

# **Wastewater Efficiency Program Impact Evaluation (2009 - 2011)**

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## **Final Report**

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## **NOTICE**

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## **SECTION 1: EXECUTIVE SUMMARY**

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Through a Memorandum of Understanding,<sup>1</sup> the NYS Environmental Facilities Corporation (EFC)<sup>2</sup> and NYSERDA established and jointly administered the Wastewater Efficiency Program (Program) to coordinate energy efficiency efforts at wastewater facilities for the American Recovery and Reinvestment Act and subsequent federal programs. NYSERDA provided energy efficiency studies<sup>3</sup> and the EFC administered incentives and financing for the participating wastewater treatment facilities.

The Program funded 59 energy efficiency studies in total that were completed between November 2009 and January 2011. Through information gathered by the EFC, 44 projects were reported to have installed measures through the end of 2015. The financed energy measures improved operations at wastewater treatment facilities while achieving other benefits, including optimizing energy use through efficiency and renewable energy, mitigating greenhouse gas impacts, and saving energy costs.

This report describes the impact evaluation of the New York State Energy Research and Development Authority's (NYSERDA) Regional Greenhouse Gas Initiative (RGGI) funded energy efficiency studies that were completed as part of this Program. The objective of this impact evaluation was to estimate the evaluated gross savings<sup>4</sup>, which includes the electric energy and demand<sup>5</sup> and fossil fuel energy savings for projects with known installed measures. The evaluated savings are based on desk reviews and interviews performed on a statistically valid sample of 14 projects from the population. Many projects contained multiple measures. Table 1-1 summarizes the results of the evaluation.

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<sup>1</sup> A Memorandum of Understanding (January 28, 2010) between NYSERDA and the EFC formalized their agreement to jointly administer the Wastewater Energy Efficiency Program.

<sup>2</sup> The EFC received federal funding from the American Recovery and Reinvestment Act (ARRA) and subsequent Green Project Reserve funding for the Clean Water State Revolving Fund (CWSRF) for wastewater infrastructure to protect and enhance water quality; energy efficiency was mandated in the guidelines.

<sup>3</sup>NYSERDA's FlexTech Program provides objective and customized energy-related information and opportunities to customers. Program participants receive analyses targeting their specific energy and business needs.

<sup>4</sup> Evaluated gross savings are calculated by applying the realization rate (ratio of evaluated savings to program estimated savings) to the program estimated savings. More detail can be found in Section 3.1.1

<sup>5</sup> Demand savings were not estimated by the Program and therefore were not a primary parameter of investigation; however, the Impact Evaluation Team did quantify the peak demand savings for projects where they existed. In total the Impact Evaluation Team estimated 1.73 MW of peak demand reduction were attributable to the program.

**Table 1-1. Wastewater Efficiency Program Evaluation Results**

Parameter	Program-Estimated Savings	Realization Rate <sup>1</sup>	Evaluated Savings	Relative Precision <sup>2</sup>
Electric energy (MWh/yr.)	21,548	0.91	19,503	14%
Fuel (MMBtu/yr.) <sup>3</sup>	52,567	0.98	51,425	2%

<sup>1</sup> A Realization Rate of 1, is when the evaluated savings match the Program-estimated savings

<sup>2</sup> The total overall relative precision achieved was 11%

<sup>3</sup> Fuel savings are a mix of natural gas, oil, and marine diesel fuel.

N/A = Not applicable

## 1.1 APPROACH

NYSERDA used RGGI funds to conduct 59 energy efficiency studies for wastewater plants around New York State. Measure adoption<sup>6</sup> was not investigated as part of this effort as it was already completed by the EFC in mid-2015. At that time, out of the 59 energy efficiency studies, 44 projects had installed measures, and additional projects and measures were still undergoing planning and construction.

The evaluators estimated the evaluated gross savings using data collected from telephone interviews with a statistically representative sample<sup>7</sup> of 14 site contacts who were knowledgeable about the completed energy efficiency studies and the measures that were installed. Prior to the survey, the Impact Evaluation Team engineers reviewed each report in the project sample to extract information to customize a script for each sampled energy efficiency study. The script was reviewed for accuracy by NYSERDA and EFC before being administered by the Impact Evaluation Team engineer. The 14 completed interviews included questions regarding the operations of the facility and the continued operation of the installed measures. The Impact Evaluation Team used the outcome of the interviews to update the measure savings analyses where appropriate. The savings from the updated analyses were then used along with the original Program-estimated savings to quantify the total realization rates (RRs) for the installed measures.

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<sup>6</sup> Measure adoption rate is ratio that quantifies the percentage of study-recommended savings to those that the customer adopted/installed. This factor solely addresses decision-making. It does not consider evaluated performance.

