NAVIGANT

Impact Evaluation of the Efficiency Maine Trust 2010-2011 Commercial Projects Grant Program: Funded by the American Recovery and Reinvestment Act of 2009 (ARRA)

Prepared for:
Efficiency Maine Trust

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Prepared by:

Navigant Consulting, Inc.
125 College Street, Suite 400
Burlington, VT 05401
(802) 526-5112
www.navigant.com

Turner Building Science
26 Pinewood Lane
Harrison, ME 04040
(207) 583-4571
www.turnerbuildingscience.com

Key Contacts:
Navigant: Justin Spencer, Keith Downes, Toben Galvin
Turner Building Science: Jeff Preble

Table of Contents

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List of Figures and Tables

Figures:

Tables:

Executive Summary

This report presents the results of an impact evaluation of Efficiency Maine Trust's (EMT's) Commercial Projects Grant Program for the 2010-2011 time period. The program provides competitive matching grants for custom electric and fossil fuel energy efficiency and renewable energy projects. The program was implemented in response to the funding opportunities made available from the American Recovery and Reinvestment Act of 2009, State Energy Program (ARRA-SEP). Funding of up to $50,000 per project was awarded through a competitive review and selection process conducted by EMT. The program disbursed $1.6 million through December 31, 2011 and is scheduled to be discontinued effective April 30, 2012.

Navigant Consulting, Inc. (Navigant) and Turner Building Science were selected by EMT to conduct an impact evaluation of the program results to date. Navigant's scope of work focused on quantifying and verifying the energy savings and greenhouse gas reductions achieved by the program. This work explicitly did not include any process evaluation objectives. Specific research objectives included:

- Measure and verify energy savings, including:
    - Site and source[1] energy savings and greenhouse gas reductions for all projects
    - Fossil fuel savings, including fuel oil savings
    - Electric demand savings
    - Renewable capacity generation for renewable projects
- Analyzing the attribution of impacts to the SEP/ARRA-funded grants to Commercial Projects and impacts on job creation
- Analyzing the cost effectiveness of the individual projects and program overall according to the Maine TRC test and the U.S. Department of Energy (DOE) SEP Recovery Act benefit/cost test.

As summarized in Table ES-1, the verified site energy impacts of the program found a gross realization rate of 0.67 and a net-to-gross ratio (freeridership adjustment only) of 0.62.

[1] Source energy refers to the total energy consumed through the entire process of mining, transporting, and burning fuel to provide a given fuel at the home. For a fuel like natural gas with very little energy input outside of the fuel delivered, the ratio between source energy and energy delivered might only be 1.02 to 1.1. For electricity, where fossil fuels are converted at the expense of significant thermodynamic losses, the ratio of source energy to energy provided is closer to 3.

Table ES-1: Verified Program Impacts

Metric	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)
Annual Site Energy Savings (MMBtu)	31,335	20,992	0.67	0.62	13,029
Lifetime Site Energy Savings (MMBtu)	N/A	442,181	N/A	0.61	269,966

Note: Values in this table are site energy savings. Source energy savings may be found in Section 3.2.5.
The NTG values are not the same because variations in the lifetime cause the strata weights to change.

Unlike EMT's existing, and ongoing, Business Incentive Program which provides incentives for electric measures, this Commercial Projects Grant program offered funding for non-electricity projects. The program also provided funding for a variety of renewable energy projects, with energy savings coming primarily from biofuel cogeneration and solar hot water systems. Projects included in the evaluation were stratified into different strata for purposes of sampling, as summarized in Table ES-2.

Table ES-2: Projects Included in Evaluation

Strata	Number of Projects	Types of projects included
Very Large	2	HVAC, Controls
Other Large	6	Shell measures and HVAC upgrades (boilers and controls)
Renewable Electric	3	Vegetable Oil Cogeneration, Process Solar Thermal*, Solar Photovoltaic (PV)
Non-Renewable Electric	5	Lighting, HVAC, Controls
Renewable Non-Electric	12	Solar Thermal
Non-Renewable Non-Electric	12	Shell measures and HVAC upgrades (boilers and controls)
Other Very Small Projects (not sampled)	11	-

*Process Solar Thermal refers to solar thermal collection for use in a commercial/industrial process application. In this case, the application heated water for use in a hot water disinfection operation in a water treatment plant, offsetting the consumption of an electric immersion heating element.
Source: Navigant analysis.

Table ES-3 presents verified program impacts by the different fuel type savings.

