Anti-Sweat Controls	Program Measure		
Electric Only	Existing Construction Only	Refrigeration	Demand Control Defrost	Program Measure		
Electric Only	Existing and New Construction	Refrigeration	Evaporator Fan Controller	Program Measure		
Electric Only	Existing Construction Only	Refrigeration	Floating Head Pressure Controls	Program Measure		
Electric Only	Existing and New Construction	Refrigeration	Smart Controls for Central Refrigeration	Stakeholder Suggestion		
Electric Only	Existing and New Construction	Refrigeration	Walk-In ECM	Program Measure		
Electric Only	Existing Construction Only	Refrigeration	Display Case ECM	Program Measure		
Electric Only	Existing Construction Only	Refrigeration	Strip Curtains	Program Measure		
Electric Only	Existing and New Construction	Refrigeration	No Heat Case Doors	Program Measure		
Electric Only	Existing and New Construction	Refrigeration	Display Case Add Doors	Program Measure		
Electric and Natural Gas	Existing and New Construction	Appliance	Dishwasher - Commercial Sized	Program Measure		
Electric and Natural Gas	Existing and New Construction	Water Heat	Refrigeration Heat Recovery to Water Heater	Program Measure		
Electric and Natural Gas	Existing and New Construction	Water Heat	Faucet Aerator	2021 Focus Study		
Electric Only	New Construction Only	Lighting	Networked Lighting Controls for New Construction	Program Measure		
Electric Only	Existing and New Construction	HVAC	Variable Refrigerant Flow	2021 Focus Study		Yes
Electric and Natural Gas	Existing Construction Only	HVAC	Behavioral Energy Management	Program Measure		
Electric Only	Existing Construction Only	HVAC	Fan - Variable Speed	Program Measure		
Electric Only	Existing Construction Only	HVAC	Pump - Variable Speed	Program Measure		
Electric Only	Existing and New Construction	Embedded Data Center	IT Systems - High Efficiency Computer Room Air Conditioner (CRAC)	2021 Focus Study		
Electric Only	Existing and New Construction	Refrigeration	Mechanical Subcooling - Commercial Refrigeration System	Program Measure		

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing and New Construction	Refrigeration	Ultra-Low Temperature Freezers with Sterling Engine	2021 Focus Study		
Electric Only	Existing and New Construction	HVAC	Boiler Draft Fan - VFD	Program Measure		
Natural Gas Only	Existing and New Construction	HVAC	Garage Door Hinges	Program Measure		
Natural Gas Only	Existing and New Construction	HVAC	Modulating Gas Dryer	2021 Focus Study		
Natural Gas Only	Existing and New Construction	Cooking	Rack Oven	2021 Focus Study	Yes	
Natural Gas Only	Existing and New Construction	Cooking	Charbroiler	Cadmus Suggestion	Yes	
Natural Gas Only	Existing and New Construction	Cooking	Broiler - Salamander	2021 Focus Study	Yes	
Natural Gas Only	Existing and New Construction	Cooking	Conveyor Oven	2021 Focus Study	Yes	
Natural Gas Only	Existing and New Construction	HVAC	Boiler Oxygen Trim Controls	Program Measure		
Natural Gas Only	Existing Construction Only	HVAC	Boiler Tune-up	Program Measure		
Natural Gas Only	Existing Construction Only	HVAC	Furnace Tune-up	2021 Focus Study		
Natural Gas Only	Existing Construction Only	HVAC	Boiler - Economizer	2021 Focus Study		
Natural Gas Only	Existing and New Construction	HVAC	Boiler - Pipe Insulation	2021 Focus Study		
Natural Gas Only	Existing and New Construction	HVAC	Boiler Controls - Reset Temperature Control	2021 Focus Study		
Natural Gas Only	Existing and New Construction	HVAC	Boiler Controls - Linkageless	2021 Focus Study		
Natural Gas Only	Existing Construction Only	HVAC	Steam Trap Repair	2021 Focus Study		
Natural Gas Only	Existing and New Construction	HVAC	Boiler Controls - High Turndown Burners	2021 Focus Study		
Electric Only	Existing and New Construction	Lighting	Bi-Level Control - High Bay	Program Measure		
Electric and Natural Gas	New Construction Only	HVAC	New Construction Program Building	Program Measure		
Electric and Natural Gas	Existing and New Construction	Other	Waste Water Treatment	Program Measure		
Electric Only	Existing and New Construction	Other	Waste Water Treatment Aeration	Program Measure		
Electric and Natural Gas	Existing and New Construction	HVAC	Direct Fired Make-up Air Unit	Program Measure		
Electric Only	Existing and New Construction	Other	Efficient Rectifier	Program Measure		
Electric and Natural Gas	Existing and New Construction	HVAC	Energy Recovery Ventilator	Program Measure		
Electric Only	Existing and New Construction	Other	Solar PV	2021 Focus Study		

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric and Natural Gas	Existing and New Construction	HVAC	Thermostat Load Shift	Cadmus Suggestion		Yes
Electric Only	Existing and New Construction	Other	Electric Vehicle Charging Load Shift	Cadmus Suggestion		Yes
Electric and Natural Gas	Existing and New Construction	HVAC	Loading Dock Door and Pit/Ramp Seals	2024 WI TRM		
Electric Only	Existing and New Construction	Air Compressor	Air Compressor - Process Load Shifting	2024 WI TRM		Yes
Electric Only	Existing and New Construction	Air Compressor	Air Compressor - Storage	2024 WI TRM		
Electric Only	Existing and New Construction	Air Compressor	Air Compressor - Desiccant Dryer	2024 WI TRM		
Electric and Natural Gas	Existing and New Construction	HVAC	Morning Warmup Optimization	2024 WI TRM		
Electric and Natural Gas	Existing and New Construction	HVAC	Adaptive Optimal Start	2024 WI TRM		
Electric and Natural Gas	Existing and New Construction	HVAC	Custom Project	Cadmus Suggestion	Yes	Yes
Electric Only	Existing and New Construction	Lighting	Custom Project	Cadmus Suggestion		
Electric and Natural Gas	Existing and New Construction	Water Heat	Custom Project	Cadmus Suggestion	Yes	
Electric Only	Existing and New Construction	Air Compressor	Custom Project	Cadmus Suggestion		
Electric Only	Existing and New Construction	Embedded Data Center	Custom Project	Cadmus Suggestion		
Electric Only	Existing and New Construction	Refrigeration	Custom Project	Cadmus Suggestion		
Electric Only	Existing and New Construction	HVAC	Thermal Storage	Aptim Suggestion		Yes

Industrial Measures

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Natural Gas Only	Existing Construction Only	Boilers & Burners	Boiler Management	Program Measure		

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Natural Gas Only	Existing Construction Only	Boilers & Burners	Boiler Heat Recovery	Program Measure		
Natural Gas Only	Existing Construction Only	Boilers & Burners	Boiler Controls	Program Measure		
Natural Gas Only	Existing Construction Only	Boilers & Burners	Boiler Pipe Insulation	Program Measure		
Natural Gas Only	Existing Construction Only	Boilers & Burners	Boiler Draft Fan VFD	Program Measure		
Natural Gas Only	Existing Construction Only	Boilers & Burners	Boiler High Efficiency	Program Measure		
Natural Gas Only	Existing Construction Only	Boilers & Burners	Boiler - Custom	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - VFD	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - No Air Loss Drain	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Pressure/Flow Controller	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Heat Recovery	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Mist Eliminators	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Nozzles	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Cycling Dryers	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Dew Point Controls for Desiccant Dryers	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Leakage Reduction	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Desiccant Compressed Air Dryer	Program Measure		
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Storage and Load Shift	Program Measure		

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing Construction Only	Compressed Air, Vacuum Pumps	Compressed Air - Custom	Program Measure		
Electric Only	Existing Construction Only	HVAC	Air Conditioning Upgrade	Program Measure		
Natural Gas Only	Existing Construction Only	HVAC	Steam Trap	Program Measure		
Electric Only	Existing Construction Only	HVAC	Advanced Rooftop Unit Controller	Program Measure		
Electric Only	Existing Construction Only	HVAC	Air Filtration Upgrade	Program Measure		
Electric Only	Existing Construction Only	HVAC	Air Source Heat Pump Upgrade	Program Measure		
Electric and Natural Gas	Existing Construction Only	HVAC	Building Shell Upgrade	Program Measure		
Electric Only	Existing Construction Only	HVAC	Cooling Chillers Upgrade	Program Measure		
Electric Only	Existing Construction Only	HVAC	Ventilation Upgrade	Program Measure		
Electric Only	Existing Construction Only	HVAC	Economizer Upgrade	Program Measure		
Natural Gas Only	Existing Construction Only	HVAC	Efficient Furnace	Program Measure		
Electric and Natural Gas	Existing Construction Only	HVAC	HVAC Commissioning	Program Measure		
Electric and Natural Gas	Existing Construction Only	HVAC	Energy Management System	Program Measure		
Natural Gas Only	Existing Construction Only	HVAC	Radiant Heater	Program Measure		
Electric Only	Existing Construction Only	HVAC	Variable Speed ECM Pump - HVAC Space Cooling Recirculation	Program Measure		
Electric Only	Existing Construction Only	HVAC	Cooling Tower Fan Upgrade	Program Measure		
Electric and Natural Gas	Existing Construction Only	HVAC	Building Duct System Improvements	Program Measure		
Electric and Natural Gas	Existing Construction Only	HVAC	HVAC Controls	Program Measure		
Electric and Natural Gas	Existing Construction Only	HVAC	HVAC - Custom	Program Measure		
Electric Only	Existing Construction Only	Lighting	Interior Lighting Upgrade	Program Measure		
Electric Only	Existing Construction Only	Lighting	Exterior Lighting Upgrades	Program Measure		
Electric Only	Existing Construction Only	Lighting	Lighting Controls	Program Measure		
Electric and Natural Gas	Existing Construction Only	Lighting	Advanced Lighting and Controls Design	Program Measure		
Electric and Natural Gas	Existing Construction Only	Lighting	Lighting - Custom	Program Measure		
Electric Only	Existing Construction Only	Motor	Pulper Rotors	Program Measure		
Electric Only	Existing Construction Only	Motor	Motor Upgrade and Drives	Program Measure		

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing Construction Only	Motor	Motor Management and Optimization	2021 Focus Study		
Electric Only	Existing Construction Only	Motor	Fan Upgrades and Drives	Program Measure		
Electric Only	Existing Construction Only	Motor	Pump Upgrades and Drives	Program Measure		
Electric Only	Existing Construction Only	Motor	Motor - Custom	Program Measure		
Electric and Natural Gas	New Construction	New Construction	New Construction Design	Program Measure		
Electric Only	Existing Construction Only	Other	Industrial Battery Charger	Program Measure		
Electric Only	Existing Construction Only	Other	Efficient Welder	Program Measure		
Electric Only	Existing Construction Only	Process	High Efficiency Injection Mold Machines	2021 Focus Study		
Electric Only	Existing Construction Only	Process	Lime Kiln Improvements	2021 Focus Study		
Electric and Natural Gas	Existing Construction Only	Process	Process Heat Recovery	Program Measure		
Electric Only	Existing Construction Only	Process	Side Entry Agitators	Program Measure		
Electric and Natural Gas	Existing Construction Only	Process	Process Exhaust Filtration	Program Measure		
Electric and Natural Gas	Existing Construction Only	Process	Strategic Energy Management	Program Measure		
Electric Only	Existing Construction Only	Process	Spline Upgrade	Program Measure		
Electric and Natural Gas	Existing Construction Only	Process	Operations and Maintenance	2021 Focus Study		
Electric and Natural Gas	Existing Construction Only	Process	Process - Custom	Program Measure		
Electric and Natural Gas	Existing Construction Only	Process	Process - Custom Tier 2 with Optimization	Program Measure		
Electric and Natural Gas	Existing Construction Only	Process	Other Plant Operations Improvements To Reduce Energy Requirements	2021 Focus Study		
Electric Only	Existing Construction Only	Process	Water Use Reduction	Program Measure		
Electric Only	Existing Construction Only	Process	Industrial Heat Pump	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Process	Radio Frequency Heating	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Process	Electric Arc Furnace	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Process	Electric Infrared Heaters	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Process	Electrochemical Process Change (from thermochemical)	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Process	Microwave Heating	Cadmus Suggestion	Yes	

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?	Customer Load Shift/Reduction Application?
Electric Only	Existing Construction Only	Process	Electric Induction Melting	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Process	Resistance Heating	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Process	Plasma Melting	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Process	Electrolytic Reduction	Cadmus Suggestion	Yes	
Electric Only	Existing Construction Only	Refrigeration	Refrigeration Upgrade	2021 Focus Study		
Electric Only	Existing Construction Only	Refrigeration	Refrigeration Controls	Program Measure		
Electric Only	Existing Construction Only	Refrigeration	Refrigeration - Custom	Program Measure		
Electric Only	Existing Construction Only	Renewable Energy	Solar PV	Program Measure		
Electric Only	Existing Construction Only	Streetlighting	Efficient Streetlights	Program Measure		
Electric Only	Existing Construction Only	Waste Water	Wastewater System Upgrade	Program Measure		
Electric Only	Existing and New Construction	HVAC	Thermal Storage	Aptim Suggestion		Yes

Agricultural Measures

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?
Electric Only	Existing Construction Only	Dairy	Plate Heat Exchanger - Dairy	Program Measure	
Electric Only	Existing Construction Only	Dairy	Water Heater - Refrigeration Heat Recovery Unit	Stakeholder Suggestion	
Electric Only	Existing Construction Only	Dairy	Dairy Refrigeration Tune-Up	Program Measure	
Electric Only	Existing Construction Only	Dairy	Vacuum Pump - VFD	Program Measure	
Electric Only	Existing Construction Only	Dairy	Milk Pump - VFD	Stakeholder Suggestion	
Electric Only	Existing Construction Only	HVAC	Ventilation Fan	Program Measure	
Electric Only	Existing Construction Only	HVAC	Circulation Fan	Program Measure	
Electric Only	Existing Construction Only	HVAC	Advanced Fan Controls	Stakeholder Suggestion	
Electric Only	Existing Construction Only	HVAC	High-Volume Low-Speed Fan	Program Measure	
Electric Only	Existing Construction Only	Other	Livestock Waterer < 250 Watts	Program Measure	
Electric Only	Existing Construction Only	Other	Livestock Waterer - Energy Free	Program Measure	
Electric Only	Existing Construction Only	Irrigation	Agricultural Pump - VFD	Program Measure	

Fuel Type	Construction Vintage	End Use Category	Measure Category	Measure Source	Electrification Measure?
Electric Only	Existing Construction Only	Lighting	Lighting Interior High Bay LED	Program Measure	
Electric Only	Existing Construction Only	Lighting	Lighting Interior Linear LED	Program Measure	
Electric Only	Existing Construction Only	Lighting	Lighting Controls	2021 Focus Study	
Electric Only	Existing Construction Only	Irrigation	Irrigation Pump Motor HP Reduction	Program Measure	
Electric and Natural Gas	Existing Construction Only	Other	Grain Dryer Tune-Up	Program Measure	
Electric Only	Existing Construction Only	Other	Swine Farrowing Crate Heater	2021 Focus Study	
Electric Only	Existing Construction Only	Lighting	Horticultural Lighting	Program Measure	
Natural Gas Only	Existing Construction Only	Other	Grain Dryer - Efficient	Program Measure	
Natural Gas Only	Existing Construction Only	Water Heat	Water Heater Gas Upgrade	2021 Focus Study	Yes
Natural Gas Only	Existing Construction Only	HVAC	Boiler - Efficient	Stakeholder Suggestion	Yes
Natural Gas Only	Existing Construction Only	HVAC	Furnace - Efficient	Stakeholder Suggestion	Yes
Natural Gas Only	Existing Construction Only	HVAC	Greenhouse Infrared Heater	Stakeholder Suggestion	Yes
Natural Gas Only	Existing Construction Only	HVAC	Greenhouse Thermal Blanket	Program Measure	
Natural Gas Only	Existing Construction Only	HVAC	Greenhouse Climate Controls	Program Measure	
Natural Gas Only	Existing Construction Only	HVAC	Greenhouse Perimeter Insulation	Program	
Electric Only	Existing Construction Only	HVAC	High Speed Ventilation/Circulation Fan - VFD	Program	
Electric Only	Existing Construction Only	Other	Constant Torque - VFD	Stakeholder Suggestion	
Electric Only	Existing Construction Only	Other	Solar PV	2021 Focus Study	
Electric Only	Existing Construction Only	Dairy	Custom Project	Cadmus Suggestion	
Electric and Natural Gas	Existing Construction Only	HVAC	Custom Project	Cadmus Suggestion	Yes
Electric Only	Existing Construction Only	Irrigation	Custom Project	Cadmus Suggestion	
Electric and Natural Gas	Existing Construction Only	Water Heat	Custom Project	Cadmus Suggestion	Yes
Electric Only	Existing Construction Only	Lighting	Custom Project	Cadmus Suggestion	

Appendix D. Methodology and Model Inputs

This appendix provides the methodology and data inputs for the Focus on Energy Quad V Planning study. For the residential, commercial, and agricultural sectors Cadmus used a uniform approach to develop technical, economic, and optimized energy impacts. Cadmus used distinct approaches for the industrial sector, solar PV potential, and load-shifting measures. This chapter describes the modeling approach for each of these sectors separately.

In addition to the methodologies for estimating energy impacts in the agricultural, commercial, industrial, and residential sectors, this appendix also provides the methodology for developing electric emissions factors and cost-effectiveness screens, as well as the approach for developing end-use-specific hourly load shapes.

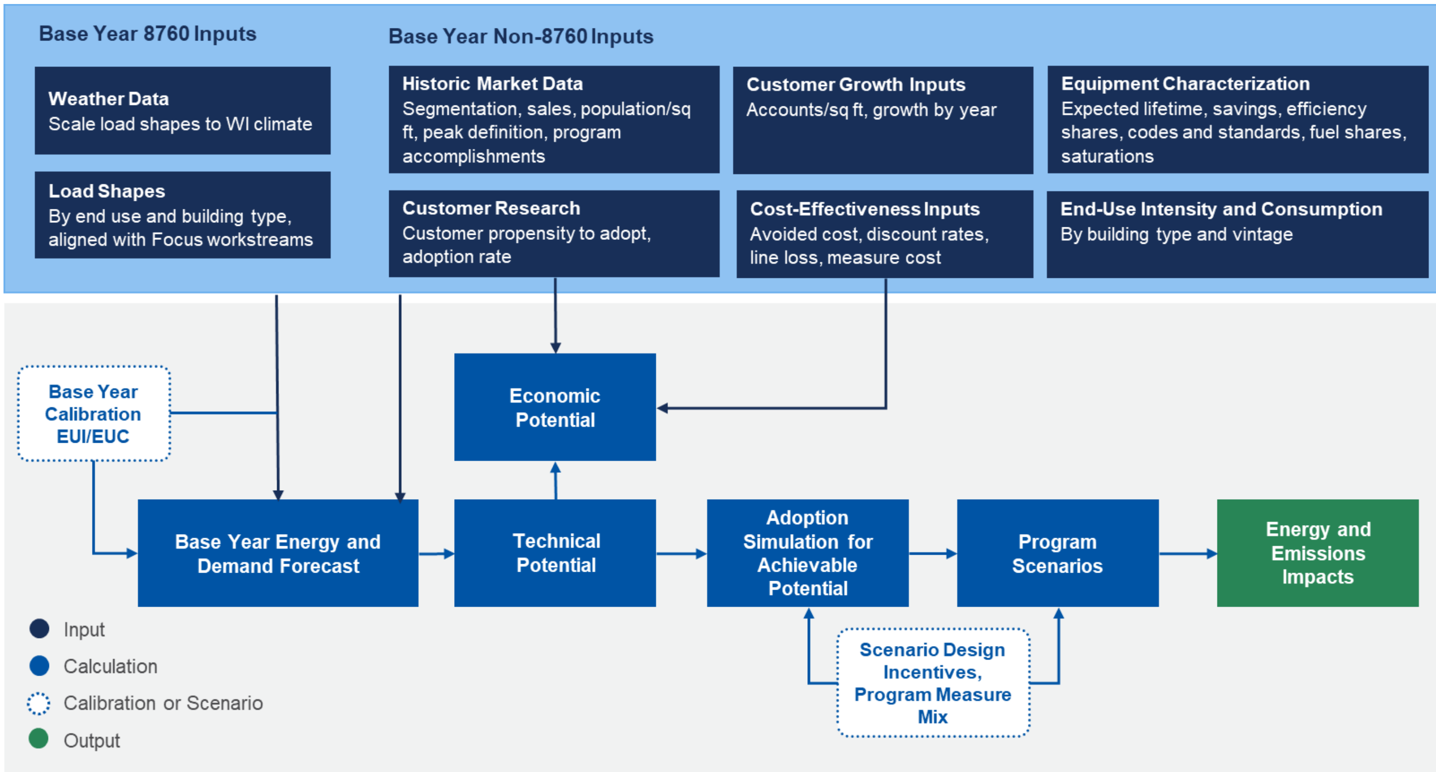
Residential, Commercial, and Agricultural Modeling Approach

Overview

To estimate technical, economic, and optimized potential, Cadmus first developed a baseline energy consumption forecast based on market and measure characteristics and calibrated to utility base-year energy sales. Cadmus used this forecast to calculate technically and economically feasible (economic measures are measures that pass a cost-effectiveness screen) energy and emissions impacts from study measures and estimated market adoption (optimized potential) and program scenario potential under six scenarios: a baseline scenario reflecting the most likely market conditions and program design and five scenarios developed in collaboration with Focus on Energy stakeholders.

Figure D-1 depicts how Cadmus modeled measure impacts in the agricultural, commercial, industrial, and residential sectors, including for energy efficiency and fuel-switching measures. As illustrated, the model developed impacts at an hourly level to calculate emissions and demand impacts. While the figure shows the impact of energy and emissions only as an output from program scenarios, energy and emissions impacts were outputs of each calculation.

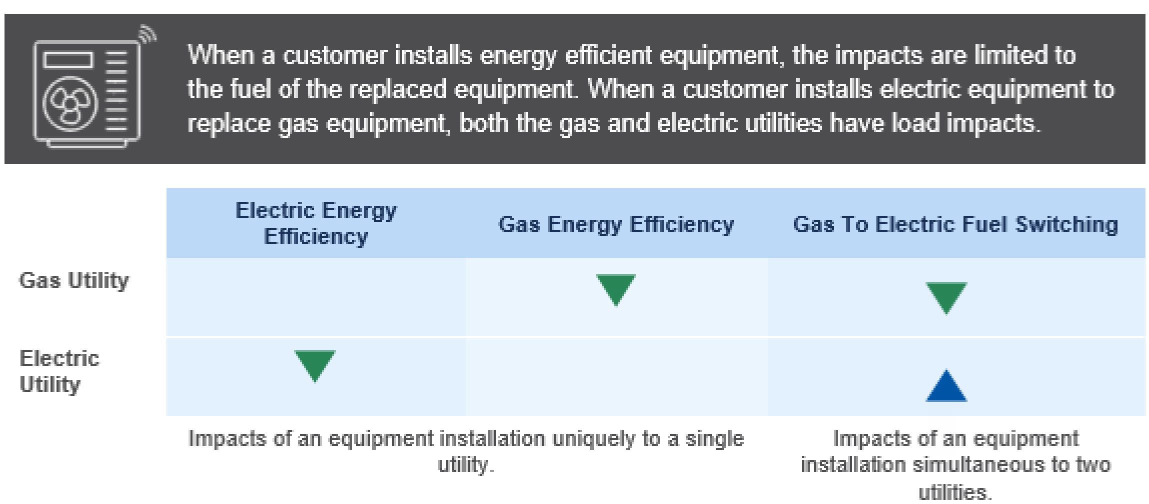
Figure D-1. Modeling Process



The results are organized by utility service territory, population segment, building type, measure, and program.

Figure D-2 Illustrates how the modeling process accounts for the impacts from both the increased electric loads and decreased gas loads as a result of electrification

Figure D-2. Accounting for Gas and Electric Impacts from Fuel Switching



Develop Baseline Energy Consumption Forecast

Following the development of a study measure list and market characterization database, Cadmus developed a calibrated baseline energy consumption forecast. The calibrated forecast accounts for the impacts to future load associated with electric vehicle adoption and changes in equipment standards and energy codes. Cadmus used this forecast of baseline market conditions to inform the energy and emissions impacts analysis.

Cadmus applied individual end-use characteristics, such as fossil fuel consumption from furnaces, derived from a market characteristics database developed for this study to build statewide energy consumption forecasts for the residential, commercial, and industrial sectors. Since the study's potential model characterizes and applies measure-level energy impacts as percentage savings relative to the end-use consumption, end-use level forecasts are critical to estimate potential.

Baseline Inputs: To create accurate baseline forecasts for Wisconsin, Cadmus first developed a market characterization. A market characterization is an analysis of key market sectors using a variety of data:

- Using utility account data to calculate the number homes, businesses, and industrial facilities in Wisconsin.
- Calculating building-level energy loads based on utility data.
- Segmenting building counts and energy loads into building categories, such as single family homes, manufactured homes, retail stores, hospitals, and so on. Cadmus used a variety of data sources to conduct this analysis, including utility data, site visit and survey data from the 2021 potential study, and American Community survey data.
- Estimating the energy end-use profile of each building type, including space and water heating equipment fuel, equipment type and efficiency, insulation levels, and so on. Cadmus used site visit data from the 2021 potential study, Focus on Energy program data, and other sources such as the United States Energy Information Administration's (EIA's) Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS).

Residential and Commercial Estimates. Cadmus calculated annual end use consumption for each end use in each segment in the commercial and residential sectors using the following equation:

$$TEUC_{ij} = \sum ACCTS_i \times UPA_i \times SAT_{ij} \times FSH_{ij} \times ESH_{ije} \times EUI_{ije}$$

Where:

$TEUC_{ij}$	=	The total energy consumption for end-use j in customer segment i
$ACCTS_i$	=	The number of accounts/customers in customer segment i
UPA_i	=	The number of units per account in customer segment i (UPA_i generally equals the average square feet per customer in commercial segments, and 1.0 in residential dwellings, assessed at the whole-home level)
SAT_{ij}	=	The share of customers in customer segment i with end-use j
FSH_{ij}	=	The share of end-use j of customer segment i served by electricity

ESH_{ije}	=	The market share of efficiency level e in equipment for customer segment i and end use j
EUI_{ije}	=	The end-use intensity, or energy consumption per unit (per square foot for commercial, 1.0 for residential) for the electric equipment configuration ije

For each sector, we estimated the total annual consumption as the sum of $TEUC_{ij}$ across the end uses j, and customer segments i.

Apply End-Use Load Shapes to Equipment Energy Consumption Characteristics

The Cadmus potential study model develops impacts on an hourly basis to accurately estimate peak energy demand and emissions impacts, both of which can vary by hour. To develop hourly impacts, Cadmus developed load shapes drawing from the National Renewable Energy Laboratory (NREL) Comstock and Restock database within ASHRAE climate zones 6a and 7a, with a specific focus on shapes that result from implementing efficient fuel switching measures.

Calibrate Baseline Forecast to Actual Utility Sales

The end-use forecast relies on averages, such as average energy consumptions from equipment types or average building EUIs, that are applied to the market and measure characteristics. Averages are used because it is not feasible to incorporate the characteristics of every individual building and piece of equipment in Wisconsin. This approach introduces uncertainty into the bottom-up baseline energy sales forecast. This uncertainty is addressed by calibrating the end-use forecast to utility energy sales data received from Wisconsin utilities.

The model's top-down approach calibrates the bottom-up end-use consumption forecast to utility energy sales data to avoid over- or underestimation of potential. Cadmus calibrated a baseline energy consumption forecast for each sector and fuel type to match the corresponding utility energy sales forecast.

Potential Development

After developing our baseline energy use forecast, we used our potential study model to develop the technically feasible impacts from study measures, including electric and gas impacts, peak demand impacts, and emissions impacts in the agricultural, residential and commercial sectors. The approach for the industrial sector is distinct because it uses a top-down percentage impact model, whereas the residential and commercial sectors use a measure- and equipment-based model.

Measure Characterization

Using the measure list developed in consultation with study stakeholders, Cadmus completed measure characterization for all measures, leveraging actual evaluated program data from the Focus on Energy SPECTRUM database when feasible. After creating a list of energy efficiency measures, Cadmus classified the energy efficiency measures into two categories:

- ***Lost opportunity measures:*** These measures affect equipment at the end of their useful life, incorporating energy efficiency at this point when it is most cost-effective. The lost opportunity measures in any given year are based on stock turnover and normal replacement patterns according to each measure's EUL.
- ***Discretionary measures (retrofit):*** These measures affect end uses without replacing end-use equipment (such as insulation). As such, they do not have timing constraints from equipment turnover and could be acquired at any point during the planning horizon.

Cadmus used several relevant inputs for each lost opportunity and discretionary measure:

- ***Technical feasibility:*** the percentage of buildings where customers could install this measure, accounting for physical constraints.
- ***Energy savings:*** average annual savings attributable to installing the measure, in absolute or percentage terms.
- ***Equipment cost:*** full or incremental equipment cost, depending on the nature of the measure and the application.
- ***Labor cost:*** the expense of installing the measure, accounting for differences in labor rates by region and other variables.
- ***Measure life:*** the expected lifespan of the equipment.

Cadmus also used two inputs for only non-equipment (discretionary) measures:

- ***Percentage incomplete:*** the percentage of buildings where customers have not installed the measure, but where it could technically (and feasibly) be installed.
- ***Measure competition:*** for mutually exclusive measures, accounting for the percentage of each measure likely to be installed to avoid double-counting savings—for example, an air source heat pump or a ground source heat pump compete for a single customer installation decision.

Energy Savings

For each energy efficiency (and load-shifting) measure, Cadmus estimated energy savings, both per unit (kWh) and as a percentage of end use. These estimates also account for savings interactions and results across end uses (for example, upon installing efficient lighting, cooling loads decrease due to the reduction of waste heat).

Measure Life

Cadmus uses estimates of each measure's EUL to calculate the lifetime net present value (NPV) benefits and costs for each measure. Many data sources for measure savings and costs also provide estimates for measure lifetimes. For this study Cadmus relied primarily on the Wisconsin Technical Reference Manual for measure life.

Calculate Technical Potential

Technical potential represents the theoretical maximum energy impacts from study measures and includes all technically feasible energy efficiency, electrification, and solar PV measures, regardless of costs or market barriers. Technical potential accounts for replacement cycles, assuming decision-makers consider upgrades periodically (rather than evaluating decisions every year). A key assumption when estimating technical potential is that the option with the highest energy impact is installed among competing options weighed by decision-makers, regardless of cost or other barriers.

Once the measure characterization database was fully populated, Cadmus used measure-level inputs to estimate technical potential over the 12-year study period. To do this, Cadmus estimated impacts from all measures in the analysis and then aggregated the results to the fuel type, sector, segment, end use, and utility.

The first step in estimating impacts from individual measures required characterizing individual measure savings by the percentage of end-use consumption in a particular customer segment. For each non-equipment measure, Cadmus estimated absolute savings using the following equation:

$$SAVE_{ijm} = EUI_{ije} * PCTSAV_{ijem} * APP_{ijem}$$

Where:

$SAVE_{ijm}$	=	Annual energy savings for measure, m, for end use *j* in customer segment *i*
EUI_{ije}	=	Calibrated annual end-use energy consumption for equipment *e* for end use *j* and customer segment *i*
$PCTSAV_{ijem}$	=	The percentage savings of measure *m* relative to the base use for the equipment configuration *ije*, accounting for interactions among measures (such as lighting and HVAC)
APP_{ijem}	=	Measure applicability: a fraction representing combined technical feasibility, existing measure saturation, end-use interaction, and any adjustments used to account for competing measures

As an example, to determine the percentage of baseline consumption that a wall insulation measure saved in an average home, we would begin with a wall insulation measure that saved 10% of space heating consumption. We would then multiply this measure's overall applicability of 50% by its percentage savings to calculate the final percentage the end use (space heating) saved as 5%.