<sup>7</sup> The sample drawn was based on estimated energy savings of the projects that participated in the program. In this case, the 14 projects captured represented about 47% of the total estimated source Btu savings for the program.

## **1.2 FINDINGS AND RECOMMENDATIONS**

Overall, based on this evaluation, the Program sufficiently estimated the savings and plant operations. RRs did not vary much from 1, indicating that the Program-estimated savings were close to the savings impact of the Program.

The Impact Evaluation Team offers this recommendation based on the impact evaluation research:

- 1) If NYSERDA funds wastewater measures in the future, development of new baselines should be considered. This Program referenced market practices based on studies completed in 2003 and 2008 when defining baselines. This was appropriate for the energy efficiency studies, which were conducted in 2009 and 2010, and clearly provided strong Program results. NYSERDA should update these now decade old baseline references if future wastewater programs are pursued.



## **SECTION 2: INTRODUCTION**

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This section presents the Program description, the evaluation goals, and a summary of other Program considerations.

### **2.1 PROGRAM DESCRIPTION**

As discussed in Section 1, the EFC and NYSERDA established and jointly administered the Program to coordinate energy efficiency efforts at wastewater facilities for the American Recovery and Reinvestment Act and subsequent federal programs. NYSERDA provided energy efficiency studies and the EFC administered incentives and financing for the participating wastewater treatment facilities.

The Program funded 59 energy efficiency studies in total. Through information gathered by the EFC, 44<sup>8</sup> projects were reported to have installed measures. The financed energy measures improved operations at wastewater treatment facilities while achieving other benefits, including optimizing energy use through efficiency and renewable energy, mitigating greenhouse fuel impacts, and saving energy costs.

Some of the 15 projects that installed no measures through mid-2015 were still in active planning and construction phases and expected to complete installations. Other of the 15 projects that installed no measures through mid-2015 were not expected to install measures recommended in the studies because the community opted not to implement the recommended energy efficiency improvements, or in some cases due to long payback periods

#### **2.1.1 Summary of Program-Estimated Savings**

This evaluation covered energy efficiency studies completed through the Program between 2009 and 2011 that EFC had verified that measures were installed. The Program has not formally been evaluated in the past. A summary of the Program-estimated savings is provided in Table 2-1.

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<sup>8</sup> Ultimately, this population was reduced to 43 projects. Updated information provided during the evaluation indicated one project was still under construction. Please see Section 3.2 Sample Design for further discussion.

**Table 2-1. Program-Estimated Savings (44 Energy efficiency studies with Installed Measures)**

Parameter	Electric Energy (MWh/yr.)	Fuel (MMBtu/yr.)
Study recommended and tracked savings	21,548	52,567

## 2.2 EVALUATION OBJECTIVES

The primary objective of this evaluation was a review of electric and fuel savings estimates to establish RRs for each that can be applied to projects with installed measures through a study of a statistically significant number of projects.

## 2.3 OTHER PROGRAM CONSIDERATIONS

In energy efficiency study-only programs, it is common for some study recipients to secure installation incentives or grants to offset the costs to install recommended measures.

NYSERDA does not believe that any additional incentives came from other NYSERDA programs. The EFC provided installation incentives and financing, but is not believed to have claimed energy savings at the state level. Although co-funding from other energy efficiency programs run by entities such government organizations or utilities was possible for some measures, identifying any such overlap was not within the scope of this evaluation.

Another challenging topic with industrial – or in this case wastewater process-based facilities – relates to the appropriate baseline technology for projects that are considered new construction or a plant expansion, as there is no energy code to reference for these types of facilities or projects. In order to address this challenge, the Program used two sources to help define baselines. The first, a report entitled *Municipal Wastewater Treatment Plant Energy Baseline Study*, was prepared by M/J Industrial Solutions for Pacific Gas & Electric (PG&E) in June 2003 to support PG&E's Savings by Design Program. The findings from that report were cross-referenced with process information for New York State's wastewater sector using the data collected during the development of NYSERDA's *Statewide Assessment of Energy Use by the Municipal Water and Wastewater Sector*, which was completed in November 2008. These baselines demonstrated leadership in energy efficiency analysis at the time of the energy efficiency studies (2009 and 2010). NYSERDA should update these now decade old baseline references if future wastewater programs are pursued.

## SECTION 3: METHODS

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This section describes the methods used to develop impact estimates.

### 3.1 EVALUATION METHODS

This section describes the techniques used to estimate the savings from installing measures recommended in the Program energy efficiency studies.

