Energy Management Practices (Industrial)

2017-2020 Impact Evaluation Phase 2

Final Report

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Introduction

In 2017, NYSERDA began to approve applications to enroll participants in the new programs associated with the Energy Management Practices (EMP) Investment Plan with the goal of integrating energy efficiency as a core business practice by guiding participants through a process of identifying, developing, and executing new energy management strategies in their facilities. In 2017 NYSERDA expanded the On-Site Energy Manager (OsEM) program to include Commercial participants.

There were two different programs for industrial participants:

1. Strategic Energy Management (SEM), including a wastewater-specific segment called Wastewater Energy Coaching (WEC)

2. On-site Energy Manager (OsEM)

Strategic Energy Management (SEM), including Wastewater Energy Coaching (WEC), used independent third-party energy efficiency teams (herein referred to as the implementers). These programs encouraged energy efficiency through:

- Treasure hunts, where the implementers and owners' representatives walked through the facilities and identified areas of energy waste (behavioral, operational, and equipment-based) and possible measures to reduce or eliminate that energy waste.

- Cohort trainings, where other program participants met to share best practices and learn how other participants approached similar issues.

- Billed-use regression modeling for savings tracking, where the program implementer identified independent variables that drive energy use in the facility (e.g., production levels) and built statistical models to forecast how the building uses energy. The difference between the facility's actual energy use and this forecasted model then measures the impact of the sum total savings of the energy measures put into place. These reports were updated and shared with the participant throughout their participation and provided immediate feedback to show how projects have impacted the facility's energy use.

- Project management and tracking, where all the potential measures are tracked, including their current status, so participants can move as many identified measures through to completion as possible.

The Industrial OsEM offering also seeks to assist participants with putting into place an energy management process. However, rather than having a third-party energy coach, the program offers cost-sharing with sites to embed part- or full-time energy managers (staff or consultants) into their facilities and operations. These energy managers are responsible for identifying measures, calculating potential energy savings, securing management approval, and tracking projects to completion.

In 2021, NYSERDA contracted with an impact evaluator to conduct a multi-year evaluation of the programs, and this report details the findings and recommendations as part of that process. This report summarizes the second of five impact evaluations planned from 2021 to 2025 using a phased incremental sampling approach described below.

The evaluation objectives are listed in Table 1.

Table 1. Evaluation Objectives and Main Research Questions

Objective	Evaluation Questions	Data Sources
Evaluate verified gross energy impacts	What is the annualized evaluated gross energy savings based on electric (kWh) and fuel savings (MMBtu) at customer sites?	On-site or remote measurement and verification (M&V) using IPMVP recommended methods, program data.
Verified gross savings realization rate (VGS RR)	What is the ratio of the sum of the evaluated savings divided by the sum of the Program-reported savings?	
Provide assistance to market evaluation in determining indirect impacts	What are the program's indirect impacts?	Market Evaluation Contractor, M&V and CEI Market Evaluation Year 3 Report.

Sampling Methodology

The Impact Evaluation Team is using a phased incremental sampling approach that will achieve a 10% precision level for gross energy savings at 90% confidence at the end of the multi-year evaluation. In the first evaluation

year, the Impact Evaluation Team sampled 22 industrial projects from a population of 26 completed projects from the earliest completed program participants.

In this evaluation (Phase 2), the Impact Evaluation Team identified 23 completed projects. These included the 2019 SEM cohort (7 projects), the 2020 WEC cohort (5 projects), and all completed OsEM projects not previously evaluated (11 projects).[1]

From this population, the Impact Evaluation Team selected a total of 21 projects using a stratified random sampling approach as necessary. The number of projects sampled for each program was based on the expected number of projects to be completed by 2025 and achieving the desired level of precision at the end of the evaluation. Table 2 shows the population of completed projects and sample for each program.

[1] The OsEM sample frame included all projects which have completed the program participation phase but may still be in the bonus period. This differs from the first evaluation, in which all projects in the population had completed the bonus period.

