
Minnesota Energy Efficiency Potential Study: 2020–2029

Appendix C: Energy Efficiency Measure Selection Methodology

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Introduction

The full report that this appendix supports, *Minnesota Energy Efficiency Potential Study: 2020-2029*, is available for download on the [project website](#).

Minnesota has a thirty-plus year history of leadership in energy efficiency policy and achievements. In order to continue to maximize the benefits of cost-effective energy efficiency resource acquisition by utilities, the project team, consisting of Center for Energy and Environment (CEE), Optimal Energy (Optimal) and Seventhwave, was commissioned to:

- Estimate statewide electric and natural gas energy efficiency and carbon-saving potential for 2020-2029;
- Produce data-driven and stakeholder-informed resources defining market segments, end uses, measures, and programs that could be targeted in the decade ahead to realize the state's cost-effective energy efficiency potential; and
- Engage stakeholders in order to help advance robust energy policies and energy efficiency programs in the state, and to inform future efficiency portfolio goals.

This Appendix describes the methodology used by the study team to select measures to include for the study. A total of 332 individual measures were included in the study; of these, 75 were gas-only technologies, 205 were electric-only, and 52 saved both gas and electricity. The measure list began with Version 2.1 of the Minnesota Technical Reference Manual (MN TRM)¹ and was supplemented by several new measures added to Version 2.2² that was released during the project. Additional measures were drawn from other state's TRMs, published utility potential studies, utility programs, current research on energy efficiency, interviews with utility staff, and interviews with other stakeholders. All of these sources were included in a gap analysis performed by E-Source at the outset of the project.

There were a number of ground rules for the further consideration of all identified measures. No measures that only included fuel-switching were included. Demand-response measures were only included if they also had energy consumption savings, per current CIP policy. In addition, each proposed measure was then analyzed to determine if it was applicable to one or more combinations of the four market approaches (retrofit, replacement, renovation or new construction) and the 16 individual building segments. In some cases, separate tiers of efficiency levels of a given technology were also divided into separate measures (e.g., "Tier 1" simple programmable thermostats and "Tier 3" smart thermostats). This resulted in modelling of a total of 3,378 individual measure permutations. The measures included in the model are listed in six tables in the Results section below, which includes a reference number to the Excel workbook with the measure summary and characteristics.

¹ Minnesota Technical Reference Manual [Version 2.1](#)

² Minnesota Technical Reference Manual [Version 2.2](#)

Table 1. Source of Measures Selected for the Study

Source of measure	Residential	Commercial/ Industrial	Total
Minnesota Technical Reference Manual	119	131	250
Other TRMs	2	11	13
Utility Programs	1	30	31
Potential Studies	0	7	7
Research and Emerging Technologies	9	8	17
Behavioral Programs and Research	10	4	14
Total	141	191	332

In order to be included in the modelling, each measure needed well-defined values for each of the following attributes:

- Energy savings from the baseline (including any baseline shifts over the study period);
- Incremental cost;
- Future O&M and capital replacement cost impacts;
- Lifetime; and
- Applicability to specific building types and end uses.

For some emerging technologies, these values were not yet well defined, so the measure was excluded.

Methodology

Based on the process described in this Appendix a total of 332 measures were selected for inclusion in the study (Table 1); of these, 75 were gas-only technologies, 205 were electric-only, and 52 saved both gas and electricity. To come up with the list of measures a two-step process was used: 1) Discovery of measures for consideration, and 2) selection of the measures for the model.

The measure list began with versions 2.1 and 2.2 of the MN TRM, and expanded to all published TRMs in the U.S., published utility potential studies, research reports on energy efficiency, particularly those presented in ACEEE conferences, interviews with utility staff, interviews with other stakeholders, and a gap analysis performed by E-Source.

Conventional Measures

Version 2.1 of the MN TRM includes 107 electric measures, 36 natural gas measures, and 6 combined measures, 6 electric measures and 2 natural gas measures were added from Version 2.2. Fourteen measures from the MN TRM were excluded from the model. Of these, twelve were lighting measures that will not apply under the new EISA standards (for example, replacing T-12 and T-8 fluorescent tubes with T-8's), one was behavioral (Building Operator Certification) and one was a demand management measure, Residential Load Management. Residential Load Management is made up of four individual demand response measures each with some associated energy savings; these measures are discussed in the Demand Response/Load Management Appendix. An analysis of TRMs from 25 other states and Canadian provinces identified another 241 measures for consideration.

A similar process was followed when looking at measures in other potential studies, which yielded seven additional measures. These came from potential studies for [Focus on Energy \(Wisconsin\)](#), [NYSERDA \(New York\)](#) and [Vermont](#).

Utility programs were the source of the largest number of additional measures. Most of the measures came from Minnesota programs, but all the exemplary programs that have been recognized by ACEEE were considered, as were many other programs that have been discussed at E-Source and other fora. Many of the measures derived from utility programs were not in the TRM because they are classified as custom by Minnesota utilities. In general, this is because they involve more complex calculations than is appropriate for the TRM. Several examples are Strategic Energy Management, Recommissioning, and Process Efficiency programs. In addition to these established programs, several new program entries were included as they are expected to have a significant impact in the period 2020-2029. These include Building Energy Management System programs, other controls-based programs focused on individual systems such as chillers, lighting and waste heat recovery, and optimized system design programs for lighting, HVAC and refrigeration.

Custom Measures

Although not listed specifically in the measure list, custom measures are included. Even with a comprehensive measure list, not every discrete efficiency opportunity can be predicted or characterized at such a granular level. The custom measures capture opportunities that exhibit highly site-specific operating parameters or are otherwise not broadly applicable, especially in industrial facilities.

Historical efficiency program results for custom measures were used to inform savings estimates and costs in terms of dollars per unit of energy saved. Results from MN programs were prioritized, but we also incorporated data from other national energy efficiency leaders and studies published by efficiency “think tanks” such as the New Buildings Institute, Rocky Mountain Institute, and the national laboratories.

Behavioral Measures

The behavioral measures were selected from a comprehensive literature review of existing program evaluations, conference proceedings, and recent research such as CARD-supported studies. We defined residential behavioral measures as *any low/no-cost elective action or default that manages the use of equipment or space in a home.*

For commercial measures, we relied primarily on the recently completed CARD-support research conducted by Illume and Seventhwave to elect measures. Commercial measures were defined as *any elective action, policy or default that manages the use of equipment (or space) in a business.* This includes, but is not limited to:

- Employee behaviors;
- Building operator behaviors and maintenance practices;
- Management or control of equipment or space that is facilitated by technology, such as occupancy sensors or Energy Management System / Building Automation System timers.