#### 3.1.1 Electric and Fuel Realization Rates

The primary objective of this evaluation was to develop the savings RRs for Program-estimated electricity and fuel savings projects. To do this, the Impact Evaluation Team investigated the operation of installed efficiency measures and updated the savings analysis to reflect this up-to-date operation resulting in the evaluated savings on a sample of projects. RRs represent this adjustment to the Program-estimated savings, upward or downward, to account for differences between the evaluated savings and Program-estimated savings. The *RR* is defined as follows:

$$RR = \frac{Savings_{Evaluated}}{Savings_{Estimated}}$$

where:

*RR* = Realization rate

*Savings<sub>Evaluated</sub>* = Savings as per interview and desk review evaluation

*Savings<sub>Estimated</sub>* = Savings as estimated by the Program

The RR is applied to the Program-estimated savings, resulting in the evaluated gross savings estimates. Investigation of the RRs for this evaluation occurred through desk review and phone interviews of sites that were known to have installed measures. Preceding the calls, Impact Evaluation Team engineers reviewed the EFC-provided reports of installations and wrote detailed and site-specific questions surrounding the installed measures to be used in the interviews.

The Impact Evaluation Team engineers conducted each site interview in an effort to collect up-to-date information about the installed measures and equipment operation. Information such as current operating hours, updated load profiles, and up-to-date wastewater flow rates were collected.

The interview results were used to update the energy savings calculations in cases where the Impact Evaluation Team found that the operation or equipment was different from the original report.

### 3.1.2 Measure Adoption Rate

The measure adoption rate (MAR) was not investigated as part of this evaluation. Measure adoption rate is ratio that quantifies the percentage of study-recommended savings to those that the customer adopted/installed. This factor solely addresses decision-making. It does not consider evaluated performance. Although this is often a primary research objective for study or audit programs, the investigation was deemed unnecessary because NYSERDA was provided with an updated database by the EFC that listed the sites that had installed measures and which measures were installed.

## 3.2 SAMPLE DESIGN

The evaluation's data collection centered on individual telephone interviews with a sample of the 44 sites that completed an energy efficiency study through the Program between 2009 and 2011 and who had installed measures since the study was completed. A stratified ratio estimation (SRE) was used to select the projects to be evaluated.

In total 18 projects were selected. As can be seen in Table 3-1, five strata<sup>9</sup> were created using source-equivalent<sup>10</sup> MMBtu savings as the sampling unit, with Stratum 5, the bottom (having the lowest 0.1% of the program's installed savings) being eliminated from the population frame. The remaining projects were split into four strata with roughly equal total source MMBtu savings. Three of these strata were census, i.e., all projects in the stratum population would be in the sample. Together these three strata contained seven projects which accounted for 75% of the reported installed savings. The fourth stratum contained 32 projects, 11 of which were randomly selected.

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<sup>9</sup> The initial evaluation scope of work planned that the study completion year would be used as the upper-level stratification variable; however, it was not ultimately used. There were three reasons the Impact Evaluation Team did not utilize the upper-level stratification variable, the first was that the tracking data submitted did not contain the study completion year and would have required pulling the information out of the reports or portal, which would have added time and cost to the study, second there was a relatively small population overall, which meant less stratification was desirable; and third, the original analytical reason for including it was to ensure balanced distribution over time, which the evaluators did by checking the completion years after drawing the sample to ensure a representative mix of projects with varying study completion years.

<sup>10</sup> Total source MMBtu is calculated using the following equation: Conversion factor described below:

$$\text{kWh} \times 3.41 \times 2.95/1000 = \text{Total MMBtu.}$$

$$3.41/1000 = \text{conversion from kWh to MMBtu}$$

$$2.95 = \text{Represents 33.9\% grid efficiency.}$$

**Table 3-1. Sample Design Summary**

Stratum	Total Recommended Source-Equivalent MMBtu Savings <sup>1</sup>	Number of Projects, N	Percent of Savings	Error Ratio	Original Sample Size, n	Relative Precision	Completed Interviews	Notes
1	43,035	1	25%	N/A	1	0.0%	0	Census (removed due to project being incomplete)
2	40,010	2	24%	N/A	2	0.0%	1	Census (unable to solicit response from 1 site)
3	44,550	4	26%	N/A	4	0.0%	4	Census
4	41,386	32	24%	1.00	11	40.2%	9	Random (unable to solicit responses from 2 sites)
5	141	5	<1%	N/A	0	N/A	0	Eliminated
<b>Total</b>	<b>169,123</b>	<b>44</b>	<b>100%</b>	<b>1.00</b>	<b>18</b>	<b>N/A</b>	<b>14</b>	<b>N/A</b>

<sup>1</sup> Includes all energy savings: converted electric savings from MWh to source MMBtu. For the equation used see footnote on previous page.

N/A = Not applicable

Through the completion of site interviews and correspondences with NYSERDA and the EFC, the Impact Evaluation Team learned that the largest project – the only project in Stratum 1 – was not completely installed at the time of this evaluation and construction was still in progress. There will be savings in the future attributable to that project, but it could not be evaluated as part of this investigation; therefore, the evaluators removed this project from the population entirely.

