EFFICIENT TECHNOLOGY ACCELERATOR

High-Performance RTU Energy Savings and Market Evaluation Plan

Center for Energy and Environment

Spring 2024

CONTENTS

Background and Summary of Potential

Minnesota Efficient Technology Accelerator

Minnesota's Efficient Technology Accelerator (ETA) is a statewide market transformation program to accelerate deployment and reduce the cost of emerging and innovative efficient technologies, bringing lower energy bills and environmental benefits to Minnesotans. The ETA is funded by the state's investor-owned utilities (IOUs),[1] administered by the Minnesota Department of Commerce, Division of Energy Resources (DER), and implemented by Center for Energy and Environment (CEE). Savings generated by the program will be claimed by the funding utilities to help meet state goals.

As a market transformation program, ETA will work to overcome market barriers, leading to greater market adoption of targeted technologies and, ultimately, energy savings. In the initial years of a market transformation program, energy savings can be small as it can take time to grow the market. In addition, the savings methodology for counting savings from market transformation initiatives (described further in this plan) is more involved than is typically the case for utility rebate programs. Therefore, a careful evaluation plan is a complementary endeavor to estimating savings from market transformation programs because it can provide additional evidence of the effectiveness of programmatic efforts to break down barriers and support the estimation and claiming of energy savings.

Within the overall ETA program, individual market transformation initiatives (a programmatic effort around a specific technology or approach) are developed. This Energy Savings and Market Evaluation Plan focuses on the Commercial Rooftop Unit (RTU) Initiative. Here, we provide a thorough plan to both estimate savings and to measure market progress, prior to launching our initiative in the market. As we learn more about the market through additional research and our market engagement, we will continue to refine and update our approach.

High-performance rooftop units

Summary

RTUs provide an all-in-one heating, ventilation, and air-conditioning (HVAC) solution for commercial and industrial buildings. Given this utility, it is the most common equipment choice for meeting commercial HVAC needs, and while the cooling load is usually electric, the heating fuel type of Minnesota RTUs is generally natural gas (97% of RTUs as of 2017).[2] Even though it

---

[1] Specifically, electric and natural gas IOUs with more than 30,000 customers as specified in Minnesota Statutes § 216B.241 subd. 14, which includes Xcel Energy, Minnesota Power, Otter Tail Power, CenterPoint Energy, and Minnesota Energy Resources.

[2] Schuetter et al. "Commercial Roof-top Units in Minnesota Conservation Applied Research & Development Final Report." Minnesota Department of Commerce Conservation Applied Research & Development. 2017. https://www.cards.commerce.state.mn.us/CARDS/security/search.do?method=showPoup&documentId=%7BAC3FB94A-9598-4A9C-BF02-967BFAC28FF3%7D&documentTitle=386204&documentType=6

is the most common commercial HVAC choice, the RTU industry has remained stagnant for more than 30 years, with RTU heating efficiency only improving by 1% over that time.[3]

In the state of Minnesota, there are approximately 21,000 buildings[4] that rely on RTUs for space conditioning (heating, cooling, ventilation), which represents 80%[5] of the commercial buildings in the state. The average age of these units is 13 years, which means they are approaching the end of their expected 15-year lifetime and are operating below federal minimum standards for efficiency.

This presents a huge opportunity for energy and emissions savings, because commercial HVAC accounts for more than 60% of the energy use in commercial buildings in Minnesota.[6] So, it will be imperative to increase the efficiency and reduce the emissions of the most common commercial HVAC equipment: RTUs. The two technologies that can best increase the efficiency of RTUs are heat pumps and energy recovery ventilators (ERVs). While there is some momentum for all-electric heat pump RTUs nationwide, given Minnesota's climate and the need for a backup fuel source in cold weather, we will focus on dual fuel heat pump RTU systems and ERVs for this initiative.

Even though these technologies can save a lot of energy, our market research indicates they have a very low market share. The results of the market actor interviews concluded that ERVs are only included on 1–2% of the total RTU annual sales.[7] For dual fuel heat pumps, we conducted an analysis of the 2018 Comstock data,[8] which indicated that there were no dual fuel heat pump RTUs in Minnesota's building stock. This has changed since 2018, as we know that there are a few dual fuel heat pump RTUs in Minnesota, but market actor interviews confirmed that sales are still very low (<1%).

The current barriers to the adoption of dual fuel heat pump RTUs include long lead times, limited products in the market, high upfront costs, and manufacturer resource limitations. ERVs have their own unique barriers to adoption that include limited integration options, low awareness and understanding of how the systems work, and low development from manufacturers.

---

[3] Federal minimum standards for RTUs increased from 80% to 81% starting in 2024. This is the first change in minimum efficiency standards since 1994.

[4] Center for Energy and Environment. 2017. "Market and Performance Characterization of Commercial Rooftop Units." Minnesota Department of Commerce Conservation Applied Research & Development. https://www.mncee.org/market-and-performance-characterization-commercial-rooftop-units

[5]https://www.cards.commerce.state.mn.us/CARDS/security/search.do?method=showPoup&documentId=%7BAC3FB94A-9598-4A9C-BF02-967BFAC28FF3%7D&documentTitle=386204&documentType=6

[6] Parker, Andrew, et al. 2023. ComStock Reference Documentation. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-83819. https://www.nrel.gov/docs/fy23osti/83819.pdf

[7] High-Performance RTU Market Characterization Report – Cadeo Group, 2023

[8] As noted in the ComStock reference documentation, the ComStock model "uses multiple data sources, statistical sampling methods, and advanced building energy simulations to estimate the annual subhourly energy consumption of the commercial building stock across the United States."

ETA plans to deploy several market support strategies to accelerate adoption of ERV and dual fuel heat pump RTUs. Anticipated market support strategies include the following.

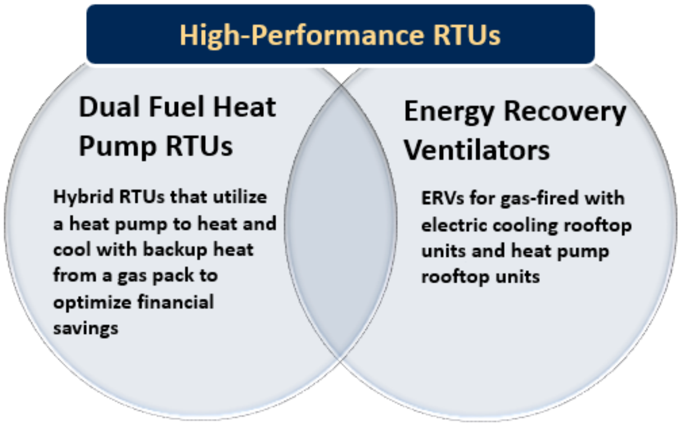
1. Generate and leverage field studies, pilots, and data to create case studies and market resources to build market awareness and confidence.
2. Partner with manufacturers and distributors to expand product availability, decrease product lead time, and increase product development.
3. Create, leverage, and deliver market education and training in collaboration with market actors.
4. Create and leverage resources and conduct targeted consumer outreach to build awareness and demand.
5. Engage with utilities on program opportunities and tools to highlight commercial rate options and bill impacts.
6. Collaborate with national partners to create a unified voice and alignment on high-performance RTU specifications, efficiency standards, and test standards.
7. Develop strategies and work with appropriate entities to advance state or federal energy codes and code compliance.

For more information about barriers, opportunities, and market support strategies, please see the Market Transformation Plan.

Product description

This initiative is focused on advancing the adoption of high-performance RTUs, which this initiative defines as an RTU with either an ERV (integrated or bolt-on) or a dual fuel heat pump. We will work to advance the adoption of both technologies, with a long-term goal of promoting systems that have incorporated both technologies, meaning a customer can buy a dual fuel heat pump RTU with an ERV incorporated into the system. In the meantime, we will promote, track, and advance the adoption of both technologies under the program umbrella of high-performance RTUs as shown in Figure 1.

Figure 1. Diagram of high-performance RTU program overview



Dual fuel heat pump RTUs

A heat pump RTU can provide both heating and cooling to a building using one refrigeration system. These systems are similar to a traditional air conditioning RTU but can also reverse the flow of refrigerant to move heat from the outside environment into the building. Heat pumps are much more efficient than gas furnaces because they move heat from one location to another instead of generating heat by combusting natural gas or propane. Heat pumps can operate well in colder ambient temperatures but lose efficiency at low temperatures and can have capacity limitations. Dual fuel heat pump RTUs are equipped with a gas heat exchanger that can provide heating at low ambient temperatures as necessary. Using gas heat at low temperatures can help optimize bill savings, while offsetting most of the heating load with the heat pump can greatly reduce energy use and carbon emissions.

The high-performance RTU product definition includes two levels of products for heat pumps. The two-level system for heat pumps was created to capture the two different types of heat pumps available in the market. The first level consists of the more common heat pumps equipped with staged compressors. Level 2 comprises premium heat pumps that use variable speed compressors, which increase efficiency and allow the heat pumps to operate at lower temperatures. There are very few of these systems and they are sold at a premium.

Energy Recovery Ventilators (ERVs)

Rooftop units provide more than just heating and cooling to buildings — they also provide fresh outdoor air to occupied spaces. To maintain good indoor air quality, commercial buildings have fresh outdoor air requirements. This prevents the buildup of harmful gases like carbon monoxide in the indoor environment. RTUs transfer fresh outdoor air into the building while exhausting indoor air that has collected VOCs, pollutants, and dirt. While this is necessary, it comes with a significant energy penalty if an ERV is not used. The ERV acts as a passive heat exchanger between the incoming fresh outdoor air and exhausted indoor air. By conditioning the incoming fresh air, an ERV saves energy by reducing the amount that the RTU needs to condition (heat or cool) the fresh air that enters the building. ERVs also possess a few non-energy benefits such as improving comfort by balancing humidity and potentially reducing the required HVAC tonnage for a building.

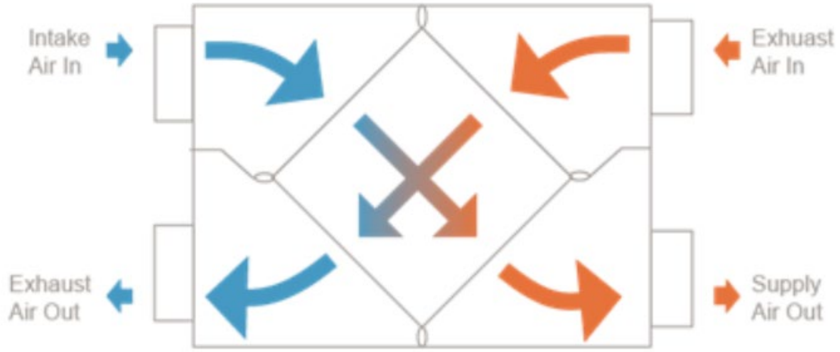
ERVs and heat recovery ventilators (HRVs) are often compared when considering energy recovery. They are the two different types of recovery ventilators. Both types can save a significant amount of energy but have slight differences. ERVs can transfer sensible (related to temperature change) and latent heat (related to moisture), while HRVs can only transfer sensible heat. The key difference between these two energy recovery systems is the material they are made of — ERVs have a membrane that can transfer both sensible and latent heat. This program is focused on ERVs because Minnesota has a humid climate (lots of latent energy), which means ERVs can produce more energy savings.

There are different types of ERVs. One is a fixed-plate ERV that acts as a passive heat (and moisture) exchanger, only exchanging heat and not directly mixing the indoor and outdoor air streams. The exhaust air entering the heat exchanger transfers heat to the fresh incoming outdoor air. Each air stream has its own passageway through the membrane. This type of ERV does not require a motor and is passive. Some RTUs have a motor-driven ERV wheel that is called an energy recovery wheel (ERW) or enthalpy wheel. The ERW rotates, absorbing and emitting heat like the passive heat exchanger. In this scenario, the two separate air streams pass over the same membrane, resulting in heat and moisture transfer. An example of how a fixed membrane ERV works can be found below in Figure 2.

We are focused on the following energy recovery types with at least a 50% total effectiveness:

- Rotating energy recovery wheel or enthalpy wheel
- Fixed membrane
- Bolt-on or integrated

Figure 2: Example of fixed membrane energy recovery ventilator diagram[9]



Application focus

The high-performance RTU program is focused on units that are up to 25 tons in the commercial sector. The target building types for this program will be:

- Municipalities
- Universities
- Schools
- Hospitals
- Commercial retail
- Grocery
- Small commercial buildings three stories or less
- Industrial buildings/warehouses

These are the most common building types for commercial RTUs because of their size, occupancy, and cooling/heating loads. We will focus on new construction and the replacement market.

[9] MN CEE CARD Study – Energy Recovery in Minnesota Commercial and Institutional Buildings 2017

Energy savings potential

To understand a technology's savings potential, we can consider both the absolute maximum amount of savings possible with the technology (the technical potential) and, more realistically, the savings the program may expect to achieve (program potential).

Technical potential is the theoretical maximum amount of energy use (first-year savings) that could be displaced by the measure with consideration of engineering constraints. It is a snapshot in time, assuming immediate implementation of the technology across all buildings and applications where it is feasible. In other words, if we were to replace all existing technology in our building stock with this technology, including projected new construction, the savings of that transition would be our technical potential.

The technical potential is helpful to compare savings across initiatives and provide an order of magnitude of savings potential. Technical potential assumes that all possible retrofit opportunities and all new construction opportunities over a 20-year timeframe are fully captured.

The program potential is a smaller subset of the technical potential that considers both broader factors like turnover rates and workforce limitations, other market barriers as well as program implementation constraints.