Table 2. Phase 1 and 2 Evaluation Sample

	2021 Evaluation		2022 Evaluation		Aggregated Counts	
	Population	**Sample**	**Population**	**Sample**	**Population**	**Sample**
Industrial SEM (Non-WEC)	12	10	7	7	19	17
Industrial SEM (WEC)	7	5	5	5	12	10
Industrial SEM Subtotal	*19*	*15*	*12*	*12*	*31*	*27*
Industrial OsEM	7	7	11	9	18	16
Industrial EMP Total	**26**	**22**	**23**	**21**	**49**	**43**

While the realization rates shown in this report are weighted by savings, the realization rates may not be representative of the final population of program participants due to the incremental sample design and the size of the sample in this phase of this study. The Impact Evaluation Team will compare the characteristics of the sample and the population in subsequent phases and will develop weighting strategies as needed to ensure the study's results are representative of the final population of program participants.

Savings Calculation Methodology

To estimate verified gross savings, the Impact Evaluation Team used two IPMVP approaches: IPMVP Option A (Partially Measured Retrofit Isolation) and IPMVP Option C (Whole Facility Billing Regression).

The Implementation Team used regression modeling for claiming savings for all SEM and WEC projects, while the industrial OsEM projects used engineering calculations to estimate and claim energy savings. The Impact Evaluation Team attempted to use Option C wherever possible, but used Option A for projects where Option C was not viable due to poor regression metrics. In both approaches, the Impact Evaluation Team conducted interviews with program participants to identify measure performance-related issues.

IPMVP Option A Methodology

IPMVP Option A allows for partial measurement of relevant data or direct metering of energy use to calculate a project's energy savings. It allows for some flexibility to stipulate values with a low overall impact on the savings error.

The primary approach the Impact Evaluation Team took to calculate savings using IPMVP Option A was to collect or recreate energy savings calculations and gather any necessary data or updates to assumptions. The Impact Evaluation Team then reviewed and adjusted the original calculations or created new calculations based on the data and feedback collected from participants.

IPMVP Option C Methodology

IPMVP Option C is a whole building meter verification approach. The process involves first identifying independent variables that drive energy use (e.g., production, weather, and schedule variables). Using these independent variables, the Impact Evaluation Team creates a statistical model of the baseline energy use to represent the counterfactual energy use. In other words, the model represents how the building would have used energy in the absence of some intervention. Savings are then calculated by taking the difference between this counterfactual model and the facility's actual energy use.

To validate savings, the Impact Evaluation Team first recreated each of the implementer's regression models or calculated saving methodologies to verify the claimed savings values and better understand the approach being used by the Implementation Team. Next, the Impact Evaluation Team validated each baseline model and the claimed savings using a set of industry-accepted validation metrics as described below. Finally, the validation results were combined with engineering judgment based on the project documentation to determine whether the evaluators could improve each baseline model to provide more accurate savings results, accept the implementer's model, or move to IPMVP Option A.

The primary validation metrics and thresholds used, based on IPMVP and ASHRAE Guideline 14, in order of importance, are:

1. Net Determination Bias Error: Less than 0.005%
2. CV(RSME): Less than 15% for monthly models; less than 30% for daily models
3. Independent Variable T-Statistics: No variables with an absolute value t-statistic below 2
4. Adjusted R^2: Greater than 75%

The Impact Evaluation Team also used Fractional Savings Uncertainty (FSU) as an additional validation metric for the claimed savings value, which indicates whether a model can confidently distinguish actual savings from random variation. To validate the savings claim, the model had to have an FSU of less than 50% at 68% confidence.

Wherever possible, the Impact Evaluation Team looked to improve the models used by the Implementation Team. For each implementation model, the Implementation Team selected a set of independent variables that they identified as the primary driver of energy consumption. The Impact Evaluation Team reviewed these independent

variables and also attempted to identify any additional independent variables that could be added to the model to improve the goodness-of-fit validation metrics without overfitting the model.