### 3.2.1 Precision and Bias

The key parameters evaluated were the RRs for electric and fuel measures. The evaluation target precision was 10%. The total precision for the combined source Btu sample was 11%. The evaluation achieved a relative precision of 14% on the electric savings after the loss of Stratum 1. The precision for the fuel savings achieved was 2% for the evaluation.

## **SECTION 4: RESULTS, FINDINGS, AND RECOMMENDATIONS**

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This section presents the results and findings from the evaluation and concludes with a recommendation.

### **4.1 ELECTRIC ENERGY SAVINGS RESULTS**

This section summarizes the results of the interviews and analyses for electric energy projects.

#### **4.1.1 Program Electric Energy Savings and Realization Rates**

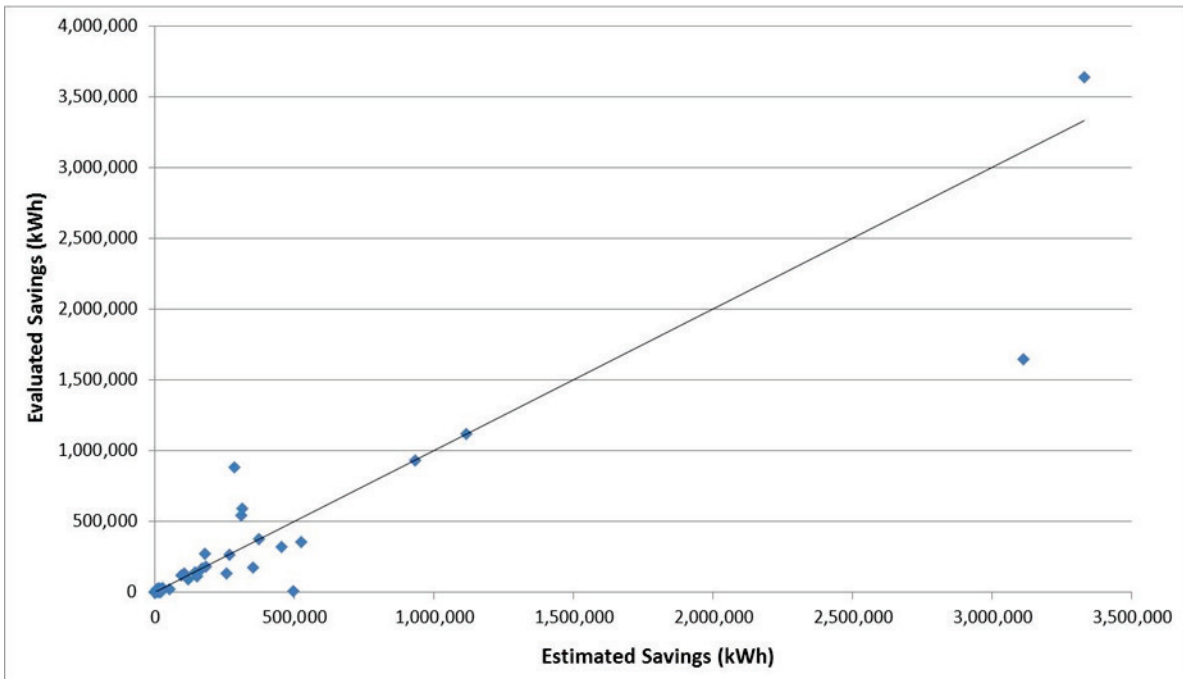
The RR for the electric energy savings of the Program, calculated as the evaluated savings divided by the Program-estimated savings, is 0.91. Table 4-1 provides the key Program results including the estimated savings, RR, evaluated electric energy savings, relative precision, and error ratio.

**Table 4-1. Study-Recommended and Evaluated Electric Energy Savings**

<b>Parameter</b>	<b>Program- Estimated Savings (MWh/yr.)</b>	<b>Realization Rate</b>	<b>Evaluated Savings (MWh/yr.)</b>	<b>Relative Precision at 90% Confidence</b>	<b>Error Ratio</b>
Electric energy	21,548	0.91	19,503	14%	0.56

Figure 4-1 illustrates the comparison between the evaluated annual electric energy savings and the savings estimated by the Program. For a RR of 1, the evaluated savings would match the Program-estimated savings; this is shown as a solid black line on the chart. The actual findings are plotted as points on the graph. A pattern of points below the line illustrates a RR of less than 1; points above the line illustrate a RR greater than 1. The error ratio is a measure of the degree of variance between the Program savings estimates and the evaluated estimates. The higher the error ratio, the greater the amount of scatter between points.

**Figure 4-1. Estimated and Evaluated Measure Electric Energy Savings**



The Program-level electricity savings error ratio was calculated to be 0.56. This is lower than the error ratio of 1 shown in Table 3-1, which was assumed in estimating the sample sizes, indicating less scatter in the point distribution than was assumed when estimating the sample sizes.