When estimating potential, Cadmus accounted for interactions between efficiency measures and between efficiency and fuel-switching, as discussed in the following subsections.

Interactions Between Energy Measures

Cadmus examined measures that affect a single end use to capture applicable measures, assess cumulative impacts, and account for interactions among measures—a treatment called *measure stacking*—to avoid overestimating total savings.

Our primary method to account for stacking effects establishes a rolling, reduced baseline that is applied sequentially upon assessment of measures in the stack. The following equations illustrate this technique, applying measures 1, 2, and 3 to the same end use:

$$SAVEij1 = EUIije * PCTSAVije1 * APPije1$$

$$SAVEij2 = (EUIije - SAVEij1) * PCTSAVije2 * APPije2$$

$$SAVEij3 = (EUIije - SAVEij1 - SAVEij2) * PCTSAVije3 * APPije3$$

After iterating measures in a bundle, we divided the final percentage of the reduced end-use consumption provided by the sum of each measure's stacked savings by the original baseline consumption. We then ranked the retrofit measures in a bundle from the highest- to lowest-saving measures in terms of the percentage of energy savings for that end use. Our model applies this methodology when estimating technical, economic, and optimized potential.

Interaction Between Energy Efficiency and Fuel-Switching

Potential studies that estimate only energy efficiency potential (i.e., no fuel-switching) typically assume that energy efficiency savings from measures persist after the upgrades for the remainder of the study. The introduction of fuel-switching complicates this assumption, as illustrated in Figure D-2 above. Our model not only attributes savings from a future building retrofit for the correct fuel but also changes persisting annual savings from a retrofit preceding the fuel switch to the correct fuel after a fuel switching measure is installed. For example, an insulation retrofit in a home that uses a natural gas furnace for space heating will save natural gas. However, when the customer installs an electric heat pump for space heating to replace a natural gas furnace (a fuel-switching measure), that same insulation retrofit will now save electricity rather than natural gas.

Our model accounts for the interaction between efficiency and fuel-switching by recalculating measure unit energy savings annually using the measure's percentage savings and the saturations and fuel shares of the relevant end use(s) each year. This means that cumulative efficiency savings in a given year reflect the fuel and efficiency mix of end-use equipment stock in that year. Consequently, cumulative efficiency savings for a specific fuel can decrease over time if many buildings are converting away from that fuel. Our model uses this approach for technical, economic, and optimized potential.

Measure Adoption Methodology for Optimized and Program Scenario Potential

Optimized potential is a subset of technical potential that accounts for real-world market barriers to adopting efficiency measures.

A key assumption when estimating optimized potential is that among competing options weighed by decision-makers, all options are installed in fractions proportional to their predicted market share. Our model uses a sophisticated approach to estimate the number and type of measure units installed; the model considers customers' decisions over the study horizon, accounting for changes in fuel prices, energy use, and other variables. This approach to estimating customer decisions is well vetted and draws from the Building Efficiency and Electrification Model (BEEM) used by the New York State Energy Research and Development Authority (NYSERDA) [20] and the National Renewable Energy Laboratory's Distributed Generation Market Demand Model (dGen).[21]

The Cadmus model applies the same energy algorithm for technical potential to estimate unit energy savings for optimized potential. The difference between technical and optimized potential is the number and type of measure units assumed installed.

Modeling Customer Decisions

Customer fuel and efficiency decisions are complex and depend on many factors, such as knowledge of benefits and drawbacks, up-front costs (including relevant incentives), energy bill impacts, personal preferences, contractor recommendations, and market barriers. Cadmus accounted for this complexity by marrying diffusion of innovation theory with customer-facing economics.

Diffusion of innovation theory, of which Bass diffusion is the most widely known, models the diffusion of new technology through the market. It often assumes that the new technology is superior to existing technology and will eventually reach complete market saturation. The market share of a new technology often follows a distinctive S-shaped curve, with a slow initial ramp period reflecting early adopters, an increasing ramp to an inflection point reflecting mass adoption, and finally, a reduction in slope as late adopters convert and market saturation approaches 100%.

While this assumption is appropriate for LED lighting, which is strictly superior to its alternatives, it is less so for modeling electrification adoption, which largely depends on the relative customer-facing economics of the options. Instead of assuming that the market cap is 100%, we modeled the market cap as a function of the payback period of participating in a Focus on Energy program relative to the counterfactual alternative. For example, if customers perceive electrification as a bad economic investment due to the relative nature of electric and gas prices, then electrification adoption will be low until the underlying economics improve.

Our model calculated the $Final\ Annual\ Percent\ Adoption$ according to the following equation:

$$Final\ Annual\ Percent\ Adoption = MaxAdopt\% * BassDiffAdopt\% * CompShare$$

Where:

$MaxAdopt\%$	=	Maximum adoption percentage
$BassDifAdopt\%$	=	Bass diffusion annual adoption percentage
$CompShare$	=	Competition share

[20] For a model description please see: Cadmus, Energy + Environmental Economics, and Industrial Economics Incorporated. April 2023. Assessment of Energy Efficiency and Electrification Potential in New York State Residential and Commercial Buildings. https://www.nyserda.ny.gov/About/Publications/Evaluation-Reports/Building-Stock-and-Potential-Studies/Assessment-of-Energy-Efficiency-and-Electrification-Potential

[21] Distributed Generation Market Demand Model. Accessed June 2025. https://www.nrel.gov/analysis/dgen/

When combined, these factors form an adoption curve for each study measure. The following subsections discuss each factor in more detail.

Develop Maximum Adoption Percentage through Hurdle Rates

The maximum adoption percentage (market cap) projects the maximum adoption percentage a technology will ever achieve. We modeled this component of the algorithm as a function of the payback period of program participation and recalculated it annually to capture any changes in economic conditions. Payback period, which is used in financial analysis to estimate the attractiveness of investments, is based on discounted cash flow analysis. We used the following key variables to calculate payback period:

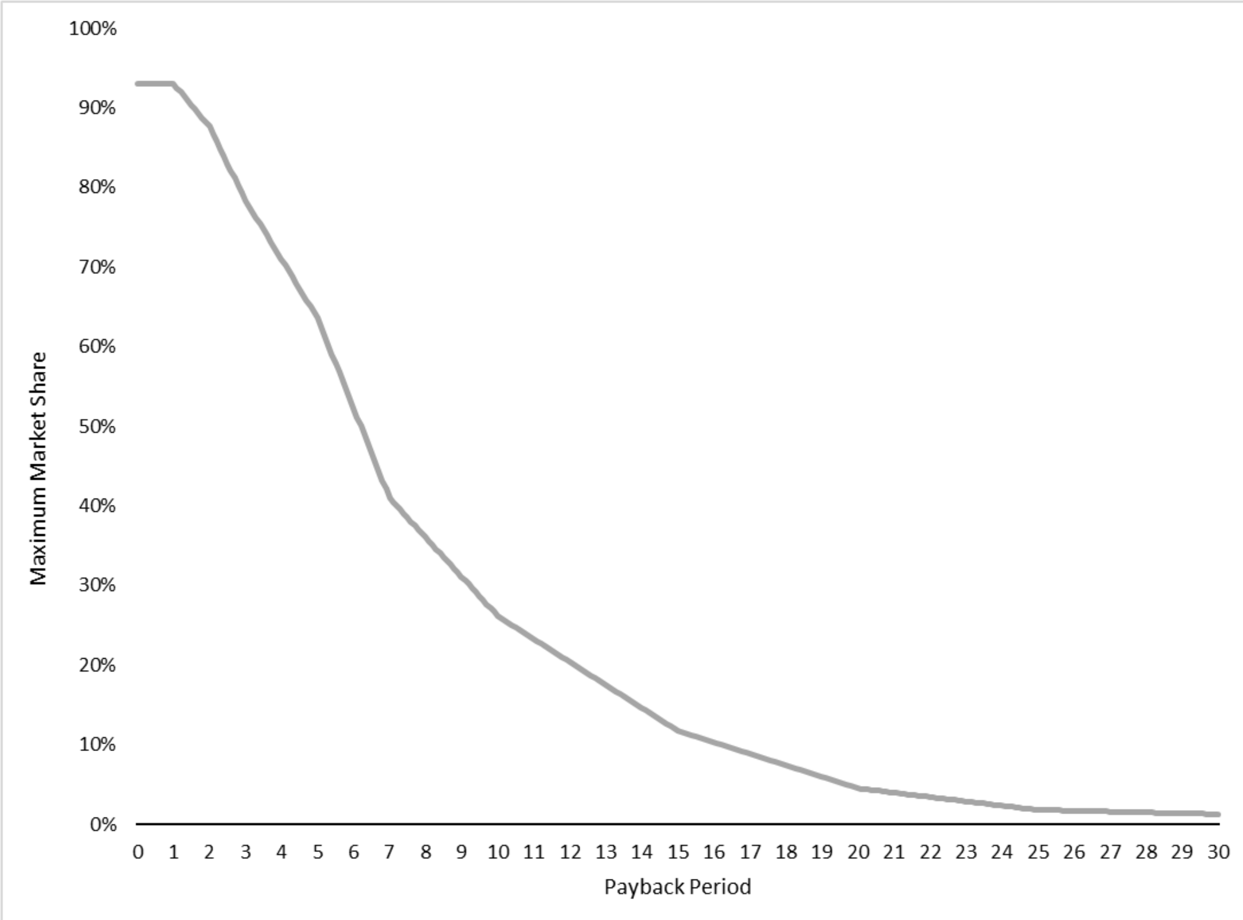
- Measure and baseline equipment capital costs
- Maintenance costs
- Lifetime fuel costs (according to current and projected electric and other fuel costs)
- Focus on Energy program incentives
- Discount rate for annual cash flows

The inputs for many of these variables were an important part of the optimized and program potential scenarios, which Cadmus developed in consultation with stakeholders.

A lower payback period represents a more economical choice and a higher payback period represents a less economic choice. Thus, the adoption model connects payback period to a maximum market share, with which measures with a low payback period have a high maximum market share, and measures with a high payback period have low maximum market share. Cadmus extrapolated the relationship between payback period and maximum adoption percentage from measure group–specific hurdle rates. A hurdle rate represents the payback period at which the estimated market adoption of a measure group is 50%. Cadmus determined the customer discount rate via willingness-to-pay survey questions. These questions asked survey respondents to state if they would or would not install measures with various payback periods.

Figure D-3 illustrates the relationship between payback period and maximum adoption percentages. Cadmus estimated this relationship specifically for various market segments: commercial standard customers, commercial institutional customers, residential standard income customers, and residential income-qualified populations. Cadmus also estimated the hurdle rate for various technology groupings, including standard equipment upgrades (non-fuel switching), electrification upgrades, and whole building retrofits. This is because customers can think about building upgrades differently, depending on the magnitude of the change to their current home or business. For additional information about the measure groups for which we estimated hurdle rates, please see *Measure Grouping and Research*.

Figure D-3. Maximum Adoption Percentage versus Payback Period



Develop Bass Diffusion S-Curve

The Bass diffusion S-curve projects how adoption percentages will increase over time from current values, typically low levels, to reach the final maximum adoption percentage. This component is based on an assessment of barriers to adoption, including customer behavior barriers, technology barriers, and other nonfinancial barriers, such as market readiness. This part of the algorithm is expressed through a market diffusion curve (S-curve), which shows how the speed of adoption increases over time to reach the maximum adoption percentage. S-curve adoption modeling is often used to model measure penetration (the percentage of the total market that has adopted a given measure) over time; however, we modeled the adoption of some measures as linked to end-of-life replacement cycles. As a result, it is more appropriate to apply S-curve modeling in the form of annual adoption rate modeling. In other words, we modeled adoption as a percentage of the sites that are up for end-of-life replacement each year rather than as a percentage of total building stock. This modeling approach also means that achieving a certain level of penetration for total building stock takes longer. To reach 100% penetration, it is necessary not only to achieve an annual adoption percentage of 100% but to also maintain this adoption percentage until all relevant equipment has failed and been replaced. This prolonged adoption period is an accurate reflection of lost opportunity building energy measures, particularly HVAC measures, which are typically adopted only when the existing device reaches the end of its life.

As noted, the S-curve describes the length of time and shape of the adoption pattern to achieve the maximum adoption percentage. The Bass diffusion algorithm is as follows:

$$BassDifAdopt\%(t) = \frac{1 - e^{-(p+q)t}}{1 + (\frac{q}{p})e^{-(p+q)t}}$$

The Bass diffusion model is a differential equation that describes the S-curve pattern of technology or product adoption. Two coefficients, p and q, influence the slope and duration of the adoption curve produced by the Bass diffusion model, with *p* representing the coefficient of innovation and *q* representing the coefficient of imitation. In the formula, *t* indicates the time period of the calculation, and *e* is a part of the mathematical function.

Cadmus developed initial measure *p* and *q* values by reviewing historical program data when available and conducting a literature review for emerging technologies. After assigning preliminary *p* and *q* values to measure groups, we calibrated a technology scoring matrix to those values. The technology scoring matrix allowed us to adjust the rate of adoption of specific measures for optimized potential scenarios.

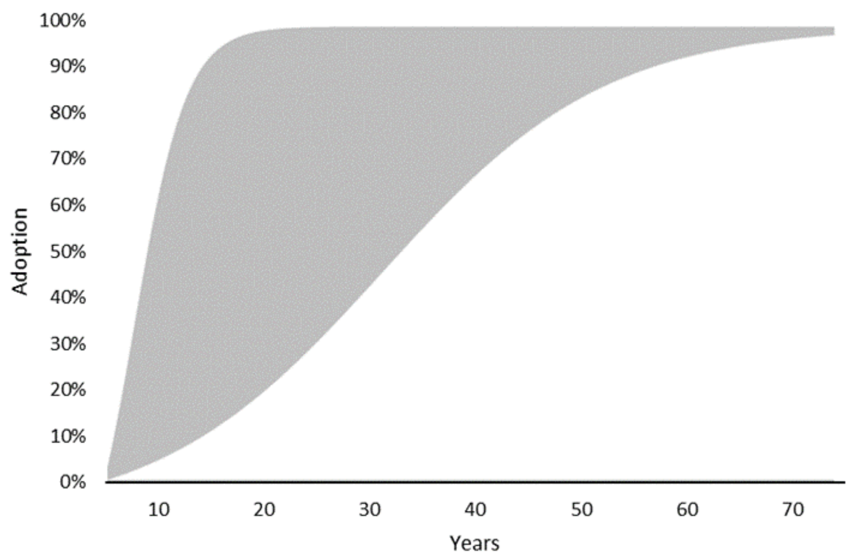
The technology scoring matrix included the following variables:

- The **customer/market acceptance attribute** captures customers' ease of adopting and willingness to adopt a measure package (not including project economics, which we addressed using the maximum adoption percentage as discussed above). For example, when a measure meets financial requirements, commercial customers may respond more quickly than multifamily customers, who must weigh the impacts of measures across many tenants. The customer scoring is intended to capture inherent differences between customer types, with the commercial sector receiving a favorable score, the single-family sector receiving a neutral score, and the multifamily sector receiving an unfavorable score.
- The ***ease of adoption attribute*** captures aspects of technologies, such as transaction costs, hassle factor, technology complexity, depth of required renovation or operational change, and ancillary benefits. For example, lighting receives a favorable score because it is a relatively simple solution to implement. Conversely, invasive shell upgrades receive an unfavorable score due to their potentially high level of intrusiveness and complexity.
- The ***barriers attribute*** captures other characteristics that limit measure adoption or are impacted by policy interventions, such as customer awareness and confidence, supply chain and workforce development, and availability of finance solutions. For example, due to workforce limitations, technologies with less mature markets face greater barriers than those with more mature markets.

Based on our initial review of program data we developed the technology group reference attributes or characteristics that captured the current state of a measure group. We scored each measure group attribute on a 5-point scale and combined these scores into a weighted score. A measure group that scores least favorably on all three attributes will use the slowest S-curve from a range of curves falling between the upper and lower bounds illustrated in Figure D-4. Conversely, a measure application that scores most favorably on all three attributes will use the fastest S-curve from Figure D-4. As noted, we calibrated the measure group attributes based on our review of historical data or other benchmarks.

We based the upper and lower limit of the S-curves range in Figure D-4 on the methodology from Technology Forecasting for Residential Energy Management Devices (Daim, Tugrul, Ibrahim Iskin, and Daniel Ho, October 2011) to analyze the pace, cost, and value of adoption and the efficiency of residential energy management technologies to develop a set of adoption curves. We assumed these adoption curves are reasonable for technology uptake for which barriers to adoption (e.g., technology complexity, customer awareness, and supply chain issues) are effectively addressed.

Figure D-4. Modeled S-Curve Range



Competition Shares

Cadmus accounted for competing equipment and fuel options by estimating the proportion of applicable buildings that will choose a distinct upgrade option (e.g., ASHP, ccASHP, ground source heat pump, efficient furnace, or standard efficiency furnace). These proportions, which are called competition shares, are calculated annually according to the following equation:

$$CompShare_{Option(i)}(t) = \frac{MaxAdopt\%_{Option(i)}(t) * BassDifAdopt\%_{Option(i)}(t)}{\sum_{i=1}^{n} MaxAdopt\%_{Option(n)}(t) * BassDifAdopt\%_{Option(n)}(t)}$$

Where:

$CompShare_{Option(i)}(t)$ = Competition share of option i at forecast year t

$MaxAdopt\%_{Option(i)}(t)$ = Maximum adoption percentage that can be achieved as a function of the project return for the equipment (option i) and at forecast year t

$BassDifAdopt\%_{Option(i)}(t$ = Result of the Bass diffusion S-curve equation for the equipment (option i) and at forecast year t

n = Number of feasible equipment alternatives to the counterfactual equipment

Competition shares for competing equipment sum to 100% across competing equipment for a given customer and end use, and equipment options with higher products of Bass diffusion adoption and maximum adoption rate in a given year outcompete equipment options with lower resultant values. For example, If Option 1 and Option 2 are competing equipment, and the products of their Bass diffusion annual adoption and max adoption rates are 45% for Option 1 and 5% for Option 2, their competition shares are $\frac{45\%}{45\%+5\%} = 90\%$ for Option 1 and $\frac{5\%}{45\%+5\%} = 10\%$ for Option 2

Measure Grouping and Research

It was not feasible to develop distinct diffusion S-curves and hurdle rates for each measure in the study. Therefore, Cadmus developed measure groups to estimate hurdle rates and S-curves. Hurdle rate estimates also vary by sector and income strata. Table D-1, Table D-2 and Table D-3 show the measure groupings for the residential, commercial, and agricultural sectors respectively. A brief narrative below each table provides further explanation.

Table D-1. Residential Measure Groups

<table>
<tr><th rowspan="3">Measure Group</th><th rowspan="3">Market Diffusion Coefficients: All segments</th><th colspan="3">Hurdle Rate: All Building Segments</th></tr>
<tr><th colspan="2">Owned-Occupied</th><th rowspan="2">Rented</th></tr>
<tr><th>Standard Income</th><th>Income Qualified</th></tr>
<tr><td>Low Cost Appliances and Lighting</td><td rowspan="7">Historical data or benchmarks</td><td colspan="2" rowspan="7">Residential Surveys</td><td rowspan="7">Commercial Surveys</td></tr>
<tr><td>Load Management Program Participation</td></tr>
<tr><td>Efficient Space or Water Heating</td></tr>
<tr><td>Large Appliances</td></tr>
<tr><td>Cooking Electrification</td></tr>
<tr><td>Space and Water Heating, and Clothes Dryer Electrification</td></tr>
<tr><td>Home retrofit</td></tr>
</table>

Table D-2 shows how Cadmus grouped the study's residential measures to develop market diffusion coefficient from Focus on Energy program data or benchmarks. Cadmus developed these groupings based on likely cost, customer attitudes about home investments or program participation, and similarity of measures in terms of maturity and type. Since there was no available data to distinguish between technology and measure adoption in the study's building and population segments, Cadmus conducted this research at the measure level.

Cadmus developed hurdle rates for each measure group with data collected through surveys. For hurdle rates, Cadmus collected data for the following population segments: standard income, income qualified, and owned. Because renters are unlikely to invest in their homes, Cadmus relied on proxy data from commercial surveys to develop hurdle rates for rented properties. Residential surveys also included several questions about the payback period required to make generic investments, specifying only a price range for projects. Cadmus used this data to sense-check results for the measure groups. The survey instruments can be found in *Appendix F*.

Table D-2. Commercial Measure Groups

<table>
<tr><th rowspan="3">Measure Group</th><th rowspan="3">Market Diffusion Coefficients: All segments</th><th colspan="3">Hurdle Rate: All Building Segments</th></tr>
<tr><th colspan="2">Owner-Occupied</th><th>Rented</th></tr>
<tr><th>Standard Business</th><th>Institutional Business</th><th>All Business</th></tr>
<tr><td>Efficient Space or Water Heating, or Large Appliances</td><td rowspan="7">Historical data or benchmarks</td><td colspan="3" rowspan="7">Commercial Surveys
(The Planning Study does not distinguish between large and small businesses. Thus, the survey controlled for businesses not needing a large system or not having sufficient revenue for high-cost upgrades).</td></tr>
<tr><td>Space or Water Heating, or Large Appliances Electrification</td></tr>
<tr><td>Cooking Equipment Electrification</td></tr>
<tr><td>Low Cost Appliances and Equipment and Lighting</td></tr>
<tr><td>Energy Management Program</td></tr>
<tr><td>Custom Project</td></tr>
<tr><td>Custom Electrification Project</td></tr>
</table>

Like for the residential sector research, Cadmus developed market diffusion coefficients by measure group, while conducting hurdle rate research via surveys for distinct business segments. As with residential sector, Cadmus developed hurdle rates for owner-occupied and rented spaces separately, and distinguished between institutional and standard businesses. The team made this distinction based on the theory that building owners have a higher incentive to achieve bill savings when they also occupy the building and with the assumption that institutions such as government buildings or schools may have distinct policies in place to reduce energy consumption.

The Planning Study does not segment the commercial building segment between large and small businesses. This means that survey respondents may be sensitive to the capital cost relative to their business income, or other factors related to business size. Cadmus controlled for business size skewing the hurdle rate results by asking survey respondents about the size of their businesses and incorporated these control questions in our analysis.

Table D-3. Agricultural Measure Groups

<table>
<tr><th></th><th>Market Diffusion Coefficients</th><th>Hurdle Rate</th></tr>
<tr><td>Agricultural System Upgrade</td><td rowspan="6">Historical data or benchmarks</td><td rowspan="6">Agricultural Surveys
(The Planning Study does not distinguish between large and small businesses. Thus, the survey controlled for businesses not needing a large system or not having sufficient revenue for high-cost upgrades).</td></tr>
<tr><td>Lighting Upgrade</td></tr>
<tr><td>HVAC or Water Heater Electrification</td></tr>
<tr><td>Efficient HVAC or Water Heater</td></tr>
<tr><td>Custom Project</td></tr>
<tr><td>Custom Electrification Project</td></tr>
</table>

For the agricultural sector we did not distinguish hurdle rates by business types. As with the residential sector we asked survey respondents about generic investments, and asked control questions about the business size.

Data Collection and Results

Cadmus conducted email surveys with 100 agricultural business owners, 300 commercial business owners, and 323 residential home owners (including 161 home owners that meet Focus on Energy's income qualification) in May 2025. The surveys asked respondents to state whether or not they would install the measure groups identified above, and how decreasing the payback period of the measure would impact their willingness to install equipment. Based on this data, Cadmus extrapolated a sensitivity curve that relates the maximum adoption percentage to payback period. The key inputs to developing this curve were the maximum market adoption percentage (100% minus the percentage of respondents who would never install a measure), the minimum market share (the percentage of respondents who would install a measure under any economic circumstances) and percentages of respondents who would adopt measures at different payback periods.

Figure D-5 through Figure D-10 show the relationship between maximum market share and payback period for measure groups and customer segments in the residential, commercial, and agricultural market sectors. This relationship was an input to simulate market adoption for optimized and program scenario potential.

Figure D-5. Residential Owned Standard Income Payback Period – Maximum Market Share Relationship

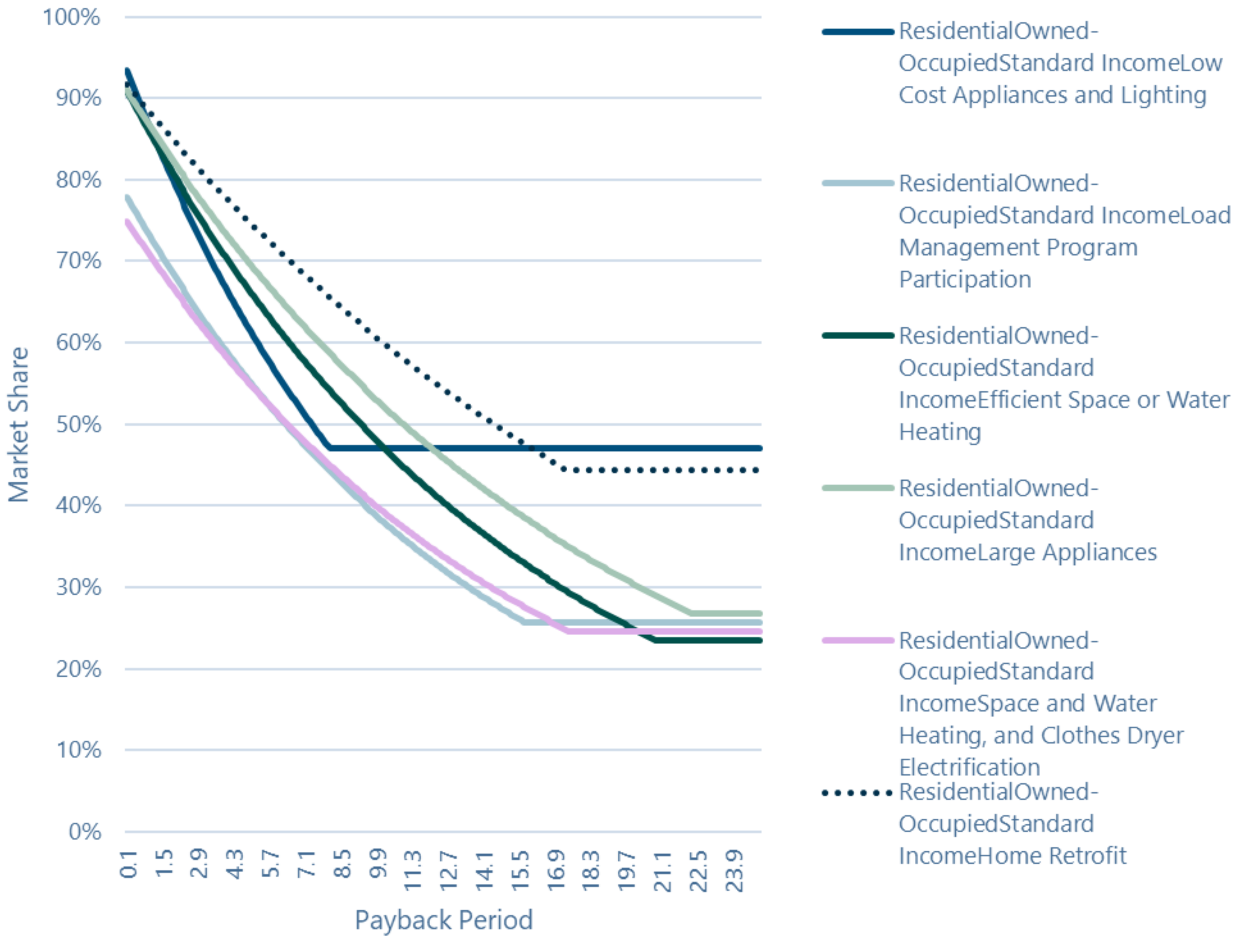


Figure D-6. Residential Owned Income-Qualified Payback Period – Maximum Market Share Relationship

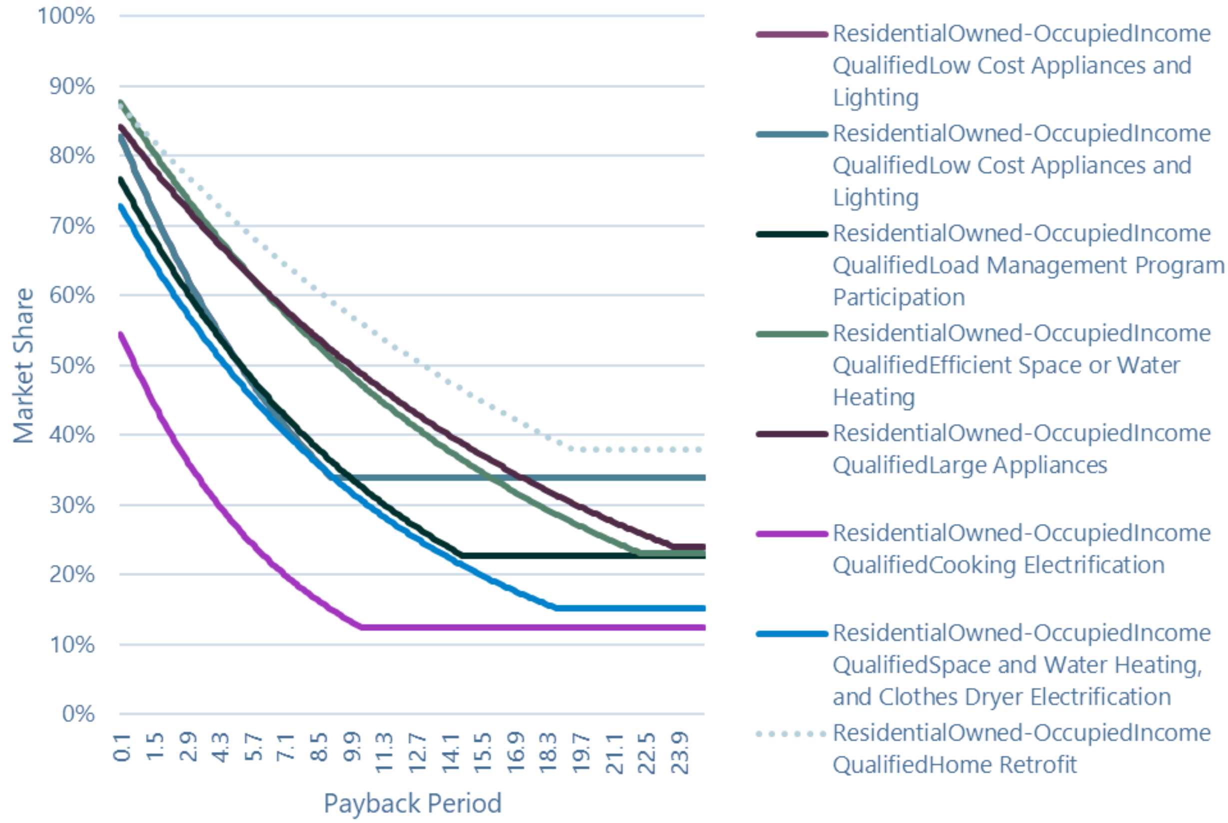


Figure D-7. Commercial Rented Payback Period – Maximum Market Share Relationship

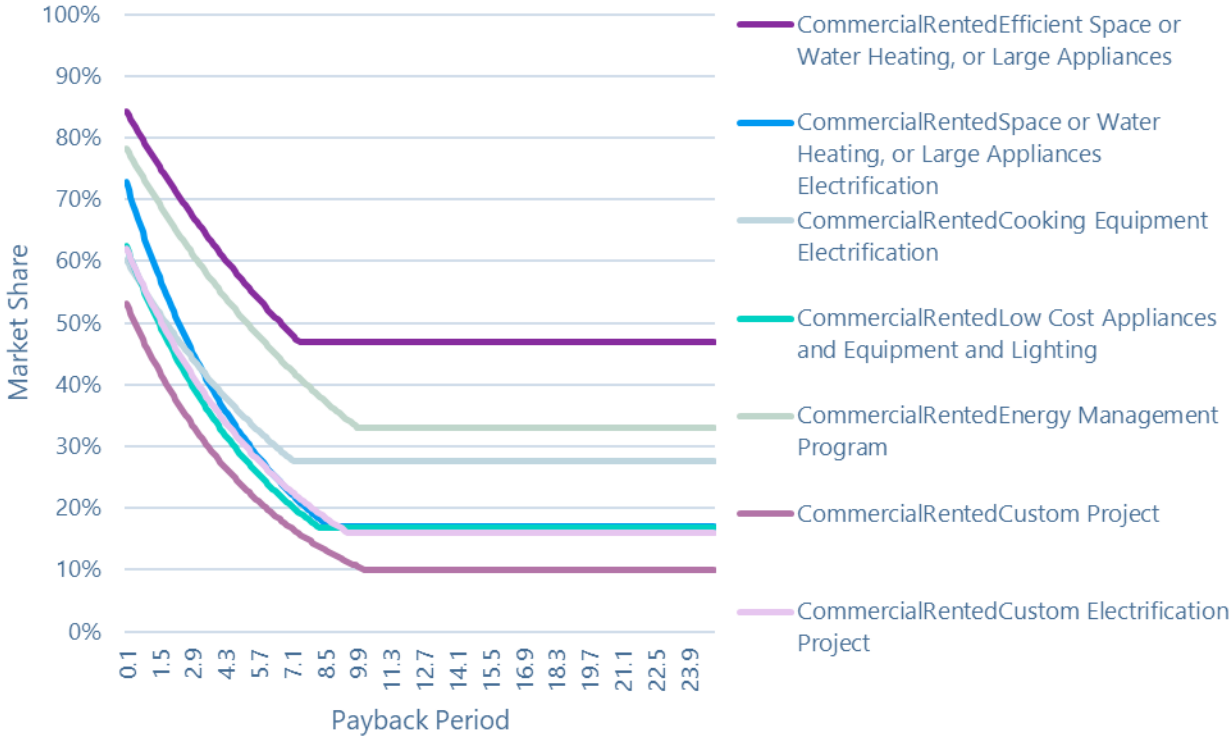


Figure D-8. Commercial Owner-Occupied Institutional Business Payback Period – Maximum Market Share Relationship