The Impact Evaluation Team also reviewed the projects for non-routine events (NREs). NREs are events with significant energy impacts (causing either an increase or decrease in energy use) on the facility that are not attributable to the program. Common examples of NREs include a small building addition, a production line being decommissioned/modified, or a temporary equipment failure. Additionally, the COVID-19 pandemic is considered a significant NRE that impacted the occupancy and production of many facilities in 2020 and 2021. Where any potential NREs were identified, the Impact Evaluation Team interviewed the participant to attempt to identify the event. If the participant could identify the NRE with rough start and end dates, the Impact Evaluation Team made a non-routine adjustment (NRA) following the *IPMVP Application Guide on Non-Routine Events & Adjustments* guidance. Two SEM (non-WEC) sites were reviewed and removed from further analysis due to non-routine operation related to COVID. If the participant could not identify the NRE, no adjustment was made.

Results

Annualized Savings

As in the previous evaluation, the Impact Evaluation Team annualized savings for the industrial SEM and WEC programs to normalize the results if projects claimed savings over irregular periods. In this approach, both the claimed and evaluated savings are those accumulated during the 12 months following the model workshop with the program participants. This one-year period avoids periods of non-savings before program participants begin to fully engage with the program and limits uncertainty associated with non-routine events that occurred after program engagement.

Table 3 and Table 4 show the total annualized savings for all programs under study. For the combined Industrial EMP programs, the Impact Evaluation Team found the verified gross realization rate of 100% for electric energy savings and 121% for natural gas savings. The verified gross realization rate (RR) is the verified gross (evaluator-calculated) savings divided by the gross (implementer-calculated) savings. While the aggregate realization rates were close to 100% in aggregate, they varied by program and also by individual projects, and were driven by the relatively larger industrial OsEM program. The tables also show the verified savings percentage relative to the baseline energy usage.

Table 3. Total Annualized Electric Energy Savings for Phase 2 Projects

	Gross Savings (kWh)	Verified Gross Savings (kWh)	Savings Weighted VGS RR	Verified % Savings Relative to Baseline	Relative Precision (90% Confidence)
Industrial SEM (Non-WEC)	1,391,282	2,579,528	185%	3.7%	N/A, Census
Industrial SEM (WEC)	1,205,393	1,254,803	104%	4.9%	N/A, Census
Industrial SEM Subtotal	*2,596,675*	*3,834,331*	148%	*4.0%*	*N/A, Census*
Industrial OsEM	41,501,020	40,083,879	97%	6.4%	2.8%
Industrial EMP Total	**44,097,695**	**43,918,210**	100%	**6.1%**	**2.7%**

Table 4. Total Annualized Natural Gas Energy Savings for Phase 2 Projects

	Gross Savings (MMBtu)	Verified Gross Savings (MMBtu)	Savings Weighted VGS RR	Verified % Savings Relative to Baseline	Relative Precision (90% Confidence)
Industrial SEM (Non-WEC)	58,910	95,472	162%	0.5%	N/A, Census
Industrial SEM (WEC)	--	--	--	--	--
Industrial SEM Subtotal	*58,910*	*95,472*	*162%*	*0.5%*	*N/A, Census*
Industrial OsEM	287,346	322,926	112%	16.4%	8.6%
Industrial EMP Total	**346,256**	**418,398**	**121%**	**1.9%**	**6.5%**

In addition to electric and natural gas savings, some projects also achieved other fuel savings. However, in each case, at most five projects realized these savings. A single SEM (non-WEC) site with on-site generation was reviewed and removed from analysis due to insufficient implementation data required for evaluation. Overall, the NYSERDA SEM and OsEM initiatives resulted in three industrial OsEM with fuel oil or diesel savings, and one industrial OsEM project with steam savings. Realization rates for these fuels were 39% for fuel oil and diesel and 9% for steam.