The technical potential estimates are described in the following section. Program potential will be estimated over the next year as more data become available.

Technical potential

To project technical potential, we used the following equation:

Technical Potential = Number of RTUs in MN by 2044 x Energy Savings per RTU

The 2017 Conservation Applied Research and Development (CARD) project on Commercial Rooftop Units in Minnesota quantified the number of RTUs in Minnesota in 2017 by cooling capacity. The study also estimated a total of 6,400 RTUs are shipped to commercial buildings in Minnesota annually, of which 2,600 are for new construction and 3,800 are for existing retrofits and replacements. Some RTUs installed in retrofit projects may replace non-RTU systems, resulting in an increase in total number of RTUs in the state. Since the exact number is unknown, we used a conservative value of 2,600 in our growth estimates. Using these values, we can determine the number of RTUs in Minnesota in 2024 and 2044 (Table 1).

Table 1. Number of RTUs in Minnesota by cooling capacity

Cooling Capacity (Ton)	Number of RTUs 2017	Number of RTUs 2024	Number of RTUs 2044	% of Total
<5.4	62,200	71,563	98,317	51.4%
≥5.4 to <11.3	35,200	40,499	55,639	29.1%

Cooling Capacity (Ton)	Number of RTUs 2017	Number of RTUs 2024	Number of RTUs 2044	% of Total
≥11.3 to <20	12,000	13,806	18,967	9.9%
≥20 to 25	5,700	6,558	9,010	4.7%
>25 to <63.3	3,900	4,487	6,165	3.2%
≥63.3	1,900	2,186	3,003	1.6%
Total	120,900	139,100	191,100	100%

The scope of this initiative is limited to RTUs with a cooling capacity of up to 25 tons. We estimated the number of 20- to 25-ton RTUs using the ComStock energy model.

ComStock is an open-source commercial building energy model developed by the U.S. Department of Energy (DOE) and maintained by the National Renewable Energy Laboratory (NREL). The model uses a sample of building characteristics from DOE's commercial building models, as well as a variety of additional public- and private-sector datasets. Collectively, this information represents commercial buildings in a given climate zone, state, county, or census. We can use this model to estimate 6,558 RTUs installed in Minnesota in the 20- to 25-ton subset of the 20 to 63.3 range shown in Table 1. This model is also used to calculate a weighted average per-building savings for heat pump and ERV RTUs.

For the technical potential, we assume all existing RTUs can be replaced with a heat pump and ERV RTU.

Dual fuel heat pump RTU Energy Savings

To calculate the unit energy savings for dual fuel heat pump RTUs we use a CEE-developed model. A description of the model, inputs, and sources are noted in the energy savings methodology overview section.

This initiative includes two levels of heat pumps. Level 1 meets DOE minimum efficiency standards whereas Level 2 heat pumps are above the federal minimum performance requirements. Level 2 products are able to provide more of a building’s heating load than Level 1 but are often more expensive. When calculating the technical potential of dual fuel heat pump RTUs, we used the per-unit energy savings for Level 1 to be conservative.

The 2017 CARD project on Commercial Rooftop Units in Minnesota provides a distribution of the RTUs in Minnesota for five cooling capacity ranges; however, a single cooling capacity value is needed to calculate the technical potential. For both the technical potential and energy savings per building we use the midpoint capacity for each range shown in Table 1.

Energy Recovery Ventilator RTU Energy Savings

To calculate the unit energy savings for RTU ERVs we use a model developed by CEE for the 2017 CARD *Energy Recovery in Minnesota Commercial and Institutional Buildings: Expectations and Performance Study*. The inputs for the energy savings equations come from a variety of sources including but not limited to NREL ComStock database, the MN TRM v4.0, the 2017 CARD study on Energy Recovery in Minnesota, and manufacturer specification sheets. The equation, input definitions, and sources are noted in the energy savings estimation overview section.

Like with the dual fuel heat pump RTU technical potential calculation, we use the midpoint capacity from Table 1 in the per-building energy savings calculation. For heat pump and ERV RTUs, we calculate the energy savings per unit for each system size, building applications, and climate zone combination. The result is per-unit energy savings estimate for 144 scenarios. Using the system size distributions from the 2017 CARD research project and building type distributions from the ComStock model, we can calculate a weighted average per-unit energy savings representative of a typical commercial building in Minnesota.

ERVs can be installed on standard RTUs with natural gas heat or heat pump RTUs. The heating savings potential is lower if the ERV is installed on a heat pump RTU because heat pumps are more efficient at delivering heat than traditional natural gas RTUs. When calculating the technical potential, we assumed 100% of the ERVs were installed on dual fuel heat pump RTUs to be conservative. When calculating annual impact, we will use market insights to estimate the share of ERVs installed on heat pump RTUs versus standard natural gas RTUs.

Given these assumptions, we have calculated the technical potential of both ERVs and dual fuel heat pump RTUs to be 4,350,000 and 11,360,000 MMBtus respectively for a combined savings of 15,710,000 MMBtus (Table 2).

Table 2: RTU technical potential

	Energy Efficiency Savings			Efficient Fuel Switching Savings			Total
	Electric Peak Demand (kW)	Electric Cooling Savings (MWh)	Gas (Dth)	Electric (MWh)	Gas (Dth)	Net Energy Savings (MMBtu)	Energy Savings across fuel types (MMBtu)
Statewide Technical Potential	320,000	550,000	2,720,000	-2,060,000	17,640,000	10,610,000	15,200,000
RTU ERVs	290,000	480,000	2,720,000	n/a	n/a	n/a	4,350,000
RTU HPs	30,000	70,000	n/a	-2,060,000	17,640,000	10,610,000	10,850,000

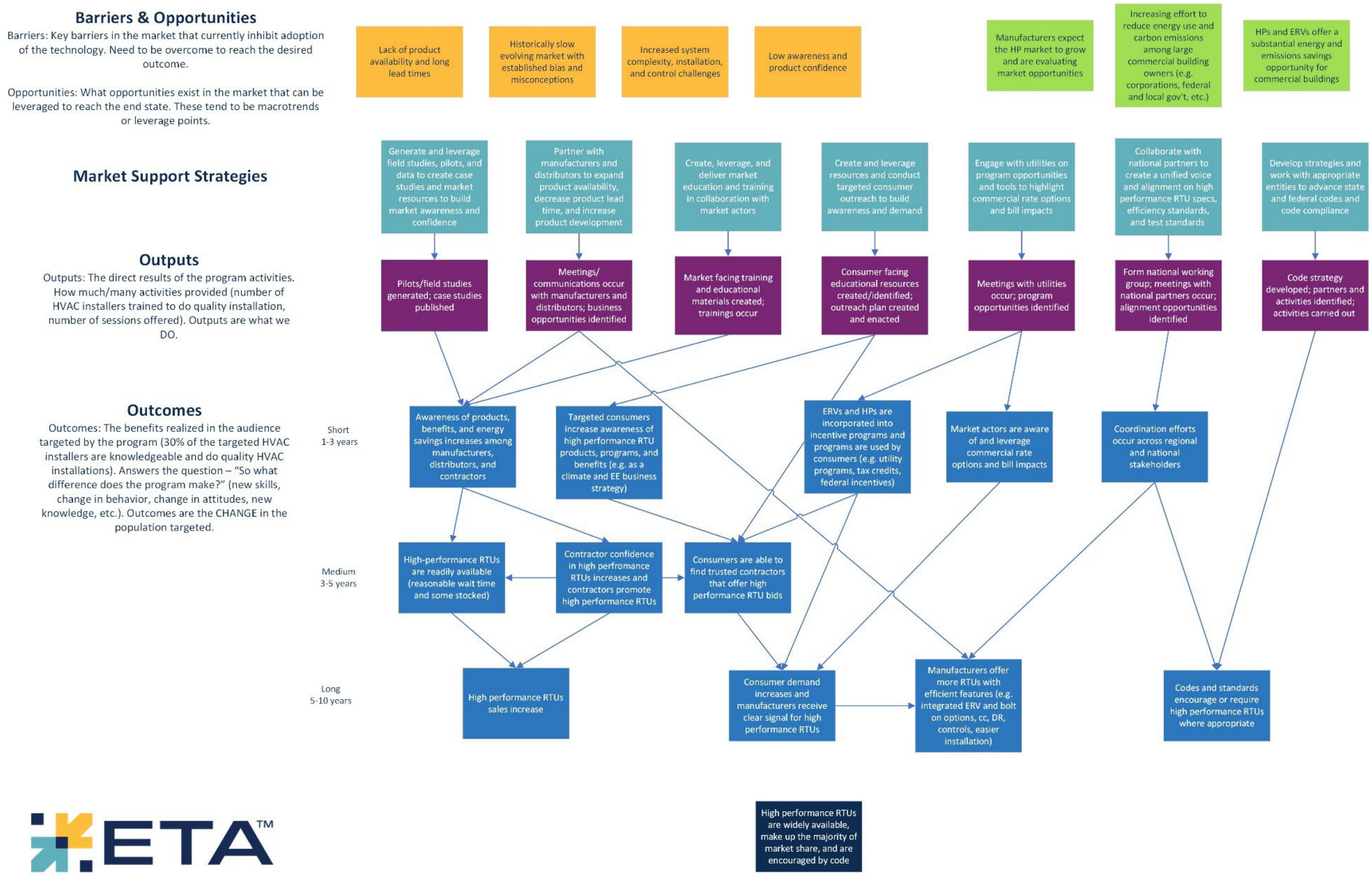
LOGIC MODEL

Market transformation programs are different than traditional energy efficiency programs (i.e., resource acquisition programs) in that savings do not occur necessarily at the same time as activities. Market transformation relies on removing barriers in the market to increase product adoption and eventually achieve savings, so it is important to document the theory of market progress that will lead to energy savings. The program theory is derived from carefully documenting market barriers and opportunities, identifying activities to leverage opportunities and overcome barriers, and describing intended outcomes in the market, which will ultimately lead to energy savings. This theory draws a through line of logic from the current market conditions, to what we plan to do, and how we think the market will change as a result. Given that the market will take time to develop and absorb these changes before energy savings are fully realized, ETA will rely on other market progress indicators (MPIs) to show intermediate progress.

To document the program theory and identify MPIs, ETA engaged in a logic modeling process with support from NEEA. The logic model is a visual flow chart representation of the program theory, showing the key barriers and opportunities; ETA's market support strategies; the immediate results of ETA's market support strategies (outputs); and the short-, medium-, and long-term market outcomes that we anticipate being the market result from these support strategies. All these lead to the overarching, long-term impact that we hope to make at the end of our market intervention work. Market progress indicators are then derived from the outcomes indicated in the logic model, and outputs will also be tracked to document that the market support strategies are implemented. For more details about market support strategies, please see the Market Transformation Plan.

The logic model serves as a guiding document for the program and is used as a check for specific market activities to ensure alignment with the intended plan. We anticipate reviewing the logic model periodically to ensure the program theory remains sound and to adjust for new barriers and opportunities that arise. The logic model and identified MPIs will also serve as a basis for market progress evaluation, benchmarking the progress the initiative has made in the outlined program theory. The current logic model for the RTU initiative is shown in Figure 3.

Figure 3: RTU Logic Model



Evaluation efforts

Various data, in addition to energy savings inputs, will need to be collected and tracked to understand the market and the initiative's progress. Output tracking will help show that we are implementing the outlined market support strategies, indicating implementation progress and completion of important milestones. Market progress indicators will show the state of the market and whether we are achieving the intended outcomes from our work. For more information about data sources and collection, see the Data collection plan section.

Outputs

Outputs are the direct result of ETA's actions and are therefore largely something we can measure and/or document internally or on a collective partner level depending on the market support strategy. The metrics used to assess outputs are essentially to show that the strategy is being implemented and the expected outputs and milestones are occurring, not that the market is changing, which is captured through outcomes and MPIs. Unlike with some market outcomes where the goal may be to achieve a year-over-year increase in a specific metric (MPI), outputs and associated metrics do not necessarily result in continued increases. Rather, they indicate how we anticipate reporting on our activities. For example, an output-based metric may be the number of trainings held. We may do four trainings one year, and only two the next as we are focusing on other strategies. That difference is acceptable; we will simply plan on reporting the number of trainings held and qualitative details about the trainings each year.

In other times, we may want to focus our strategies and subsequent outputs on quality over quantity, though quality may require more resources and outside market actor perspectives to effectively gauge. We intend to focus resources and market actor time on MPI tracking rather than output tracking as MPIs are more critical to showing market progress. When quality can be proxied via internally trackable metrics, we will denote those metrics. For example, we may include the number of individuals contacted and number of times we engaged with those individuals; we may only engage with a small number of key market actors, but engage with them deeply through numerous encounters, which is a proxy for quality engagement.

The market support strategy, output, and metric to measure the output are listed in Table 3. Outputs will be tracked and documented on an ongoing basis by program staff.