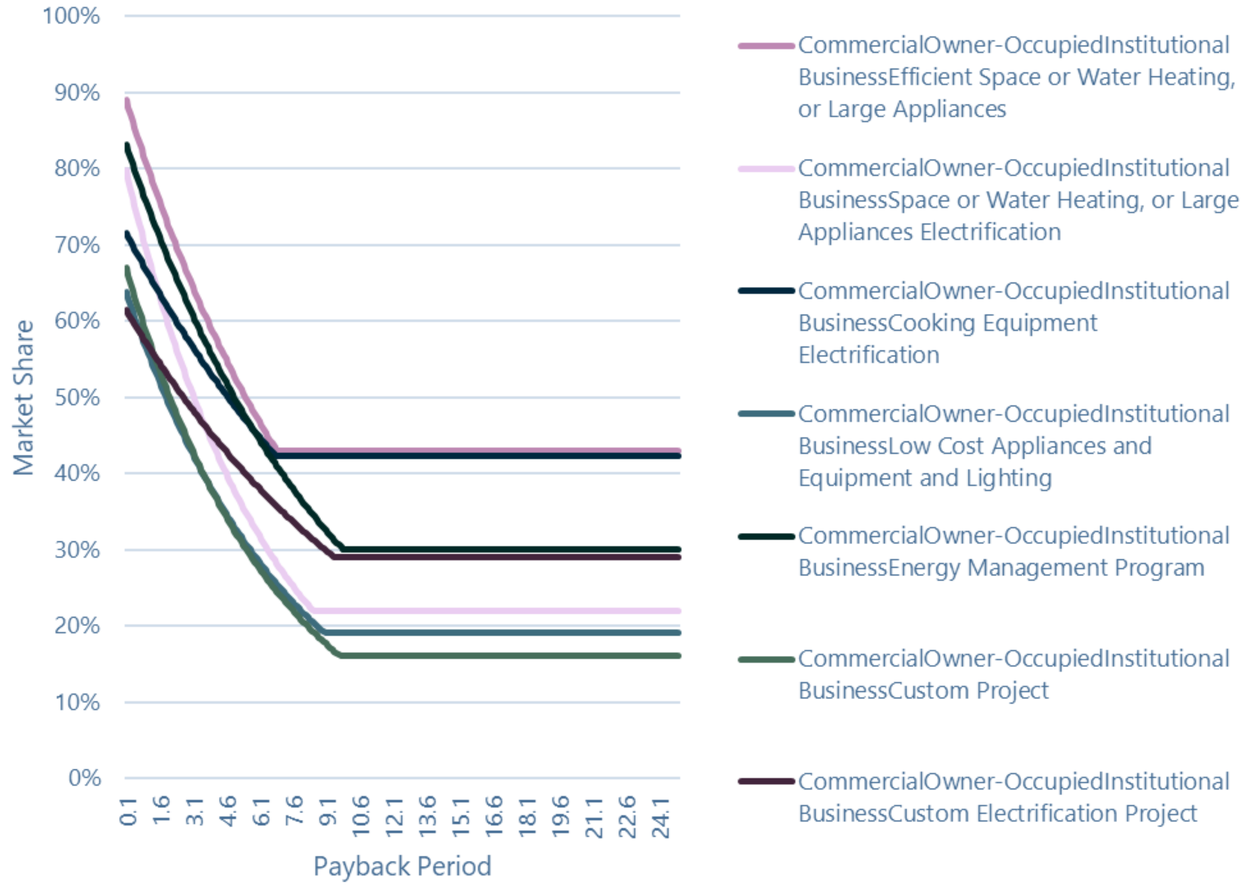


Figure D-9. Commercial Owner-Occupied Standard Business Payback Period – Maximum Market Share Relationship

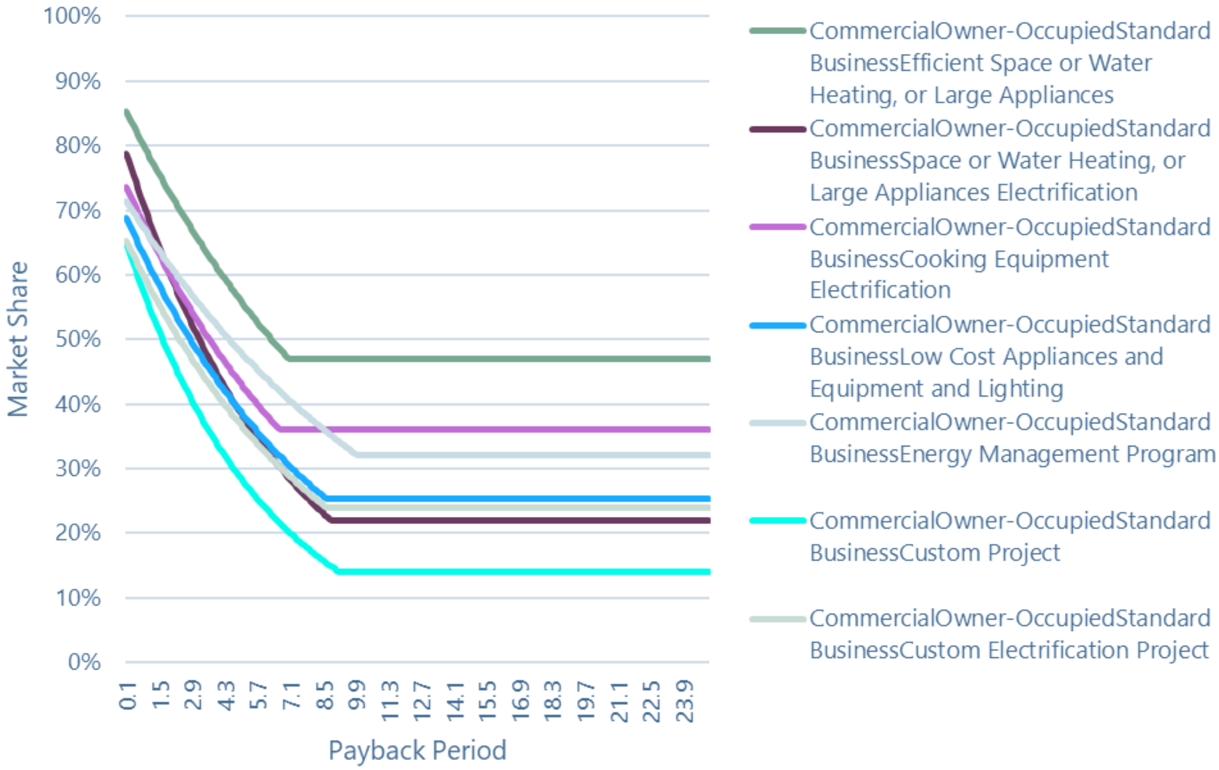
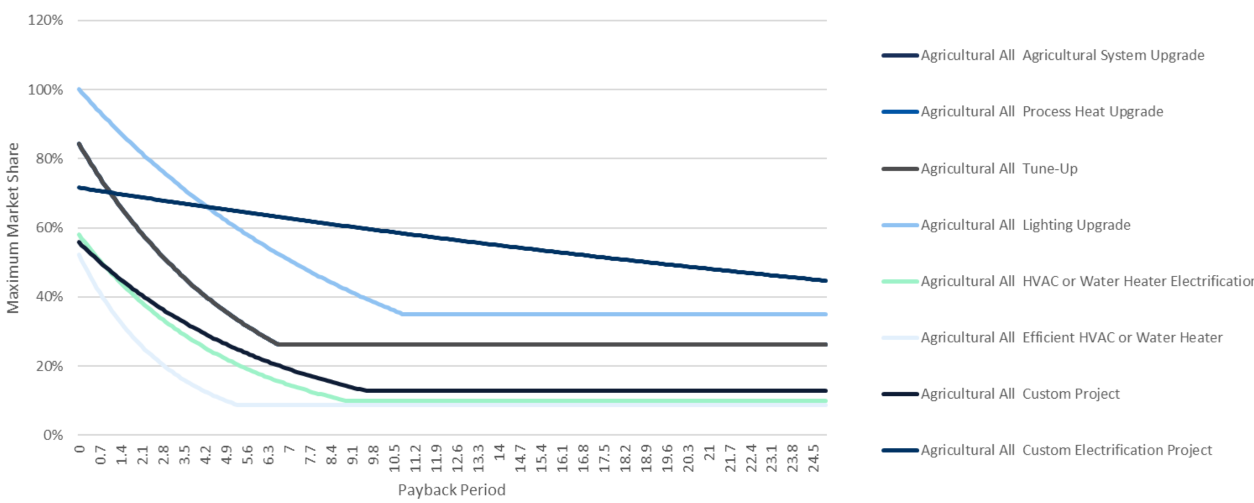


Figure D-10. Agricultural Payback Period – Maximum Market Share Relationship



Market and Measure Characterization

For this study Cadmus had to develop tens of thousands of model inputs to accurately characterize the Wisconsin building stock and study equipment and retrofit measures.

Developing Baseline Forecasts

Creating a baseline forecast required multiple data inputs to accurately characterize energy consumption in Focus on Energy's service area. Baseline forecasts included the following key inputs:

- Participating utility sales and customer forecasts
- Major customer segments (e.g., residential dwelling types, commercial business types)
- End-use saturations (percentage of an end use such as an air conditioner present in a building)
- Equipment saturations (e.g., average number of units in a building)
- Fuel shares (proportion of units using electricity versus natural gas)
- Efficiency shares (the percentage of equipment below, at, and above standard)
- Annual end-use consumption estimates by efficiency levels

Collecting Baseline Data

Data specific to Focus on Energy's service territory not only provided the basis for baseline calibration but also supported estimation of technical potential. The study included a significant effort to collect the best available primary data. Table D-4. identifies the key data sources used for each of the inputs.

Table D-4. Baseline Forecast Data Sources

Data	Residential Single-Family and Multifamily	Commercial and Government	Industrial	Agricultural
Baseline Sales and Customers	Wisconsin utilities customer databases, actual	Wisconsin utilities customer databases, actual	Wisconsin utilities customer databases, actual	Wisconsin utilities customer databases, actual
Forecasted Sales and Customers	Wisconsin utilities forecasts	Wisconsin utilities forecasts	Wisconsin utilities forecasts	Wisconsin utilities forecasts
Percentage of Sales by Building Type	Wisconsin utilities customer databases	Wisconsin utilities customer databases	Wisconsin utilities customer databases	Wisconsin utilities customer databases
End-Use Energy Consumption	Wisconsin utilities load forecasts, primary research, EIA's Residential Energy Consumption Survey (RECS), ENERGY STAR, Wisconsin Focus on Energy 2024 TRM	Wisconsin utilities load forecasts, primary research, EIA's Commercial Building Energy Consumption Survey (CBECS), ENERGY STAR, Wisconsin Focus on Energy 2024 TRM	Wisconsin utilities load forecasts, primary research, EIA's Manufacturing Energy Consumption Survey (MECS), Wisconsin Focus on Energy 2024 TRM	Wisconsin utilities load forecasts, primary research, Cadmus research, Wisconsin Focus on Energy 2024 TRM
Saturations and Fuel Shares	Primary data collection survey, Wisconsin Focus on Energy program evaluations, EIA's RECS	Primary data collection survey and virtual site visits, Wisconsin Focus on Energy program evaluations, EIA's CBECS	Primary data collection expert interviews, Industrial Assessment Center, EIA's MECS, Cadmus research	Primary data collection survey, Cadmus research
Efficiency Shares	Primary data collection survey, EIA's RECS, ENERGY STAR unit shipment reports	Primary data collection survey and Virtual Site Visits, Wisconsin Focus on Energy program evaluations, EIA's CBECS	Primary data collection expert Interviews, Industrial Assessment Center, EIA's MECS, Cadmus research	Primary data collection survey, Cadmus research

Baseline Forecast of Sales and Customers

Cadmus requested customer counts, sales (consumption), and peak demand by sector and segment, where available, from Focus on Energy participating utilities. The initial data request included these additional details:

- Data should include number of customers and weather-normalized actual electric and natural gas sales for a historical period, which served as a base year and a forecast period.
- Forecast sales should be absent energy efficiency to avoid double-counting savings.
- These customer data should represent the number of buildings or dwellings but accounts and premises can be used as a proxy where available and necessary.
- Utility forecasts should reflect customers in Wisconsin only.

The following Focus on Energy participating utilities provided data on actual and forecasted sales and on customers by sector:

- Madison Gas and Electric
- WE Energies
- WPPI Energy
- Northern States Power – Wisconsin (Xcel Energy)
- Manitowoc Public Utilities
- Wisconsin Power and Light (Alliant Energy)
- Wisconsin Public Service

Once Cadmus received all the customer counts and sales from the base year, we compared the information to the U.S. Energy Information Administration (EIA) Form 861 and 176 data for reasonableness and adjusted the sales and customer forecasts for the remaining share of Focus on Energy participating utilities from which no data were received. Cadmus then calibrated each sector and fuel type model to match the segmented utility load and sales forecasts. Prior to estimating technical potential, Cadmus also adjusted the load and sales forecasts to account for future federal standards to avoid double-counting the savings from these end uses.

End-Use Energy Consumption

The per-unit end-use energy consumption—sometimes called *unit energy consumption* for a residential forecast and *energy-use intensity* for a commercial forecast—provides a crucial input for end-use forecasts. Industry studies have derived this consumption using a variety of methods, including statistical methods (e.g., conditional demand modeling), physics-based building simulation models (e.g., the U.S. Department of Energy's [DOE] EnergyPlus model), and simple algorithms (e.g., ENERGY STAR calculators).

Cadmus drew from several resources to estimate the end-use energy consumption for each sector, segment, and fuel type combination in the study. We prioritized data from primary research—either virtual site visits or surveys—before relying on secondary data sources. Using primary data from Wisconsin data sources allows for better baseline energy use estimates and ensured that results were based upon local data sources, when possible. Using local data sources improves the potential savings estimates compared with relying on regional or national data for end-use energy consumption.

Saturations and Fuel Shares

To produce a bottom-up, end-use forecast, Cadmus first determined how many units of each end use would be found in a typical home. End-use saturations represent the average number of units in a home, and fuel shares represent the proportion of those units using electricity versus natural gas. For instance, on average, a typical home has 0.9 clothes dryers (the saturation), and 85% of these units are electric (the fuel share).[22]

End-use saturations represent the average number of units in a home.

Fuel shares represent the proportion of those units using electricity versus natural gas.

Efficiency Shares

Efficiency shares equal the current saturation of a specific type of equipment (of varying efficiency). Within an end use, these shares sum to 100%. For instance, the efficiency shares for a central air conditioning end use may be 50% SEER 13, 25% SEER 15, and 25% SEER 16.

End-use Consumption Estimates

Prior to estimating the technical potential of electric and natural gas energy efficiency measures, Cadmus developed annual end-use consumption estimates for each fuel type, sector, and segment. This equation specified the forecast for each end use in the study:

$$EUSE_{ij} = \Sigma_{e} ACCTS_{i} * UPA_{i} * SAT_{ij} * FSH_{ij} * ESH_{ije} * EUI_{ije}$$

Where:

EUSEij	=	Total energy consumption for end use j in customer segment i
ACCTSi	=	The number of accounts/customers in segment i
UPAi	=	The units per account in customer segment i
SATij	=	The share of customers in customer segment I with end use j
FSHij	=	The share associated with electric or natural gas in end use j in customer segment i
ESHije	=	The market share of efficiency level e in the equipment for customer segment ij
EUIije	=	End-use intensity or unit energy consumption for the equipment configuration ije

Each end-use forecast was summed within each segment, sector, and fuel type combination to determine the overall sales forecast.

Measure Characterization

Cadmus developed a comprehensive measure database of technical and market data that applied to all end uses in various market segments, and estimated costs, savings, and applicability for a comprehensive set of energy efficiency measures. Through this process, measure savings were calculated as unit energy

22 Saturations are less than 1.0 when some homes do not have the end use.

savings or measure percentage savings to estimate the end-use present savings. These measure end-use percentage savings produced estimates of energy efficiency potential when applied to the baseline end-use forecast.

Cadmus developed an initial list of measures for a database from the following sources:

- Measures included in the Wisconsin Focus on Energy's 2024 TRM
- Measures currently included in the Focus on Energy's prescriptive programs and selective SPECTRUM custom measures
- Efficiency tiers from the Consortium for Energy Efficiency and ENERGY STAR
- Measures from Cadmus' extensive database, including measures in regional or national databases (e.g., California Database for Energy Efficient Resources [DEER][23]) and TRMs
- Selected emerging technologies and behavioral measures

Residential emerging technologies examined in this study included the following:

- Cold climate heat pumps
- CO2 heat pump water heaters
- Heat pump dryers
- Smart Wi-Fi water heater controller
- Specialty framing (insulating concrete forms/structural insulated panels)

Nonresidential emerging technologies included the following:

- Active chilled beam cooling with dedicated outdoor air system
- Advanced lighting and controls design
- Boiler oxygen trim controls
- Cold climate heat pumps
- Continuous commissioning
- CO2 heat pump water heaters
- Natural ventilation design for new construction
- Spring-loaded garage door hinges
- Ultra-low temperature freezers with sterling engine

Cadmus focused on emerging technologies approaching commercialization or that may become cost-effective within the next five years.

Upon identifying measures, Cadmus compiled all inputs required to estimate potential. Table D-5 shows key inputs and possible data sources. Virtual site visits and surveys were designed to collect information on key measures, and data were supplemented for other measures by the other sources.

---

23 California Energy Commission Database for Energy Efficient Resources. http://www.deeresources.com/

Table D-5. Key Measure Data Sources

Input	Residential Single-Family and Multifamily	Commercial and Government	Industrial	Agricultural
Energy Savings	Primary data collection survey, Wisconsin Focus on Energy program evaluations, Wisconsin Focus on Energy 2024 TRM, ENERGY STAR, U.S. DOE/EERE,[1] Regional Technical Forum, Cadmus research	Primary data collection survey and virtual site visits, Wisconsin Focus on Energy program evaluations, Wisconsin Focus on Energy 2024 TRM, CBECS 2012 Microdata, ENERGY STAR, DEER, DOE/EERE, Regional Technical Forum, Cadmus research	Primary data collection expert interviews, Wisconsin Focus on Energy program evaluations, Wisconsin Focus on Energy 2024 TRM, DOE's Industrial Assessment Center Database, Industrial Savings Potential Project (ISPP), Northwest Power and Conservation Council (NWPCC) industrial data, Cadmus research	Primary data collection survey, Wisconsin Focus on Energy program evaluations, Wisconsin Focus on Energy 2024 TRM, Regional Technical Forum, Cadmus research
Equipment and Labor Costs	Wisconsin Focus on Energy 2024 TRM, Wisconsin Focus on Energy program evaluations, National Residential Efficiency Measures Database,[2] RSMeans,[3] ENERGY STAR, DOE/EERE, DEER, Regional Technical Forum, incremental cost studies, online retailers, Cadmus research, SPECTRUM cost data	Wisconsin Focus on Energy 2024 TRM, Wisconsin Focus on Energy Program Evaluations, RSMeans, ENERGY STAR, DOE/EERE, DEER, Regional Technical Forum, Incremental Cost Studies, online retailers, Cadmus research, SPECTRUM cost data	Wisconsin Focus on Energy 2024 TRM, Wisconsin Focus on Energy program evaluations, DOE's IAC Database, ISPP, NWPCC industrial data, Cadmus research, SPECTRUM cost data	Wisconsin Focus on Energy 2024 TRM, Wisconsin Focus on Energy program evaluations, RSMeans, ENERGY STAR, DOE/EERE, DEER, Regional Technical Forum, incremental cost studies, online retailers, Cadmus research, SPECTRUM cost data
Measure Life	Wisconsin Focus on Energy 2024 TRM, Wisconsin Focus on Energy program evaluations, ENERGY STAR, DEER, Cadmus research	Wisconsin Focus on Energy 2024 TRM, Wisconsin Focus on Energy program evaluations, ENERGY STAR, DEER, Cadmus research	Wisconsin Focus on Energy 2024 TRM, Wisconsin Focus on Energy program evaluations, DOE's Industrial Technologies Program, DEER, NWPCC industrial data, Cadmus research	Wisconsin Focus on Energy 2024 TRM, Wisconsin Focus on Energy program evaluations, ENERGY STAR, DEER, Cadmus research
Technical Feasibility	Primary data collection survey, Cadmus research	Primary data collection survey and virtual site visits, Cadmus research	Primary data collection expert interviews, Wisconsin Focus on Energy program evaluations, NWPCC industrial data, Cadmus research	Primary data collection survey, Cadmus research
Percentage Incomplete	Primary data collection survey, Wisconsin Focus on Energy program accomplishments, RECS, Cadmus research	Primary data collection survey and virtual site visits, Wisconsin Focus on Energy program accomplishments, Cadmus research	Primary data collection expert interviews, Wisconsin Focus on Energy Program accomplishments, Cadmus research	Primary data collection survey, Wisconsin Focus on Energy program accomplishments, Cadmus research

[1] Department of Energy Office of Energy Efficiency and Renewable Energy (EERE). http://energy.gov/eere/office-energy-efficiency-renewable-energy

[2] National Renewable Energy Laboratory National Residential Efficiency Measures Database. https://remdb.nrel.gov/

[3] RSMeans Cost Data. https://www.rsmeans.com/products/online

Energy Savings and Measure Interactions

Cadmus relied on the following sources to develop savings estimates:

- **2024 and 2025 Data: Wisconsin Focus on Energy's most recent program evaluations and program data.** Program evaluations can inform estimates of energy savings, and many program evaluations use engineering algorithms (such as those found in TRMs), metering data, billing analyses, or building simulations to estimate savings for energy efficiency measures. Also included were any program data from implementation contractors (e.g., reports, work papers, impact calculations).
- **2024 and 2025 Data: Wisconsin Focus on Energy 2024 TRM.** The TRM was used as the primary method to calculate the estimate per-unit energy savings for a variety of measures. Cadmus supplemented default TRM values with primary data when possible.
- **2024 and 2025 Data: DOE Uniform Methods Project or other standard evaluation protocols.** The Uniform Methods Project defined standard calculations used to estimate energy savings for a number of measures. Cadmus' savings calculations were consistent with such industry standards.
- **2024 and 2025 Data: ENERGY STAR Calculators.** U.S. Environmental Protection Agency (EPA) ENERGY STAR calculators provided estimates of per-unit savings for a number of measures, including efficient appliances (e.g., refrigerators, freezers, clothes washers) and efficient home electronics (e.g., televisions, computers, monitors).
- **2024 and 2025 Data: DOE/EERE technical support documents.** DOE included estimates of equipment energy consumption in its technical support documents for a number of different types of energy-efficient equipment.
- **2020 Data: Survey and virtual site visits for the 2021 potential study.** Primary data collection involved virtual site visits and surveys in the commercial sector and surveys in the residential and agriculture sectors. For the industrial sector, expert interviews were conducted rather than surveys or virtual site visits. Primary data provided comprehensive information on building characteristics, energy-consuming end uses, and equipment efficiencies.

Equipment and Labor Costs

Cadmus estimated equipment and labor costs for each energy efficiency measure and used these costs to calculate benefit-cost ratios and to estimate potential program expenditures. Cadmus relied on a number of sources in developing cost estimates:

- **2024 and 2025 Data: Wisconsin Focus on Energy 2024 TRM.** The TRM provided estimates of per-unit costs for a variety of measures as part of the incremental cost database. When possible, Cadmus supplemented default TRM values with primary data. In some cases, secondary data were used due to differences in measure definitions between the TRM and the Planning Study.
- 2024 and 2025 Data: Wisconsin Focus on Energy's most recent program evaluations and program data. When applicable, Cadmus used Focus on Energy equipment cost data from program data.
- 2024 and 2025 Data: National Renewable Energy Laboratory (NREL) National Residential Efficiency Measures Database. NREL maintains a detailed, up-to-date dataset of measure costs for a number of energy efficiency measures.

- **2024 and 2025 Data: RSMeans.** RSMeans provided construction cost data, including costs for a number of home retrofits (e.g., weatherization, windows, other shell upgrades). Cadmus used data from RSMeans Online, the most recent version.
- **2024 and 2025 Data: ENERGY STAR.** EPA provided current equipment costs for a number of ENERGY STAR–rated units.
- **2024 and 2025 Data: DOE/EERE technical support documents.** DOE included estimates of equipment and labor costs in its technical support documents for a number of different types of energy-efficient equipment.
- **2024 and 2025 Data: Incremental cost studies.** TRMs often require incremental cost studies that show baseline and efficiency measure costs (e.g., labor, equipment, O&M) and states frequently update these studies to incorporate the most recent cost data. These studies included the measures most commonly offered through utility-sponsored energy efficiency programs.
- **2024 and 2025 Data: Online retailers.** Cadmus staff continuously reviewed prices listed on manufacturer or retailer websites. Though online retailers may not provide estimates of installation (labor) or annual O&M costs, they provide reliable equipment costs.
- **2024 and 2025 Data: Focus on Energy SPECTRUM cost data.** The database contained project costs, mainly for custom projects and measures. Most data represented full costs in the database and could be used only for certain measures.

Measure Life

Cadmus used estimates of each measure's EUL to calculate the lifetime net present value (NPV) benefits and costs for each measure. Many data sources for measure savings and costs (described above) also provided estimates for measure lifetimes.

Cadmus relied on the following sources to develop measure life estimates:

- Wisconsin Focus on Energy 2024 TRM, which includes the results of a comprehensive review conducted by Cadmus in 2021 of measure lifetimes for all active Focus on Energy measures
- NREL's National Residential Efficiency Measures Database
- EUL studies, including the Northeast Energy Efficiency Partnership's 2016 EUL study or EULs derived by the Association of Home Appliance Manufacturers.[24]
- ENERGY STAR
- DOE/EERE technical support documents
- Regional TRMs

Technical Feasibility

Technical feasibility factors represented the percentage of homes or buildings that could feasibly install an energy efficiency measure. Technical limitations included equipment capability or space limitations. For

---

[24] Northwest Energy Efficiency Partnerships. "NEEP Load Shape Research and Data." Accessed July 2025: https://neep.org/loadshape-report-and-catalogue

example, solar water heaters could not be feasibly installed in all buildings, given some buildings did not have the required roof orientation and pitch. Cadmus relied on a number of sources to develop feasibility estimates:

- **Surveys and virtual site visit.** Cadmus collected data about building characteristics that could inform estimates of technical feasibility. For instance, some water heaters located in small spaces reduced the feasibility of installing a heat pump water heater, which would require airflow above that of a standard water heater.
- **Stock assessments and surveys (e.g., EIA's RECS and CBECS).** These assessments included building characteristics that could inform estimates of technical feasibility. For instance, some floor insulation measures required a basement or a crawlspace; using EIA's RECS, Cadmus could determine the proportion of homes with a basement or crawlspace and that could, therefore, feasibly install this measure.
- **Energy efficiency program evaluations.** Some energy efficiency program evaluations included research to identify technical barriers to installing energy efficiency measures.
- **Power plans and other potential studies.** Regional potential studies, such as the Northwest Power and Conservation Council's Seventh Power Plan,[25] provided estimates of the technical feasibility for common energy efficiency measures.
- **Cadmus research, third-party research (including the Federal Energy Management Program, DOE, or Toolbase.org).** Various third-party measure characterization reports identified technical limitations for energy efficiency measures. Cadmus used these assessments to estimate the proportion of homes or businesses that could feasibly install each measure. In some instances, Cadmus' engineering judgment was used to proximate technical constraints.

Percentage Incomplete

Percentage incomplete factors represent the percentage of remaining homes or businesses yet to install an energy efficiency measure. This equals one minus the current saturation of energy efficiency measures. The study had to account for Wisconsin Focus on Energy's program accomplishments, building energy codes and standards, and the natural adoption of efficiency measures, so Cadmus relied on these sources to develop percentage incomplete estimates:

- Wisconsin Focus on Energy's most recent program evaluations and program data
- Recent stock assessments and surveys (e.g., U.S. EIA's RECS and CBECS)
- ENERGY STAR reports
- DOE/EERE technical support documents

Compiling Energy Efficiency Technology Measure Database

After creating a list of electric and gas energy efficiency measures applicable to Focus on Energy's service territory, Cadmus classified energy efficiency measures into these two categories:

25 Northwest Power Planning Council. "Power Planning." Accessed July 2025: https://www.nwcouncil.org/energy/7th-northwest-power-plan/about-seventh-power-plan

- **High-efficiency equipment measures.** These measures directly affected end-use equipment (e.g., high-efficiency central air conditioners) that followed normal replacement patterns and were based on EULs.
- Non-equipment measures (retrofit). These measures affected end-use consumption without replacing end-use equipment (e.g., insulation). Such measures did not include timing constraints from equipment turnover (except for new construction) and therefore should be considered discretionary (i.e., savings could be acquired at any point over the planning horizon).