Emerging Technology Measures

Emerging technology measures were defined as those measures not yet included in the MN TRM or in current Minnesota utility programs. In order to be included in the study, a measure had to be sufficiently well understood that it was possible to characterize the potential savings quantitatively.

Research was the primary source of potential measures, including these specific sources:

- [ACEEE Intelligent Efficiency and Market Technology Assessment 2017](#)
- [ACEEE: New Horizons for Energy Efficiency: Major Opportunities to Reach Higher Electricity Savings by 2030](#)
- Reports of the [NYSERDA Technology and Market Development Program](#)
- Proceedings of the [California Energy Commission’s Emerging Technologies Coordinating Council \(ETCC\)](#)
- The Research Program of the U.S. Department of Energy, including the [Building America Research-to-Market-Plan of November 2015](#)
- [E-Source Conference presentations](#)
- [Proposals submitted to the Minnesota Department of Commerce’s Commerce Applied Research and Development \(CARD\) program](#)
- Independent research known to members of the project team.

Candidate technologies were divided into three categories:

1. **Near-term:** those measures that are currently or soon-to-be available, but not yet implemented in Minnesota. It includes measures that are market-ready or expected to be market-ready at the potential study baseline year of 2020 (<3yr) (e.g. Aerosol residential envelope sealing). For the most part these are technologies for which published savings estimates or credible technology demonstrations are available. These measures may represent extensions of existing measures to a new end use. There is little technological risk for the measure: basic research and development (R&D) is complete and commercialization is underway. The major uncertainty is associated with the rate of adoption of the measures.
2. **Mid-term:** those measures for which significant R&D is still needed. The majority of these technologies have already been associated with specific products, services, and end uses. However, the measures are not expected to be commercially available by the potential study baseline year of 2020. They may become available over the analysis period (3 – 13yr). These measures may exist as prototypes that demonstrate savings potential, but robust third-party savings estimates or pilot demonstrations are incomplete. This lack of certainty means that it is not clear whether these technologies will develop into energy savings measures. Many mid-term measures are implicitly included by keeping the savings relative to the baseline for the technology (such as appliances and heat pumps) at a constant percentage. This allows for incremental improvements in both base and high efficiency versions of the measure.
3. **Long-term –** those measures that encompass theoretical, conceptual, or academic ideas for which significant, and even, basic R&D is still necessary. This includes measures for which specific applications may not yet be identified and savings may be more speculative or theoretical (e.g. acoustic refrigeration technologies). There is significant technological uncertainty that these technologies will develop into relevant potential savings measures within the timespan of this study (<13 yr.). This group of technologies are built into utility sales forecasts based on historical introductions of new efficiency measures to the market. The total contribution of these measures to the savings potential over the period of the study is assumed to be small, although as noted in the body of the report, one could turn out to be the next disruptive technology, as was the case with LED lighting.

Demand Response Measures

The methodology for identification and selection of Demand Response measures is discussed in Appendix E.

Measure Selection

The 241 measures found in other TRMs primarily served as validation of our selection process, and as a secondary source of measure attributes, including savings calculations for measures already selected. Thirteen measures were added from the other TRMs. The added measures came from Arkansas, Illinois, Iowa, Wisconsin and Vermont. While seemingly a small fraction of the total candidate measures (13/241

= 5%) analysis determined that the majority of measures found in other TRMs were already included in the existing measures.

In a few cases the measures were not found to be appropriate (whether in terms of energy savings or cost-effectiveness) for Minnesota. A few examples are evaporative cooling, radiant barriers for attics, (which the Minnesota Department of Commerce warns consumers about [annually](#)); and sun-blocking window films (which were investigated in CARD project using energy modeling and found to increase residential heating needs in the winter by a larger amount than they save in reduced cooling in the summer in Minnesota's climate zone³). Other states have TRM measures that are classified as custom measures in Minnesota (for example, 10 different specialized industrial equipment measures were found in other TRMs) or are included in a broader category (for example the MN TRM has three Heat Pump categories: Air Source, Ground Source and Ductless, while eight subtypes of these were found in other TRMs).

Finally, a qualitative screening was done to eliminate measures with negligible savings potential or measures that are highly unlikely to pass the cost-effectiveness screening. Some measures with small savings and low levels of projected implementation were excluded because while they do save energy on a statewide scale their impact would be negligible. Many of these measures can be incorporated in similar TRM measures, for example, a lower energy heat lamp used in a barn for warming piglets can be included by utilities as a lighting measure.

137 emerging technology measures were initially considered. After deeper analysis, 59 unique measures were identified and all of these were then analyzed based on likelihood of implementation in the time frame of the study (2020-2029), state of commercialization, certainty of savings and costs, and predicted impact.

Once the measures were selected, they were analyzed to determine interactions between measures as well as to remove duplicates and overlapping measures. In a number of cases this resulted in measures being combined for the purposes of running the modeling software. For example, Mini Split Ductless Systems A/C and Heat Pump are both existing Residential (v2.1 page 259) and Commercial (v2.1 page 50) TRM measures and included as conventional measures for both new construction and retrofits. For residential installations the new unit needs to have a SEER exceeding 14.5 (13.0 for commercial units), but recent improvements in cold climate air source heat pumps offer even greater efficiencies (SEER above 20). These are included in the model under the same measure as the traditional Mini-Split Systems, but as a high efficiency option, with its own set of savings and costs.

Finally, the measures were applied to individual building types, and classified by their market approach for the model. The four market approaches were aggregated into two, "Market Driven" (replacement at end of life, renovation or new construction) and "Retrofit" (replacement of existing equipment, generally with new equipment of higher efficiency). Each measure was characterized for up to 16 separate building types, resulting in 3,378 separate measure permutations.

³ *Window Retrofit Technologies: Increased Energy Efficiency without Replacement*. By Christopher Plum, Gustav Brandstrom, Kerry Haglund and John Carmody. Minnesota Department of Commerce, Division of Energy Resources. COMM-20130501-53155 (2015).

Results

List of Selected Measures

The result of the selection process was a list of measures that were used in the model to determine energy savings potential. The list below includes basic information about each measure, including a short title; whether it is an electric or natural gas saving measure; the Sector (“R”, residential or “C”, Commercial/Industrial); Market Driven, “MD” (new construction, renovation or replacement at the end of useful life) or a Retrofit, “RET” (replacement before normal end of life); and an index number that refers to the model.

