Guidehouse

Michigan Energy Waste Reduction Statewide Potential Study (2021-2040)

Prepared for:

LARA
MPSC

State of Michigan

Department of Licensing and Regulatory Affairs

Submitted by:

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Common Acronyms

ACEEE	American Council for an Energy Efficient Economy
ACS	American Community Survey
Btu	British Thermal Unit
C&I	Commercial and Industrial
CBECS	Commercial Building End Use Consumption Survey
CBSA	Commercial Building Stock Assessment
CFL	Compact Fluorescent
Com	Commercial
Consumers	Consumers Energy
COVID-19	Coronavirus 2019
DOE	United States Department of Energy
DR	Demand Response
DSM	Demand-Side Management
DSMore	Demand Side Management Option Risk Evaluator
DSMSim™	Guidehouse's Proprietary Demand Side Management Simulator
DTE	DTE Energy
EWR	Energy Waste Reduction
EIA	US Energy Information Administration
EWR	Energy Waste Reduction
FERC	Federal Energy Regulatory Commission
GWh	Gigawatt-Hour
HVAC	Heating, Ventilation, and Air Conditioning
I&M	Indiana Michigan Power
kWh	Kilowatt-Hour
LED	Light-Emitting Diode
MECS	Manufacturing Energy Consumption Survey
MEMD	Michigan Energy Measures Database
MGU	Michigan Gas Utilities
MISO	Midcontinent Independent System Operator
MPSC	Michigan Public Service Commission
MW	Megawatt
MWh	Megawatt-Hour
NEW	New Construction

NSP	Northern States Power
NPV	Net Present Value
NTG	Net-to-Gross
PJM	PJM Interconnection
PV	Present Value
RECS	Residential Energy Consumption Survey
Res	Residential
RET	Retrofit
ROB	Replace-on-Burnout
SEER	Seasonal Energy Efficiency Ratio
SEMCO	SEMCO Energy Gas Company
TRC	Total Resource Cost
TRM	Technical Reference Manual
TSD	Technical Support Document
UMERC	Upper Michigan Energy Resources Corporation
UPPCO	Upper Peninsula Power Company
US	United States
UCT	Utility Cost Test

Executive Summary

The Michigan Public Service Commission (MPSC) engaged Guidehouse Inc. (Guidehouse) to prepare a statewide energy waste reduction (EWR) potential study for electricity and natural gas in the Michigan Lower and Upper Peninsulas over a 20-year forecast horizon from 2021 to 2040. The study was conducted simultaneously with a study (reported separately) of active demand response (DR) potential for the same time period.

This study's objective was to assess the potential in the residential, commercial, and industrial sectors, with the addition of small commercial, multifamily and low-income segments, by analyzing EWR measures and improvements to end-user behaviors to reduce energy consumption. Measure and market characterization data was input into Guidehouse's Demand Side Management Simulator (DSMSim™) model, which calculates technical, economic, and achievable potential across utility service areas in Michigan for more than 600 measure permutations. Results were developed and are presented separately for the Lower and Upper Peninsulas. These results will be used to inform EWR goal setting and associated program design for the MPSC.

Three scenarios were modeled:

1. **Reference Scenario:** Estimates of achievable potential calibrated to 2021 program expectations and refined with 2019 actual achievements. Key assumptions include non-low income measure incentives of 40% of incremental cost (low income segments incentivized at 100% of incremental cost) and administrative costs representing 33% of total utility program spending.
2. **Aggressive Scenario:** Increased measure incentives and marketing factors and decreased program administrative costs.
    - Analyzed measure incentive levels to determine the 1.0 Utility Cost Test (UCT) ratio tipping point. Developed measure-level incentive estimates based on these results and adjusted where necessary to ensure program-level cost-effectiveness.
        - This adjustment models a more optimized incentive strategy that results in higher spending and reduced alignment with detailed calibration while maintaining a cost-effective program UCT ratio.
    - Increased marketing factors above calibrated values for specific end use and sector combinations.
        - This adjustment estimates an increase in marketing effectiveness and implementation of program design enhancements, while not increasing the relative administrative cost burden of programs.
3. **Carbon Price Scenario:** Acknowledging the regulatory uncertainty around carbon price legislation, provides a high-level fuel cost adder, ramping up through time as the probability of regulatory action increases.
    - Increased electricity ($/MWh) and natural gas ($/therm) avoided costs by 50% in 2021, escalating with a 2.5% multiplier growth until a 100% increase was met.

Estimation of Energy Waste Reduction Potential

Guidehouse employed its proprietary DSMSim model to estimate the technical, economic, and achievable potential for electricity and natural gas energy waste reduction and summer peak demand savings across Michigan. DSMSim is a bottom-up technology diffusion and stock tracking model implemented using a system dynamics[1] framework. The model explicitly accounts for different types of efficient measures, such as retrofit (RET), replace-on-burnout (ROB), and new construction (NEW), and the impacts these measures have on savings potential. The model then reports the technical, economic, and achievable potential savings in aggregate by sector, customer segment, end-use category, and highest impact measures.

Guidehouse developed potential and cost estimates using a bottom-up analysis. The analysis involved five steps:

1. Characterize the market
2. Develop baseline projections
3. Define and characterize EWR options
4. Develop key assumptions for potential and costs
5. Estimate potential and costs

This study defines **technical potential** as the energy savings that can be achieved assuming that all installed measures can immediately be replaced with the efficient measure, wherever technically feasible, regardless of the cost, market acceptance, or whether a measure has failed (or burned out) and is in need of being replaced.

Economic potential is a subset of technical potential, using the same assumptions regarding the immediate replacement as in technical potential, but limiting the calculation only to those measures that have passed the benefit-cost test chosen for measure screening—in this case, the UCT test as used in Michigan.

Achievable potential further considers the likely rate of demand-side management (DSM) resource acquisition given factors like the rate of equipment turnover (a function of a measure's lifetime), simulated incentive levels, consumer willingness to adopt efficient technologies, and the likely rate at which marketing activities can facilitate technology adoption. The adoption of DSM measures can be broken down into the calculation of the equilibrium market share and the calculation of the dynamic approach to equilibrium market share, as discussed in more detail in Section 7.1.

Achievable potential savings reported in this study are net rather than gross, meaning these values include the impacts of free ridership, spillover, and market effects attributable to DSM programs. Providing net potential is appropriate for MPSC's primary intended purposes for conducting this study—setting EWR goals and targets for Michigan utilities—because net savings is the definition used in Michigan.

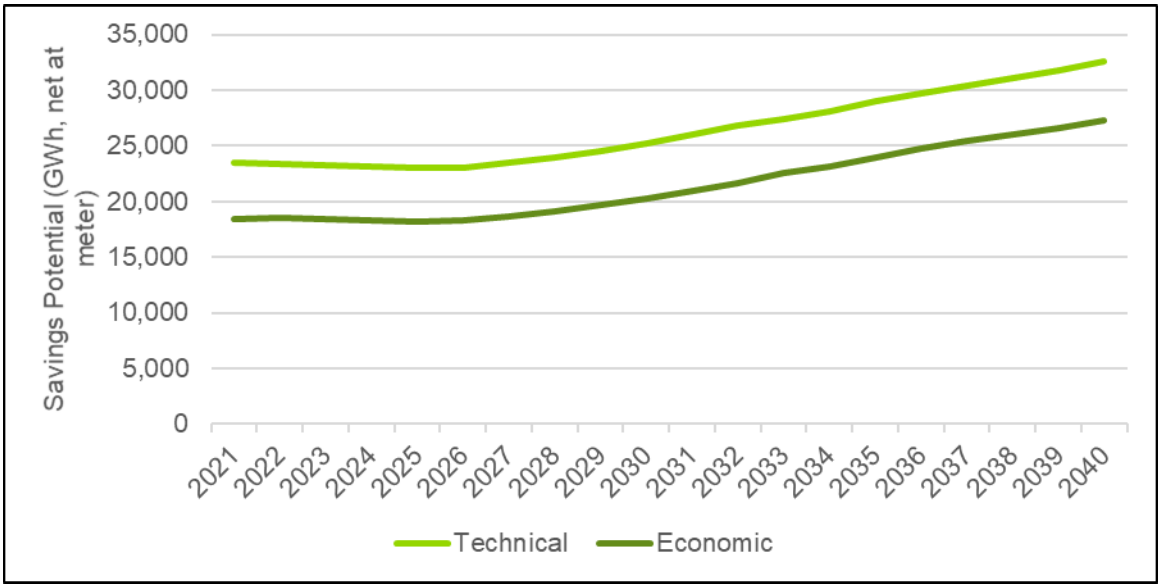
[1] See Sterman, John D. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin McGraw-Hill, 2000, for detail on system dynamics modeling. Also see http://en.wikipedia.org/wiki/System_dynamics for a high level overview.

Findings

EWR Potential Results

Figure ES-1 presents the net technical and economic electricity potential at the meter for utilities in Michigan's Lower Peninsula. Technical and economic potential remain relatively flat or slightly declining through 2026 due to minor year-over-year decreases in stock and sales forecasts throughout the early study years, and then steadily increase over the remaining period. In 2026, unidentified future emerging technologies begin to phase in, causing the increase in technical potential in later years, in addition to increased customer stocks over the study period. Economic potential is close to technical, indicating the prevalence of established measures (i.e., ones that have already passed cost-effectiveness screening and are included in the Michigan Energy Measures Database, or MEMD) and that most might impact measures pass the economic UCT threshold ratio of 1.0.

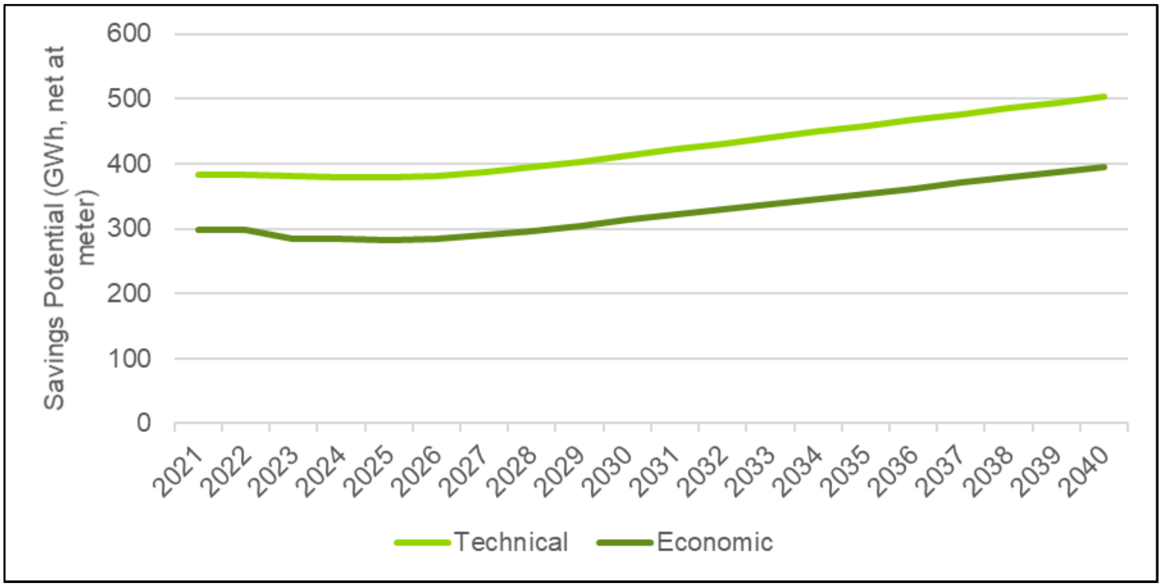
Figure ES-1. Lower Peninsula EWR Technical and Economic Potential Electricity Savings (GWh, Net at Meter)



Source: Guidehouse analysis

Figure ES-2 presents the net technical and economic electricity potential at the meter for utilities in Michigan's Upper Peninsula. Technical and economic potential remain relatively flat or slightly declining through 2026 due to minor year-over-year decreases in stock and sales throughout the early study years, and then steadily increase over the remaining period. In 2026, unidentified future emerging technologies begin to phase in, causing the increase in technical potential in later years. Economic potential is close to technical, indicating the prevalence of established measures (i.e., ones that have already passed cost-effectiveness screening and are included in the MEMD) and that most high impact measures pass the economic UCT threshold ratio of 1.0.

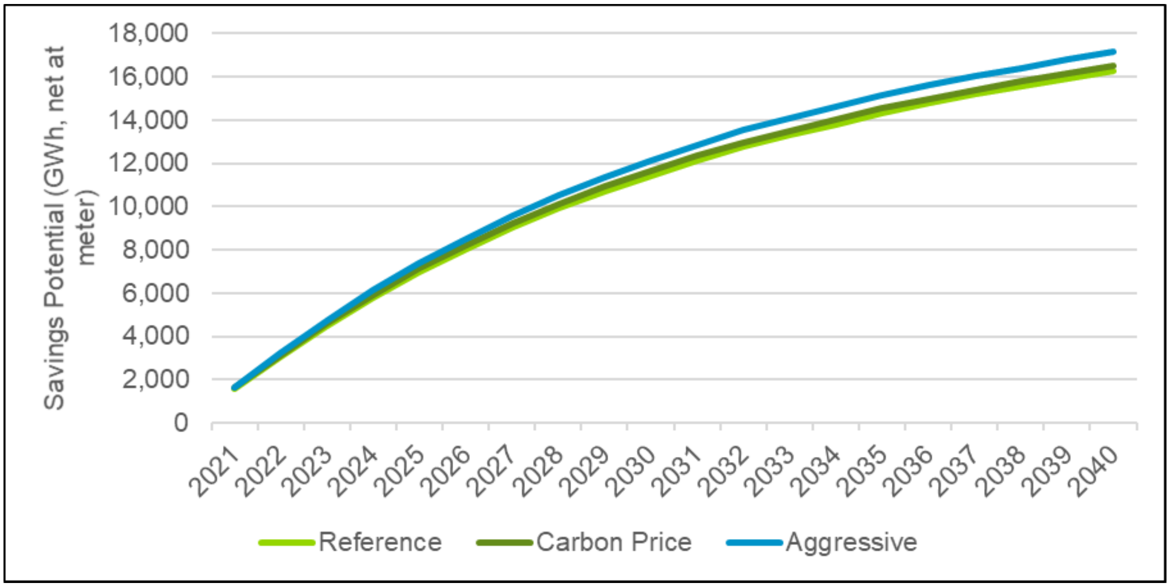
Figure ES-2. Upper Peninsula EWR Technical and Economic Potential Electricity Savings (GWh, Net at Meter)



Source: Guidehouse analysis

Figure ES-3 presents the cumulative annual net achievable electricity potential at the meter for utilities in Michigan's Lower Peninsula. The potential for all three scenarios (Reference, Aggressive, and Carbon Price) in 2021 is around 1,600 GWh net at meter, and increases to more than 16,000 GWh net at meter over the 20-year study period, with all three scenarios resulting in similar overall savings potential. In 2040, the Aggressive Scenario achieves about 5% more total savings compared to the Reference Scenario, indicating that utilities' current calibrated achievements are capturing a majority of the achievable incremental annual savings.

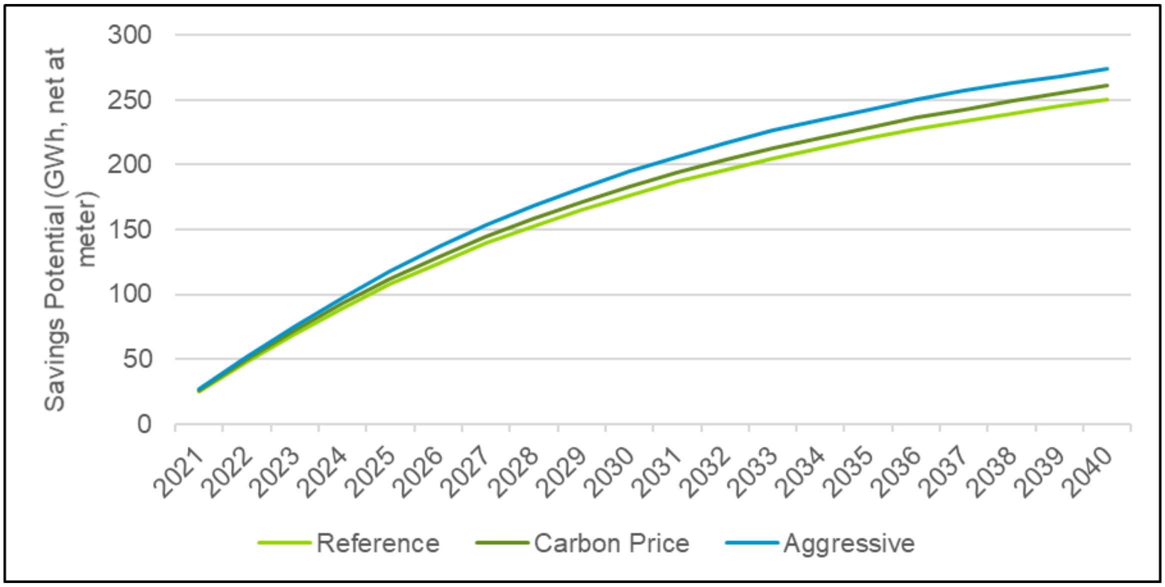
Figure ES-3. Lower Peninsula EWR Achievable Potential Electricity Cumulative Annual Savings by Scenario (GWh, Net at Meter)



Source: Guidehouse analysis

Figure ES-4 presents the cumulative annual net achievable electricity potential at the meter for utilities in Michigan's Upper Peninsula. The potential for all three scenarios (Reference, Aggressive, and Carbon Price) in 2021 is around 25 GWh net at meter and increases to at least 250 GWh net at meter over the 20-year study period, with all three scenarios resulting in similar overall savings potential. In 2040, the Aggressive Scenario achieves about 10% more total savings compared to the Reference Scenario, and twice the increase expected in the Lower Peninsula, indicating that the Upper Peninsula has generally lower efficient saturation of technologies in 2021.

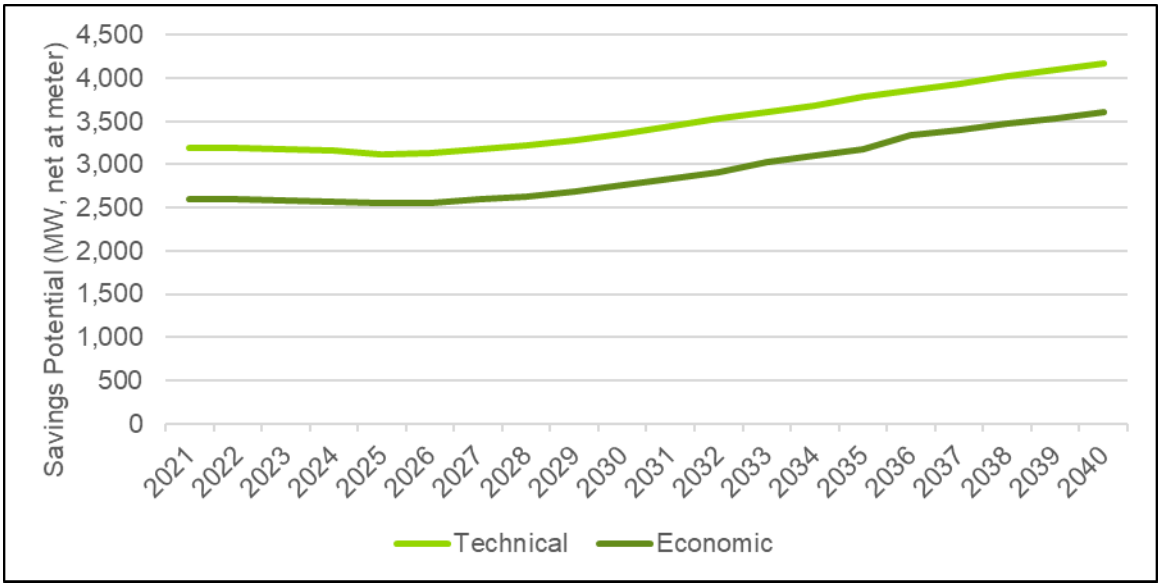
Figure ES-4. Upper Peninsula EWR Achievable Potential Electricity Cumulative Annual Savings by Scenario (GWh, Net at Meter)



Source: Guidehouse analysis

Figure ES-5 presents the net technical and economic summer peak demand potential at the meter for utilities in Michigan's Lower Peninsula. Technical and economic potential remain relatively flat through 2026, and then steadily increase over the remaining period. Similar to the electricity technical potential, the peak demand savings remains relatively flat until 2026, when unidentified future emerging technologies begin to phase in. The economic potential is around 80% of technical, indicating the prevalence of established measures (i.e., measures that have already passed cost-effectiveness screening and are included in the MEMD) and that most high impact measures pass the economic UCT threshold ratio of 1.0.

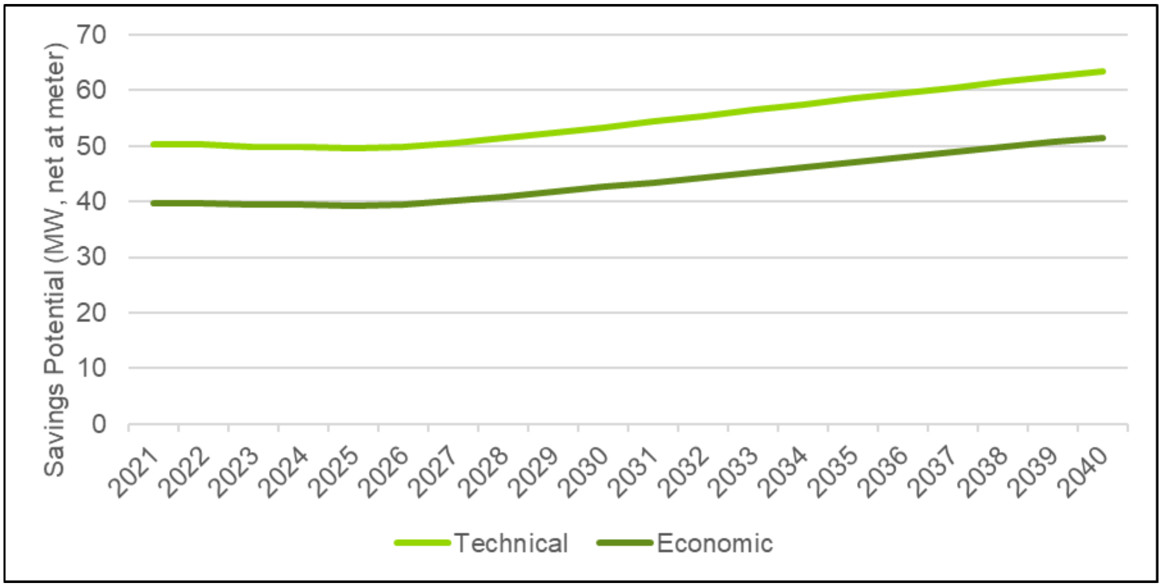
Figure ES-5. Lower Peninsula Technical and Economic Potential Summer Peak Demand Savings (MW, Net at Meter)



Source: Guidehouse analysis

Figure ES-6 presents the net technical and economic summer peak demand potential at the meter for utilities in Michigan's Upper Peninsula. Technical and economic potential remain relatively flat through 2006, and then steadily increase through the remaining period. Similar to the electricity technical potential, the peak demand savings remains relatively flat until 2026, when unidentified future emerging technologies begin to phase in. Economic potential is around 80% of technical, indicating the prevalence of established measures (i.e., measures that have already passed cost-effectiveness screening and are included in the MEMD) and that most high impact measures pass the economic UCT threshold ratio of 1.0.

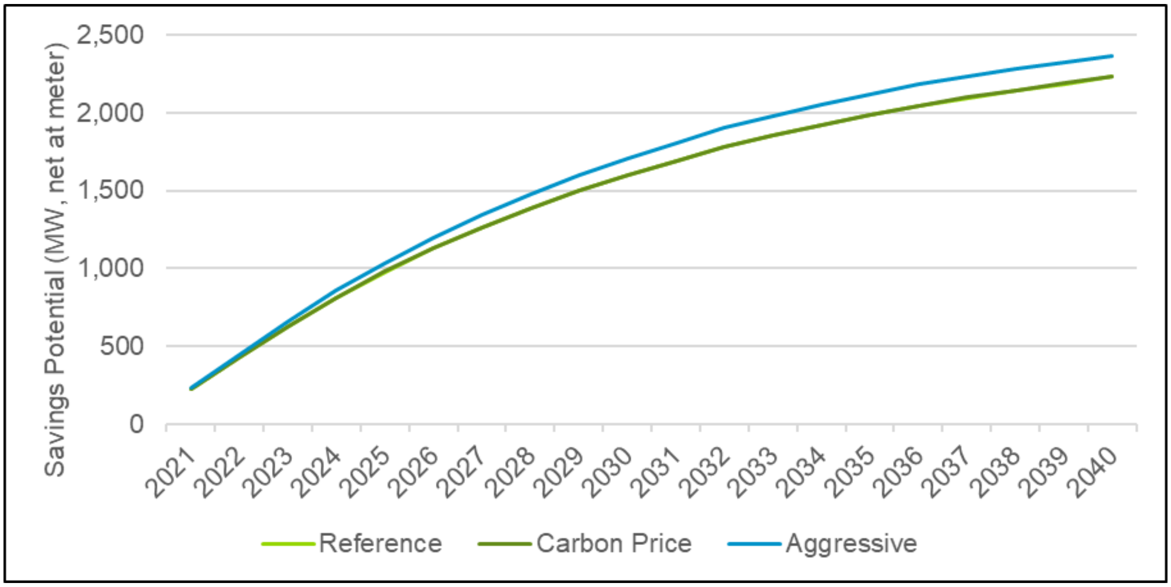
Figure ES-6. Upper Peninsula Technical and Economic Potential Summer Peak Demand Savings (MW, Net at Meter)



Source: Guidehouse analysis

Figure ES-7 presents the cumulative annual net achievable summer peak demand potential at the meter for utilities in Michigan's Lower Peninsula. The potential for all three scenarios (Reference, Aggressive, and Carbon Price) in 2021 is around 250 MW net at meter, and increases overall to around 2,300 GWh net at meter over the 20-year study period, with the Reference and Carbon Price Scenarios mirroring each other, indicating that achievable potential is not highly sensitive to increases in avoided costs. The Aggressive Scenario achieves about 6% greater cumulative savings in 2040 when compared to the Reference and Carbon Price Scenarios.

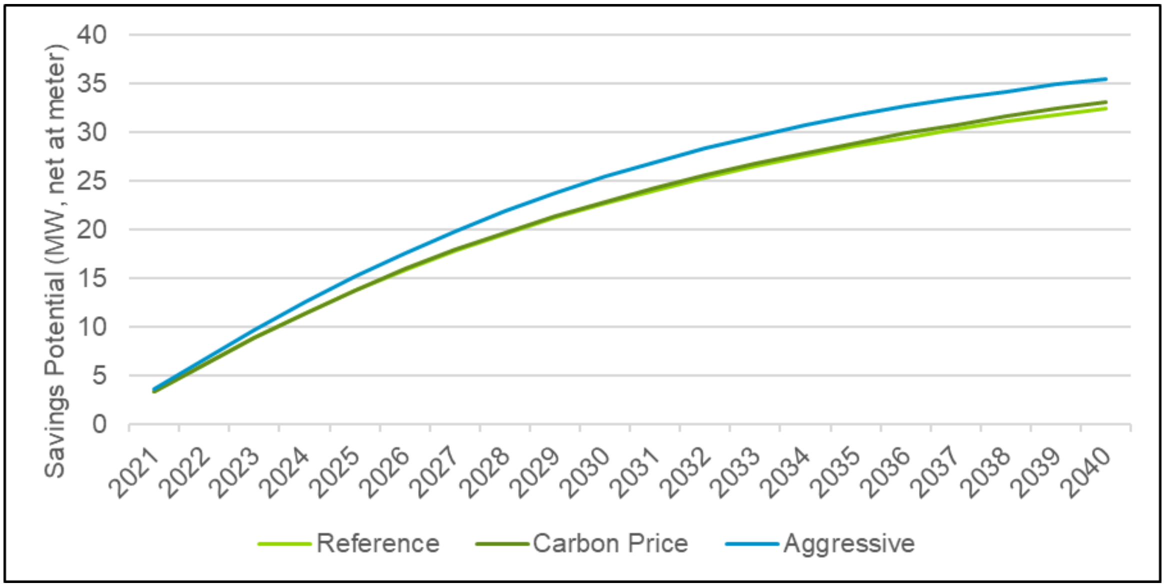
Figure ES-7. Lower Peninsula EWR Achievable Potential Summer Peak Demand Cumulative Annual Savings by Scenario (MW, Net at Meter)



Source: Guidehouse analysis

Figure ES-8 presents the cumulative annual net achievable summer peak demand potential at the meter for utilities in Michigan's Upper Peninsula. The potential for all three scenarios (Reference, Aggressive, and Carbon Price) in 2021 is around 4 MW net at meter and increases to around 34 MW net at meter over the 20-year study period, with the Reference and Carbon Price Scenarios mirroring each other, indicating that, similar to the Lower Peninsula, potential is not highly sensitive to increases in avoided costs. The Aggressive Scenario achieves about 10% greater cumulative savings in 2040 when compared to the Reference and Carbon Price Scenarios.

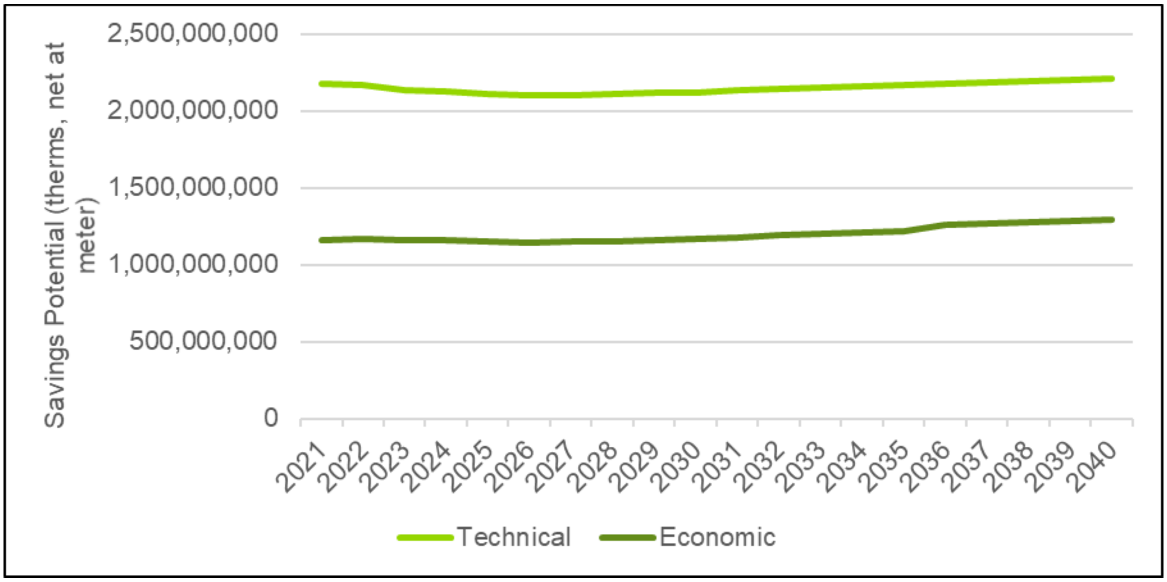
Figure ES-8. Upper Peninsula EWR Achievable Potential Summer Peak Demand Cumulative Annual Savings by Scenario (MW, Net at Meter)



Source: Guidehouse analysis

Figure ES-9 presents the net technical and economic natural gas potential at the meter for utilities in Michigan's Lower Peninsula. Technical and economic potential remain relatively flat throughout the 20-year study period, with slight decreases in early years due to stock forecasts. Compared to electricity, natural gas savings are less impacted by the unidentified future technology assumptions, increasing slightly after a small decrease in the initial years. Economic potential is about 50% of technical, indicating that fewer natural gas measures pass the economic UCT threshold ratio of 1.0, as compared to electricity measures.

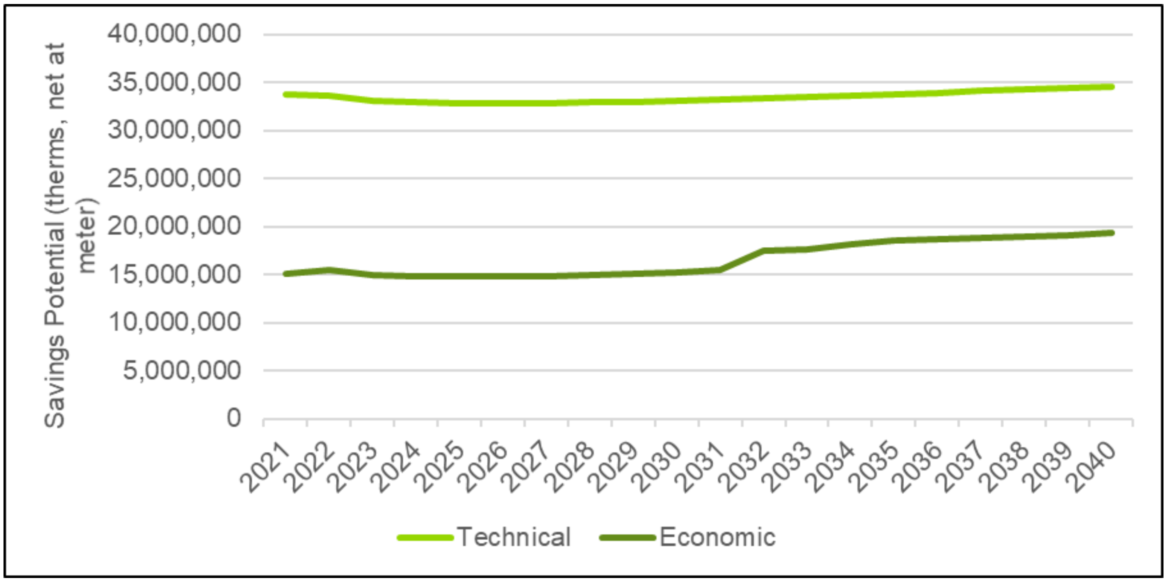
Figure ES-9. Lower Peninsula EWR Technical and Economic Potential Natural Gas Savings (therms, Net at Meter)



Source: Guidehouse analysis

Figure ES-10 presents the net technical and economic natural gas potential at the meter for utilities in Michigan's Lower Peninsula. Technical and economic potential remain relatively flat throughout the 20-year study period. Compared to electricity, natural gas savings are less impacted by the unidentified future technology assumptions, increasing slightly after a small decrease in the initial years. Economic potential is about 50% of technical, indicating that fewer measures pass the economic UCT threshold ratio of 1.0, as compared to electricity measures.