The Impact Evaluation Team reviewed results from similar SEM programs in other jurisdictions and found that the verified savings relative to sites' baselines ranged from 1% to 8% for electric savings and 1% to 7% for

natural gas savings. Savings from NYSERDA's SEM program are comparable to these results. The table below shows the verified savings relative to baseline for comparable programs.[2]

Table 5. Verified Savings Percentages From Comparable SEM Programs

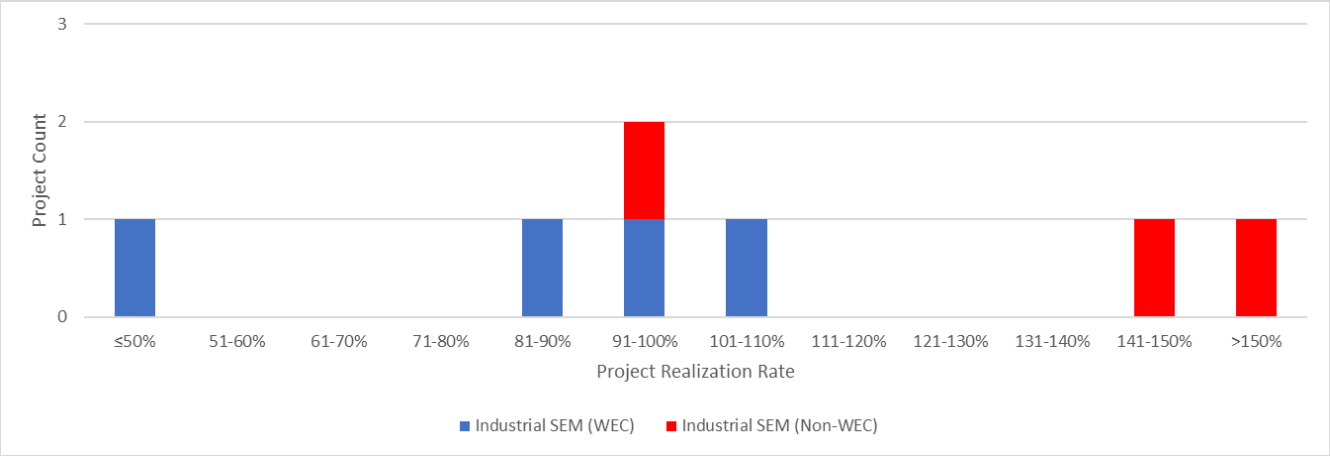
State/ Region	Program Administrator	Study Period	Verified % Savings Relative to Baseline		Sector
			Electric (kWh)	Natural Gas	
NY	NYSERDA	2017-2019	5.3%	3.5%	Industrial
OR	Energy Trust of Oregon	2010-2013	3.2%	3.5%	Industrial
IL	ComEd/ Nicor Gas	2015-2016	1.55%	1.12%	Industrial
Pacific Northwest	Bonneville Power Administration	2010-2014	4.1%	Not evaluated	Industrial
WA	Puget Sound Energy	2015-2016	4.4%	7.0%	Commercial

Industrial SEM Savings

The Impact Evaluation Team adjusted three of the four sampled non-WEC industrial SEM projects with electric savings as well as three of the four WEC projects for various reasons. For the WEC projects, these adjustments largely offset each other, as shown in Figure 1, leaving the program with an overall electric realization rate of 104% for WEC projects. The non-WEC program achieved a realization rate of 185%. This high realization rate was driven by one large project with a realization rate of over 300%. Verified savings for this project were much higher because it incorporated additional production data not used in the baseline model.