Table 2: Market support strategies and associated outputs and metrics

Strategy	Output	Metric
Generate and leverage field studies, pilots, and data to create case studies and market resources to build market awareness and confidence	O1. Pilots/field studies generated	# of pilots/field studies
	O2. Case studies developed	Case studies are developed (# of case studies and documentation)
Partner with manufacturers and distributors to expand product availability, decrease product lead	O3. Meetings/communication occur with manufacturers and distributors, business opportunities identified	# of meetings held, # of partners engaged, business opportunities documented (e.g., meeting notes)

Strategy	Output	Metric
time, and increase product development		
Create, leverage, and deliver market education and training in collaboration with market actors	O4. Market-facing training and educational materials created	Training materials are developed
	O5. Trainings occur	# of trainings and educational activities (incl. conference presentations and events), # of trainees, level of satisfaction with training
Create and leverage resources and conduct targeted consumer* outreach to build awareness and demand	O6. Consumer-facing educational resources created/identified	Educational materials are developed/identified
	O7. Outreach and education plan created and enacted	Plan developed, outreach channels identified, # of consumers engaged with
Engage with utilities on program opportunities and tools to highlight commercial rate options and bill impacts	O8. Meetings with utilities occur, program opportunities identified	# of meetings held, # of utilities engaged, program opportunities documented (e.g., meeting notes)
Collaborate with national partners to create a unified voice and alignment on high-performance RTU specs, efficiency standards, and test standards	O9. Form national working group on high-performance RTUs, meetings with national partners occur, alignment opportunities identified	# of meetings held, # of partners engaged, alignment opportunities documented (e.g., meeting notes)
Develop strategies and work with appropriate entities to advance state and federal codes and code compliance	O10. Code strategy developed and partners identified, activities identified are carried out	Code strategy exists, # of partners identified, documentation of activities, # of code proposals submitted

*Note: Consumer is a broad term meant to encompass building decision makers, purchasers, end users, and other appropriate parties.

Market progress indicators

Outcomes are the anticipated *market* result of the market support strategy implementation. As they are a market result, they rely on market actors to come to fruition and are not fully within ETA's control. Thus, they require evaluation of indicators (MPIs), which are tracked via external data sources or primary data collection. The logic model outcomes, MPIs, associated metrics, and data sources are listed below. A single outcome may require measuring multiple MPIs to assess progress. Conversely, progress toward multiple outcomes might be tracked via the measurement of a single MPI. Table 4 lists all outcomes and their respective MPIs, so there may be duplicative MPIs listed. Similarly, multiple strategies can lead to the same outcome, or conversely, one strategy can lead to multiple outcomes, so strategies are not included in the table for simplicity. However, one can review the logic model to see the connection between strategies and associated outcomes. Table 4 also includes anticipated data sources to gather information about MPIs; these are discussed in more detail in the Data collection plan section.

As MPIs also relate to short-, medium-, and long-term outcomes, not all MPIs will be tracked initially or concurrently. We anticipate evaluating the time relevant MPIs every one to three years, depending on how quickly ETA can implement market support strategies and how frequently market insights are needed to guide strategies.

Table 3: Logic model outcomes and associated MPIs

Logic Model Outcome	MPI	Data source
High-performance RTUs are readily available (reasonable wait time and some stocked)	A. Increasing % of contractors indicate that high-performance RTUs are readily available with reasonable lead times	Contractor survey
	B. Increasing % of distributors stock high-performance RTUs that align with our recommended specifications	Distributor survey
Awareness of products, benefits, and energy savings increases among manufacturers, distributors, and contractors	C. Increasing #/% of market actors reporting familiarity with dual fuel heat pump RTU products[a]	Manufacturer survey, distributors survey, contractor survey
	D. Increasing #/% of market actors reporting agreement that ERVs are beneficial for different applications (e.g., outdoor air requirements, existing buildings, new construction performance pathways)[b]	Manufacturer survey, distributors survey, contractor survey
	E. Increasing #/% of market actors report that selling high-performance RTUs are valuable to their business	Manufacturer survey, distributors survey, contractor survey
Contractor confidence in high-performance RTUs increases, and contractors promote high-performance RTUs	F. Contractors report greater preparedness/confidence in installing high-performance RTUs	Contractor survey
	G. Contractors increasingly report promotion of high-performance RTUs (e.g., in bids, better/best lineup)	Contractor survey
	H. Market actors increasingly report a favorable opinion of high-performance RTUs	Manufacturer survey, distributors survey, contractor survey
High-performance RTU sales increase	I. Increase in # and share of high-performance RTUs sold	Sales data, contractor survey
Targeted consumers* increase awareness of high-performance RTUs products, programs, and benefits (e.g., as a climate and EE business strategy)	J. Increasing # of consumers aware of high-performance RTU products	Consumer survey
	K. Increasing # of consumers are aware of a program or incentive around high-performance RTUs	Consumer survey
	L. Increasing # of consumers report that high-performance RTUs can be helpful in reaching company goals	Consumer survey

Logic Model Outcome	MPI	Data source
Consumers are able to find trusted contractors that offer high-performance RTUs bids	M. Increasing #/% of consumers report satisfaction with their bids and contractor search	Consumer survey
Manufacturers receive clear signal for high-performance RTUs	N. Manufacturers report that they are seeing an increased demand for high-performance RTUs	Manufacturer survey
ERVs and heat pumps are incorporated into incentive programs and programs are used by consumers (e.g., utilities, tax credits, federal incentives)	O. Utility or federal programs include ERVs and heat pumps	Program documentation
	P. Increasing # of program participants	Program documentation
Market actors are aware of and leverage commercial rate options and bill impacts	Q. Increasing #/% of market actors familiar with commercial rate options and bill impacts	Consumer survey, contractor surveys, distributor surveys, manufacturer surveys
Manufacturers offer more RTUs with efficient features (e.g., integrated ERV and bolt-on options, cold climate, demand response, controls, easier installation)	R. Increasing % of products that align with our recommended features/specifications	AHRI product directory
	S. # of manufacturers offering high-performance RTUs increases	AHRI product directory
Coordination efforts occur across regional and national stakeholders	T. Unified input to manufacturers and other market actors (memos, specs, etc.)	Program documents, program partner survey,
	U. # of national or regional stakeholders participating in coordinating efforts	Program documentation
Codes and standards encourage high-performance RTUs where appropriate	V. Code or appliance standard encourages high-performance RTUs	Code or standard

*Note: Consumer is a broad term meant to encompass building decision makers, purchasers, end user, and other appropriate parties.

a) As ERVs are not new to the market, we understand the barrier to be less around familiarity with the technology and more about the belief in the technology to be appropriate and save energy in different applications. Thus, this MPI around familiarity is more appropriate for heat pumps, specifically.

b) Again, we understand the barrier for ERVs to be more about the fact that they are used in limited application types related to outdoor air requirements and code compliance pathways, when they could be appropriate for a wider range of applications. They also can be used in retrofit applications as a bolt-on addition to existing RTUs, as well as in replacement and new construction markets. This variation in application does not apply for heat pump RTUs, as application types for heat pumps are largely driven by fuel type, which is consistently natural gas.

Energy savings methodology overview

As outlined in the ETA filing, ETA will apply an approach consistent with how savings are estimated for traditional utility Conservation Improvement Program (CIP) offerings.

In its most basic form, energy savings are estimated using the following equation:

[market transformation savings] = [number of units] x [savings per unit]

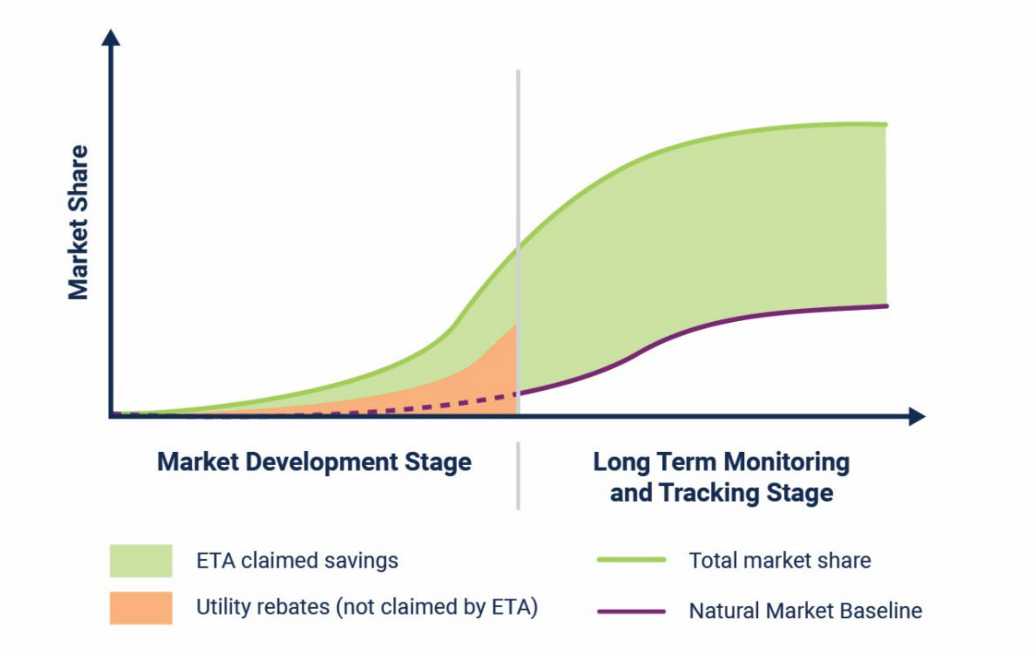
However, there are some key differences in approach and additional adjustments made to estimate market transformation savings, which were described in the filing and approved in the ETA final order. The approach involves three basic steps:

1. **Counting total statewide savings from market sales data.** For market transformation, the number of units is counted at the whole market level, rather than at the individual customer level. This is because the market support strategies influence the whole market, not just a single customer's decision. Thus, because the program will not be collecting site-level data for the whole state, the program will use an average statewide savings number across all applicable customer sites, and multiply that by data typically collected at the manufacturer, distributor, or retailer level.[10] In traditional CIP programs, savings accuracy depends on precisely capturing customer site information, while in market transformation it is more important to accurately characterize the whole market.
2. **Adjusting the total savings to account for utility rebates.** Frequently, at least a portion of a market transformation initiative's life cycle will overlap with rebates offered by a traditional CIP program, as entities work together to advance the adoption of energy efficient products and practices in the market. Savings from this type of joint program effort are referred to as co-created savings because both programs contribute to the total savings and to the market transformation effects. However, these savings should not be double counted in savings claimed through ETA. Therefore, when rebates are provided by a traditional CIP program during the course of a market transformation initiative, the savings claimed through these rebates will be subtracted from the total market transformation savings to avoid double counting.
3. **Adjusting for a natural market baseline during the Long-Term Monitoring and Tracking Stage.** The natural market baseline is a forecast of the future in which no utility-funded intervention exists (CIP or ETA). It is a counterfactual, hypothetical forecast that allows us to recognize that there is some current market adoption, albeit very minimal, and that market adoption may change on its own. Minnesota, however, does not require the subtraction of the natural market baseline from the statewide savings data during the Market Development

[10] We note that distributors could provide product to contractors in Minnesota that may install them in other states. A similar situation can occur for retail products sold directly to customers. In this case, an adjustment to account for this leakage to adjacent states may be needed. NEEA has developed methodologies to account for this leakage, and we would follow best practices in making those adjustments.

Stage, as it is a gross savings state (Figure 4). However, it is appropriate to adjust for the natural market baseline in the Long-Term Monitoring and Tracking Stage, per the filing.

Figure 4: Market Development and Long-Term Monitoring and Tracking savings accounting

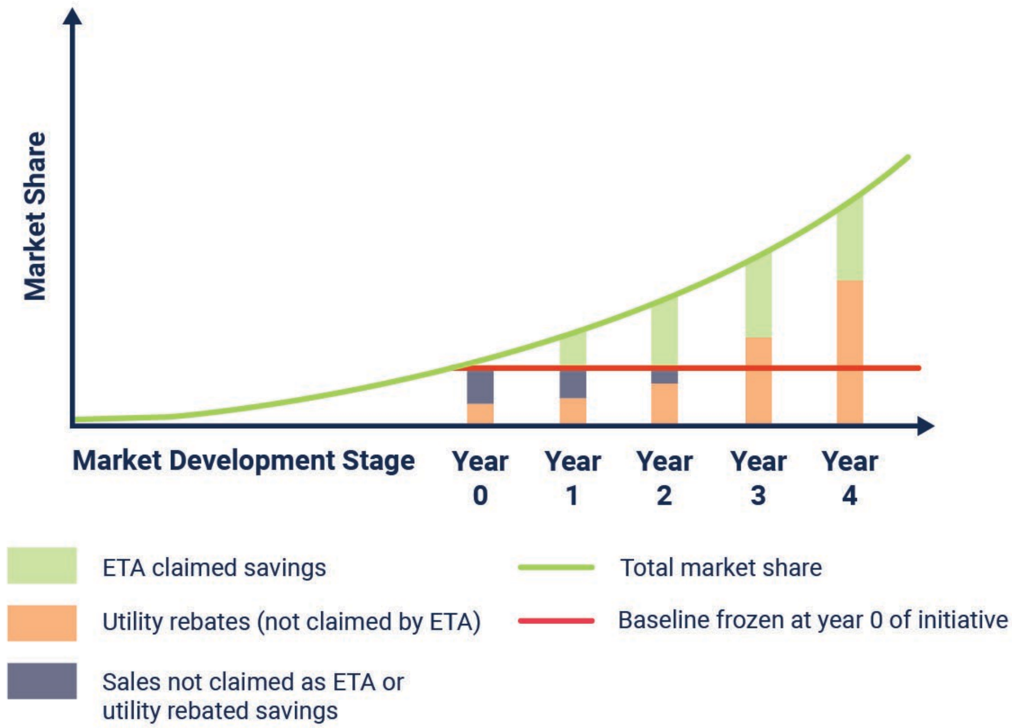


Modification for simplified baseline approach

While it is not a regulatory requirement to account for the natural market baseline (NMB) during the Market Development Stage, there are currently commercially available products that meet our product definition in the market with a small portion of sales prior to ETA strategy implementation. Therefore, we plan to modify the approach outlined in the filing and follow a more conservative, simplified baseline approach to adjust for some naturally occurring sales during the Market Development Stage. This will be accounted for by freezing a baseline at the total market share of the product in the year prior to the Market Development Stage (Figure 5). Trendlines or averages may also be considered if we believe the year before contained anomalies (e.g., supply chain shortages, COVID-19).