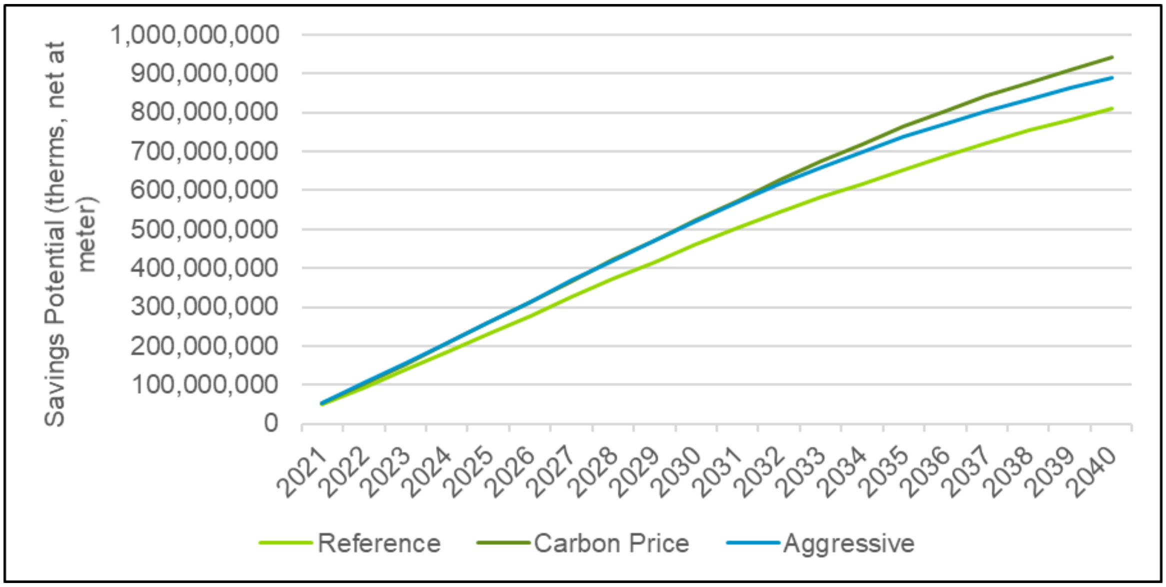
Figure ES-10. Upper Peninsula EWR Technical and Economic Potential Natural Gas Savings (therms, Net at Meter)



Source: Guidehouse analysis

Figure ES-11 presents the cumulative annual net achievable natural gas potential at the meter for utilities in Michigan's Lower Peninsula. The potential for all three scenarios (Reference, Aggressive, and Carbon Price) in 2021 is around 60 million therms net at meter, and increases overall to between 800 million to around 950 million therms net at meter over the 20-year study period. The Carbon Price Scenario shows the greatest increase relative to the Reference Scenario, indicating that the natural gas potential is more sensitive to avoided costs than incentive refinements. The Carbon Price Scenario achieves about 16% greater cumulative potential in 2040 compared to the Reference Scenario.

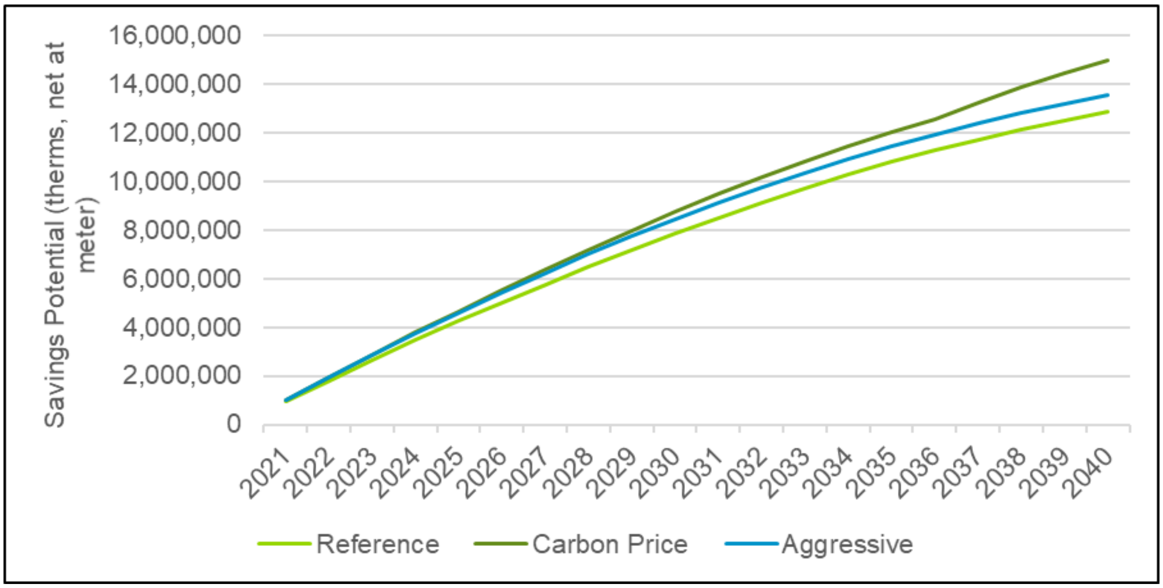
Figure ES-11. Lower Peninsula EWR Achievable Potential Natural Gas Cumulative Annual Savings by Scenario (therms, Net at Meter)



Source: Guidehouse analysis

Figure ES-12 presents the cumulative annual net achievable natural gas potential at the meter for utilities in Michigan's Upper Peninsula. The potential for all three scenarios (Reference, Aggressive, and Carbon Price) in 2021 is around 1 million therms net at meter, and increases overall to between 12.5 million to around 15 million therms net at meter over the 20-year study period. The Carbon Price Scenario shows the greatest increase relative to the Reference Scenario, indicating that the natural gas potential is more sensitive to avoided costs than incentive refinements. The Carbon Price Scenario achieves about 16% greater cumulative potential by 2040 compared to the Reference Scenario.

Figure ES-12. Upper Peninsula EWR Achievable Potential Natural Gas Cumulative Savings (therms, Net at Meter)



Source: Guidehouse analysis

Table ES-1, Table ES-2, Table ES-3, and Table ES-4 summarize the EWR potential for each of the three achievable potential scenarios (Reference, Carbon Price, and Aggressive) for each year of the analysis, and in total over the 20-year study period, in terms of electricity savings and natural gas savings, and percent of sales, for the Lower Peninsula and Upper Peninsula.

Table ES-1 shows the EWR achievable electricity potential for the Lower Peninsula starts around 1,600 GWh in 2021, and increases to between 16,290 to 17,160 GWh across the three scenarios (Reference, Carbon Price, and Aggressive). The achievable potential reaches more than 18% of sales over the 20-year study period, with more than half the increase in sales in the first six years, through 2026.

Table ES-1. Lower Peninsula Energy Waste Reduction Cumulative Achievable Electricity Potential and Percent of Sales by Scenario

Year	Reference		Carbon Price		Aggressive	
	GWh Savings Net at Meter	% of Sales	GWh Savings Net at Meter	% of Sales	GWh Savings Net at Meter	% of Sales
2021	1,580	1.9%	1,618	2.0%	1,659	2.0%
2022	3,059	3.7%	3,132	3.8%	3,221	3.9%
2023	4,481	5.4%	4,582	5.5%	4,724	5.7%
2024	5,805	7.0%	5,926	7.2%	6,123	7.4%
2025	6,992	8.6%	7,132	8.7%	7,382	9.0%
2026	8,069	9.9%	8,226	10.1%	8,529	10.5%
2027	9,061	11.1%	9,235	11.3%	9,588	11.7%
2028	9,930	12.2%	10,119	12.4%	10,517	12.9%
2029	10,719	13.1%	10,920	13.4%	11,360	13.9%
2030	11,435	14.0%	11,648	14.2%	12,124	14.8%
2031	12,115	14.6%	12,339	14.9%	12,851	15.5%
2032	12,755	15.2%	12,976	15.4%	13,521	16.1%
2033	13,302	15.7%	13,520	16.0%	14,090	16.7%
2034	13,798	16.3%	14,013	16.5%	14,603	17.2%
2035	14,323	16.6%	14,541	16.8%	15,153	17.5%
2036	14,783	17.0%	15,003	17.2%	15,626	18.0%
2037	15,183	17.4%	15,406	17.6%	16,036	18.4%
2038	15,563	17.7%	15,789	18.0%	16,422	18.7%
2039	15,920	18.1%	16,150	18.3%	16,783	19.1%
2040	16,292	18.4%	16,526	18.6%	17,158	19.3%

Source: Guidehouse analysis

Table ES-2 shows the EWR achievable electricity potential for the Upper Peninsula starts around 25 GWh in 2021, and increases to between 250 to 275 GWh across the three scenarios (Reference, Carbon Price, and Aggressive). The achievable potential reaches 18.9% or more of sales over the 20-year study period, with more than half the increase in sales in the first seven years, through 2027.

Table ES-2. Upper Peninsula Energy Waste Reduction Cumulative Achievable Electricity Potential and Percent of Sales by Scenario

Year	Reference Scenario		Carbon Price Scenario		Aggressive Scenario	
	GWh Savings Net at Meter	% of Sales	GWh Savings Net at Meter	% of Sales	GWh Savings Net at Meter	% of Sales
2021	25	1.9%	26	2.0%	27	2.0%
2022	48	3.6%	50	3.7%	52	3.9%
2023	69	5.2%	72	5.4%	75	5.6%
2024	89	6.7%	93	6.9%	98	7.3%
2025	108	8.0%	112	8.4%	118	8.8%
2026	124	9.3%	129	9.6%	136	10.2%
2027	139	10.4%	145	10.8%	153	11.5%
2028	153	11.4%	159	11.9%	168	12.6%
2029	165	12.4%	171	12.8%	182	13.6%
2030	176	13.2%	183	13.7%	195	14.6%
2031	187	14.0%	194	14.5%	206	15.4%
2032	196	14.7%	203	15.3%	217	16.2%
2033	205	15.4%	213	15.9%	226	17.0%
2034	213	16.0%	221	16.6%	235	17.6%
2035	220	16.5%	229	17.2%	243	18.2%
2036	227	17.1%	236	17.7%	250	18.8%
2037	233	17.6%	243	18.3%	257	19.3%
2038	239	18.0%	249	18.7%	263	19.8%
2039	245	18.4%	255	19.2%	268	20.2%
2040	250	18.9%	261	19.6%	273	20.6%

Source: Guidehouse analysis

Table ES-3 shows the EWR achievable natural gas potential for the Lower Peninsula starts around 50 million therms in 2021, and increases to between 810 to 891 million therms across the three scenarios (Reference, Carbon Price, and Aggressive). The achievable potential reaches more than 18% of sales over the 20-year study period, with more than half the increase in sales in the first six years, through 2026.

Table ES-3. Lower Peninsula Energy Waste Reduction Cumulative Achievable Natural Gas Potential and Percent of Sales by Scenario

Year	Reference Scenario		Carbon Price Scenario		Aggressive Scenario	
	Therm Savings Net at Meter	% of Sales	Therm Savings Net at Meter	% of Sales	Therm Savings Net at Meter	% of Sales
2021	48,793,613	1.1%	53,113,808	1.2%	54,294,476	1.2%
2022	93,736,869	2.1%	102,762,455	2.3%	104,909,575	2.3%
2023	139,212,470	3.1%	153,597,221	3.4%	156,591,614	3.5%
2024	185,807,356	4.1%	206,747,249	4.6%	209,407,362	4.6%
2025	231,948,693	5.2%	259,755,434	5.8%	261,873,170	5.8%
2026	278,433,475	6.2%	313,349,468	7.0%	314,659,442	7.0%
2027	325,337,432	7.2%	367,511,999	8.2%	367,730,235	8.2%
2028	371,264,279	8.2%	420,713,395	9.3%	419,869,566	9.3%
2029	416,433,025	9.2%	473,071,012	10.5%	471,119,201	10.5%
2030	460,243,136	10.2%	524,663,350	11.6%	520,753,533	11.5%
2031	503,011,379	11.1%	574,944,392	12.7%	569,159,596	12.6%
2032	543,839,031	12.0%	626,469,029	13.8%	615,368,915	13.6%
2033	581,759,351	12.8%	674,620,024	14.9%	658,227,382	14.5%
2034	617,328,198	13.6%	719,837,243	15.9%	698,321,002	15.4%
2035	651,610,769	14.3%	763,092,844	16.8%	736,872,788	16.2%
2036	687,876,422	15.1%	803,585,377	17.6%	772,176,813	16.9%
2037	721,602,397	15.8%	842,164,403	18.4%	804,827,249	17.6%
2038	753,143,903	16.5%	877,751,070	19.2%	835,168,158	18.3%
2039	782,557,261	17.1%	910,471,230	19.9%	863,415,025	18.8%
2040	810,328,389	17.6%	940,901,460	20.5%	890,171,294	19.4%

Source: Guidehouse analysis

Table ES-4 shows the EWR achievable natural gas potential for the Upper Peninsula starts around 1 million in 2021, and increases to between 12.9 to 14.9 million therms across the three scenarios (Reference, Carbon Price, and Aggressive). The achievable potential varies between 14.7% to 17.0% of sales over the 20-year study period with the Carbon Price Scenario higher indicating gas measures are more sensitive to increases in avoided costs than incentives, with more than half the increase in sales in the first eight years, through 2028.

Table ES-4. Upper Peninsula Energy Waste Reduction Cumulative Achievable Natural Gas Potential and Percent of Sales by Scenario

Year	Reference Scenario		Carbon Price Scenario		Aggressive Scenario	
	Therm Savings Net at Meter	% of Sales	Therm Savings Net at Meter	% of Sales	Therm Savings Net at Meter	% of Sales
2021	952,861	1.2%	1,024,805	1.3%	1,028,348	1.3%
2022	1,803,188	2.2%	1,953,465	2.4%	1,952,009	2.4%
2023	2,642,031	3.2%	2,875,322	3.5%	2,860,444	3.5%
2024	3,466,185	4.2%	3,787,084	4.6%	3,750,534	4.5%
2025	4,255,711	5.2%	4,667,352	5.7%	4,601,799	5.6%
2026	5,021,800	6.1%	5,525,577	6.7%	5,425,292	6.6%
2027	5,768,281	7.0%	6,363,740	7.7%	6,224,177	7.5%
2028	6,491,371	7.8%	7,176,218	8.6%	6,994,324	8.4%
2029	7,191,767	8.6%	7,973,219	9.5%	7,735,449	9.3%
2030	7,867,635	9.4%	8,740,743	10.4%	8,445,100	10.1%
2031	8,516,519	10.1%	9,475,233	11.2%	9,120,537	10.8%
2032	9,135,586	10.8%	10,173,115	12.0%	9,759,176	11.5%
2033	9,722,408	11.4%	10,831,580	12.7%	10,359,383	12.2%
2034	10,275,035	12.0%	11,448,596	13.4%	10,920,458	12.8%
2035	10,792,342	12.6%	12,023,212	14.0%	11,442,783	13.3%
2036	11,274,087	13.1%	12,555,552	14.6%	11,927,637	13.8%
2037	11,720,984	13.5%	13,220,765	15.3%	12,377,059	14.3%
2038	12,134,413	13.9%	13,861,091	15.9%	12,793,453	14.7%
2039	12,516,471	14.3%	14,436,022	16.5%	13,179,547	15.1%
2040	12,869,751	14.7%	14,947,018	17.0%	13,538,197	15.4%

Source: Guidehouse analysis

Conclusions

This EWR potential study has resulted in updated, expanded, and improved information on the Michigan customer base, and the potential for energy and demand reductions possible through EWR programs and initiatives by building upon previous studies, with the addition of natural gas potential and analysis of the Upper Peninsula. While much EWR potential remains, there are unique challenges in Michigan in realizing this potential over the 20-year study period. The potential study incorporates these real factors into the analysis by using primary research findings, Michigan baseline study data, and historical and expected program achievements, to estimate efficient measure and fuel type saturations, as well as calibration targets. The following are the key findings and takeaways from the potential analysis.

- **Near-term electricity and summer peak demand savings:** The top five electricity measures—consisting of commercial and industrial custom and lighting, residential LED bulbs, and residential home energy reports—represent approximately 50% of achievable savings in 2021 for both the Lower and Upper Peninsulas. This situation presents challenges for program administrators interested in maintaining a high rate of incremental annual savings. LED bulbs and industrial custom stocks saturate quickly in the study period due to aggressive early year calibration. Home energy reports do not, by definition, saturate in year-over-year contributions to potential; however, their 1-year lifetime and contribution limits as a percentage of total residential potential presents uncertainty around the longevity of this measure.

- **Near-term natural gas savings:** The top five measures for each peninsula comprise nearly 60% of the natural gas savings. The Upper Peninsula's top five measures—residential furnaces, commercial custom, residential boilers, home energy reports, and residential showerheads—consist mostly of residential savings due to the large share of residential load to overall natural gas load in the Upper Peninsula. The Lower Peninsula contains many of the same top measures—commercial custom, residential furnaces, and residential home energy reports—but because of the larger share of commercial load in the Lower Peninsula, two other commercial measures round out the remaining top five measures in the Lower Peninsula (commercial demand controlled ventilation, and commercial HVAC).

- **Long-term electricity and summer peak demand savings trends:** Incremental annual electricity potential decreases year-over-year over the 20-year study period, as some end uses, such as lighting in all sectors, begin to saturate. The calibration resulted in high lighting savings in the first few years of the study, but little overall total lighting potential remains due to existing high LED saturations identified from the primary data collection, causing the projected lighting savings to saturate quickly. Custom savings potential also deteriorates over time, and the market also saturates. The HVAC end uses show strong and steady increases year-over-year, which is a product of relatively low current participation and stock turnover limits.

- **Long-term natural gas savings:** Natural gas savings are much steadier over the study period than electricity savings. The top two end-use categories for both peninsulas are residential HVAC and commercial HVAC, which are limited by stock turnover and relatively low historical accomplishments, resulting in these categories ramping up more over time. Other end-use categories, such as residential water heating, begin to saturate, resulting in lower incremental savings potential years. However, the variance from the incremental savings potential in the early years (about 1% per year) compared to later years (about 0.7% per year) is much lower than the variance of electricity savings over time.

- **Cost test results:** All sectors achieve a UCT ratio of above 1.0 at the start of the study. However, as time progresses, the residential sector UCT drops below 1.0 for both electricity and natural gas residential program bundles. For residential electricity, this result is largely due to low cost lighting measures saturating in the market and being backfilled with more expensive technologies in later years. Additionally, low income segments receive 100% incentives and are inherently less cost-effective at the UCT level. As the highly cost-effective lighting programs diminish, these less cost-effective segments have much more of an impact on overall residential program bundle cost-effectiveness. This effect is true for residential natural gas programs as well, though it is a more muted effect because there is not a measure with an analogous impact to that of lighting. However, this result is observed in the natural gas programs when a low income furnace measure passes the UCT threshold of 0.8 in 2036 in the Lower Peninsula.

- **Scenario comparison:** There are modest differences in cumulative annual achievable potential in 2040 across the three scenarios. The Aggressive Scenario yields the highest electricity potential in the Lower and Upper Peninsulas, with an increase of around 5% and about 10%, respectively, as compared to the Reference Scenario. The Carbon Price Scenario results in an increase of around 16% in natural gas potential, outpacing the Aggressive Scenario for this fuel type. These results indicate the electricity potential is more sensitive to changes in incentives and spending, while natural gas potential is more sensitive to increases in avoided costs.

- **Sensitivity results:** Electricity potential exhibits a symmetrical and high sensitivity to net-to-gross (NTG) ratio and marketing effect variances, and a high negative impact from decreasing avoided costs, with a lower positive impact from increasing avoided costs. Natural gas potential shows a similar behavior to electricity, with the addition of a high positive impact from decreasing incremental costs. Changes to line loss factors, discount rates, and word of mouth effects have little impact on potential for each territory and fuel type.

1. Introduction

This section provides an overview of the potential study, including background and study goals, a discussion of the report's organization, and key caveats and limitations of the study. Guidehouse's modeling tools ensure the rigor, validity, and sensibility required of the demand-side management (DSM) potential study results. Our potential study models have been validated in numerous US states, and our DSM potential studies and models have been quoted by the American Council for an Energy Efficient Economy (ACEEE) as being "robust and transparent… [and] their methodology for forecasting participation is industry standard best-practice."[2]

As is typical in the development of such studies, Guidehouse worked collaboratively with the Michigan Public Service Commission (MPSC) and its stakeholders to ensure the study, to the fullest extent, reflects current Michigan market conditions. We received considerable guidance and feedback from MPSC staff, particularly in the development of global input assumptions, measure characterizations, and historical portfolio performance calibration. Guidehouse also carefully considered, and as appropriate, was responsive to stakeholders' input, incorporating their feedback into the analysis approach.

1.1 Context and Study Goals

MPSC retained Guidehouse to develop an estimate of the potential for electricity waste reduction (EWR) in Michigan during the 20-year timeframe covering the period 2021 to 2040. Concurrently, Guidehouse estimated the potential for active demand response (DR) for the same period; that potential is included in a separate report. We worked with MPSC to develop information on current levels and patterns of energy use in Michigan, characterize potential measures that could be implemented to increase EWR through DSM programs in the state, and develop estimates of EWR potential. The study data and analysis will be used to inform EWR program design for utilities in Michigan. Table 1-1 summarizes the various elements of the project scope.

Table 1-1. Summary of Project Scope

Element	Dimensions
Forms of Energy	Electricity, natural gas
Type of Potential	Energy waste reduction Technical, economic, achievable
Sectors	Residential, commercial, and industrial
Income	Residential: low income, non-low income
Characteristics	Multifamily, C&I small business
Climate	Single weather zone
Time Horizon	2021-2040 (20 years)

Source: Guidehouse analysis

[2] ACEEE, "Cracking the TEAPOT: Technical, Economic, and Achievable Energy Efficiency Potential Studies," August 2014.

1.2 Stakeholder Engagement and Interactive Review Process

The stakeholder engagement process and level of participation in Michigan was greater than what Guidehouse has seen in many other jurisdictions due to the number of affected utilities. We appreciate the thorough review and comments provided by stakeholders, and thank them for their feedback and participation in the process. Modifications related to feedback from the reviews were incorporated into this final report.

Three virtual stakeholder meetings were conducted using the Microsoft Teams platform. Each meeting provided an update of study progress and provided stakeholders the opportunity to ask questions. Guidehouse used a project-specific email address to receive study-specific feedback from stakeholders.

- **December 2, 2020:** The initial stakeholder meeting provided an overview of the potential study approach and summarized the project's status. The meeting also solicited stakeholder feedback on the EWR measure and DR option lists.
- **February 4, 2021:** The second stakeholder meeting provided a general project update. Guidehouse presented on, and solicited feedback to, the market characterization results, and provided an overview of stakeholder feedback from the draft customer survey instruments.
- **June 17, 2021:** The final stakeholder meeting included a presentation of the EWR and DR achievable potential study draft results and provided stakeholders an opportunity to provide feedback and request clarifications on the analysis and results. Questions and clarifications from the meeting were incorporated into this final report.

Key reviews occurred and stakeholder feedback was incorporated into the Research Plan, measure list, customer survey, global inputs/market characterization, and draft technical, economic, and achievable potential.

This study began in September 2020, and encompassed five phases. Each phase involved interactive engagement and review.

1. **Research Plan.** The Research Plan details how Guidehouse planned to gather and analyze project data and model the estimated potentials. The Research Plan summarized planned stakeholder engagement, our process for drafting and finalizing the reports, and included the project's planned schedule and assumptions.
2. **Measure List.** Guidehouse compiled a comprehensive measure list based on historical Michigan program data and an assortment of recent potential studies in comparable jurisdictions. A high level screen was applied based on savings potential (high, medium, low) and measure market maturity to develop a final list of 110 measures with the greatest savings potential or market opportunity. We developed savings assumptions, baseline measure characteristics, load shapes, and measure costs based on regionally appropriate program research. Measure savings not included in the top 110 were incorporated as uncharacterized potential (which was less than 10% of total potential).
3. **Customer Surveys.** Survey objectives included assessing customer program and measure awareness, willingness to pay, and effect of the COVID-19 pandemic to inform modeling. The surveys identified customer perspectives on EWR, barriers and recent energy use decisions, associated impacts on achievable potential, and customer

willingness to adopt joint EWR-DR technologies (e.g., smart thermostats, networked LEDs, smart water heaters).

4. **Market Characterization.** Several rounds of data requests and review were conducted from the applicable Michigan utilities to inform the market characterization. The information received through the data request was used as the preferred source for model inputs. However, secondary sources such as US Census Bureau (census) data and publicly available US Energy Information Administration (EIA) data were used to estimate statewide input values after utility data gaps were identified. Input values were adjusted throughout the study period as new data and resulting modifications to the modeling methodology became relevant.
5. **Draft Technical, Economic, and Achievable Results**. Guidehouse presented draft potential results to stakeholders on May 24, 2021, and incorporated their feedback to develop the final potential results.

1.3 Caveats and Limitations

Several caveats and limitations are associated with the results of this study, as detailed in the following sections.

1.3.1 Program Design

The results of this study provide the savings potential for the State of Michigan and provide insights into how this potential can be translated into program design in key areas. However, this potential study is not intended to provide, nor does it have information on, detailed program designs. Different program designs and delivery mechanisms would inevitably result in different levels of adoption of efficient technologies, which means the output of this study is an estimate of what can be achieved under the specific set of assumptions outlined in this study. Program design is typically a separate activity and is outside the scope of this study.

1.3.2 Measure Characterization

The scope of this study included primary data collection techniques and a variety of secondary data sources for estimates of measure savings, costs, and market presence (e.g., saturations and densities). Primary data specific to Michigan was used wherever possible. Where Michigan-specific data was not available, the best available data was used. This situation and approach did not limit Guidehouse's ability to achieve the study objectives and is consistent with the previous EWR potential study for Michigan and Guidehouse's experience in other jurisdictions.

Furthermore, we consider the measure list used in this study to appropriately focus on those technologies likely to have the highest impact on savings potential over the study horizon. However, unidentified emerging technologies may arise that could increase savings opportunities over the study period, and broader societal changes may affect levels of energy use in ways not anticipated in the study. Guidehouse included an estimate of unidentified future technology emergence for each sector and primary fuel type (electricity and natural gas) beginning in 2026 and accelerating through the study horizon. These estimates are high level, and are meant to represent the directional probability of unknown technology contributions to potential toward the end of the study period, and add uncertainty to later year estimates. This study does not make assumptions about future code and standard changes beyond those already planned for the study period.

Potential studies must make assumptions about the adoption of technologies and options that inevitably come with a degree of uncertainty. While techniques such as use of payback acceptance curves and technology diffusion models are considered to provide reasonable aggregate estimates of savings potential, such techniques (which must be applied to dozens or in some cases hundreds of measures) are limited in their ability to accurately predict the adoption for specific measures or in specific customer segments.

For EWR, model calibration steps (e.g., comparing projected results with past achieved results) seek to ground the analysis in the real world, but inaccuracies are bound to exist the further one drills into a technology or segment—even if the aggregate results are considered to be reasonable. One reason that aggregate results can, in many cases, be more reliable than individual technology or segment results is that the uncertainty of inputs at the measure level will exhibit a pooling effect when aggregated up to the portfolio (whereby positive or negative differences at a finer level of aggregation can help to offset each other in an aggregate result). While more in-depth technology adoption techniques do exist (e.g., discrete choice analysis) to improve the projection accuracy for any given technology, application of these techniques to the quantity of measures analyzed in studies such as this are not typically warranted, considering the dramatic increase in cost one would have to incur to calibrate a different adoption model for every single measure.

1.4 Interpreting Results

This report includes a high level account of savings potential results for MSPC in Michigan and focuses largely on aggregated forms of savings potential. EWR potentials are estimated at the finest level of granularity, which is at the measure level within each customer segment. The measure-level data is mapped to the various customer segments and end-use categories to permit a reviewer to easily create custom aggregations. Top measure achievable potential results in 2021 are available in the study appendices and in the results section of this report for the Reference Scenario. Inputs were gathered from utilities in Michigan and aggregated to the service territory level, Lower and Upper Peninsulas. Results were not developed at the utility level as part of this study.

1.5 Utilities

Guidehouse engaged utilities within the State of Michigan as part of this process. The utilities provided information on their utility EWR and DR programs, and provided Guidehouse with customer emails to allow us to collect information for modeling via surveys. We received data from the following utilities:

- Alpena Power Company (electric)
- Consumers Energy (gas and electric)
- DTE Energy (gas and electric)
- Indiana Michigan Power (I&M) (electric)
- Michigan Gas Utilities (MGU) (gas)
- Northern States Power (NSP) (gas and electric)
- SEMCO Energy Gas Company (gas and electric)

- Upper Michigan Energy Resources Corporation (UMERC) (gas and electric)
- Upper Peninsula Power Company (UPPCO) (electric)

Unless otherwise specified, all utilities will be referred to jointly in this report.

1.6 Report Organization

The report is organized as follows:

- Section 2 provides an overview of the **Global Data** developed and used in the study.
- Section 3 summarizes the **Primary Data Collection** conducted for the study, including the Michigan utility customer survey.
- Section 4 discusses the **Energy Waste Reduction Measure Characterization**, including key parameters.
- Section 5 presents the **Energy Waste Reduction Technical Potential Results** for energy waste reduction measures, including a summary of results by sector and end use. This is presented both for electricity and natural gas measures.
- Section 6 provides the **Energy Waste Reduction Economic Potential Results** for energy waste reduction measures, including a summary of results by sector and end use. This is presented for both electricity and natural gas measures.
- Section 7 presents the **Energy Waste Reduction Achievable Market Potential Approaches**, including discussion of equilibrium market share, behavioral measures, investment and incentive strategy, re-participation, and model calibration.
- Section 8 discusses the **Energy Waste Reduction Scenario Configuration Approach** for the Carbon Price and Aggressive Scenarios.
- Section 9 presents the **Energy Waste Reduction Achievable Potential Results** for energy waste reduction measures for electricity and natural gas, including a summary of results by sector, end use, customer segment, and measure, as well as cost-effectiveness tests and investment insights.
- Section 10 presents the **Conclusions** of the study.

The report also includes four appendices:

- Appendix A. Residential Survey Instrument
- Appendix B. Commercial & Industrial Survey Instrument
- Appendix C. Michigan 2021-2040 Potential Study Modeling Methodology
- Appendix D. Energy Waste Reduction Results File

2. Global Data

Guidehouse aggregated multiple data sources to simulate many elements of the market conditions in Michigan that help to define the potential for energy-saving technologies modeled in this study. These inputs are separated into technical potential inputs and economic potential inputs, as Table 2-1 shows.

Table 2-1. Global Inputs Elements

Technical Potential Global Inputs	Economic Potential Global Inputs
Electricity, peak demand, and natural gas consumption forecasts	Electricity, demand, and natural gas avoided costs
Residential household stock forecasts	Electric and gas retail rates
Commercial and industrial building stock forecasts	Electric and gas load shapes
End-use allocations	Line losses
Space and water heating fuel type multipliers	Discount rate, inflation rate, reserve margins

Source: Guidehouse

Many of the global inputs rely on segmentation by sector or subsector. This study includes three sectors: residential, commercial, and industrial. Per discussions with the MPSC, the residential sector is further segmented into the following sub-sector segments: single-family, single-family – low income, multifamily, and multifamily – low income. Commercial is split into large and small commercial segments based on consumption thresholds outlined in Section 2.1.1. Industrial is not segmented any further than the sector level.

To develop the technical and economic global inputs, Guidehouse prioritized data provided by Michigan utilities or the MPSC and primary data collected from surveys fielded for this study. In many cases, the data provided by a utility or the MPSC required augmentation with secondary data, such as:

- EIA Form 861 – Annual Electric Power Industry Report[3]
- Federal Energy Regulatory Commission (FERC) Form 1 – Electric Utility Annual Report[4]
- US Census Bureau – American Community Survey (ACS)[5]
- EIA's Residential Energy Consumption Survey (RECS)[6]
- EIA's Commercial Building End Use Consumption Survey (CBECS)[7]
- EIA's Manufacturing Energy Consumption Survey (MECS)[8]

The following sections outline the data sources used to develop each of the global inputs.

[3] https://www.eia.gov/electricity/data/eia861/
[4] https://www.ferc.gov/industries-data/electric/general-information/electric-industry-forms/form-1-electric-utility-annual
[5] https://data.census.gov/cedsci/
[6] https://www.eia.gov/consumption/residential/
[7] https://www.eia.gov/consumption/commercial/
[8] https://www.eia.gov/consumption/manufacturing/data/2014/

2.1 Technical Potential Global Inputs

2.1.1 Electricity and Peak Load Forecasts

Guidehouse used energy sales forecasts data provided by utilities and supplemented with MPSC filings for those utilities that did not provide data. Data granularity provided by the utilities varied, but allowed for disaggregation at the sector level. For utilities that did not provide sector-level data, the average proportion of sales by sector from other MI utilities was applied. In some cases, certain years of forecast or historical data were missing, and average compound annual growth rates (CAGRs) across years with submitted data were used to estimate sales for any missing years.

For the residential sector, census data and usage per home type from EIA's RECS[9] were used to determine the fraction of housing types (single-family vs. multifamily). Census data was also used to determine the percentage of income-eligible customers by segment (percentage of households below 200% of the federal poverty line).

To disaggregate commercial loads into small versus large commercial, Guidehouse leveraged DTE, Consumers, and UPPCO 2019 FERC Form 1 data, which reports customer counts and total annual energy sales by tariff. This data was used to calculate the average annual energy usage per customer for each tariff and classify it either as small commercial (<1,200 MWh/year) or large commercial (>1,200 MWh/year). The average segment sales proportion between DTE, Consumers, and UPPCO was applied statewide.

To determine peak load forecasts, Guidehouse applied peak factors to electricity sales forecasts based on the Michigan Energy Measures Database's (MEMD's) peak definition of 3 p.m. to 6 p.m. on the three consecutive hottest weekdays in July. Peak factors are developed based on 8,760 hourly data and 2019 sales from DTE (Lower Peninsula) and UMERC (Upper Peninsula). Data from these utilities provide the most comprehensive 8,760 hourly data in their region and comprise the largest share of the peak demand in their region. All residential segments use the same peak factor. Where additional granularity was available, different peak factors were developed for the commercial and industrial subsegments.

2.1.2 Natural Gas Forecasts

Gas sales were forecasted similarly to electricity sales using utility data, and data from MPSC filings, where needed. For utilities that did not distinguish between commercial and industrial sector sales, data from MPSC Annual Report Form P-522 was used for disaggregation. For SEMCO and DTE, which operate in both the Lower and Upper Peninsulas, Guidehouse allocated 97.5% of sales to the Lower Peninsula and 2.5% of the sales to the Upper Peninsula.