This study assumed that all high-efficiency equipment measures would be installed at the end of the existing equipment's remaining useful life; therefore, Cadmus did not assess energy efficiency potential for early replacement.

Many measures naturally turn over within the study horizon, and long-run technical potential from early replacement measures equals savings from replace-on-burnout measures. However, early replacement measure costs are much higher than replace-on-burnout measure costs because the former reflect the full measure cost, not incremental costs. The economic potential, therefore, depends on the allocation of early replacement and replace-on-burnout measures. Including these early replacement measures would contribute to estimates of technical and economic potential inconsistent with their definitions.[26]

Early replacement, however, could be considered in estimating program potential. Short-run savings from early replacement measures could exceed savings from replace-on-burnout iterations as early replacement savings would be calculated using a below-standard baseline. Because this study did not include program potential, Cadmus excluded early replacement measures from the analysis.

Following is a list of relevant inputs for each measure type:

Equipment and non-equipment measures:

- Technical feasibility—the percentage of buildings where customers could install this measure, accounting for physical constraints
- Energy savings—average annual savings attributable to installing the measure, in absolute and/or percentage terms
- Equipment cost—full or incremental, depending on the nature of the measure and the application
- Labor cost—the expense of installing the measure, accounting for differences in labor rates by region, urban versus rural areas, and other variables
- Measure life—the expected life of the measure's equipment

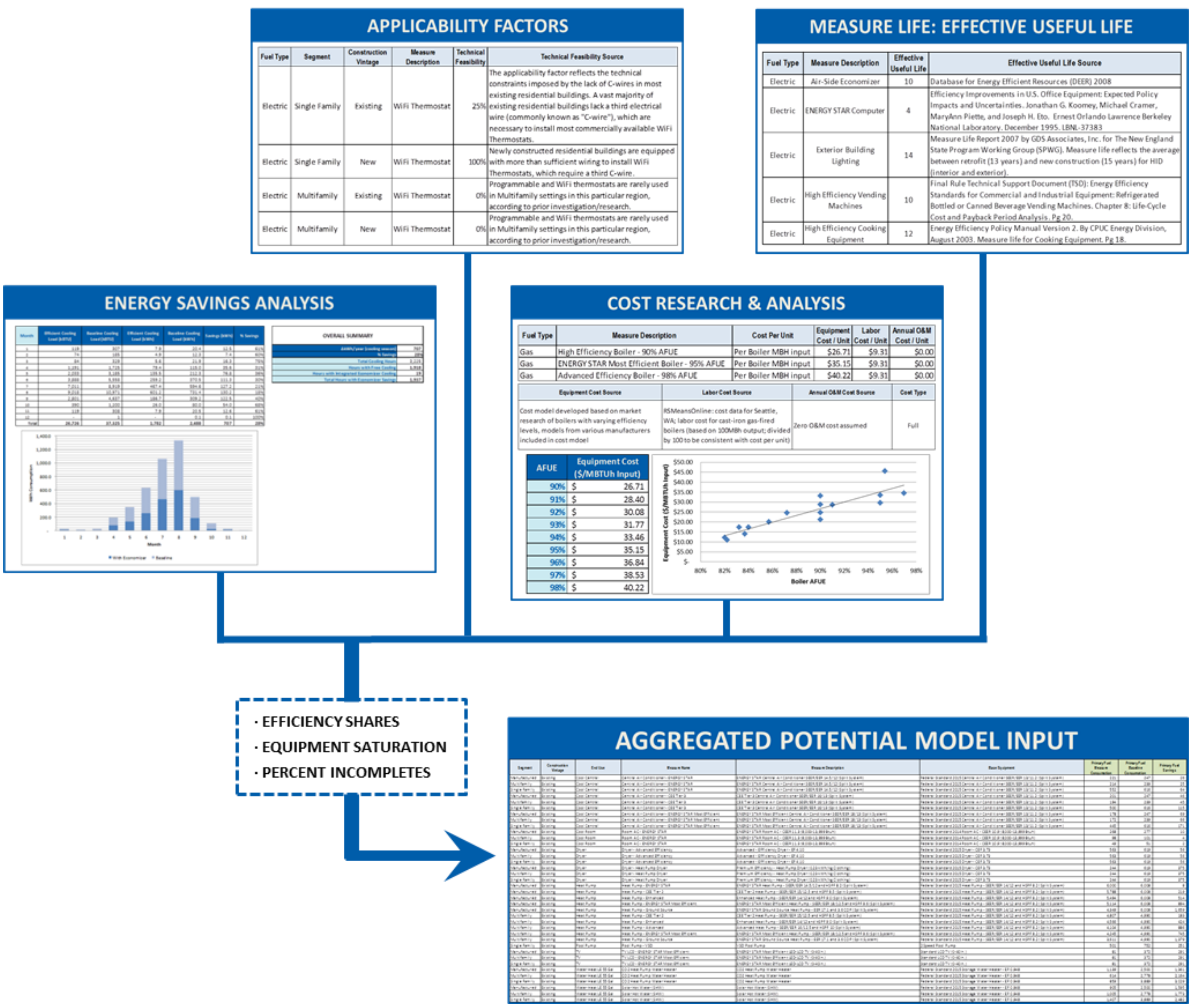
[26] Cadmus considered refrigerator, freezer, and room air conditioner recycling to estimate savings associated with the removal of below-standard secondary units. These measures, however, could not be considered "early replacement" as they did not assume secondary units would be replaced with efficient units.

Non-equipment measures only:

- Percentage incomplete—the percentage of buildings in which customers had not installed the measure, but where, technically, it could be feasibly installed
- Measure competition—for mutually exclusive measures, accounting for the percentage of each measure likely installed to avoid double-counting savings (e.g., 1.5 GPM and 2.0 GPM showerheads cannot both be installed in the same showerhead socket; therefore, only one permutation could possibly be installed depending on technical feasibility for technical potential and technical feasibility and cost-effectiveness for economic potential)

Underlying measure assumptions and analysis were characterized in Excel workbooks (by measure), as shown in Figure D-11. The measure workbooks contained detailed saving calculations, cost research, EUL data, applicability factor values, and measure assumptions as well as well-documented source descriptions. Cadmus aggregated all measure data into a final master input file for use in the potential model.

Figure D-11. Example of Measure Technical Workbooks



Incorporating Codes and Standards

Cadmus' assessment accounted for changes in codes and standards over the planning horizon. These changes affected customers' energy-consumption patterns and behaviors and determined which energy efficiency measures would continue to produce energy savings over minimum requirements. Cadmus captured current efficiency requirements, including those enacted but not yet in effect. For the residential state energy code, this study used Wisconsin's Uniform Dwelling Code SPS 320-325. For the commercial and government energy code, this study used the International Energy Conservation Code, 2015 edition, with amendments found in SPS 361.05, which was in place while Cadmus conducted analysis for this study. Wisconsin has now adopted a more efficient energy code.

Cadmus did not attempt to predict how federal standards might change in the future. Rather, the study factored in only the legislation already enacted.

Cadmus explicitly accounted for several other pending federal standards. Table D-6. and Table D-7 list recent enacted or pending equipment standards that are accounted for in this study's commercial and residential sectors for electric and gas end uses. For measures where a future standard would have a higher efficiency than a current standard market practice baseline, Cadmus adjusted the baseline to the new federal standard.

Table D-6. Current and Pending Electric Standards by End Use

Equipment Electric Type	Existing (Baseline) Standard	New Standard	Sectors Impacted	Study Effective Year
Appliances				
Clothes dryer	Federal standard 2015	Federal standard 2029	Residential	2029
Clothes washer	Federal standard 2018	Federal standard 2029	Residential	2029
Dishwasher	Federal standard 2014	Federal standard 2028	Residential	2028
Freezer	Federal standard 2015	Federal standard 2029 and 2030	Residential	2029
Refrigerator	Federal standard 2015	Federal standard 2029 and 2030	Residential	2029
HVAC				
Room air conditioner	Federal standard 2015	Federal standard 2027	Nonresidential/ Residential	2027
Small, large, and very large commercial air conditioners and heat pumps	Federal standard 2023	Federal standard 2029	Nonresidential	2029
Water Heat				
Water heater	Federal standard 2015	Federal standard 2030	Nonresidential/ Residential	2030

Table D-7. Current and Pending Gas Standards by End Use

Equipment Gas Type	Existing (Baseline) Standard	New Standard	Sectors Impacted	Study Effective Year
Appliances				
Clothes dryer	Federal standard 2015	Federal standard 2029	Residential	2029
Other				
Pool heater	Federal standard 2014	Federal standard 2029	Nonresidential/ Residential	2029
Water Heat				
Water heater	Federal standard 2015	Federal standard 2030	Nonresidential/ Residential	2030

Cadmus also incorporated other standards that, prior to 2025, have become effective for equipment:

- Commercial ice maker (2018)
- Commercial boilers (2023)
- Commercial package terminal air conditioners (2017)
- Commercial package terminal heat pumps (2013)
- Commercial packaged rooftop outdoor units (2023)
- Commercial refrigeration equipment (2017)
- Commercial single package three phase air conditioners and heat pumps (2017)
- Cooking ovens and ranges (2012)
- Dehumidifiers (2019)
- Faucet aerators (1994)
- General service fluorescent lamps (2018)
- General service screw-based lamps (2023)
- Metal halide lamp fixtures (2017)
- Motors (2019)
- Pool pumps (2022)
- Residential boilers (2016) [27]
- Residential central air conditioners (2023)
- Residential centrally ducted heat pumps (2023)
- Residential furnaces (2016) 20
- Residential furnace fans (2019)
- Showerheads (1994)
- Walk-in cooler and freezer (2017)

Naturally Occurring Conservation

Cadmus' baseline forecast included naturally occurring conservation, which refers to reductions in energy use that occur due to normal market forces (e.g., technological change and changes in energy prices) and improved energy codes and standards. These impacts resulted in changed baseline sales, from which Cadmus could estimate technical and achievable technical potential.

This analysis accounted for naturally occurring conservation in three ways:

[27] The Wisconsin residential Uniform Dwelling Code (UDC) requires a minimum boiler and furnace Annual Fuel Utilization Efficiency (AFUE) of 90%, which exceeds the boiler federal standard 2021 requirements of 84% AFUE and the furnace federal standard 2016 requirements of 80% AFUE. The Wisconsin residential UDC requirement of 90% AFUE was used in place of these federal standard at the start of the study.

- The potential associated with certain energy-efficient measures assumed a natural adoption rate, net of current saturation. For example, total potential savings associated with ENERGY STAR appliances account for current trends in customer adoption. As such, the baseline energy forecast reflected the total technical savings potential from ENERGY STAR appliances.
- The assessment accounted for gradual increases in efficiency due to retirement of older equipment in existing buildings, followed by replacement with units meeting or exceeding minimum standards at the time of replacement.
- The assessment accounted for pending improvements to equipment efficiency standards that will take effect during the planning horizon, as discussed above; however, the assessment did not forecast changes to standards yet to be passed.

Industrial Potential Modeling Approach

To estimate the adoption and load impacts from industrial energy efficiency and electrification technologies for the Quad V Focus on Energy Planning Study, Cadmus developed a hybrid model that incorporates historical customer energy consumption data and energy efficiency program participation data, as well as top-down assumptions about industrial facilities' energy use.

Cadmus used this hybrid model to help manage the industrial sector's unique challenges:

- Highly customized equipment
- Interventions customized to the industrial equipment
- Implementation of costly equipment and retrofits and disruption of operations
- Long lifespans of existing industrial equipment

Modeling Approach Overview

Cadmus estimated an end-use forecast, as well as technical, economic, optimized, and program scenario energy efficiency and electrification potential. To develop these estimates, we followed the steps below:

1. Classified the industrial customers into manufacturing sectors based on facility type and size, using industrial customer data obtained from Wisconsin utilities.
2. Within a given manufacturing sector, segmented energy use by end-use based on manufacturing-sector-specific secondary data and interview feedback from industrial customers within that manufacturing sector (targeting 20 total interviews with subject-matter experts).
3. Developed a forecast of industrial end-use energy consumption based on utility forecasts and the results of steps 1 and 2.
4. Characterized industrial measures based on Focus on Energy program data, secondary data, and interviews, expressing the energy impact of measures as a percentage of industrial end-use energy consumption.
5. Developed adoption scenarios and simulated energy efficiency and electrification measure adoption for optimized and program scenario potential using input from customer interviews and leveraging adoption curves from the Northwest Power Council.

6. Applied measure energy impacts to industrial end-use load based on measure adoption simulations to predict energy impacts.

Cadmus used this approach to estimate technical, economic, and optimized potential, as defined below:

- **Technical potential:** The total technically feasible energy impacts (not accounting for market barriers and industry decisions).
- **Economic potential:** The portion of technical potential that passes a cost-effectiveness screen.
- **Optimized potential:** The simulated adoption of study measures.

Figure D-12 depicts Cadmus' approach to modeling energy impacts in the industrial sector.

Figure D-12. Approach to Modeling Industrial Potential

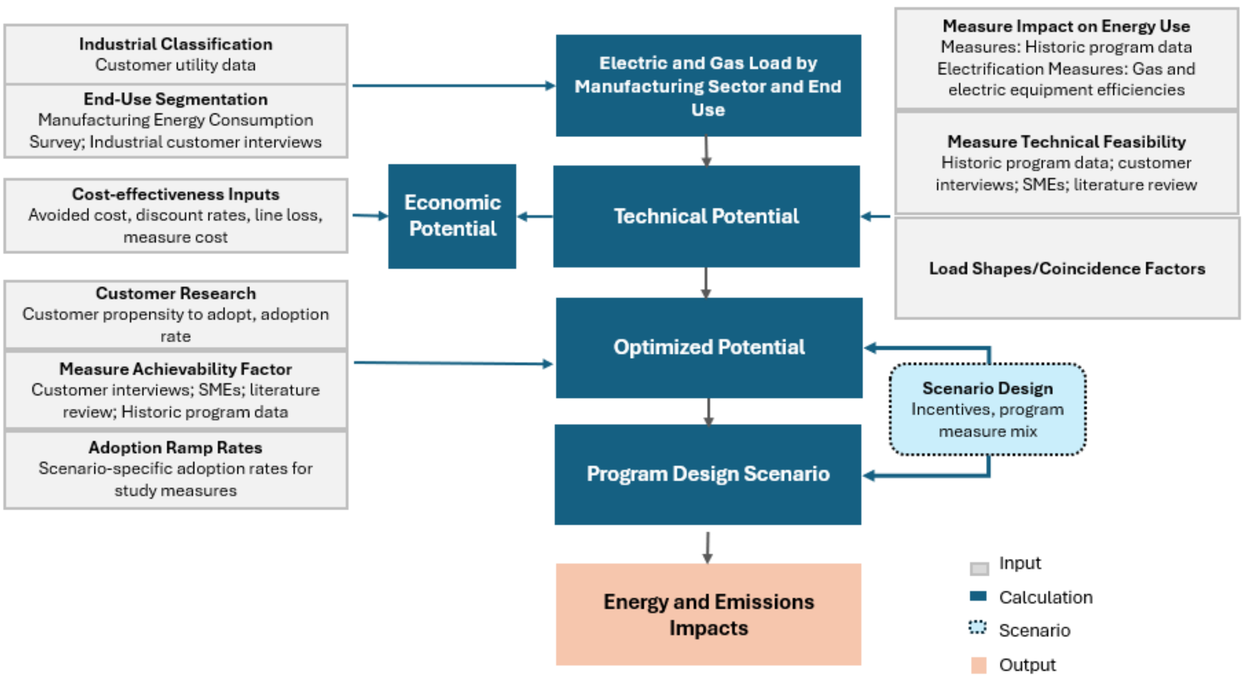


Table D-8 shows key modeling inputs for the industrial analysis. Cadmus reviewed modeling inputs and assumptions with Focus on Energy staff and Wisconsin industrial experts in *ad hoc* meetings.

Table D-8. Key Components of Industrial Potential Model

Characterization Component	Modeling Inputs	Primary Data Sources
Industry Classification	• Industrial customer gas and electric data • Large industrial customers list	• Wisconsin utility customer data • Wisconsin utility large energy user list filings with Wisconsin Public Service Commission (PSC)
End-Use Segmentation	• Industrial segment gas and electric load characterization	• Wisconsin utility customer data • EIA MECS
Energy Efficiency Measure Characterization	• Measure gas and electric savings • Measure saturation	• Historical Focus on Energy industrial program data, industrial segment gas and electric load characterization, industrial customer interviews
Electrification Measure Characterization	• Measure electrification impacts • Gas equipment efficiency • Electric equipment efficiency • Technical feasibility of electrification measure • Measure achievability factor • Measure costs	• Interviews with 20 industrial facilities • DOE Industrial Assessment Center's database • Literature review of publications from the ACEEE, Regional Technical Forum, and others • Research from national labs such as National Renewable Energy Laboratory • Wisconsin TRM • Historical program data
Adoption Rates	• Scenario-specific measure adoption rates	• Northwest Power and Conservation Council • Study stakeholder and expert input

Industrial End-Use Forecast

One of the first steps in modeling potential industrial program impacts is to develop an industrial end-use forecast. This forecast estimates energy use for each industrial manufacturing sector at the end-use level over the study horizon. This end-use forecast was the foundation from which Cadmus calculated measure energy impacts. Developing the forecast involved developing a first-year end-use consumption profile and applying growth rates derived from Wisconsin utility data to produce energy use forecasts by industrial sector over the study horizon. The following sections detail the process for developing the end-use consumption profiles and industrial end-use forecast.

Industry Classification

Cadmus used the North American Industry Classification System (NAICS) codes reported in utility data to segment Wisconsin's industrial customer base into manufacturing sectors. Common manufacturing sectors and their NAICS codes are shown in Table D-9. We also included a miscellaneous sector as a catch-all for other industrial sectors in Wisconsin. We further segmented manufacturing sectors by size based on the Wisconsin utilities' filings of large energy customers with the PSC. This enabled us to set different assumptions and inputs for large customers versus small/medium customers in a given manufacturing sector based on different considerations the two may have.

Table D-9. NAICS Code by Manufacturing Sector

NAICS Code	Manufacturing Sector
3313	Alumina and Aluminum
327310	Cement
325	Chemicals
334 and 335	Computers, Electronics, and Electrical Equipment
332	Fabricated Metals
311 and 312	Food and Beverage
321 and 322	Forest Products
3315	Foundries
3272 and 327993	Glass
331110 and 3312	Iron and Steel
333	Machinery
324110	Petroleum Refining
326	Plastics
313-316	Textiles
336	Transportation Equipment

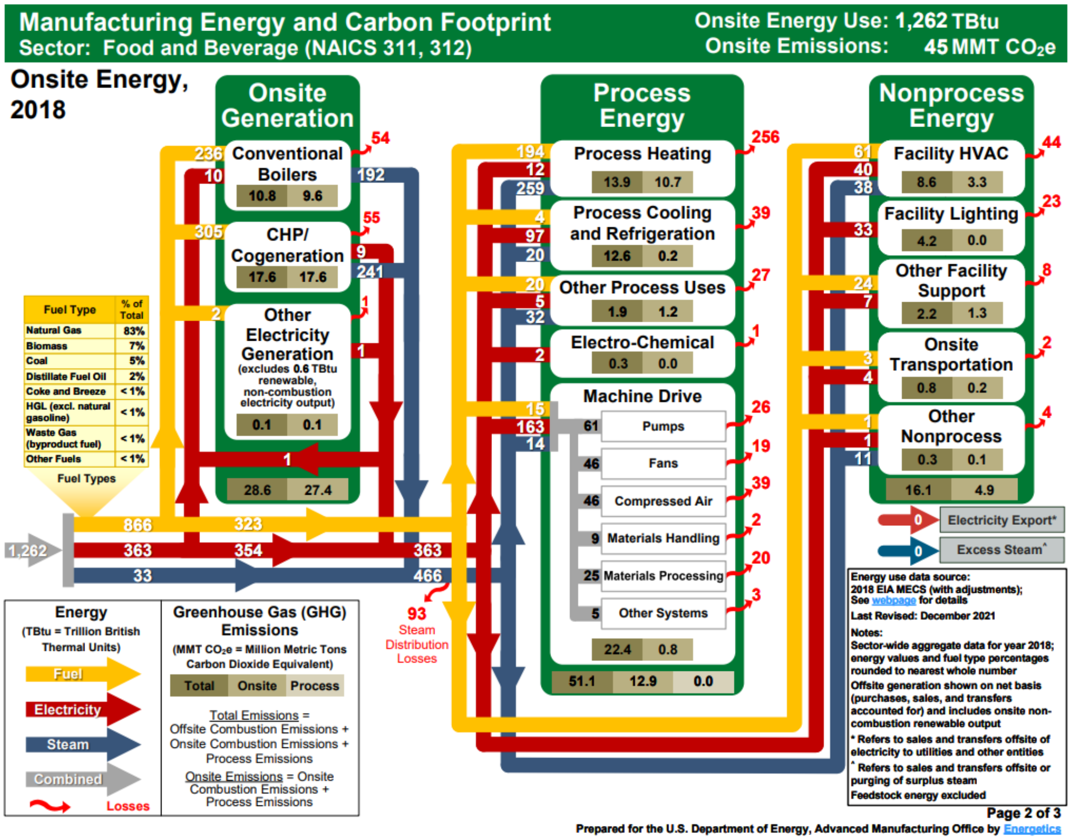
By conducting industry classification, Cadmus developed a base year energy consumption profile by manufacturing sector, utility service territory, and customer type (large industrial customer or other).

Industry End-Use Segmentation

For each manufacturing sector, Cadmus segmented energy use by end use based on the utility customer gas and electric data and the EIA 2018 MECS. We defined the flow of energy in the form of fuel, electricity, or steam to major end uses in manufacturing, including boilers, combined heat and power generation, process heaters, process coolers, machine-driven equipment, and facility HVAC.

For example, as illustrated in Figure D-13, in the food and beverage industry, on average, according to MECS data, approximately 68% of energy consumed is non-electric fuel (majority natural gas), of which approximately 27% goes to boilers, approximately 35% to combined heat and power (CHP)/cogeneration, and approximately 38% to process energy (process heating, machine drive, and other processes).

Figure D-13. Food and Beverage Manufacturing Sector Energy Consumption



Source: Manufacturing Energy Consumption Survey (2018).
www.eia.gov/consumption/manufacturing/

Cadmus conducted end-use segmentation for each manufacturing sector using information from MECS for the relevant manufacturing sectors. If a manufacturing sector in Wisconsin did not have MECS results, we used either the overall industrial MECS results or the Miscellaneous Industrial MECS results.

Because industrial equipment is highly customized, Cadmus conducted interviews with 20 industrial facilities managers to understand how the assumptions in MECS data apply to Wisconsin industrial facilities. Based on these interviews, we adjusted the end-use segmentation from the MECS segmentation. For the Paper Manufacturing customers interviewed, we updated the MECS assumptions to accurately capture the split of their steam generation via combined heat and power versus conventional boiler. For a large Primary Metals customer and a large Chemicals customer, we adjusted their coal consumption to zero based on interview findings. For both a Primary Metals customer, as well as a Transportation Equipment Manufacturer, the customer reported a higher percentage of energy (both gas and electricity) going towards process heating than MECS assumed. An Electro-Chemical customer had the largest change in end use energy profile from their initial MECS breakdown. They were assigned an end use profile based on being part of the Chemicals sector but this didn't capture that nearly all of their electricity was consumed by electrochemical processes. By keeping the granularity of industrial customer available in the utility data, we were able to make these adjustments in order to more accurately capture how the largest industrial customers are using energy, and ultimately, where the potential is for them to save energy.

End-use segmentation of annual gas and electric for industrial customers enabled us to map the energy efficiency and electrification measures to their relevant end uses in each manufacturing sector and determine each measure's impact on the energy use for that end use if it were adopted.

Industrial Load Forecast

After developing the baseline first-year end-use energy consumption profile, Cadmus developed an end-use forecast that estimates baseline energy consumption at the end-use level of detail over the study's 12-year planning horizon. To make this forecast, we applied industrial sector energy consumption growth rates, as provided by the Wisconsin utilities. We used secondary data from customer interviews and input from Focus on Energy staff and industry experts to determine if the growth (or load declines) applied to specific customer segments. Applying the industrial load forecast allowed our team to estimate end-use energy consumption over the study horizon and estimate what, if any, proportion of future load is from new construction or facility expansions. Facility expansion and new construction projects have different energy efficiency or electrification potential because high efficiency or electric equipment may be selected upon construction.

Industrial Peak Impacts

To further characterize baseline industrial energy consumption, Cadmus utilized industrial end-use load shapes for each industrial end use to estimate the peak demand for each manufacturing sector. We conducted secondary research to identify industrial end-use load shapes appropriate for Wisconsin industries, beginning this research by reviewing industrial load shapes from the following sources:

- Northwest Power and Conservation Council[28]
- The Energy Trust of Oregon[29]
- Electric Power Research Institute[30]

Cadmus estimated industrial peak impacts based on industrial load coincidence with the Focus on Energy definition of summer and winter peak periods.

---

[28] Northwest Power and Conservation Council. Accessed December 9, 2024. "End Use Load and Consumer Assessment Program.". https://rtf.nwcouncil.org/elcap/ and https://rtf.nwcouncil.org/capacity-benefits-efficiency-load-shape-recommendation-memos/

[29] Cadmus. January 29, 2021. *Industrial Load Shape Research*. https://www.energytrust.org/wp-content/uploads/2021/03/Industrial-Load-Shape-Research-FINAL-w-SR.pdf

[30] Electric Power Research Institute. Accessed December 9, 2024. "Load Shape Library 8.0." https://loadshape.epri.com/

Measure Characterization

In parallel with developing an end-use level energy consumption forecast, Cadmus developed and characterized the energy efficiency and electrification measure model inputs that impacted the end uses. These inputs informed the industrial sector's technical and economic potential as well as the program scenario's program budgets. To develop industrial measures, we used the following steps:

1. Defined the list of energy efficiency measures and electrification measures relevant to the Wisconsin Industrial sector
2. Characterized the **energy impacts** of each measure
3. Characterized the **applicability** of each measure for the relevant manufacturing sectors
4. Characterized the **estimated maximum adoption** of each measure for the relevant manufacturing sectors
5. Characterized measure costs and associated measure incentives

The energy impact of a measure is the impact it has on the gas and electricity consumption by the manufacturing sector and end use. Because the measure list includes electrification measures, these impacts can increase electricity consumption.

Industrial Measure List

Cadmus, with input from stakeholders, developed a list of industrial measures for this study. The list incorporates measures from the Focus on Energy industrial program, the 2021 Potential Study, and input from Cadmus and APTIM industrial experts.

All end uses include a custom measure to account for an historically large percentage of Focus on Energy's savings realized through custom industrial projects. The measure list includes both energy efficiency measures and electrification measures.

We determined the applicability of measures to each manufacturing sector based on the historical program data, interviews, and SME input on heating requirements and fuel uses in each manufacturing sector. We expected to see overlap between manufacturing sectors—that is, the opportunity to electrify boilers is available across all manufacturing sectors, but the adoption of electric boilers depends on the temperature levels required by the manufacturing sector as, in general, lower temperature heat is more prone to electrification, given that extremely high heat thresholds cannot be readily achieved with existing electric technology.

Measure Energy Impacts

Cadmus used distinct approaches to develop the impacts that energy efficiency and electrification measures can have on industrial end-use energy consumption.

Energy Efficiency Measures

Cadmus determined an energy efficiency measure's impact on gas and electric use as a percentage of the relevant end-use energy consumption using the 2020–2023 Industrial Program impact evaluation data, the baseline industrial customers' annual utility energy data, and customer interviews. We calculated the impact using the following steps:

1. Determined the end uses that energy efficiency measures impact via Cadmus expert review.
2. Mapped measures from historical Focus on Energy program data to utility customer data by address or other identifier. This allowed us to see a utility customer's annual energy consumption by end-use and the evaluated energy savings for a given measure they installed.
3. Calculated the measure's impact as a percentage by dividing the measure's evaluated energy savings by the customer's energy consumption for the impacted end use for a given fuel type (electric or gas).

We performed this calculation at the customer level and then determined the average percentage impact for a measure across all participating customers within the same manufacturing sector.

It has been common practice for industrial facilities to claim savings for existing construction measures even when the measure was implemented in a facility expansion. For these projects, the percentage savings we calculated differed significantly from that of other projects because the customer's energy consumption used in the percentage savings calculation was the baseline pre-expansion annual energy use, but the savings were from an expansion, leading to overstated savings percentages. We excluded these projects from the savings analysis based on an analysis of the data and consultations with Focus on Energy industrial staff.

For any energy efficiency measures with limited historical performance data, we utilized secondary sources to develop savings impacts. These sources include the DOE Industrial Assessment Center's recommendation database, TRMs, ACEEE publications, other peer-reviewed journal papers, and previous potential studies. Table D-10 summarizes the inputs specific to calculating energy efficiency measure impacts.

Table D-10. Inputs for Calculating Energy Efficiency Measure Impacts

Input	Description	Level of Detail
Baseline End-Use Gas Consumption	Input from the customer utility data combined with MECS. Used to calculate a measure's percentage savings and as a baseline for projected energy use.	Manufacturing sector, customer
Baseline End-Use Electricity Consumption		
Measure Deemed Gas Savings	Input from the historical program data. Used to calculate the measure's percentage as gas and electric savings.	Manufacturing sector, measure, customer
Measure Deemed Electricity Savings		

Cadmus calculated an energy efficiency measure's impact using the following equation for both gas and electric fuels:

$$FuelImpact_{mji} = \frac{FuelDeemedSavings_{mi}}{FuelBaseLoad_{ji}}$$

Where:

$FuelImpact_{mji}$	=	The percentage impact of measure *m* relative to the base fuel (electric or gas) usage for the end-use *j* in manufacturing sector i
$FuelDeemedSavings_{mi}$	=	Deemed savings for measure m in manufacturing sector i
$FuelBaseLoad_{ji}$	=	Baseline annual fuel consumption for end-use *j* in manufacturing sector i

Electrification Measures

To characterize electrification measures, Cadmus relied on primary data collected through customer interviews and supplementing the data with the DOE Industrial Assessment Center's recommendation database, a literature review of publications by the ACEEE, Regional Technical Forum, peer-reviewed journal papers and other industrial electrification research, a review of publications from national laboratories, and using internal subject matter expertise and information from current and previous industrial electrification studies and research.

To estimate the energy impact of switching fuels for a given end use, Cadmus needed to characterize the existing gas equipment's efficiency and the proposed electric equipment's efficiency. Table D-11 shows the primary inputs we used to estimate the impact of electrification measures.

Table D-11. Inputs for Calculating Electrification Measure Impacts

Input	Description	Level of Detail
Gas End-Use Equipment Efficiency	Input in the calculations to determine the electric energy required if a given gas end use was electrified. Efficiency is defined the ratio of input to output energy (coefficient of performance).	Manufacturing sector, measure
Electric End-Use Equipment Efficiency		

Cadmus calculated electrification measures impacts using the following equation:

$$ElecImpact_{mji} = \frac{Gas\ Equip\ Effic_j}{Electric\ Equip\ Effic_{jm}}$$

Where:

$ElecImpact_{mji}$	=	The percentage impact of electrification measure *m* on electric energy required relative to baseline gas usage for the end use *j* in manufacturing sector *i*.
$GasEquipEffic_j$	=	The gas equipment efficiency for the end use *j*.
$ElectricEquipEffic_j$	=	The measure *m*'s electric equipment efficiency for the end use *j*.