With this simplified baseline approach, ETA will only claim savings for sales above the initial frozen baseline. In early years, rebate participation may be below the simplified baseline (e.g., years one and two). Therefore, there is no need to subtract the rebated savings from ETA savings since they are already accounted for within the simplified baseline. Once utility rebate amounts cross the simplified baseline amount, we will simply subtract utility savings instead of the baseline. Utility rebate participation will likely grow over time, and while we anticipate having a positive influence on volume of rebated sales, we plan to only count ETA savings above the rebated amount, so it is possible that ETA savings may temporarily shrink over time until reaching Long-Term Monitoring and Tracking (e.g., years three and four in Figure 5).

Figure 5: Simplified baseline approach for savings calculations in market development stage



The simplified baseline approach is more conservative than claiming all gross savings, as is allowable in statute, and requires less evaluation spend than a full NMB. The NMB is also hypothetical and uncertain, and this approach relies on a more tangible sales figure. We will, however, still provide NMB projections and use the NMB in the Long-Term Monitoring and Tracking Stage.

For the RTU initiative, we plan to freeze the simplified baseline using the market share percentages we have from 2023, earmarking 1.5% of sales as including ERVs and 0.2% of sales including dual fuel heat pump RTUs. We aim to collect data from distributors (discussed in greater detail in the Data collection plan section) to corroborate and adjust these figures as we get more data. After five years, the program will review the baseline assumptions to account for unforeseen market disruptions or new data to inform the baseline adoption, and we may adjust the baseline accordingly.

RTU-specific savings equation

Savings per unit

The equations and inputs used to calculate energy savings are discussed in more detail below. The value of these inputs is based on our current understanding of the technology and market, which may shift over time as different data become available. For this initiative the tonnage of the RTU is a key input that impacts savings, so market data will be used to determine the range of tonnages that were installed each year. Currently, the per-unit savings are calculated for the tonnage ranges outlined in Table 6, choosing the midpoint of each range for the savings calculation.

Dual fuel heat pump RTU savings

To calculate the unit energy savings for dual fuel heat pump RTUs, we use a CEE-developed model that considers climate data, specifications for a typical dual fuel heat pump RTU, and performance as a function of temperature. The model calculates the energy savings per unit using a series of steps: 1) model average heating and cooling load for 144 applications[11]; 2) calculate baseline heating and cooling energy usage for an RTU that meets the federal minimum efficiency standards; 3) calculate heating and cooling usage for a dual fuel heat pump RTU and its natural gas backup; 4) compare the baseline and heat pump energy usage to determine savings; 5) calculate a weighted average heating and cooling savings using building characteristics and distributions from the NREL ComStock commercial building model. The inputs for the model come from the MN TRM v4.0, the 2017 CARD study on Commercial Roof-top Units in Minnesota, manufacturer specification sheets, and updated field research results as available. Details on how the model calculates energy savings provided below.

First, the model calculates the average heating and cooling load for a typical commercial building in Minnesota using the following equations.

Annual Cooling Load (Btu) = Size (tons) x EFLH_cool x 12,000 btu/ton

Annual Heating Load (Btu) = Size (tons) x EFLH_heat x 12,000 btu/ton

The 2017 CARD study on Commercial Roof-top Units in Minnesota provided a distribution of RTUs binned by RTU size. As discussed, the scope for this initiative includes RTUs up to 25 tons. For the energy savings calculations we use the midpoint of each capacity bin shown in Table 1 that is within the scope of the initiative.

The MN TRM v4.0 provides equivalent full load hours (EFLH) for 16 building types and three climate zones. Of the 16 building types, 12 overlap with the ComStock commercial building database, representing the most frequently occurring building activities. Using the four RTU sizes and EFLH estimates for 12 building types and three climates zones we get an estimate of the cooling and heating load for 144 RTU applications.

Next, we calculate the heating and cooling usage for the baseline scenario using the integrated energy efficiency ratio (IEER) and average fuel utilization efficiency (AFUE) of the baseline equipment.

Cooling usage_kWh_baseline = (Annual Cooling Load (Btu) / 1000) / IEER_base

Heating usage_dth_baseline = (Annual Heating Load (Btu) / 10^6) / AFUE_base

The heating and cooling usage for the energy efficient scenario is calculated using a seasonal coefficient of performance (COP) for heating, manufacturer reported IEER for cooling, and an AFUE for the backup gas system.

---

[11] 144 applications refers to three climate zones, four RTU capacity bins, and 12 building types.

Cooling usage kWh_EE = (Annual Cooling Load (Btu) / 3412) / IEER_EE

Heating usage kWh_EE_electric = (Annual Heating Load (Btu) x HP utilization / 3412) / SCOP_heating_EE

Heating usage dth_EE_gas = (Annual Heating Load (Btu) x (1 - HP utilization) / 10^6) / AFUE_backup_EE

The seasonal COP of a dual fuel heat pump RTU changes with outdoor air temperature and switchover temperature. We can calculate a seasonal load-weighted average COP for the energy efficient scenario using typical meteorological year (TMY[12]) data, specifications for Level 1 and Level 2 heat pump RTUs, a derate factor, and switchover temperature. Preliminary field monitoring conducted by CEE shows actual heat pump RTU heating efficiency is typically 30% lower than manufacturer specified efficiency. Therefore, we apply a derate factor of 30% to account for differences in observed and manufacturer reported system efficiency. As additional field data becomes available, we will update the derate factor to reflect the latest results.

Additionally, 20°F was chosen as the switchover temperature. This switchover temperature was selected based on manufacturer data on capacity and performance, initial field research results, and energy modeling, which have shown these systems are able to provide cost-effective heating down to 20°F and lower in some situations. This value may be adjusted as additional field, modeling, and market data is collected. We plan to re-evaluate both the derate factor and optimal switchover temperature.

The use of a gas backup below the switchover temperature requires the use of a heat pump utilization factor (HP utilization) in the equations above. The heat pump utilization factor is the percentage of the annual heating load delivered by the electric heat pump.

The cooling and heating savings is calculated by comparing the baseline to the dual fuel heat pump RTU scenarios, which produces the average modeled savings for the 144 scenarios. We then aggregate the cooling and heating savings over the 144 scenarios using the NREL ComStock model to get a weighted average value representative of commercial buildings in Minnesota.[13]

Finally, we calculate the summer peak demand savings using a variation of the MN TRM v4.0 C/I HVAC – Heat Pump Systems equation.

*kW_saved = Size * 12 x (1 / EER_base – 1 / EER_EE) x CF*

Table 5 summarizes the model inputs and sources for the equations described above. Further details on these inputs can also be found in Appendix B.

---

[12] TMY-2022 data retrieved for Minneapolis, Brainerd, and Duluth from the NREL NSRDB data viewer, accessible here: https://nsrdb.nrel.gov/data-viewer.

[13] The values used to weight the savings across building types can be found in Table 7 of Appendix B.

Table 4: Dual fuel heat pump RTU measure-level input values and sources

Input	Definition	Source
Size	Nominal cooling capacity in tons of the new equipment (1 ton = 12,000 btu/h)	2017 CARD *Commercial Roof-top Units in Minnesota* study. Use midpoint of bins shown in Table 1 of Appendix B.
EFLH_cool	Equivalent full load cooling hours	MN TRM v4.0. See Table 2 of Appendix B for details.
EFLH_heat	Equivalent full load heating hours	MN TRM v4.0. See Table 2 of Appendix B for details.
IEER_base	Cooling integrated energy efficiency ratio of the baseline equipment	Federal minimum performance standard. See Table 3 of Appendix B for details.
IEER_EE	Cooling integrated energy efficiency ratio of the heat pump RTU	From manufacturer data representative of Level 1 and Level 2 products available in the market. See Table 3 of Appendix B for details.
AFUE_base	Average fuel utilization efficiency of baseline equipment	Federal minimum performance standard. See Table 3 of Appendix B for details.
AFUE_backup_EE	Average fuel utilization efficiency for the gas backup	From manufacturer data representative of Level 1 and Level 2 products available in the market.
SCOP_heating_EE	Seasonal heating coefficient of performance of the heat pump	Temperature dependent curve representative of the Level 1 and Level 2 products available in the market. See Table 5 of Appendix B for details.
HP Utilization	The percentage of annual heating load provided by the heat pump without backup	Calculated using a temperature dependent curve of heating capacity representative of Level 1 and Level 2 products, TMY weather data[14], and switchover temperature
EER_Base	Cooling energy efficiency ratio for the baseline scenario	Federal minimum performance standard. See Table 3 of Appendix B for details.
EER_EE	Cooling energy efficiency ratio of the heat pump RTU	From manufacturer data representative of Level 1 and Level 2 products available in the market
CF	Coincidence factor	0.9 from MN TRM v4.0

Average per-unit savings

Table 6 below outlines the per-unit savings for each tonnage range based on current inputs. Each year the savings will be calculated using the methodology outlined above, but the inputs

[14] TMY-2022 data retrieved for Minneapolis, Brainerd, and Duluth from the NREL NSRDB data viewer, accessible here: https://nsrdb.nrel.gov/data-viewer.

will vary based on market data. Specifically, the tonnage and efficiency inputs will likely vary year to year. The assumptions used in this analysis are a conservative representation of savings.

Table 6: Average dual fuel heat pump RTU per-unit savings for each tonnage range

	Energy Efficiency Savings		Efficient Fuel Switching Savings		
Per unit	Electric Peak Demand (kW)	Electric Cooling Savings (kWh)	Electric (kWh)	Gas (Dth)	Net Energy Savings (MMBtu)
RTU HPs < 5.4 ton	0.2	151	-6,329	55.4	33.8
RTU HPs 5.4 - 11.3 ton	0.0	87	-12,570	108.8	65.9
RTU HPs 11.3 - 20 ton	0.0	1,248	-23,526	199.4	119.1
RTU HPs 20 - 25 ton	0.9	2,944	-32,336	261.3	151.0

ERV RTU savings

To calculate per-unit energy savings for ERVs we use a CEE model based on the 2017 CARD *Energy Recovery in Minnesota Commercial and Institutional Buildings: Expectations and Performance* Study. The core equations of the model are shown below. These equations can be used for a variety of scenarios that include a range of outside airflows, backup heat sources (dual fuel versus natural gas only), and outdoor temperatures. Calculating sensible savings is the first step, with the equation outlined below.

*Sensible_Savings = Sens_eff * (cp * rho_oa * CFM * (T_outdoor – T_indoor))*

Sensible savings is calculated hourly for efficient heating, backup heating, and cooling temperature ranges. The resulting value is in Btu. The relevant values are then used in the following equations.

Heating_Savings_Dth = (Sensible_Savings_heat / AFUE)/10^6

*Latent_Savings_cool = Lat_eff * (rho_oa * CFM * LHV * (AH_oa – AH_ra))*

Cooling_Savings_kWh = ((Sensible_Savings_cool + Latent_Savings_cool) / (IEER)) / 1000

*Fan_impact_kWh = (CFM * (delta_P_erv) / (fan_efficiency)) * 0.0001174*

Unit kWh Savings = Cooling_Savings_kWh + Heating_Savings_kWh - Fan_impact_kWh

Cooling_Savings_kW_peak = ((Sensible_Savings_cool + Latent_Savings_cool) / (EER)) / 1000 for the peak cooling hour

*Fan_impact_kW_peak = (CFM * (delta_P_erv) / (fan_efficiency)) * 0.0001174 for the peak cooling hour*

Unit Peak kW Savings = (Cooling_Savings_kW_peak - Fan_impact_kW_peak) x CF

Unit Dth Savings per Year = Heating_Savings_Dth

The input definitions and sources are shown in Table 7.

Table 7: RTU ERV measure-level input values and sources

Input	Definition	Source or Value
Sens_eff	Sensible effectiveness	0.68, representative of the ERV products available in the market[15]
Cp	Isobaric specific heat of water in Btu/lbm-°F	0.24 Btu/lbm-°F
rho_oa	Density of outdoor air in lbm/ft.^3	Modeled value; varies with temperature[16]
CFM	Outside air flow in ft.^3/min.	Median commercial building characteristic per NREL ComStock data. 18% outdoor air based on RTU full load CFM.[17]
T_indoor	Indoor conditioned space temperature in °F	Median commercial building characteristic per NREL ComStock data. See Table 9 in Appendix B for details.
T_outdoor	Outdoor temperature in °F	Typical Meteorological Year temperature for three climate zones in Minnesota[18]
AFUE	Annual fuel utilization efficiency of the RTU	80, Value representative of the RTU products available in the market
Lat_eff	Latent effectiveness	0.60, representative of the ERV products available in the market[19]
LHV	Latent heat of vaporization of water at various outdoor temperatures in Btu/lbm	Modeled value; varies with temperature[20]
AH_oa	Absolute humidity of outside air, the ratio of the mass of water content for a given mass of air	Modeled value; varies with temperature[21]

[15] Example unit with sensible efficiency of 68% - www.ruskinrooftopsystems.com/doc/Id/7082

[16] Example lookup table available from https://www.engineeringtoolbox.com/air-density-specific-weight-d_600.html

[17] Comstock data based on outside air CFM per square footage – found in Table 18 - https://www.nrel.gov/docs/fy23osti/83819.pdf

[18] TMY-2022 data retrieved for Minneapolis, Brainerd, and Duluth from the NREL NSRDB data viewer, accessible here: https://nsrdb.nrel.gov/data-viewer.