The list of measures is broken into six sections:

1. Measures from the MN TRM (250)
2. Measures from other TRMs (13)
3. Measures from Minnesota Utility Programs (31)
4. Measures from Other Potential Studies (7)
5. Measures from Research Projects and Emerging Technology Programs (17)
6. Behavioral Measures (14)

Table 2. Selected Measures Group 1. MN TRM (250 Measures)

Measure Name	Electric	Gas	Sector	Market	Retrofit	Ref #
ENERGY STAR Clothes Washer with Electric Water Heating and Electric Drying, Appliance	E		R	MD		1
ENERGY STAR Clothes Washer with Electric Water Heating and Electric Drying, Water Heating	E		R	MD		2
ENERGY STAR Clothes Washer with Electric Water Heating and Gas Drying - Appliance	E	G	R	MD		3
ENERGY STAR Clothes Washer with Electric Water Heating and Gas Drying - Water Heating	E		R	MD		4
ENERGY STAR Clothes Washer with Gas Water Heating and Electric Drying	E	G	R	MD		5
ENERGY STAR Clothes Washer with Gas Water Heating and Gas Drying - Appliance	E	G	R	MD		6
ENERGY STAR Clothes Washer with Gas Water Heating and Gas Drying - Water Heating		G	R	MD		7
ENERGY STAR Dishwashers with Electric Water Heating - Appliance	E		R	MD		8
ENERGY STAR Dishwashers with Electric Water Heating - Water Heating	E		R	MD		9
ENERGY STAR Dishwashers with Gas Water Heating	E	G	R	MD		10
ENERGY STAR Refrigerators and Freezers	E		R	MD	RET	11
Secondary Fridge and Freezer Removal	E		R		RET	12
ENERGY STAR Dehumidifier	E		R	MD		13

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Central Air Conditioner	E		R	MD	RET	14
Central Air Conditioner with Quality Install	E		R	MD	RET	15
Air Source Heat Pump (Cool)	E		R	MD	RET	16
Air Source Heat Pump (Heat)	E		R	MD	RET	17
Air Source Heat Pump Replacing Electric Heat and Central Air Conditioner (Cool)	E		R	MD		18
Air Source Heat Pump Replacing Electric Heat and Central Air Conditioner (Heat)	E		R	MD		19
Air Source Heat Pump with Quality Install (Cool)	E		R	MD	RET	20
Air Source Heat Pump with Quality Install (Heat)	E		R	MD	RET	21
Air Source Heat Pump Replacing Electric Heat and Central Air Conditioner with Quality Install (Cool)	E		R	MD		22
Air Source Heat Pump Replacing Electric Heat and Central Air Conditioner with Quality Install (Heat)	E		R	MD		23
Central Air Conditioner Tune-Up	E		R		RET	24
Central Air Conditioner Recommissioning	E		R		RET	25
ENERGY STAR Room Air Conditioner	E		R	MD		26
Ground Source Heat Pump Replacing Electric Heat and Split Air Conditioner (Cool)	E		R	MD	RET	27
Ground Source Heat Pump Replacing Electric Heat and Split Air Conditioner (Heat)	E		R	MD	RET	28
Ductless Mini Split Air Conditioner	E		R	MD	RET	29
Ductless Mini Split Heat Pump Replacing Electric Resistance Heat and Split Air Conditioner (Cool)	E		R	MD	RET	32
Ductless Mini Split Heat Pump Replacing Electric Resistance Heat and Split Air Conditioner (Heat)	E		R	MD	RET	33
ECM Circulators - Domestic Hot Water	E		R	MD		34
ECM Circulators - Cooling Water	E		R	MD		35
ECM Circulators - Heating Water	E		R	MD		36
ECM Blower Motor	E	G	R		RET	37
Duct Sealing, Electric Heat (Cool)	E		R		RET	38
Duct Sealing, Electric Heat (Heat)	E		R		RET	39
Duct Sealing, Gas Heat (Cool)	E		R		RET	40
Duct Sealing, Gas Heat (Heat)		G	R		RET	41
Wall Insulation Exterior Application - Heating, Gas Heating		G	R		RET	42
Wall Insulation Interior Application - Heating, Gas Heating		G	R		RET	43
Attic Insulation - Heating, Gas Heating		G	R		RET	44
Air Sealing, Gas Heating		G	R		RET	45
Electronic Ignition Hearth		G	R	MD		46
Furnace, AFUE 90-94%		G	R	MD	RET	47
Furnace, AFUE >94%		G	R	MD	RET	49
Boiler, AFUE 84-90%		G	R	MD	RET	53
Boiler, AFUE > 90%		G	R	MD	RET	54
Furnace Tune Up		G	R		RET	56

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Boiler Tune Up		G	R		RET	57
Tier 1 Thermostats with Electric Heating - Cooling	E		R		RET	58
Tier 1 Thermostats with Electric Heating - Heating	E		R		RET	59
Tier 1 Thermostats with Gas Heating	E	G	R		RET	60
Tier 2 Thermostats with Electric Heating - Cooling	E		R	MD	RET	61
Tier 2 Thermostats with Electric Heating - Heating	E		R	MD	RET	62
Tier 2 Thermostats with Gas Heating	E	G	R	MD	RET	63
Tier 3 Thermostats with Electric Heating - Cooling	E		R	MD	RET	64
Tier 3 Thermostats with Electric Heating - Heating	E		R	MD	RET	65
Tier 3 Thermostats with Gas Heating	E	G	R	MD	RET	66
Variable Speed Pool Pump	E		R	MD		71
Advanced Tier 2 Power Strips	E		R		RET	72
ENERGY STAR LED A-Line Lamp, Interior	E		R		RET	73
ENERGY STAR LED A-Line Lamp, Exterior	E		R		RET	74
ENERGY STAR LED Globe Lamp, Interior	E		R		RET	75
ENERGY STAR LED Globe Lamp, Exterior	E		R		RET	76
ENERGY STAR LED PAR/Flood Lamp, Interior	E		R		RET	77
ENERGY STAR LED PAR/Flood Lamp, Exterior	E		R		RET	78
ENERGY STAR LED Downlight Fixture, Interior	E		R		RET	79
ENERGY STAR LED Outdoor Fixture	E		R		RET	80
ENERGY STAR Ceiling Fan & Lights	E		R		RET	81
ENERGY STAR Ceiling Fan	E		R		RET	82
Ext Lighting Controls	E		R		RET	83
Interior LED Holiday Lights	E	G	R		RET	84
Exterior LED Holiday Lights	E		R		RET	85
LED Tube Replacement Lamps	E	G	R		RET	86
Electric Water Heater Jacket Insulation	E		R		RET	87
Electric Water Heater Drainpipe Heat Exchange	E		R		RET	88
Gas Water Heater Drainpipe Heat Exchange		G	R		RET	89
Electric Water Heater Setback	E		R		RET	90
Gas Water Heater Setback		G	R		RET	91
Faucet Aerator (1.5 gpm) with Electric Water Heater	E		R		RET	92
Faucet Aerator (1.5 gpm) with Gas Water Heater		G	R		RET	93
Heat Pump Water Heater ≤ 55 gal, Electric Space Heating	E		R	MD	RET	94
Heat Pump Water Heater ≤ 55 gal, Gas Space Heating	E	G	R	MD	RET	95
Heat Pump Water Heater > 55 gal, Electric Space Heating	E		R	MD	RET	96
Heat Pump Water Heater > 55 gal, Gas Space Heating	E	G	R	MD		97
Low Flow Showerhead (1.5 gpm) with Electric Water Heater	E		R		RET	98
Low Flow Showerhead (1.5 gpm) with Gas Water Heater		G	R		RET	99
Thermostatic Restriction Valve with Electric Water Heater	E		R		RET	100
Thermostatic Restriction Valve with Gas Water Heater		G	R		RET	101
Pipe Insulation with Electric Water Heater	E		R		RET	102
Pipe Insulation with Gas Water Heater		G	R		RET	103
Storage Gas Water Heater		G	R	MD	RET	104