**4.1.2 Difference between Program and Evaluated Electrical Energy Savings**

For each project with a RR other than 1, a difference analysis was performed to identify the major driver or drivers of the RR. The difference analysis results are aggregated in an attempt to identify systematic differences between the estimates outlined in studies performed by the Program and the results from the Impact Evaluation Team interviews. The results of the difference analysis are presented in Table 4-2. This figure shows the impact of the difference in terms of increased and decreased savings.

**Table 4-2. Differences Analysis Results – Electric Energy**

Consolidated Categories	# of Occurrences	Impact on kWh
Difference in hours of operation	15	8.3%
Difference in equipment efficiency	6	-1.4%
Difference in methodological assumptions	5	-0.6%
Difference in installed equipment capacity	3	0.2%
Difference in equipment load profile	6	0.5%

Figure 4-2, above, demonstrates the key contributors to the 0.91RR for electric energy savings. Some of the major drivers to the RR are discussed below:

- Differences in operating hours:
  - There were several projects with both increases and decreases in hours of operation based on the survey results.
  - One project accounted for almost 25% of the difference under this category –the annual hours of operation for a system were assumed to be 8,760 but the interview found that the system only operated during very specific times of excessive flow throughout the year, reducing the operating hours to 240 hours per year.
- The category of differences in equipment load profiles contained the largest project that seemed to have a significant reduction in the RR; however, overall this category accounted for an increase in the savings attributable to the Program due to other projects offsetting that impact.
- These differences generally represent stand-alone events. The analysis found no systematic differences when compared with the evaluation.

#### **4.1.3 Additional Electric Energy Savings Results**

The Impact Evaluation Team also reviewed the evaluated projects to identify patterns or provide feedback about project performance based on measure type and other key project features. The resulting observations are presented below. Although these results do not adhere to the same 90/10 confidence precision targets as the evaluation sample, the Impact Evaluation Team is presenting the results because they are useful as feedback on project and measure performance.

##### ***Electric Energy Savings by Measure Type***

Wastewater process was the most common measure type evaluated. This category was fairly broad and accounted for several types of measures recommended at wastewater plants including but not limited to aeration systems, filtering systems, plant water systems, and disinfection systems. This category also accounted for 77% of the recommended electric energy savings from the Program. The RR for measures varied widely within this category, from 0.02 up to 4.33, with the unweighted average at 0.8 for the category.



The second largest measure category in quantity of measures was motors, while the second largest contributor to the total savings was controls (even though there was only one electric measure characterized as a controls measure).

**Figure 4-2. Number of Evaluated Electric Efficiency Measures by Measure Category**

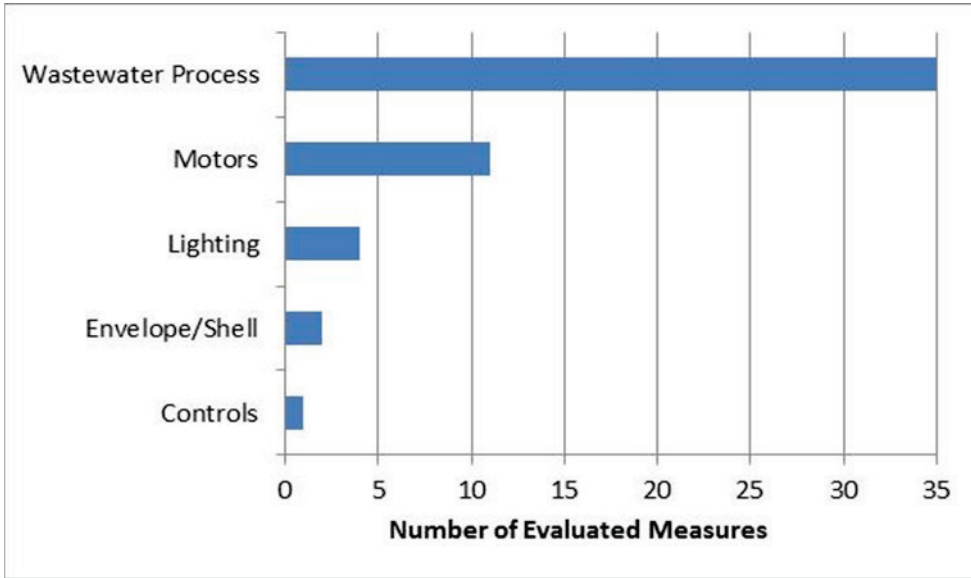


Figure 4-3 provides the savings by measure type for the sampled projects.