[19] Example unit with 60% latent efficiency - www.ruskinrooftopsystems.com/doc/Id/7082

[20] Example lookup table available from https://www.engineeringtoolbox.com/water-properties-d_1573.html

[21] Singh, P. Absolute Humidity Calculator. Available at: https://www.omnicalculator.com/physics/absolute-humidity.

Input	Definition	Source or Value
AH_ra	Absolute humidity of indoor return air	Modeled value; varies with temperature[21]
IEER	Integrated energy efficiency ratio of cooling system	Values representative of the RTU products available in the market. See Table 3 of Appendix B for details.
delta_P_ERV	Pressure drop through heat and moisture exchanger, inches of water column	0.39 in H2O, representative of the ERV products available in the market
fan_efficiency	Efficiency of the fan	0.85, representative of the ERV products available in the market
EER	Energy efficiency ratio	Value representative of the ERV products available in the market. See Table 3 of Appendix B for details.
CF	Coincidence factor	0.90 from MN TRM v4.0

Unit CFM was extrapolated from a few different sources. Manufacturer supply CFM is rated at 350 CFM per ton of cooling. The outdoor air CFM was chosen to be 18% as this is the median airflow used for RTUs.[22] This outdoor air percentage is a conservative estimate and excludes commercial warehouses. Manufacturer product literature was used to validate that 350 CFM/ton was an accurate measure for total supply CFM. The tonnages we selected landed in the middle of each of the four tonnage ranges.

Average per-unit savings

Tables 8 and 9 outline the per-unit savings for a dual fuel heat pump RTU and a baseline RTU for each tonnage range based on current inputs. Each year, the savings will be calculated using the methodology outlined above, but the inputs will vary based on market data. Specifically, the tonnage, efficiency, and outdoor air percentage will likely vary year to year. The assumptions used in this analysis are a conservative representation of savings.

Table 8: Average ERV per-unit savings for each tonnage range – gas RTU baseline

Per unit	Electric Peak Demand (kW)	Electric (MWh)	Gas (Dth)
<5.4 ton	0.9	0.2	19.5
≥5.4 - <11.3 ton	1.6	0.4	35.3
≥11.3 - <20 ton	3.3	1.0	69.8
≥20 - 25 ton	6.3	1.7	113.6

[22] National Renewable Energy Laboratory (NREL) ComStock Model and Database. https://www.nrel.gov/buildings/comstock.html

Table 9: Average ERV per-unit savings for each tonnage range – dual fuel heat pump RTU baseline

Per unit	Electric Peak Demand (kW)	Electric (MWh)	Gas (Dth)
< 5.4 ton	0.8	1.4	8.5
≥5.4 - <11.3 ton	1.6	2.7	15.5
≥11.3 - <20 ton	3.3	5.4	30.4
≥20 - 25 ton	6.1	9.2	50.1

Statewide sales estimates

Currently, we have limited insight into dual fuel heat pump RTU and ERV sales data. In subsequent years, we will work on collecting distributor-level, whole-product category sales data, including RTU sales. This will only represent a portion of statewide sales, as it is unlikely every distributor will provide data. We will then extrapolate data to estimate statewide sales.

We hope to discern Level 1 heat pumps, Level 2 heat pumps, ERVs on standard RTUs, and ERVs on heat pump RTUs within the sales data or determine an approximate share of products from market insights. The appropriate per-unit savings will then be applied to the sales in each sales category. If this information is unavailable, we will create a singular weighted per-unit savings estimate to apply to all qualified product sales.

Utility rebate data

Commercial rebates for direct expansion cooling rooftop units were available from utilities in the previous triennial and were typically based on a two-step rebate eligibility. Equipment tonnage and a combination of minimum rating requirements for EER and IEER must be met to qualify for a rebate.

Up until 2024, prescriptive rebates for dual fuel commercial heat pump RTUs have not existed. However, this will change starting in 2024. Xcel Energy's 2024–2026 Energy Conservation and Optimization (ECO) plan includes prescriptive rebates for commercial dual fuel RTUs.

Some electric and gas utilities offer prescriptive rebates for ERVs. CenterPoint Energy added the measure back to the Company's prescriptive rebate offerings for ventilation on air handling units in 2024.[23] CenterPoint Energy's rebate is $0.50/CFM outside air through the device. Xcel Energy offers rebates of $1 per CFM heating and $1 per CFM cooling on ERVs installed with 60% total cooling effectiveness and 60% total heating sensible effectiveness.[24] Minnesota Energy Resources Corporation (MEC) also added a new prescriptive rebate for ERVs in their 2024–2026 ECO plan.

---

[23] *CenterPoint Energy's 2024-2026 Natural Gas Energy Conservation and Optimization Triennial Plan*. Docket No. G008/CIP-23-095. June 20, 2023.

[24] Xcel Energy Energy Recovery Ventilators (ERV) Information Sheet. 2017. https://www.xcelenergy.com/staticfiles/xe/Marketing/Files/MN-Bus-Energy-Recovery-Ventilators-Information-Sheet.pdf

We anticipate working with utilities to increase ERV and dual fuel heat pump RTU rebate offerings that align with this initiative's product definition and will track rebates accordingly. This data will be collected annually for savings calculations. We will also coordinate with utilities on any commercial new construction programs that may claim modeled savings. It will be important to account for any savings claimed through these programs for ERVs or heat pump RTUs.

We will also work with DER and non-funding consumer-owner utilities (COUs) to identify additional rebate programs and amounts.

Simplified baseline

We do not currently have sales data for dual fuel heat pump RTUs, but we expect the sales volume to be very low based on our recent market characterization and additional analysis. An analysis of the most recent 2018 ComStock data suggests that there are no dual fuel heat pump RTUs within Minnesota's building stock.[25] While we know that some buildings have added dual fuel heat pump RTUs since 2018, this suggests a very low volume. Additionally, data from Northeast Energy Efficiency Partnerships (NEEP)[26] suggests dual fuel heat pump RTUs comprise 0.6% of annual RTU sales in the northeast region. While this is not representative of Minnesota, we anticipate a somewhat similar seasonal weather pattern and sales volume. Because of this, we asked manufacturers in recent conversations if roughly 0.5% of sales felt appropriate within Minnesota, and most felt that it was still a little too high. Thus, we are setting the simplified baseline at 0.2% of market share.

For ERVs, our market characterization research completed by Cadeo indicated that current ERV sales make up roughly 1–2% of the total RTU market. This was corroborated by recent manufacturer conversations, so we will use 1.5% of sales as our simplified baseline.

These data points will be confirmed and updated through the sales and market share data that we plan to gather directly from distributors (extrapolated to the full state). Our plan for this data collection is described in more detail in the data collection plan section.

Natural market baseline

The natural market baseline (NMB) is created using a method developed by NEEA that typically results in an s-curve shaped model of the projected market adoption for technologies if the ETA did not intervene in the market. Since these are hypothetical models, a large amount of uncertainty around estimated figures exists. However, market characterization, expert opinion on future projections, and current understandings of the market inform the NMB inputs.

For RTUs, two baselines have been developed, one for dual fuel heat pump RTUs and the other for ERVs. While we expect program savings to follow an s-curve shape, the RTU market has changed so little over a long period of time that we expect these models to be relatively flat with

---

[25] Parker, Andrew, et al. 2023. ComStock Reference Documentation. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-83819. https://www.nrel.gov/docs/fy23osti/83819.pdf

[26] Northeast and Mid-Atlantic High-Performance Rooftop Unit Markey Transformation Strategy Report – NEEP 2016

minimal change. However, the models will be refined over the next year as the program launches and reviewed periodically to confirm the assumptions are still appropriate. As we receive data from the market, the s-curve will be updated.

Based on our current understanding of the market, we anticipate the natural market baseline curve over the program lifetime of 20 years to be similar to those in Figures 6 and Figure 7.

Figure 6: Dual fuel heat pump RTU natural market baseline over the 20-year program life

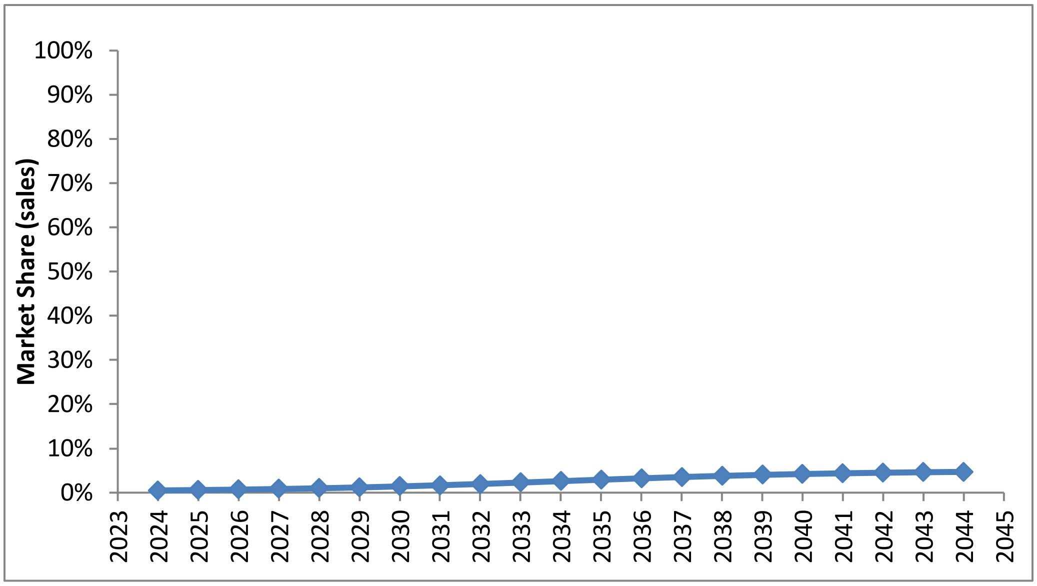
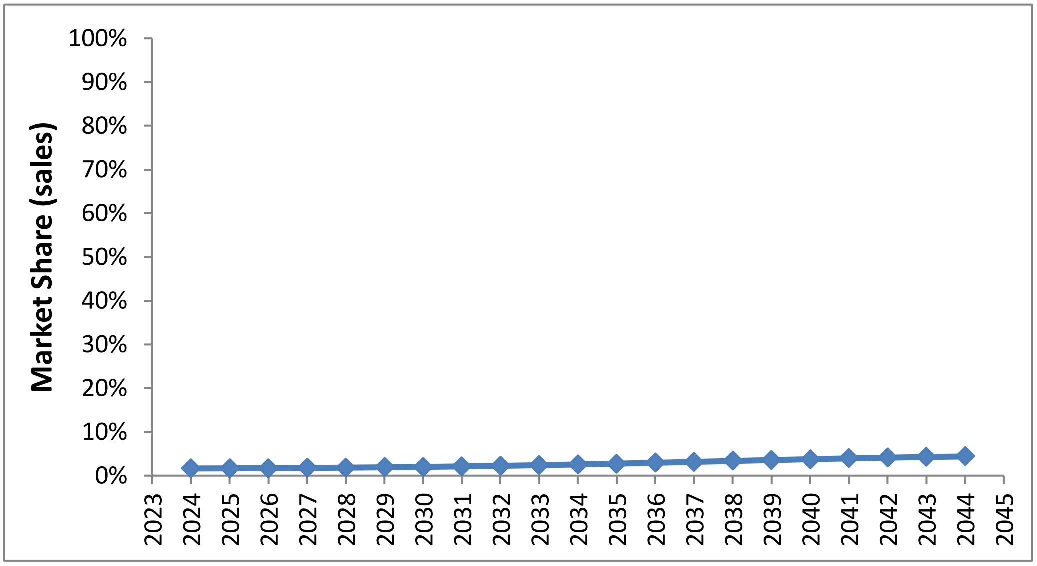


Figure 7: ERV natural market baseline over the 20-year program life



Commercial RTU market evolution

In general, the commercial RTU market has been relatively stagnant over the past 40 years, suggesting minimal growth for both heat pump RTUs and ERVs without market intervention. Our market characterization work indicated efficiency has largely been related to cooling, rather than heating, so we are not anticipating large changes to the heating efficiency of RTUs. Product development has largely focused on meeting code, and a review of federal minimums and codes confirms that the heating efficiency has stagnated between 80–81% for 30 years.[27] Due to this emphasis on federal standards, most current product development is focused on meeting refrigerant changes, and given the dearth of changes to the federal minimum standards on heating efficiency, we expect both ERV and heat pump products to maintain a minimal market share.

Rationale for dual fuel heat pump RTUs NMB

As described when deriving our simplified baseline, while we do not have concrete sales figures, we anticipate dual fuel heat pump RTUs make up a very small portion of annual RTU sales. To corroborate this, an analysis of 2018 ComStock data suggests that there are no dual fuel heat pump RTUs in Minnesota.[28,29] While we know there are some dual fuel heat pump RTUs in the state, this suggests a very low volume of sales and installation. Additionally, data from Northeast Energy Efficiency Partnerships (NEEP) suggests that dual fuel heat pump RTUs make up 0.6% of annual RTU sales in the northeast region.[30] To see if this was consistent with the Minnesota market, CEE recently completed follow-up interviews with manufacturers, and they confirmed that dual fuel heat pump RTUs make up less than 0.5% of their annual sales in MN, with some stating that they didn’t recall any sales in Minnesota. Given this information, we are setting the initial condition at 0.2% of market share.