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Market Driven Instantaneous Gas Water Heater		G	R	MD	RET	105
Interior Lighting Controls	E	G	C		RET	106
Exit Sign Retrofit with LED/LEC	E	G	C		RET	107
Exterior Canopy/Soffit Retrofit with LEDs	E		C	MD	RET	108
Exterior Wall Pack Retrofit with LEDs	E		C	MD	RET	109
Fluorescent to LED High Bay Systems	E	G	C		RET	110
Incandescent Over 100W LED Retrofit, Fixture	E	G	C		RET	111
Incandescent Over 100W LED Retrofit, Lamp	E	G	C		RET	112
Incandescent Up to 100W LED Retrofit, Fixture	E	G	C		RET	113
Incandescent Up to 100W LED Retrofit, Lamp	E	G	C		RET	114
LED Screw-In Lamps in Walk-in Coolers and Freezers	E		C		RET	115
LED Troffers	E	G	C		RET	116
LED Troffer Retrofit Kits	E	G	C		RET	117
Com LED Tube Replacement Lamps	E	G	C		RET	118
Pin-Based LED Replacing CFL	E	G	C		RET	119
New Construction Indoor Lighting	E			MD		120
Refrigerator/Freezer Case LEDs	E		C		RET	121
Refrigerator/Freezer Case Occupancy Controls	E		C		RET	122
Stairwell Fixtures with Integral Occupancy Sensors	E	G	C		RET	123
Motors, Fans	E		C	MD	RET	125
Motors, Pumps	E		C	MD	RET	126
Tier 1 Advanced Power Strip	E		C	MD	RET	127
Tier 2 Advanced Power Strip	E	G	C	MD		128
Beverage Machine Controls	E		C		RET	129
Computer Power Management	E	G	C		RET	130
Snack Machine Controls	E		C		RET	131
Add Doors to Open Multideck Case	E	G	C		RET	133
Anti-Sweat Heat Control	E		C	MD	RET	134
Case Night Covers	E		C		RET	135
Loading Dock Pit Seals	E		C	MD	RET	136
ECM Compressor/Condenser Fan Motors	E		C	MD	RET	137
ENERGY STAR Refrigerator and Freezer	E		C	MD		138
Evaporator Fan Motor Retrofit	E		C	MD	RET	139
Evaporator Fan Speed Controls	E		C	MD	RET	140
Low-Heat and No-Heat Doors	E		C	MD	RET	141
Faucet Aerator (1.5 gpm) with Electric Water Heater	E		C		RET	147
Heat Pump Water Heater	E	G	C	MD		148
Pre-Rinse Sprayers (1.6 gpm) with Electric Water Heater	E		C		RET	149
Fast Acting Doors	E		C	MD	RET	150
Chiller Systems	E		C	MD		151
Chiller Tune-Up	E		C		RET	152
Computer Room Air Conditioner	E		C	MD		153
Com ECM Circulators, DHW	E		C	MD		154
Com ECM Circulators, HHW	E		C	MD		155
Com ECM Circulators, CW	E		C	MD		156
ECM Blower Motors	E		C		RET	157

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ECM Fan Motors	E		C	MD		158
Unitary Packaged HP System-Cool	E		C	MD		159
Unitary Packaged HP System-Heat	E		C	MD		160
PTHP-Cool	E		C	MD		161
PTHP-Heat	E		C	MD		162
High Volume Low Speed Fans	E	G	C	MD		163
Mini Split Ductless AC	E		C	MD	RET	164
Mini Split Ductless HP	E		C	MD	RET	165
Mini Split Ductless HP	E		C	MD	RET	166
Programmable Thermostats with Electric Heating	E		C	MD		167
Smart Thermostat with Electric Heating	E		C	MD		168
Unitary Packaged AC Systems	E		C	MD		169
Unitary Split AC Systems	E		C	MD		170
PTAC Systems	E		C	MD		171
Unitary Equipment Economizer	E		C		RET	172
Variable Speed Drive, Chilled Water Pump	E		C		RET	173
Variable Speed Drive, Heating Hot Water Pump	E		C		RET	174
Variable Speed Drive, Condenser Water Pump	E		C		RET	175
Variable Speed Drive, HVAC Fan	E		C		RET	176
Variable Speed Drive, Cooling Tower Fan	E		C		RET	177
Garage Exhaust Control	E	G	C		RET	178
Electric Oven and Range	E		C	MD		181
ENERGY STAR Electric Combination Oven	E		C	MD		182
ENERGY STAR Electric Convection Oven	E		C	MD		183
ENERGY STAR Electric Fryer	E		C	MD		184
ENERGY STAR Electric Griddle	E		C	MD		185
ENERGY STAR Electric Hot Food Holding Cabinet	E		C	MD		186
ENERGY STAR Electric Steamer	E		C	MD		187
ENERGY STAR Ice Machine	E		C	MD		188
Kitchen Demand Control Ventilation	E	G	C	MD	RET	189
Commercial ENERGY STAR Dishwasher with Gas Water Heating	E	G	C	MD		191
Commercial ENERGY STAR Dishwasher with Electric Water Heating -Appliance	E		C	MD		192
Commercial ENERGY STAR Dishwasher with Electric Water Heating -DHW	E		C	MD		193
ENERGY STAR Gas Combination Oven		G	C	MD		194
ENERGY STAR Gas Convection Oven		G	C	MD		195
ENERGY STAR Gas Fryer		G	C	MD		196
ENERGY STAR Gas Griddle		G	C	MD		197
ENERGY STAR Gas Steamer		G	C	MD		198
Gas Conveyor Oven		G	C	MD		199
Gas Oven, Broiler, Pasta Cooker	E	G	C	MD		200
Gas Rack Oven		G	C	MD		201
Demand Control Ventilation-Cool	E	G	C		RET	202
Demand Control Ventilation-Heat	E		C		RET	203