Like the electricity sales forecasts, census data and usage per home type from EIA's RECS were used to determine the fraction of housing types (single-family vs. multifamily) for the residential sector. Census data was also used to determine the percentage of income-eligible customers (percentage of households below 200% of the federal poverty line). For the commercial sector, Guidehouse used the same share of large versus small commercial as the

[9] https://www.eia.gov/consumption/residential/index.php

electricity load because there was not an analogous way to disaggregate gas sales in the data provided.

2.1.3 Residential Housing Stock Forecasts

The total number of residential households was primarily developed using utility customer count databases and supplemented by publicly available FERC and EIA form data. However, this customer tracking data lacked the granularity to develop customer segment level estimates. Therefore, census data was used to determine the fraction of housing types (single-family vs. multifamily) and percentage of income eligible customers (below 200% of federal poverty line). Residential demolition rates are set to a standard 0.05% per year, which indicates an expected 200-year full building stock turnover. Demolished stock is available for new construction installation in the next modeled year.

2.1.4 Commercial and Industrial Building Stock Forecasts

Commercial building stocks are expressed in thousands of square feet, and industrial stocks are expressed as annual load. Therefore, industrial stocks are already complete from the sales forecasts outlined previously. For commercial buildings, utility data received through the data request process lacked enough information to develop complete square footage stock forecasts. Therefore, average building energy use intensities (EUIs) were sourced from EIA's CBECS data and applied to the sales forecast to estimate total building square footage. As noted previously, commercial sales disaggregation to the segment level leveraged DTE, Consumers, and UPPCO 2019 FERC Form 1 data, which gives customer counts and total annual energy sales by tariff. Commercial demolition rates are set to a standard 0.05% per year, which indicates an expected 200-year full building stock turnover. Demolished stock is available for new construction installation in the next modeled year. Industrial demolition rates are set to a standard 0.00%.

2.1.5 End-Use Allocations

End-use allocations were used solely for quality control purposes in this model. End-use breakout data received by utilities was high level and limited. DTE provided detailed breakouts for the residential sector, and Consumers provided some distributions for the main end uses such as heating. Because of the sparsely received end-use allocation data, national survey data from EIA's RECS, CBECS, and MECS was used as the basis to derive the end-use allocations estimate for the residential, commercial, and industrial sectors, respectively. Whenever possible, regional numbers were used to approximate Michigan-specific values. End-use allocations from EIA were compared to utility-provided data and were deemed appropriate for use at the statewide level.

2.1.6 Space and Water Heating Fuel Type Multipliers

Space heating and water heating electricity and gas fuel splits are critical global inputs that parse out the total building stocks to applicable fuel types. This approach ensures that measures that are only applicable to one fuel type for space and water heating are applied only to the proper subset of building stocks. In this model, these inputs are essential for residential building stocks, but not for commercial and industrial, which weight measure-level density data to account for fuel shares.

Residential fuel type multipliers were developed from the primary data collection and census data. The primary data collection was initially used as the primary data source for each customer segment in the residential sector. However, upon stakeholder review, Guidehouse updated the primary data source to census data because multifamily electric heat saturation was skewed low compared to other sources. 2019 census data was used to develop average fuel type multipliers for single-family and multifamily, and primary data collected was used to estimate the fuel share difference between low income and non-low income stocks.

2.2 Economic Potential Global Inputs

Economic global inputs were either provided directly by the utility during the data request or derived from utility-provided DSMore[10] benefit-cost calculators. These inputs are required in the model to estimate the Utility Cost Test (UCT) for each measure and subsequent inclusion into economic potential if the measure passes the UCT. Guidehouse received data from all utilities but Alpena and MGU. We analyzed the received data into separate economic inputs for the Lower and Upper Peninsulas, weighted based on each utility's load in that territory.

2.2.1 Electricity Avoided Costs

DTE and I&M provided electricity avoided cost data through the data request. Guidehouse also received DSMore input data from NSP, UPPCO, and Consumers to supplement the electricity avoided costs already provided. We used the data from DTE, I&M, and the DSMore files to analyze this data for load shape periods common across available avoided cost information (on vs. off peak).

2.2.2 Electricity Peak Demand Avoided Costs

Electricity peak demand avoided costs include $/kW avoided for generation, transmission and distribution, and ancillary costs. DTE and I&M provided electricity demand avoided cost data during the data request. Guidehouse also received DSMore input data from NSP, UPPCO, and Consumers to supplement the electricity demand avoided costs already provided. DTE and I&M provided capacity avoided costs as a forecast, while the DSMore data files had predefined escalators to apply to the first-year avoided capacity and transmission and distribution values. We used the data from DTE, I&M, and the DSMore files to analyze this data for load shape periods common across available avoided cost information (on vs. off peak).

2.2.3 Natural Gas Avoided Costs

DTE provided gas avoided cost data during the data request. Guidehouse also received DSMore input data from NSP and Consumers to supplement the gas energy avoided costs already provided from DTE. This data was not provided for different load shape periods; therefore, Guidehouse summarized this data to create one gas avoided cost stream for both the Lower and Upper Peninsulas, weighted by gas sales in each region.

[10] Demand Side Management Option Risk Evaluator, Integral Analytics, https://iawpwebappp01.azurewebsites.net/index.php/dsmore-2/

2.2.4 Electricity and Gas Retail Rates

Electricity and gas retail rates were not provided by utilities during the data request, and the DSMore data provided limited detail on rates. Guidehouse used data on the MPSC website[11] [12] for residential, commercial, and industrial electricity and gas retail rates. These rates were weighted by sales within the Lower and Upper Peninsulas to create weighted rates specific to each region.

2.2.5 Electricity and Gas Load Shapes

DTE and I&M provided electricity load shapes during the data request. DTE provided a suite of 8,760 load shapes for all sectors and many end uses. I&M's load shapes are only for major end uses, such as heating, cooling, and lighting. Guidehouse also requested DSMore input data for each utility from its most recent DSM program evaluation to supplement currently obtained economic inputs. Load shapes are embedded into the DSMore model, which are identified in the input page, but are not extractable with the data provided. However, the load shapes identified in the utility input tabs of the DSMore files provided mostly identified DTE load shapes as the source for analysis.

Based on this information, Guidehouse used DTE load shapes as the base for this analysis, weighting in I&M load shapes where available. Load shapes were analyzed as the percentage of annual load that is during on-peak and off-peak market price hours for each end use. We used PJM and Midcontinent Independent System Operator's (MISO's) definition of on versus off peak market prices, defined as follows: on-peak is a period of time when consumers typically use more electricity - normally on weekdays, when many businesses are operating. PJM considers weekdays from 7 a.m. to 11 p.m. on peak, except for the following holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day.[13]

No gas load shapes were provided during the data request.

2.2.6 Line Losses

Alpena, Consumers, MGU, and DTE provided line loss assumptions or a line loss study. DTE and Consumers provided detailed line loss studies with average and marginal loss options. Guidehouse derived line loss assumptions for NSP, I&M, UPPCO, UMERC, and SEMCO from the DSMore data each of those utilities provided. The DSMore data is much less granular than the line loss studies provided, with only one line loss apparently applied to all sectors; the line losses appear to be averages and not marginal. To remain consistent between data sources, we used the average line losses from the DTE and Consumers line loss studies and weighted the losses by utility sales data for the Lower and Upper Peninsulas.

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[11] Comparison of Average Electric Rates for MPSC-Regulated Electric Utilities in Michigan – February 1, 2021: https://www.michigan.gov/documents/mpsc/rates1_594951_7.pdf

[12] Gas Cost Recovery Factors - February 1, 2021: https://www.michigan.gov/documents/mpsc/gasrates_592543_7.pdf

[13] https://www.pjm.com/Glossary

2.2.7 Discount Rate, Inflation Rate, and Reserve Margins

2.2.7.1 Discount Rates

I&M, DTE, and MGU provided discount rates during the data request. Guidehouse was able to summarize discount rates from DSMore input files for Consumers, NSP, and SEMCO by different cost test types (UCT, Total Resource Cost [TRC], Societal, etc.). We summarized this data across the Lower and Upper Peninsulas, weight based on utility sales as a percentage of total in each region, which resulted in discount rates by cost test for the Lower and Upper Peninsulas.

2.2.7.2 Reserve Margin

I&M and DTE provided reserve margins during the data request. I&M's reserve margins are for PJM, and DTE's reserve margins are for MISO. Upon review of the PJM and MISO territory for Michigan, I&M is a part of PJM and the rest of the state is under MISO. Therefore, Guidehouse applied the MISO reserve margins to all the other utilities and created a weighted average statewide reserve margin.

2.2.7.3 Inflation

UMERC, Consumers, I&M, MGU, and DTE provided inflation rates data during the data request. We summarized this data across utilities and weighted the values based on utility sales as a percentage of total to approximate statewide inputs. Inflation rates were not available in the utility DSMore data.

3. Primary Data Collection

Guidehouse conducted online surveys of Michigan's electricity and gas utility end-use customers to collect primary data that supplemented secondary sources to develop market acceptance and adoption forecasts. Through the primary data collection process, we emphasized the collection of Michigan-specific data to improve the quality of the potential modeling and address data gaps that were not already available through recent studies.

As discussed in the following sections, primary data collection included two online surveys: a residential survey and a C&I survey. Each survey was used to collect data to inform both the EWR and DR potential analyses.

3.1 Approach to Primary Data Collection

The surveys' primary objective was to collect information on customer awareness of and willingness to pay for EWR measures, and awareness and willingness to participate in DR programs. Guidehouse also included a limited number of measure baseline and saturation questions to supplement data from other studies and further inform the potential study.

Guidehouse also collected customer feedback in the surveys to support achievable potential model calibration related to:

- Impacts of the COVID-19 pandemic on customer decision-making around energy efficiency upgrades.
- Motivating factors driving customer decision-making about energy-consuming equipment in their home or business.
- Major barriers to customers taking action on the ways they consume energy in their home or business, including installation of energy efficient equipment.

All survey respondents were recruited through email solicitations, sourced from utility tracking data. Customers were offered an incentive through Tango to encourage participation; Tango allows customers to select an e-gift card from a participating retailer or restaurant (including Amazon.com, CVS, Dunkin' Donuts, etc.) or an online debit card (Visa or MasterCard), as Table 3-1 shows.

Table 3-1. Customer Incentive Details

Survey/Customer Type	Customer Incentive
Residential	$15
C&I	$25

Source: Guidehouse 2021

The survey instruments and recruitment methodologies are detailed in the following sections: survey instruments are included in Appendix A (residential) and Appendix B (C&I).

3.2 Residential Survey Response Summary

Residential customer responses are tabulated by region (Lower Peninsula and Upper Peninsula), customer income level (low income and non-low income), and residence type (single-family and multifamily). Table 3-2 shows the stratification for residential customers and the number of completed surveys in each stratum.

Table 3-2. Stratification of Residential Customer Surveys

Segment (Region-Residence Type-Income Level)	Completed Surveys
Lower-Multifamily-Low Income	36
Lower-Multifamily-Non-Low Income	34
Lower-Multifamily-Unknown	11
Lower-Single-Family-Low Income	48
Lower-Single-Family-Non-Low Income	170
Lower-Single-Family-Unknown	70
Lower-Unknown-Unknown	1
Upper-Multifamily-Low Income	13
Upper-Multifamily-Non-Low Income	5
Upper-Multifamily-Unknown	2
Upper-Single-Family-Low Income	64
Upper-Single-Family-Non-Low Income	99
Total Residential Surveys	**591**

Source: Guidehouse 2021

3.3 C&I Survey Response Summary

C&I customer responses are tabulated by region (Lower Peninsula and Upper Peninsula), customer size[14] (small and large), and business type[15] (commercial or industrial). Table 3-3 shows the stratification for C&I customers and the number of completed surveys in each stratum.

[14] Large customers are defined as those customers who indicated their combined gas and electricity bills were more than $65,000 per year. Small customers are defined as those customers who indicated their combined gas and electricity bills were less than $65,000 per year.

[15] Customer business type was determined based on customer responses to a survey question.

Table 3-3. Stratification of Completed C&I Customer Surveys

Segment (Region-Customer Size-Business Type)	Completed Surveys
Lower-Large-Commercial	45
Lower-Large-Industrial	9
Lower-Large-Unknown	2
Lower-Small-Commercial	261
Lower-Small-Industrial	32
Lower-Small-Unknown	49
Upper-Large-Commercial	5
Upper-Large-Unknown	1
Upper-Small-Commercial	51
Upper-Small-Industrial	3
Upper-Small-Unknown	12
Total C&I Surveys	**470**

Source: Guidehouse 2021

To maximize online survey responses from large C&I customers and in the absence of a utility data flag to sample around customer size, Guidehouse implemented a small C&I customer quota of 400 in the online survey. This means that after receiving 400 small C&I completes, the survey remained open only for large customers. Upon closing the survey, Guidehouse received 408 small C&I completes and 62 large C&I completes.

3.4 Survey Methodology and Results

This section details the methodology for the primary research objectives of the survey for which responses were used as direct model inputs and briefly discusses the results.

3.4.1 EWR Awareness

To assess customer awareness of EWR measures, respondents were asked whether they are familiar with a sample of two measures. One was a higher cost measure (e.g., insulation, boiler) and one was a lower cost measure (e.g., a light bulb, thermostat). The two measures were randomly selected from a set of representative measures to provide context across an array of measure types. Table 3-4 and Table 3-5 show high cost and low cost measure awareness for the residential and C&I sectors.

Table 3-4. Residential EWR Awareness

Measure Type	% Customers Aware (n=591)
Low Cost EWR Measure	70%
High Cost EWR Measure	57%

Source: Guidehouse 2021

Table 3-5. C&I EWR Awareness

Measure Type	% Customers Aware (n=470)
Low Cost EWR Measure	51%
High Cost EWR Measure	57%

Source: Guidehouse 2021

An awareness index is calculated for each respondent at the high and low cost measure level. The combined awareness index was applied to measures with similar cost and decision-making influencers in the EWR potential model.

3.4.2 EWR Willingness to Pay

Respondents were asked two sets of questions to assess customer willingness to pay for EWR measures: one from a set of low cost measures (e.g., a light bulb, thermostat) and one from a set of high cost measures (e.g., insulation, boiler); low and high cost measures varied between the two surveys to ensure the measures included were relevant for the survey respondent population. These questions probe customers on alternative payback times required to adopt representative high and low cost energy efficient technologies. Each respondent started at a randomly assigned payback period. Results from these questions were used to develop acceptance curves (i.e., willingness to accept a simple payback period) that were calibrated for low cost and high cost measures. The results of interpolating the relevant willingness to pay curves derived from survey data were applied to forecasted measure simple paybacks to inform the long-run market equilibrium of each measure in the EWR potential model. Results from the EWR willingness to pay questions are included in the payback curves in Section 7.

3.4.3 Baseline and Saturation

Guidehouse included a limited number of baseline and saturation questions to supplement existing studies to inform the potential study models. Respondents were asked questions to assess the baseline number of bulbs in a variety of common interior and exterior fixture types and the saturation of given bulb types (e.g., LED, CFL, linear fluorescent). In addition, questions were asked to understand customer fuel and system type for domestic water and space heating. Details on these results and how they informed the model are included in Sections 2.1.6.

3.4.4 COVID-19 Pandemic Impacts

Respondents were asked to provide feedback on the impacts of the COVID-19 pandemic on their decision-making around energy efficiency upgrades. In aggregate, the pandemic has little-to-no impact on customer decision-making around energy efficiency.

More than half (60%) of residential customers say they are just as likely to pursue energy efficiency upgrades. Some customers say they are less likely to pursue upgrades (19%), and a similar proportion of customers say they are more likely to pursue upgrades (22%). Similarly, more than half (55%) of C&I customers say they are just as likely to pursue energy efficiency upgrades. Some customers say they are less likely to pursue upgrades (28%), and a similar proportion of customers say they are more likely to pursue upgrades (17%).

Based on the minimal, self-reported impact of the pandemic on customer decision-making around energy efficiency upgrades and a comparison of willingness to pay curves developed from this primary research to a range of previous studies, Guidehouse opted to not adjust the model scenarios.

4. Energy Waste Reduction Measure Characterization

Guidehouse fully characterized 110 detailed EWR measures and nine end use measure buckets across the utilities' residential, commercial, and industrial sectors. These sectors were further segmented (four residential segments and two commercial segments), with measures identified as eligible for either retrofit, new construction, or both. Measures also include electricity and gas end uses; however, impacts from fuel switching are not evaluated. The net combined impact of the dimensionality defined above produced 608 unique measure permutations that were incorporated into Guidehouse's Demand Side Management Simulator (DSMSim™) model.

4.1 Energy Waste Reduction Measure List

Guidehouse developed a comprehensive measure list of EWR measures likely to contribute to economic potential. To build this list of the most promising measures, we first compiled lists from current program offerings, MEMD, Michigan's 2017 Energy Waste Reduction Potential Study[16], and measure lists of top performing measures from other jurisdictions. The resulting list was ranked and prioritized to identify EWR measures with the greatest potential for achievable energy and economic impacts.

For the measure screening process, Guidehouse focused on EWR measures that would pass the UCT cost screen and, in aggregate, are projected to achieve 90% or more of the incremental achievable savings in 2021. We then worked with the MSPC and stakeholders to iterate and finalize the measure list, and ensure it contained technologies viable for future DSM program planning activities, to include current top performers and measures anticipated to offer the greatest future potential within the 20-year study period.

As one of the measure categories, Guidehouse included an estimate of unidentified future technology emergence for each sector and primary fuel type (electricity and gas) beginning in 2026 and accelerating through the study horizon. These estimates are high level, and are meant to represent the directional probability of unknown technology contributions to potential toward the end of the study period, and add uncertainty to later year estimates.

With the exception of the unidentified future technologies and custom measures, all remaining EWR measures included in the model are available in the market and economically viable. For measures not included in the primary list, Guidehouse benchmarked recent studies across North America compared to the primary list, removed measures that are no longer relevant[17], and modeled and aggregated results by end use with a high level percentage of sales savings estimates and customer costs. Nine end use bucket characterizations were included through this process and represent less than10% of achievable potential. In this way, the results provide a comprehensive assessment of potential.

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[16] https://www.michigan.gov/mpsc/0,9535,7-395-93309_93439_93463_93723_93730-406251--,00.html

[17] Measures were removed if these have been superseded (e.g. ,T8 lamps having been superseded by LEDs) or if the former energy conservation measure is now a standard market practice.

4.2 Energy Waste Reduction Measure Characterization Key Parameters

The measure characterization effort consisted of defining more than 50 individual parameters for each measure included in this study. Table 4-1 defines 14 of the most critical parameters and how these items impact technical and economic potential savings estimates.

Table 4-1. Key Measure Characterization Parameters

Parameter Name	Definition	Example
Baseline Measure	Existing inefficient equipment or process to be replaced.	T5/T8 Fluorescent Lighting
Energy Waste Reduction Measure	Efficient equipment, process, or project to replace the baseline measure.	Indoor LED Linear Lamp
Measure Lifetime	The lifetime in years for the base and energy efficient technologies. The base and energy efficient lifetimes only differ in instances where the two cases represent inherently different technologies, such as solar water heaters compared to a baseline of regular storage water heaters.	T5/T8 Fluorescent Lighting: 10 years Indoor LED Linear Lamp: 12 years
Measure Costs	The incremental cost between the assumed baseline and efficient technology using the following variables: • Base Costs: The cost of the base equipment, including both material and labor costs. • Energy Efficient Costs: The cost of the energy efficient equipment, including both material and labor costs. Retrofit measure costs will include the full material cost of the efficiency measure and associated labor rates for removal of existing equipment and installation of the efficient technology. Dual baseline measures consider the initial retrofit measure cost and savings and that of the portion of measure life once a new code or standard is projected to become effective.	Baseline cost: $690 Efficient cost: $500
Replacement Type	Identifies when in the technology or building's life an efficiency measure is introduced. Replacement type affects when in the potential study period the savings are achieved and the duration of savings.	Retrofit (RET), replace-on-burnout (ROB) and new construction (NEW)
Annual Energy Consumption	The annual energy consumption for electricity in kWh and demand in kW, for gas in therms, for propane and fuel oil in MMBtu, and for each baseline and EWR measure.	Baseline: 196 kWh/year Efficient: 163 kWh/year
Unit Basis	The normalizing unit for energy, demand, cost, and density estimates.	Per bulb, per hp, per kWh consumption, per therm consumption
Scaling Basis	The unit used to scale the energy, demand, cost, and density estimate for each measure according to the reference forecast.	Per home, per 1,000 square feet of commercial area, etc.

Parameter Name	Definition	Example
Sector and End-use Mapping	The team mapped each measure to the appropriate end uses, customer segments, and sectors. Where Michigan-specific information was not available, Guidehouse used secondary data, including internal Guidehouse data sources. Guidehouse's review of these resources was used to support the data sources provided by the utilities and to ensure consistency among the utilities' data, Guidehouse's estimates, and publicly available resources. Section 2.1 describes the breakdown of customer segments with each sector.	Commercial Chiller Tune-up is mapped to the commercial sector, HVAC end use, and has customized inputs for small and large market segments
Fuel Type Multiplier	Assigns the percentage of electric/gas fuel type to measures with electricity/gas fuel type, such as water heaters and space heating equipment.	The Electric space heating multiplier only assigns electric space heating measures to customers that have electric heating
Measure Density	Used to characterize the occurrence or count of a baseline or EWR measure, or stock, within a residential household or within 1,000 square feet of a commercial building. This parameter was not defined for industrial measures as they scaled by consumption.	35 bulbs per household
Energy Waste Reduction Saturation	The fraction of the residential housing stock or commercial building space that has the efficiency measure installed each year. For the industrial sector, saturations are based on energy consumption.	40% of all residential bulbs are LEDs so saturation of LEDs is 40%
Technical Suitability	The percentage of the base technology that can be reasonably and practically replaced with the specified efficient technology.	Occupancy sensors have a technical applicability <1.0 because they are not practical on fixtures that have constant use, require manual control, or have alternate controls (e.g., timer)
Competition Group	Identifies measures competing to replace the same baseline density to avoid double counting of savings.	Efficient storage tank water heater or a tankless water heater can replace an inefficient storage water heater, but not both.

Source: Guidehouse

4.3 Energy Waste Reduction Measure Characterization Approaches and Sources

This section provides approaches and sources for the main measure characterization variables. Table 4-2 lists sources of data accessed for measure characterization.

Table 4-2. Sources for Measure Characterization Inputs

Measure Input	Data Sources
Measure Costs, Measure Life, Energy Savings	• Michigan MEMD • MI Utilities' program data • US Department of Energy (DOE) Appliance Standards and Rulemakings supporting documents • Engineering analyses • Guidehouse measure database and previous potential studies
Fuel Type Applicability Splits, Density, Baseline Initial Saturation, Technical Suitability, End-Use Consumption Breakdown	• Primary research conducted by Guidehouse • 2016-2017 Michigan Baseline Study • Residential Building Stock Assessment (RBSA) • Commercial Building Stock Assessment (CBSA) • Guidehouse's other potential studies
Codes and Standards	• US DOE engineering analyses • Local building code

Source: Guidehouse

4.3.1 Energy and Demand Savings

Guidehouse took four general bottom-up approaches to analyzing measure energy and demand savings for all measures, except for proxy measures representing custom projects and emerging technologies. Inputs to these bottom-up analysis are based on the following:

- **MEMD:** This reference has two parts: one covers weather-dependent measures, and a separate document provides guidance around the remainder of measures with previously defined prescriptive savings applicable for utilities in Michigan. This document is the primary source for inputs on energy and demand savings, as well as effective useful life and incremental measure cost.
- **Utilities' Program Data**: For custom measures, Guidehouse used the custom program data to estimate consumption and savings for all custom measures included in this study. The savings assumptions for custom measures were derived from the utilities' recently reported custom program data, which was provided through the data request. We also leveraged the characterization from the 2017 Energy Waste Reduction Potential Study[18].
- **Technical Reference Manual (TRM):** For measures or associated inputs not covered by the MEMD, Guidehouse cross-referenced various TRMs from the Midwest, New England, and Mid-Atlantic states to determine standard algorithms and, when necessary, various inputs to the savings analysis.
- **Previous Potential Studies:** When applicable, Guidehouse leveraged research and analysis conducted for other recent potential studies. This data was calibrated to ensure applicability in Michigan and consistency in inputs from other sources, such as the MEMD.

[18] Michigan's 2017 Energy Waste Reduction Potential Study

- **Engineering Analysis:** Guidehouse used secondary research and custom engineering analysis to calculate any inputs not included in the sources listed previously.

4.3.2 Incremental Costs

For incremental cost data, Guidehouse relied primarily on the MEMD and utility-provided program data. To fill any remaining gaps in cost data, Guidehouse also leveraged market research our team has conducted as part of other, recent evaluation and potential studies. Incremental costs for custom measures were calculated based on utilities' actual program data.

4.3.3 Incentives, Administrative Costs, and Net-to-Gross

Net-to-gross (NTG) ratios were included from the utilities' 2019 tracking datal for all electricity and natural gas measures. All low-income measures received a NTG ratio of 1.0. Generally, non-low income measure received a NTG ratio of 0.90, with the exception of screw-based lighting. The general service screw-based bulbs NTG ratio is 0.54, and specialty bulbs is 0.67. Incentive levels and administrative costs are defined in the scenario characteristics, as discussed in Section 8.1.

4.3.4 Building Stock and Densities

Guidehouse relied heavily on the primary data for information on equipment densities and saturations for lighting, HVAC, and water heating measures in the residential and commercial sector. Density and saturation inputs for between 50% and 60% of savings (depending on impact and potential type) were sourced from this research. For lower impact measures and measures not included in the primary data collection, Guidehouse referred to previous baseline studies[19] conducted in Michigan secondary data from other baseline studies to estimate density and saturation values. To estimate density and saturation values for these measures, we also leveraged the historical data in the RBSA[20] and CBSA[21] databases, along with data from other potential and baseline studies.

4.4 Codes and Standards Adjustments

Estimates of future adjustments in savings related to codes and standards are included as part of the measure characterization process.

DOE publishes federal energy waste reduction regulations for many types of residential appliances and commercial equipment. The DOE Technical Support Documents (TSDs)[22] contain information on energy and cost impacts of each appliance standard. In the TSD, Section 5 includes engineering analysis, Section 7 includes energy use analysis, and Section 8 includes cost impact. As these codes and standards take effect, the energy savings from existing

[19] Including: DTE Energy 2016 - 2017 Residential Baseline Study, DTE Energy 2016 - 2017 Commercial & Industrial Baseline Study, and 2011 Michigan Residential and Commercial Baseline Studies (https://www.michigan.gov/mpsc/0,9535,7-395-93309_94801_95000---,00.html)

[20] https://neea.org/data/residential-building-stock-assessment

[21] https://neea.org/data/commercial-building-stock-assessments

[22] Appliance standards rulemaking notices and TSD can be found at: https://www.energy.gov/eere/buildings/appliance-and-equipment-standards-program

measures impacted by these codes and standards decline and the reduction is transferred to the codes and standards savings potential.

Guidehouse accounts for the effect of codes and standards through baseline energy and cost multipliers (sourced from DOE's analysis), which reduce the baseline equipment consumption starting from the year a code or standard takes effect. The baseline cost of an efficient measure affected by codes and standards will often increase upon the code's implementation. As such, computed measure-level potential is net of these adjustments from codes and standards implemented after the study's first year.

5. Energy Waste Reduction Technical Potential Results

This section briefly describes Guidehouse's approach to calculating technical potential and presents the results for the utilities pertaining to total technical savings potential at different levels of aggregation. Results are shown by sector and end-use category. For more detail and levels of aggregation of technical potential, see Appendix D.

5.1 Approach to Estimating Energy Waste Reduction Technical Potential

This study defines **technical potential** as the total energy savings available assuming that all applicable installed baseline measures can *immediately* be replaced with the efficient measure or technology—wherever technically feasible—regardless of the cost, market acceptance, or whether a measure has failed and must be replaced. Therefore, technical potential is neither cumulative nor incremental; instead, it shows the total potential if all savings were to be achieved in a single year.

The *Michigan 2021-2040 Potential Study Modeling Methodology* (see Appendix C) discusses the approach to estimating technical potential in more detail. Guidehouse used its DSMSim model to estimate the technical potential for demand-side resources considered for this study. DSMSim is a bottom-up, technology-diffusion and stock tracking model implemented using a system dynamics framework.[23]

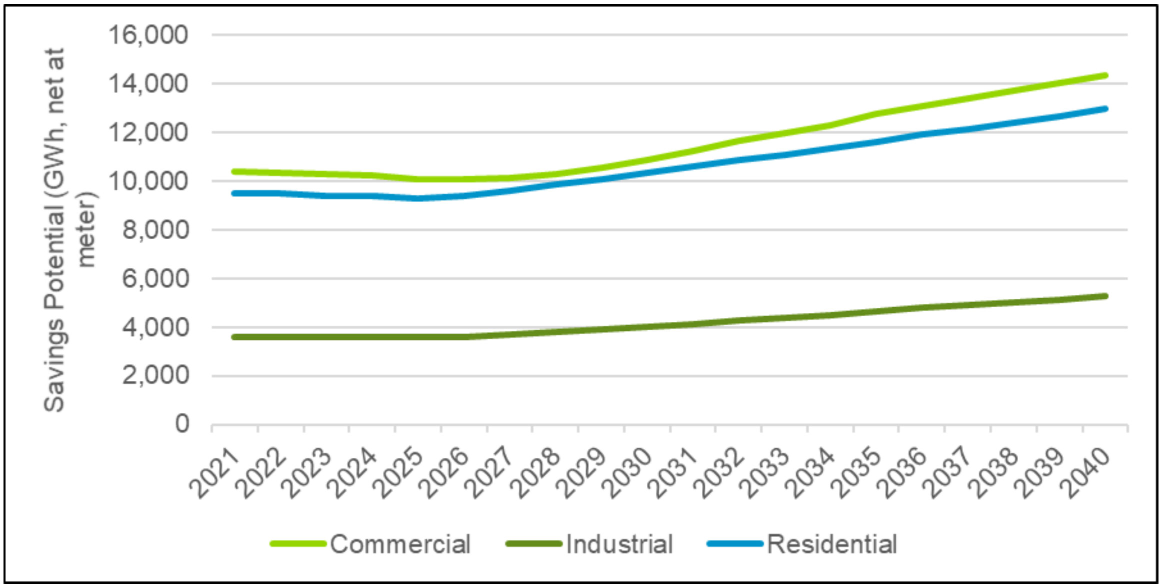
5.2 Energy Waste Reduction Technical Potential Results by Sector

Figure 5-1 shows the total electricity technical savings potential, net at meter, for each sector in the Lower Peninsula in GWh. The technical potential remains relatively flat for all sectors for the first 5 years of the study period. In 2026, unidentified future emerging technologies begin to phase in, causing the increase in technical potential in later years, in addition to increased customer stocks over the study period.

Figure 5-2 shows the total electricity technical savings potential, net at meter, for each sector in the Upper Peninsula in GWh. The technical potential remains relatively flat for all sectors for the first 5 years of the study period. In 2026, unidentified future emerging technologies begin to phase in, causing the increase in technical potential in later years.

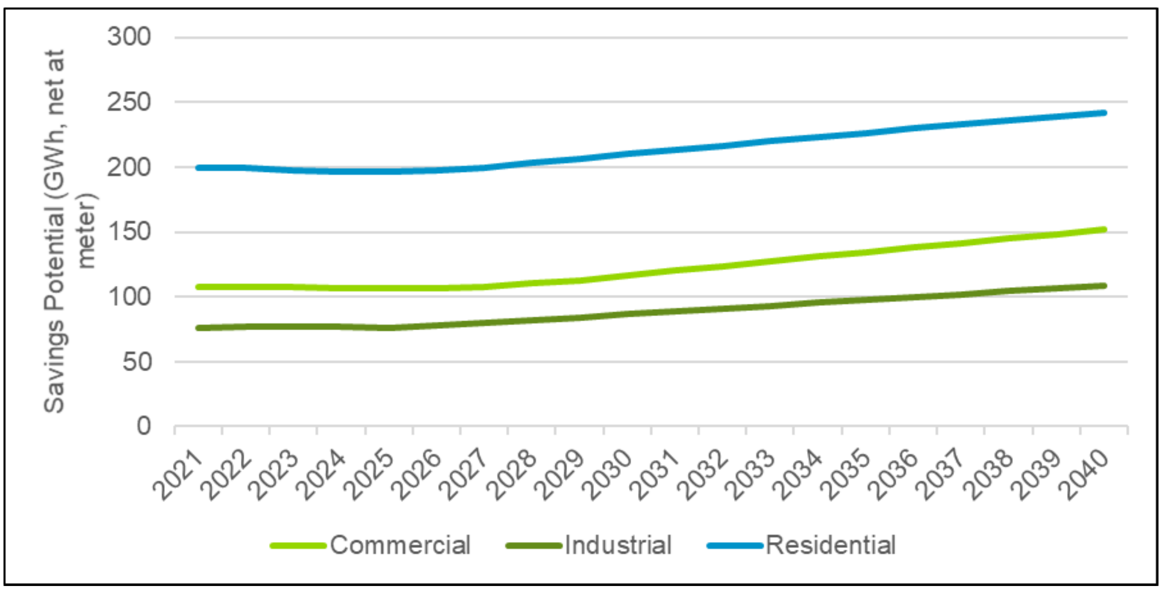
[23] See Sterman, John D. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin McGraw-Hill. 2000 for detail on system dynamics modeling. Also see http://en.wikipedia.org/wiki/System_dynamics for a high level overview.