As noted, we anticipate a very flat growth rate for dual fuel heat pump RTUs. Grand View Research, an international market research firm, suggests a 9.7% compound annual growth rate (CAGR)[31] for heat pumps in the U.S., including both residential and commercial applications as well as air source, water source, and geothermal applications. A different research firm, Global Market Insights, suggest that heat pumps in the commercial sector will “observe a growth rate of over 8% till 2032, due to ongoing implementation of green building requirements and government initiatives to increase foreign investment.”[32] While neither of these estimates are a perfect match for the dual fuel heat pump RTUs in our initiative, we can assume a similar growth trajectory. Using a CAGR of 8.5% and extending the growth rate to a 20-year analysis period, we could expect a 1% market share by 2044.

---

27 https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431#431.72

28 Parker, Andrew, et al. 2023. ComStock Reference Documentation. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-83819. https://www.nrel.gov/docs/fy23osti/83819.pdf

29 As noted in the ComStock reference documentation, the ComStock model “uses multiple data sources, statistical sampling methods, and advanced building energy simulations to estimate the annual subhourly energy consumption of the commercial building stock across the United States.”

30 NEEP Northeast and Mid-Atlantic High-Performance Rooftop Unit Market Transformation Strategy Report 2016

31 https://www.grandviewresearch.com/industry-analysis/heat-pump-market

32 U.S. Heat Pump Market Size – By Product (Air Source, Ground Source, Water Source), By Application (Residential, Commercial, Industrial) COVID-19 Impact Analysis & Forecasts, 2024–2032, May 2023. https://www.gminsights.com/industry-analysis/us-heat-pump-market

When discussing growth trajectories with manufacturers, 6 of 7 indicated they either had a dual fuel heat pump RTU product or were developing one, and most expect the market to grow. However, since the initial sales volume is so small, even a large percentage growth in sales still equates to a very small share of the RTU market. The RTU market is expected to remain dominated by gas RTUs nationwide, and even more so in Minnesota. We also anticipate some market growth due to momentum around electrification with policy and sustainability goals and recognizing heat pump RTUs as a way to meet those goals. However, we also know that the market is dominated by replace-on-fail scenarios. Even if heat pump RTUs are recognized as a way to meet sustainability goals, if a customer is in a replace-on-fail situation, they will likely select the available option, which is unlikely to be a heat pump option. Thus, given the uncertainty around small market share percentages and our market research indicating some additional growth potential for heat pump RTUs, we are adjusting the market share saturation modestly upward to be 5% of annual sales in 2044 for the NMB.

Additionally, we note that heat pump technology awareness and adoption is increasing quickly in the residential sector, potentially reaching 20–30% of sales over the next 20 years,[33] with an influx of programs and resources encouraging residential heat pumps. However, we do not expect the commercial heat pump products to reach the same level of sales. Unlike the residential market, there are no federal or state incentives for heat pump RTUs, there is little manufacturer participation in ENERGY STAR and inconsistent definitions of efficient or cold climate RTU products, and despite the recent interest, there has still been little product development in a slow-to-evolve market. While excited about heat pump offerings, manufacturers are currently focused on refrigerant changes and recent federal standards changes, so fewer resources have been devoted to heat pump product development. Given these current conditions, we do not expect heat pump RTUs to have the same growth trajectory as their residential counterparts without significant market interaction.

Rationale for ERV NMB

Our market characterization research completed by Cadeo indicated that current ERVs sales make up roughly 1–2% of the total RTU market, and we will therefore use 1.5% as our initial baseline condition for 2023. The first ERV products were introduced in the early 1980s,[34] and given that after 40 years in the market they only make up 1–2% of RTU sales, we do not anticipate substantial growth.

Based on recent manufacturer engagement, manufacturers confirmed that ERVs make up approximately 1–2% of the total RTU market. In some interviews, manufacturers stated that 2% may even be a little high based on their sales data.

Negative perception and lack of understanding of ERV controls by both installers and owners is a major market barrier to the use of ERVs. Mistakes by technicians and operating staff leads to

---

33 ASHP Energy Savings and Evaluation Plan. CEE 2023.

34 https://www.ashrae.org/file%20library/technical%20resources/covid-19/si_s20_ch26.pdf

ASHRAE. 1982. Symposium on energy recovery from air pollution control. ASHRAE Transactions 88(1):1197-1225.

75% of energy recovery being lost.[35] This reinforces entrenched biases against ERVs. Without significant market interaction, we believe the entrenched bias against ERVs would continue and there would be little market growth.

Following this current growth trajectory, we could expect another one percentage point growth in sales over the next 20 years, yielding to a saturation of 2.5% of RTU sales. However, our market research indicated that while there are very low sales, some manufacturers are considering ERV integration into their RTUs. Thus, we estimate the 20-year saturation rate to be 5% instead of 2.5%.

Utility savings allocation

The allocation of statewide savings to individual utilities is based on their level of funding. We use the total funding approved by the Department of Commerce in each triennial to determine the allocation. For the 2024 through 2026 triennial, funding and savings for efficient fuel switching (EFS) measures is thus 37.8% from gas utilities and 62.2% from electric utilities. Measures that only result in energy efficiency (EE) savings for gas or electric utilities are allocated to the respective utilities based on the gas or electric funding alone. When a measure, like dual fuel heat pump RTU's, produces both EE and EFS savings, these savings will be accounted for separately, and allocated using the methodology described above and the values in the tables below.

The resulting 2024 through 2026 funding allocations for this initiative are listed in the tables below. Funding percentages will be reviewed on an annual basis for adjustments in funding (e.g., additional utilities voluntarily contributing).

Table 10: Electric funding and savings percentages for the RTU heat pump initiative

Utility	% of funding/savings
Electric utilities	
Xcel Energy (electric)	88.4%
MN Power	8.2%
Otter Tail Power	3.4%
Electric total	**100.0%**

[35] 2017 CEE MN CARD Study: Energy Recovery in Minnesota Commercial and Institutional Buildings: Expectations and Performance. https://www.mncee.org/energy-recovery-minnesota-commercial-and-institutional-buildings

Table 11: EFS funding and savings percentages for the RTU heat pump initiative

Utility	% of funding/savings
Electric utilities	
Xcel Energy (electric)	55%
MN Power	5.1%
Otter Tail Power	2.1%
Electric total	**62.2%**
Gas utilities	
CenterPoint Energy	21%
Xcel Energy (gas)	11.3%
MERC	5.5%
Gas total	**37.8%**
Total	**100.0%**

Table 12: Gas funding and savings percentages for the RTU ERV initiative

Utility	% of funding/savings
Gas utilities	
CenterPoint Energy	55.5%
Xcel Energy (gas)	29.8%
MERC	14.7%
Gas total	**100.0%**

Table 13: Electric Funding and savings percentages for the RTU ERV initiative

Utility	% of funding/savings
Electric utilities	
Xcel Energy (electric)	88.4%
MN Power	8.2%
Otter Tail Power	3.4%
Electric total	**100.0%**

ETA savings attribution

While ETA plans to claim savings only above and beyond the simple baseline and utility rebates, we anticipate that ETA activities will increase product demand in a way that will benefit utility rebate programs, which should be partially attributed to ETA when the program is evaluated.

When the state evaluates the program, we anticipate highlighting co-created savings, which is a mixture of utility rebated savings and ETA claimed savings, as an overall indicator of ETA's effectiveness. We will also work with the third-party evaluator to determine any additional adjustments necessary to account for these activities as they arise.

Post code/standard adoption plan

Energy codes or appliance standards are often the endpoint of market transformation efforts. A given market transformation initiative helps accelerate the technology's adoption into the code or standard, and savings can continue to accrue from the ETA initiatives after they have been adopted into a code or standard. The method to calculate savings after code adoption is well established nationally and involves adjusting the savings by an attribution rate[36] to account for the degree to which the market transformation effort influenced the code or standard. Thus, the basic savings equation for market transformation initiatives after code or standard adoption is as follows:

- *[market transformation savings] = [number of units*] x [savings per unit*] x [attribution rate]*
  **Note: for LLLCs units is kW rather than unit sold*

The number of years after the code or standard is adopted that the program can claim savings must also be determined. NEEA generally reports savings from energy codes for 10 years, while savings claimed from appliance standards vary more based on the extent to which earlier standards were adopted due to market support activities. Therefore, we plan to claim savings for 10 years for energy codes, while standards changes will be based on an estimate by an independent evaluator of how much earlier the standard was adopted. The attribution rate will be determined based on an evaluation completed by an independent evaluator after the code or standard has been adopted.

For this initiative, we are still developing our code strategy. If there is a new code adoption, we will generally follow the process outlined above.

NET BENEFITS

Calculation and allocation of net benefits

In addition to energy savings, we will calculate net benefits, which are the total benefits of an efficiency measure minus the total costs over its lifetime. They are used to assess the cost-effectiveness of programs and as inputs to calculate the financial incentive mechanism for the IOUs. All net benefits will be allocated to utilities based on funding level, following the same formula for attributing energy savings.

---

36 The attribution rate is initiative-specific and determined as an outcome of the evaluation. It is an estimate of the extent to which market transformation efforts influenced the savings (considering other factors) and is typically expressed as a percent.

The inputs needed to calculate net benefits can be divided into measure-level inputs, utility inputs, and DER-specified inputs, and vary based on fuel type. All inputs are outlined in Appendix A. In general, DER-specified inputs are set by DER and publicly available, and we will work with utilities to gather utility input data including confidential trade secret data. For the RTU initiative, we anticipate the following measure-level values and data sources (Table 14).

Table 14: RTU measure-level input values and sources

<table>
<tr><th colspan="3">ELECTRIC INPUTS</th></tr>
<tr><th>Measure</th><th>Dual fuel heat pump RTU</th><th>ERV</th></tr>
<tr><td>Utility project costs (program costs)</td><td>ETA program</td><td>ETA program</td></tr>
<tr><td>Incremental cost</td><td>Xcel Energy 2024–2026 ECO Plan Dual fuel RTU Deemed Savings Technical Assumptions (varies by system size)</td><td>MN TRM v4.0 ($6/CFM)</td></tr>
<tr><td>Project life</td><td>Xcel Energy 2024–2026 ECO Plan Dual fuel RTU Deemed Savings Technical Assumptions (20 years)</td><td>MN TRM v4.0 (15 years)</td></tr>
<tr><td>Energy savings/unit[37]</td><td rowspan="2">Average energy savings/unit depends on actual sales distribution across system sizes (tons) and levels.[38] See Savings per unit section for details.</td><td rowspan="2">Average energy savings/unit depends on actual sales distribution across system sizes[39] (CFM) and levels. See Savings per unit section for details.</td></tr>
<tr><td>Capacity savings/unit</td></tr>
<tr><td>Number of units</td><td>Annual sales data</td><td>Annual sales data</td></tr>
<tr><td>Load shape</td><td>NREL or similar</td><td>NREL or similar</td></tr>
<tr><th colspan="3">GAS INPUTS</th></tr>
<tr><th>Measure</th><th>Dual fuel heat pump RTU</th><th>ERV RTU</th></tr>
<tr><td>Utility project costs (program costs)</td><td>ETA program</td><td>ETA program</td></tr>
<tr><td>Incremental costs</td><td>Xcel Energy 2024–2026 ECO Plan Dual fuel RTU Deemed Savings Technical Assumptions (varies by system size)</td><td>MN TRM v4.0 ($6/CFM)</td></tr>
<tr><td>Project life</td><td>Xcel Energy 2024–2026 ECO Plan Dual fuel RTU Deemed Savings Technical Assumptions (20 years)</td><td>MN TRM v4.0 (15 years)</td></tr>
</table>

[37] Values based on current data can be found in Tables 6, 7, and 8 of the savings per unit section.

[38] We assume we will obtain sales data from distributors with system size. If we do not receive sales data as a function of system size, we'll use ComStock data to estimate the distribution of system sizes.

Energy savings/unit[40]	Average energy savings/unit is dependent on actual sales distribution across system sizes (tons) and levels. See Savings per unit section for details.	Average energy savings/unit is dependent on actual sales distribution across system sizes (CFM) and levels. See Savings per unit section for details.
Number of units	Annual sales data	Annual sales data

MARKET PROGRESS REPORTING

To monitor progress, we will create an annual status report, referred to in the filing as the Energy Savings and Market Progress Reports.

The content of each of these reports will include:

1. Output tracking and MPI progress
2. Total savings and net benefits
3. Savings and net benefit allocations to individual utilities

Some outputs and MPIs may not be appropriate to track initially or annually based on when we focus on particular market support strategies and whether the outcome is intended to be a short-, medium-, or long-term outcome. Thus, every report will include an update of outputs and MPIs — however, the particular metrics reported will be tailored to include only those that are most appropriate at that time. Savings and net benefits, as well as utility allocations, will be included in each annual Energy Savings and Market Progress Measurement Report. The reports will fully document the final methodology and data sources used to calculate energy savings and net benefits.

These reports will continue throughout the Market Development and Long-term Monitoring and Tracking stages. When the initiative switches into the Long-Term Monitoring and Tracking, the Energy Savings Report will include the same contents listed in 1–3 and will periodically assess the need for market re-entry (i.e., additional Market Development work). Re-entry to the market may be justified if market indicators show that progress and increased market share, or diffusion, are not proceeding as anticipated.

We will periodically assess the right time to sunset long-term monitoring and tracking of an initiative. For initiatives with an end goal that includes an energy code or standard, the initiative often continues to accrue savings for many years after the technology or practice is included in that code or standard. The methodology for calculating savings from the ETA initiatives after a technology is adopted into codes or efficiency standards is covered in Post code/standard adoption plan.