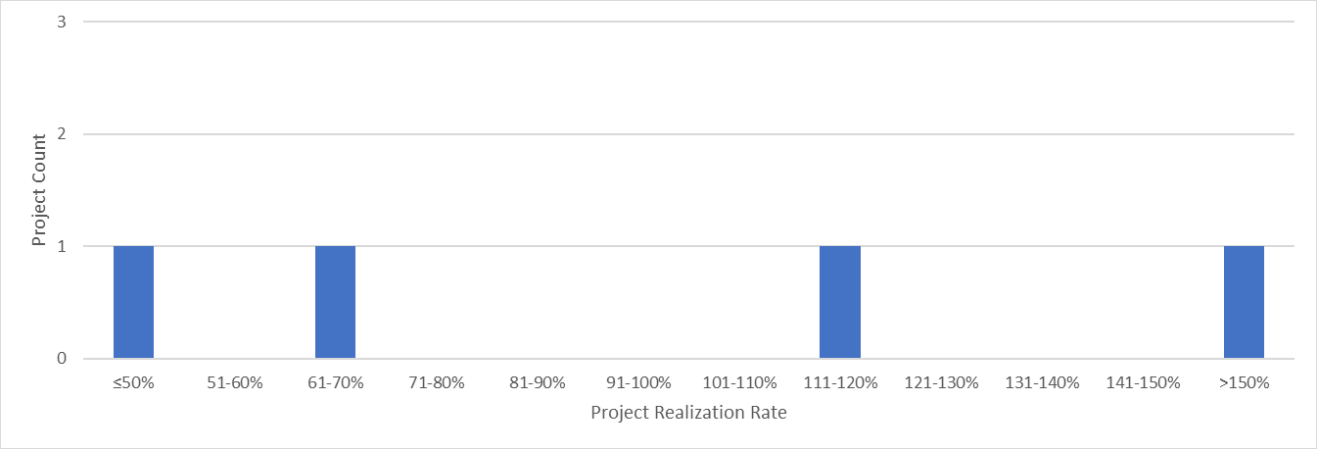
[2] Note that some of these programs have been evaluated multiple times. The listed reports are the most recent evaluations of the programs that include savings relative to baseline.

Figure 1. Distribution of Electric Industrial SEM Project Realization Rates



No WEC projects claimed natural gas savings; therefore this section only applies to non-WEC SEM projects. The Impact Evaluation Team adjusted all four evaluated industrial SEM projects with natural gas savings for various reasons. For three of the projects, savings were adjusted due to the availability of more granular data or the use of additional statistical variables which improved the savings models. One small project did not implement any measures that resulted in gas savings, resulting in a 0% realization rate.

Figure 2. Distribution of Natural Gas Industrial SEM (Non-WEC Only) Project Realization Rates



The Impact Evaluation Team made four different types of adjustments on the industrial SEM projects. They include:

- Model Input Adjustment (four cases), including:
  - Adding production variables (two non-WEC projects)
  - Adding a flow variable (one WEC project)
  - Adding a precipitation variable (one WEC project)

    - Adding an influent temperature variable (one WEC project)
- Alternate Temperature Variable (seven cases)
- Schedule Variable (one non-WEC project), including adding a "plant shutdown" variable.
- Alternative Non-Routine Adjustment (one non-WEC project)

Industrial OsEM

The Impact Evaluation Team adjusted savings calculations for seven of the nine industrial OsEM projects with electric savings and six of the nine natural gas calculations for various reasons. The adjustments largely offset each other, resulting in realizations rates of 97% and 112% for electric and natural gas savings, respectively. The individual project level realization rates are shown in Figure 3 and Figure 4.