Figure 5-1. Lower Peninsula EWR Technical Potential, Electricity Savings by Sector (GWh, Net at Meter)



Source: Guidehouse analysis

Figure 5-2. Upper Peninsula EWR Technical Potential, Electricity Savings by Sector (GWh, Net at Meter)

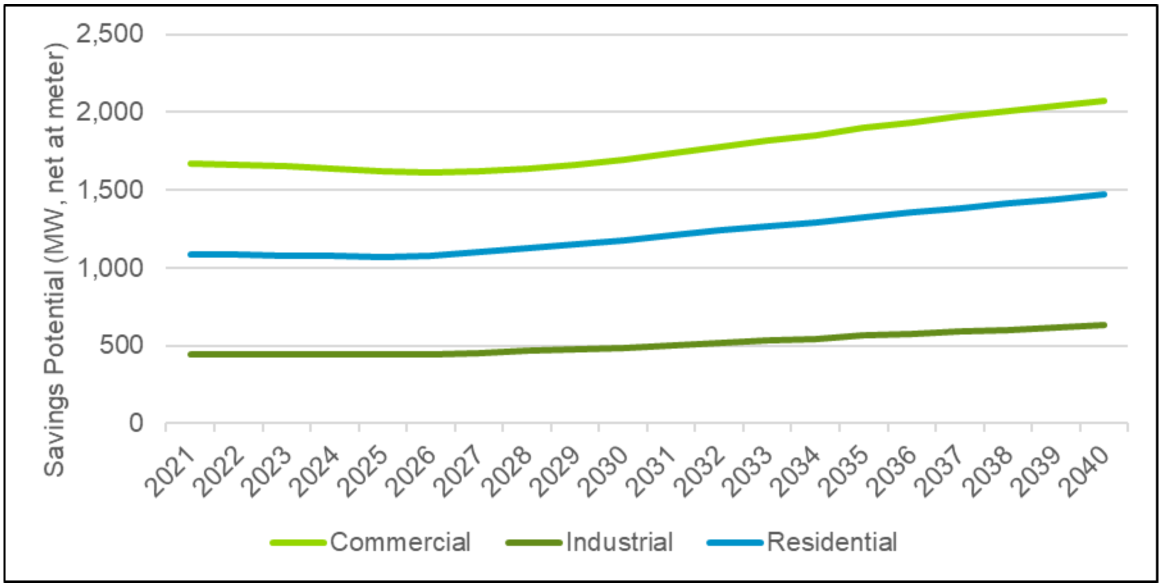


Source: Guidehouse analysis

Figure 5-3 shows the total summer peak demand technical savings potential, net at meter, for each sector in the Lower Peninsula in MW. Like the electricity technical potential, the peak demand remains relatively flat until 2026, when unidentified future emerging technologies begin to phase in and increase the projected savings.

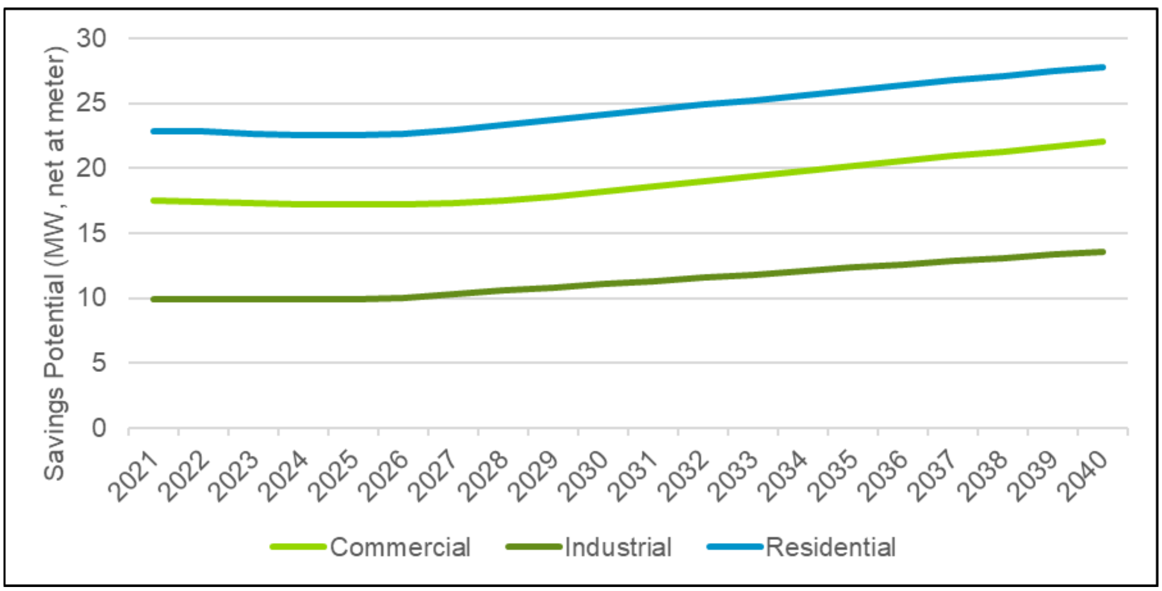
Figure 5-4 shows the total summer peak demand technical savings potential, net at meter, for each sector in the Upper Peninsula in MW. Similar to the electricity technical potential, the peak demand remains relatively flat until 2026, when unidentified future emerging technologies begin to phase in.

Figure 5-3. Lower Peninsula EWR Technical Potential, Summer Peak Demand Savings by Sector (MW, Net at Meter)



Source: Guidehouse analysis

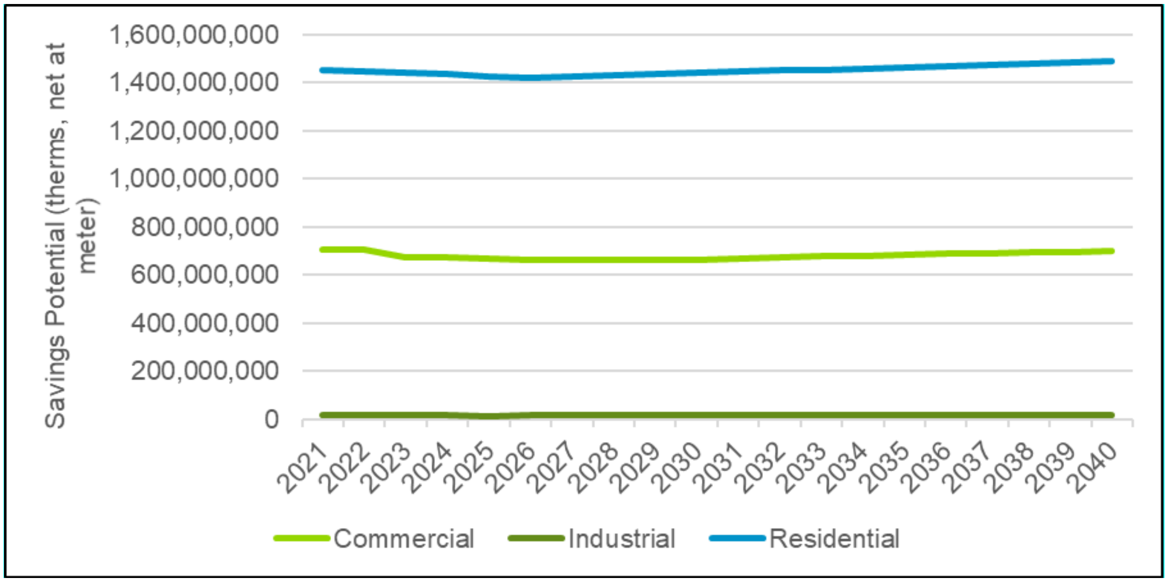
Figure 5-4. Upper Peninsula EWR Technical Potential, Summer Peak Demand Savings by Sector (MW, Net at Meter)



Source: Guidehouse analysis

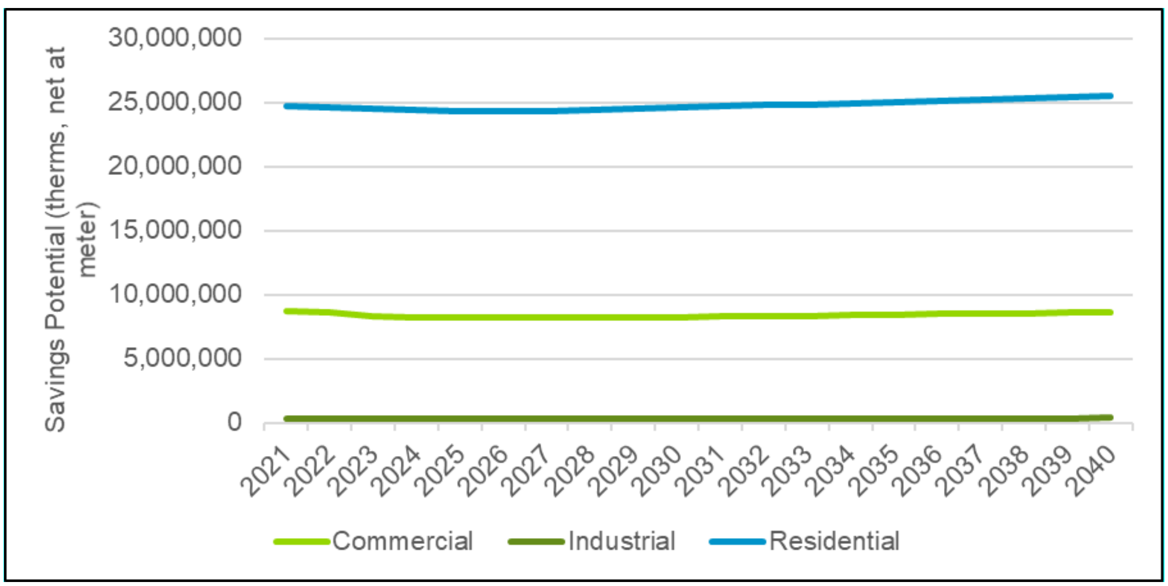
Figure 5-5 and Figure 5-6 show the total natural gas technical potential in therms for the Lower and Upper Peninsulas, respectively. Natural gas savings are less impacted by the unidentified future technology assumptions, increasing slightly after a small decrease in the initial years.

Figure 5-5. Lower Peninsula EWR Technical Potential, Natural Gas Savings by Sector (therms, Net at Meter)



Source: Guidehouse analysis

Figure 5-6. Upper Peninsula EWR Technical Potential, Natural Gas Savings by Sector (therms, Net at Meter)



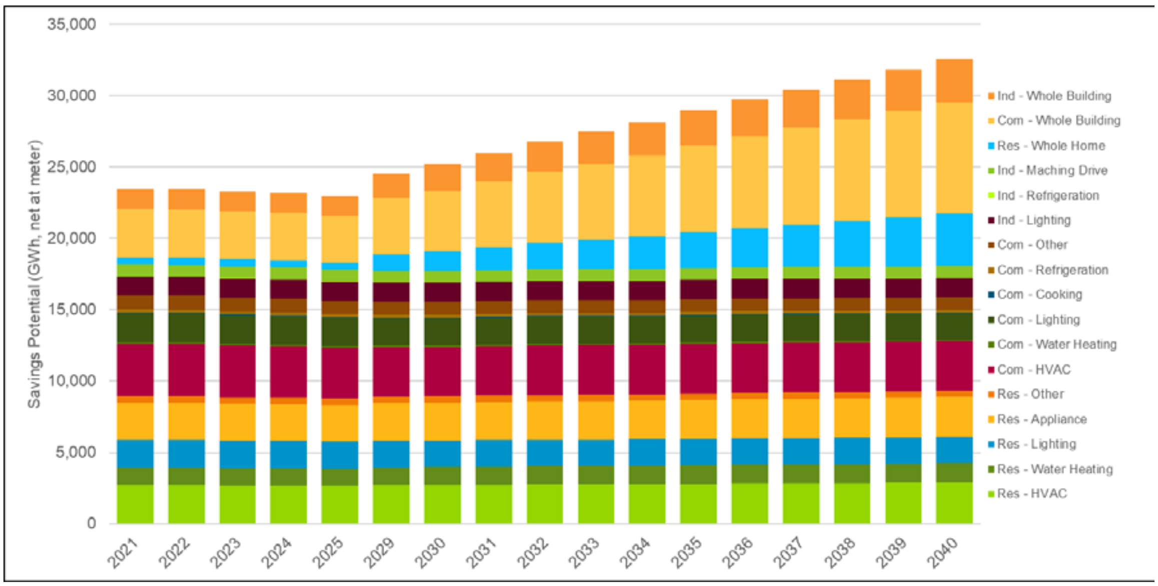
Source: Guidehouse analysis

5.3 Energy Waste Reduction Technical Potential Results by End Use

Figure 5-7 shows the electricity technical savings potential, net at meter, across all end uses and sectors in the Lower Peninsula. The leading end uses in the Lower Peninsula are commercial whole building, residential whole building, commercial HVAC, and residential HVAC. This result reflects that there are still large opportunities in these end uses compared to lighting, which is relatively small in this study due to large increases in LED lighting saturations. The whole building and whole home end uses increase in savings over time because those end uses contain the unidentified future measure.

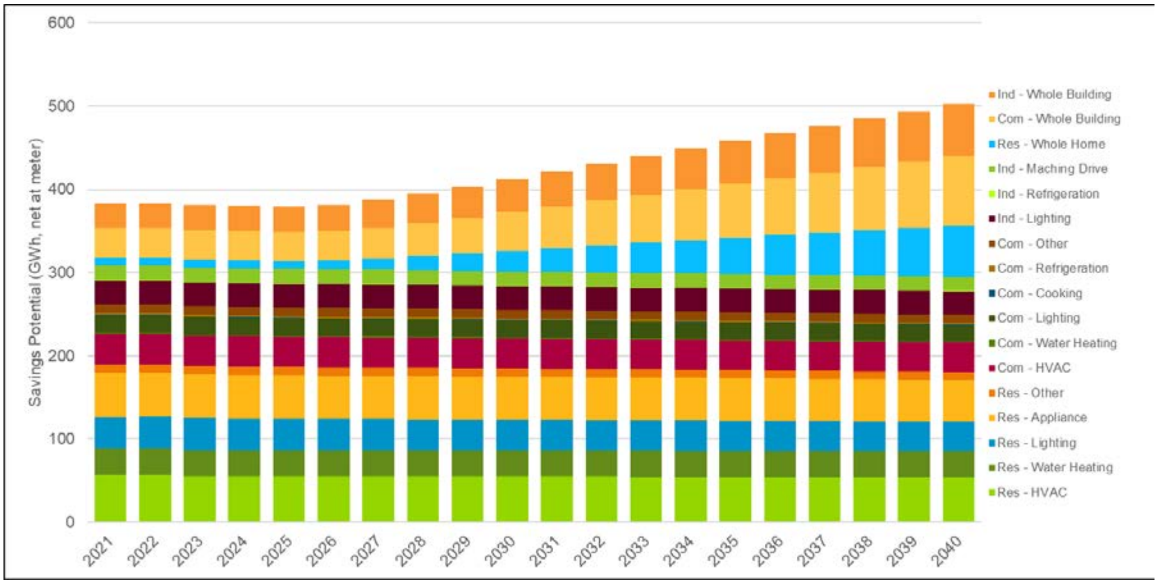
Figure 5-8 shows the electricity technical savings potential, net at meter, across all end uses and sectors in the Upper Peninsula. The dominant end uses in the Upper Peninsula are residential HVAC, residential appliances, and commercial whole building. This difference from the Lower Peninsula is reflective of a larger share of residential customers and load in the Upper Peninsula compared to the Lower Peninsula. The whole building and whole home end uses increase in savings over time because those end uses contain the unidentified future measure.

Figure 5-7. Lower Peninsula EWR Technical Potential, Electricity Savings by End Use (GWh, Net at Meter)



Source: Guidehouse analysis

Figure 5-8. Upper Peninsula EWR Technical Potential, Electricity Savings by End Use (GWh, Net at Meter)

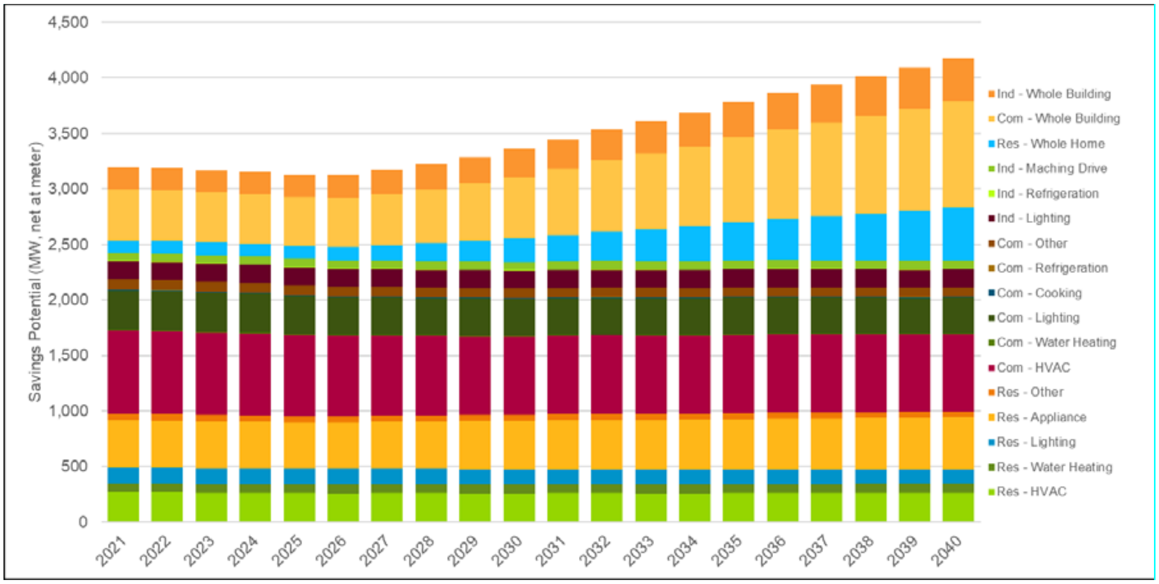


Source: Guidehouse analysis

Figure 5-9 shows the summer peak demand technical savings potential, net at meter, across all end uses and sectors in the Lower Peninsula. The dominant end uses are commercial HVAC and commercial whole building, which coincide most with the MEMD peak hours definition.

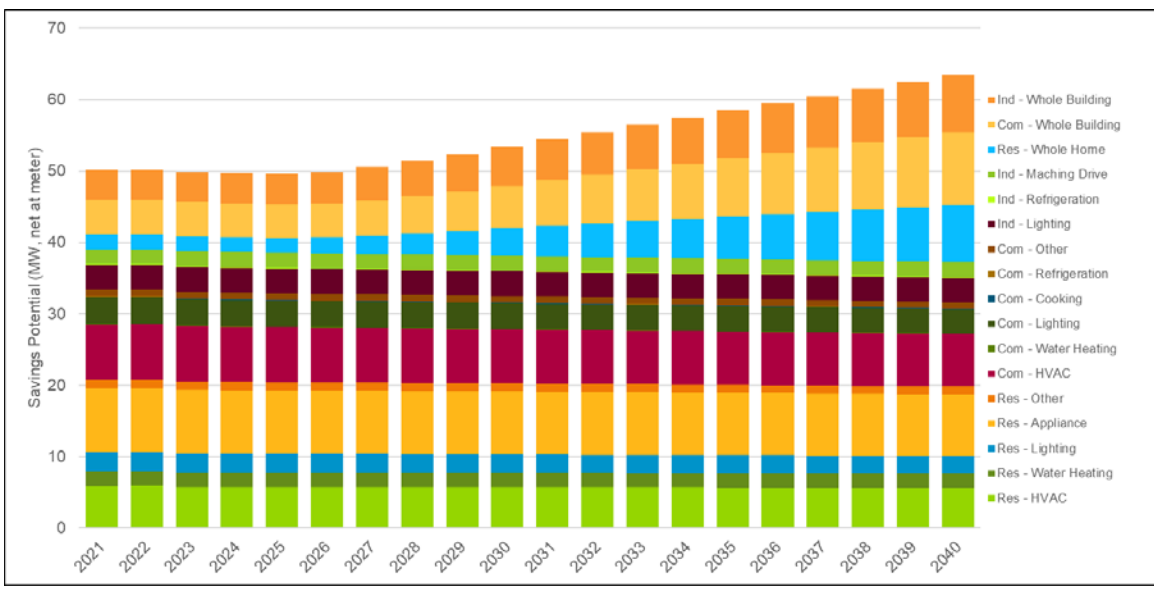
Figure 5-10 shows the summer peak demand technical savings potential, net at meter, across all end uses and sectors in the Upper Peninsula. Residential end uses contribute more to the total peak savings in the Upper Peninsula than the Lower Peninsula due to the higher share of residential customers and load in the Upper Peninsula.

Figure 5-9. Lower Peninsula EWR Technical Potential, Summer Peak Demand Savings by End Use (MW, Net at Meter)



Source: Guidehouse analysis

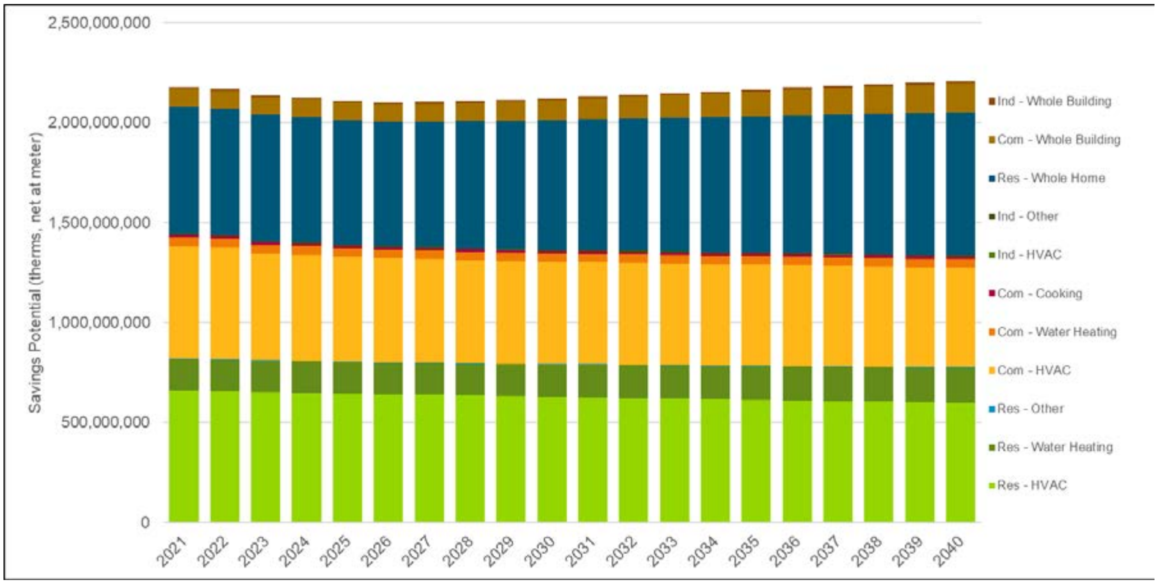
Figure 5-10. Upper Peninsula EWR Technical Potential, Summer Peak Demand Savings by End Use (MW, Net at Meter)



Source: Guidehouse analysis

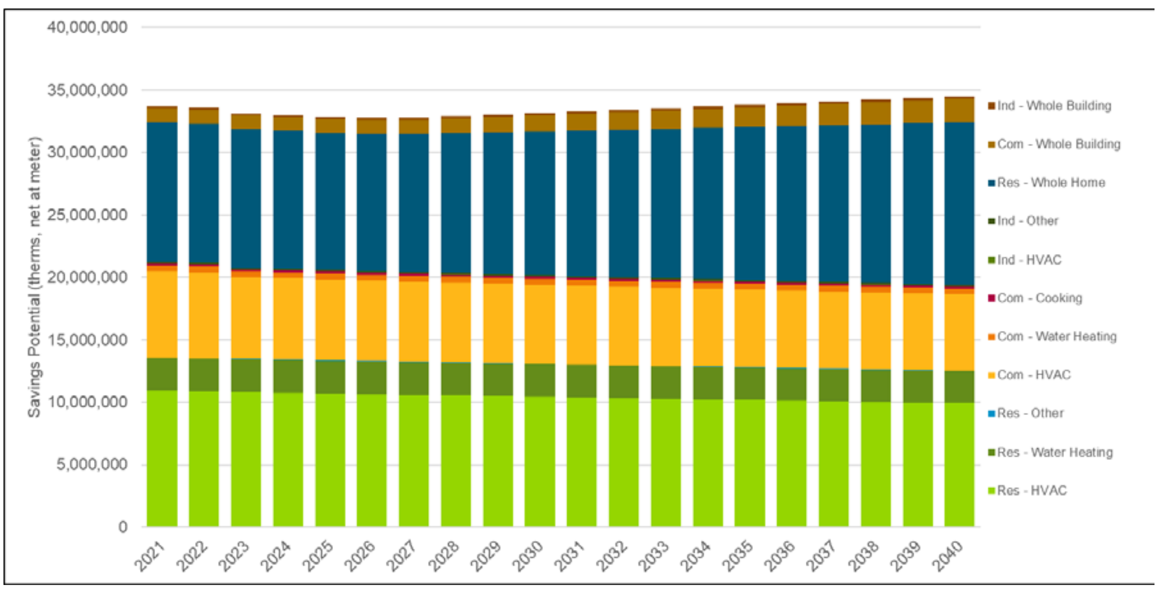
Figure 5-11 and Figure 5-12 show the natural gas technical savings potential across all end uses and sectors in the Lower and Upper Peninsulas, respectively. In both cases, weather-sensitive HVAC and whole building/home end uses make up the majority of the gas savings potential. Whole building/home measures contain envelope measures, which are also affected by seasonality.

Figure 5-11. Lower Peninsula EWR Technical Potential, Natural Gas Savings by End Use (therms, Net at Meter)



Source: Guidehouse analysis

Figure 5-12. Upper Peninsula EWR Technical Potential, Natural Gas Savings by End Use (therms, Net at Meter)



Source: Guidehouse analysis

6. Energy Waste Reduction Economic Potential Results

This section describes the economic savings potential, which is potential that meets a prescribed level of cost-effectiveness, available for the utilities in Michigan. The section begins by explaining Guidehouse's approach to calculating economic potential, and then presents the results for economic savings potential at different levels of aggregation. Results are shown by sector and end-use category. We developed economic potential using a UCT threshold ratio of 1.0 as the measure screen. For more detail and levels of aggregation of economic potential, see Appendix D.

6.1 Approach to Estimating Economic Potential

Economic potential is a subset of technical potential, using the same assumptions regarding immediate replacement as technical potential, but including only those measures that have passed the benefit-cost test chosen for measure screening—in this case, the UCT test per Michigan protocols. The UCT for each measure is calculated each year and compared against the measure-level UCT ratio screening threshold of 1.0. A measure with a UCT ratio greater than or equal to 1.0 is a measure that provides monetary benefits greater than or equal to its costs. If a measure's UCT meets or exceeds the threshold, it is included in the economic potential. Measures with UCT ratios less than 1.0 were non-cost-effective and do not appear in the economic potential.

The UCT test is a benefit-cost metric that measures the net benefits of EWR measures from a program administrator's viewpoint. The UCT benefit-cost ratio is calculated in the model using Equation 6-1.

Equation 6-1. Benefit-Cost Ratio for Utility Cost Test

$$UCT = \frac{PV(Avoided\ Costs)}{PV(Incentive\ Costs + Admin\ Costs)}$$

Where:

- *PV( )* is the present value calculation that discounts cost streams over time using the selected nominal discount rate (6.54% and 7.19% for the Lower Peninsula and Upper Peninsula, respectively).
- *Avoided Costs* are the monetary benefits resulting from electricity, natural gas, and capacity savings (e.g., avoided costs of infrastructure investments and fuel purchases due to the energy conserved and demand reduced by efficient measures).
- *Incentive Costs* are the utility incentive amounts paid at the measure level to help cover the incremental equipment cost to the customer. This is set to 40% of the technology incremental costs for non-low income customers in the Reference Scenario.
- *Admin Costs* are the administrative costs (including marketing and channel management) incurred by the program administrator.

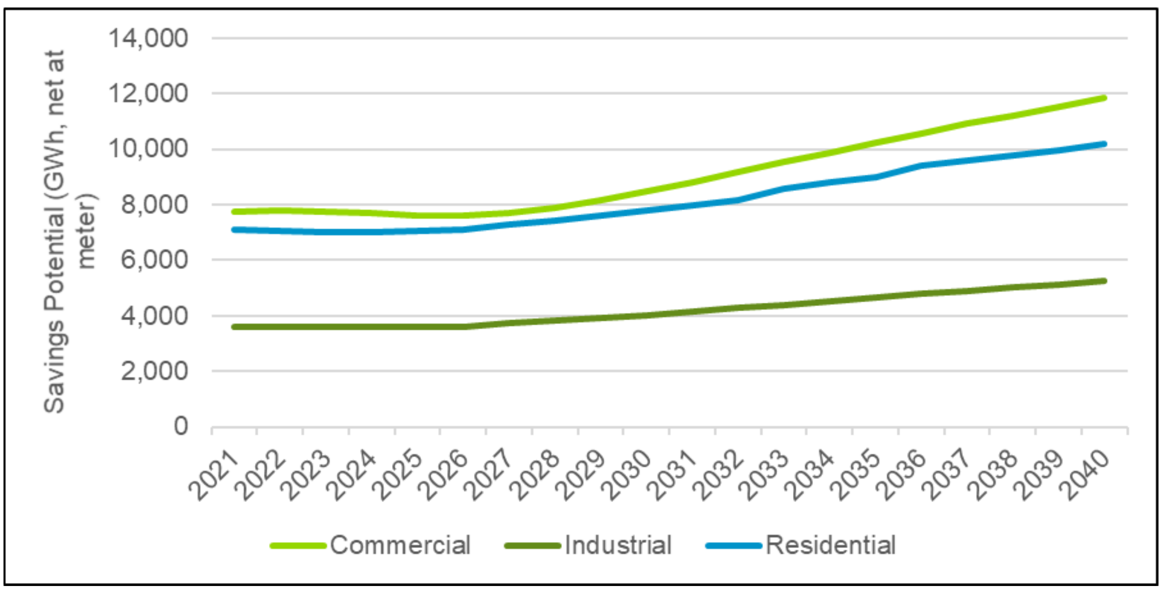
Guidehouse calculated UCT ratios for each measure based on the present value of benefits and costs (as defined previously) over each measure's life. Similar to technical potential, only one economic measure (meaning that its UCT ratio meets the threshold) from each competition group is included in the summation of economic potential across measures (e.g., at the end-use category, customer segment, sector, service territory, or total level). If a competition group is composed of more than one measure that passes the UCT test, then the economic measure that provides the greatest savings potential for its primary fuel type is included in the summation of economic potential. This approach ensures that double counting is not present in the reported economic potential.

Demand Response incentives and DR program awareness rates from the survey were integrated into the EWR adoption model to account for increased adoption of DR-enabled EWR technologies. The incorporation of these program design inputs results in reduced customer simple paybacks for specific measures with a DR incentive option weighted by the awareness of DR options as determined through Guidehouse primary research. To avoid double counting, only the EWR-specific incentive portion for these measures is included in budget and UCT calculations in the EWR study.

6.2 Energy Waste Reduction Economic Potential Results by Sector

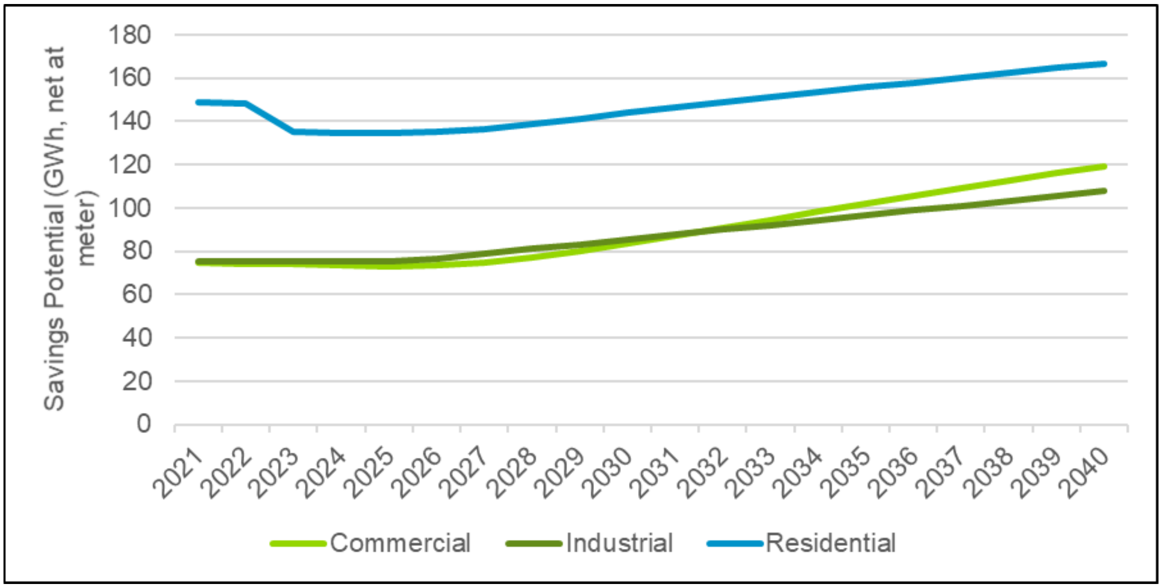
Figure 6-1 and Figure 6-2 show economic electricity savings potential, net at meter, across all sectors in the Lower Peninsula and Upper Peninsula, respectively. Avoided costs are different for the Lower and Upper Peninsulas. Additionally, these values change over time, and some measures fall in or out of cost-effectiveness over the study period. This is reflected most obviously in the residential sector. For the Lower Peninsula (Figure 6-1), some small stepwise increases can be seen in 2032 and 2035 as measures become cost-effective. Inversely, in the Upper Peninsula (Figure 6-2), some measures initially drop out of cost-effectiveness earlier on before rising back up.