We determined an electrification measure's impact on gas consumption during the final modeling steps once we had determined the technical and economic potential for the electrification measure. We calculated the final gas consumption using the following equation:

$$FinalGas_{mji} = BaselineGas_{mji}(\,1\, - ElecPotential_{mji})$$

Where:

$FinalGas_{mji}$	=	The final gas consumption for end-use *j* in manufacturing sector *i* after measure *m* is applied
$BaselineGas_{ji}$	=	The baseline gas consumption end-use *j* in manufacturing sector *i*
$ElecPotential_{mji}$	=	The determined percentage of energy for end-use *j* in manufacturing sector *i* that will electrify by adopting measure *m* (varies for technical, economic, and optimized potential)

Measure Applicability Factor

Measure applicability is a fraction that combines a measure's technical feasibility and the existing saturation of the measure to determine how applicable a measure is for a manufacturing sector.

Technical feasibility considers only the impact of technical constraints on measure adoption. We used interview findings, a literature review, SME input, and process temperature ranges typical for a sector to inform technical feasibility.

Cadmus used interview findings from large industrial customers to estimate the measure saturation, or the percentage of load that was already impacted by adoption of the measure, for each measure in a given manufacturing sector. We verified estimates provided by industrial customers and Wisconsin industrial experts by analyzing historical program accomplishment data when available.

Measure saturation is not relevant for electrification measures because any electrification measures that have been implemented are reflected in the baseline electric and gas consumption of a manufacturing sector.

Measure Estimated Maximum Adoption

The maximum adoption factor reflects customers' willingness to adopt the given measure. We relied heavily on feedback from our industrial customer interviews to determine this characterization. The maximum adoption factor varies by measure, manufacturing sector, and scenario.

Measure Costs and Incentives

Cadmus characterized the cost and incentives per energy unit per year for each measure. We utilized historical program cost and incentive data for energy efficiency measures. For electrification measures, we collaborated with Focus on Energy staff to determine the best estimates for program and incentive costs (industrial electrification measures have not been a part of any Focus on Energy program to date). For incremental measure costs, Cadmus leveraged the Wisconsin TRM and other secondary sources, such as the Industrial Assessments Center.[31]

---

31 Department of Energy, Industrial Assessment Center. Accessed November 12, 2024. "Saving Energy and Reducing Costs at Small and Medium-sized U.S. Manufacturers." https://iac.university/

Potential Modeling

Using the end-use forecast and measure characteristics, Cadmus estimated the technical, economic, optimized, and program potential scenario energy impacts in the industrial sector.

Technical Potential

Technical potential is defined as the theoretical maximum amount of energy and capacity that could be displaced by efficiency, regardless of cost and other barriers that may prevent the installation or adoption of a measure. Only technical factors constrain technical potential (e.g., technical feasibility, applicability of measures).

For each electric and gas **energy efficiency measure**, Cadmus estimated impact using the following basic relationship:

$$\Delta elec_{mji} = ElecBaseLoad_{ji} * ElecImpact_{mji} * MA_{mi}$$

Where:

$\Delta elec_{mji}$	=	Change in electric energy use by measure *m* for end use *j* in manufacturing sector *i*.
$ElecBaseLoad_{ji}$	=	Baseline annual electric consumption for end use *j* in manufacturing sector *i*.
$ElecImpact_{mj}$	=	The percentage impact of measure *m* relative to the base electric usage for the end use *j* in manufacturing sector i.
MA_{mi}	=	Measure applicability, a fraction that represents a combination of technical feasibility, existing saturation of the measure, end-use interactions, and any adjustments to account for competing measures.

$$\Delta Gas_{mji} = GasBaseLoad_{ji} * GasImpact_{mji} * MA_{mi}$$

Where:

ΔGas_{mji}	=	Change in gas energy use by measure *m* for end use *j* in manufacturing sector *i*.
$GasBaseLoad_{ji}$	=	Baseline annual gas consumption for end use *j* in manufacturing sector *i*.
$GasImpact_{mj}$	=	The percentage impact of measure *m* relative to the base gas usage for end use *j* in manufacturing sector *i*.
MA_{mi}	=	Measure applicability by measure *m* in manufacturing sector *i*, is a fraction that represents a combination of technical feasibility, existing saturation of measure *m*, end-use interactions, and any adjustments to account for competing measures.

For each **electrification measure**, Cadmus estimated impact using the following basic relationship:

$$\Delta elec_{mji} = GasBaseLoad_{ji} * Elec\ Impact_{mj} * MA_{mi}$$

Where:

$\Delta elec_{mji}$	=	Change in electric energy use by measure *m* for end use *j* in manufacturing sector *i*.
$GasBaseLoad_{ji}$	=	Baseline annual gas consumption for end use *j* in manufacturing sector *i*. *Note that the baseline end-use energy considered is the gas baseline for electrification measures because of the nature of fuel-switching.*
$ElecImpact_{mj}$	=	The percentage impact of measure *m* relative to the base gas usage for end use *j*.
MA_{mi}	=	Measure applicability by measure *m* in manufacturing sector *i*, is a fraction that represents a combination of technical feasibility, existing saturation of the measure, end-use interactions, and any adjustments to account for competing measures.

The change in gas energy use for an electrification measure is simply the baseline gas end-use energy consumption multiplied by the fraction of that baseline that will be electrified. The change in gas for an electrification measure will be a reduction from the baseline, while electricity consumption will increase from the baseline.

$$\Delta Gas_{mji} = GasBaseLoad_{ji} * (MA_{mi})$$

Where:

ΔGas_{mji}	=	Change in gas energy use by measure *m* for end use *j* in manufacturing sector *i*.
$GasBaseLoad_{ji}$	=	Baseline annual gas consumption for end use *j* in manufacturing sector *i*.
MA_{mi}	=	Measure applicability, a fraction that represents a combination of technical feasibility, existing saturation of the measure, end-use interactions, and any adjustments to account for competing measures. Essentially the percentage of the end-use load that will electrify.

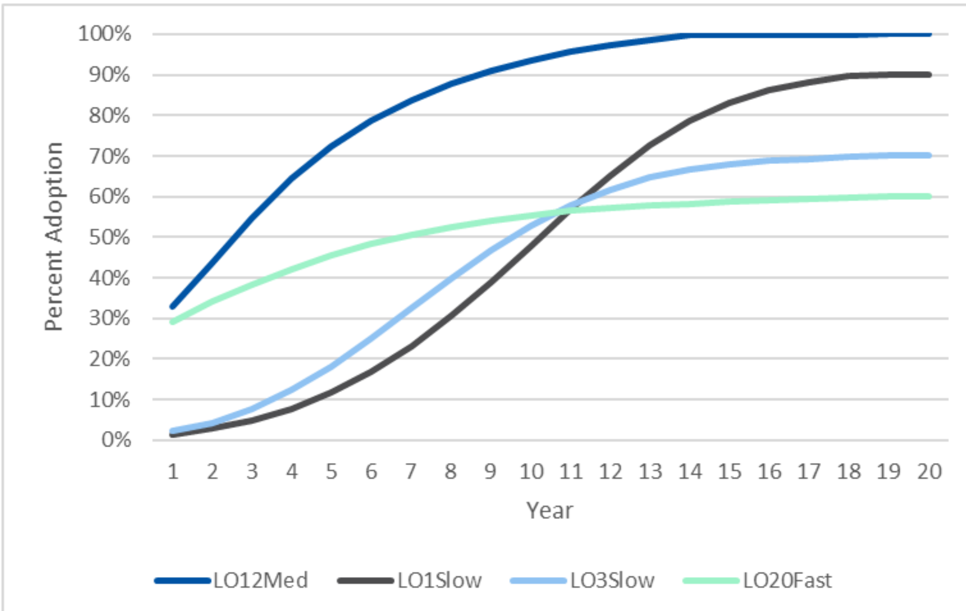
Cadmus estimated technical potential based on the industry-standard bottom-up approach, which estimates phase-in technical potential by introducing all technically feasible measures into the baseline forecast and calculating the resulting impacts. We calculated the technical potential for energy efficiency and electrification measures distinctly. We introduced any competition between measures in the optimized potential.

Adoption Modeling

To estimate optimized potential, Cadmus applied adoption rates to measures. These rates of adoption estimate how energy efficiency and electrification measures are adopted by industrial facilities in Wisconsin and consider the competition between certain measures. For the technical and economic potential, we treated the measures as independent of each other.

We developed custom technology- and scenario-specific adoption rates based on general technology adoption curves taken from the Northwest Power Planning Council and adjusted them based on insights from customer interviews, as well as scenario-specific assumptions about electrification policies and incentives. The ramp rates differ at both the measure and scenario levels and incorporate the estimated maximum adoption percentage we determined during the measure characterization step. Figure D-14 shows example adoption rates with maximum adoption percentages ranging from 60% to 100%.

Figure D-14. Example Adoption Rates with Varying Maximum Adoption Percentages



In addition to the maximum adoption percentages, we adjusted the adoption curves for certain measures to account for the competition between specific energy efficiency and electrification measures. For example, a facility with a natural gas furnace heating system could upgrade to a high-efficiency natural gas furnace (adopting an energy efficiency measure) or switch to an electric air-source heat pump (ASHP), an electrification measure. The facility has the potential to do both but can ultimately do only one and realize savings from a single option. We introduced any competition between energy efficiency and electrification measures in the measure-specific adoption curves via measure, manufacturing sector, and scenario-specific competition factors based on interview findings. In a 2017 NREL study on electrification, NREL analyzed adoption and cost data from the DOE Industrial Assessment Center Database (U.S. DOE Energy Efficiency and Renewable Energy Advanced Manufacturing Office 2017) for various industrial electrification technologies.[32] The study concluded that the length of payback for a given technology does not correlate with adoption and cannot be used to predict adoption behavior. Additional literature research and anecdotal evidence indicate that productivity or profitability benefits are often key considerations in adoption. Based on these findings, Cadmus determined that the best method for

---

[32] Jadun, Paige, Colin McMillan, Daniel Steinberg, Matteo Muratori, Laura Vimmerstedt, and Trieu Mai. 2017. *Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050.* Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-70485. https://www.nrel.gov/docs/fy18osti/70485.pdf

developing competition factors is to interview customers in each manufacturing sector to which the measure applies. This method allows variation and nuance in determining the factors to best capture the complex considerations that go into an industrial facility's decision to adopt new technology.

Program Scenario Potential

The program scenario potential reflects the four-year energy impacts from the energy efficiency and electrification measures adopted by Wisconsin industrial facilities, as achieved through the scenario program design, including the types of measures included and the incentive budgets allocated to the programs. Cadmus estimated the energy impacts of program measures, including the industrial program's overall budget and portfolio cost-effectiveness, to determine program scenario potential.

Industrial customer interviews informed the adoption rates for specific scenarios (i.e. Cadmus inquired about measure adoption given different program designs).

Solar PV Potential Modeling Approach

Cadmus relied on the 2021 Focus on Energy Solar Potential Study to estimate solar potential in Wisconsin.[33] The 2021 study included an adoption scenario in which the federal investment tax credits had expired by 2024, and Cadmus used this forecast to anchor the analysis. However, given other significant developments to the Wisconsin solar market, Cadmus made some further refinements to the 2021 analysis:

- Used the solar PV load shapes developed for the 2021 study to estimate both emissions and peak demand impacts in alignment with the Quad V Planning Study's methodology.
- Updated future incentives in collaboration with the Focus on Energy Program Administrator to constrain program scenario potential to available incentive budgets. For residential systems the Planning Study assumed that Focus on Energy incentives would be $160 per kW installed for systems installed with agricultural, commercial, and industrial customers, and $343 per kW installed with residential customers.

Load Shape Development

To develop hourly load shapes to apply to each study measure, Cadmus first identified the relevant end-use load shapes found in NREL's ResStock (Residential) and ComStock end use load shape libraries.[34] Cadmus queried the NREL load shape library, downloaded sector, building, and end-use-specific load shapes, and then normalized these load shapes so that they reflected a distribution of each end-use load over an entire year.

Cadmus further manipulated these load shapes to account for shifts in load as the weekday-weekend occurrence for each day of the year changes for each year of the study (for example, whereas

---

33 To review the solar potential study methodology and base results, please find the original report at https://focusonenergy.com/about/2021-potential-study-documents

34 https://www.nrel.gov/buildings/end-use-load-profiles

January 2, 2027, falls on a Sunday, January 2, 2029, falls on a Tuesday). As weekday and weekend loads differ, this distinction is important.

At the end of this process Cadmus developed a database of load shapes unique to each year, that included the following end-use load shapes (with each end-use load shapes assigned to a specific measure in the study), which can be found in *Appendix E*.

Load-Shifting Program Approach

This section describes the commercial and residential load-shifting measure included in the Focus on Energy Quad V Planning Study in a stand-alone program. These measures are designed to shift end-use electric load from Focus on Energy-defined peak periods to off peak periods. Focus on Energy has three defined peak periods: a four-hour afternoon summer peak period (2 p.m. to 6 p.m.), a four-hour winter morning peak period (8 a.m. to 12 p.m.), and a four-hour winter evening (5 p.m. to 9 p.m.) winter peak period. Table D-12 names each of the load-shifting measures included in the study, as well as the electric end uses that the measures target, and peak period impacted. Table D-13 through Table D-19 provide an in-depth description of each measure.

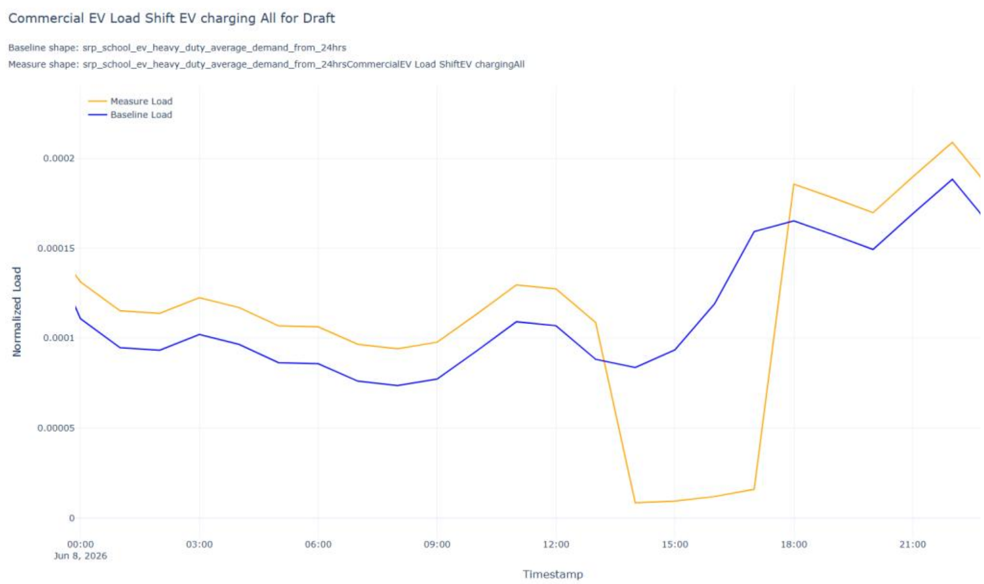
Table D-12. Load-Shifting Measures

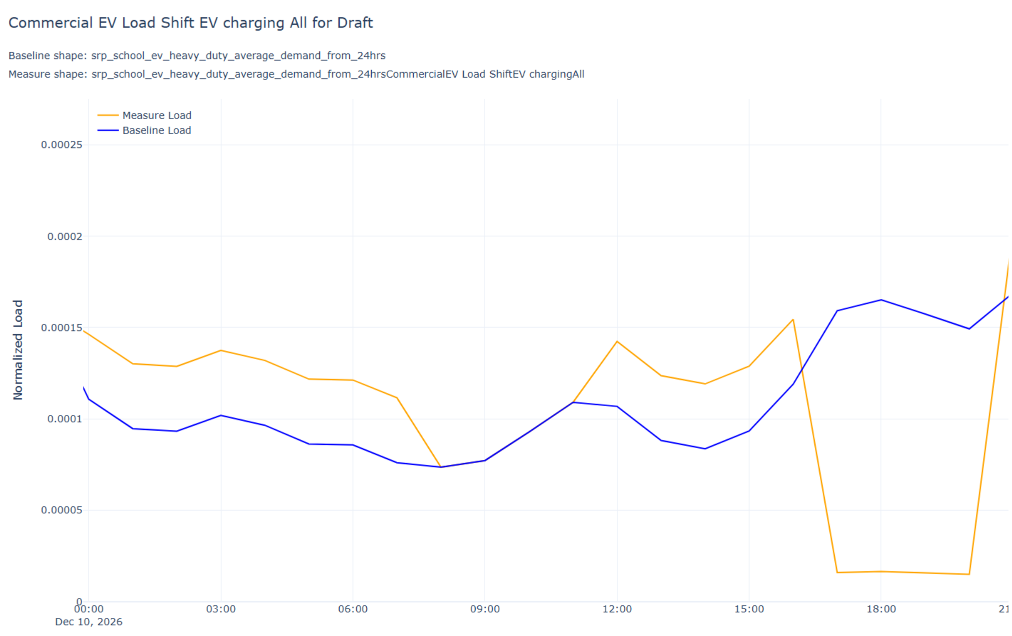
Sector	Load-Shifting Measure	Electric End Use Shifted	Peak Period Impacted
Commercial	EV Load Shift	EV charging	Summer PM, Winter PM
	Thermal Storage	Electric Cooling	Summer PM
	Thermostat Load Shift	Electric Cooling	Summer PM
	Thermostat Load Shift	Space Heating	Winter AM, Winter PM
Residential	Battery Storage	Electric Cooling	Summer PM
	Battery Storage	Electric Heating	Winter AM, Winter PM
	EV Load Shift	Electric Vehicles	Summer PM, Winter PM
	Thermal Storage	Electric Heating	Winter AM, Winter PM
	Thermostat Load Shift	Electric Cooling	Summer PM
	Thermostat Load Shift	Electric Heating	Winter AM, Winter PM

Table D-13. Commercial Electric Vehicle Charging Load Shift

Technology/ Program Description	Businesses receive an incentive to program their electric vehicle chargers to charge only during the night-time, beginning with the end of summer and winter afternoon / evening peak period. The New York State Energy Research and Development Authority (NYSERDA) developed a white paper that provides program design considerations for a managed load charging program, including software requirements and integration with time-of-use energy rates.[35]
Sector / Applicable Buildings	Commercial electric vehicle fleets (i.e. this program will focus on vehicle fleets that are likely to charge overnight). We assume that these fleets have existing charging infrastructure that enable automated load shifting. The population of potential program participants is the number of buildings with charging fleets.

[35] www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Transportation/22-09-Electric-Vehicle-Managed-Charging-White-Paper.pdf

<table>
<tr><td>End-Use Load Assumptions</td><td>Standard commercial EV chargers
Standard Electric Vehicle Charging (951 kWh per year times 20 vehicles)</td></tr>
<tr><td>End-Use Load Shape Affected</td><td>Commercial EV charging
srp_school_ev_heavy_duty_average_demand_from_24hrs</td></tr>
<tr><td>Load Shift</td><td>Adjust EV load shape to shift 90% of vehicle charging from afternoon on-peak hours to off peak hours. The reduced charging load is distributed over all off-peak hours of the same day.</td></tr>
<tr><td>Summer</td><td>


</td></tr>
<tr><td>Winter</td><td>


</td></tr>
<tr><td>Efficiency Considerations</td><td>Energy savings will not occur as the total charging load will not change.</td></tr>
</table>

Adoption Considerations	Program participation (a participant can opt into a program at any time). We assume that there is no participation in the first year of the program, but that participation increases each year in the program. We apply the Northwest Power and Conservation Councils' emerging technology adoption rate. A potential program design would likely pair managed commercial EV charging with time-of-use rates.
Incentives	$50 per year per vehicle in fleet.
Incremental Equipment Cost	Software costs for the program participants are unknown. This study assumes that commercial fleets already have capabilities to integrate with managed charging. Program software costs are part of the program administrative budget.

Table D-14. Commercial Thermal Storage Load Shift

Technology/ Program Description	Thermal energy storage system for managing cooling loads on commercial buildings. System works as a load-shifting measure; transferring cooling system energy use from afternoon peak hours to morning or evening hours. Ice Energy offers a market-ready technology.[36] Xcel Energy currently offers a program for commercial thermal storage in Minnesota. This program offers commercial participants a first year rebate of 10% of the project cost the first year of the project, and 5% each year thereafter.[37] Utilities pair rebates with participation in peak time pricing. Commercial thermal storage systems would likely be installed as a cooling system retrofits, rather than on burnout of an existing system.
Sector / Applicable Buildings	All commercial spaces with cooling loads and available rooftop area. The system uses two prototypical building to model energy impacts: Large offices and large retail buildings.
System Assumptions	Large retail: • Chillers 150-300 tons (screw): IECC 2015 - 0.66 kW/ton (full load); 0.54 kW/ton (IPLV) Large office: • Chillers > 300 tons (centrifugal): IECC 2015 - 0.56 kW/ton (full load); 0.52 kW/ton (IPLV)
End-Use Load Shape Affected	Large retail: • category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out.electricity.cooling.energy_consumption.kwh Large office: • category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out.electricity.cooling.energy_consumption.kwh
Load Shift	Summer season – reduce electric space cooling load by 80% of highest peak demand during total period. Increase electric demand by 50% during off-peak periods three hours before peak period.[38]

36 https://www.iceenergy.com/commercial/

37 https://www.xcelenergy.com/staticfiles/xe-responsive/Energy%20Solutions/Business%20Solutions/23-10-508_MN-DynamicThermoStorage_IS_P04.pdf

38 Extrapolated from "Integrated Thermal Energy Storage for Cooling Applications Final Report". NYSERDA. June 2017.

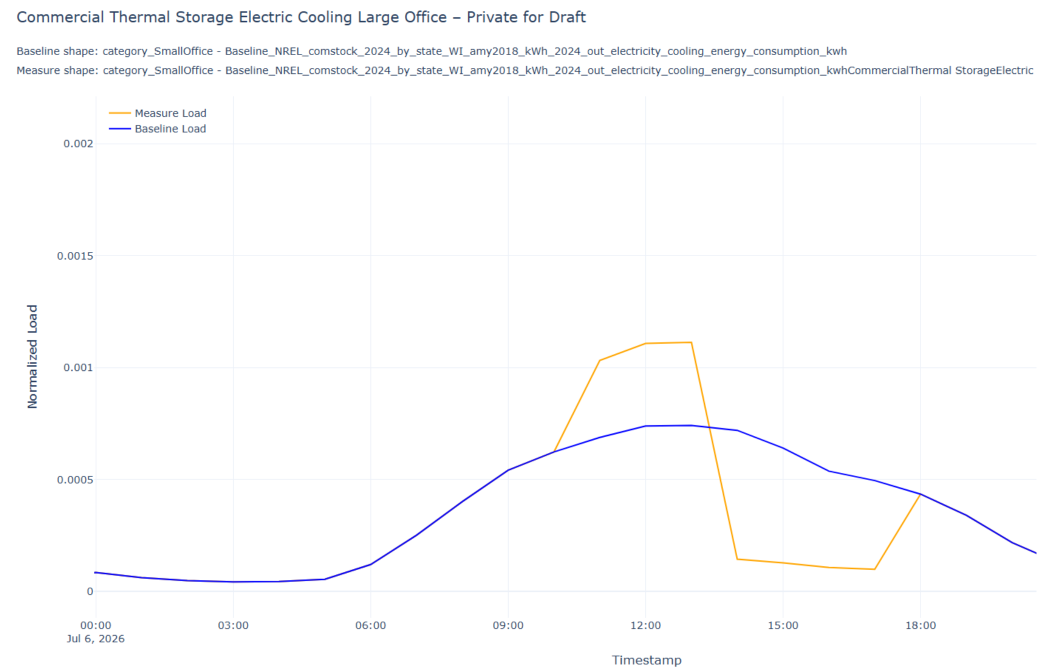
Large Private Office Summer	
Efficiency Considerations	Actual performance of system is unknown. This analysis assumes that the measure will produce energy savings.
Adoption Considerations	Program participation (a participant can opt into a program at any time). The study applies the Northwest Power and Conservation Councils' emerging technology adoption rate, and assumes a low maximum market achievability cap, given the high cost of the systems.
Incentives	Xcel offers 10% of the project cost the first year of the project, and 5% each year thereafter.
Incremental Equipment Cost	$40,000 per system estimated by NYSEDA[39]. $500-$1,350 estimated per system by EPRI[40]. For Large retail office the cooling system size assumption is approximately 150kW (300 tons * 0.66 kW/ton) . For large and private offices the cooling system size assumption is approximately 170kw (300 tons * 0.56 kw/ton). Assuming an incremental cost of $925 per kw, the incremental costs are approximately: o Large retail: $140,000 o Large public and private office public: $160,000

Table D-15. Commercial Thermostat Load Shift

Technology/ Program Description	This analysis relies on the definition for commercial load-shifting measures from a 2024 National Renewable Energy Laboratory's (NREL) study ("End-Use Savings Shapes Measure Documentation: Thermostat Control for Load Shifting in Large Offices". The NREL study defines Thermostat Control for Load Shifting as follows: Compared to the baseline, the HVAC load is increased for the pre-conditioning period with adjusted setpoints, and decreased in peak window with pre-conditioned (initial) thermal conditions, and thus the load is shifted from the peak window to the pre-peak period.

[39] See: "Integrated Thermal Energy Storage for Cooling Applications Final Report". NYSERDA. June 2017.

[40] See: "Technology Brief: Energy Efficiency and Demand Response. Thermal Energy Storage". Electric Power Research Institute. 2008.

	The measure is flexible and allows users to adjust the heating and cooling offset values, as well as the length of pre-conditioning before the peak period. (p. 1) This measure is distinct from a direct load control program, as it does not limit load adjustments to specific events. The NREL study states that "we do not limit the number of days (events) and fix the daily dispatch window for thermostat demand control, as we are targeting daily peak load reduction from the perspective of individual buildings, which is beneficial to building owners/managers/operators, and could provide insight of achievable demand flexibility in accord with grid needs from the end use (building) point of view. (p. 4).
Sector/ Applicable Buildings	For this study's program design the target population is commercial buildings with space cooling and electric heating. The study uses system assumptions for large offices and retail buildings as proxies for the population of commercial buildings.
System Assumptions	Large retail cooling: • Chillers 150-300 tons (screw): IECC 2015 - 0.66 kW/ton (full load); 0.54 kW/ton (IPLV) Large office cooling: • Chillers > 300 tons (centrifugal): IECC 2015 - 0.56 kW/ton (full load); 0.52 kW/ton (IPLV) Large retail and office heat pump: • Air Source Heat Pump > 240 kBtuh: Federal Standard 2023 - 12.5 IEER, 3.2 COP (11.3 IVEC, 5.3 IVHE)
End-Use Load Shape Affected	Electric cooling (central air conditioner and heat pump) and space heating (Heat Pump) loads. • category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh • category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh • category_SmallOffice - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh • category_RetailStandalone - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out.electricity.heating.energy_consumption.kwh
Load Shift	Identify the highest hour of load during each Focus on Energy peak period. Increase end use load in the hour prior to that building peak, reduce the end use load during peak, and increase building load again in the hour after the peak period. These shifts are extrapolated from a NYSERDA workpaper[41]. • Increase cooling and heating load by 4% in hour prior to peak. • Reduce cooling and heating load by 8% in hour of highest peak. • Increase cooling and heating load by 4% in hour after to peak.

41 "Integrated Thermal Energy Storage for Cooling Applications Final Report". NYSERDA. June 2017.

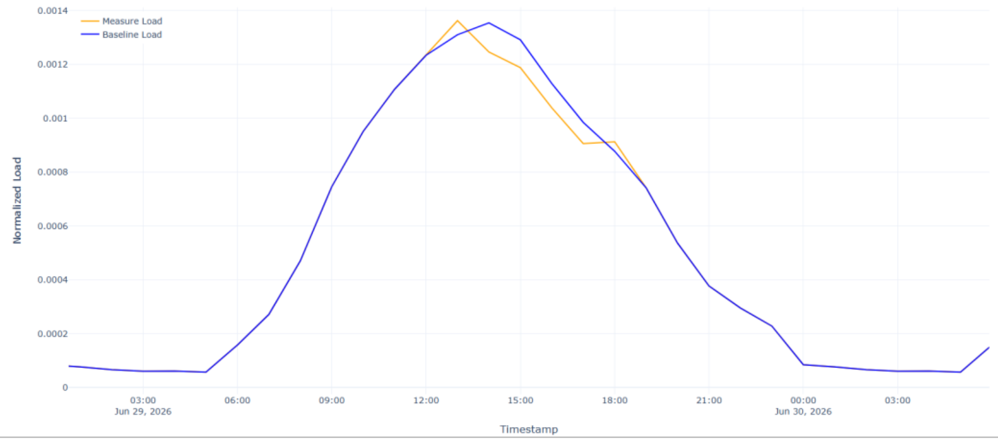
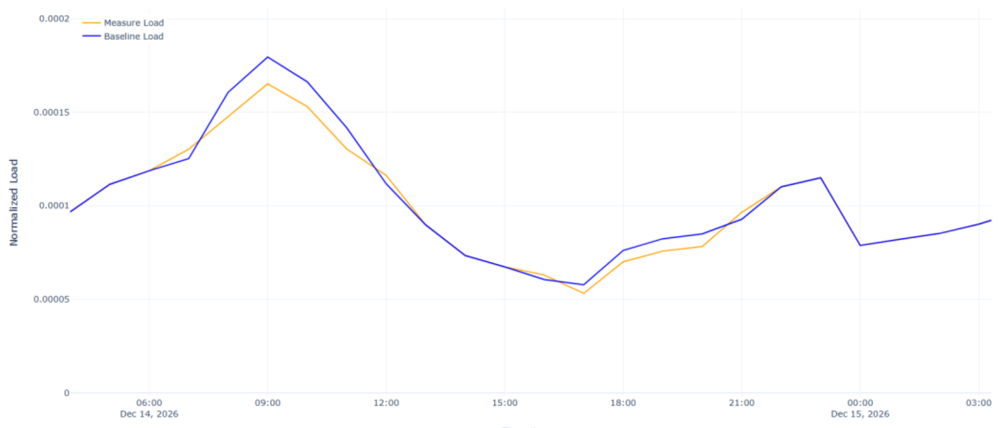
Large Private Office Cooling, Summer	
Large Private Office, Heating (Winter)	
Efficiency Considerations	Energy savings may occur because the AC conducts pre-cooling in hours prior to an event and snap-back after the event. This impact is applied with the load shape adjustment.
Adoption Considerations	Program participation (a participant can opt into a program at any time). We apply the Northwest Power and Conservation Councils' emerging technology adoption rate.
Incentives	$500 per season.
Incremental Equipment Cost	Since the program design assumes that customers already have controls installed, there is no incremental equipment cost to participating in the program. Program software costs are part of the program's administrative cost.
Graphics	Commercial Thermostats

Table D-16. Residential Battery Storage Load Shift

Technology/ Program Description	The load shift behavior described here is for a standalone battery storage system that can only charge from the grid (no on-site solar). Battery storage systems are increasingly able to participate in demand response and managed charging initiatives to help shift peak load. Batteries integrated with utility Distributed Energy Resource Management Systems (DERMS) platforms can automatically dispatch during grid events. Smart inverters enable precise control over battery charging and discharging. Batteries can enable load shifting by charging during off-peak (night) or when renewable energy generation is high (sunny days). Then during peak times, batteries can discharge their stored energy and reduce the peak load.