[40] Values based on current data can be found in Tables 6, 7, and 8 of the savings per unit section.

DATA COLLECTION PLAN

There are many different data types and sources discussed throughout this document. These are compiled in Table 15 to provide a comprehensive view of how we plan to collect or access data for this initiative. We also acknowledge that this data landscape represents our current understanding of potential data availability, which may change in the future as other data sources are discovered or become available. We will also plan to work with third-party evaluators to collect supplemental data and review approaches and assumptions as necessary.

Table 15: Evaluation data purpose, type, and sources

Purpose	Data type	Data source
Market support outputs tracking	Output tracking	Internal data documents: ▪ Engagement plans ▪ Meeting records and documented communication ▪ Activity records ▪ Additional documents as relevant
MPI measurement – secondary data sources	Product data	AHRI product directory
	Rebate data	Utility data
	Dichotomous outcome confirmation	Web searches/literature review Utility conversations and rate data
	Sales data	Distributor data/AHRI or other data sources
MPI measurement – primary data collection	Primary survey/interview data for appropriate MPIs	Contractor survey Consumer* survey Manufacturer survey Distributor survey Training surveys and records
Energy savings	Whole product category sales data	Distributor data
	Per-unit savings for dual fuel heat pump RTUs	See Table 5
	Per-unit savings for ERV RTUs	See Table 6
	Utility rebate data	Utilities and DER database
Net benefits	DER inputs	DER guidance

	Utility data	Utility data transfers, IRPs, filings
	Measure-level inputs (see Table 7)	TRM, NREL, utilities

*Note: Consumer is a broad term meant to encompass building decision makers, purchasers, end users, and other appropriate parties.

Sales data

Sales data is used for both calculating energy savings and tracking MPIs, thus is critical to understand market impact over time. In 2024 and beyond, we will aim to collect distributor-level sell-through data to estimate the statewide market. The benefit of collecting data at the distributor level vs. the manufacturer level includes:

- Data will reflect zip code of units sold to contractors vs. number of units shipped to a particular zip code. This provides better accuracy and confidence that the product was sold and installed in MN vs. moved in inventory to other geographies.

The process of data collection will be as follows.

- Develop value proposition for distributors to share data (likely by providing anonymized local market insights back to distributors in exchange for sharing data).
- Establish data sharing agreements and secure file transfer process with distributors.
  - Targeted distributor partners include Auer Steel, Stevens Equipment Supply, Dakota Supply, Gustave A. Larson, Ferguson HVAC Supply, First Supply, Minnesota Air, RHI Supply, SVL, etc.
  - Additional distributor partners may be added to data sharing process as the program increases partnerships.
- Initiate the agreement and data sharing process with as many distributors as possible; will likely begin with two or three and ideally increase data sharing and coverage over time.
- Estimate the whole market based on available data.

Additional insights on this anticipated process are described in the following.

- Data transfer will occur and be analyzed semiannually.
- Initial data transfer will be requested for historic data beginning in 2019 through the present and each subsequent data transfer will include data in six-month batches.
- Requested data fields may include:
  - Manufacturer
  - Model numbers
  - System size (tonnage)
  - Zip code
  - Month sold
- Data sharing incentives can be offered if needed.
- If data sharing at the distributor level doesn't yield intended results, the ETA team will shift focus to the manufacturer level to receive ship-to data by ZIP code.

Finally, we are using the same approach for residential ASHPs and can likely consolidate those agreements and processes across the two initiatives, streamlining distributor data collection.

AHRI data and alternative data sources

AHRI collects and reports on manufacturer ship-to data nationally. They provide data insights and reporting back to manufacturers only and do not provide local-level data to third parties. AHRI does provide national sales data publicly, which can be leveraged to understand national macro trends. In 2024 and beyond, we will continue to engage with manufacturers and AHRI to explore ways to access AHRI data to improve market visibility with improved efficiency. Additionally, the ETA team will continue to explore alternative and emerging methods of collecting whole-market data to ensure that the largest portion of the market is represented, with the highest fidelity at the local level and the most efficient cost as possible to acquire.

Utility data

Data from utilities will also be used for a variety of purposes including energy savings, net benefits calculations, and additional benefits tracking. More specifically, we will request a variety of data from funding utilities including:

- Utility rebate data
- Measure-level inputs for net benefits calculations (e.g., project costs, incentive amounts, load shapes)
- Utility-level inputs for net benefits calculations (e.g., avoided energy costs, avoided emissions)

Given that these data span a wide range of utility functions, we will work with each funding utility to determine the appropriate person for each data point to ensure smooth data transfer. We will also use existing documentation, such as Integrated Resource Plans and filings to glean appropriate information.

We will also connect with non-funding COUs for these data points to ensure statewide representation, though we recognize data collection efforts and quality may vary based on utility, and not all metrics are needed from COUs. We will also work with DER to utilize their Energy Savings Platform database to glean additional information entered by COUs.

Output tracking – internal data documents

Most logic model outputs, or results of our market support activities, will be tracked through internal sources. These may include records of trainings, participant lists, meeting notes, engagement or strategy plans, and materials created. We plan to use an adapted version of SalesForce to track market engagement and will have documents saved on our internal systems to share with future evaluators. Specific tracking processes for each output will be developed as the market support activities are rolled out.

MPI secondary data sources

AHRI product directory

AHRI maintains a comprehensive product directory with unique reference numbers for equipment combinations and pairings. These reference numbers correspond to a variety of details about HVAC equipment, including metrics required to meet specifications. We anticipate purchasing a subscription for this directory and tracking new products that align with our specifications.

Rebate data

Currently, we have relationships with funding utilities and COUs to share rebate participation data.

Dichotomous outcome confirmation

There are several dichotomous MPIs that rely on proof that something happened or is in existence. It either happens or it doesn't. These include outcomes like RTU specifications being adopted or codes being adopted. These outcomes have many data sources but are relatively easy to track as most are publicly available, and proof of achievement is only needed once.

MPI primary data collection

Many MPIs will need to be measured outside of sources that currently exist. In general, this will be done using survey, interviews, focus groups, or other data collection options. Most often, this will involve a third-party evaluator — however, in areas where ETA has extensive knowledge and skillsets, ETA may undertake research in-house. We anticipate the following groups will be important to engage with data collection.

- Contractors
- Distributors
- HVAC consumers (incl. building owners/decision makers, end users, etc.)
- Manufacturers

Net benefits

For information about net benefits inputs and data sources, please see Appendix A. Net benefits memo.

APPENDIX A. NET BENEFITS MEMO

TECHNICAL MEMORANDUM

Draft Methodology for Calculating ETA Net Benefits

September 13, 2023

Authors: Chidinma Emenike, Isaac Smith, Carl Nelson, Maddie Hansen-Connell

---

Purpose

ETA statute requires the calculation and allocation of net benefits as well as energy savings. This document lays out a draft methodology for calculating net benefits from ETA initiatives. This methodology will be included as part of the Market Transformation Plan documents to be approved by the ETA Coordinating Committee prior to launching ETA initiatives.

Net benefits are used for assessing program cost-effectiveness and as inputs for calculating utility financial incentives. As with other CIP programs, net benefits for ETA will be reported when there are savings from specific initiatives to be claimed. Once ETA initiatives are approved and launched, CEE will file annual ETA Energy Savings Reports (similar to an individual utility's Status Report) of total savings and net benefits for each participating utility.

Background

The ETA filing approved by DER provides some overall guidance on calculation of net benefits.[41] As described in the filing, ETA net benefits calculations differ from other CIP programs in several key respects, as outlined in Table 16 below.

Table 16: ETA net benefits calculations compared to traditional CIP program savings calculations

ETA net benefits	CIP program net benefits
Calculated on a statewide basis	Calculated by individual utility territory
Allocated based on financial contribution to ETA (same as ETA savings)	Calculated based on each individual utilities' spending and savings

[41] Center for Energy and Environment. "Minnesota Efficient Technology Accelerator Program Proposal" (2022). Submitted to Minnesota Department of Commerce, Division of Energy Resources. Docket No. E,G999/CIP-21-548. P. 21-34.

ETA net benefits will be calculated based on the primary approved cost-effectiveness test (Minnesota Test) and all other secondary approved cost-effectiveness tests (Societal, Utility, and Ratepayer Impact Tests). Consistent with the approved filing, we will not calculate participant net benefits.[42] Participant cost-effectiveness is a more impactful metric earlier in the program cycle (i.e., when considering program rebates, as opposed to reporting net benefits), and is already considered as part of the ETA initiative selection process.

Included impacts for calculating net benefits

Table 17 shows a list of various impacts (benefits and costs). Per DER guidance, these impacts will be included in each of the four cost-effectiveness tests. Shaded cells indicate values that are currently not quantified and/or do not have an approved estimation methodology.[43]

Table 17: DER-approved cost-benefit impacts (non-quantified impacts in grey)

Utility	Category	Impact	MN Test	Societal Test	Utility Test	RIM
Electric Utility	Generation	Energy Generation	X	X	X	X
		Capacity	X	X	X	X
		Environmental Compliance	X	X	X	X
		RPS Compliance	X	X	X	X
		Market Price Effects	X	X	X	X
		Ancillary Services	X	X	X	X
	Transmission	Transmission Capacity	X	X	X	X
		Transmission System Losses	X	X	X	X
	Distribution Costs	Distribution Costs	X	X	X	X
		Distribution System Losses	X	X	X	X
	General	Program Incentives[44]	X	X	X	X
		Program Administration Costs	X	X	X	X
		Utility Performance Incentives	X	X	X	X

[42] The participant test is designed to assess cost-effectiveness from a participant's perspective, considering rebates provided by the program. As described in the filing, this test is not as meaningful for ETA initiatives (which may intervene in the market prior to a technology being cost-effective and do not provide rebates).
Center for Energy and Environment. "Minnesota Efficient Technology Accelerator Program Proposal" (2022). Submitted to Minnesota Department of Commerce, Division of Energy Resources. Docket No. E,G999/CIP-21-548.

[43] DER Decision, "In the Matter of 2024-2026 CIP Cost-Effectiveness Methodologies for Electric and Gas Investor-Owned Utilities", dated March 31, 2023, in Docket No. E,G999/CIP-23-46.

[44] Note that ETA is not expected to have any costs in this category as ETA initiatives do not provide customer rebates.

Utility	Category	Impact	MN Test	Societal Test	Utility Test	RIM
		Utility Revenue Impacts				X
		Credit and Collection Costs	X	X	X	X
		Risk	X	X	X	X
		Reliability	X	X	X	X
		Resilience	X	X	X	X
Gas Utility	Commodity / Supply	Fuel and Variable O&M	X	X	X	X
		Capacity and Storage	X	X	X	X
		Environmental Compliance	X	X	X	X
		Market Price Effects	X	X	X	X
	Transportation	Transportation	X	X	X	X
	Delivery	Delivery	X	X	X	X
	General (same as Electric)	Program Incentives[44]	X	X	X	X
		Program Administration Costs	X	X	X	X
		Utility Performance Incentives	X	X	X	X
		Credit and Collection Costs	X	X	X	X
		Risk	X	X	X	X
		Reliability	X	X	X	X
		Resilience	X	X	X	X
Non-Utility System	Other Fuels	Other Fuels	X	X		
	Participant	Participant Costs		X		
		Participant Benefits		X		
Societal	Societal Impacts	GHG emissions	X	X		
		Criteria air emissions	X	X		
		Other Environmental	X	X		
		Economic and Jobs (Macroeconomic)	X	X		
		Energy Security	X	X		
		Energy Equity	X	X		

Basic methodology – electric utilities

Below we outline the methodology plan to employ to calculate these impacts for the ETA. In general, this is very similar to calculating net benefits for an individual utility, with the exception of calculating the time value of avoided energy for electric utilities, as described below.

Step 1: Calculate total annual energy and capacity savings. This is based on energy savings calculation methodology, discussed in the Energy Savings and Evaluation plans (generally, it will be total units * energy savings/unit or capacity savings/unit). To the extent possible, savings will be consistent with the most recent TRM.

Step 1a (electric utilities only): DER guidance provides for calculating the benefits of avoided energy by each hour of the year (8760 hours) for each year of measure life, resulting in a high level of data granularity that is needed to calculate net benefits. It is reasonable to expect that we might be able to get this level of granularity of data from ETA-participating utilities, but data for the rest of the state will be challenging. Thus, a simplified method will be used for calculating the time value of efficiency, by breaking down the year into periods, and estimating the $/kWh value for each time period. Savings from measure-specific load shapes will also be allocated to these discrete time periods.

For illustrative purposes, Table 18 shows the time periods used for calculating energy savings in the 2018 Minnesota Potential Study. We will base the actual time periods and percentage allocations used for ETA net benefits calculations according to what makes the most sense based on the data that is received.

Table 18: Potential Study energy time periods, for calculating time value of electric energy savings

Period	Period definition	% of year
Summer on-peak	Jun-Aug: weekdays 9 a.m. – 10 p.m.	10%
Summer off-peak	Jun-Aug: weekdays 10 p.m. – 9 a.m.	8%
Winter on-peak	Nov-Mar: weekdays 8 a.m. – 10 p.m.	17%
Winter off-peak	Nov-Mar: weekdays 10 p.m. – 8 a.m.	12%
Shoulder on-peak	Apr-May & Sep-Oct: Weekdays 7 a.m. – 11 p.m. + All weekend days 9 a.m. – 11 p.m.	33%
Shoulder off-peak	Apr-May & Sep-Oct: Weekdays 11 p.m. – 7 a.m. + All weekend days 11 p.m. – 9 a.m.	20%

Step 2: Multiply energy and capacity savings by the appropriate values. Energy savings will be multiplied by each relevant $/kWh value (value of avoided energy, value of avoided emissions,

etc.), for each period shown in Table 3. Capacity savings will be multiplied by each relevant $/KW value (value of avoided capacity, value of avoided T&D, etc.) per year of measure life. Calculate total benefits by adding together all resulting dollar amounts for each value.