**Figure 4-3. Electric Energy Savings by Measure Category**

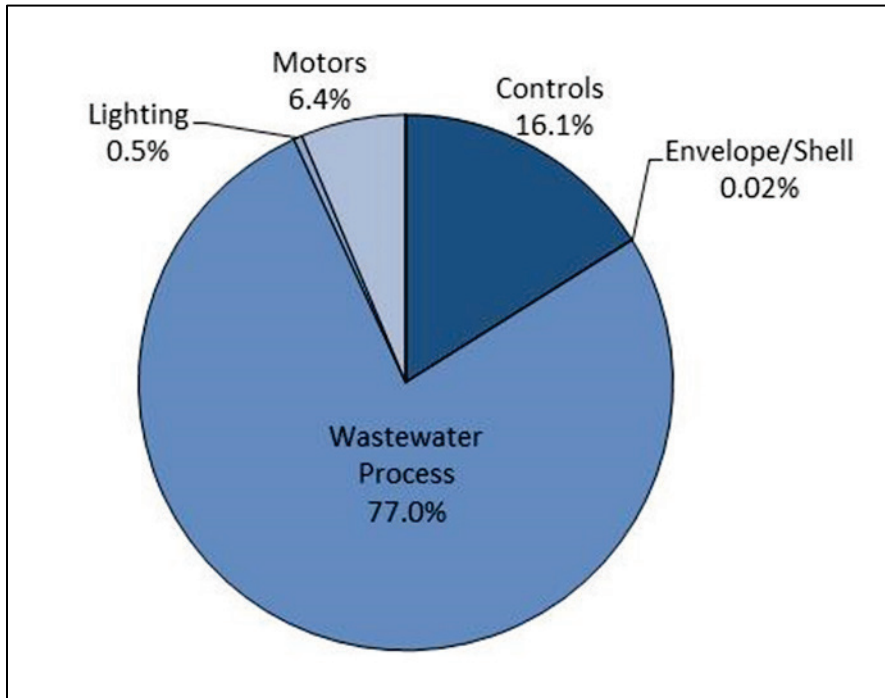


Table 4-3 presents the RRs for each measure group and are presented for informational purposes only. Since measure type was not a unique sampling stratum<sup>11</sup>, the measure level results are only representative of those projects evaluated. These RRs should not be extrapolated out to the Program level.

**Table 4-3. Unweighted Electric Energy Realization Rates by Measure Group**

Measure Category	Percentage of Electric Savings	Unweighted MWh RR <sup>1</sup>
Controls	16.1%	1.1
Envelope/shell	0.02%	1.0
Wastewater process	77.0%	0.8
Lighting	0.5%	0.5
Motors	6.4%	1.4

<sup>1</sup> These RRs should not be extrapolated out to the Program level, only RRs based on sampled stratum can be used to make statistically valid statements about the program.

### ***Electric Demand Savings***

Demand savings were not estimated by the Program and therefore were not a primary parameter of investigation; however, the Impact Evaluation Team did quantify the peak demand savings for projects where they existed. The evaluators found 28 measures that had peak electric demand savings as part of this evaluation. It is important to note that this is an evaluation engineering estimate without statistical certainty.

**Table 4-4. Evaluated Electric Demand Savings**

Parameter	Program-Estimated Savings (MW)	Realization Rate	Evaluated Savings (MW)	Relative Precision at 90% Confidence	Error Ratio
Peak demand reduction	N/A	N/A	1.73	N/A	N/A

N/A = Not applicable

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<sup>11</sup> Only RRs based on sampled stratum can be used to make statistically valid statements about the Program.

## 4.2 FUEL-SAVINGS RESULTS

This section summarizes the results of the interviews and analyses for fuel-saving projects.