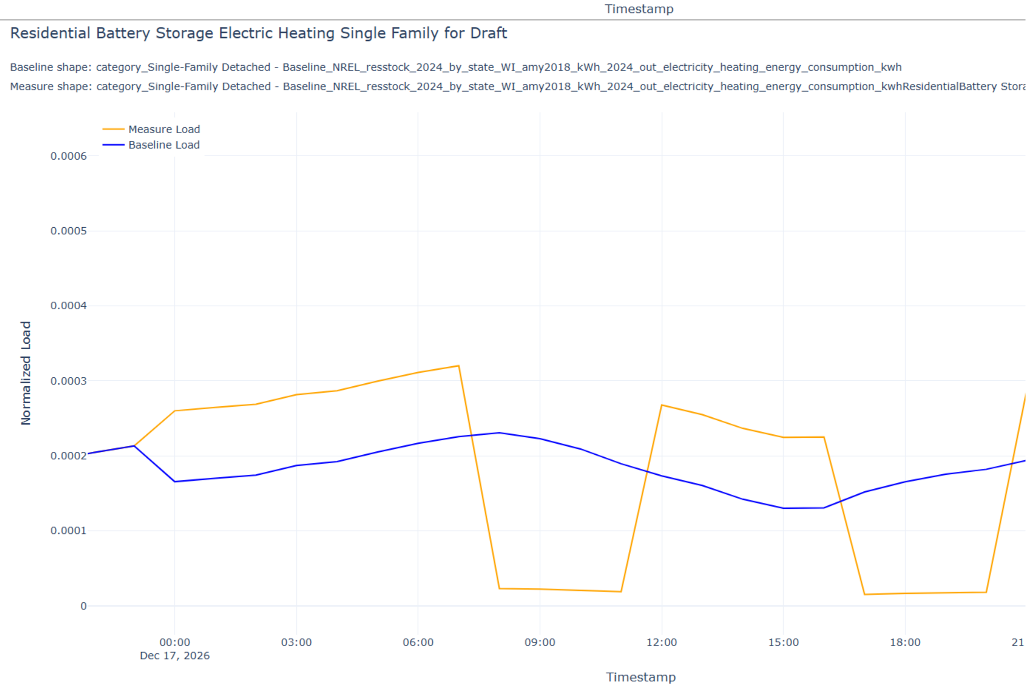
	This measure is modeled on programs that provide incentives for residential customers to install batteries at their homes and agree to the use of their battery's power during peak events. Several utilities offer residential battery storage programs, including: Eversource (MA).[42] and Green Mountain Power (VT).[43,44].
Sector/ Applicable Buildings	Single family homes.
Installation Type	Systems would be installed as a home retrofit (i.e. not when existing equipment fails).
System Assumptions	Tesla Powerwall 3 Battery Storage system: 13.5 kWh capacity; 11.5 kW continuous power; 5 kW max charge current/power (https://www.tesla.com/powerwall). The Planning Study does not have a whole home load shape or energy load (the study breaks loads into distinct end uses). Therefore this analysis assumes impacts to space cooling and space heating loads. This analysis assumes the following space cooling and space heating loads. Impacted/shifted load: • Federal Standard 2023 Central Air Conditioner - SEER2 13.4 (Split System) • Standard Electric Furnace - HSPF2 3.41
End-Use Load Shape Affected	Electric cooling (central air conditioner) and space heating (electric furnace) loads. While batteries theoretically shift the whole building's electric load, the Cadmus model only considers end-use load shapes. • category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh • category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Load Shift	Utilize battery during peak periods/events to reduce the peak. Charge battery during low demand periods (at night, middle of day). This analysis assumes that the battery can provide 5 kW of load reduction during peak events which for most single family homes, reducing most, if not all of the peak space cooling and heating load. Therefore we reduced peak by 90%. The load is redistributed over the off peak hours that day. This analysis, in line with the Green Mountain Power program design, assumes there is one peak event each week of a summer and winter month. The weekly peak event will be the highest load of the given week that falls within the peak period. Peak event will last for that entire 4-hour peak period window as defined by Focus on Energy.

42 www.eversource.com/content/residential/save-money-energy/energy-efficiency-programs/demand-response/battery-storage-demand-response

43 greenmountainpower.com/rebates-programs/home-energy-storage/bring-your-own-device/battery-systems/

44 greenmountainpower.com/wp-content/uploads/2020/11/BYOD-Customer-Agreement-11-2-20.pdf

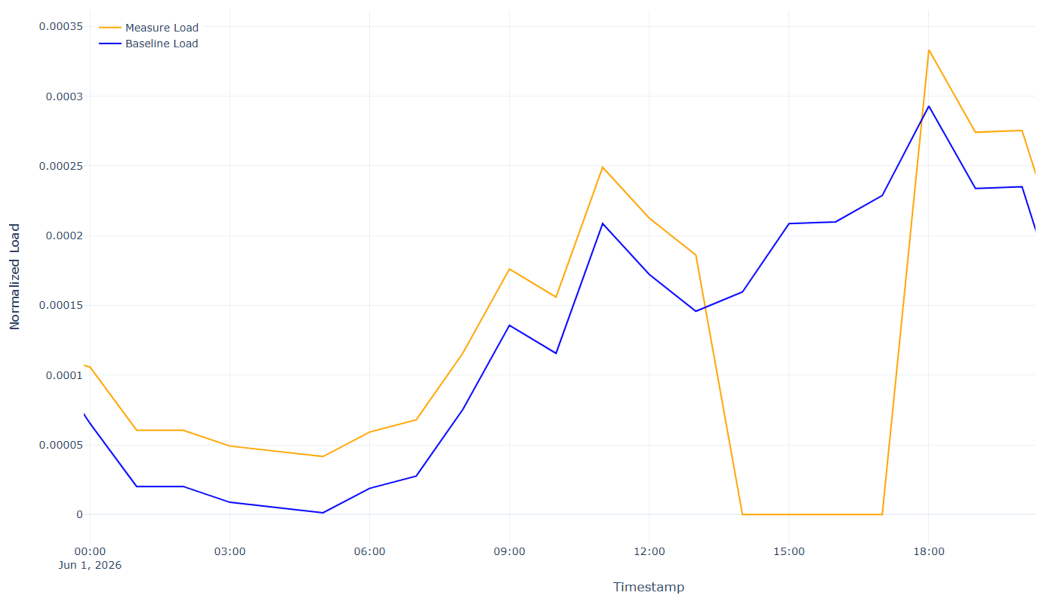
<table>
<tr><td>Cooling (Summer)</td><td>


</td></tr>
<tr><td>Heating (Winter)</td><td>


</td></tr>
<tr><td>Efficiency Considerations</td><td>Some efficiency lost when charging the battery from the grid to then discharging the energy to the grid to lower peak demand. Based on Tesla Powerwall 3 Spec Sheet, we assume 90% round trip efficiency. Therefore the peak reduction due to battery use will result in requiring a x1.1 charge of that reduced amount.</td></tr>
<tr><td>Adoption Considerations</td><td>Program participation (a participant can opt into a program at any time). We assume that there is no participation in the first year of the program being offered, but that participation increases each year following the first year of the program. We apply the Northwest Power and Conservation Councils' emerging technology adoption rate. Given the high cost of the measure this study assumes a low maximum market adoption threshold.</td></tr>
<tr><td>Incentives</td><td>$275 per average kW reduced per event that are paid out on an annual basis (based on Eversource's program). We assume a 5 kW reduction per event (based on Powerwall power</td></tr>
</table>

	capacity). If annually you averaged a 5 kW reduction per event, the **annual incentive is $1,375** (275*5).
Incremental Equipment Cost	Cost of Tesla Powerwall 3 (including installation cost): • Equipment: $9,300 • Installation: $6,100 • Total (pre-30% federal solar tax credit): $15,400
Measure Life	15 years (warranty is ten years)

Table D-17. Residential EV Load Shift

Technology/ Program Description	This program incentivizes program electric vehicle (EV) owners to avoid charging their vehicles during peak hours by programming their Level-2 chargers to charge only during specific non-peak time intervals. While the program offers an incentive to gain enrollment in the program, utilities usually tie program participation to enrollment in a time-of-use electric rate, so that households achieve savings on charging their EVs through lower rates.
Sector/ Applicable Buildings	Residential single family homes with Level-2 EV chargers.
System Assumptions	Level-2 EV chargers • Home Charger - Level 2
End-Use Load Shape Affected	Electric vehicle load shape • Consumers Loadshape Database_RES-ALL-ALL-EV-LEV2 CHARGE-BASE-NREL RES EV PROFILES-MW
Load Shift	Adjust EV load shape to completely shift vehicle charging from on-peak hours to off peak hours (shifted load is redistributed equally over all off peak hours of that day).
Summer	
Efficiency Considerations	Energy savings will not occur as the total charging load will not change.
Adoption Considerations	Program participation (a participant can opt into a program at any time). We assume that there is no participation in the first year of the program, but that participation increases each year in the program. We apply the Northwest Power and Conservation Councils' emerging technology adoption rate.
Incentives	$50 per year per participant

Incremental Equipment Cost	Since the program design assumes that customers already have an EV charger installed, there is no incremental equipment cost to participating in the program.

Table D-18. Residential Thermal Storage Load Shift

Technology/ Program Description	Electric space heating systems that heat solid materials / bricks during off-peak hours[45]. Systems can be installed as substitutes / complements to electric resistance and electric furnaces. Rebates offered by several electric municipal utilities, including Eau Claire Energy Cooperative (WI),[46] Jackson Electric Cooperative (WI),[47] Chippewa Valley Electric Cooperative (WI),[48] La Plata Electric Association (CO),[49] and Otter Tail Power Company (MN).[50] Utilities frequently pair rebates with participation in time of use programs. These systems would be installed as a retrofit measure, rather than on burnout of an existing system.
Sector / Applicable Buildings	Residential single and multifamily buildings. Single family buildings with electric furnaces and electric baseboard heating, multifamily buildings with electric baseboard heating.
System Assumptions	Single family • Standard Electric Furnace - HSPF2 3.41 Multifamily • Standard Baseboard Heating - HSPF2 3.41
End-Use Load Shape Affected	Single family • category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh Multifamily • category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Load Shift	Winter season: remove electric space heating load completely from peak periods. Shift space heating load to off-peak hours. Shifted load is redistributed over all off peak hours of that day.

45 https://steffes.com/ets/room-unit

46 https://www.ecec.com/energy-efficiency/energy-programs/electric_thermal_storage

47 https://www.jackelec.com/electric-heat-options

48 https://www.cvecoop.com/ets.php

49 https://lpea.coop/ETS

50 https://www.otpco.com/ways-to-save/topics/heating-and-cooling/thermal-storage-systems/

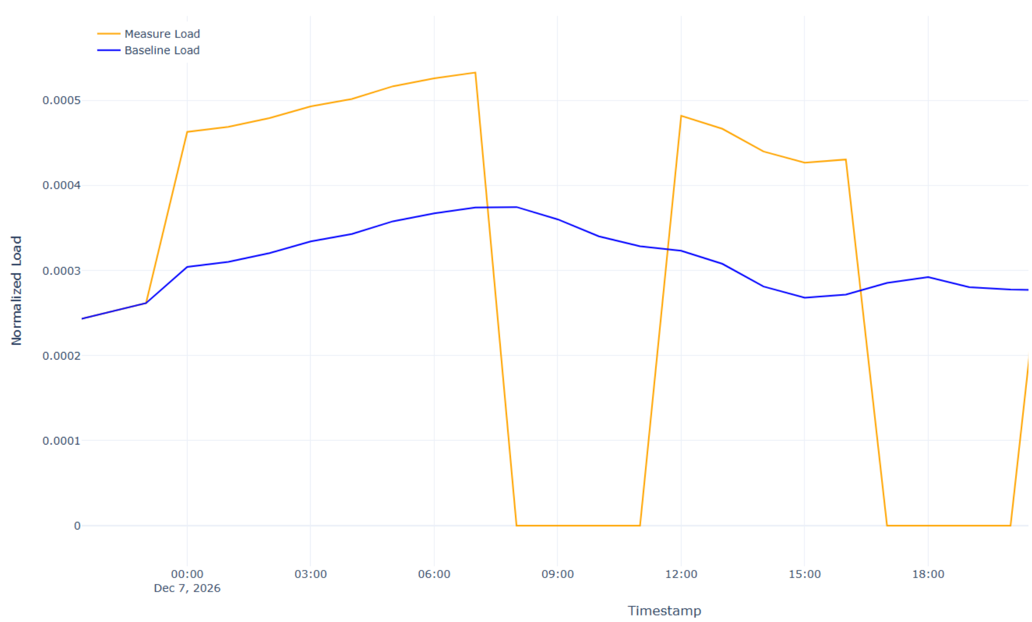
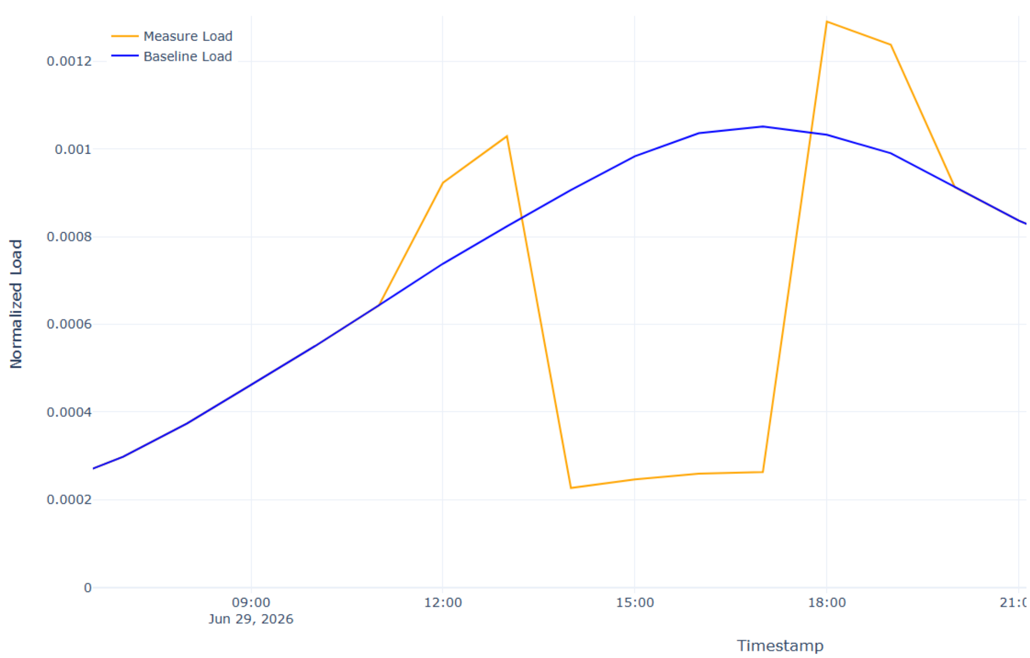
Winter, Heating	
Efficiency Considerations	Actual performance of system is unknown. This analysis assumes that systems are likely at least as efficient as existing systems.
Adoption Considerations	Program participation (a participant can opt into a program at any time). We assume that there is no participation in the first year of the program, but that participation increases each year in the program. We apply the Northwest Power and Conservation Councils' emerging technology adoption rate. Due to the high cost of the measure, the maximum market cap is conservative.
Incentives	$500 per system kW. Other programs vary between $20 and $50 per system kW. Assuming a 3.4 kW system a $50/kw incentive other incentives is $170 per. Assume that significantly more incentive is needed to move the market, so this analysis doubles the incentive.
Incremental Equipment Cost	Since this is a retrofit measure, the incremental cost is the total cost of the installed measure. Cost: $1,200.[51]

Table D-19. Residential Thermostat Load Shift

Technology/ Program Description	Internet-enabled smart thermostats connected to central air conditioning systems or heat pumps can receive signals from Focus on Energy to shift cooling load from peak to off peak hours during summer. When connected to heat pumps these systems can also shift winter heating load from peak to off peak hours. A typical program design includes a seasonal incentive for participation in a defined number events, typically around ten events for a 3 to 4 hour period. During these events the air conditioners or heat pumps are either cycled to reduce the compressor run-time or have their temperature set points adjusted: both of which result in lower equipment energy use during peak periods. For this analysis we assume that air conditioning participants take part in 6 summer events during Focus on Energy peak period, and that space heating participants take part in six winter peak periods (3 morning and 3 afternoon winter periods). This assumption includes an assumption that while a program may be designed for ten events, a derating factor of 60% should be applied to account for customer behavior and connectivity issue (p. 24, Navigant 2019).

51 Estimated from product website: www.storageheatersdirect.com

	To model impacts from program participation we assume that events are called during periods with the highest summer and winter loads (during Focus on Energy peak periods). Focus on Energy has a four hour afternoon summer peak period (2pm to 6pm), a four hour winter morning peak period (8am to 12pm), and a four hour winter evening (5pm to 9pm) winter peak period.
Sector/ Applicable Buildings	Single family and multifamily homes with air conditioners or heat pumps and smart thermostats
System Assumptions	Federal standard central air conditioner and heat pump with smart thermostats installed. • Federal Standard 2023 Central Air Conditioner - SEER2 13.4 (Split System) • Federal Standard 2023 Air Source Heat Pump - SEER2 14.3 and HSPF2 7.5 (Split System - Ducted)
End-Use load Shape Affected	Electric cooling (central air conditioner and heat pump) and space heating (heat pump) loads. • category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh • category_Multi-Family with 5+ Units - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh • category_Multi-Family with 5+ Units - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh • category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Load Shift	Shift cooling load and space heating load from peak to off peak hours during six summer and six winter events. The loads will be shifted as follows: • Increase cooling and heating load by 25% in two hours prior and after the event. • Reduce heating and cooling load by 75% during the event.
Summer Multifamily, Cooling	
Efficiency Considerations	Energy impacts occur because the AC conducts pre-cooling in hours prior to an event and snap-back after the event. This impact is applied with the load shape adjustment.

Adoption Considerations	Program participation (a participant can opt into a program at any time). We assume that there is no participation in the first year of the program, but that participation increases each year in the program. We apply the Northwest Power and Conservation Councils' emerging technology adoption rate.
Incentives	$50 per season (requires participation in ten events each summer and winter season).
Incremental Equipment Cost	Since the program design assumes that customers already have thermostats installed, there is no incremental equipment cost to participating in the program.

Cost-Effectiveness Analysis

Cadmus estimated the total feasible impact of energy efficiency and fuel-switching for all measures that passed an applicable cost-effectiveness screen. As with technical potential, we ran two distinct scenarios to calculate economic potential.

Cadmus used three different cost-effectiveness screens to estimate economic potential for this study. The three tests were the modified total resources (mTRC) test, the Program Administrator Test (PAT), and the Societal Cost Test (SCT). Table D-20 shows the cost and benefits included with each test. Cadmus conducted this analysis for each measure. A measure is cost-effective when the measure's benefits are greater than its costs.[52]

Table D-20. Test Benefits and Costs

Test	Benefits	Costs
Modified Total Resource Cost Test (mTRC)	kW-based avoided utility cost kWh-based avoided utility costs Therms-based avoided utility costs kWh-based avoided emissions Therms-based avoided emissions Market effects for Residential New Construction program	Incremental costs Program admin costs
Program Administrator Test (PAT)	kW-based avoided utility cost kWh-based avoided utility costs Therms-based avoided utility costs Market effects for Residential New Construction program	Incentive costs Program admin costs

52 For a list of the cost-effectiveness inputs, please review Appendix J in Volume III of the Calendar Year 2024 Evaluation report. CY 2024 Focus on Energy Volume III

Test	Benefits	Costs
Societal Cost Test (SCT)	kW-based avoided utility cost kWh-based avoided utility costs Therms-based avoided utility costs kWh-based avoided emissions Therm-based avoided emissions Low income adder per participant arrearages benefit (bill savings) Low income per participant property benefit Market effects for Residential New Construction program Water benefits for measures using municipal water supply kWh-based health benefits (first five years after each measure installation) Economic impacts analysis benefits (added at portfolio level)	Incremental costs Program admin costs

Electric Emissions Factors

As part of the Focus on Energy Quad V Planning Study, Cadmus estimated hourly emissions factors for five Wisconsin utilities (Alliant Energy, Madison Gas and Electric [MGE], Northern States Power - Wisconsin [NSPW], WE Energies, and Wisconsin Public Service [WPS]) over the 12-year study horizon of 2027 to 2038. The emissions analysis counts impacts from only load-following resources (used to balance load within an hour), it does not count impacts from baseload generation or must-take resources (such as renewable energy).

This section details the specific steps taken to conduct this analysis. Primary data inputs include utility-specific generation data from the Wisconsin SEA,[53] hourly generation profiles from the Energy Information Administration (EIA) Grid Monitor, and utility hourly energy needs developed specifically for the Quad V Planning Study from end-use load shapes, estimated equipment saturations, and utility load forecast data.

Approach to Emissions Factor Analysis

Cadmus framed its approach to the analysis by classifying generation resources into three categories detailed in Table D-21.

Table D-21. Generation Resource Classification

Baseload Resources	Must-Take Resources	Load-Following Resources
• Coal plants • Nuclear plants • Fuel oil generators • Gas turbines that are replacing retiring baseload coal/nuclear	• Wind turbines • PV solar	• Gas turbines • Hydroelectric generation • Battery storage

53 Public Service Commission of Wisconsin. Strategic Energy Assessment Report Data. https://apps.psc.wi.gov/APPS/SEAreport/SEAQuery.aspx

- **Baseload resources** are resources that consistently generate every hour to provide the base supply of electricity that the grid needs. This includes coal plants, nuclear plants, fuel oil generators, and gas turbines that are explicitly used for baseload application.
- **Must-take resources** are resources that incur negligible variable cost or downside to keep running. The analysis assumes that when these resources produce power, that energy will be used within that hour. Must-take resources include wind and PV solar energy.
- **Load-following resources** adjust their output to meet changing electricity demand. This study thus examined the emissions factors related to load-following resources on an hourly basis, assuming that they are primarily responsible for responding to gaps between supply and demand. For this study, load-following resources address the difference between hourly demand and hourly generation provided by baseload and must-take resources. Load-following resources include gas turbines, hydroelectric generators, and battery storage.

Each utility in this study has different mixes of the above resources. The exact level of each resource also changes over time as generation resources are retired or added. Cadmus followed the steps below to calculate the emissions factors for load-following resources:

Data Collection

1. Collected annual generation mix data for each utility from the SEA. For battery storage systems the SEA only included dispatch information for MGE. For other utilities this study used the ratio of energy dispatch to capacity from MGE. This ratio is 828 MWh of dispatch to 1 MW of battery capacity.
2. Collected hourly generation profiles from the EIA Grid Monitor for each resource for 2024.

Analysis

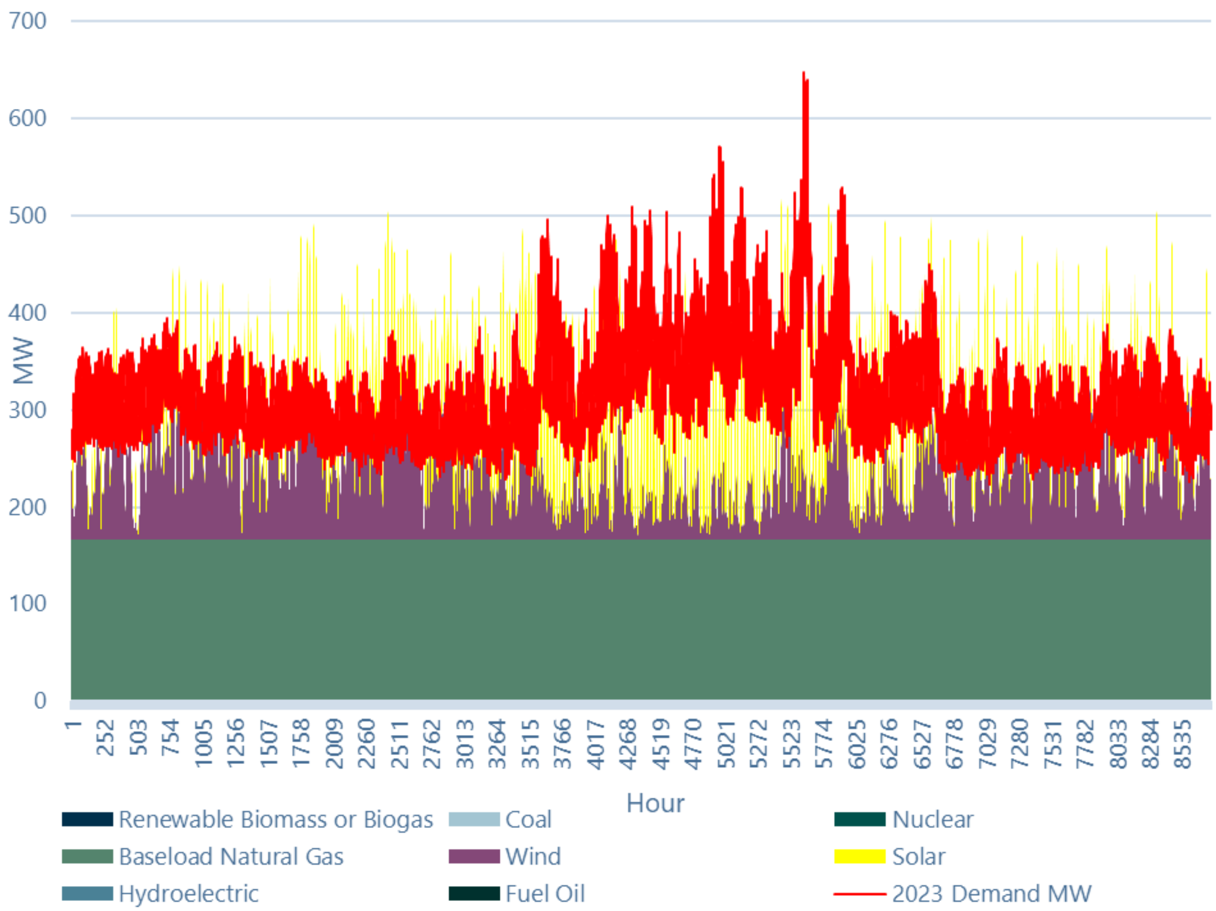
3. Applied generation profiles from the EIA Grid Monitor to develop hourly generation shapes for each utility's generation resources identified in Step 1.
4. Classified each generation resource as baseload, must-take, or load-following.
5. Developed an hourly energy demand profile based on utility-provided load shapes. This hourly data provides the other half of the grid-balance equation: electricity demand. With both hourly electricity supply (by resource and classification), and electricity demand, Cadmus modeled and identified gaps between the two where load-following resources would be needed for balancing, as demonstrated through the sample Figure D-15, which is illustrative only:

Hours

6. Extracted utility-specific emissions factors from SEA data-sets, which provided the emissions factors for each existing and planned generation resource.
7. Compared available resources from baseload and must-take generation to hourly demand and identified gaps between supply and demand (where load-following resources would be needed).
8. Applied load-following resources to balance the grid between supply and demand on an hourly basis.

9. Applied emissions factors for load-following resources.
10. Developed weighted emissions factors for load-following resources based on the resource mix needed for each hour, across the 12-year study period. If a specific hour did not require a load following resource, such as hours when there are significant amounts of renewable energy, the emissions factors for that hour is zero.

Figure D-15. Illustrative Hourly Electricity Supply and Demand Snapshot



Utility-Specific Data

Each utility in the study has a different resource mix in any given year. Table D-22 provides a snapshot of year 2030 to show how utility resource mixes differ. In some cases, a utility's baseload resources comprised less than half of their total resource mix for the year. For example, gauging the projected non-baseload natural gas and fuel oil uses, WE Energies would need to dispatch a comparatively significant amount of load-following resources in 2030, while MGE has a smaller proportion of load following resources to dispatch.

Table D-22. Year 2030 Resource Mix by Utility (MWh)

Resource	Alliant	MGE	NSPW	WE Energies	WPS
Baseload Resources					
Coal	-	-	222,000	6,634,000	3,571,000
Nuclear	-	-	2,249,000	9,015,000	-
Baseload Natural Gas	5,112,000	1,461,000	-	-	3,993,000
Fuel oil	-	-	-	3,000	-
Total Baseload	5,112,000	1,461,000	2,471,000	15,652,000	7,564,000
Baseload percentage of total resources	32%	52%	30%	44%	57%
Non-Baseload Resources					
Battery Storage	228,000	64,000	-	425,000	43,000
Natural Gas	4,617,000	169,000	916,000	13,847,000	1,933,000
Wind	3,179,000	675,000	3,261,000	1,477,000	1,556,000
Solar	2,326,000	450,000	1,304,000	3,149,000	1,800,000
Biomass/biogas	-	-	40,000	387,000	70,000
Hydro	306,000	-	169,000	425,000	397,000
Total Resources	**15,768,000**	**2,819,000**	**8,161,000**	**35,362,000**	**13,363,000**

Further examining 2030 as an example, according to the SEA, emissions factors also vary from utility to utility, as demonstrated in Table D-23, which provides a snapshot of the input emissions factors (from SEA) for load-following resources (natural gas and fuel oil):

Table D-23. Year 2030 Load-Following Resource Emissions Factors by Utility (CO_2lb/kWh)

Resource	Alliant	MGE	NSPW	WE Energies	WPS
Natural Gas	1.172	0.989	1.216	0.964	0.876

Cadmus used these input emissions factors to calculate weighted averages based on all utility resources for each fuel type (Step 10) on an hourly basis across the 12-year study period.

Assumptions and Limitations to the Analysis

This model does not account for electricity imports and exports, assuming that no trading is occurring between utilities and in the open market. All utility generation is assumed to be used within the utility's own service territory. Additionally, the SEA only forecasts utility generation changes through 2030, whereas the study estimates lifecycle emissions for measures, some of which are in place well beyond 2030. Thus, the analysis does not capture future, longer term changes to the generation resources in Wisconsin.

Appendix E. Load Shape Table

Table E-1 provides a list of the load shapes Cadmus developed for this study.