Figure 3: Distribution of Industrial OsEM Electric Project Realization Rates

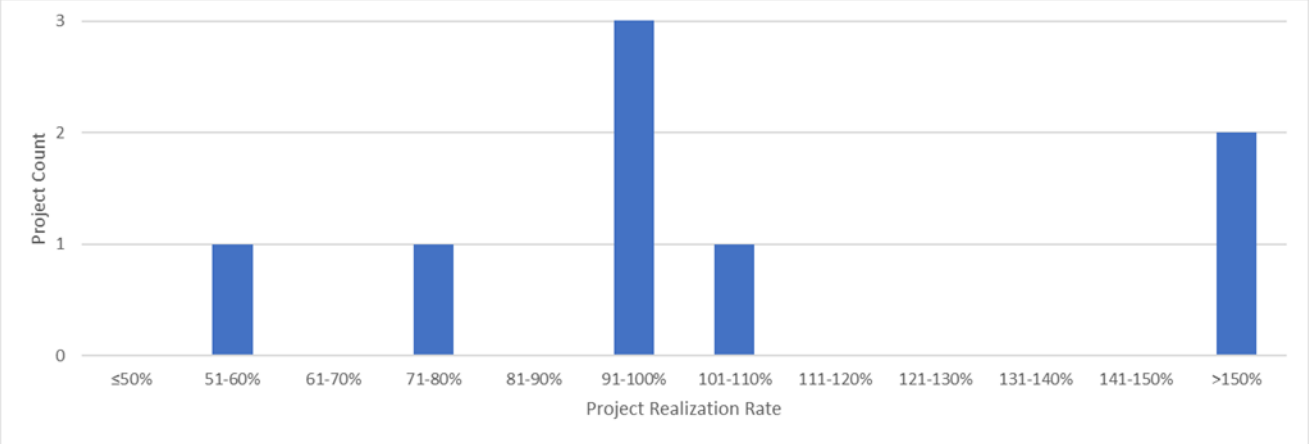
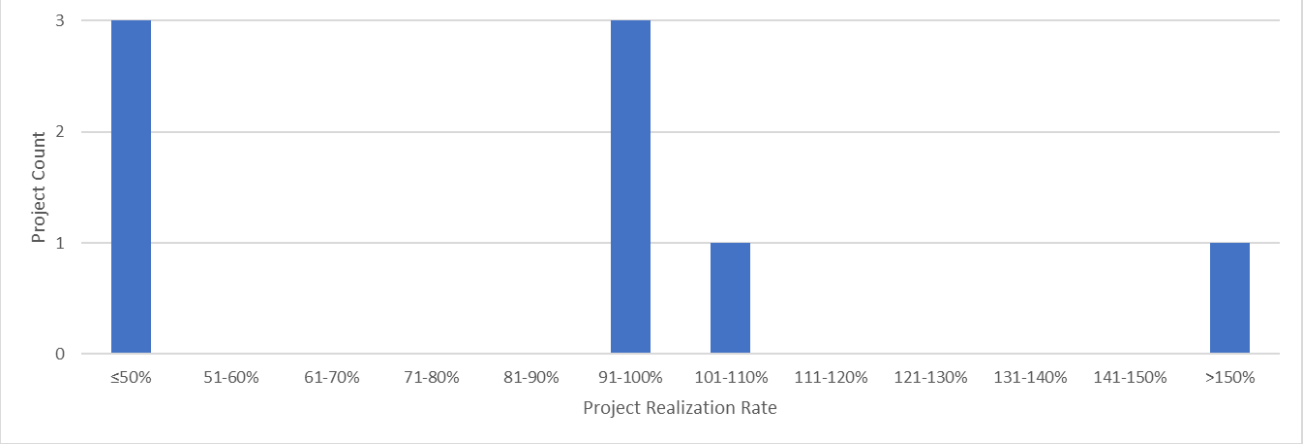


Figure 4. Distribution of Industrial OsEM Projects Natural Gas Project Realization Rates



In most cases, the Impact Evaluation Team found the OsEM's calculations to be sound and reasonable. Most measure-level adjustments were minor, consisting of changes such as adding in HVAC interactive factors or

transformer losses. For one project, the low realization rate for both electric and natural gas was a result of the installation of measures that the Impact Evaluation Team verified as only temporarily installed due to COVID.

Disadvantaged Communities

NYSERDA was interested in the program's impact and whether there were differences between sites located in disadvantaged communities[3] (DAC) compared to sites located outside of DACs. Table 6 shows the share of electric and natural gas savings in disadvantaged communities for both the sample and population of projects included in this report. Approximately one third of the program's electric and natural gas savings were from sites located in disadvantaged communities.