Figure 6-1. Lower Peninsula EWR Economic Potential, Electricity Savings by Sector (GWh, Net at Meter)



Source: Guidehouse analysis

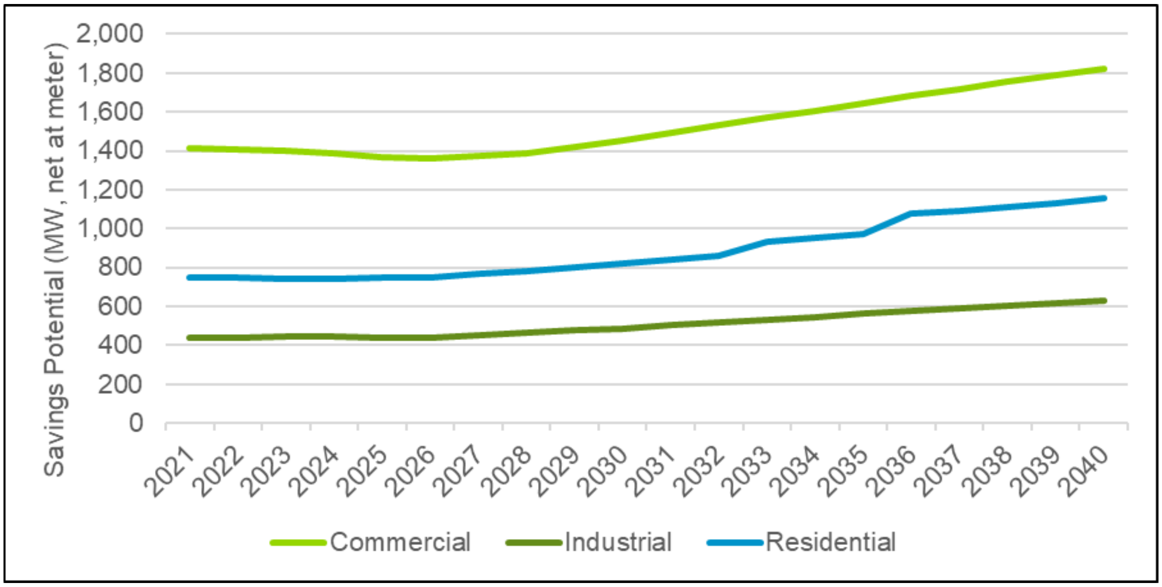
Figure 6-2. Upper Peninsula EWR Economic Potential, Electricity Savings by Sector (GWh, Net at Meter)



Source: Guidehouse analysis

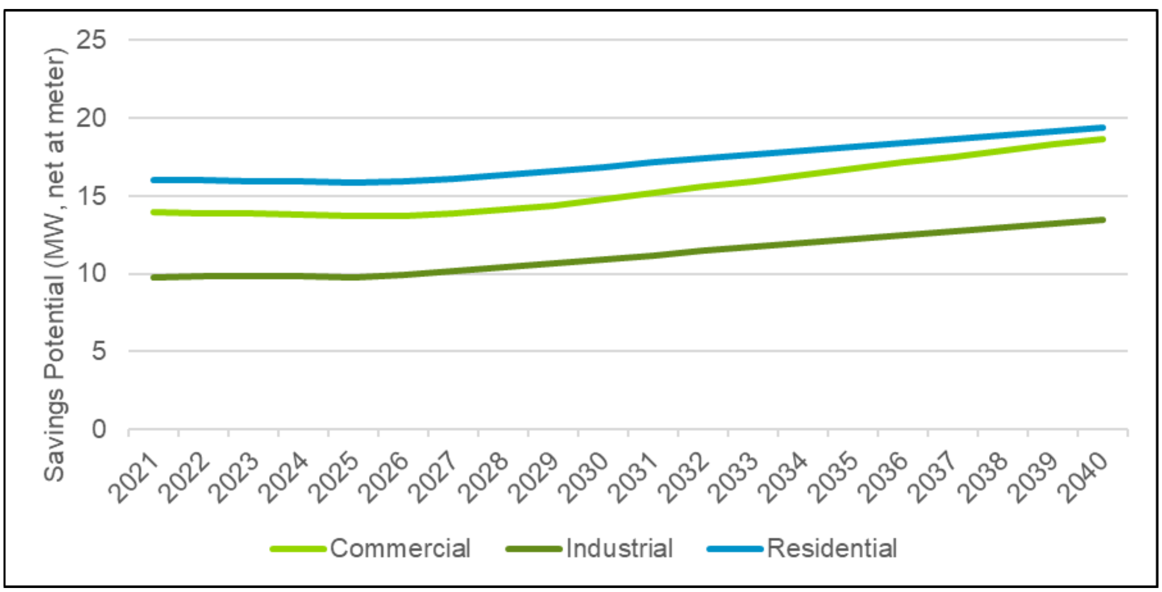
Figure 6-3 and Figure 6-4 show the economic summer peak demand potential, net at meter, in each of the sectors. The Lower Peninsula (Figure 6-3) has the highest peak potential in the commercial sector, while the Upper Peninsula (Figure 6-4) has the most peak demand potential in the residential sector due to the makeup of the customers.

Figure 6-3. Lower Peninsula EWR Economic Potential, Summer Peak Demand Savings by Sector (MW, Net at Meter)



Source: Guidehouse analysis

Figure 6-4. Upper Peninsula EWR Economic Potential, Summer Peak Demand Savings by Sector (MW, Net at Meter)

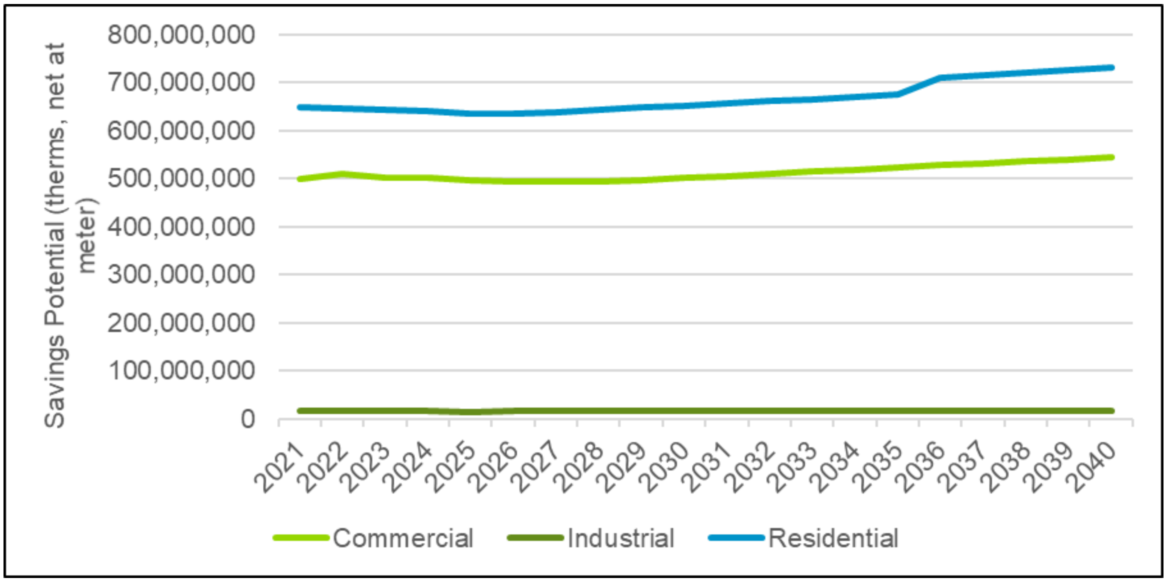


Source: Guidehouse analysis

Figure 6-5 and Figure 6-6 show the economic net natural gas potential. Avoided natural gas costs in the Upper Peninsula are lower than the Lower Peninsula. As Figure 6-5 shows, the

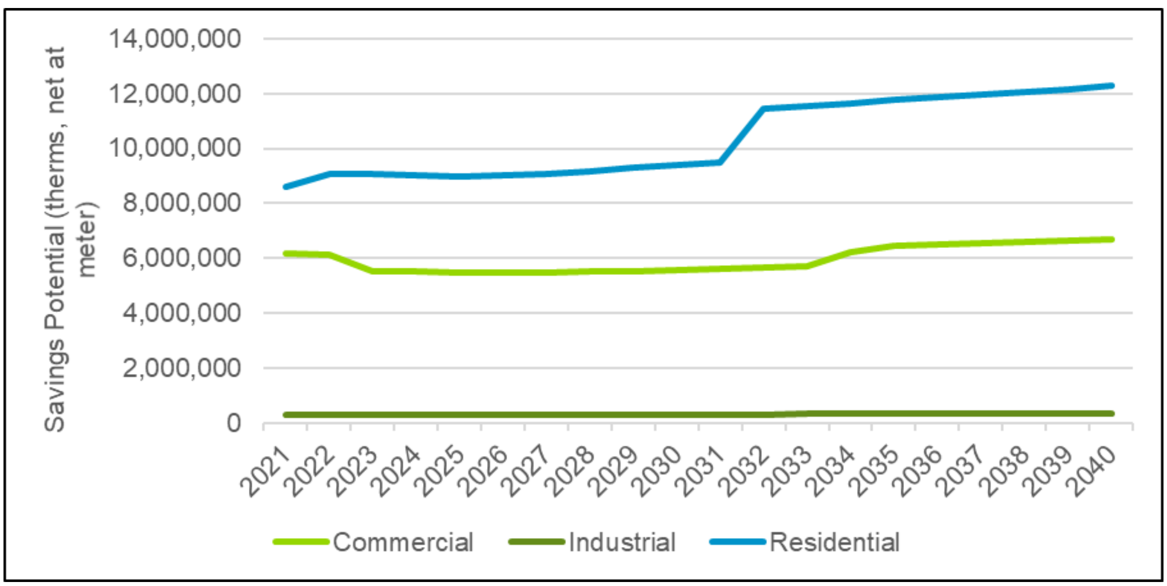
Lower Peninsula has a residential water heating measure become cost-effective in 2026. Figure 6-6 shows the Upper Peninsula with residential thermostats coming into cost-effectiveness in 2032. By contrast, this thermostat measure is cost-effective the entire study period in the Lower Peninsula.

Figure 6-5. Lower Peninsula EWR Economic Potential, Natural Gas Savings (therms, Net at Meter)



Source: Guidehouse analysis

Figure 6-6. Upper Peninsula EWR Economic Potential, Natural Gas Savings (therms, Net at Meter)



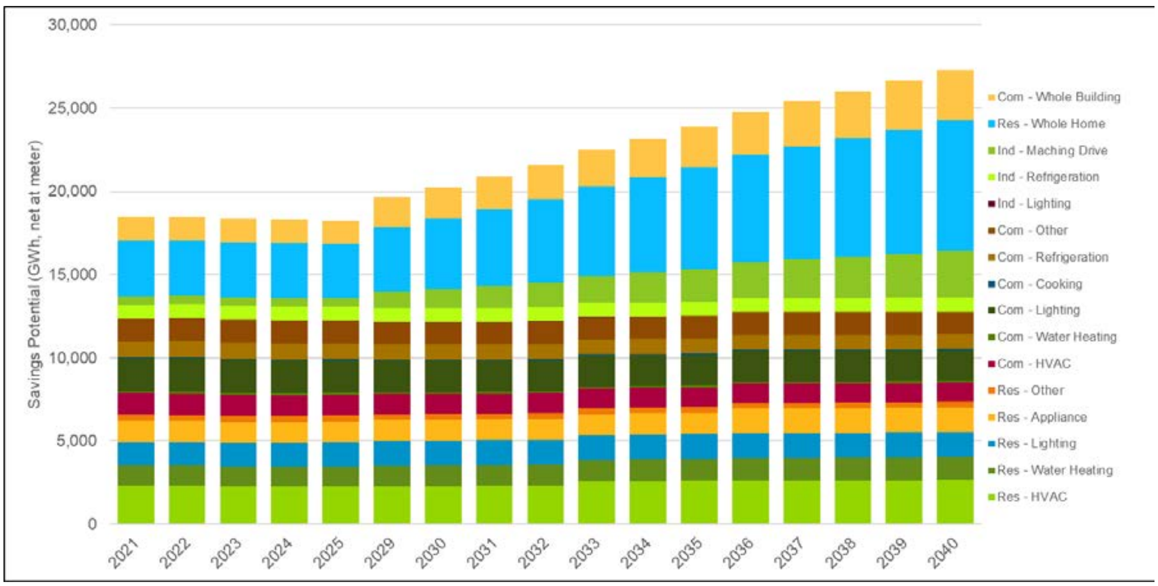
Source: Guidehouse analysis

6.3 Energy Waste Reduction Economic Potential Results by End Use

Figure 6-7 shows the economic electricity potential, net at meter, by end use for all sectors in the Lower Peninsula. Overall, the breakdown of potential is similar to technical potential, except that commercial HVAC and residential appliances have a much lower share of economic potential than technical potential.

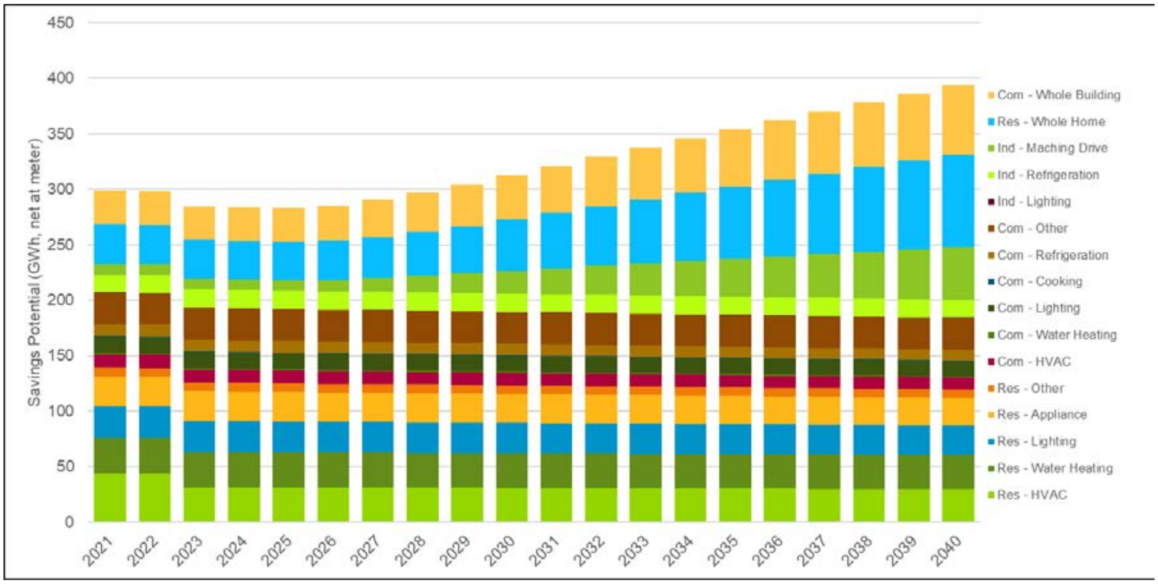
Figure 6-8 shows the economic electricity potential, net at meter, by end use for all sectors in the Upper Peninsula. As with the Lower Peninsula, the breakdown of potential is similar to technical potential. The largest variances come from residential HVAC, commercial HVAC, and residential appliances, which all have lower shares of economic potential compared to technical potential.

Figure 6-7. Lower Peninsula EWR Economic Potential, Electricity Savings by End Use (GWh, Net at Meter)



Source: Guidehouse analysis

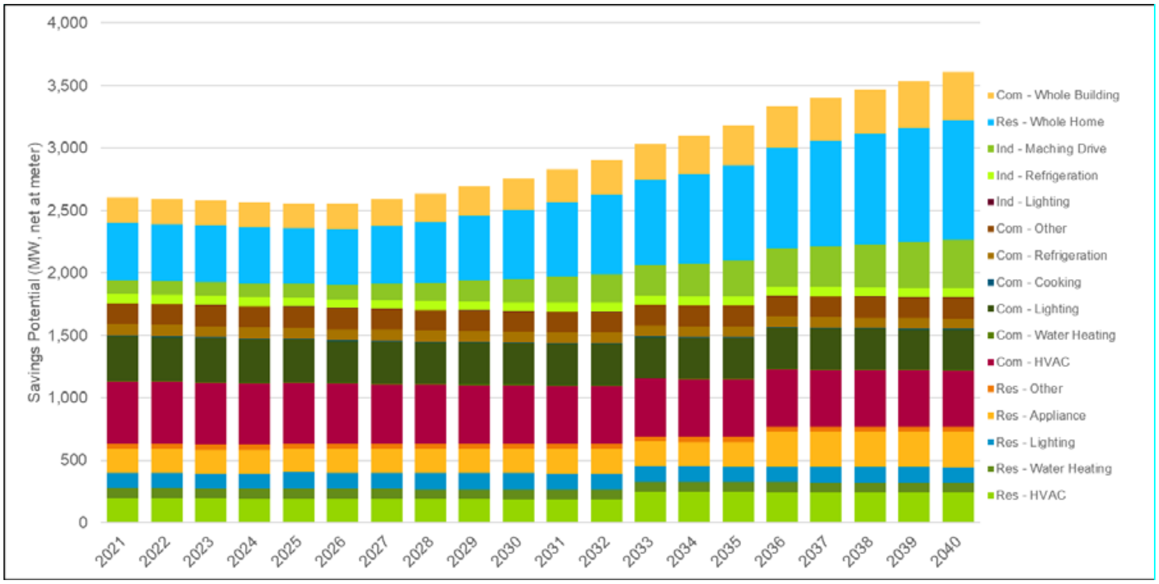
Figure 6-8. Upper Peninsula EWR Economic Potential, Electricity Savings by End Use (GWh, Net at Meter)



Source: Guidehouse analysis

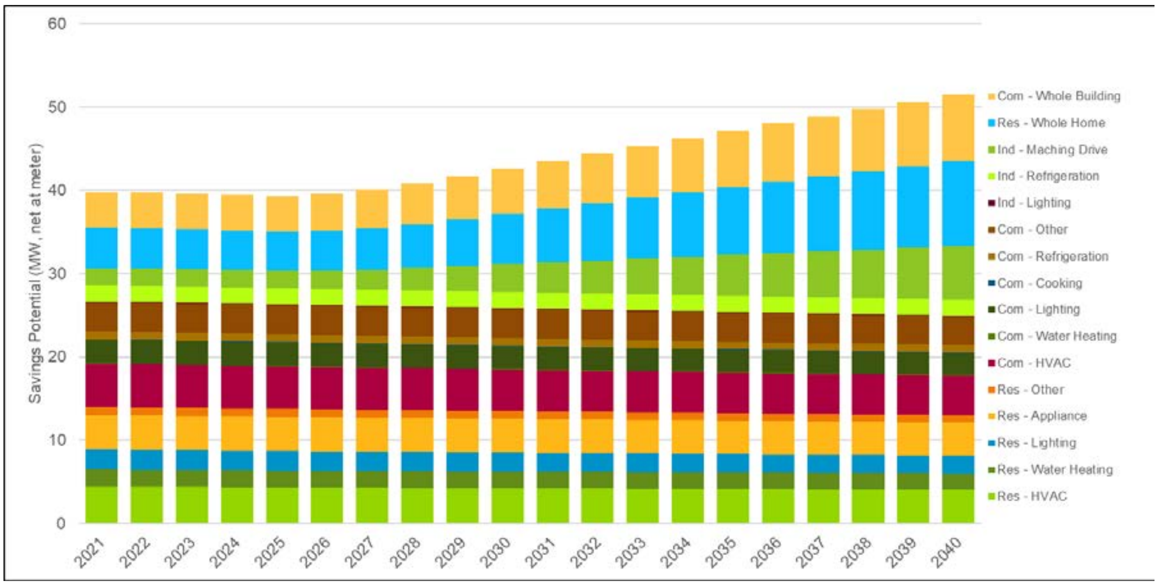
Figure 6-9 and Figure 6-10 show the summer peak demand savings for all sectors and end uses in the Lower and Upper Peninsulas, respectively. The demand savings trends compared to technical are the same as the electricity trends detailed previously.

Figure 6-9. Lower Peninsula EWR Economic Potential, Summer Peak Demand Savings by End Use (MW, Net at Meter)



Source: Guidehouse analysis

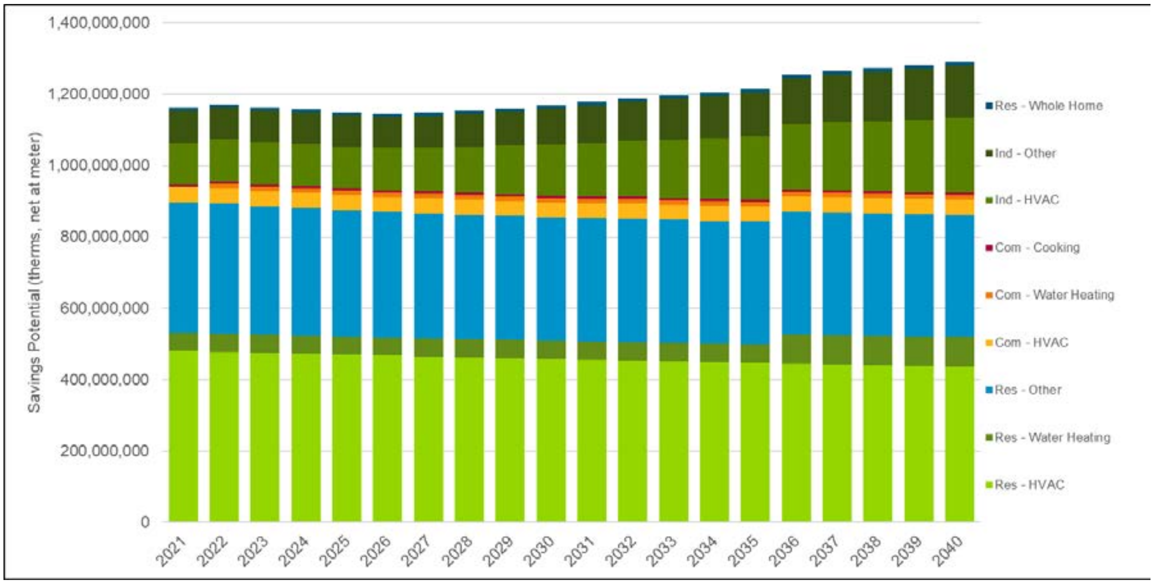
Figure 6-10. Upper Peninsula EWR Economic Potential, Summer Peak Demand Savings by End Use (MW, Net at Meter)



Source: Guidehouse analysis

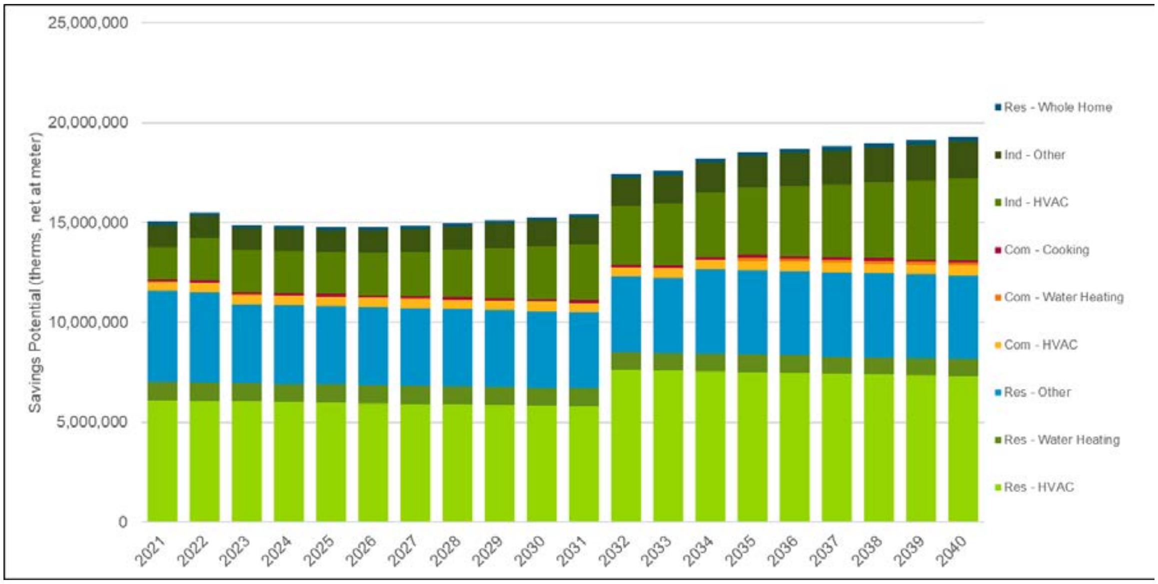
Figure 6-11 shows the economic natural gas potential by end use for all end uses and sectors in the Lower Peninsula. Figure 6-12 shows the economic natural gas potential by end use for all end uses and sectors in the Upper Peninsula. Similar to the natural gas technical potential, the residential sector, specifically HVAC, dominates the savings potential for natural gas in the Lower and Upper Peninsulas.

Figure 6-11. Lower Peninsula EWR Economic Potential, Natural Gas by End Use (therms, Net at Meter)



Source: Guidehouse analysis

Figure 6-12. Upper Peninsula EWR Economic Potential, Natural Gas by End Use (therms, Net at Meter)



Source: Guidehouse analysis

7. Energy Waste Reduction Achievable Market Potential Approaches

Achievable market potential further considers the likely rate of DSM resource acquisition given factors like the rate of equipment turnover (a function of a measure's lifetime), simulated incentive levels, consumer willingness to adopt efficient technologies, word-of-mouth effects that increase awareness in customers, and the likely rate at which marketing activities can facilitate technology adoption. The adoption of DSM measures can be broken down into the calculation of the equilibrium market share and the calculation of the dynamic approach to equilibrium market share, as discussed in more detail throughout this section.

Achievable potential differs from program potential in that achievable potential does not specifically consider the various delivery mechanisms that can be used by program managers to tailor their approach depending on the specific measure or market. Rather, achievable potential represents a high level assessment of savings that could be achieved over time, factoring in broader assumptions about customer acceptance and adoption rates that are not dependent on a specified program design. Additional effort is typically undertaken by program designers using the directional guidance from a market potential study to develop detailed plans for delivering EWR programs. Achievable potential in this report relies on a UCT measure screen for cost-effectiveness, with the threshold set at a UCT of 0.80 for the majority of measures, intended to reflect Michigan's regulatory practice of screening at the portfolio level. Some measures achieve a UCT ratio between the 0.8 and 1.0 achievable and economic thresholds and are included in achievable potential, but not the economic potential. The total potential attributed to these measures is minimal.

Table 7-1 summarizes the key methodology considerations and decision points informing the analysis in this report, with more detail provided in the report sections noted in the right-hand column of the table. Guidehouse decided on this methodology through discussions with MSPC, and in consideration of best practices and stakeholder feedback, about which approach best serves the objective of the study to understand achievable potential.

Table 7-1. EWR Achievable Potential Methodology Overview

Methodology Parameters	Approach
Benefit-cost test screen	Use the UCT as the primary screen for economic and achievable potential.
Diffusion parameters	Adjust diffusion parameters referencing ranges recommended by industry standard data sources to produce savings that are reasonably aligned with the utilities' DSM sector-level historical achievements.
Budget constraints	Do not apply budget constraints.
Incentive strategy	Set incentive levels at 40% of incremental costs for non-low income segments.
Treatment of administrative costs	Include program-level incentive to administrative cost ratios that scale administrative costs with calculated incentive budget.
NTG	Achievable potential estimates are developed using net savings based on historical program NTG inputs and TRM values.
Re-participation	Assume 100% of measures re-participate as an efficient measure at the end of their measure life.
Codes and standards	Use the same assumptions about codes and standards as in technical and economic potential.

7.1 Calculation of Equilibrium Market Share

The equilibrium market share can be thought of as the percentage of individuals choosing to purchase a technology provided those individuals are fully aware of the technology and its relative merits (e.g., the energy- and cost-saving features of the technology). For DSM measures, a key differentiating factor between the base technology and the efficient technology is the energy and cost savings associated with the efficient technology. That additional efficiency often comes at a premium in initial cost. This study calculates an equilibrium market share as a function of the payback time of the efficient technology relative to the baseline technology. In effect, measures with more favorable customer payback periods after incorporating incentives will have higher equilibrium market share, which reflects consumers' economically rational decision-making. While such approaches have limitations, these are directionally reasonable and simple enough to permit estimation of market share for the hundreds of technologies appearing in most potential studies.

To inform this study, Guidehouse fielded primary research to develop equilibrium payback acceptance curves. To develop these curves, we relied on surveys of 591 residential and 470 C&I customers. These surveys presented decision makers with two sets of questions to assess customer willingness to pay for EWR measures: one from a set of low cost measures (e.g., a light bulb, thermostat) and one from a set of high cost measures (e.g., insulation, boiler). Guidehouse fitted generalized logit models to customer willingness to pay survey results by technology cost bin and segment to develop the set of curves, which we used in this study. The resulting willingness to pay curves are used as starting points for achievable potential calibration described in Appendix C. The willingness to pay curves by territory, segment, and cost level used in the potential model are show in Appendix D.

Because the payback period of a technology can change over time (as technology or energy costs change over time), the equilibrium market share can also change over time. The equilibrium market share is recalculated for every year of the study period to ensure the dynamics of technology adoption take this effect into consideration. As such, equilibrium market share is a bit of an oversimplification and a misnomer, as it can itself change over time and is never truly in equilibrium, but it is used nonetheless to facilitate understanding of the approach.

7.2 Calculation of the Approach to Equilibrium Market Share

Two approaches are used for calculating the approach to equilibrium market share: one for technologies being modeled as retrofit (RET) measures, and one for technologies simulated as replace-on-burnout (ROB) or new construction (NEW) measures.[24] *Michigan 2021-2040 Potential Study Modeling Methodology* (see Appendix C) discusses the approach to equilibrium market share in more detail.

7.3 Behavioral Measures

Behavior measures typically impose little-to-no direct costs to the participant,[25] and their rate of adoption is highly dependent on the marketing and incentive efforts taken by program administrators. Given these unique characteristics of behavior measures, the payback acceptance curves and technology diffusion models have limited applicability to these types of measures. As such, this study models the adoption of behavior measures in terms of an equilibrium saturation level relative to economic potential and a given amount of time to reach that equilibrium state. Behavioral measure equilibrium saturation levels were derived from Guidehouse's discussions with the MPSC and calibrated to about 20%-25% of residential sector electricity and natural gas achievable potential.

7.4 Energy Waste Reduction Investment Strategy

Achievable potential is viewed without imposing any explicit budget constraints on the simulated results. The implication of this decision is that achievable potential is only constrained by stock turnover, customer willingness to adopt efficient measures, and calibration to historical savings levels. Without future budget constraints, the program administrator spending falls out naturally from the input assumptions for per-unit incentives and program administrative cost, without tying spending to a given budget level. In this study, the per-unit incentive and administrative spending levels are fixed at the same levels (in real dollars, compared with nominal dollars) over the study horizon. Therefore, changes in spending (in real dollars) only reflect a changing mix and magnitude of savings among measures.

7.5 Energy Waste Reduction Incentive Strategy

Per MPSC guidance, this study sets measure incentives at 40% of incremental cost for non-low income customer segments for the Reference Scenario. Incentive levels are varied for the Aggressive Scenario, as described in Section 8.1.

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[24] Each of these approaches can be better understood by visiting Guidehouse's technology diffusion simulator, available at: http://forio.com/simulate/navigantsimulations/technology-diffusion-simulation.

[25] Participants may incur indirect costs through implementation of adjustments to typical operations in response to energy information feedback (e.g., through upgrading a water heater). However, estimating these indirect costs requires additional data on the actions taken by the participant beyond participating in the behavioral program and is beyond the scope of this analysis.

7.6 Re-Participation

The model assumes that 100% of program participants re-adopt energy efficient measures after the end of the efficient measure's expected useful lifetimes. This implies that efficient measures generally do not revert to a minimum code or lower efficiency level. As such, the model's cost accounting incurs an incentive cost on the initial conversion of a minimum code or lower efficiency measure to an efficient measure, but it does not incur incentive costs when replacing incumbent equipment that was already updated to efficient equipment during the study horizon. Incremental savings are counted only for new program participants, and these savings are summed up year-over-year to represent cumulative potential.

Behavior measures, such as home energy reports, are an exception to this approach. When a behavior measure is re-adopted at the end of its expected useful lifetime, the incentives provided for those measures are added to total program administrator spending. The rationale is that similar savings opportunities provided by behavior measures are only available with ongoing support or administration from the program administrator. Because ongoing program administrator support is required to achieve behavior measure savings, the incentives provided to repeat adopters are incurred multiple times throughout the study horizon.

7.7 Energy Waste Reduction Model Calibration

Any model simulating future product adoption faces challenges with calibration because there is no future world against which one can compare simulated results to actual results. Engineering models can often be calibrated to a higher degree of accuracy because simulated performance can be compared directly with performance of actual hardware. DSM potential models do not have this luxury. Guidehouse had to rely on other techniques to provide recipient of the model results with a level of comfort that simulated results are reasonable. For this study, we took several steps to ensure that model results were reasonable, including:

- Identifying the subset of potential measures that were included in historical Michigan utilities' program offerings to have a basis for comparison with historical program achievements.
- Ensuring sector-level savings magnitudes in the early years align reasonably with current utility annual achievements and plans. Sector calibration targets were developed through consultation with the MPSC and stakeholder feedback to set an estimated percentage of sales reduction in 2021.
- Ensuring similar trends and magnitudes between the utilities' historical sector- and end use-level savings and simulated sector- and end use-level savings from the measure subset in the model's base year. 2019 historical achievements were used in the calibration refinement process because these results represent the most recent available data at this level of granularity. Separate estimates were developed for the Lower Peninsula and Upper Peninsula.
- Studying draft results with stakeholders to identify trends, high impact measure mixes, and savings trajectories for review at a more granular level than the sector and end-use calibration. This review resulted in significant assumption updates to high impact measures including residential screw-based lighting and C&I custom.

Before making comparisons of model results to historical achievements, it was first necessary to identify the potential measures included in the utilities' historical program offerings. The simulated savings from this subset of potential measures became the basis for comparing modeled savings to historical savings during the calibration process. Although the team calibrated to historical results for this subset of measures, the model's results for total achievable potential may differ from the utilities' historically achieved program savings. This situation is due to the iterative process for achievable potential review and addition of new measures and competition groups to the portfolio. The subset measure calibration step is an important starting point for calibration; this step is built to account for the differences in measure mix between the potential study and historical DSM programs. Guidehouse and the MPSC designed a detailed measure list of the top 110 measures, which account for the vast majority of cost-effective savings. To account for the other measures, Guidehouse created measure buckets by sector and end use based on our other previously completed studies as described in Section 4.1.

To align as close as possible with the utilities' historical savings, we adjusted technology diffusion coefficients and payback acceptance curves. Calibration required an iterative process of modifying the aforementioned parameters until all goals of calibration were reasonably satisfied. For example, the marketing effectiveness parameters are the key lever for calibrating the magnitude of historical savings for each sector and end-use combination, the word-of-mouth parameter strongly influences the rate of adoption and savings growth over time, and the measure-level payback acceptance curves allow for detailed calibration of high impact measures with significant historical data to support granular review. Guidehouse varied these diffusion parameters within commonly observed ranges until simulated savings were trending reasonably compared with historical sector-level savings.

To summarize, the calibration process ensures that the potential analysis is grounded against real-world data considering the many factors that determine likely adoption of DSM measures, including economic and non-economic factors.

8. Energy Waste Reduction Scenario Configuration Approach

The Reference Scenario was developed through the calibration process, as detailed in Section 7.7. Two alternative scenarios—the Aggressive Scenario and the Carbon Price Scenario—were developed through adjustments to incentive levels, administrative burdens, marketing effects, and avoided costs.

8.1 Scenario Configuration

Guidehouse developed two alternative achievable scenarios and seven sensitivity cases relative to the Reference Scenario.

The two scenarios are as follows:

- **Aggressive Scenario**
    - Analyzed measure incentive levels to determine the 1.0 UCT tipping point. Developed measure-level incentive estimates based on these results, and tweaked where necessary to ensure program-level cost-effectiveness.
        - This adjustment models a more optimized incentive strategy that results in higher spending and reduced alignment with detailed calibration, while maintaining a cost-effective program UCT.
    - Increased marketing factors above calibrated values for specific end use and sector combinations.
        - This adjustment estimates an increase in marketing effectiveness and implementation of program design enhancements, while not increasing the relative administrative cost burden of programs.
- **Carbon Price Scenario**
    - Increased electricity ($/MWh) and natural gas ($/therm) avoided costs by 50% in 2021, escalating with a 2.5% multiplier growth until a 100% increase was met.
        - This adjustment acknowledges regulatory uncertainty around carbon price legislation with a high level adder, ramping up through time as probability of regulatory action increases.