Table E-1. Load Shapes Developed for Quad V Planning Study

Sector	End Use	Building Type	Load shape name
Agricultural	All	N/A	A-Irr-Irr-Irrigation-All-All-E
Residential	Electric clothes dryer	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_clothes_dryer_energy_consumption_kwh
Residential	Electric clothes dryer	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_clothes_dryer_energy_consumption_kwh
Residential	Electric clothes dryer	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_clothes_dryer_energy_consumption_kwh
Residential	Electric clothes washer	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_clothes_washer_energy_consumption_kwh
Residential	Electric clothes washer	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_clothes_washer_energy_consumption_kwh
Residential	Electric clothes washer	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_clothes_washer_energy_consumption_kwh
Commercial	Electric cooling	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Residential	Electric cooling	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhResidentialThermostat Load ShiftElectric CoolingMultifamily
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhCommercialThermostat Load ShiftElectric CoolingLarge Office â€“ Public

Sector	End Use	Building Type	Load shape name
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhCommercialThermostat Load ShiftElectric CoolingLarge Office â€“ Private
Residential	Electric cooling	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhResidentialThermostat Load ShiftElectric CoolingSingle Family
Commercial	Electric cooling	RetailStandalone	category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhCommercialThermostat Load ShiftElectric CoolingLarge Retail
Commercial	Electric cooling	LargeOffice	category_LargeOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeOffice	category_LargeOffice - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeHotel	category_LargeHotel - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	RetailStandalone	category_RetailStandalone - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Warehouse	category_Warehouse - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SecondarySchool	category_SecondarySchool - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	PrimarySchool	category_PrimarySchool - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	PrimarySchool	category_PrimarySchool - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	FullServiceRestaurant	category_FullServiceRestaurant - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Hospital	category_Hospital - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric cooling	RetailStripmall	category_RetailStripmall - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	FullServiceRestaurant	category_FullServiceRestaurant - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeHotel	category_LargeHotel - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Mobile Home	category_Mobile Home - Geothermal heat pump_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Geothermal heat pump_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Single-Family Detached	category_Single-Family Detached - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Mobile Home	category_Mobile Home - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Mobile Home	category_Mobile Home - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Single-Family Detached	category_Single-Family Detached - Geothermal heat pump_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric cooling	RetailStandalone	category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Warehouse	category_Warehouse - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Warehouse	category_Warehouse - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Warehouse	category_Warehouse - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeOffice	category_LargeOffice - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	RetailStandalone	category_RetailStandalone - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	RetailStripmall	category_RetailStripmall - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	RetailStripmall	category_RetailStripmall - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	RetailStandalone	category_RetailStandalone - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Outpatient	category_Outpatient - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	RetailStandalone	category_RetailStandalone - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	PrimarySchool	category_PrimarySchool - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric cooling	Hospital	category_Hospital - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeHotel	category_LargeHotel - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SecondarySchool	category_SecondarySchool - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	PrimarySchool	category_PrimarySchool - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Warehouse	category_Warehouse - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeHotel	category_LargeHotel - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeOffice	category_LargeOffice - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	LargeOffice	category_LargeOffice - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Hospital	category_Hospital - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SecondarySchool	category_SecondarySchool - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	RetailStripmall	category_RetailStripmall - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Outpatient	category_Outpatient - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SecondarySchool	category_SecondarySchool - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric cooling	Hospital	category_Hospital - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	FullServiceRestaurant	category_FullServiceRestaurant - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Outpatient	category_Outpatient - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	Outpatient	category_Outpatient - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Residential	Electric cooling	Mobile Home	category_Mobile Home - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwh
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhCommercialThermal StorageElectric CoolingLarge Office â€" Public
Commercial	Electric cooling	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhCommercialThermal StorageElectric CoolingLarge Office â€" Private
Commercial	Electric cooling	RetailStandalone	category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhCommercialThermal StorageElectric CoolingLarge Retail
Residential	Electric cooling	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_energy_consumption_kwhResidentialBattery StorageElectric CoolingSingle Family
Residential	Electric cooling	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_fans_pumps_energy_consumption_kwh
Residential	Electric cooling	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_fans_pumps_energy_consumption_kwh
Residential	Electric cooling	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_cooling_fans_pumps_energy_consumption_kwh
Commercial	Electric fans	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric fans	LargeOffice	category_LargeOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Commercial	Electric fans	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Commercial	Electric fans	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Commercial	Electric fans	Warehouse	category_Warehouse - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Commercial	Electric fans	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Commercial	Electric fans	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Commercial	Electric fans	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Commercial	Electric fans	RetailStandalone	category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Commercial	Electric fans	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_fans_energy_consumption_kwh
Residential	Electric freezer	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_freezer_energy_consumption_kwh
Residential	Electric freezer	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_freezer_energy_consumption_kwh
Residential	Electric freezer	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_freezer_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwhResidentialThermostat Load ShiftElectric HeatingSingle Family
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwhResidentialThermostat Load ShiftElectric HeatingMultifamily
Commercial	Electric heating	SmallOffice	category_SmallOffice - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwhCommercialThermostat Load ShiftHeat PumpsLarge Office â€“ Private

Sector	End Use	Building Type	Load shape name
Commercial	Electric heating	SmallOffice	category_SmallOffice - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwhCommercialThermostat Load ShiftHeat PumpsLarge Office â€" Public
Commercial	Electric heating	RetailStandalone	category_RetailStandalone - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwhCommercialThermostat Load ShiftHeat PumpsLarge Retail
Commercial	Electric heating	RetailStripmall	category_RetailStripmall - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SecondarySchool	category_SecondarySchool - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	FullServiceRestaurant	category_FullServiceRestaurant - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Hospital	category_Hospital - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Warehouse	category_Warehouse - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	PrimarySchool	category_PrimarySchool - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SmallOffice	category_SmallOffice - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Warehouse	category_Warehouse - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Outpatient	category_Outpatient - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Hospital	category_Hospital - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	RetailStripmall	category_RetailStripmall - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SecondarySchool	category_SecondarySchool - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric heating	LargeOffice	category_LargeOffice - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SmallOffice	category_SmallOffice - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeOffice	category_LargeOffice - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeHotel	category_LargeHotel - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Outpatient	category_Outpatient - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Warehouse	category_Warehouse - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	RetailStandalone	category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	PrimarySchool	category_PrimarySchool - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SmallOffice	category_SmallOffice - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SecondarySchool	category_SecondarySchool - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Warehouse	category_Warehouse - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	PrimarySchool	category_PrimarySchool - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SecondarySchool	category_SecondarySchool - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric heating	RetailStandalone	category_RetailStandalone - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	RetailStandalone	category_RetailStandalone - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	RetailStripmall	category_RetailStripmall - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	RetailStripmall	category_RetailStripmall - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Warehouse	category_Warehouse - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	FullServiceRestaurant	category_FullServiceRestaurant - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Mobile Home	category_Mobile Home - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Geothermal heat pump_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Residential	Electric heating	Mobile Home	category_Mobile Home - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	FullServiceRestaurant	category_FullServiceRestaurant - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeHotel	category_LargeHotel - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeOffice	category_LargeOffice - Variable Speed HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	SmallOffice	category_SmallOffice - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	RetailStandalone	category_RetailStandalone - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	PrimarySchool	category_PrimarySchool - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeOffice	category_LargeOffice - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Outpatient	category_Outpatient - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Outpatient	category_Outpatient - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	RetailStandalone	category_RetailStandalone - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	Hospital	category_Hospital - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric heating	Hospital	category_Hospital - Comprehensive Geothermal Heat Pump Package, Hydronic GHP, Packaged GHP, or Console GHP_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeHotel	category_LargeHotel - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeOffice	category_LargeOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Commercial	Electric heating	LargeHotel	category_LargeHotel - Standard Performance HP RTU, Electric Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Mobile Home	category_Mobile Home - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - Geothermal heat pump_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Mobile Home	category_Mobile Home - Geothermal heat pump_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwhResidentialThermal StorageElectric HeatingSingle Family
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwhResidentialThermal StorageElectric HeatingMultifamily
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_energy_consumption_kwhResidentialBattery StorageElectric HeatingSingle Family
Residential	Electric heating fans	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_fans_pumps_energy_consumption_kwh
Residential	Electric heating fans	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_fans_pumps_energy_consumption_kwh
Residential	Electric heating fans	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_fans_pumps_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_hp_bkup_energy_consumption_kwh
Residential	Electric heating	Mobile Home	category_Mobile Home - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_hp_bkup_energy_consumption_kwh
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Geothermal heat pump_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_hp_bkup_energy_consumption_kwh
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_hp_bkup_energy_consumption_kwh
Residential	Electric heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_hp_bkup_energy_consumption_kwh
Residential	Electric heating	Mobile Home	category_Mobile Home - High efficiency cold-climate heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_hp_bkup_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - Geothermal heat pump_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_hp_bkup_energy_consumption_kwh
Residential	Electric heating	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with elec backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_heating_hp_bkup_energy_consumption_kwh
Residential	Electric hot water	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_hot_water_energy_consumption_kwh
Residential	Electric hot water	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_hot_water_energy_consumption_kwh
Residential	Electric hot water	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_hot_water_energy_consumption_kwh
Commercial	Electric interior equipment	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric interior equipment	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	Warehouse	category_Warehouse - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	RetailStandalone	category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	LargeOffice	category_LargeOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior equipment	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_equipment_energy_consumption_kwh
Commercial	Electric interior lighting	Warehouse	category_Warehouse - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric interior lighting	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	LargeOffice	category_LargeOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Commercial	Electric interior lighting	RetailStandalone	category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_interior_lighting_energy_consumption_kwh
Residential	Electric lighting interior	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_lighting_interior_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Residential	Electric lighting interior	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_lighting_interior_energy_consumption_kwh
Residential	Electric lighting interior	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_lighting_interior_energy_consumption_kwh
Residential	Electric plug loads	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_plug_loads_energy_consumption_kwh
Residential	Electric plug loads	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_plug_loads_energy_consumption_kwh
Residential	Electric plug loads	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_plug_loads_energy_consumption_kwh
Residential	Electric pool heater	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_pool_heater_energy_consumption_kwh
Residential	Electric pool pump	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_pool_pump_energy_consumption_kwh
Residential	Electric range oven	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_range_oven_energy_consumption_kwh
Residential	Electric range oven	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_range_oven_energy_consumption_kwh
Residential	Electric range oven	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_range_oven_energy_consumption_kwh
Commercial	Electric refrigeration	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_refrigeration_energy_consumption_kwh
Commercial	Electric refrigeration	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_refrigeration_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric refrigeration	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_refrigeration_energy_consumption_kwh
Commercial	Electric refrigeration	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_refrigeration_energy_consumption_kwh
Commercial	Electric refrigeration	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_refrigeration_energy_consumption_kwh
Residential	Electric refrigerator	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_refrigerator_energy_consumption_kwh
Residential	Electric refrigerator	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_refrigerator_energy_consumption_kwh
Residential	Electric refrigerator	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_refrigerator_energy_consumption_kwh
Residential	Electric total	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_total_energy_consumption_kwh
Residential	Electric total	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_total_energy_consumption_kwh
Residential	Electric total	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_total_energy_consumption_kwh
Commercial	Electric water systems	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh
Commercial	Electric water systems	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh
Commercial	Electric water systems	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Electric water systems	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh
Commercial	Electric water systems	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh
Commercial	Electric water systems	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh
Commercial	Electric water systems	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh
Commercial	Electric water systems	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh
Commercial	Electric water systems	LargeOffice	category_LargeOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_electricity_water_systems_energy_consumption_kwh
Residential	EV	N/A	RES-ALL-ALL-EV-LEV2 CHARGE-BASE-NREL RES EV PROFILES-MWResidentialEV Load ShiftElectric VehiclesSingle Family
Commercial	EV	N/A	RES-ALL-ALL-EV-LEV2 CHARGE-BASE-NREL RES EV PROFILES-MW
Industrial	All	N/A	IndShift2
Commercial	EV	N/A	srp_school_ev_heavy_duty_average_demand_from_24hrs
Commercial	EV	N/A	srp_school_ev_heavy_duty_average_demand_from_24hrsCommercialEV Load ShiftEV chargingAll
All	N/A	All	Flat
Residential	Natural gas clothes dryer	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_clothes_dryer_energy_consumption_kwh
Residential	Natural gas clothes dryer	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_clothes_dryer_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Residential	Natural gas clothes dryer	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_clothes_dryer_energy_consumption_kwh
Commercial	Natural gas heating	RetailStandalone	category_RetailStandalone - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	RetailStripmall	category_RetailStripmall - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	Hospital	category_Hospital - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	RetailStandalone	category_RetailStandalone - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	PrimarySchool	category_PrimarySchool - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	Warehouse	category_Warehouse - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	SmallOffice	category_SmallOffice - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Residential	Natural gas heating	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Residential	Natural gas heating	Mobile Home	category_Mobile Home - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_hp_bkup_energy_consumption_kwh
Residential	Natural gas heating	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Residential	Natural gas heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Residential	Natural gas heating	Single-Family Detached	category_Single-Family Detached - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_hp_bkup_energy_consumption_kwh
Residential	Natural gas heating	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - ENERGY STAR heat pump with existing system as backup_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_hp_bkup_energy_consumption_kwh
Commercial	Natural gas heating	LargeOffice	category_LargeOffice - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	Warehouse	category_Warehouse - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	LargeOffice	category_LargeOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	LargeHotel	category_LargeHotel - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	Outpatient	category_Outpatient - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	SecondarySchool	category_SecondarySchool - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Commercial	Natural gas heating	FullServiceRestaurant	category_FullServiceRestaurant - Variable Speed HP RTU, Original Heating Fuel Backup_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_heating_energy_consumption_kwh
Residential	Natural gas hot water	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_hot_water_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Residential	Natural gas hot water	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_hot_water_energy_consumption_kwh
Residential	Natural gas hot water	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_hot_water_energy_consumption_kwh
Commercial	Natural gas interior	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_interior_equipment_energy_consumption_kwh
Commercial	Natural gas interior	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_interior_equipment_energy_consumption_kwh
Commercial	Natural gas interior	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_interior_equipment_energy_consumption_kwh
Commercial	Natural gas interior	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_interior_equipment_energy_consumption_kwh
Commercial	Natural gas interior	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_interior_equipment_energy_consumption_kwh
Commercial	Natural gas interior	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_interior_equipment_energy_consumption_kwh
Commercial	Natural gas interior	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_interior_equipment_energy_consumption_kwh
Residential	Natural gas pool	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_pool_heater_energy_consumption_kwh
Residential	Natural gas range	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_range_oven_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Residential	Natural gas range	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_range_oven_energy_consumption_kwh
Residential	Natural gas range	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_range_oven_energy_consumption_kwh
Residential	Natural gas total	Single-Family Detached	category_Single-Family Detached - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_total_energy_consumption_kwh
Residential	Natural gas total	Mobile Home	category_Mobile Home - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_total_energy_consumption_kwh
Residential	Natural gas total	Multi-Family with 5+ Units	category_Multi-Family with 5+ Units - Baseline_NREL_resstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_total_energy_consumption_kwh
Commercial	Natural gas water systems	PrimarySchool	category_PrimarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh
Commercial	Natural gas water systems	Hospital	category_Hospital - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh
Commercial	Natural gas water systems	RetailStripmall	category_RetailStripmall - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh
Commercial	Natural gas water systems	Outpatient	category_Outpatient - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh
Commercial	Natural gas water systems	FullServiceRestaurant	category_FullServiceRestaurant - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh
Commercial	Natural gas water systems	SmallOffice	category_SmallOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh
Commercial	Natural gas water systems	LargeHotel	category_LargeHotel - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh

Sector	End Use	Building Type	Load shape name
Commercial	Natural gas water systems	LargeOffice	category_LargeOffice - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh
Commercial	Natural gas water systems	SecondarySchool	category_SecondarySchool - Baseline_NREL_comstock_2024_by_state_WI_amy2018_kWh_2024_out_natural_gas_water_systems_energy_consumption_kwh

Appendix F. Survey Instruments

Following are three Planning Surveys Cadmus used to measure market acceptance of Focus on Energy measures and to understand how measure installation decisions change when the measure payback periods change. Cadmus administered these surveys by email to a representative sample of businesses and households in Wisconsin's agricultural, commercial, and residential sectors.

CADMUS

Wisconsin Focus on Energy
2025 Planning Survey

Estimate survey launch: February 2025

Survey format: Online

Target Quotas

- Group 1: Minimum of 150 owner-occupied standard income
- Group 2: Minimum of 150 owner-occupied income qualified

General Instructions

- Programming instructions are in red **[LIKE THIS]** (the style is “Survey: Programming”).
- All questions are single-response unless specified otherwise.
- All questions are forced response, unless specified otherwise.

A. *Introduction and Screening*

Thank you for participating in our study about how people make decisions about upgrading and investing in their homes.

A1. What is your current age?

1. Under 18 [TERMINATE]
2. 18 to 34
3. 35 to 54
4. 55 to 74
5. 75 or older

A2. What state do you reside in? If you have residences in more than one state, please select the one where you live most of the time.

1. **[DROP DOWN LIST OF 50 STATES]** [TERMINATE IF THEY DO NOT SELECT WISCONSIN]

A3. What is the zip code of this residence?

1. **[NUMERIC ENTRY]**

A4. Are you a decision maker when it comes to making decisions about investments in your home, such as buying appliances or heating and cooling equipment, or making your home more energy efficient?

1. Yes
2. No [TERMINATE]

A5. Which of the following best describes your home? (Select your primary residence in Wisconsin if you have more than one.)

1. Single-family home, duplex, or town house (row house)
2. Apartment or condominium in a building with 3 or more units
3. Manufactured home
4. Mobile home [TERMINATE]
5. Retirement community or senior facility [TERMINATE]
6. University housing (dormitory) [TERMINATE]
7. I don't know [TERMINATE]

A6. Do you own or rent this home?

1. Own [QUALIFIES FOR GROUP 1 OR 2]
2. Rent [TERMINATE]
3. Some other living situation [TERMINATE]

A7. About how many years have you lived in your current [IF A5 = 1, 3 "home"; IF A5 = 2 "unit"]?

1. **[NUMERIC ENTRY]**

A8. How many people currently live in your home year-round, including yourself? (In other words, what is the *total number of year-round residents* in your household)? [DROP DOWN LIST]

1. One
2. Two
3. Three
4. Four
5. Five
6. Six
7. Seven
8. Eight
9. Nine
10. Ten
11. Eleven
12. Twelve or more
13. I prefer not to say [TERMINATE]

A9. Please indicate your household's approximate total pre-tax income for 2024 including wages, salaries, pensions, social security, etc. for all members of this household. Drag the slider to your approximate income level - if your total household income was more than $200,000, please select $200,000.

1. **[SLIDER FROM $0 to $200,000]** [TERMINATE IF "ZERO" ENTERED]

Number in household (A7)	**Income cutoffs:** **Group 1** (Standard Income) has income **higher than this amount in A9** (*note over $141,000 is automatically Group 1*) **Group 2** (Income Qualified) has income of **this amount or lower in A9** (*note $42,800 and lower is automatically Group 2*)
1	$42,800
2	$56,000
3	$69,100
4	$82,300
5	$95,500
6	$108,700
7	$111,100
8	$113,600
9	$116,100
10	$118,500
11	$121,000
12 OR MORE	$141,000

TERMINATE MESSAGE: Thank you for taking our survey, but we have already received enough responses from households with your characteristics and have no further questions.

B. *Home Characteristics*

B1. In what year was your [IF A5 = 1, 3 "home"; IF A5 = 2 "building"] built? If you don't know exactly, an estimate is fine. (Numerical validation)

1. [TEXT ENTRY BOX]
2. I don't know

B2. What is the approximate square footage of your [IF A5 = 1, 3 "home"; IF A5 = 2 "unit"]? Please only include the basement, attic, or garage if these are heated spaces.

1. [TEXT ENTRY BOX]

C. *Home Energy Systems*

C1. What fuel do you use primarily to heat your home?

1. Electricity
2. Natural Gas
3. Oil
4. Other (please specify): [TEXT ENTRY BOX]
5. I don't know

C2. What is the main type of heating system in your home?

1. Central forced air furnace
2. Hot water boiler with radiators or radiant floor heating
3. [C1=1] Air-source heat pump
4. [C1=1] Ground-source heat pump
5. [C1=1] Ductless heat pump
6. [C1=1] Baseboard heat
7. [C1=1] Wall heaters with fans
8. [C1=1] Portable heaters
9. [C1=2 or 3] Steam boiler with radiators
10. [C1=2 or 3] Fireplace or stove
11. Other (please specify): [TEXT ENTRY BOX]
12. I have no heating system
13. I don't know

C3. What is the main type of cooling system in your home?

1. I have no cooling system
2. Central air conditioner
3. Room or window air conditioners
4. Air source heat pump
5. Ground source heat pump
6. Ductless mini-split air conditioner
7. Other (please specify): [TEXT ENTRY BOX]
8. I don't know

C4. What type of thermostat do you use to control the temperature in your home?

1. Programmable thermostat
2. Wifi-enabled smart thermostat
3. Manual digital thermostat
4. Dial control thermostat
5. Other (please specify): [TEXT ENTRY BOX]
6. I don't know

C5. What type of fuel does the oven and range you use most often in your home use?

1. Electricity
2. Natural Gas
3. Other (please specify): [TEXT ENTRY BOX]
4. I don't know

C6. What type of fuel does your water heater use?

1. Electricity
2. Natural Gas
3. Oil
4. Solar
5. Other (please specify): [TEXT ENTRY BOX]
6. I don't know

C7. Do you have a clothes washer in your [IF A5 = 1, 3 "home"; IF A5 = 2 "unit"]?

1. Yes
2. No

C8. Do you have a clothes dryer in your [IF A5 = 1, 3 "home"; IF A5 = 2 "unit"]?

1. Yes
2. No

C9. [IF C8=1] What type of fuel does your clothes dryer use?
1. Electricity
2. Natural Gas
3. Other (please specify): [TEXT ENTRY BOX]
4. I don't know

C10. [IF A7>=10 "In the last 10" IF A7<10 "In the last [INSERT RESPONSE FROM A7]"] years, have you made any of the following upgrades to your [IF A5 = 1, 3 "home"; IF A5 = 2 "unit"]? Please select all that apply. [RANDOMIZE ORDER EXCEPT FOR LAST ITEM, ALLOW MULTIPLE RESPONSES]
1. Installed insulation
2. Sealed leaks or replaced windows or doors
3. Replaced gas-powered heating equipment or appliances with electric equipment
4. Upgraded heating and cooling systems with high efficiency equipment
5. None of the above [EXCLUSIVE RESPONSE]
6. I don't know [EXCLUSIVE RESPONSE]

D. Adoption Rates

The next questions will ask about how you make decisions about purchasing new equipment and upgrading systems in your home.

Often, when people purchase new equipment, they can purchase something that has a lower initial cost but is less efficient, so the energy cost is higher in the long run compared to a more expensive but more efficient piece of equipment. Or, they can purchase something that has a higher initial cost but is more efficient, so the energy cost is lower in the long run and the extra cost pays for itself by reducing energy bills over time. There is often a range of options to choose from in between the most and least efficient equipment.

D1. Please think about a situation where you might purchase efficient appliances or equipment that use energy in your [IF A5 = 1, 3 "home"; IF A5 = 2 "unit"] – either because you had to replace something that failed, because you wanted to replace something that still worked, or because you wanted to add something to your home that it doesn't already have. **Based on your current financial situation, how would you think about each of the investment scenarios listed below? [RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options			
	1. I would not do this upgrade regardless of cost savings from energy efficiency	2. I would do this upgrade only if the energy savings from the efficient upgrade paid for itself quickly enough	3. I would make this upgrade regardless of the cost savings from energy efficiency	98. Don't know
a. An energy-efficient home appliance where your initial out-of-pocket cost is about **$30 more compared to an inefficient version.**				
b. An energy-efficient appliance or piece of equipment where your initial out-of-pocket cost is about **$300 more compared to an inefficient version.**				
c. An energy-efficient appliance or piece of equipment where your initial out-of-pocket cost is about **$3,000 more compared to an inefficient version**				

D2. [ASK IF ANY ITEMS a-c in D1=2] You indicated that some upgrades would depend on how quickly the energy savings would pay for the cost of getting a more efficient unit. **For each upgrade listed below, what is the longest payback period you would be willing to accept to justify the investment?** Here is an example of what we mean by "payback period": if the more efficient version of something costs an extra $500, but it saves $100 on energy costs every year, then the savings would cover the extra cost in 5 years ($500 divided by $100 per year = 5 years). **[RECORD RESPONSE FOR EACH ROW]**

Efficient Appliance or Equipment	What is the longest payback period in years you would be willing to accept for an upgrade that cost this much extra out-of-pocket?
a. [IF D1a=2] An energy-efficient home appliance where your initial out-of-pocket cost is about **$30 more compared to an inefficient version**	
b. [IF D1b=2] An energy-efficient home appliance or piece of equipment where your initial out-of-pocket cost is about **$300 more compared to an inefficient version**	
c. [IF D1c=2] An energy-efficient home appliance or piece of equipment where your initial out-of-pocket cost is about **$3,000 more compared to an inefficient version**	

D3. [ASK IF ANY ITEMS a-c in D1=1] You indicated that you would not make the investments below regardless of cost savings from energy efficiency. Please select the most important reason why not from the list below.

Efficient Appliance or Equipment	Response Options			
	1. The cost is too much / I would buy the least expensive option	2. I am not concerned about energy efficiency	3. Some other reason	98. Don't know
a. [IF D1a=1] An energy-efficient home appliance where your initial out-of-pocket cost is about **$100 more compared to an inefficient version.**				
b. [IF D1b=1] An energy-efficient appliance or piece of equipment where your initial out-of-pocket cost is about **$1000 more compared to an inefficient version.**				
c. [IF D1c=1] An energy-efficient appliance or piece of equipment where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient version**				

D4. [ASK IF ANY ITEMS a-c in D1=3] You indicated that you would make the investments below regardless of cost savings. Please select the most important reason from the list below.

Efficient Appliance or Equipment	Response Options			
	1. The cost is not high enough to concern me / I generally prefer to buy the best rather than the cheapest2.	2. I am willing to pay more to conserve energy regardless of my cost savings	3. Some other reason	98. Don't know
d. [IF D1a=1] An energy-efficient home appliance where your initial out-of-pocket cost is about **$30 more compared to an inefficient version.**				
e. [IF D1b=1] An energy-efficient appliance or piece of equipment where your initial out-of-pocket cost is about **$300 more compared to an inefficient version.**				
f. [IF D1c=1] An energy-efficient appliance or piece of equipment where your initial out-of-pocket cost is about **$3,000 more compared**				

to an inefficient version				

D5. Next, please consider the specific pieces of equipment listed below. If you were considering these types of equipment, either because you had to replace something that failed, because you wanted to replace something that still worked, or because you wanted to add something to your home that it doesn't already have. **Based on your current financial situation, how would you think about investing in the types of equipment and upgrades listed below?** **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options			
	1. I would not do this upgrade regardless of cost savings from energy efficiency	2. I would do this upgrade only if (if b = the incentives were high enough, and the investment paid for itself quickly enough. otherwise = the energy savings from the efficient upgrade paid for itself quickly enough.)	3. I would make this upgrade regardless of the cost savings from energy efficiency	98. Don't know
a. Efficient lighting upgrades (LEDs and lamps) and high-efficiency small appliances (dehumidifiers, air purifiers, mini-fridges, etc.)				
b. Participation in a program where you receive incentives to use energy during specific times of the day. You might need to purchase specific equipment, such as a battery or smart thermostat to participate in this program. You would receive incentives to use this equipment in certain ways to help your utility manage the electric grid.				
c. Upgrading to high-efficiency home heating, cooling, and water heating equipment				
d. Installing high-efficiency large household appliances (washing machines, dryers, refrigerators, dishwashers, etc.)				
e. [IF C5=natural gas] Installing high-quality efficient electric cooking equipment instead of stoves and ovens that run on natural gas.				

f. [IF C1, C6, OR C9=natural gas] Replacing furnaces, water heaters, and clothes dryers that run on natural gas with efficient electric versions				
g. Improvements to your home's energy efficiency by adding insulation, upgrading windows and doors, sealing leaks, weatherizing, etc.				

D6. [ASK IF ANY ITEMS a-g in D5=2] You indicated that some upgrades would depend on how quickly the energy savings would pay for the cost of the additional cost. **For each type of upgrade listed below, what is the longest payback period you would be willing to accept?** Here is an example of what we mean by "payback period": if the more efficient version of something costs an extra $500, but it saves $100 on energy costs every year, then the savings would "pay for itself" in 5 years ($500 divided by $100 per year = 5 years). **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	What is the longest payback period you would be willing to accept for an upgrade for this equipment?
a. [IF D5a=2] Efficient lighting upgrades (LEDs and lamps) and high-efficiency small appliances (dehumidifiers, air purifiers, mini-fridges, etc.)	
b. [IF D5b=2] Participation in a program where you receive incentives to use energy during specific times of the day	
c. [IF D5c=2] Upgrading to high-efficiency home heating, cooling, and water heating equipment	
d. [IF D5d=2] Installing high-efficiency large household appliances (washing machines, dryers, refrigerators, dishwashers, etc.)	
e. [IF D5e=2] Installing efficient electric cooking equipment instead of stoves and ovens that run on natural gas	
f. [IF D5f=2] Replacing furnaces, water heaters, and clothes dryers that run on natural gas with efficient electric versions	
g. [IF D5g=2] Improvements to your home's energy efficiency by adding insulation, upgrading windows and doors, sealing leaks, weatherizing, etc.	

D7. [ASK IF ANY ITEMS a-g in D5=1] You indicated that you would not make the investments below regardless of cost savings from energy efficiency. Please select the most important reason why not from the list below. **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options				
	1. I usually buy the least expensive option	2. I prefer equipment like what I already own to the more efficient version	3. Making this change would be too difficult or disruptive to household routines	4. Some other reason	98. Don't know
a. [IF D5a=1] Efficient lighting upgrades (LEDs and lamps) and high-efficiency small appliances (dehumidifiers, air purifiers, mini-fridges, etc.)					
b. [IF D5b=1] Participation in a program where you receive incentives to use energy during specific times of the day					
c. [IF D5c=1] Upgrading to high-efficiency home heating, cooling, and water heating equipment					
d. [IF D5d=1] Installing high-efficiency large household appliances (washing machines, dryers, refrigerators, dishwashers, etc.)					
e. [IF D5e=1] Installing efficient electric cooking equipment instead of stoves and ovens that run on natural gas					
f. [IF D5f=1] Replacing furnaces, water heaters, and clothes dryers that run on natural gas with efficient electric versions					
g. [IF D5g=1] Improvements to your home's energy efficiency by adding insulation, upgrading windows and doors, sealing leaks, weatherizing, etc.					

D8. [ASK IF ANY ITEMS a-g in D5=3] You indicated that you would make the investments below regardless of cost savings. Please select the most important reason why from the list below. **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options			
	1. I generally prefer to buy the best rather than the cheapest	2. I am willing to pay more to conserve energy regardless of my cost savings	3. Some other reason	98. Don't know
h. [IF D5a=3] Efficient lighting upgrades (LEDs and lamps) and high-efficiency small appliances (dehumidifiers, air purifiers,				

mini-fridges, etc.)				
i. [IF D5b=3] Participation in a program where you receive incentives to use energy during specific times of the day				
j. [IF D5c=3] Upgrading to high-efficiency home heating, cooling, and water heating equipment				
k. [IF D5d=3] Installing high-efficiency large household appliances (washing machines, dryers, refrigerators, dishwashers, etc.)				
l. [IF D5e=3] Installing efficient electric cooking equipment instead of stoves and ovens that run on natural gas				
m. [IF D5f=3] Replacing furnaces, water heaters, and clothes dryers that run on natural gas with efficient electric versions				
n. [IF D5g=3] Improvements to your home's energy efficiency by adding insulation, upgrading windows and doors, sealing leaks, weatherizing, etc.				

Thank you, that is all of our questions. We appreciate your help with this survey. Have a nice day.

CADMUS

Wisconsin Focus on Energy
2025 Planning Survey

Commercial

Estimate survey launch: February 2025

Survey format: Online

Target Quotas

- Group 1: Minimum of 100 owner-occupied "standard" businesses
- Group 2: Minimum of 100 owner-occupied "institutional" businesses
  - *Institutional means governments, municipal facilities, schools and universities*
- Group 3: Minimum of 100 businesses who rent their facilities (all business types)

<u>General Instructions</u>

- Programming instructions are in red **[LIKE THIS]** (the style is "Survey: Programming").
- All questions are single-response unless specified otherwise.
- All questions are forced response, unless specified otherwise.

A. *Introduction and Screening*

Thank you for participating in our study about how businesses and institutions make decisions about upgrading and investing at their facilities.

A1. Are you the person in your organization who is responsible for facilities and/or energy-related decisions? *This would be the person who oversees spending on electricity and equipment that uses energy, such as lighting and heating. It may be the business owner, or the director of facilities, operations, or engineering.*

1. Yes, I am the owner of the business
2. Yes, I am responsible for energy-related decisions at our facilities (but am not the owner)
3. No [TERMINATE]

A2. In which state is the facility that you are responsible for energy-related decisions located? If you are responsible for facilities in more than one state, please select the state with the largest facility you are responsible for.