Appendix C: Measure Selection Methodology

Demand Control Ventilation-Vent	E		C		RET	204
Boiler Blowdown Controls		G	C		RET	205
Boiler Modifications, Space Heating Only		G	C		RET	206
Boilers		G	C	MD		207
Condensing Furnaces		G	C	MD	RET	208
Condensing Unit Heaters		G	C	MD		209
Destratification Fan		G	C	MD	RET	210
Energy Recovery Ventilator		G	C	MD	RET	211
Exhaust Energy Recovery	E	G	C		RET	212
Forced-Air Heating Maintenance		G	C		RET	213
Infrared Heater		G	C	MD		214
Programmable Thermostats with Gas Heating		G	C	MD		215
Smart Thermostat with Gas Heating		G	C	MD		216
Steam Trap		G		MD		217
Guest Room EM, PTAC, Elec Res-Cool	E		C		RET	218
Guest Room EM, PTAC, Elec Res-Heat	E		C		RET	219
Guest Room EM, PTHP-Cool	E		C		RET	220
Guest Room EM, PTHP-Heat	E		C		RET	221
Guest Room EM, Fan Coil	E	G	C		RET	222
Loading Dock Door and Pit Seals		G		C	MD	224
Faucet Aerator (1.5 gpm) with Gas Water Heater		G	C		RET	225
Gas Water Heater, Storage		G	C	MD		226
Pre-Rinse Sprayers (1.6 gpm) with Gas Water Heater		G	C		RET	227
Poultry Farm LED Lighting	E		C		RET	228
Dairy Farm Long Daylighting	E		C		RET	229
High Bay LED	E		C		RET	230
Screw-Based LED	E		C		RET	231
Ag Lighting Controls	E		C		RET	232
Engine Block Heater Timer	E		C		RET	233
Livestock Waterer	E		C		RET	234
High Efficiency Fan	E		C	MD		235
Milk Pre-Cooler	E		C		RET	236
VSD Milk Pump	E		C		RET	237
VSD for Vacuum Dairy Pump	E		C		RET	238
HP Water Heater	E		C	MD		241
High Efficiency Grain Dryer		G	C		RET	247
Instantaneous Water Heater		G	C	MD		249
Motors - Compressed Air	E		I		RET	256
Motors - Fans/Blowers	E		I		RET	257
Motors - Pumps	E		I		RET	258
Motors - Drives	E		I		RET	259
Gas Water Heater, Instantaneous		G	C	MD		306
Multifamily Common Area Clothes Washer with Electric Water Heating and Electric Drying - App	E		R	MD		309
Multifamily Common Area Clothes Washer with Electric Water Heating and Electric Drying - WH	E		R	MD		310

Multifamily Common Area Clothes Washer with Electric Water Heating and Gas Drying - App	E	G	R	MD		311
Multifamily Common Area Clothes Washer with Electric Water Heating and Gas Drying - WH	E		R	MD		312
Multifamily Common Area Clothes Washer with Gas Water Heating and Electric Drying	E	G	R	MD		313
Multifamily Common Area Clothes Washer with Gas Water Heating and Gas Drying - Appliance	E	G	R	MD		314
Multifamily Common Area Clothes Washer with Gas Water Heating and Gas Drying - Water Heating		G	R	MD		315
Wall Insulation Exterior Application - Cooling, Gas Heating	E		R		RET	320
Wall Insulation Interior Application - Cooling, Gas Heating	E		R		RET	321
Attic Insulation - Cooling, Gas Heating	E		R		RET	322
ENERGY STAR LED A-Line Lamp, Multifamily Common Area	E		R		RET	323
ENERGY STAR LED Globe Lamp, Multifamily Common Area	E		R		RET	324
ENERGY STAR LED PAR/Flood Lamp, Multifamily Common Area	E		R		RET	325
ENERGY STAR LED Downlight Fixture, Multifamily Common Area	E		R		RET	326
Air Source Heat Pump Tune-Up - Cool	E		R		RET	338
Air Source Heat Pump Tune-Up - Heat	E		R		RET	339
Air Source Heat Pump Recommissioning - Cool	E		R		RET	340
Air Source Heat Pump Recommissioning - Heat	E		R		RET	341
Variable Speed Drive/Custom, Other	E		C		RET	349
Attic Insulation - Heating, Electric Heating	E		R		RET	350
Attic Insulation - Cooling, Electric Heating	E		R		RET	351
Air Sealing, Electric Heating	E		R		RET	352
Wall Insulation Exterior Application - Heating, Electric Heating	E		R		RET	353
Wall Insulation Exterior Application - Cooling, Electric Heating	E		R		RET	354
Wall Insulation Interior Application - Heating, Electric Heating	E		R		RET	355
Wall Insulation Interior Application - Cooling, Electric Heating	E		R		RET	356

Table 3. Selected Measures Group 2. Measures from Other TRMs (13 Measures)

Measure Name	Electric	Gas	Sector	Market	Retrofit	Ref #
Demand Control Recirculation Pump	E	G	R		RET	70
Energy Star Refrigerated Beverage Vending Machine	E		C	MD		142
Reach-in Storage Freezers	E		C	MD		143

Scroll-type Refrigeration Compressor	E		C	MD		239
Refrigeration Heat Recovery	E		C		RET	240
Ventilation Fan VFD	E		C		RET	242
Heat Mat for Piglets	E		C		RET	243
Refrigeration Heat Recovery		G	C		RET	248
Retrofit duct sealing fan energy	E		C		RET	279
Retrofit duct sealing heating		G	C		RET	280
Retrofit duct sealing cool	E		C		RET	281
Pipe Insulation, Space Heat		G	R		RET	316
Reach-in Storage Refrigerator	E		C	MD	RET	318

Table 4. Selected Measures Group 3. Measures found in Minnesota Utility Programs, but not in the current Minnesota TRM (31 Measures)