Table ES-3: Verified Program Impacts

Metric		Reported Gross Savings	Verified Gross Savings	Verified Net Savings
Overall Program Annual Savings	Site Energy Savings (MMBtu)	31,335	20,992	13,029
	Greenhouse Gas Savings (metric tons CO2e)	2,218	2,058	1,312
Overall Program Lifetime Savings	Site Energy Savings (MMBtu)	663,118	442,181	269,966
	Greenhouse Gas Savings (metric tons CO2e)	51,261	62,889	42,656
Annual Electricity Savings	Energy (MWh)	938	712	565
	Summer Peak Demand (kW)	N/A	109	86
	Winter Peak Demand (kW)	N/A	85	69
Lifetime Electricity Savings	Energy (MWh)	N/A	13,222	10,624
Annual Fossil Fuel Savings	Total Fossil Fuel Savings (MMBtu)	28,134	18,639	11,170
Lifetime Fossil Fuel Savings	Total Fossil Fuel Savings (MMBtu)	N/A	398,468	234,956
Annual Renewable Energy Impacts	Installed Electric Capacity (kW)	N/A	33	30
	Annual Electricity Generation (kWh)	228,772	154,537	143,606
	Annual Energy Production (MMBtu)	2,969	1,482	1,290
Lifetime Renewable Energy Impacts	Lifetime Electricity Generation (kWh)	N/A	3,855,267	3,582,557
	Lifetime Energy Production (MMBtu)	N/A	37,100	32,304

Source: Navigant analysis
Note: CO2e refers to CO2-equivalent tons; Source energy savings may be found in Section 3.2.5; Fossil Fuel Savings includes Oil, Natural Gas, and Propane converted to MMBtu

Because the program was able to generate significant high value propane and fuel oil savings, the program had a very strong TRC test result, 2.85, as shown in Table ES-4. For comparison, the Business Incentive Program TRC result for FY2011 was 1.9.[2] The SEP Recovery Act Cost (SEP-RAC) test measures the net source energy impacts attributable to the SEP-ARRA funds compared to the SEP-ARRA funds. The program SEP-RAC test result of 7.5 falls short of the DOE goal of SEP-RAC tests greater than 10.

[2] *Evaluation of the Efficiency Maine Business Incentive Program*, prepared for Efficiency Maine Trust, Opinion Dynamics Corporation, 2011.

Table ES-4: Cost-Effectiveness Results

Cost-Effectiveness Tests	Result
Maine TRC Test	2.85
SEP Recovery Act Cost Test (Source MMBtu/$1000 SEP-ARRA Funds)	7.5

Source: Navigant analysis.
Note: The Maine TRC Test uses gross benefits and costs. The net TRC is 2.35. Source MMBtu refers to the total energy consumed from extraction through consumption. For example, for each unit of electricity consumed, between 3 and 3.5 units of fossil energy input are generally required to produce and deliver that electricity.

Given the strong energy savings and cost-effectiveness performance of this program, it is unfortunate that the program is slated to end when the ARRA funding runs out. **If a source of funds for continuing a similar custom program focused on fossil fuel savings were made available, the program has everything necessary to generate a very strong return on societal investment.**

1. Introduction

1.1 Objectives

This report presents the results of an impact evaluation study of the Efficiency Maine Trust's (EMT) ARRA funded Commercial Projects Grant Program over the 2010-2011 time period. Navigant Consulting, Inc. (Navigant) and Turner Building Science (Turner) were selected to conduct the evaluation.

Navigant's scope of work was designed to provide a comprehensive impact evaluation that focused on quantifying and verifying the energy savings and greenhouse gas reductions achieved by the program. This work explicitly did not include any process evaluation objectives. Specific research objectives included:

- Measure and verify energy savings, including:
    - Site and source[3] energy savings and greenhouse gas reductions for all projects
    - Fossil fuel savings, including fuel oil savings
    - Electric demand savings
    - Renewable capacity generation for renewable projects
- Analyzing the attribution of impacts to the SEP/ARRA-funded grants for Commercial Projects and impacts on job creation
- Analyzing the cost effectiveness of the individual projects and program overall according to the Maine TRC test and the U.S. Department of Energy (DOE) SEP Recovery Act benefit/cost test.

1.2 Background

Efficiency Maine Trust's (EMT's) Commercial Projects Grant Program provides competitive matching grants for custom energy efficiency and greenhouse gas reduction projects. The program was implemented in response to the funding opportunities made available from the American Recovery and Reinvestment Act of 2009, State Energy Program (ARRA-SEP). The program administered two rounds of grants in March and August 2010 respectively, for a total of 65 projects. In each round, funding of up to $50,000 per project was awarded through a competitive review and selection process conducted by EMT. Grants were awarded on the basis of several factors including: annual energy savings per $1 of grant funds, technical viability, economic impact and job creation potential, project budget, including matching funds, and team qualifications.