9. Energy Waste Reduction Achievable Potential Results

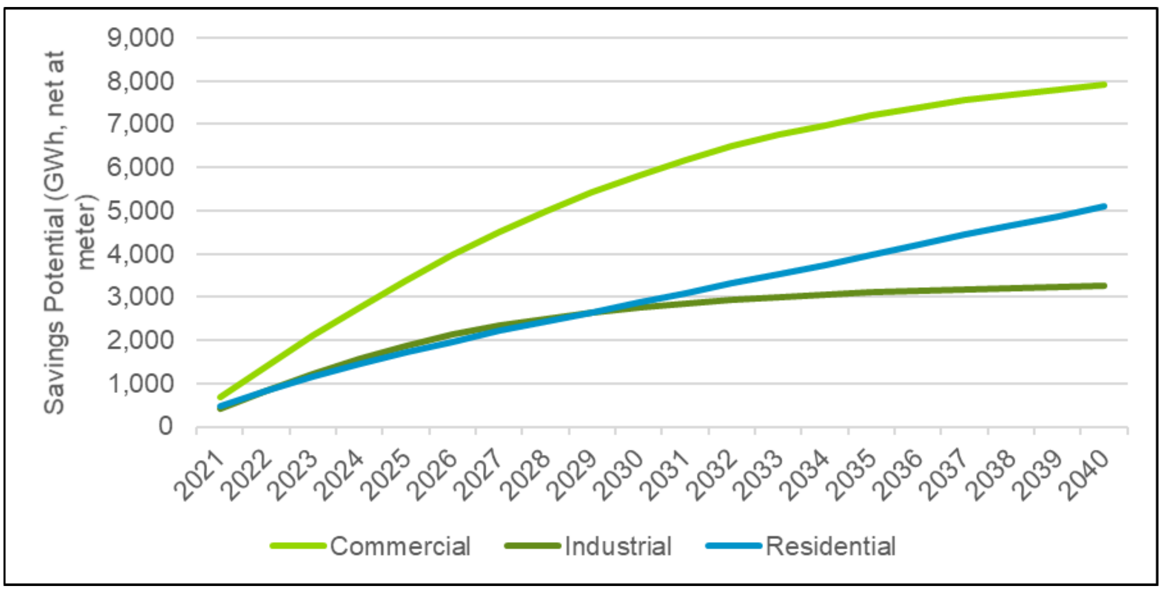
This section provides the achievable potential results calculated by the model at varying levels of aggregation, using the UTC benefit-cost test as a screen set to 0.80 for most measures, with the exception of the end use bucket measures and unidentified future technologies which bypass the UCT requirement, but are calibrated to account for technologies that may not produce economic savings. At the meter net savings results are shown by sector, end-use category, and by highest impact measures. For more detail and levels of aggregation of achievable potential, including summaries for the Aggressive and Carbon Price Scenarios, see Appendix D.

9.1 Reference Scenario Energy Waste Reduction Achievable Potential Results by Sector

Figure 9-1 shows the reference case cumulative annual electricity achievable savings potential, net at meter, for all sectors in the Lower Peninsula. The commercial sector makes up the largest portion of achievable savings of all the sectors, though it begins to flatten by the end of the study period. The residential potential remains steady throughout, while industrial savings flattens relatively quickly.

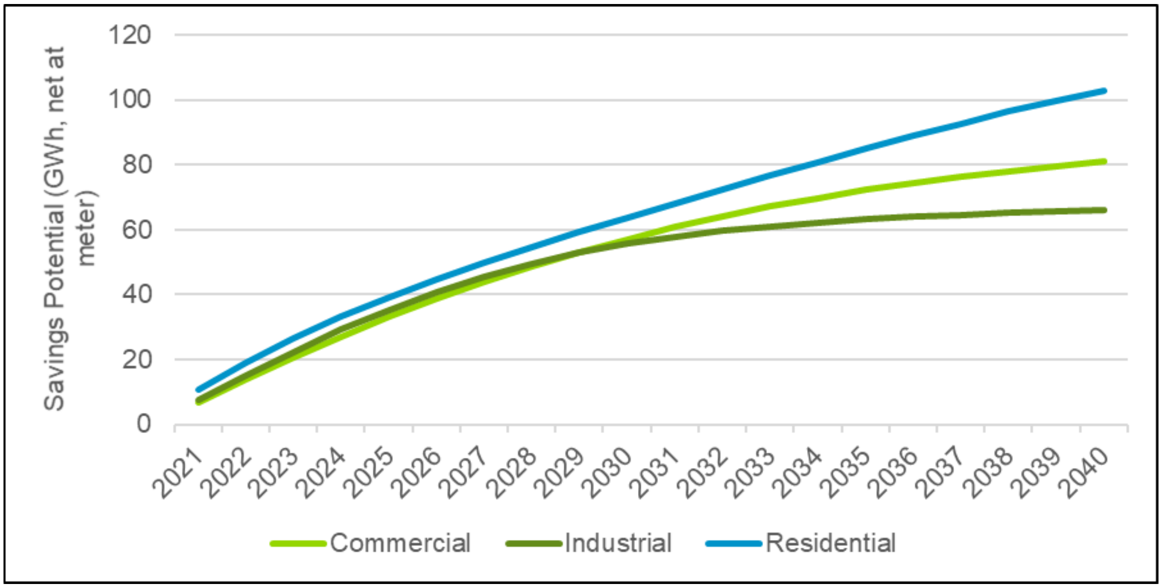
Figure 9-2 shows the reference case cumulative annual electricity achievable savings potential, net at meter, for all sectors in the Upper Peninsula. Due to the different make up of customer stocks in the Upper Peninsula, the residential sector makes up the largest percentage of the Upper Peninsula potential.

Figure 9-1. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Electricity Savings by Sector (GWh, Net at Meter)



Source: Guidehouse analysis

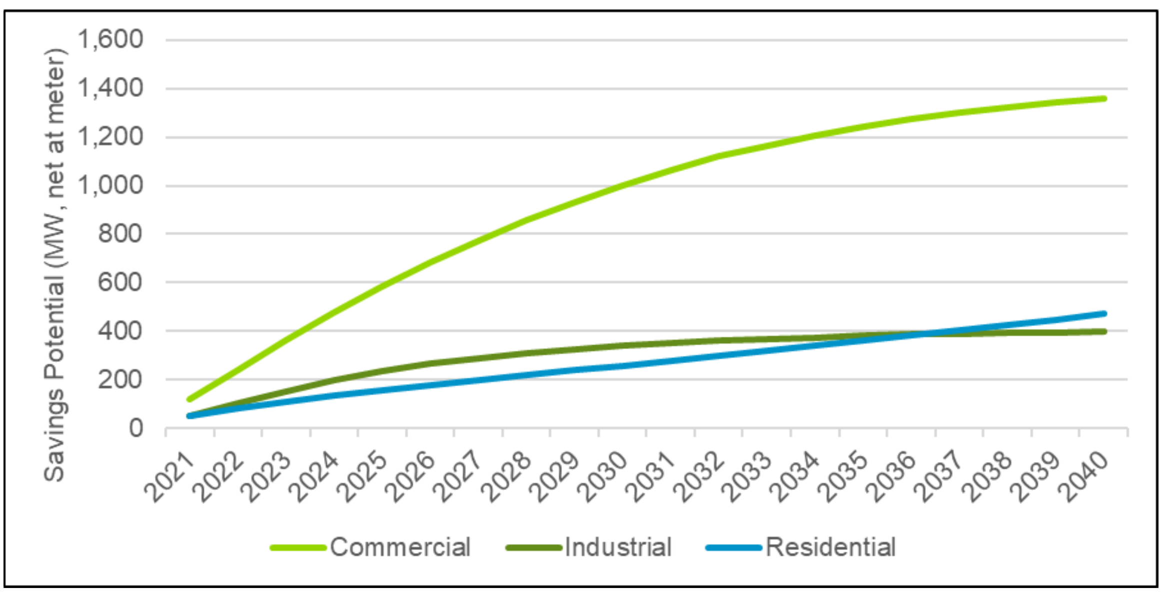
Figure 9-2. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Electricity Savings by Sector (GWh, Net at Meter)



Source: Guidehouse analysis

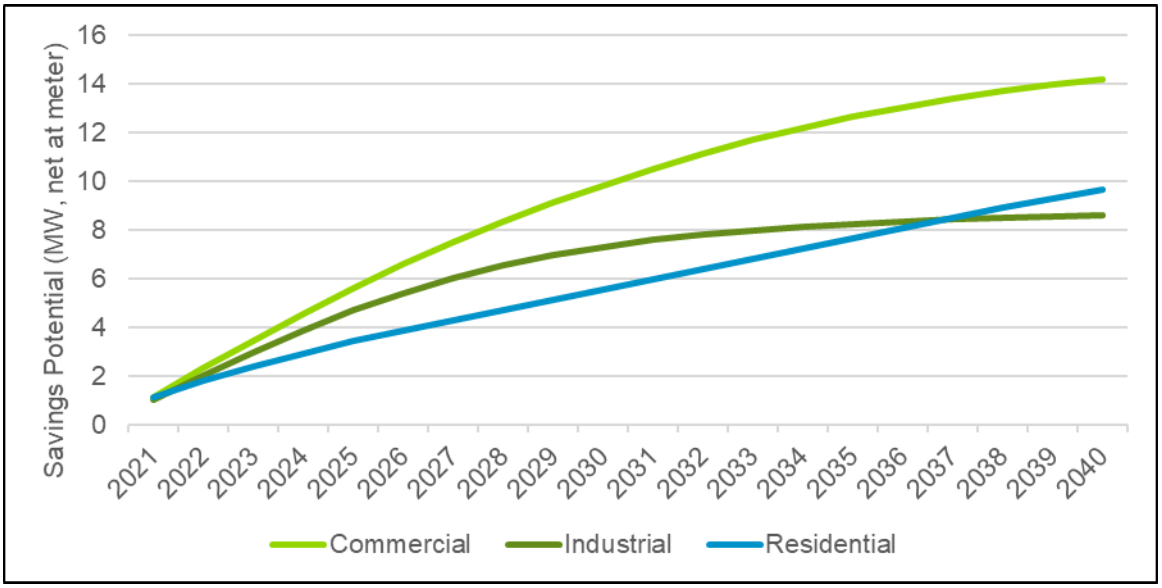
Figure 9-3 shows the reference case cumulative summer peak demand achievable potential, net at meter, by scenario for all sectors in the Lower Peninsula. Figure 9-4 shows the reference case cumulative summer peak demand achievable potential, net at meter, by scenario for all sectors in the Upper Peninsula. For peak demand, in both the Lower and Upper Peninsulas, commercial makes up the largest percentage of savings due to commercial's high coincidence with system peaks.

Figure 9-3. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Summer Peak Demand Savings by Sector (MW, Net at Meter)



Source: Guidehouse analysis

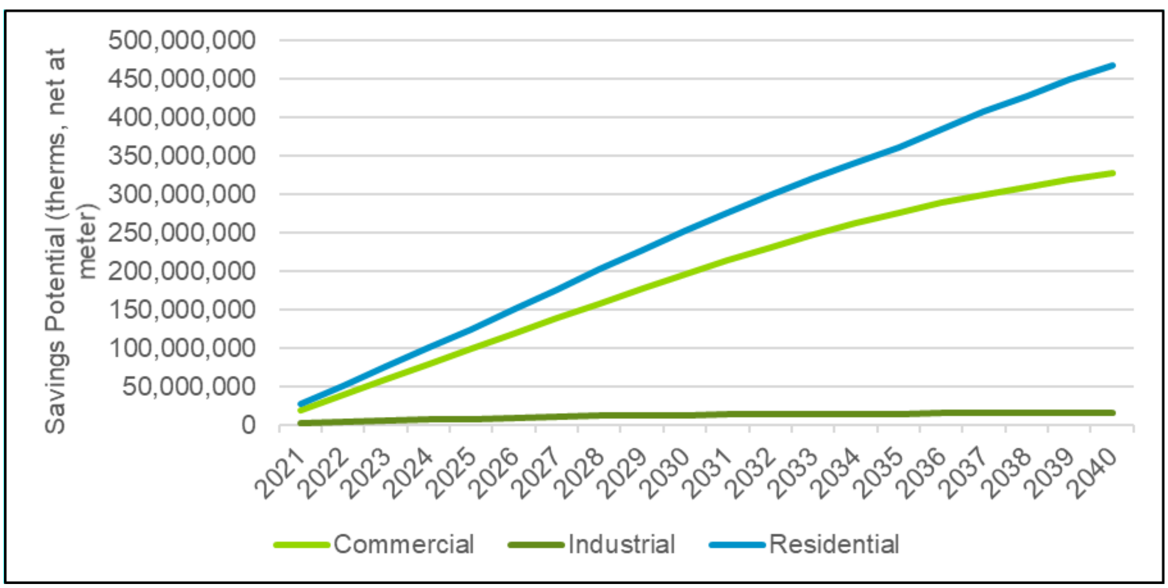
Figure 9-4. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Summer Peak Demand Savings by Sector (MW, Net at Meter)



Source: Guidehouse analysis

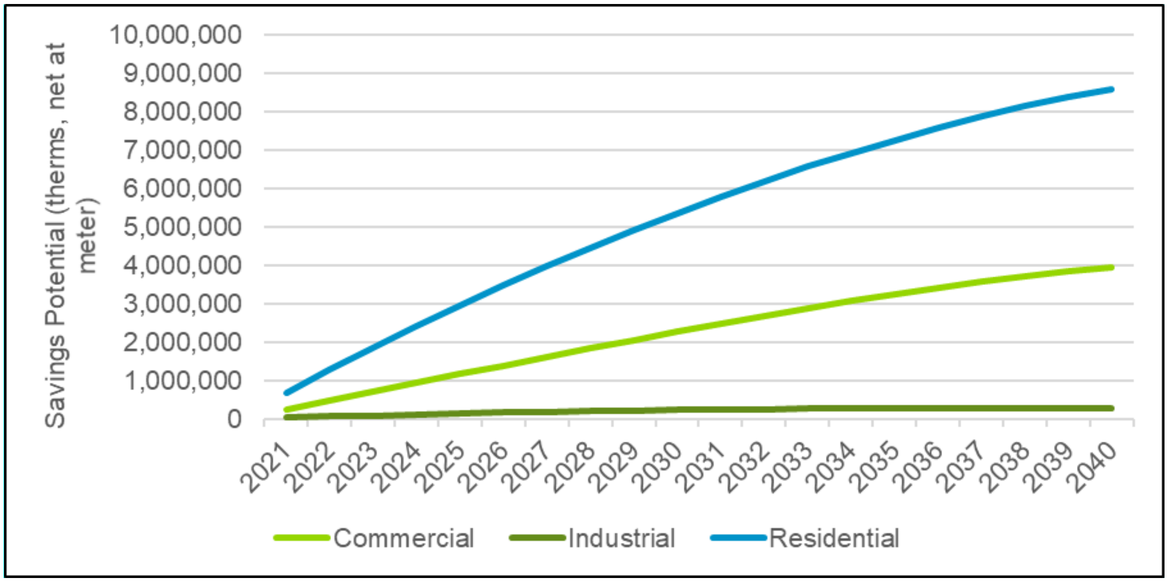
Figure 9-5 shows the reference case cumulative natural gas achievable potential, net at meter, by scenario for all sectors in the Lower Peninsula. Figure 9-6 shows the reference case cumulative natural gas achievable potential, net at meter, by scenario for all sectors in the Lower Peninsula. Residential gas energy savings makes up the highest percentage of savings for both peninsulas due to the high saturation of natural gas in residential homes.

Figure 9-5. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Natural Gas Savings by Sector (therms, Net at Meter)



Source: Guidehouse analysis

Figure 9-6. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Natural Gas Demand Savings by Sector (therms, Net at Meter)

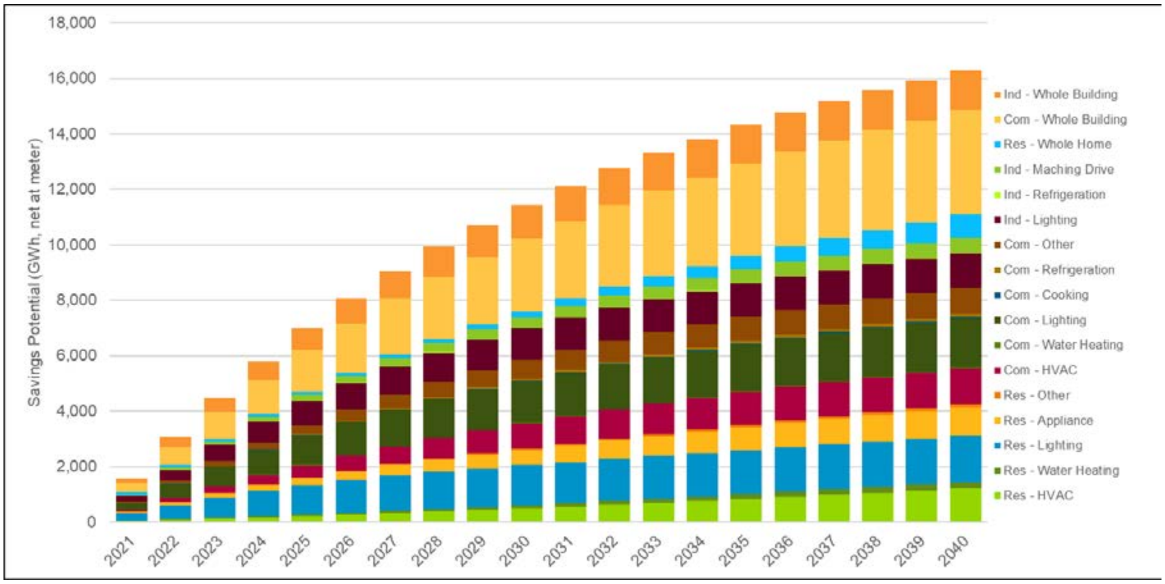


Source: Guidehouse analysis

9.2 Reference Scenario Energy Waste Reduction Achievable Potential Results by End Use

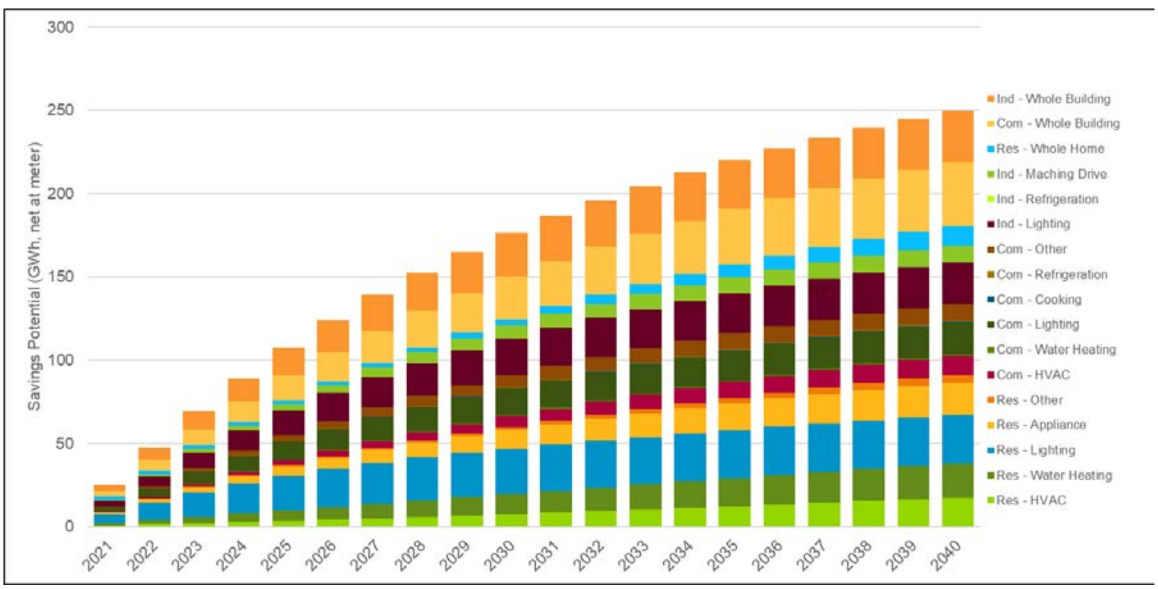
Figure 9-7 shows the incremental annual electricity achievable potential, net at meter, across end uses in the Lower Peninsula. Figure 9-8 shows the incremental annual electricity achievable potential, net at meter, across end uses in the Upper Peninsula. In the Lower and Upper Peninsulas, lighting and custom (within the whole building end uses) dominate the early years' potential. However, by the later years, lighting remains relatively flat, indicating it has saturated out and other end uses, such as HVAC and whole building/home, become much larger portions of the overall savings potential.

Figure 9-7. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Electricity Savings by End Use (GWh, Net at Meter)



Source: Guidehouse analysis

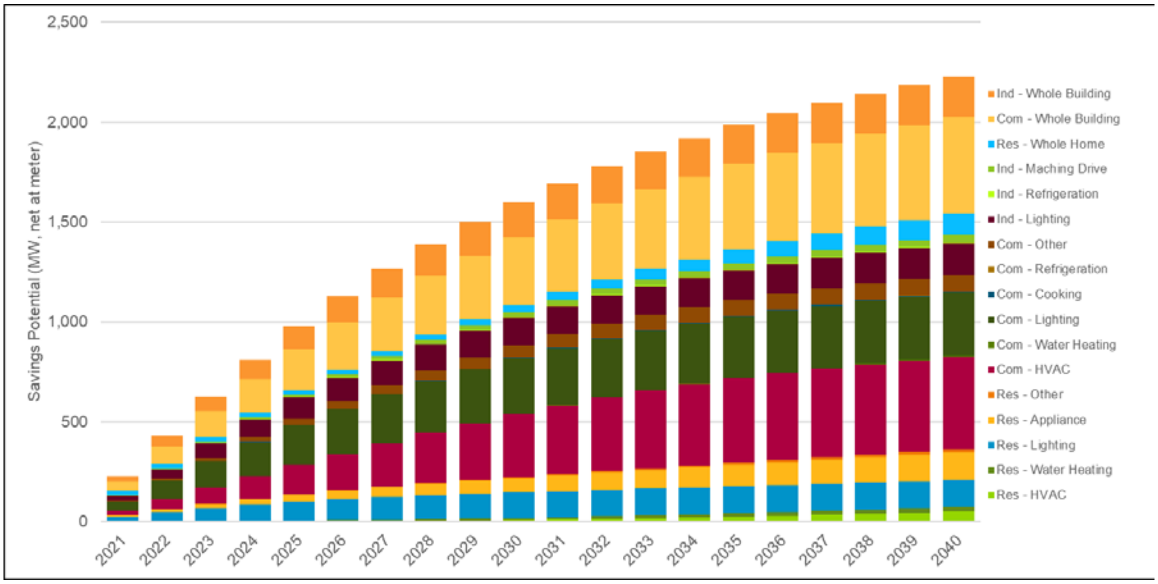
Figure 9-8. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Electricity Savings by End Use (GWh, Net at Meter)



Source: Guidehouse analysis

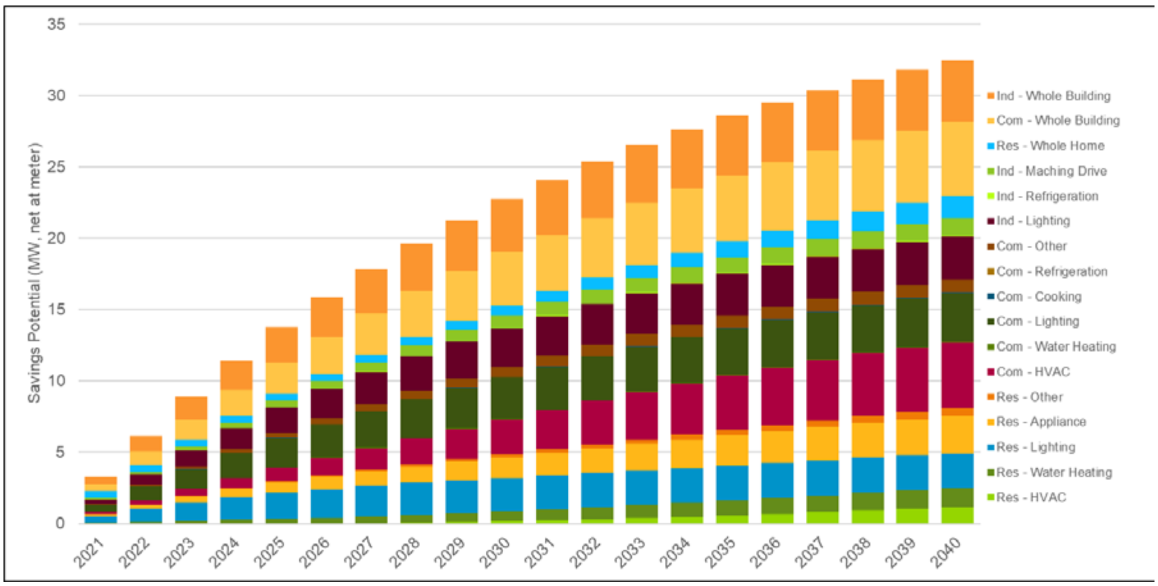
Figure 9-9 shows the cumulative summer peak demand achievable potential, net at meter, across end uses in the Lower Peninsula. Figure 9-10 shows the cumulative summer peak demand achievable potential, net at meter, across end uses in the Upper Peninsula. In both figures, the dominant end uses are commercial HVAC, commercial lighting, and commercial whole building, all of which have a high peak coincidence.

Figure 9-9. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Summer Peak Demand Savings by End Use (MW, Net at Meter)



Source: Guidehouse analysis

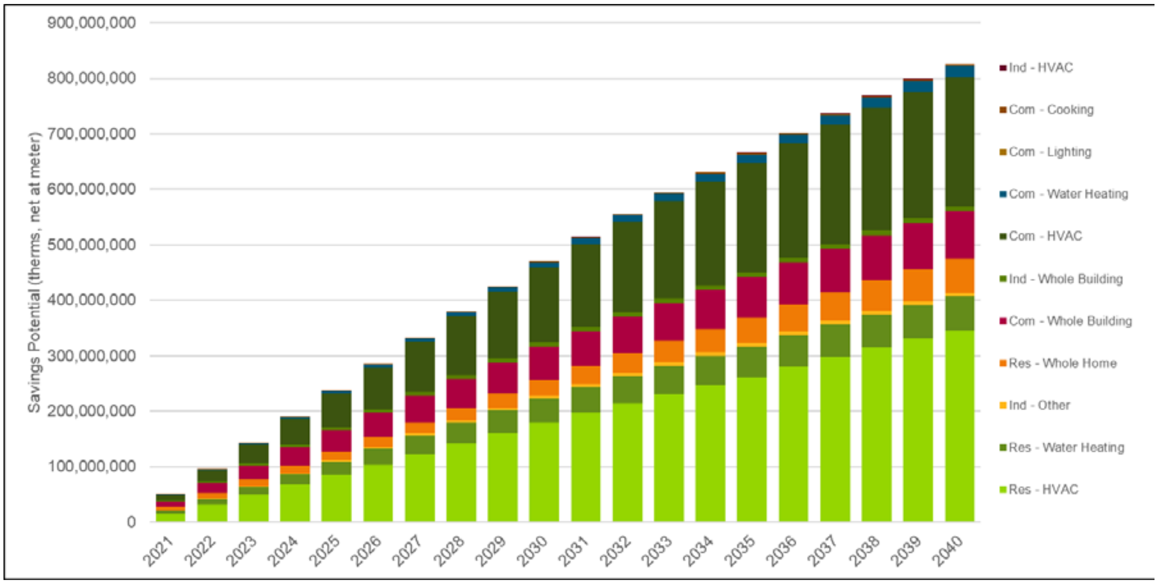
Figure 9-10. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Summer Peak Demand Savings by End Use (MW, Net at Meter)



Source: Guidehouse analysis

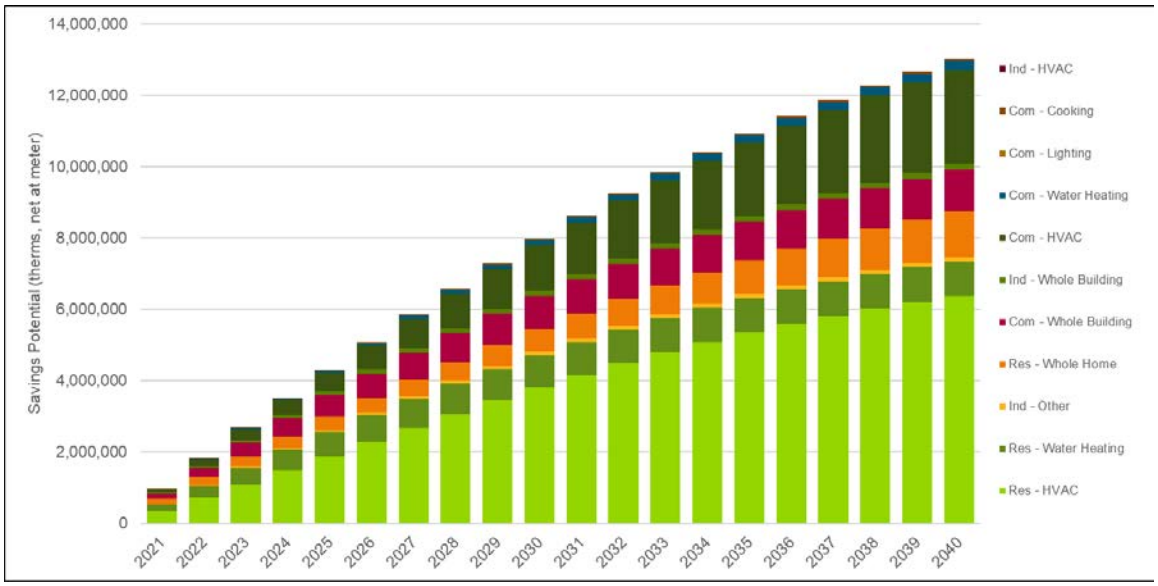
Figure 9-11 shows the incremental natural gas net achievable potential across end uses in the Lower Peninsula. Figure 9-12 shows the incremental natural gas net achievable potential across end uses in the Upper Peninsula. The dominant end uses are residential HVAC, commercial HVAC, and commercial whole building.

Figure 9-11. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Natural Gas Savings by End Use (therms, Net at Meter)



Source: Guidehouse analysis

Figure 9-12. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Natural Gas Savings by End Use (therms, Net at Meter)

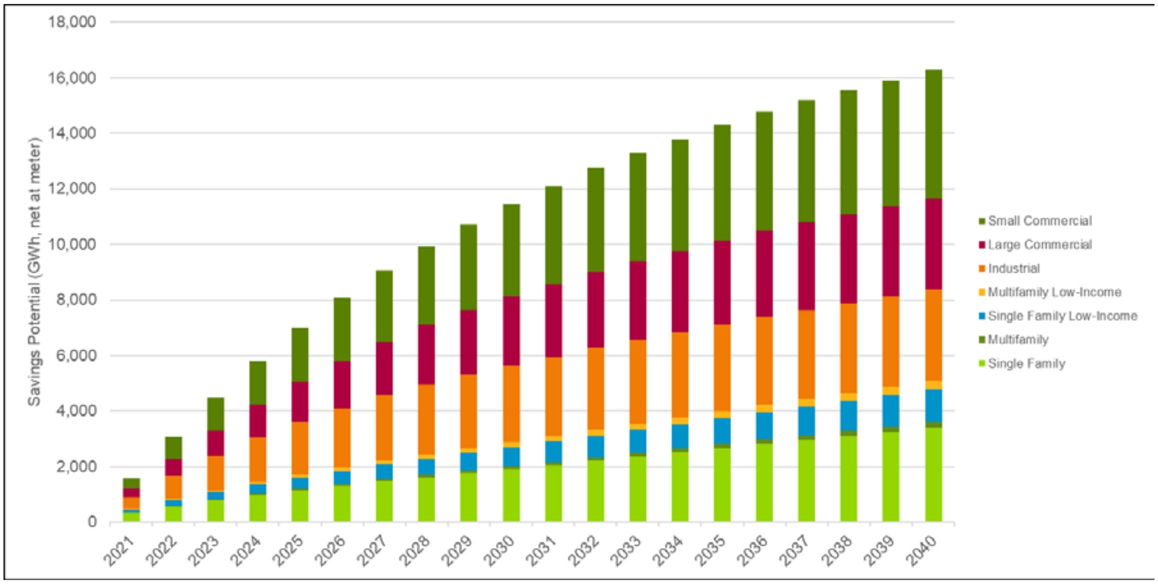


Source: Guidehouse analysis

9.3 Reference Scenario Energy Waste Reduction Potential Results by Customer Segment

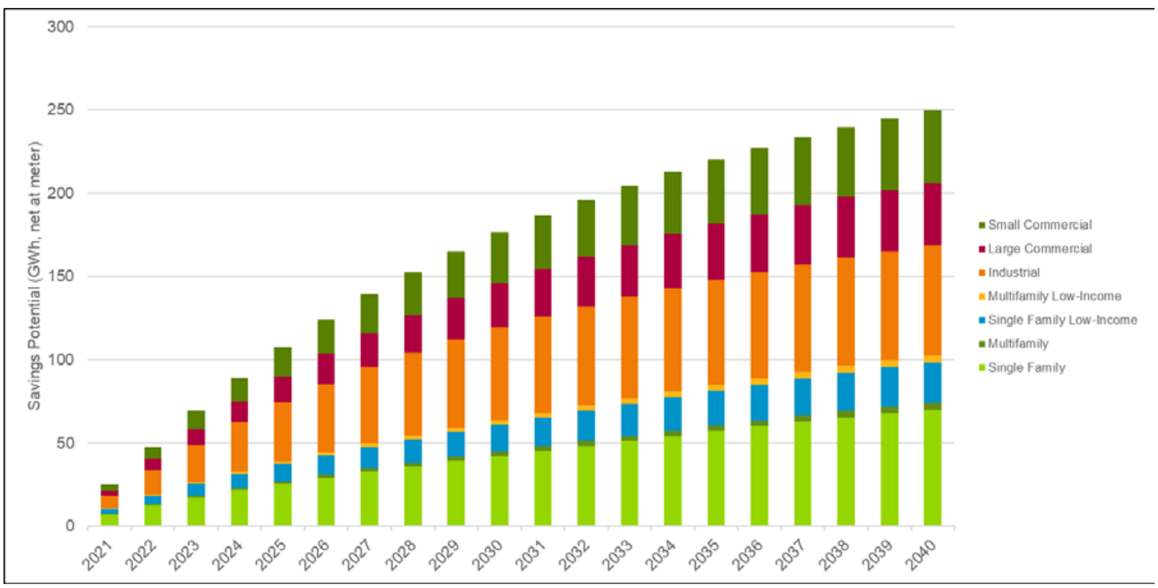
Figure 9-13 shows the cumulative electricity achievable potential, net at meter, across customer segments in the Lower Peninsula. Figure 9-14 shows the cumulative electricity achievable potential, net at meter, across customer segments in the Upper Peninsula. Small commercial represents the highest savings potential segment in the Lower Peninsula, while industrial represents the highest savings potential segment in the Upper Peninsula. In both peninsulas, multifamily and multifamily – low income represent the lowest portion of savings. Additional detail and tabular data for customer segment-level results are provided in Appendix D.