Table 6. Share of Verified Savings in Disadvantaged Communities

	Electric Savings		Natural Gas Savings	
	Sample	**Population**	**Sample**	**Population**
Industrial SEM (Non-WEC)	75%	75%	43%	43%
Industrial SEM (WEC)	30%	30%	--	--
Industrial SEM Subtotal	*60%*	*60%*	*43%*	*43%*
Industrial OsEM	31%	27%	41%	32%
Industrial EMP Total	**33%**	**30%**	**42%**	**35%**

Table 7 and Table 8 show the electric and natural gas verified gross savings realization rates for DAC and non-DAC participating sites. Overall, there appeared to be no clear trend in the amount of savings or the realization rates of DAC and non-DAC sites by program and fuel. While the difference in total realization rates for projects inside and outside DACs is statistically significant (at the 90/10 confidence/precision level) for both electric and natural gas savings, the conflicting direction of the results and the small sample sizes suggest that it is too early to assess any systemic differences between the two groups. The Impact Evaluation Team will continue to explore this in future phases of this work.

[3] https://www.nyserda.ny.gov/ny/Disadvantaged-Communities

Table 7. Program-Level Verified Electric (kWh) Gross Savings Realization Rate by Disadvantaged Community Status

	In DAC	Outside of DAC	Total
Industrial SEM (Non-WEC)	260%	100%	185%
Industrial SEM (WEC)	124%	97%	104%
Industrial SEM Subtotal	*221%*	*99%*	*148%*
Industrial OsEM	97%	97%	97%
Industrial EMP Total	**107%**	**97%**	**100%**

Table 8. Program-Level Verified Natural Gas (MMBtu) Gross Savings Realization Rate by Disadvantaged Community Status

	In DAC	Outside of DAC	Total
Industrial SEM (Non-WEC)	137%	188%	162%
Industrial SEM (WEC)	--	--	--
Industrial SEM Subtotal	*137%*	*188%*	*162%*
Industrial OsEM	167%	91%	112%
Industrial EMP Total	**157%**	**102%**	**116%**

Aggregated Results

Table 9 and Table 10 provide the verified gross savings and savings weighted verified gross savings realization rates for the projects covered in the 2021 and 2022 evaluations, as well as their aggregated results. Industrial SEM (non-WEC) projects in the 2021 evaluation accounted for more savings, despite the projects in the 2022 having a higher average realization rate. The verified gross savings for the industrial OsEM program had similar savings in both evaluation years. The difference in savings was largely driven by the presence of a few very large projects in the 2021 evaluation, while the difference in the realization rates was due to variations in individual projects rather than a systematic difference.

Table 9. Total Annualized Electric Energy Savings by Evaluation Period

	2021 Evaluation		2022 Evaluation		Aggregated Results	
	Verified Gross Savings (kWh)	**Savings Weighted VGS RR**	**Verified Gross Savings (kWh)**	**Savings Weighted VGS RR**	**Verified Gross Savings (kWh)**	**Savings Weighted VGS RR**
Industrial SEM (Non-WEC)	28,139,349	104%	2,579,528	185%	30,718,877	108%
Industrial SEM (WEC)	3,127,773	101%	1,254,803	104%	4,382,576	102%
Industrial SEM Subtotal	*31,267,122*	*103%*	*3,834,331*	*148%*	*35,101,453*	*107%*
Industrial OsEM	39,198,739	151%	40,083,879	97%	79,282,618	117%
Industrial EMP Total	**70,465,861**	**125%**	**43,918,210**	**100%**	**114,384,071**	**114%**

Table 10. Total Annualized Natural Gas Energy Savings by Evaluation Period

	2021 Evaluation		2022 Evaluation		Aggregated Results	
	Verified Gross Savings (MMBtu)	**Savings Weighted VGS RR**	**Verified Gross Savings (MMBtu)**	**Savings Weighted VGS RR**	**Verified Gross Savings (MMBtu)**	**Savings Weighted VGS RR**
Industrial SEM (Non-WEC)	56,440	101%	95,472	162%	151,912	133%
Industrial SEM (WEC)	-	N/A	-	N/A	-	N/A
Industrial SEM Subtotal	*56,440*	*101%*	*95,472*	*162%*	*151,912*	*133%*
Industrial OsEM	111,712	104%	322,926	112%	434,638	110%
Industrial EMP Total	**168,152**	**103%**	**418,398**	**121%**	**586,550**	**115%**

Findings and Recommendations

Overall, the Impact Evaluation Team finds that the programs successfully identified and implemented new energy efficiency opportunities at participating sites. Site participants typically reported overall positive feedback about the programs when asked generally for their thoughts on the program.