1. **[DROP DOWN LIST OF 50 STATES]** [TERMINATE IF THEY DO NOT SELECT WISCONSIN]

A3. What is the zip code of this facility?

1. **[NUMERIC ENTRY]**

A4. What is the primary use of this facility?

1. School (K-12), college, or university - QUALIFIES FOR GROUP 2 OR 3
2. Government or municipal organization (library, fire station, housing authority, etc.) - QUALIFIES FOR GROUP 2 OR 3
3. Retailer / store - QUALIFIES FOR GROUP 1 OR 3
4. Office, banking center, or any other type of non-government/municipal office space - QUALIFIES FOR GROUP 1 OR 3
5. Restaurant / food service - QUALIFIES FOR GROUP 1 OR 3
6. Healthcare (hospital or clinic) - QUALIFIES FOR GROUP 1 OR 3
7. Lodging / hotel - QUALIFIES FOR GROUP 1 OR 3
8. Grocery (supermarket or convenience) - QUALIFIES FOR GROUP 1 OR 3
9. Warehouse - QUALIFIES FOR GROUP 1 OR 3
10. Housing (non-government multifamily property manager) - QUALIFIES FOR GROUP 1 OR 3
11. Farming – RECRUIT FOR AGRICULTURE SURVEY INSTEAD
12. Industrial facility (manufacturing, mining, etc.) [TERMINATE]
13. Other type of commercial facility - QUALIFIES FOR GROUP 1 OR 3
14. I don't know [TERMINATE]

A5. Does your organization own its facilities and buildings, or does your organization rent? If parts of your facility are owned and others are rented, please select “own”.

1. Own facility (part or all) - QUALIFIES FOR GROUP 1 OR 2
2. Rent facility (only) - QUALIFIES FOR GROUP 3

A6. How many years have you worked at this organization?

1. **[NUMERIC ENTRY]**

TERMINATE MESSAGE: Thank you for taking our survey, but we have already received enough responses from respondents with your characteristics and have no further questions.

B. *Business Characteristics*

B1. How many buildings are in your facility?

1. **[NUMERIC ENTRY]**
2. Don't know

B2. **[IF B1 QUANTITY = 1 OR B1 = don't know]** What is the total gross square footage of your building? **[IF B1 QUANTITY>1]** What is the total gross square footage of all the buildings in your facility combined? If you don't know exactly, please give your best estimate.

1. **[NUMERIC ENTRY - SQUARE FOOTAGE]**
2. Don't know

B3. What percentage of the total gross square footage of your facility is heated or cooled? If you don't know exactly, please give your best estimate.

1. **[NUMERIC ENTRY - PERCENTAGE]**
2. Don't know

B4. **[TEXT : IF B1 QUANTITY = 1 OR B1 = don't know]** When was the building built? **[IF B1 QUANTITY > 1]** When were the buildings built? If you don't know exactly, please give your best estimate. **[ALLOW MULTIPLE RESPONSES]**

1. Before 1950
2. 1950 – 1959
3. 1960 – 1969
4. 1970 – 1979
5. 1980 – 1989
6. 1990 – 1999
7. 2000 – 2009
8. 2010 or after
9. Don't know

B5. How many hours per day does your facility operate during a typical weekday? If operation varies day to day, please estimate the average hours per day between Monday and Friday.

1. **[NUMERIC ENTRY – FROM 0 TO 24]**
2. Don't know

B6. How many hours per day does your facility operate during a typical weekend day? If operation varies day to day, please estimate the average hours per day between Saturday and Sunday.

1. **[NUMERIC ENTRY – FROM 0 TO 24]**
2. Don't know

B7. How many employees work in your facility? If you don't know exactly, please give your best estimate.

1. **[NUMERIC ENTRY]**
2. Don't know

C. Facility Energy Systems

C1. What is the main fuel used to heat your facility? **[READ LIST IF NEEDED]**

1. Electricity
2. Natural Gas
3. Propane
4. Fuel Oil
5. None, no space heating
6. Don't know

C2. **[IF C1 ≠ 5]** About what percent of your floor space is heated? If you don't know exactly, please give your best estimate.

1. **[NUMERIC ENTRY - PERCENTAGE]**
2. Don't know

C3. About what percent of your floor space is cooled? If you don't know exactly, please give your best estimate.

1. **[NUMERIC ENTRY – PERCENTAGE]**
2. None of the facility is cooled
3. Don't know

C4. From the list below, please select any equipment installed and in use at your facility. [RANDOMIZE ORDER EXCEPT FOR LAST ITEMS, ALLOW MULTIPLE RESPONSES]

1. Food preparation (ovens, stoves, etc.)
2. Pumps or motors
3. Refrigeration or chillers
4. Electric vehicle chargers
5. None of the above [EXCLUSIVE RESPONSE]
6. I don't know [EXCLUSIVE RESPONSE]

C5. [IF A6>=10 "In the last 10" IF A6<10 "In the last [INSERT RESPONSE FROM A6]"] years, have you made any of the following upgrades to your facility? Please select all that apply. [RANDOMIZE ORDER EXCEPT FOR LAST ITEMS, ALLOW MULTIPLE RESPONSES]

1. Installed insulation / sealed leaks or replaced windows or doors
2. Replaced gas-powered heating equipment or appliances with electric equipment
3. Upgraded heating and cooling systems with high efficiency equipment
4. Upgraded machinery or business operations
5. None of the above [EXCLUSIVE RESPONSE]
6. I don't know [EXCLUSIVE RESPONSE]

D. Adoption Rates

The next questions will ask about how you make decisions about purchasing new equipment and upgrading systems at your facility.

Often, when businesses purchase new equipment, they can purchase something that has a lower initial cost but is less efficient, so the energy cost is higher in the long run compared to a more expensive but more efficient piece of equipment. Or, they can purchase something that has a higher initial cost but is more efficient, so the energy cost is lower in the long run. There is often a range of options to choose from in between the most and least efficient equipment.

D1. Please think about a situation where you might purchase energy-efficient appliances or equipment in your primary operations – either because you had to replace something that failed, because you wanted to replace something that still worked, or because you wanted to add something to your facility that it doesn't already have. **Based on your current financial situation, how would you think about each of the investment scenarios listed below? [RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options			
	1. I would not do this upgrade regardless of cost savings from energy efficiency	2. I would do this upgrade only if the energy savings from the efficient upgrade paid for itself quickly enough	3. I would make this upgrade regardless of the cost savings from energy efficiency	98. Don't know
a. Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient version.**				
b. Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$50,000 more compared to an inefficient version.**				

c. Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$500,000 more compared to an inefficient version**				

D2. [ASK IF ANY ITEMS a-c in D1=2] You indicated that some upgrades would depend on how quickly the energy savings would pay for the cost of purchasing a more efficient option. **For each upgrade listed below, what is the longest payback period you would be willing to accept to justify the investment?** Here is an example of what we mean by "payback period": if the more efficient version of something costs an extra $5000, but it saves $1000 on energy costs every year, then the savings would "pay for itself" in 5 years ($5000 divided by $1000 per year = 5 years). **[RECORD RESPONSE FOR EACH ROW]**

Efficient Appliance or Equipment	What is the longest payback period you would be willing to accept for an upgrade that cost this much out-of-pocket?
a. [IF D1a=2] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient version**	
b. [IF D1b=2] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$50,000 more compared to an inefficient version**	
c. [IF D1c=2] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$500,000 more compared to an inefficient version**	

D3. [ASK IF ANY ITEMS a-c in D1=1] You indicated that you would not make the investments below regardless of cost savings from energy efficiency. Please select the most important reason why not from the list below.

Efficient Appliance or Equipment	Response Options			
	1. The cost is too much / I would pursue the least expensive option	2. I am not concerned about energy efficiency	3. Some other reason	98. Don't know
a. [IF D1a=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient version.**				
b. [IF D1b=1] Energy-efficient operational improvements (not including vehicles) where				

your initial out-of-pocket cost is about **$50,000 more compared to an inefficient version.**				
c. [IF D1c=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$500,000 more compared to an inefficient version**				

D4. [ASK IF ANY ITEMS a-c in D1=3] You indicated that you would make the investments below regardless of cost savings. Please select the most important reason from the list below.

Efficient Appliance or Equipment	Response Options			
	1. The cost is not high enough to concern me / I generally pursue the best option rather than the cheapest	2. I am willing to pay more to conserve energy regardless of my cost savings	3. Some other reason	98. Don't know
d. [IF D1a=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient version.**				
e. [IF D1b=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$50,000 more compared to an inefficient version.**				
f. [IF D1c=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$500,000 more compared to an inefficient version**				

D5. Next, please consider the specific investments listed below. If you were considering these types of equipment, either because you had to replace something that failed, because you wanted to replace something that still worked, or because you wanted to add something to your facility that it doesn't already have. **Based on your current financial situation, how would you think about investing in the types of equipment and upgrades listed below?** **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options			
	1. I would not do this upgrade regardless of cost savings from energy efficiency	2. I would do this upgrade only if the energy savings from the efficient upgrade paid for itself quickly enough	3. I would make this upgrade regardless of the cost savings from energy efficiency	98. Don't know
a. Upgrading to high-efficiency lighting and small appliances and equipment (occupancy sensors, dehumidifiers, advanced power strips, etc.)				
b. Upgrading to high-efficiency space heating, space cooling, water heating, or major appliances				
c. [IF C4 = 1] Installing efficient electric cooking equipment instead of stoves and ovens that run on natural gas				
d. [IF C1 = 2] Replacing furnaces, water heaters, and other equipment that runs on gas or fuel with efficient electric versions				
e. Participating in an energy management program where you are provided incentives to shift the timing of energy use and are provided incentives to install energy storage systems.				
f. Upgrading to high-efficiency equipment *other than heating or cooling*				
g. Replacing equipment *other than heating systems* that run on natural gas with efficient electric versions				

D6. [ASK IF ANY ITEMS a-g in D5=2] You indicated that some upgrades would depend on how quickly the energy savings would pay for the cost of the additional cost. **For each type of upgrade listed below, what is the longest payback period you would be willing to accept?** Here is an example of what we mean by "payback period": if the more efficient version of something costs an extra $5000, but it saves $1000 on energy costs every year, then the savings would "pay for itself" in 5 years ($5000 divided by $1000 per year = 5 years). **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	What is the longest payback period you would be willing to accept for an upgrade that cost this much out-of-pocket?
a. [IF D5a=2] Upgrading to high-efficiency lighting and small appliances and equipment (occupancy sensors, dehumidifiers, advanced power strips, etc.)	
b. [IF D5b=2] Upgrading to high-efficiency space heating, space cooling, water heating, or major appliances	
c. [IF D5c=2] Installing efficient electric cooking equipment instead of stoves and ovens that run on natural gas	
d. [IF D5d=2] Replacing furnaces, water heaters, and other equipment that runs on gas or fuel with efficient electric versions	
e. [IF D5e=2] Participating in an energy management program where you are provided incentives to shift the timing of energy use and are provided incentives to install energy storage systems.	
f. [IF D5f=2] Upgrading to high-efficiency equipment *other than heating or cooling.*	
g. [IF D5g=2] Replacing equipment *other than heating systems* that run on natural gas with efficient electric versions.	

D7. [ASK IF ANY ITEMS a-g in D5=1] You indicated that you would not make the investments below regardless of cost savings from energy efficiency. Please select the most important reason why not from the list below. **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options				
	1. I usually buy the least expensive option	2. I prefer equipment like what I already own to the more efficient version	3. Making this change would be too difficult or disruptive	4. Some other reason	98. Don't know
a. [IF D5a=2] Upgrading to high-efficiency lighting and small appliances and equipment (occupancy sensors, dehumidifiers, advanced power strips, etc.)					
b. [IF D5b=2] Upgrading to high-efficiency space heating, space cooling, water heating, or major appliances					
c. [IF D5c=2] Installing efficient electric cooking equipment instead of stoves and ovens that run on natural gas					
d. [IF D5d=2] Replacing furnaces, water heaters, and other equipment that runs on					

gas or fuel with efficient electric versions					
e. [IF D5e=2] Participating in an energy management program where you are provided incentives to shift the timing of energy use and are provided incentives to install energy storage systems.					
f. [IF D5f=2] Upgrading to high-efficiency equipment *other than heating or cooling.*					
g. [IF D5g=2] Replacing equipment *other than heating systems* that run on natural gas with efficient electric versions.					

D8. [ASK IF ANY ITEMS a-g in D5=3] You indicated that you <u>would</u> make the investments below regardless of cost savings. Please select the most important reason why from the list below. **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options			
	1. I generally prefer to buy the best rather than the cheapest	2. I am willing to pay more to conserve energy regardless of my cost savings	3. Some other reason	98. Don't know
a. [IF D5a=2] Upgrading to high-efficiency lighting and small appliances and equipment (occupancy sensors, dehumidifiers, advanced power strips, etc.)				
b. [IF D5b=2] Upgrading to high-efficiency space heating, space cooling, water heating, or major appliances				
c. [IF D5c=2] Installing efficient electric cooking equipment instead of stoves and ovens that run on natural gas				
d. [IF D5d=2] Replacing furnaces, water heaters, and other equipment that runs on gas or fuel with efficient electric versions				
e. [IF D5e=2] Participating in an energy management program where you are provided incentives to shift the timing of energy use and are provided incentives to install energy storage systems.				
f. [IF D5f=2] Upgrading to high-efficiency equipment *other than heating or cooling.*				

g. [IF D5g=2] Replacing equipment *other than heating systems* that run on natural gas with efficient electric versions.				

Thank you, that is all of our questions. We appreciate your help with this survey. Have a nice day.

CADMUS

Wisconsin Focus on Energy
2025 Planning Survey

Agriculture

Estimate survey launch: February 2025

Survey format: Online

Target Quotas

- Group 1: Minimum of 100 agricultural decision makers

General Instructions

- Programming instructions are in red **[LIKE THIS]** (the style is “Survey: Programming”).
- All questions are single-response unless specified otherwise.
- All questions are forced response, unless specified otherwise.

A. Introduction and Screening

Thank you for participating in our study about how farmers make decisions about upgrading and investing in their farms.

A1. Do you own or operate a farm in Wisconsin? By farm we mean a property devoted primarily to agricultural production for commercial purposes (dairy, crops, or livestock).

1. Yes
2. No [TERMINATE]

A2. Which of the following best describes the primary product of your farm?

1. Dairy
2. Livestock (beef, pork, sheep, etc.)
3. Poultry and eggs
4. Fish
5. Crops (grain, fruits, vegetables, herbs, etc.)
6. None of the above [TERMINATE]
7. I don't know [TERMINATE]

A3. What is the zip code of your farm's location?

1. **[NUMERIC ENTRY]**

A4. Do you own the farm or are you an employee (or family member)?

1. Owner
2. Employee / family member

A5. [ASK IF A4 = 2] Are you a decision maker at your farm when it comes to investing in physical facilities, such as improving the efficiency of buildings and agricultural operations and machinery?

1. Yes
2. No [TERMINATE]

A6. How many years have you worked at this farm?

1. **[NUMERIC ENTRY]**

TERMINATE MESSAGE: Thank you for taking our survey, but we have already received enough responses from respondents with your characteristics and have no further questions.

B. *Farm Characteristics*

B1. What type of agriculture does your farm primarily engage in?

1. Dairy
2. Crop farm
3. Poultry
4. Livestock (cows, sheep, etc.)
5. Greenhouse

B2. Does your farm engage in any other types of agriculture? Select all that apply. **[ALLOW MULTIPLE RESPONSE]**

1. Dairy
2. Crop farm
3. Poultry
4. Livestock (cows, sheep, etc.)
5. Greenhouse
6. No other types of agriculture [EXCLUSIVE]

B3. [ASK IF B1=1 OR 0=1] How many head of animals are on your farm? **[NUMERIC ENTRY]**

B4. [ASK IF B1=2 OR 0=2] How many acres of crops are you farming? **[NUMERIC ENTRY]**

B5. In what year did your farm begin operation? If you don't know exactly, an estimate is fine.

1. [NUMERIC ENTRY]
2. I don't know

B6. How many separate buildings on your farm are used in your primary operation? 'Primary operation' means buildings related to the primary agriculture of the farm (i.e. dairy-related buildings for a dairy farm).

1. **[NUMERIC ENTRY]**
2. Don't know

B7. What is the total gross square footage of all primary operation buildings at your facility? 'Primary operation' means buildings related to the primary agriculture of the farm (i.e. dairy-related buildings for a dairy farm). If you don't know exactly, please give me your best estimate.

1. **[NUMERIC ENTRY - SQUARE FOOTAGE]**
2. Don't know

C. Farm Energy Systems

C1. About what percent of your primary operation building square feet are heated? 'Primary operation' means buildings related to the primary agriculture of the farm (i.e. dairy-related buildings for a dairy farm). If you don't know exactly, please give me your best estimate

1. **[NUMERIC ENTRY – PERCENTAGE]**
2. None of the primary operation buildings are heated
3. Don't know

C2. **[IF C1 ≠ 2]** What is the main fuel used to heat the primary operation buildings at your facility?

1. Electricity
2. Natural Gas
3. Propane
4. Fuel Oil
5. None, no space heating
6. Don't know

C3. About what percent of your primary operation building square feet are cooled? If you don't know exactly, please give your best estimate.

1. **[NUMERIC ENTRY – PERCENTAGE]**
2. None of the primary operation buildings are cooled
3. Don't know

C4. [IF A6>=10 "In the last 10" IF A6<10 "In the last [INSERT RESPONSE FROM A6]"] years, have you made any of the following upgrades to your facilities? Please select all that apply. [RANDOMIZE ORDER EXCEPT FOR LAST ITEMS, ALLOW MULTIPLE RESPONSES]

1. Upgraded space heating, cooling, or water heating with high efficiency equipment
2. Upgraded equipment related to your primary operation with high efficiency equipment (milking equipment, grain dryers, irrigation systems, compressed air, motors)
3. Upgraded to high efficiency lighting
4. Upgraded to high efficiency fans (ventilation, circulation, exhaust, etc.)
5. Replaced gas-powered heating equipment or appliances with electric equipment
6. None of the above [EXCLUSIVE RESPONSE]
7. I don't know [EXCLUSIVE RESPONSE]

D. Adoption Rates

The next questions will ask about how you make decisions about purchasing new equipment and upgrading systems at your farm.

Often, when businesses purchase new equipment, they can purchase something that has a lower initial cost but is less efficient, so the energy cost is higher in the long run compared to a more expensive but more efficient piece of equipment. Or, they can purchase something that has a higher initial cost but is more efficient, so the energy cost is lower in the long run. There is often a range of options to choose from in between the most and least efficient equipment.

D1. Please think about a situation where you might purchase energy-efficient appliances or equipment in your primary operations – either because you had to replace something that failed, because you wanted to replace something that still worked, or because you wanted to add something to your operation that it doesn't already have. **Based on your current financial situation, how would you think about each of the investment scenarios listed below?** [RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]

Efficient Appliance or Equipment	Response Options			
	1. I would not do this upgrade regardless of cost savings from energy efficiency	2. I would do this upgrade only if the energy savings from the efficient upgrade paid for itself quickly enough	3. I would make this upgrade regardless of the cost savings from energy efficiency	98. Don't know
a. Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient option.**				
b. Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$50,000 more compared to an inefficient option.**				
c. Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$500,000 more compared to an inefficient option.**				

D2. [ASK IF ANY ITEMS a-c in D1=2] You indicated that some upgrades would depend on how quickly the energy savings would pay for the cost of purchasing a more efficient option. **For each upgrade listed below, what is the longest payback period you would be willing to accept to justify the investment?** Here is an example of what we mean by "payback period": if the more efficient version of something costs an extra $5000, but it saves $1000 on energy costs every year, then the savings would "pay for itself" in 5 years ($5000 divided by $1000 per year = 5 years). **[RECORD RESPONSE FOR EACH ROW]**

Efficient Appliance or Equipment	What is the longest payback period you would be willing to accept for an upgrade that cost this much out-of-pocket?
a. [IF D1a=2] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient option**	
b. [IF D1b=2] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$50,000 more compared to an inefficient option**	
c. [IF D1c=2] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$500,000 more compared to an inefficient option**	

D3. [ASK IF ANY ITEMS a-c in D1=1] You indicated that you would not make the investments below regardless of cost savings from energy efficiency. Please select the most important reason why not from the list below.

Efficient Appliance or Equipment	Response Options			
	1. The cost is too much / I would pursue the least expensive option	2. I am not concerned about energy efficiency	3. Some other reason	98. Don't know
a. [IF D1a=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient option**				
b. [IF D1b=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$50,000 more compared to an inefficient option**				
c. [IF D1c=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$500,000 more compared to an inefficient option**				

D4. [ASK IF ANY ITEMS a-c in D1=3] You indicated that you would make the investments below regardless of cost savings. Please select the most important reason from the list below.

Efficient Appliance or Equipment	Response Options			
	1. The cost is not high enough to concern me / I generally pursue the best option rather than the cheapest	2. I am willing to pay more to conserve energy regardless of my cost savings	3. Some other reason	98. Don't know
d. [IF D1a=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$5,000 more compared to an inefficient option**				
e. [IF D1b=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$50,000 more compared to an inefficient option**				
f. [IF D1c=1] Energy-efficient operational improvements (not including vehicles) where your initial out-of-pocket cost is about **$500,000 more compared to an inefficient option**				

D5. Next, please consider the specific investments listed below. If you were considering these types of equipment, either because you had to replace something that failed, because you wanted to replace something that still worked, or because you wanted to add something to your facility that it doesn't already have. **Based on your current financial situation, how would you think about investing in the types of equipment and upgrades listed below?** **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options			
	1. I would not do this upgrade regardless of cost savings from energy efficiency	2. I would do this upgrade only if the energy savings from the efficient upgrade paid for itself quickly enough	3. I would make this upgrade regardless of the cost savings from energy efficiency	98. Don't know
a. High-efficiency agricultural equipment upgrades not including vehicles (irrigation systems, milking equipment, grain dryers, refrigeration, motors, compressed air, etc.)				
b. High-efficiency lighting upgrades				
c. Upgrading to high-efficiency heating, cooling, and water heating equipment				

d. [IF C2 = 2] Replacing furnaces, water heaters, and other heating systems that run on natural gas with efficient electric versions				
e. Upgrading to high-efficiency equipment *other than heating, cooling or primary agriculture systems*				
f. Replacing equipment *other than heating systems* that run on natural gas with efficient electric versions				

D6. [ASK IF ANY ITEMS a-g in D5=2] You indicated that some upgrades would depend on how quickly the energy savings would pay for the cost of the additional cost. **For each type of upgrade listed below, what is the longest payback period you would be willing to accept?** Here is an example of what we mean by "payback period": if the more efficient version of something costs an extra $5000, but it saves $1000 on energy costs every year, then the savings would "pay for itself" in 5 years ($5000 divided by $1000 per year = 5 years). **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	What is the longest payback period you would be willing to accept for an upgrade that cost this much out-of-pocket?
a. [IF D5a=2] High-efficiency agricultural equipment upgrades (irrigation systems, milking equipment, grain dryers, refrigeration, motors, compressed air, etc.)	
b. [IF D5b=2] High-efficiency lighting upgrades	
c. [IF D5c=2] Upgrading to high-efficiency heating, cooling, and water heating equipment	
d. [IF D5d=2] Replacing furnaces, water heaters, and other heating systems that run on natural gas with efficient electric versions	
e. [IF D5e=2] Upgrading to high-efficiency equipment other than heating, cooling or primary agriculture systems	
f. [IF D5f=2] Replacing equipment other than heating systems that run on natural gas with efficient electric versions	

D7. [ASK IF ANY ITEMS a-g in D5=1] You indicated that you would not make the investments below regardless of cost savings from energy efficiency. Please select the most important reason why not from the list below. **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options				
	1. I usually pursue the least expensive option	2. I prefer equipment like what I already own to the more efficient version	3. Making this change would be too difficult or disruptive	4. Some other reason	98. Don't know
a. [IF D5a=2] High-efficiency agricultural equipment upgrades (irrigation systems, milking equipment, grain dryers, refrigeration, motors, compressed air, etc.)					
b. [IF D5b=2] High-efficiency lighting upgrades					
c. [IF D5c=2] Upgrading to high-efficiency heating, cooling, and water heating equipment					
d. [IF D5d=2] Replacing furnaces, water heaters, and other heating systems that run on natural gas with efficient electric versions					
e. [IF D5e=2] Upgrading to high-efficiency equipment other than heating, cooling or primary agriculture systems					
f. [IF D5f=2] Replacing equipment other than heating systems that run on natural gas with efficient electric versions					

D8. [ASK IF ANY ITEMS a-g in D5=3] You indicated that you would make the investments below regardless of cost savings. Please select the most important reason why from the list below. **[RECORD RESPONSE FOR EACH ROW, RANDOMIZE THE ORDER OF ROWS]**

Efficient Appliance or Equipment	Response Options			
	1. I generally pursue the best option rather than the cheapest	2. I am willing to pay more to conserve energy regardless of my cost savings	3. Some other reason	98. Don't know
a. [IF D5a=2] High-efficiency agricultural equipment upgrades (irrigation systems, milking equipment, grain dryers, refrigeration, motors, compressed air, etc.)				
b. [IF D5b=2] High-efficiency lighting upgrades				
c. [IF D5c=2] Upgrading to high-efficiency heating, cooling, and water heating equipment				
d. [IF D5d=2] Replacing furnaces, water				

heaters, and other heating systems that run on natural gas with efficient electric versions				
e. [IF D5e=2] Upgrading to high-efficiency equipment other than heating, cooling or primary agriculture systems				
f. [IF D5f=2] Replacing equipment other than heating systems that run on natural gas with efficient electric versions				

Thank you, that is all of our questions. We appreciate your help with this survey. Have a nice day.

Appendix G. Benchmarking Sources

Below is the list of utilities included in the benchmarking analysis and the associated reports where data was used.

1. Focus on Energy (Wisconsin)
    a. Calendar Year 2022 – 2024 Evaluation Reports VOLUME I
        i. 2015: FOC_XC__CY 13 Evaluation Report_Volume I
        ii. 2016: WI FOE CY 2016 Volume I
        iii. 2017: WI FOE CY 2017 Volume I FINAL
        iv. 2018: Focus on Energy Calendar Year 2018 Evaluation Report: Volume I
        v. 2019: Annual_Report-CY_2019_Volume_I.pdf
        vi. 2020: Evaluation_Report-2020-Volume_I.pdf
        vii. 2021: Focus on Energy CY 2021 Volume I
        viii. 2022: Evaluation_CY_2022-Vol-I_final.pdf
        ix. 2023: WI Focus on Energy CY 2023 Volume I_FINAL
        x. 2024: CY 2024 Focus on Energy Volume I
2. CenterPoint Energy (Indiana, Ohio, Minnesota, Mississippi, Louisiana, and Texas)
    a. CenterPoint Energy 2024 Corporate Sustainability Report
        i. CenterPoint-Energy-CSR-10-09-25.pdf https://sustainability.centerpointenergy.com/wp-content/uploads/2025/10/CenterPoint-Energy-CSR-10-09-25.pdf
3. Otter Tail Power Company (South Dakota)
    a. South Dakota Energy Efficiency Program 2016 – 2024 Status Reports
        i. 2015: https://puc.sd.gov/commission/dockets/electric/2016/el16-019/EEP042916.pdf
        ii. 2017: https://puc.sd.gov/commission/dockets/electric/2018/el18-022/report.pdf
        iii. 2018: https://puc.sd.gov/commission/dockets/electric/2019/el19-020/report.pdf
        iv. 2019: https://puc.sd.gov/commission/dockets/electric/2020/el20-016/Table.pdf
        v. 2020: https://puc.sd.gov/commission/dockets/electric/2021/el21-015/Table.pdf
        vi. 2021: https://puc.sd.gov/commission/dockets/electric/2022/el22-011/StatusReport.pdf
        vii. 2022: https://puc.sd.gov/commission/dockets/electric/2023/el23-012/StatusReport.pdf
        viii. 2023: https://puc.sd.gov/commission/dockets/electric/2024/el24-017/2023EEStatusReport.pdf
        ix. 2024: https://puc.sd.gov/commission/dockets/electric/2025/EL25-021/2024StatusReport.pdf
4. Consolidated Edison Company (New York)
    a. Con Edison 2024 System Energy Efficiency Plan (SEEP) Annual Report
        i. 2021: https://www.bing.com/ck/a?!&&p=40b110037be6e0e8c1177fab6e27df3f5335e71487bc7fb5388700d1dbd7bd97JmltdHM9MTc2NTA2NTYwMA&ptn=3&ver=2&hsh=4&fclid=1184ed0b-0b12-6718-0372-fb160a4b66a7&u=a1aHR0cHM6Ly9kb2N1bWVudHMuZHBzLm55Lmdvdi9wdWJsaWMvQ29tbW9uL1ZpZXdEb2MuYXNweD9Eb2NSZWZJZD17RDM5RjAzQzItRjg3Mi00OTc5LUI4RUEtNTJBQkUzM0MxNTI3fQ&ntb=1
        ii. 2022: https://www.bing.com/ck/a?!&&p=8e314386584ca7866410b4fcccbd1584fbdb1ab08c

3ac70fe396801b9519bea5JmltdHM9MTc2NTA2NTYwMA&ptn=3&ver=2&hsh=4&fclid=1184ed0b-0b12-6718-0372-fb160a4b66a7&psq=Con+Edison+2022+System+Energy+Efficiency+Plan+(SEEP)+Annual+Report&u=a1aHR0cHM6Ly9kb2N1bWVudHMuZHBzLm55Lmdvdi9wdWJsaWMvQ29tbW9uL1ZpZXdEb2MuYXNweD9Eb2NSZWZJZD0lN2I3MDRFMzk4Ny0wMDAwLUM3MUMtODk5RC01MDcyNEU0N0UwMkMlN2Q

iii. 2023: https://www.bing.com/ck/a?!&&p=283239c923becb80c38d1b6fea99d1ee8d457e0ea11bfff15a898dd80d7962cbJmltdHM9MTc2NTA2NTYwMA&ptn=3&ver=2&hsh=4&fclid=1184ed0b-0b12-6718-0372-fb160a4b66a7&psq=o+Con+Edison+2023+System+Energy+Efficiency+Plan+(SEEP)+Annual+Report&u=a1aHR0cHM6Ly9kb2N1bWVudHMuZHBzLm55Lmdvdi9wdWJsaWMvQ29tbW9uL1ZpZXdEb2MuYXNweD9Eb2NSZWZJZD17NjBFQjlBOEUtMDAwMC1DOTNFLUFEN0ItQTExOTVDRDA5NkZDfQ

iv. 2024: https://www.bing.com/ck/a?!&&p=872d11d46238e2ab76dacae92f0edc17745c27d3088ef7a275659ecc7f84db5bJmltdHM9MTc2NTA2NTYwMA&ptn=3&ver=2&hsh=4&fclid=1184ed0b-0b12-6718-0372-fb160a4b66a7&u=a1aHR0cHM6Ly9kb2N1bWVudHMuZHBzLm55Lmdvdi9wdWJsaWMvQ29tbW9uL1ZpZXdEb2MuYXNweD9Eb2NSZWZJZD17RDBEQ0YyOTUtMDAwMC1DMjJCLTg4N0MtMTg5QkVGRjEwNDE1fQ&ntb=1

5. DTE Energy (Michigan)
   a. Energy Efficiency Annual 2021 – 2024 Reports
      i. 2021: DTE 2021 Energy Efficiency Annual Report
      ii. 2022: 2022 Annual Report Energy Efficiency
      iii. 2023: Energy Efficiency 2023 Annual Report
      iv. 2024: Energy Efficiency 2024 Annual Report