Figure 9-13. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Electricity Savings by Customer Segment (GWh, Net at Meter)



Source: Guidehouse analysis

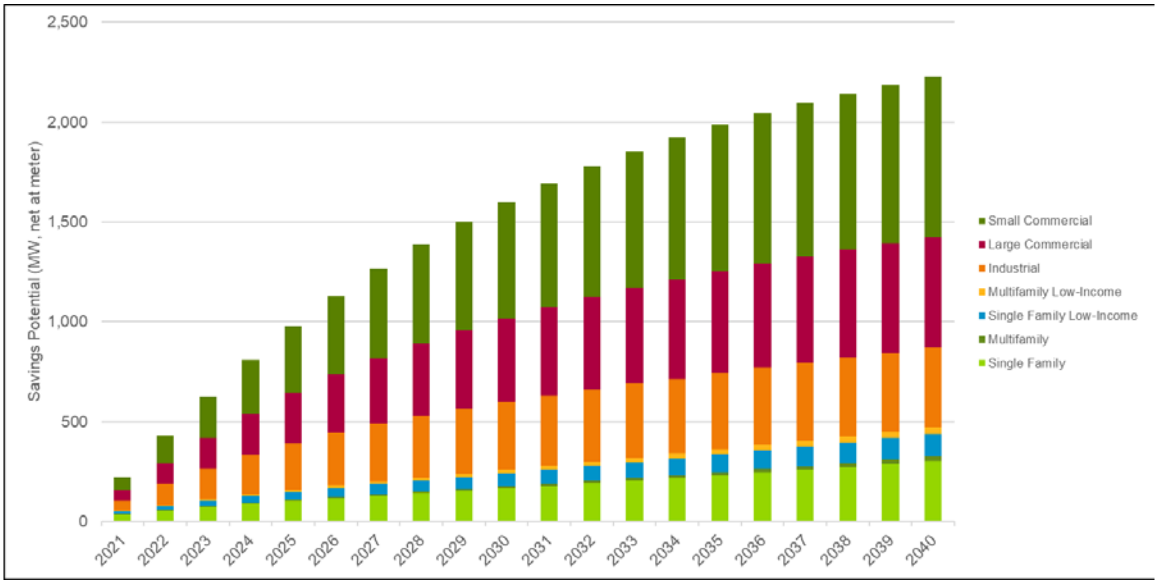
Figure 9-14. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Electricity Savings by Customer Segment (GWh, Net at Meter)



Source: Guidehouse analysis

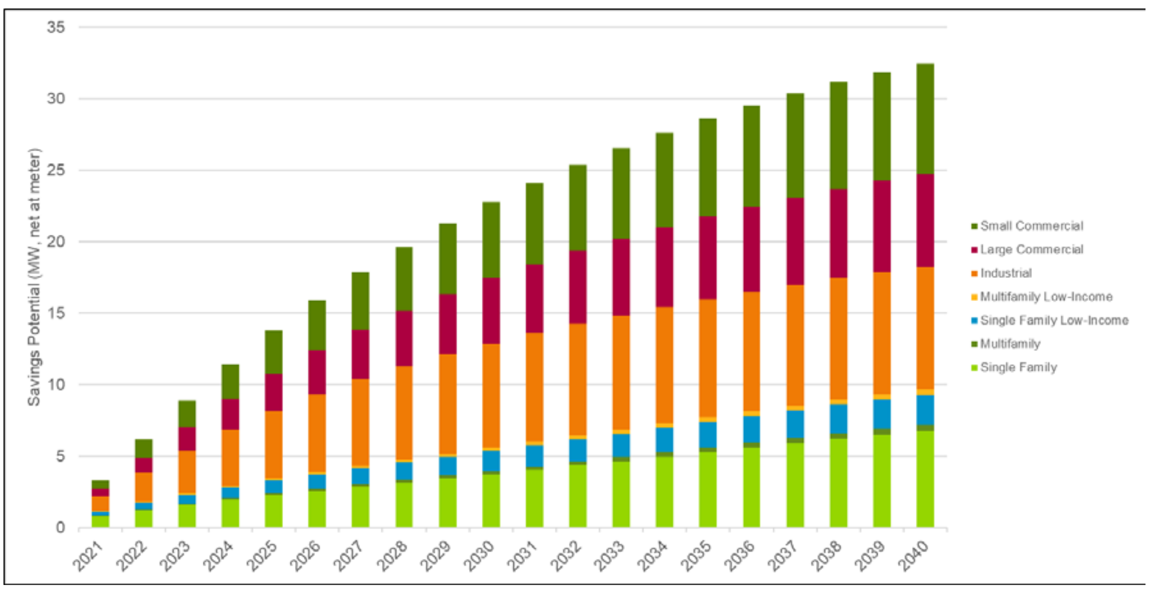
Figure 9-15 shows the cumulative summer peak demand achievable savings potential, net at meter, across customer segments in the Lower Peninsula. Figure 9-16 shows the cumulative summer peak demand achievable savings potential, net at meter, across customer segments in the Upper Peninsula. The segment-level patterns are generally the same for electricity savings for both peninsulas. Additional detail and tabular data for customer segment-level results are provided in Appendix D.

Figure 9-15. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Summer Peak Demand Savings by Customer Segment (MW, Net at Meter)



Source: Guidehouse analysis

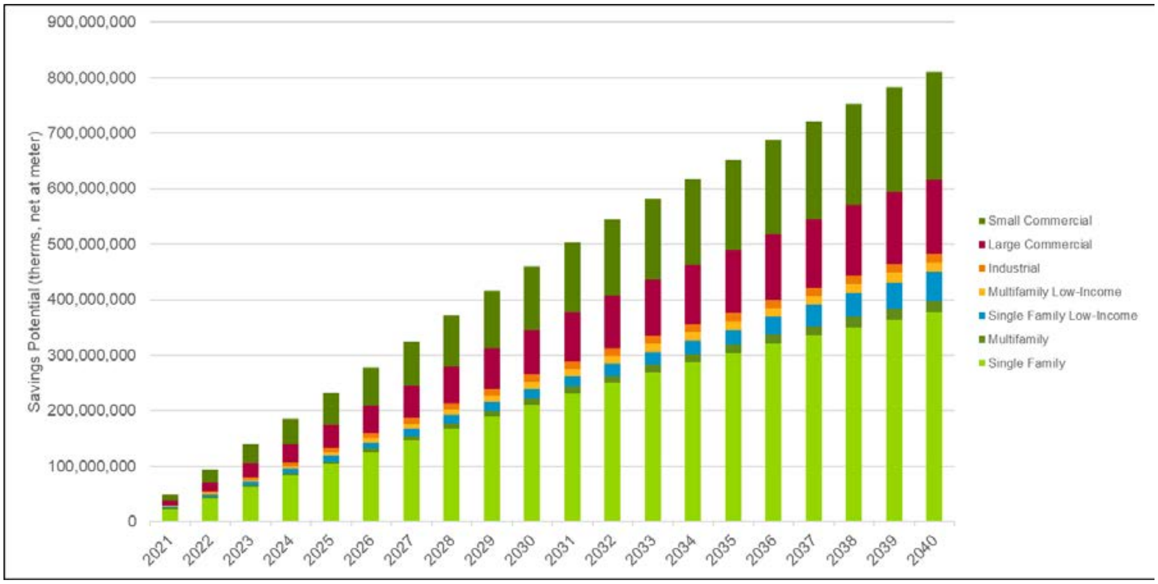
Figure 9-16. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Summer Peak Demand Savings by Customer Segment (MW, Net at Meter)



Source: Guidehouse analysis

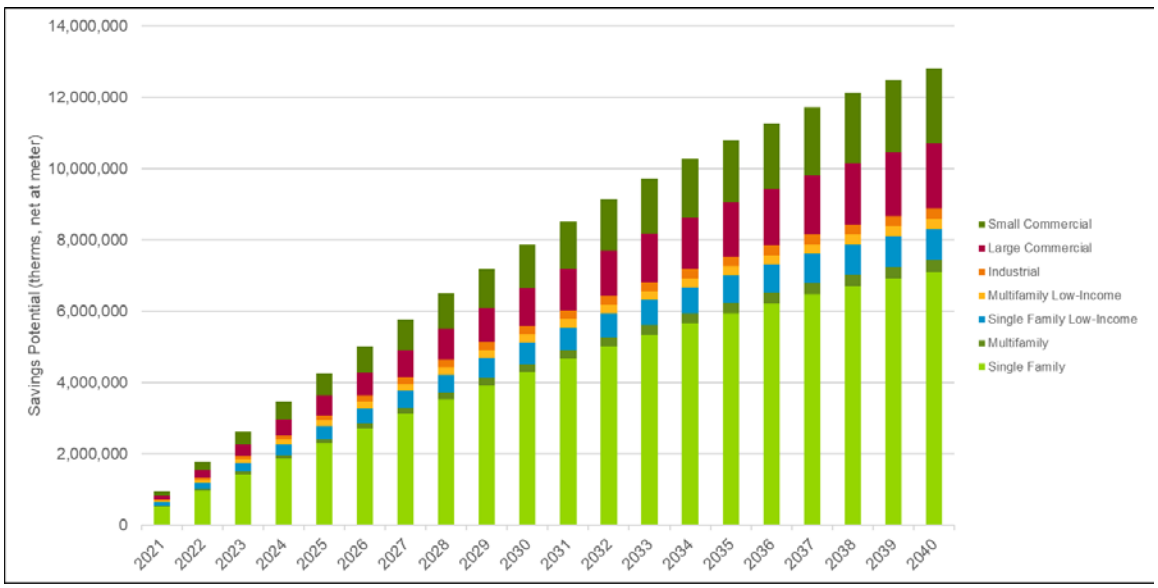
Figure 9-17 and Figure 9-18 show the cumulative net natural gas achievable potential across customer segments for the Lower and Upper Peninsulas, respectively. Unlike electricity savings, residential single-family dominates the savings potential for natural gas in both peninsulas. Additional detail and tabular data for customer segment-level results are provided in Appendix D.

Figure 9-17. Lower Peninsula EWR Cumulative Achievable Potential, Incremental Annual Natural Gas Savings by Customer Segment (therms, Net at Meter)



Source: Guidehouse analysis

Figure 9-18. Upper Peninsula EWR Cumulative Achievable Potential, Incremental Annual Natural Gas Savings by Customer Segment (therms, Net at Meter)

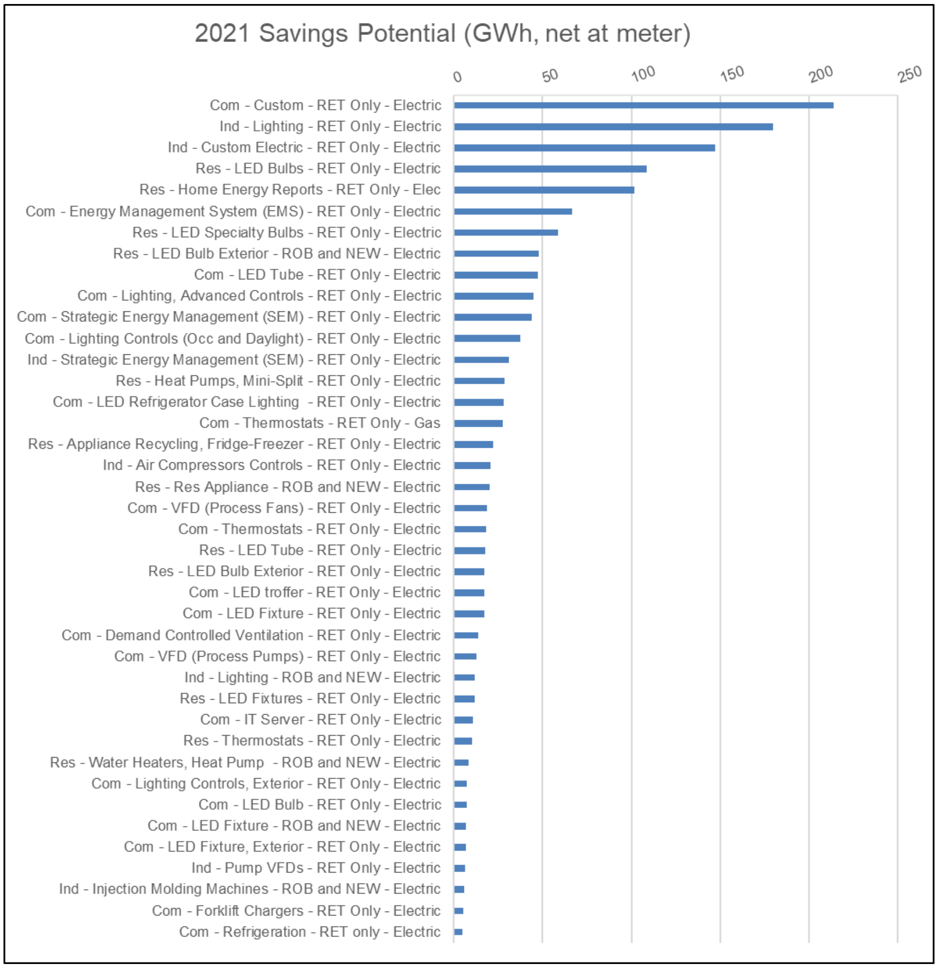


Source: Guidehouse analysis

9.4 Reference Scenario Energy Waste Reduction Potential Results by Measure

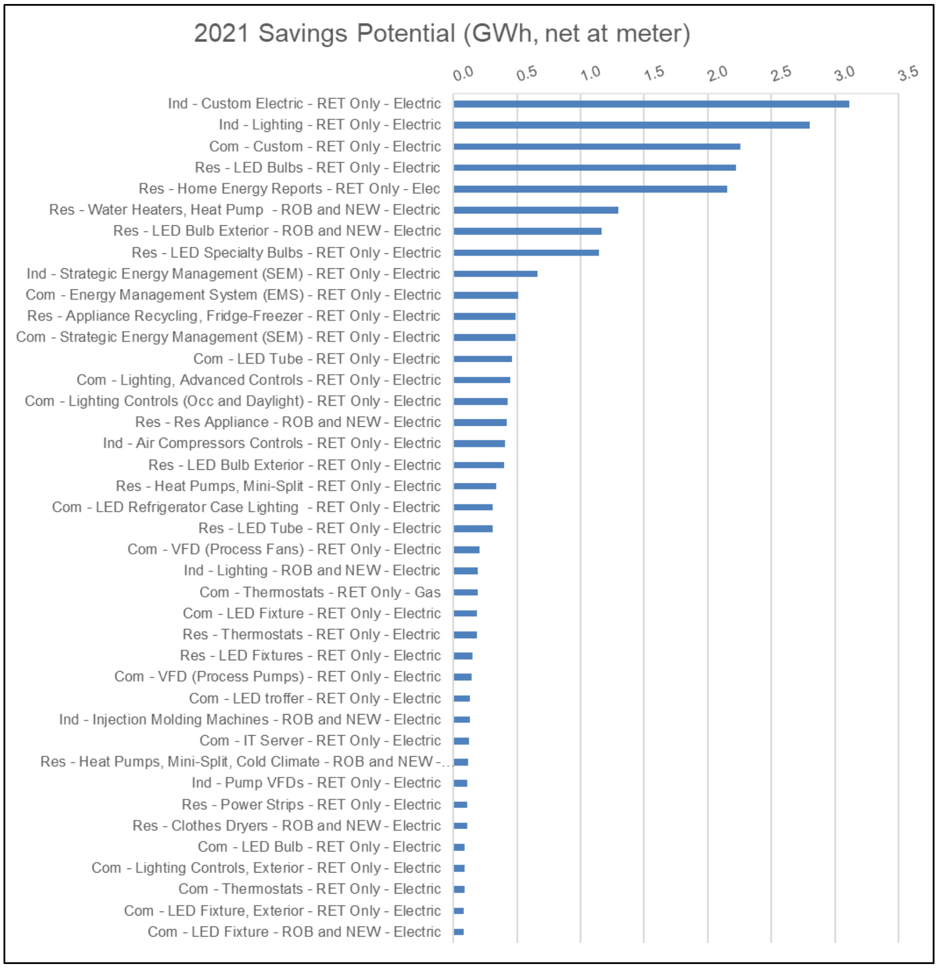
Figure 9-19 and Figure 9-20 show the top electricity-saving measures, net at meter, in 2021 for the Lower and Upper Peninsulas, respectively. In both cases, annual savings are dominated by custom, lighting, and home energy reports, making up approximately 50% of the savings in 2021. This trend does not continue throughout the study period, as both lighting and custom measures become saturated and measure mix changes.

Figure 9-19. Lower Peninsula EWR Achievable Potential, 2021 Top Measures for Electricity Savings (GWh, Net at Meter)



Source: Guidehouse analysis

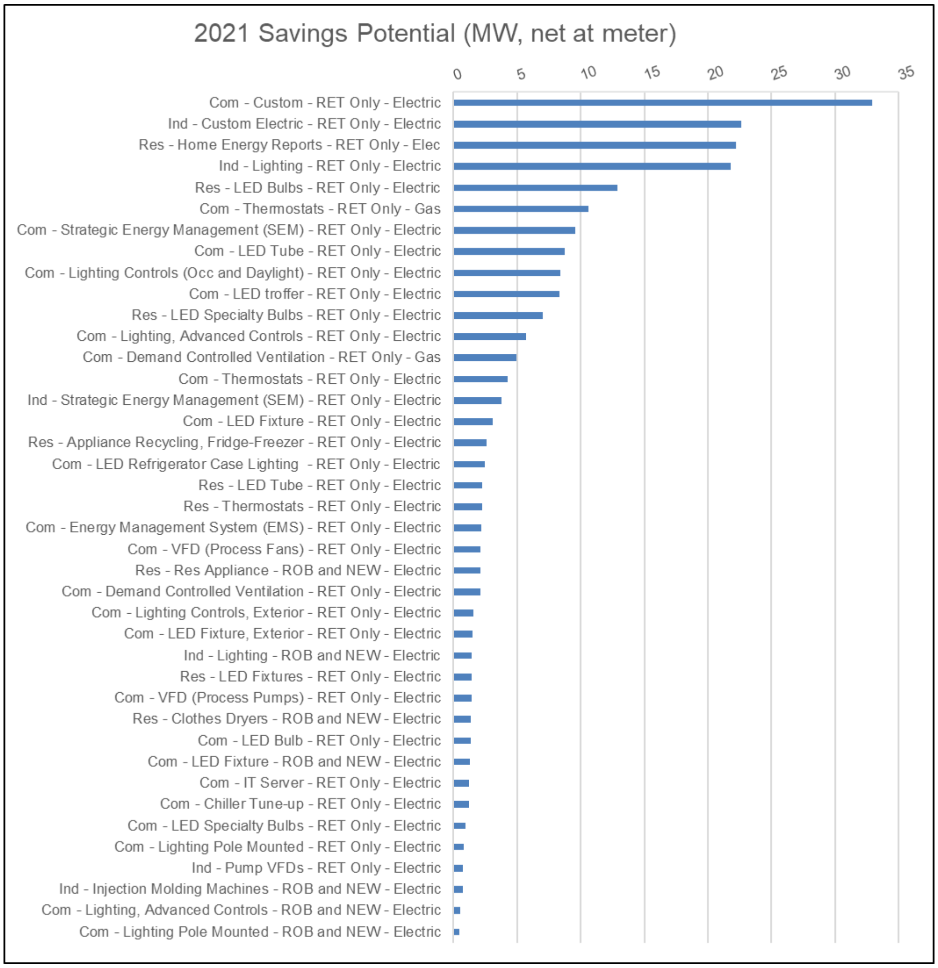
Figure 9-20. Upper Peninsula EWR Achievable Potential, 2021 Top Measures for Electricity Savings (GWh, Net at Meter)



Source: Guidehouse analysis

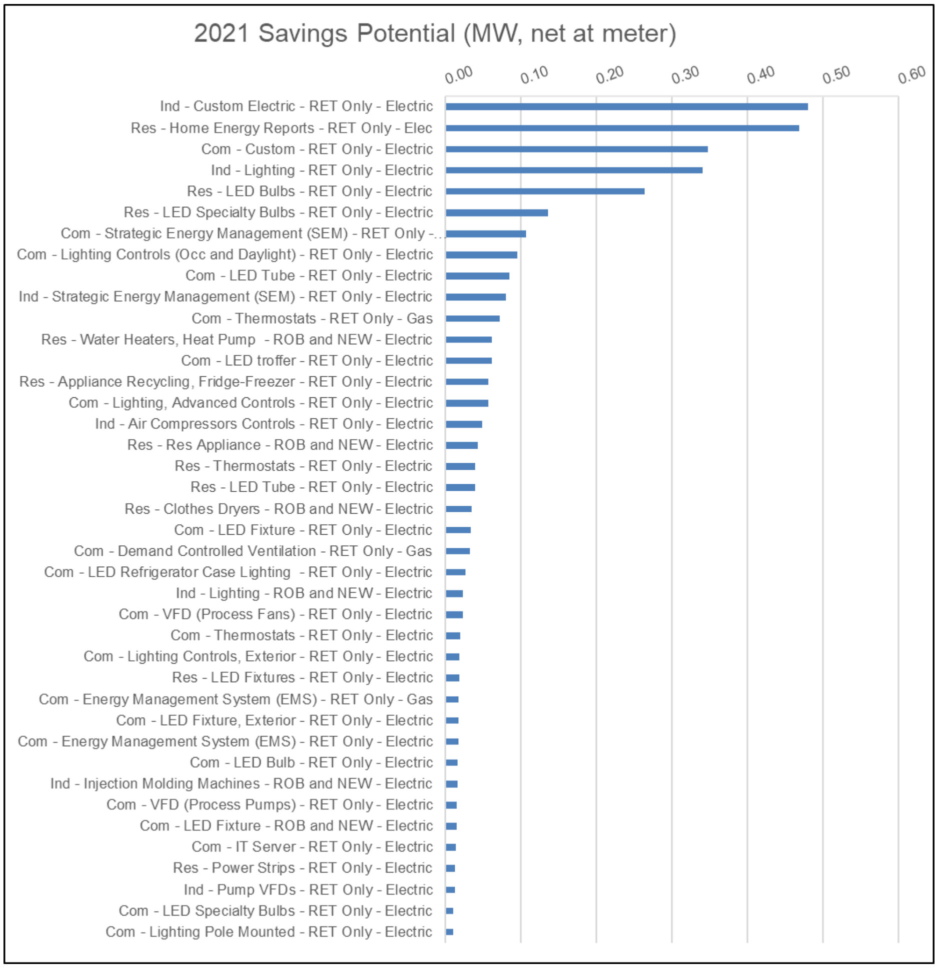
Figure 9-21 and Figure 9-22 show that the top summer peak demand savings measures, net at meter, in 2021 are dominated by the same measures as electricity savings for the Lower and Upper Peninsulas, respectively.

Figure 9-21. Lower Peninsula EWR Achievable Potential, 2021 Top Measures for Summer Peak Demand Savings (MW, Net at Meter)



Source: Guidehouse analysis

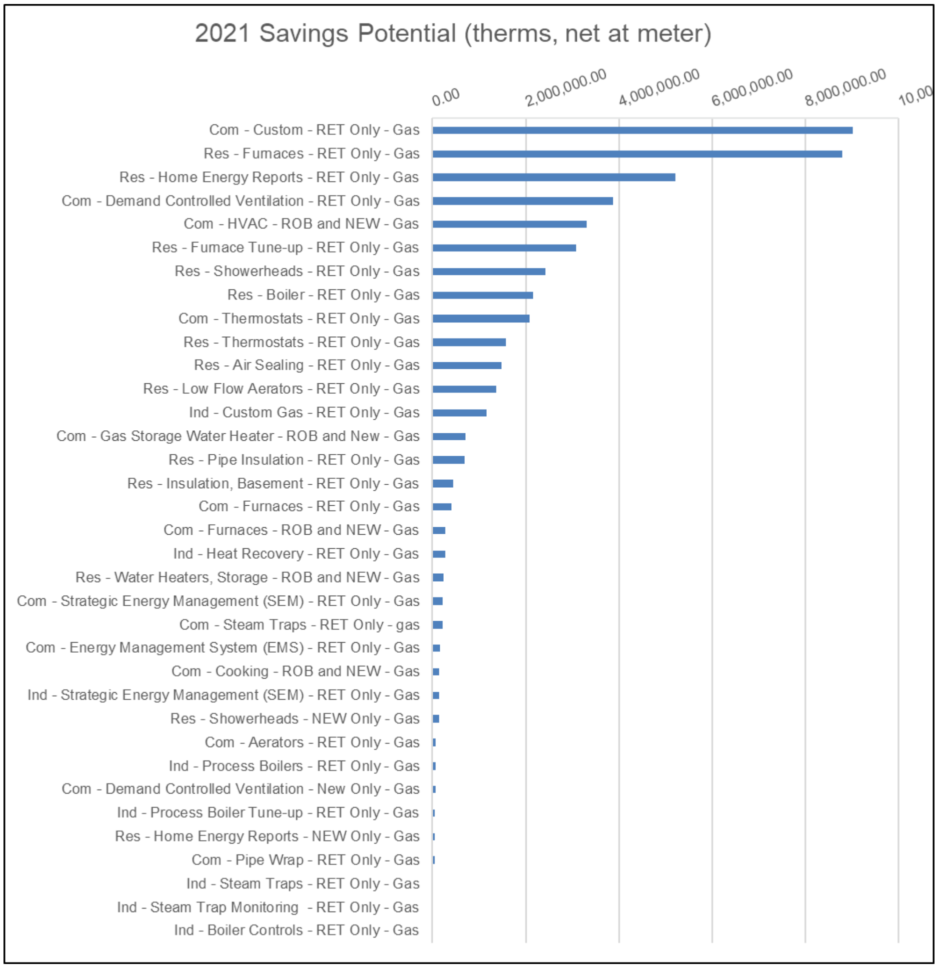
Figure 9-22. Upper Peninsula EWR Achievable Potential, 2021 Top Measures for Summer Peak Demand Savings (MW, Net at Meter)



Source: Guidehouse analysis

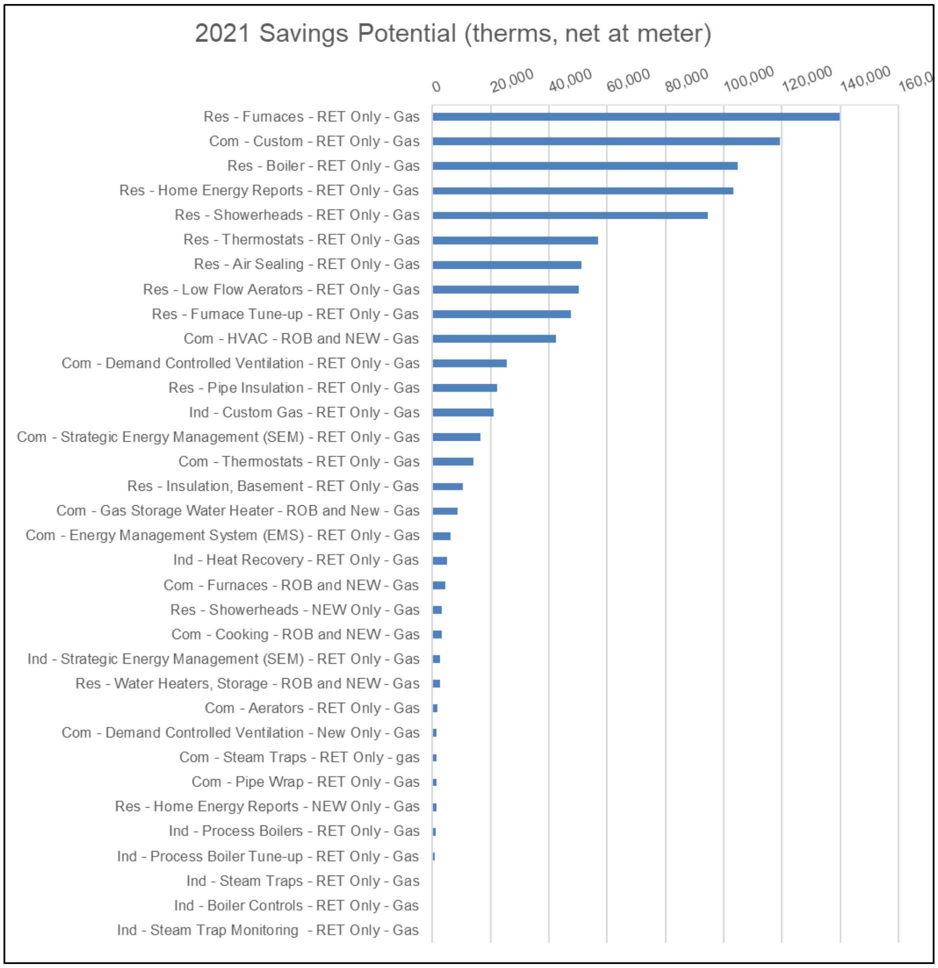
Figure 9-23 and Figure 9-24 show the top natural gas savings measures in 2021 for the Lower and Upper Peninsulas, respectively. The top two measures are the same for both peninsulas, just in different orders, with commercial custom as the top saving measure in the Lower Peninsula, and residential furnaces as the top saving measure in the Lower Peninsula.

Figure 9-23. Lower Peninsula EWR Achievable Potential, 2021 Top Measures for Natural Gas Savings (therms, Net at Meter)



Source: Guidehouse analysis

Figure 9-24. Upper Peninsula EWR Achievable Potential, 2021 Top Measures for Natural Gas Savings (therms, Net at Meter)



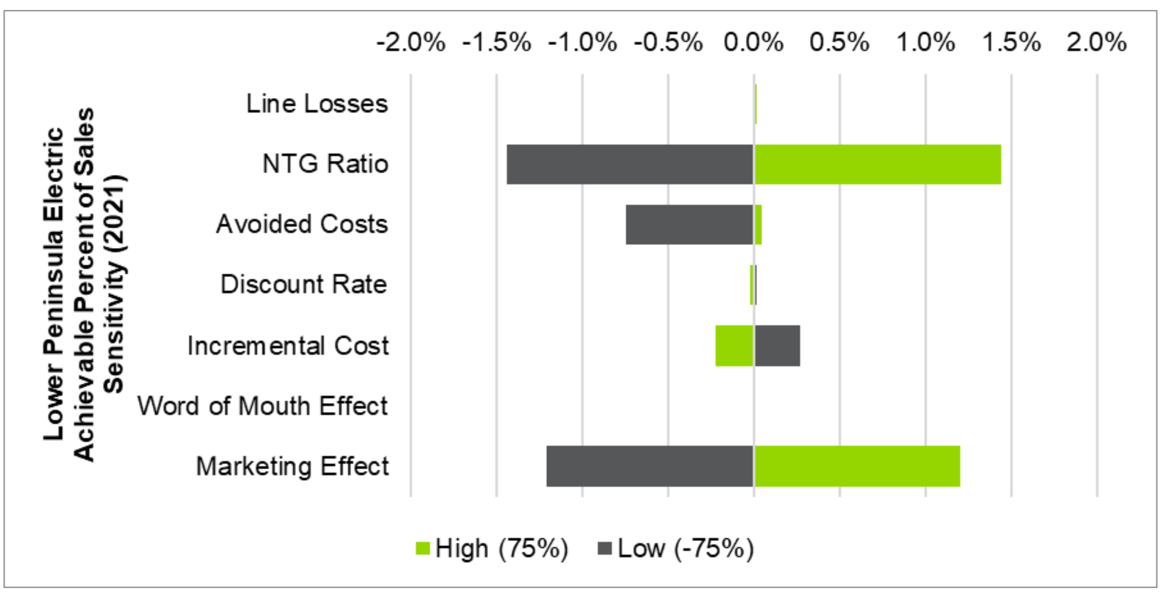
Source: Guidehouse analysis

9.5 Reference Case Sensitivity Analysis

Guidehouse conducted a parametric sensitivity analysis on the incremental achievable electricity and natural gas savings potential in the first year of the study period to evaluate the response of the Reference Scenario to changes in key potential model inputs. To determine the sensitivity of the results to seven input variables, we varied each parameter by +/-75% from base model values. Because the model has multiple non-linear components, the effects of varying a parameter is often asymmetrical. For each sensitivity, all other variables were held constant, allowing individual effects to be observed. In the interpretation of the following figures it is important to note the directionality of the +75% and -75% bars. Some variables modeled show an increase in potential when the variable is increased (e.g., NTG ratio), and some variables show a decrease in potential when increased (e.g., incremental cost).

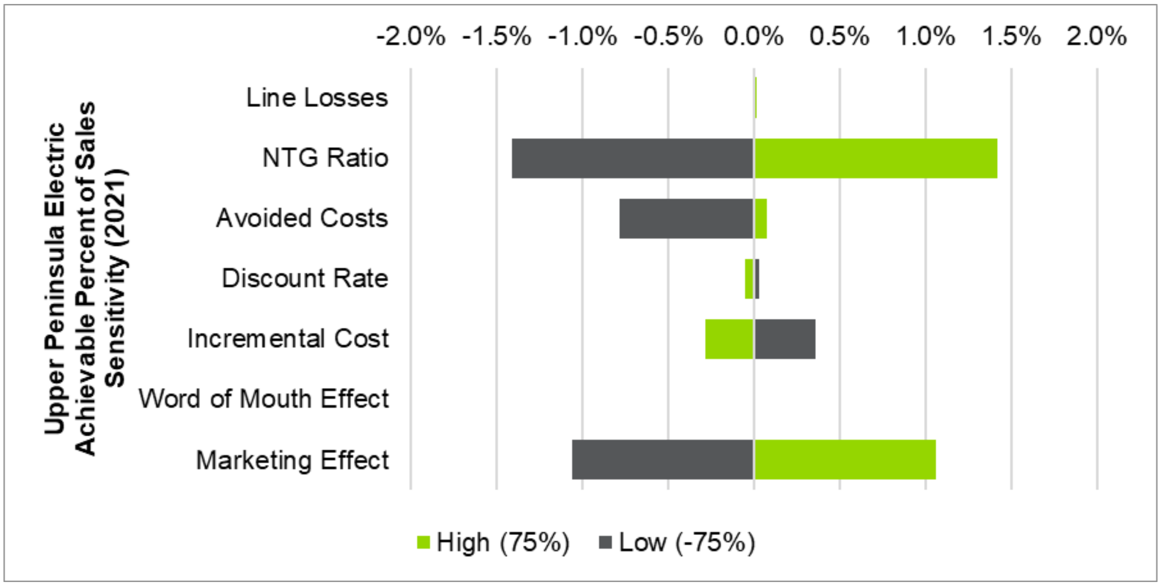
Figure 9-25 and Figure 9-26 show that of the seven parameters tested, the Lower and Upper Peninsulas' electricity potential in 2021 is the most sensitive to NTG ratio and marketing effects. Marketing effects influence the growth of customer awareness and, along with incentives, are a primary pathway that program administrators use to influence the adoption of efficient measures. Avoided costs show a non-linear impact as increasing avoided costs do little to increase potential, while reducing avoided costs has a considerable negative effect. Customers do not respond to changes in avoided costs during purchase decision-making. Therefore, because most high impact measures pass the UCT screening threshold (0.8 for achievable) in the Reference Scenario, we do not see increased customer adoption with avoided costs. However, a decrease in avoided costs will reduce measure UCTs below the screening threshold, resulting in fewer programmatic offerings for customers and negatively impacting potential. Line losses, word-of-mouth effects, and discount rates show negligible impact and the effect of incremental cost adjustments are moderate and symmetrical.