Measure Name	Electric	Gas	Sector	Market	Retrofit	Ref #
LED Street Lighting	E		C		RET	124
Refrigeration Tune-Up	E		C		RET	146
Energy Management System -Cooling and Heating	E	G	C	MD	RET	179
Energy Management System -Ventilation	E		C	MD	RET	180
Space Cooling	E		I		RET	253
Process Heating	E		I		RET	254
Process Cooling/Refrigeration	E		I		RET	255
Other	E		I		RET	260
Lighting	E		I		RET	261
Process Efficiency Natural Gas		G	I		RET	262
Space Heating Natural Gas		G	I		RET	263
Other Natural Gas		G	I		RET	264
Data center waste heat recovery - heat	E	G	C	MD		288
Data center waste heat recovery - hot water	E	G	C	MD		289
Interior Delamping	E		C		RET	302
Exterior Lighting Controls	E		C		RET	303
Agriculture Compressed Air Improvements	E		C		RET	305
Pipe Insulation, DHW		G	R		RET	317
Walk-In Cooler Retrofit	E		C		RET	319
Improved Interior Lighting Design	E	G	C	MD		327
Improved Exterior Lighting Design	E		C	MD		328
Optimized unitary HVAC distribution/control system	E	G	C	MD		329
Optimized chiller distribution/control system	E		C	MD		330
High-eff built-up refrigeration	E	G	C	MD	RET	333
Commissioning -Elec	E		C	MD		334
Commissioning -Gas		G	C	MD		335
Integrated building design -Elec	E		C	MD		336
Integrated building design -Gas		G	C	MD		337
Strategic Energy Management, Year 1	E	G	I		RET	346
Strategic Energy Management, Year 2	E	G	I		RET	347

Strategic Energy Management, Year 3	E	G	I		RET	348
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Table 5. Selected Measures Group 4. Measures from Other Potential Studies (7 Measures)

Measure Name	Electric	Gas	Sector	Market	Retrofit	Ref #
High-efficiency small walk-in	E		C	MD		144
Low Energy Spray Application	E		C	MD		244
Irrigation Pressure Reduction	E		C		RET	245
VFD for Irrigation Pump	E		C		RET	246
Greenhouse Unit Heater		G	C		RET	250
Thermal Curtain (Single Layer)		G	C		RET	251
Double Polyethylene Film		G	C		RET	252

Table 6. Selected Measures Group 5. Measures from Research Projects and Emerging Technology Programs (17 Measures)

Measure Name	Electric	Gas	Sector	Market	Retrofit	Ref #
Heat pump water heater with CO2 refrigerant	E		R	MD		265
Natural gas absorption (NH3) heat pump water heater		G	R	MD		266
Natural gas absorption (NH3) heat pump Combi system for space and water heating		G	R	MD		267
Natural gas absorption (NH3) heat pump Combi system for space and water heating		G	R	MD		268
Through-wall condensing furnace/AC package	E	G	R	MD		276
Transport Membrane Humidifier	E	G	R		RET	278
Retrofit duct sealing high fan energy	E		C		RET	282
Retrofit duct sealing high heating		G	C		RET	283
Retrofit duct sealing high cooling energy	E		C		RET	284
Aerosol envelope sealing multifamily new construction		G	R	MD	RET	285
Aerosol envelope sealing single family new construction		G	R	MD	RET	286
Permanent magnet synchronous AC motor for evaporator fans	E		C	MD		287
Unitary packaged (RTU) tune-up - cooling electric	E		C		RET	300
Unitary packaged (RTU) advanced controls	E		C		RET	301
Deep Energy Retrofit - Electric	E		C		RET	331
Deep Energy Retrofit - Gas		G	C		RET	332
Condensing Rooftop Units		G	C	MD		357

Table 7. Selected Measures Group 6. Behavioral Measures (14 Measures)

Measure Name	Electric	Gas	Sector	Market	Retrofit	Ref #
Home Energy Reports Usage Quintile 2, Electric	E		R		RET	290
Home Energy Reports Usage Quintile 3, Electric	E		R		RET	291
Home Energy Reports Usage Quintile 2, Gas		G	R		RET	292

Home Energy Reports Usage Quintile 3, Gas		G	R		RET	293
Smartphone feedback app for electric	E		R		RET	294
Smartphone feedback app for gas		G	R		RET	295
Operational savings for buildings with automation systems	E		C		RET	296
Operational savings for buildings without automation systems	E		C		RET	297
Operational savings for buildings with automation systems		G	C		RET	298
Operational savings for buildings without automation systems		G	C		RET	299
Home Energy Reports Usage Quintile 4, Electric	E		R		RET	342
Home Energy Reports Usage Quintile 5, Electric	E		R		RET	343
Home Energy Reports Usage Quintile 4, Gas		G	R		RET	344
Home Energy Reports Usage Quintile 5, Gas		G	R		RET	345

The emerging technology measures that were incorporated into existing measures, most often as high savings variants (“High Savings”) are listed here. This was treated in the model by keeping the savings relative to the baseline for the technology (such as appliances and heat pumps) at a constant percentage. This allows for incremental improvements in both base and high efficiency versions of the measure, with the higher overall efficiency as the decade progresses. In addition, a number of emerging technologies that would be treated as “Custom” measures are included above in the Utility Program Measures as “Other” (Measure #260).

Table 8. Measures Incorporated into Existing Measures

Measure	Reason
Advanced Commercial Clothes Dryer Technologies	High Savings
Advanced motor systems (including pump, fan, and air compressor technology and system design)	High Savings
Data Center “data furnaces”	High Savings
Data center cooling - Liquid cooled heat sinks in servers	High Savings
Energy Efficient Clothes Dryers	High Savings
Energy recovery - heat pump	High Savings
High efficiency AC/DC converters (small appliance, chargers)	High Savings
High-efficiency clothes washers	High Savings
High-efficiency direct drive/BLDC appliance motors	High Savings
High-efficiency refrigerators	High Savings
Incremental improvements to conventional vapor compression cooling technologies (“Advanced RTU”); EERs continue to improve; improvements in part load performance	High Savings
Networked lighting and integrated systems	High Savings
Refrigeration economizing	High Savings
Energy efficiency Grain Drying and Field Irrigation	Custom
High Efficiency Ethanol Syrup Concentration	Custom
Optimizing energy savings from heat recovery chillers	Custom

Split System Economizer	Custom
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Measures Considered but Not Included

The following tables list the measures that were considered, but not included in the final model. Short reasons are given for excluding each measure such as:

- Included in an existing measure;
- Not applicable in MN (due to CIP rules, climate or building practices);
- Negligible savings in MN (due to low savings per implementation or low likelihood of implementation);
- Emerging technology without well-defined savings;
- Obsolete (primarily older lighting technologies, but also measures no longer applicable due to code changes);
- Demand response measure that does not save energy.