### 4.2.1 Program Fuel Savings and Realization Rates

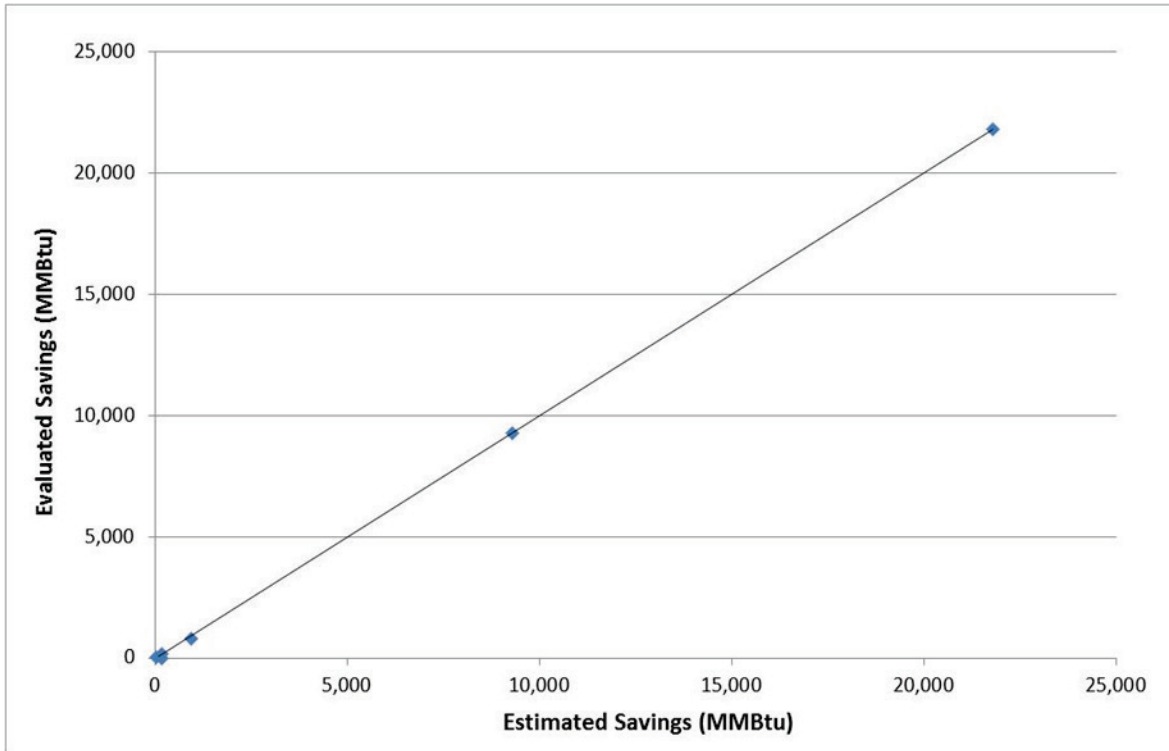
The RR for the fuel savings of the Program, analyzed for all fossil fuels together, is 0.98. Table 4-5 provides the key Program results including the estimated savings, RR, evaluated fuel savings, relative precision, and error ratio.

**Table 4-5. Study-Recommended and Evaluated Fossil Fuel Savings**

Parameter	Program- Estimated Savings (MMBtu/yr.)	Realization Rate	Evaluated Savings (MWh/yr.)	Relative Precision at 90% Confidence	Error Ratio
All Fossil Fuels	52,567	0.98	51,425	2%	0.09

Figure 4-4 illustrates the evaluated fuel savings compared with the values estimated by the Program. For a RR of 1, the evaluated savings would match the Program-estimated savings and this is shown as a solid black line on the chart. The actual findings are plotted as points on the graph. A pattern of points below the line illustrates a RR of less than 1; points above the line illustrate a RR greater than 1. The error ratio is a measure of the degree of variance between the Program savings estimates and the evaluated estimates. The higher the error ratio, the greater the amount of scatter between points.

**Figure 4-4. Estimated and Evaluated Fuel Savings**



The Program-level fuel savings error ratio was calculated to be 0.09. This is much lower than the 1.0 error ratio that was assumed in estimating the sample size, indicating less scatter in the point distribution than was assumed when estimating the sample sizes; therefore, the evaluation was able to attain better sampling precision than originally anticipated.

**4.2.2 Difference between Program and Evaluated Fuel Savings**

For each project with a RR other than 1, a difference analysis was performed to identify the major driver or drivers of the RR. The difference analysis results are aggregated in an attempt to identify systematic differences between the estimates outlined in studies performed by the Program and the results from the Impact Evaluation Team interviews. The results of the difference analysis are presented in Table 4-6. This figure shows the impact of the difference in terms of increased and decreased savings.

**Table 4-6. Differences Analysis Results – Fuel Energy**

Consolidated Categories	# of Occurrences	Impact on MMBtu
Measure not installed	1	-1.7%
Difference in hours of operation	2	-0.5%

Table 4-6, above, demonstrates the key contributors to the 0.98 RR for fuel savings. The primary driver in this case was one measure that was reported as being installed, however, discussions as part of the evaluation revealed that it was not, in fact, installed.

**4.2.3 Additional Fuel-Savings Results**

The Impact Evaluation Team also reviewed the evaluated projects to identify patterns or provide feedback about project performance based on measure type and other key project features. The resulting observations are presented below. Although these results do not adhere to the same 90/10 confidence precision targets as the evaluation sample, the Impact Evaluation Team is presenting the results because they are useful for providing feedback on project and measure performance.

***Fuel Savings by Measure Type***

There are six fuel-saving measures in the population, with half of them characterized as HVAC projects. This category also accounted for over 70% of the recommended fuel savings from the population. The unweighted RR for that category was 0.97. The remaining three categories each had one measure represented in the population.