Figure 9-25. Lower Peninsula Electricity Achievable Percent of Sales Sensitivity (2021)



Source: Guidehouse analysis

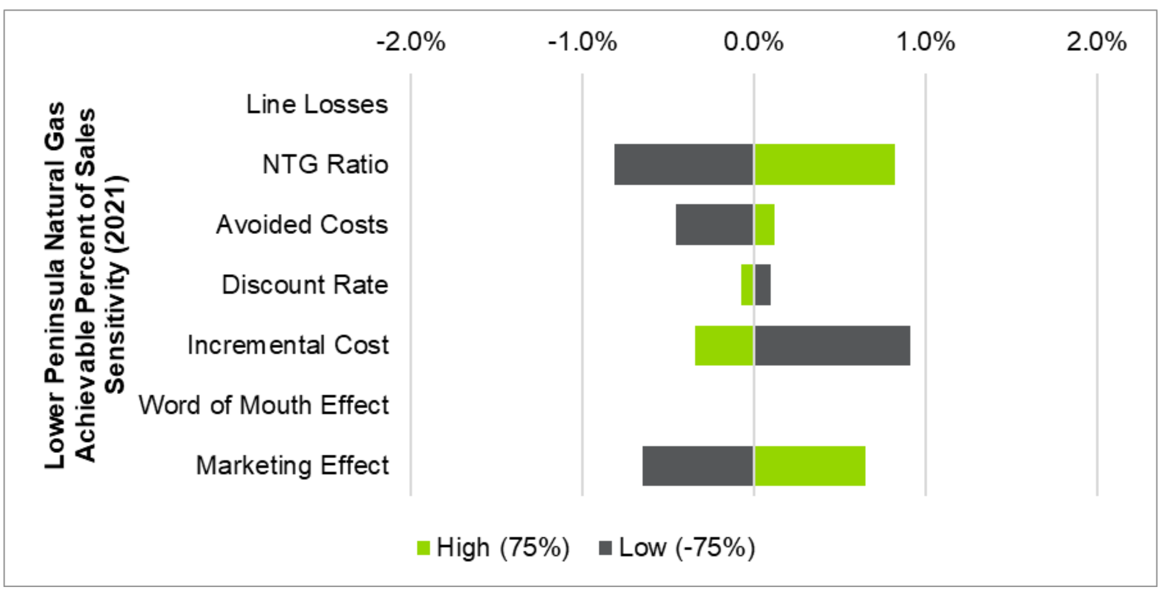
Figure 9-26. Upper Peninsula Electricity Achievable Percent of Sales Sensitivity (2021)



Source: Guidehouse analysis

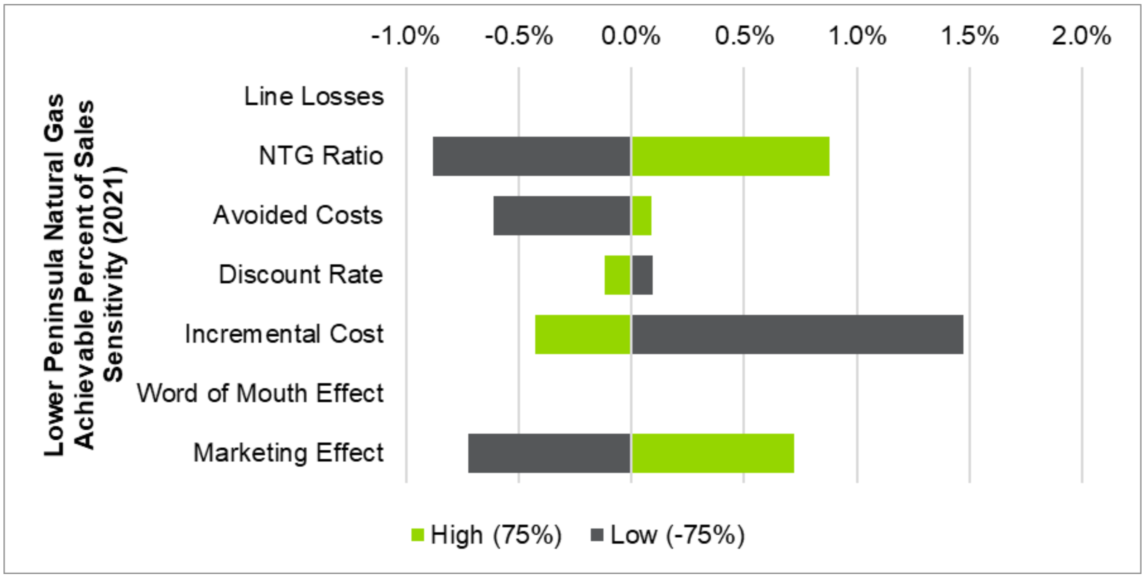
Figure 9-27 and Figure 9-28 show that of the seven parameters tested, the Lower and Upper Peninsulas' natural gas potential in 2021 has a similar relative sensitivity to the electricity results with the exception of higher sensitivity to incremental costs. Increases in incremental costs result in a modest increase in potential; however, decreases in incremental costs lead to a large increase in potential. This indicates that natural gas measures have longer payback times than electricity measures and that decreasing the upfront cost to customers is a key leverage point to capturing savings. Overall, natural gas potential is less sensitive to changes in modeled inputs than electricity potential.

Figure 9-27. Lower Peninsula Natural Gas Achievable Percent of Sales Sensitivity (2021)



Source: Guidehouse analysis

Figure 9-28. Upper Peninsula Natural Gas Achievable Percent of Sales Sensitivity (2021)

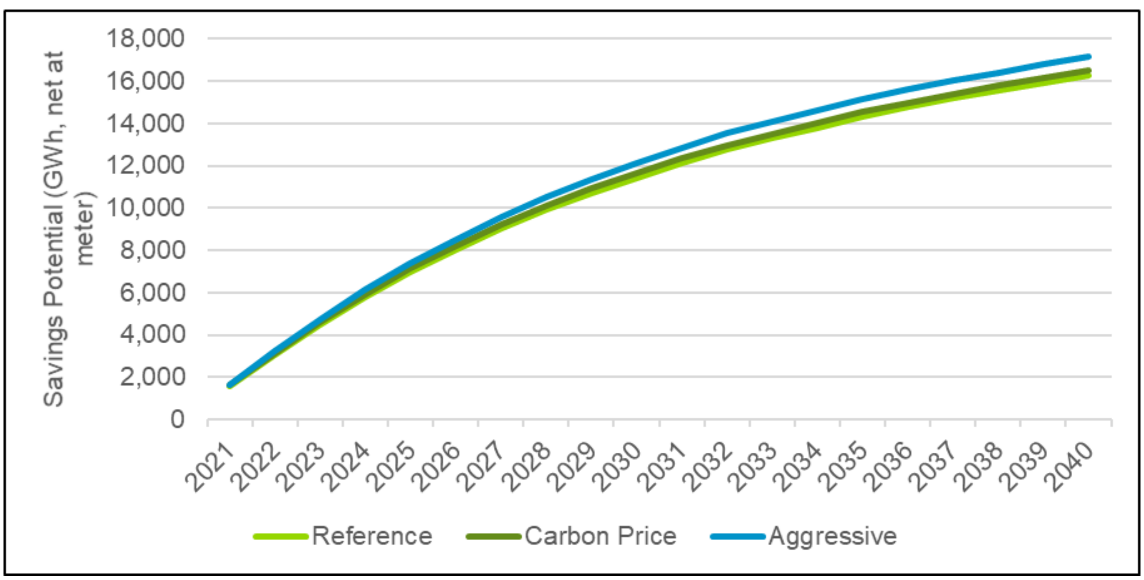


Source: Guidehouse analysis

9.6 Comparison of Energy Waste Reduction Achievable Potential Scenario

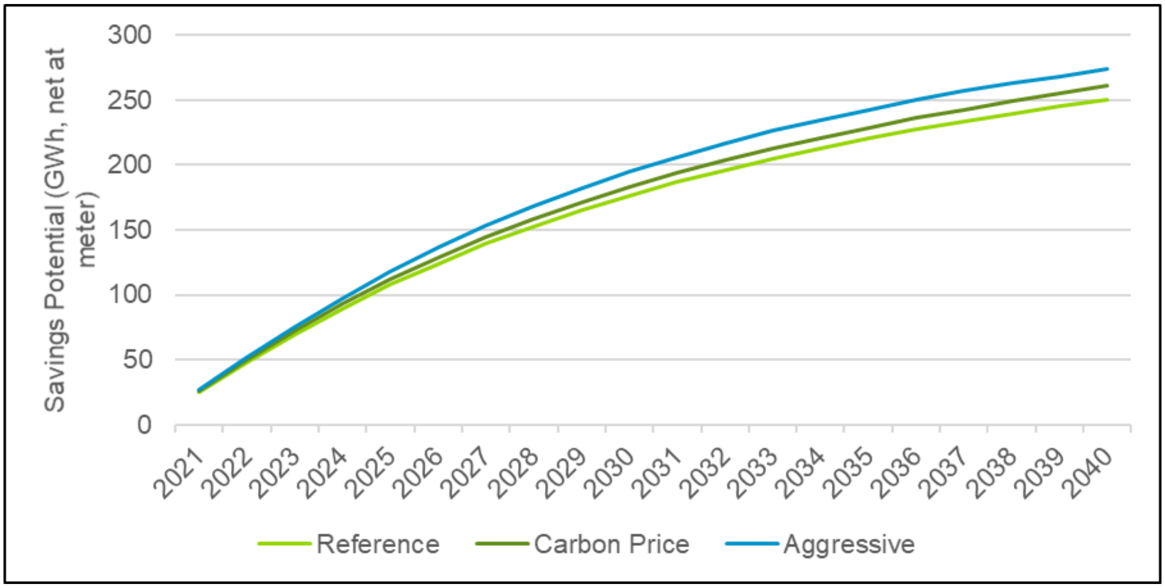
Figure 9-29 shows the scenario results for cumulative electricity achievable potential, net at meter, in the Lower Peninsula. The Aggressive Scenario results in about a 5% increase in cumulative savings compared to the Reference Scenario. Figure 9-30 shows the scenario results for cumulative electricity achievable potential, net at meter, in the Upper Peninsula. The Aggressive Scenario results in about a 10% increase in cumulative savings compared to the Reference Scenario.

Figure 9-29. Lower Peninsula EWR Achievable Potential, Cumulative Annual Electricity Savings, by Scenario (GWh, Net at Meter)



Source: Guidehouse analysis

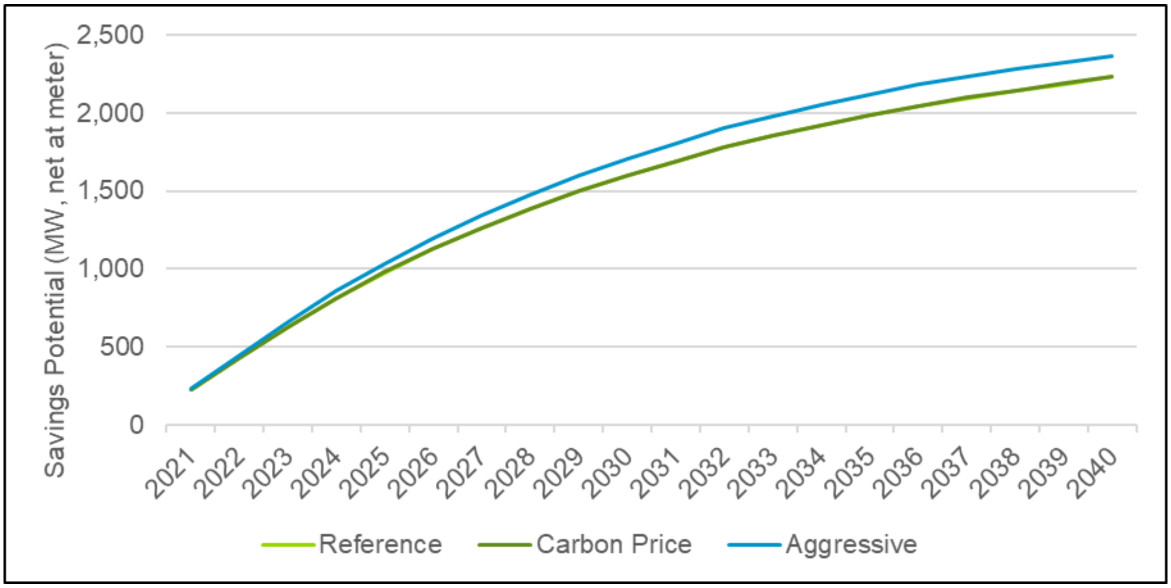
Figure 9-30. Upper Peninsula EWR Achievable Potential, Cumulative Annual Electricity Savings, by Scenario (GWh, Net at Meter)



Source: Guidehouse analysis

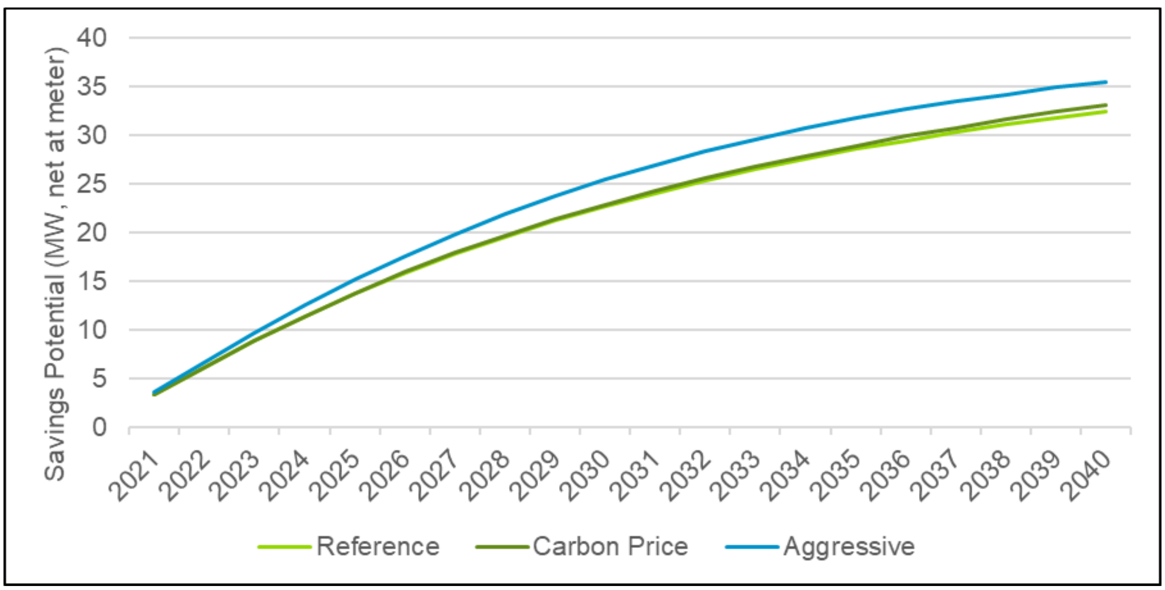
Figure 9-31 shows the cumulative annual summer peak demand potential, net at meter, by scenario for the Lower Peninsula. The peak demand increased slightly more than energy at about 6% cumulatively, indicating that more weather-sensitive measures were impacted by the Aggressive Scenario than non-weather-sensitive. The Carbon Price Scenario resulted in negligible change compared to the Reference Scenario. Figure 9-32 shows the cumulative annual summer peak demand potential, net at meter, by scenario for the Upper Peninsula. As with the electricity savings, the Upper Peninsula was affected more by the scenarios, resulting in about an 11% increase in peak demand savings in the Aggressive Scenario compared to the Reference Scenario.

Figure 9-31. Lower Peninsula EWR Achievable Potential, Cumulative Annual Summer Peak Demand Savings (MW, Net at Meter)



Source: Guidehouse analysis

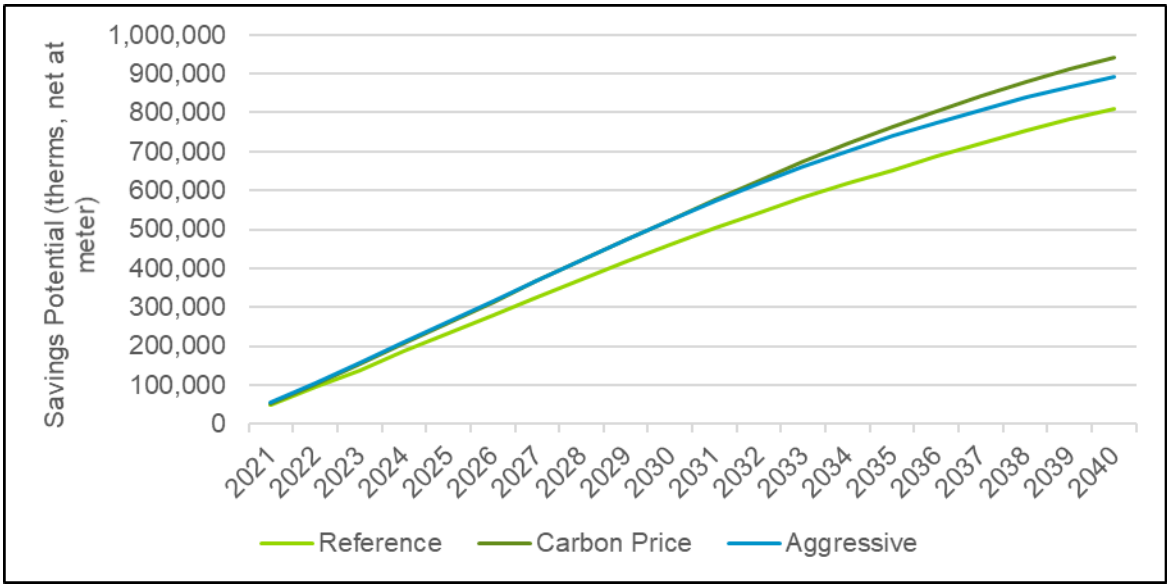
Figure 9-32. Upper Peninsula EWR Achievable Potential, Cumulative Annual Summer Peak Demand Savings, by Scenario (MW, Net at Meter)



Source: Guidehouse analysis

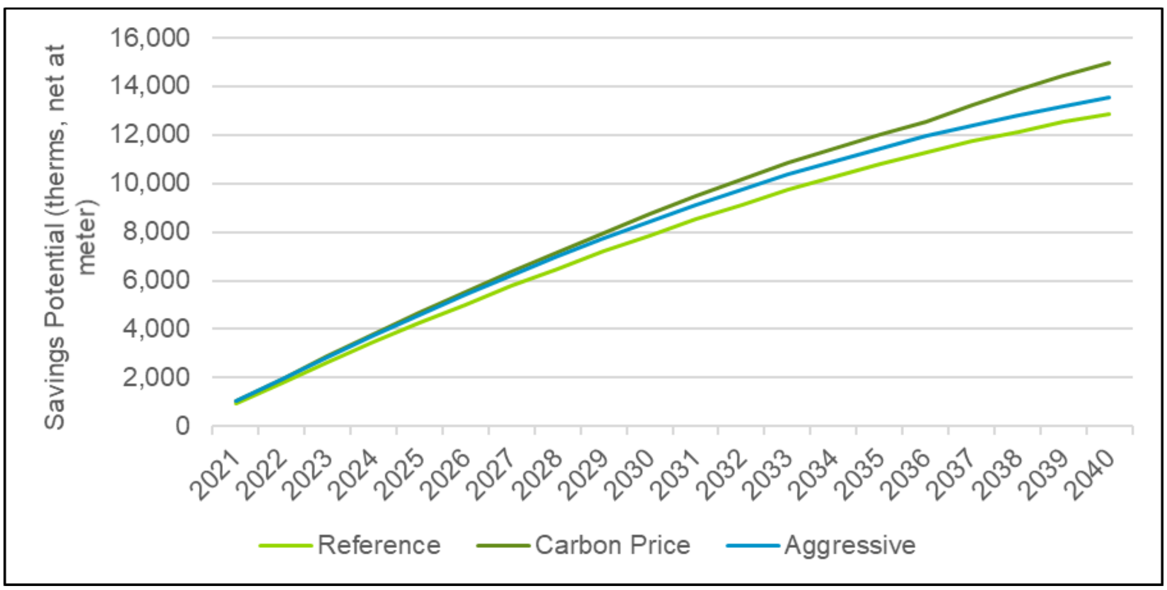
Figure 9-33 and Figure 9-34 show the cumulative natural gas savings achievable potential, in net therms, by scenario for the Lower and Upper Peninsulas, respectively. Unlike the electricity scenario results, the Carbon Price Scenario had more of an impact than the Aggressive Scenario on natural gas results, resulting in about a 16% increase in cumulative potential for both peninsulas. This indicates that gas measures are more sensitive to increases in avoided costs than changes in incentive levels.

Figure 9-33. Lower Peninsula EWR Achievable Potential, Cumulative Annual Natural Gas Savings, by Scenario (therms, Net at Meter)



Source: Guidehouse analysis

Figure 9-34. Upper Peninsula EWR Achievable Potential, Cumulative Annual Natural Gas Savings, by Scenario (therms, Net at Meter)



Source: Guidehouse analysis

9.7 Budgets and Cost-Effectiveness

This section presents UCT costs, benefits, net benefits, and test ratio results for the Reference Scenario. Results are grouped in primary fuel type and sector bundles to estimate program cost-effectiveness. Results are also presented as sector and portfolio total values for the Lower and Upper Peninsulas. Each table shows three snapshot years—2021, 2030, and 2040—to illustrate cost test and budget dynamics throughout the study period. Complete results for each scenario are presented in Appendix D.

Table 9-1 and Table 9-2 shows the UCT results for the Lower and Upper Peninsula program bundles. All program bundles are cost-effective in 2021; however, the residential program bundles decrease to a UCT below 1.0 throughout the study period. This decrease is largely due to the saturation of low cost lighting measures in the early years of the study period for the residential electricity bundle. This is highlighted by the increase in budget projected to achieve savings as program administrators will need to incentivize higher cost measures to achieve savings. Additionally, the results bundle income eligible programs in with market rate residential customer programs, which have 100% incentive levels; as the more cost-effective lighting programs diminish, these higher incentives have an increased impact.

Residential gas UCT decreases as residential income eligible furnace measures pass the measure-level UCT of 0.8, which is a lower UCT ratio than single-family because the low income segment receives 100% incentives. This measure is a major portion of the residential gas portfolio and has a significant impact on the overall sector UCT. Commercial and industrial bundles remain cost-effective throughout the study period with exception of the Upper Peninsula electricity bundle in later years; however, spending estimates decline. Saturation of currently projected custom measures occurs throughout the study period and outweighs the modeled emergence of unidentified future technologies. This effect results in an overall decline in savings potential and spending in later years. Overall, the Lower Peninsula portfolio is cost-effective throughout the study period and the Upper Peninsula portfolio remains cost-effective until late in the study period.

Table 9-1. Lower Peninsula, Benefits and Costs, Reference Scenario

Lower Peninsula	Net UCT Test Ratio = (a) / (b)	Net PV UCT Benefits NPV 2021 $ Million (a)	Net PV UCT Costs NPV 2021 $ Million (b) = (c) + (d)	Program Administrative Costs NPV 2021 $ Million (c)	Program Incentive Costs NPV 2021 $ Million (d)
Residential Electricity Program Bundle					
2021	1.1	$135,300,849	$118,294,428	$39,431,476	$78,862,952
2030	0.88	$157,461,751	$178,822,063	$59,607,354	$119,214,709
2040	0.85	$237,422,675	$279,856,964	$93,285,655	$186,571,310
Residential Natural Gas Program Bundle					
2021	1.3	$81,069,344	$64,728,771	$21,576,257	$43,152,514
2030	1.2	$111,853,792	$91,681,198	$30,560,399	$61,120,798
2040	0.93	$114,873,542	$124,108,175	$41,369,392	$82,738,783
C&I Electricity Program Bundle					
2021	1.4	$592,747,301	$428,260,444	$142,753,481	$285,506,963
2030	1.5	$327,343,257	$213,761,007	$71,253,669	$142,507,338
2040	1.3	$150,996,084	$117,716,905	$39,238,968	$78,477,936
C&I Natural Gas Program Bundle					
2021	2.5	$99,530,402	$40,554,645	$13,518,215	$27,036,430

Lower Peninsula	Net UCT Test Ratio = (a) / (b)	Net PV UCT Benefits NPV 2021 $ Million (a)	Net PV UCT Costs NPV 2021 $ Million (b) = (c) + (d)	Program Administrative Costs NPV 2021 $ Million (c)	Program Incentive Costs NPV 2021 $ Million (d)
2030	5.3	$145,717,267	$27,498,669	$9,166,223	$18,332,446
2040	3.7	$67,527,640	$18,045,654	$6,015,218	$12,030,436
Residential Programs Total					
2021	1.2	$216,370,193	$183,023,199	$61,007,733	$122,015,466
2030	1.0	$269,315,543	$270,503,261	$90,167,754	$180,335,507
2040	0.87	$352,296,217	$403,965,139	$134,655,046	$269,310,093
C&I Programs Total					
2021	1.5	$692,277,704	$468,815,090	$156,271,697	$312,543,393
2030	2.0	$473,060,523	$241,259,676	$80,419,892	$160,839,784
2040	1.6	$218,523,724	$135,762,559	$45,254,186	$90,508,372
Lower Peninsula Portfolio Total					
2021	**1.4**	**$908,647,897**	**$651,838,288**	**$217,279,429**	**$434,558,859**
2030	**1.5**	**$742,376,066**	**$511,762,937**	**$170,587,646**	**$341,175,291**
2040	**1.1**	**$570,819,941**	**$539,727,698**	**$179,909,233**	**$359,818,465**

Source: Guidehouse analysis

Table 9-2. Upper Peninsula, Benefits and Costs, Reference Scenario

Upper Peninsula	Net UCT Test Ratio = (a) / (b)	Net PV UCT Benefits NPV 2021 $ Million (a)	Net PV UCT Costs NPV 2021 $ Million (b) = (c) + (d)	Program Administrative Costs NPV 2021 $ Million (c)	Program Incentive Costs NPV 2021 $ Million (d)
Residential Electricity Program Bundle					
2021	1.3	$3,173,073	$2,446,999	$815,666	$1,631,333
2030	0.87	$2,477,571	$2,854,349	$951,450	$1,902,900
2040	0.66	$2,081,817	$3,164,112	$1,054,704	$2,109,408
Residential Natural Gas Program Bundle					
2021	1.2	$2,012,906	$1,697,472	$565,824	$1,131,648
2030	1.0	$1,976,958	$1,893,203	$631,068	$1,262,135
2040	1.0	$1,125,749	$1,085,114	$361,705	$723,409
C&I Electricity Program Bundle					
2021	1.2	$6,894,419	$5,567,214	$1,855,738	$3,711,476
2030	1.2	$3,367,418	$2,765,494	$921,831	$1,843,662
2040	0.91	$1,184,539	$1,301,513	$433,838	$867,675
C&I Natural Gas Program Bundle					

Upper Peninsula	Net UCT Test Ratio = (a) / (b)	Net PV UCT Benefits NPV 2021 $ Million (a)	Net PV UCT Costs NPV 2021 $ Million (b) = (c) + (d)	Program Administrative Costs NPV 2021 $ Million (c)	Program Incentive Costs NPV 2021 $ Million (d)
2021	2.0	$986,170	$500,672	$166,891	$333,781
2030	4.0	$1,448,365	$359b,251	$119,750	$239,501
2040	4.5	$861,285	$192,033	$64,011	$128,022
Residential Programs Total					
2021	1.3	$5,185,979	$4,144,471	$1,381,490	$2,762,981
2030	0.94	$4,454,530	$4,747,552	$1,582,517	$3,165,035
2040	0.75	$3,207,565	$4,249,227	$1,416,409	$2,832,818
C&I Programs Total					
2021	1.3	$7,880,589	$6,067,886	$2,022,629	$4,045,257
2030	1.5	$4,815,784	$3,124,745	$1,041,582	$2,083,163
2040	1.4	$2,045,824	$1,493,546	$497,849	$995,697
Upper Peninsula Portfolio Total					
2021	**1.3**	**$13,066,568**	**$10,212,357**	**$3,404,119**	**$6,808,238**
2030	**1.2**	**$9,270,313**	**$7,872,297**	**$2,624,099**	**$5,248,198**
2040	**0.94**	**$5,869,021**	**$6,238,833**	**$2,079,611**	**$4,159,222**

Source: Guidehouse analysis

10. Conclusions

This EWR potential study has resulted in updated, expanded, and improved information on the Michigan customer base, and the potential for energy and demand reductions possible through EWR programs and initiatives by building upon previous studies, with the addition of natural gas potential and analysis of the Upper Peninsula. While much EWR potential remains, there are unique challenges in Michigan in realizing this potential over the 20-year study period. The potential study incorporates these real factors into the analysis by using primary research findings, Michigan baseline study data, and historical and expected program achievements, to estimate efficient measure and fuel type saturations, as well as calibration targets. The following are the key findings and takeaways from the potential analysis.

- **Near-term electricity and summer peak demand savings:** The top five electricity measures—consisting of commercial and industrial custom and lighting, residential LED bulbs, and residential home energy reports—represent approximately 50% of achievable savings in 2021 for both the Lower and Upper Peninsulas. This situation presents challenges for program administrators interested in maintaining a high rate of incremental annual savings. LED bulbs and industrial custom stocks saturate quickly in the study period due to aggressive early year calibration. Home energy reports do not, by definition, saturate in year-over-year contributions to potential; however, their 1-year lifetime and contribution limits as a percentage of total residential potential presents uncertainty around the longevity of this measure.

- **Near-term natural gas savings:** The top five measures for each peninsula comprise nearly 60% of the natural gas savings. The Upper Peninsula's top five measures—residential furnaces, commercial custom, residential boilers, home energy reports, and residential showerheads—consist mostly of residential savings due to the large share of residential load to overall natural gas load in the Upper Peninsula. The Lower Peninsula contains many of the same top measures—commercial custom, residential furnaces, and residential home energy reports—but because of the larger share of commercial load in the Lower Peninsula, two other commercial measures round out the remaining top five measures in the Lower Peninsula (commercial demand controlled ventilation, and commercial HVAC).

- **Long-term electricity and summer peak demand savings trends:** Incremental annual electricity potential decreases year-over-year over the 20-year study period, as some end uses, such as lighting in all sectors, begin to saturate. The calibration resulted in high lighting savings in the first few years of the study, but little overall total lighting potential remains due to existing high LED saturations identified from the primary data collection, causing the projected lighting savings to saturate quickly. Custom savings potential also deteriorates over time, and the market also saturates. The HVAC end uses show strong and steady increases year-over-year, which is a product of relatively low current participation and stock turnover limits.

- **Long-term natural gas savings:** Natural gas savings are much steadier over the study period than electricity savings. The top two end-use categories for both peninsulas are residential HVAC and commercial HVAC, which are limited by stock turnover and relatively low historical accomplishments, resulting in these categories ramping up more over time. Other end-use categories, such as residential water heating, begin to saturate, resulting in lower incremental savings potential years. However, the variance from the incremental savings potential in the early years (about 1% per year) compared to later years (about 0.7% per year) is much lower than the variance of electricity savings over time.

- **Cost test results:** All sectors achieve a UCT ratio of above 1.0 at the start of the study. However, as time progresses, the residential sector UCT drops below 1.0 for both electricity and natural gas residential program bundles. For residential electricity, this result is largely due to low cost lighting measures saturating in the market and being backfilled with more expensive technologies in later years. Additionally, low income segments receive 100% incentives and are inherently less cost-effective at the UCT level. As the highly cost-effective lighting programs diminish, these less cost-effective segments have much more of an impact on overall residential program bundle cost-effectiveness. This effect is true for residential natural gas programs as well, though it is a more muted effect because there is not a measure with an analogous impact to that of lighting. However, this result is observed in the natural gas programs when a low income furnace measure passes the UCT threshold of 0.8 in 2036 in the Lower Peninsula.

- **Scenario comparison:** There are modest differences in cumulative annual achievable potential in 2040 across the three scenarios. The Aggressive Scenario yields the highest electricity potential in the Lower and Upper Peninsulas, with an increase of around 5% and about 10%, respectively, as compared to the Reference Scenario. The Carbon Price Scenario results in an increase of around 16% in natural gas potential, outpacing the Aggressive Scenario for this fuel type. These results indicate the electricity potential is more sensitive to changes in incentives and spending, while natural gas potential is more sensitive to increases in avoided costs.

- **Sensitivity results:** Electricity potential exhibits a symmetrical and high sensitivity to net-to-gross (NTG) ratio and marketing effect variances, and a high negative impact from decreasing avoided costs, with a lower positive impact from increasing avoided costs. Natural gas potential shows a similar behavior to electricity, with the addition of a high positive impact from decreasing incremental costs. Changes to line loss factors, discount rates, and word of mouth effects have little impact on potential for each territory and fuel type.

Appendix A. Residential Survey Instrument

MI Potential Study Residential Survey_FII

Appendix B. Commercial & Industrial Survey Instrument

MI Potential Study Commercial Survey_F

Appendix C. Michigan 2021-2040 Potential Study Modeling Methodology

[Note: Appendices C and D to be shared week of 8/16/2021]

Appendix D. Energy Waste Reduction Results File

[Note: Appendices C and D to be shared week of 8/16/2021]