The measures are divided into groups corresponding to the selected measures above.

Table 9. Excluded Measures Group 1: Minnesota TRM Version 2.2.

Measure Name (page number refers to MN TRM Version 2.2)	Reason	Fuel
C/I - Building Operator Certification 482	Included in operator training	Both
Residential Load Management Technologies 317	Demand Response	Both
C/I Lighting - CFL Standard to Low Wattage Retrofit 74	Obsolete by 2020	E
C/I Lighting - High Pressure Sodium Retrofit 79		E
C/I Lighting - Mercury Vapor Retrofit 84		E
C/I Lighting - Metal Halide Retrofit 85		E
C/I Lighting - Pulse Start Metal Halide Retrofit 86		E
C/I Lighting - T12 8-Foot Retrofit 89		E
C/I Lighting - T12 Up to 4-Foot Retrofit 91		E
C/I Lighting - T8 Optimization 93		E
C/I Lighting - T8 Standard to Low Wattage Retrofit 88		E
Public - LED Traffic Signal 204		E
Residential Lighting - CFLs and ENERGY STAR Torchieres 272		E
Residential Lighting - ENERGY STAR CFL Fixtures 279		E

Table 10. Excluded Measures Group 2: Measures from Other TRMs

Measure	Reason
Agricultural Equipment	
Heat Lamp	Negligible savings in MN
Heat Reclaimer	Negligible savings in MN
Plate Cooler	Negligible savings in MN
Automatic Milker Takeoff	Negligible savings in MN

Greenhouse Heat Curtains	Negligible savings in MN
Industrial Equipment	
Industrial Blower	Included in other measures
Screw Compressor	Included in other measures
Compressed Air Dryer - Refrigerated	Included in other measures
Compressed Air Receiver	Included in other measures
Scroll Compressor	Included in other measures
Air Compressor - Controls	Included in other measures
Mist Eliminator Filter	Included in other measures
Compressed Air Controller	Included in other measures
Compressed Air Dryer - Controls	Included in other measures
Compressed Air - Intake	Included in other measures
Variable Displacement Compressor	Included in other measures
Process Liquid - Pump - General Purpose Motor	Included in other measures
Process Liquid - Temperature Reset Control	Included in other measures
Process Liquid - Pump - Variable Frequency Drive	Included in other measures
Barrel Insulating Wrap	Included in other measures
Pellet Dryer	Included in other measures
Industrial Laser System	Included in other measures
Snow & Ice Melting System	Included in other measures
Electric Tools	Included in other measures
Welder	Included in other measures
Injection Molding Machine	Included in other measures
Cooking Equipment	
Infrared Charbroiler	Negligible savings in MN
Infrared Salamander Broiler	Negligible savings in MN
Infrared Upright Broiler	Negligible savings in MN
Oven - Rotisserie	Included in other measures
Pasta Cooker	Included in other measures
Oven - Double	Included in other measures
Ozone Laundry	Considered in emerging tech
Servers & IT	
Energy Star Servers	Custom
Data Center Custom Measures	Custom
Building Envelope	
Low-Income Weatherization	Not CIP
Radiant Barriers	No savings in MN
Cool Roof	Custom
IR Film for Greenhouse	Negligible savings in MN
Window Film	No savings in MN
Window Shade	Behavioral
Window - Glazing	Included in other measures
Window Awnings	Behavioral
Weather stripping	Included in other measures
Shading & Vegetation	Behavioral
Solar Screen	Negligible savings in MN

Cooling	
Non-refrigerative Cooling	Negligible savings in MN
Residential Evaporative Cooler	Negligible savings in MN
Water Side Economizer	Included in other measures
Room Air Conditioner Recycling	Not CIP
Room Air Conditioner Retirement	Included in other measures
Variable Refrigerant Flow (VRF) Air Conditioner	Included in other measures
Centrifugal Water Chiller	Included in other measures
Reciprocating Water Chiller	Included in other measures
Screw Water Chiller	Included in other measures
Package Terminal Heat Pump	Included in other measures
Variable Refrigerant Heat Pump	Included in other measures
Water Source Heat Pump	Included in other measures
Dual Fuel Heat Pump	Not CIP
Single-Phase Package and Split System Unitary Equipment	Included in other measures
Three-Phase Package and Split System Unitary Equipment	Included in other measures
Refrigerant Charge Correction	Included in other measures
Geothermal Heat Exchanger	Included in other measures
Heating	
Direct Vent Furnace	Negligible savings in MN
Wood Stove	Not CIP
Furnace Whistle	Included in other measures
Furnace Tube Inserts	Included in other measures
Wood Pellet Boiler	Not CIP
Stack Economizer for Boilers	Included in other measures
Stack Economizer for Process Boilers	Included in other measures
High Turndown Burner for Space Heating Boilers	Included in other measures
Heating - Fuel Switching	Not CIP
HVAC Controls & Strategies	
Programmable Thermostat Adjustments	Included in other measures
Carbon Dioxide Sensor	Included in other measures
Outdoor Reset Control for Hydronic Boiler	Included in other measures
HVAC - Correct Sizing	Included in other measures
HVAC - Correct Refrigerant Charge	Included in other measures
Refrigeration Economizers	Included in other measures
Pump Optimization	Included in other measures
Boiler Controls for Space Heating	Included in other measures
Oxygen Trim Controls for Space Heating Boilers	Included in other measures
Shut Off Damper for Space Heating Boilers or Furnace	Included in other measures
Boiler Turbulators	Included in other measures
Ventilation Fan Control	Included in other measures
Air Filter Alarm	Included in other measures
Demand Control Recirculation Pump	Included in other measures
Evaporative Sub Cooling	Included in other measures
Carbon Monoxide Sensor	Included in other measures
Refrigeration	