Step 3: Discount benefits in future years by the appropriate discount rate. The ETA would use the discount rates provided by DER guidance, with some extrapolation needed to calculate statewide values for the utility test, as described in a subsequent section.

Step 4: Calculate total net costs, in keeping with current DER methodology. If available, these inputs will be sourced from the most recent TRM. If costs occur beyond year one (e.g., O&M costs), they will be subtracted from the benefits in the year in which they occur.

Step 5: Calculate net benefits (total benefits minus total costs).

Electric inputs

Table 19 shows the inputs needed to calculate net benefits for electric utilities. These inputs are divided into three categories:

1) *Measure-level inputs.* These will be different for each ETA initiative. The method for estimating these inputs will be defined in the Energy Savings Plan for each initiative.
2) *Utility-specific inputs.* These are inputs that are specific to each utility; as described in the “calculating statewide inputs” section below, load-weighted statewide averages will be calculated for these values. Some utility-specific inputs utilize DER-specified values for individual utilities — refer to the footnotes for more information about these values. The statewide average will be based on DER-specified inputs where possible (not available for all utilities).
3) *Global inputs*. These are inputs that apply statewide and are provided by DER.

Table 19: Benefit-cost inputs for electric-saving measures

Measure-level Inputs	Utility-specific Inputs	Global Inputs
Utility Project Costs	Avoided Energy Costs	Participant Discount Rate (residential customers)
Project Life	Avoided Emissions	Societal Discount Rate
Energy Savings/Unit	Avoided T&D[45]	Environmental Compliance
Capacity Savings/Unit	CIP Utility Discount Rate[46]	Non-gas Fuel Cost
Number of Units	Participant Discount Rate (non-residential customers)[47]	Non-gas Environmental Damage Factor
Load Shape		Non-Gas Fuel Loss Factor
Incremental Costs		Avoided Capacity Costs
Electric Non-Energy Benefits		
Variable O&M		

Basic methodology – gas utilities

The gas utility methodology follows DER guidance.

Step 1: Calculate total annual energy savings. This is based on energy savings calculation methodology, discussed elsewhere (generally, it will be total units * energy savings/unit). To the extent possible, savings will be consistent with the most recent TRM.

Step 2: Multiply energy savings by the appropriate values. Energy savings will be multiplied by each relevant $/Dth value (value of avoided energy, value of avoided emissions, etc.). Calculate total benefits by adding together all resulting dollar amounts for each value.

Step 3: Discount benefits in future years by the appropriate discount rate, as provided by DER.

Step 4: Calculate the total net costs, in keeping with DER methodology. If available, these inputs will be sourced from the most recent TRM.

Step 5: Calculate net benefits (total benefits minus total costs).

Gas inputs

Table 20 shows the gas inputs that will be used to calculate net benefits, divided into the categories described above in the electric section.

[45] DER-approved annual values per utility

[46] Specified by DER in their order, for each investor-owned utility (IOU)

[47] Same as the CIP utility discount rate

Table 20: Benefit-cost inputs for gas-saving measures

Measure-level Inputs	Utility-specific Inputs	Global Inputs
Utility Project Costs	CIP Utility Discount Rate[48]	Participant Discount Rate (residential customers)
Project Life	Participant Discount Rate (non-residential customers)[49]	Societal Discount Rate
Energy Savings/Unit	Gas Retail Rate[50]	Environmental Compliance
Number of Units	Demand Cost[51]	Gas Environmental Damage Factor
Incremental Costs		Gas Escalation Rate
Variable O&M		Gas Commodity Cost
		Peak Reduction Factor

Calculating statewide inputs

Measure-level inputs will be estimated based on the methodology outlined in each ETA initiative's Energy Savings Plan. Global inputs will be per the latest DER guidance.

To estimate statewide values for utility-specific inputs (as shown in Tables 19 and 20), CEE will calculate a load-weighted statewide average using values from ETA utilities, as well as from non-ETA utilities when available. Other statewide data sources may supplement utility-specific data. This follows the methodology employed in the 2018 Minnesota Potential Study. Data sources will include:

- NREL's Cambium data sets (to estimate the value of avoided energy and avoided emissions)
- Confidential data requests for trade-secret, utility-specific data points
- Appropriate proxies (co-op borrowing rates, muni bond rates, etc.) to determine the value of benefits occurring outside of ETA funder utility service areas and calculate load-weighted statewide average

48 Specified by DER for each IOU

49 Same as the CIP utility discount rate

50 Per DER, this is calculated using each utility's currently approved tariffed non-natural gas margin (using a weighted average if multiple customer classes are participating), demand cost, and the DER-specified gas commodity cost.

51 Per DER, this value is sourced from the utility's March 2023 Purchased Gas Adjustment filing.

Appendix B. Data Tables

Table 21: Estimated number of RTUs in 2044, binned by cooling capacities that are applicable to the RTU initiative

Cooling Capacity Bin (tons)	Capacity Midpoint	Estimated Number of RTUs in 2044
<5.4	4.2	98,317
5.4 to <11.3	8.35	55,639
11.3 to <20	15.65	18,967
20 to 25	22.5	9,010
Total		**181,933**

Note: Data from 2017 CARD study

Table 22: Full load heating hours (FLH) for heating and cooling used for each building category

		Heating FLH			Cooling FLH		
MN TRM Category	**ComStock Category**	**CZ1**	**CZ2**	**CZ3**	**CZ1**	**CZ2**	**CZ3**
Convenience Store	Retail Standalone (<= 5000 sqft)	1887	1699	1546	647	825	986
Education - Primary	Primary School	2394	2156	1961	289	338	408
Education - Secondary	Secondary School	2561	2306	2098	484	473	563
Health/Medical Clinic	Outpatient	2234	2012	1830	558	738	865
Health/Medical Hospital	Hospital	2508	2258	2054	663	1089	1298
Office - Low Rise	Small Office	1966	1770	1610	257	359	446
Office - Mid Rise	Medium Office	2189	1970	1793	373	529	651
Office - High Rise	Large Office	2149	1935	1760	669	1061	1263
Restaurant	Quick/Full Service Restaurant	1868	1681	1530	347	535	652
Retail - Large Department Store	Retail Standalone (>5000 sq. ft.)	1763	1587	1444	462	588	686
Retail - Strip Mall	Retail Strip Mall	1701	1531	1393	307	441	574
Warehouse	Warehouse	1872	1685	1533	164	343	409

Note: data from Minnesota TRM Version 4.0

Table 23: Efficiency assumptions for baseline RTUs and dual fuel heat pump RTUs by binned capacity

Capacity Bin	IEER - Baseline	IEER - EE	EER - Baseline	EER - EE	AFUE - Baseline	AFUE - EE Backup
< 5.4	15.0	16.3*	12.0	12.8	80%	80%
5.4 to <11.3	13.8	14.1	12.0	12.0	80%	80%
11.3 to <20	13.0	15.4	12.0	12.0	80%	80%
20 to 25	11.4	14.6	9.8	10.2	80%	80%

* SEER used for < 5.4-ton systems
Note: Data from 2017 CARD study and manufacturer product literature

Table 24: Percentage of rated heating capacity retained vs. outside air temperature (OAT) for each heat pump RTU capacity bin

			Rated Capacity % - Binned by Ton		
OAT Min	**OAT Max**	**< 5.4**	**5.4 to 11.3**	**11.3 to 20**	**20 to 25**
65	>65	118%	123%	112%	105%
60	65	118%	123%	112%	105%
55	60	112%	113%	105%	99%
50	55	105%	102%	97%	93%
45	50	99%	92%	90%	87%
40	45	92%	86%	83%	81%
35	40	85%	79%	77%	75%
30	35	79%	73%	71%	69%
25	30	72%	66%	65%	64%
20	25	66%	61%	59%	58%
15	20	60%	55%	54%	53%
10	15	54%	50%	48%	48%
5	10	48%	45%	43%	44%
0	5	42%	38%	37%	39%
-5	0	37%	32%	32%	35%
< -5	-5	31%	25%	27%	31%

Note: Table data is based on currently available manufacturer product literature data and MN code minimums for baseline

Table 25: Heating COP vs. outside air temperature (OAT) for each heat pump RTU capacity bin

		COP - Binned by Ton			
OAT Min	OAT Max	< 5.4	≥5.4 to <11.3	≥11.3 to <20	≥20 to 25
65	> 65	2.76	2.75	2.72	2.61
60	65	2.76	2.75	2.72	2.61
55	60	2.68	2.62	2.60	2.48
50	55	2.56	2.49	2.47	2.36
45	50	2.42	2.37	2.35	2.23
40	45	2.31	2.24	2.22	2.11
35	40	2.14	2.11	2.09	1.98
30	35	2.01	1.99	1.95	1.86
25	30	1.88	1.87	1.81	1.73
20	25	1.73	1.74	1.68	1.60
15	20	1.58	1.61	1.54	1.48
10	15	1.46	1.49	1.41	1.37
5	10	1.31	1.37	1.28	1.25
0	5	1.19	1.26	1.15	1.14
-5	0	1.04	1.13	1.02	1.02
< -5	-5	1.00	1.02	1.00	1.00

Note: Table data is based on currently available manufacturer product literature data

Table 26: Hours and heating degree days for the three climate zones in Minnesota binned by OAT

		Heating Degree Days			Hours		
Min °F	Max °F	CZ1	CZ2	CZ3	CZ1	CZ2	CZ3
65	>65	0	0	0	1567	1900	2270
60	65	72	67	68	669	662	673
55	60	215	200	170	698	641	553
50	55	315	300	268	609	572	510
45	50	410	364	375	559	500	514
40	45	515	404	442	550	430	470
35	40	796	567	595	688	493	517
30	35	1049	899	1021	778	661	749
25	30	892	884	798	571	567	512
20	25	937	870	804	531	493	455

15	20	858	816	721	434	412	364
10	15	821	922	658	377	422	302
5	10	670	831	573	280	347	238
0	5	488	715	528	188	276	203
-5	0	307	464	361	110	166	129
< -5	-5	480	713	970	151	218	301

Note: Table data is based on typical meteorological year 2022 data from the National Renewable Energy Laboratory (NREL)[52]

Table 27: Percentage of each RTU capacity bucket found in each climate zone and building type[53]

	Climate Zone											
	CZ1				CZ2				CZ3			
Size Bin (tons)	< 5.4	≥5.4 to <11.3	≥11.3 to <20	≥20 to 25	< 5.4	≥5.4 to <11.3	≥11.3 to <20	≥20 to 25	< 5.4	≥5.4 to <11.3	≥11.3 to <20	≥20 to 25
TRM Category												
Convenience Store	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Education - Primary	0.0%	1.3%	0.0%	0.0%	0.0%	1.3%	0.0%	0.0%	1.4%	6.3%	15.6%	0.0%
Education - Secondary	0.0%	0.0%	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	4.5%	5.2%	0.0%	0.0%
Health/Medical Clinic	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Health/Medical Hospital	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Office - Low Rise	1.2%	0.1%	0.0%	0.0%	1.0%	0.5%	0.8%	0.0%	18.2%	6.8%	1.0%	0.0%
Office - Mid Rise	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%	2.4%	0.0%	0.0%
Office - High Rise	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.1%	2.4%	2.9%	0.0%
Restaurant	0.9%	1.1%	1.1%	0.0%	1.1%	2.3%	0.8%	0.0%	14.2%	16.0%	10.3%	1.2%

52 https://nsrdb.nrel.gov/data-viewer.

53 NREL ComStock 2023 release baseline metadata counting RTUs and estimating RTU sizes using TRM FLH for each TRM building category within each climate zone

Retail - Large Department Store	0.4%	0.5%	0.4%	0.0%	0.6%	0.3%	0.4%	0.0%	7.9%	15.0%	18.3%	15.2%
Retail - Strip Mall	2.6%	2.8%	3.8%	4.0%	1.8%	3.1%	1.4%	6.9%	16.1%	21.7%	33.6%	71.6%
Warehouse	0.6%	0.3%	0.2%	0.0%	0.6%	0.1%	0.2%	0.0%	15.6%	10.4%	9.3%	1.2%
Total	**8.1%**	**6.1%**	**5.4%**	**4.0%**	**6.6%**	**7.5%**	**3.5%**	**6.9%**	**85.3%**	**86.4%**	**91.1%**	**89.1%**

Note: The three columns for each climate zone category sum to 100%

Table 28: Occupied building indoor air temperature setpoints used for ERV calculations

Climate Zone	Capacity Bin	Heating Setpoint [°F]	Cooling Setpoint [°F]
1	< 5.4	68	73
1	≥5.4 to <11.3	68	72
1	≥11.3 to <20	68	72
1	≥20 to 25	68	72
2	< 5.4	68	72
2	≥5.4 to <11.3	68	72
2	≥11.3 to <20	68	72
2	≥20 to 25	68	72
3	< 5.4	68	73
3	≥5.4 to <11.3	68	72
3	≥11.3 to <20	68	72
3	≥20 to 25	68	72

Note: Data determined using median values from NREL Comstock data