Finding 1: While the Impact Evaluation Team found the SEM program's verified gross savings realization rate to be high for electric savings (104% for WEC projects and 185% for non-WEC projects), there was significant variance in the overall project level realization rates.

Recommendation: Continue to refine and improve modeling best practices and procedures and use them consistently. Specifically:

- Use only models that can be validated using model fitness tests, such as adjusted R^2 and Fractional Savings Uncertainty (FSU).
- In general, models with FSU values greater than 50% at the 68% confidence level should not be used, as there is insufficient statistical data to say that the project's savings were any different than 0. Any such model CUSUM values should be set to 0 savings.
- If a project uses a model that failed all model fitness tests but is used anyway, it would be helpful if the Implementation Team provided a description of what variables were attempted to improve the model and what attempts were made to demonstrate the model, despite failing these statistical tests, was the best that could be reasonably built.
- Where possible, identify and track dates (start and end) of any NREs, large projects, or significant production changes. This may require more frequent model updates during the participation periods.
- Include additional energy driver variables where they make sense. Heating degree days (HDD) and cooling degree days (CDD) often are improvements over average temperature and better model the non-linear effects of heating and cooling systems. Watch for scheduling variables (e.g., holidays) that can make a large impact on model accuracy.

NYSERDA response to recommendation: ***Pending: NYSERDA will consider implementation of these analyses improvements as new sites are added and for selected existing sites.***

Finding 2: In some cases, SEM models used steam consumption or chilled water consumption as an energy driver. However, the steam or chilled water is not the primary driver. Instead, the steam or chilled water consumption is driven by another variable, such as production, weather, or occupancy.

Recommendation 2: SEM models can be improved through correct consideration of primary energy drivers.

NYSERDA response to recommendation: ***Implemented: Sites with steam or chilled water consumption will incorporate additional variables, as needed.***

Finding 3: Three of the Phase 2 SEM participants had existing fossil-fuel on-site generation at their facility. One of these SEM participant sites was removed from the analysis since there was insufficient information to accurately assess direct program benefits.

Recommendation 3: Consider collecting and documenting more information (e.g., measure-specific fuel usage, savings and operational parameters both technical and economical) about sites with fossil-fuel on-site generation. This will help the program better understand the impacts of fossil-fuel on-site generation operation in New York State.

NYSERDA response to recommendation: ***Implemented: Sites with on-site generation or other fuel switching measures will be subject to additional consumption data collection and related fuel usage reporting.***

Finding 4: The Impact Evaluation Team found insufficient documentation or missing savings calculations for some limited measures in OsEM projects.

Recommendation 4: Although it will add some additional burden on the program participants, the Impact Evaluation Team recommends that NYSERDA encourage on-site energy managers to provide complete project documentation and savings calculations. When possible, documentation such as photographs, spot metering or short-term meter logging electronically saved would increase confidence in the reported savings.

NYSERDA response to recommendation: ***Pending. NYSERDA will consider implementation of these improvements as new sites are added and for selected existing sites.***

Finding 5: The Impact Evaluation Team found inconsistent use of affinity laws for pumps and fans. Some projects did not use them at all, while other used a range of values from 2.5 to 3.

Recommendation 5: OsEM report review should continue to review the affinity exponent for the calculation of energy savings from pumps and fans. When applied to variable speed drives that cause substantial speed reductions on large motors, the difference in savings when using an affinity exponent of 2.5 or 3 can be significant.

NYSERDA response to recommendation: ***Implemented. Sites with pump or fan measures will receive review for proper affinity exponent application.***