Refrigeration - Door Gasket	Included in other measures
Refrigeration - Reach-In Storage	Included in other measures
Refrigeration - Strip Curtains	Included in other measures
Refrigeration - Vertical (multi-deck) Display Fi	Included in other measures
Refrigeration - Walk-in Cooler	Included in other measures
Refrigeration - Walk-in Door	Included in other measures
Refrigeration - Automatic Door Closer	Included in other measures
Refrigeration - Line Insulation	Included in other measures
Refrigeration – Compressor	Included in other measures
Refrigeration - Floating Head Pressure Controls	Included in other measures
Refrigeration - Tune Up	Included in other measures
Refrigeration – Condenser	Included in other measures
System Design & Interactions	Included in other measures
Refrigeration Savings due to Lighting Savings	Included in other measures
Ventilation & Air Handling	
HVAC Exhaust Fan - General Purpose Motor	Included in other measures
HVAC Ventilation Fan - General Purpose Motor	Included in other measures
Whole House Fan	Negligible savings in MN
Air Purifier	Not CIP
Notched V Belts for HVAC Systems	Included in other measures
Bathroom Exhaust Fan	Not CIP
Solar Attic Fan	Negligible savings in MN
Passive Mechanical Attic Ventilation	Negligible savings in MN
Desiccant Air Dryer	Negligible savings in MN
Plug Fan With Electronically Commutated Motor (E	Negligible savings in MN
Hand Dryer	Negligible savings in MN
Lighting	
Daylighting	Included in other measures
HID	Included in other measures
Induction - Lighting	Included in other measures
Signage Lighting	Included in other measures
Night Light	Included in other measures
Reduced Lighting Power Density	Included in other measures
Motors and Drives	
Synchronous Belt	Included in other measures
Voltage Controllers	Included in other measures
Motor Rewind	Included in other measures
Irrigation Pump	Included in other measures
Centrifugal Booster Pump	Included in other measures
Electrically Commutated	Included in other measures
Predictive Energy Optimization Software	Not CIP
Renewable Energy	Not CIP
Combined Heat & Power	Not CIP
Solar Photovoltaic (PV)	Not CIP
Fuel Economizer	Not CIP
Demand Controllers	Not CIP

Network Power Management	Not CIP
Metering & Monitoring	Not CIP
Submetering	Not CIP
Prepaid Metering	Not CIP
Uninterruptible Power Supplies	Included in other measures
Internal Power Supply	Included in other measures
Comprehensive Retrofit	Included in other measures
Site Whole-Building Improvements	Included in other measures
Appliances	
Appliance Recycling	Negligible savings in MN
Fuel Switching - Clothes Dryer	Not CIP
Water Cooler	Custom
Battery Charger	Negligible savings in MN
Services	
Residential Energy Audit	Behavioral
Building Operator Certification	Behavioral
Energy Code Compliance	Not CIP
Educational Services	Behavioral
Home Energy Report	Behavioral
Home Efficiency Kit	Included in other measures
Commercial Energy Report	Behavioral
Water End Uses	Not CIP
Pool Cover	Negligible savings in MN
Pool Heater	Not CIP
Water Fixtures	Not CIP
Irrigation System	Included in other measures
Solar Water Heaters	Not CIP
Fuel Switching - Water Heating	Not CIP
Water Heater Tune Up	Negligible savings in MN

Table 11. Excluded Measures Group 3: Emerging Technology Measures

Measure	Reason
Automated load control	DR
Grid integration and demand response	DR
Conservation voltage reduction	Electric Utility Infrastructure measure (EUI)
Virtual power plants	EUI
Acoustic Cooling	Not commercialized
ARPA-E BEET-IT: Advanced HVAC Technologies (17 project)	Not commercialized
ARPA-E DELTA Personal occupant comfort (11 projects)	Not commercialized
ARPA-E SHEILD: High efficiency single pane windows (13 projects)	Not commercialized
ARPA-E SWITCHES: High efficiency high-voltage power electronics (14 projects)	Not commercialized
Emerging: scotopic (spectrally enhanced) lighting; retrofit	Not commercialized

networked lighting controls, integrated daylighting systems	
High efficiency dehumidification	Not commercialized
High efficiency inverter AC systems	Not commercialized
Innovative Energy Saving Smart Coating Technologies	Not commercialized
Integrated heat pump (heat, cool, dhw)	Not commercialized
OLED Lighting	Not commercialized
Refrigeration storage - phase change (Viking Cold Solutions)	Not commercialized
Solid-state cooling	Not commercialized
Structured plumbing	Not commercialized
Thermostatic automatic flow restriction and Low-flow showerheads and faucet aerators.	Not commercialized
High R-Value Integrated Window System	Not yet cost effective
High-Efficiency Retrofit of Residential HVAC Blower Motors	Not yet cost effective
Residential economizing	Not yet cost effective
Energy Saving from Increased use of Recycled Feedstock in MN Manufacturing	Not CIP
ICT-enabled city planning and improvement	Not CIP
Real-time Modeling based Optimization of Drinking Water Utility Operations	Not CIP
Smart apartment buildings (IOTAS)	Not CIP
Smart cities - sensors, M&V, IoT, Big Data, SaaS, Open Data, augmented reality	Not CIP
Solar boosted heat pumps	Not CIP
Advanced metering infrastructure (smart meters)	Not energy savings on its own
Real-time EM&V - Lucid Building OS, Energy Savvy, EnerNOC	Not energy savings on its own
Sensors and submetering	Not energy savings on its own

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Xcel Workbook with Measure Inputs tool will be available a month after the release of this report and will be made available on the project website: www.mncee.org/mnpotentialstudy

Proposals submitted to the Minnesota Department of Commerce’s Commerce Applied Research and Development (CARD) program can be found at: <https://mn.gov/commerce/industries/energy/utilities/cip/applied-research-development/>

Technical Reference Manuals:

Amren Missouri Technical Reference Manual

Arkansas Technical Reference Manual

Connecticut Program Savings Document

Efficiency Maine Commercial Technical Reference Manual

Efficiency Vermont Technical Reference User Manual

Hawaii Energy Technical Reference Manual

Idaho Power Technical Reference Manual

Illinois Statewide Technical Reference Manual

Indiana Technical Reference Manual

Iowa Energy Efficiency Statewide Technical Reference Manual

Maine Technical Reference Manual

Massachusetts Technical Reference Manual

Michigan Technical Reference Manual

Missouri Statewide Technical Reference Manual

National Grid Technical Reference Manual

New Jersey Technical Reference Manual

New York Technical Reference Manual

Ohio Technical Reference Manual

Pennsylvania Technical Reference Manual

Rhode Island Technical Reference Manual

Savings Estimation Technical Reference Manual for the California Municipal Utilities Association

Technical Reference Manual for APS Energy Efficiency Programs

Tennessee Valley Authority Technical Reference Manual

Texas Technical Reference Manual

Wisconsin Focus on Energy Technical Reference Manual

Xcel Colorado Demand-Side Management Plan

Xcel Energy Technical Reference Manual