**Figure 4-5. Number of Evaluated Measures by Measure Category**

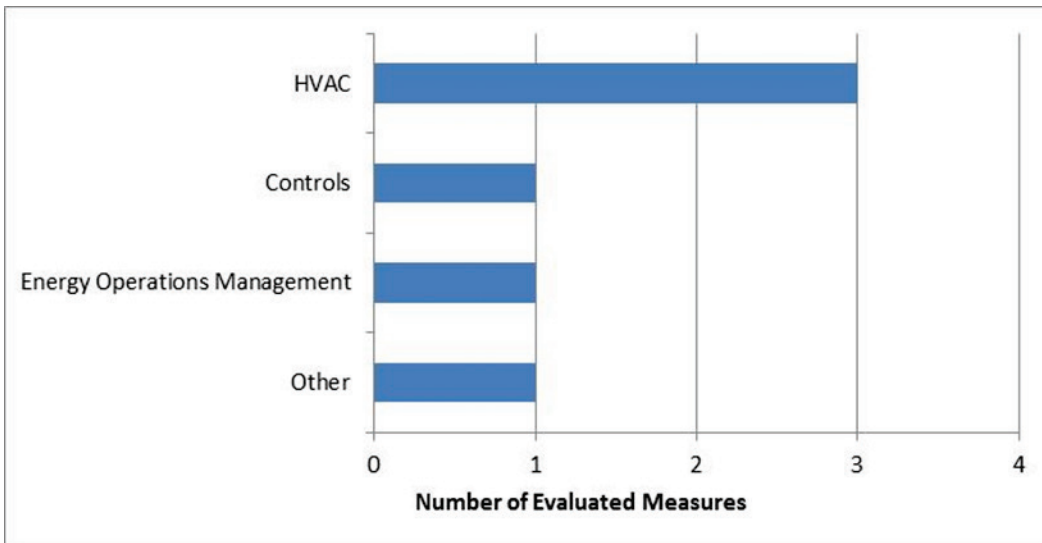


Figure 4-6 provides the savings by measure type for the sampled projects.

**Figure 4-6. Fuel Savings by Measure Category**

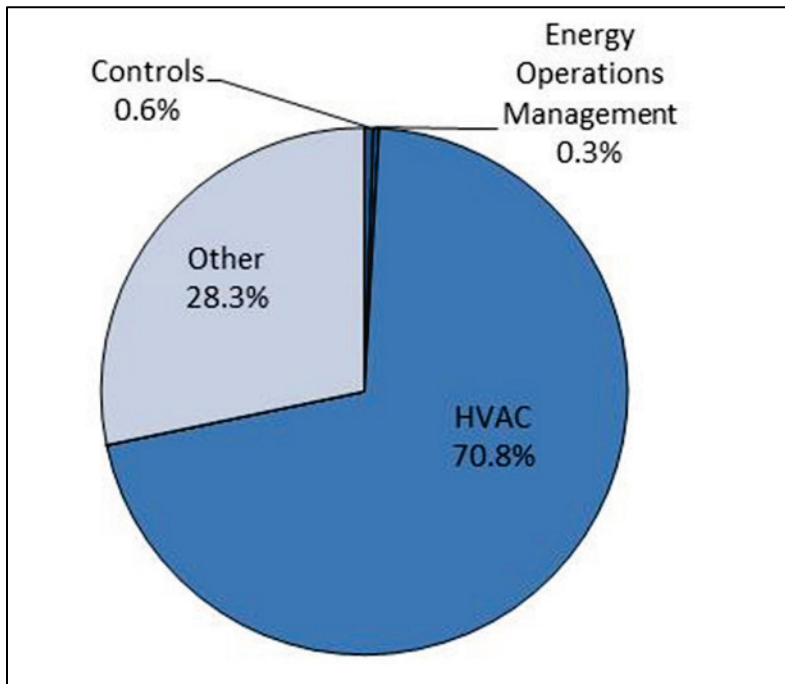


Table 4-7 presents the RRs for each measure group. Since measure type was not a unique sampling stratum, the measure-level results are only representative of those projects evaluated. These RRs should not be extrapolated out to the Program level.

**Table 4-7. Unweighted Electric Energy Realization Rates by Measure Group**

Measure Category	Percentage of MMBtu Savings	Unweighted MMBtu RR1
Controls	0.6%	0.95
Energy operations management	0.3%	1.00
HVAC	70.8%	0.97
Other	28.3%	1.00

<sup>1</sup> These RRs should not be extrapolated out to the Program level, only RRs based on sampled stratum can be used to make statistically valid statements about the program

### 4.3 FINDINGS AND RECOMMENDATIONS

The Impact Evaluation Team offers this recommendation based on the impact evaluation research.

- 1) If NYSERDA funds wastewater measures in the future, development of new baselines should be considered. This Program referenced market practices based on studies

completed in 2003 and 2008 when defining baselines. This was appropriate for the energy efficiency studies, which were conducted in 2009 and 2010, and clearly provided strong Program results. NYSERDA should update these now decade old baseline references, if future wastewater programs are pursued.