[3] Source energy refers to the total energy consumed through the entire process of mining, transporting, and burning fuel to provide a given fuel at the home. For a fuel like natural gas with very little energy input outside of the fuel delivered, the ratio between source energy and energy delivered might only be 1.02 to 1.1. For electricity, where fossil fuels are converted at the expense of significant thermodynamic losses, the ratio of source energy to energy provided is closer to 3.

The impact evaluation of the program was conducted by the Navigant and Turner from May-December 2011. Of the total 65 projects awarded grants, 51 had reported savings and were completed by December 31, 2011. The program had disbursed $1.6 million to these projects as of the end of 2011. The evaluation covers these 51 projects.

The EMT's Commercial Projects Grant Program is fuel neutral and grants may be used for electricity conservation, fossil fuel conservation, and renewable generation projects. As a result of the program design and focus on custom projects and the prevalence of oil and propane use in Maine, the program generates energy savings from a wide variety of fuels and project types. This results in high variability in the impacts across projects. It also means that impacts are measured in a variety of units. Given this variability, the evaluation of program impacts required a combination of oversampling of projects with a given type of fuel savings and also converting all savings to a common baseline, which is site energy measured in British Thermal Units (Btu).[4] The site energy results are the most indicative of the overall program results..

1.3 *Approach*

Out of the original 65 projects reported, the evaluation covered the 51 projects that had reported savings and were completed as of the end of 2011. Thirty of these projects were included in the evaluation sample and ultimately received detailed site-level savings analysis, as shown in Table 1-1.

Table 1-1: Status of Projects

Status of Projects	Number of Projects
Original Reported Projects	65
Sampled Completed Projects	30
Other Completed Projects as of 12/31/2011 (Included in Evaluation)	21
Total Projects Included in Evaluation	**51**
Feasibility Studies with 0 Reported Savings	2
Projects Delayed until 2012	11
Projects Cancelled	1

Note: The initial sample drawn included 40 projects; 10 of these projects did not complete installation within the evaluation period and are not included in the final evaluation sample; these projects are counted in "Projects Delayed until 2012" or "Projects Cancelled".

The 30 projects sampled were analyzed using a variety of data collection and analysis methods. All of the 30 projects sampled received phone verifications and attribution surveys. In a phone verification, a Navigant engineer reviews project documentation and savings assumptions and then conducts a phone interview with the grant recipient and/or contractor staff to collect project data for developing phone-verified energy savings calculations. In the attribution survey, Navigant asked questions about what the grant recipient would have done without the program, in order to determine the extent of attribution and freeridership, as well as questions to gather data on funding and inputs for cost-effectiveness

[4] Site energy refers to the thermal energy content of energy consumed in the building, not including any upstream or downstream energy consumption of energy.

analysis . As detailed in Table 1-2, out of the 30 projects with phone verifications, 23 projects received additional on-site measurement and verification. During on-site measurement and verification, Navigant field staff visited the project site to collect key information about the installed equipment and facility characteristics in order to develop site-verified energy savings calculations. The details of the site level analysis and results are documented in individual site reports.

Table 1-2: Data Collection Methods

Data Collection Method Applied	Number of Projects (Sample Size)
Phone Verifications	30
Attribution Surveys	30
On-site Measurement and Verification	23

Source: Navigant analysis.
Note: Navigant staff performed additional work on 10 sites that were not included in any of the totals above due to extended and cancelled projects that were originally in the sample .One project received an on-site that resulted in incomplete data being collected. This project is classified as a phone-verification-only site.

2. Methodology

2.1 *Impact Evaluation Approach*

Navigant's measurement and verification strategy included a document review and phone interview verification, including the attribution survey, for a sample of projects, followed by on-site measurement and verification at a sub-sample of projects.

2.1.1 Sample Design

To satisfy the key evaluation objective of estimating site energy savings for all projects, a stratified ratio estimation method was used, in which a best fit of the program realization rate was calculated by comparing the reported savings to the verified savings for each project in the sample. In this method, the larger projects have a larger influence on the program results and are sampled at a higher proportion.

In this evaluation, site energy savings had a target two-tailed confidence and precision of 90/10, consistent with DOE guidance for evaluations of ARRA-SEP funded programs. In addition, the sample was stratified to help in the evaluation of electricity savings and renewable generation. This stratification ensured that a sufficient number of sites with electricity or renewable savings were sampled in order to generate impact results for these two fuel types.

The evaluation used a two-step method, known as the double ratio estimation method[5], that relied on phone interview verification (step one) and on-site verification (step two). The overall sample of projects for source energy savings analysis (n=30) received phone interview verifications, which help reduce the uncertainty in the estimate of energy savings and reduce the accompanying coefficients of variation (CVs) for the on-site verification sub-sample.[6] This method is especially useful when reported savings are likely to have errors. Because the Commercial Projects Grant Program was implemented on a short timeline with limited technical review of projects, the double ratio estimation method proved to be very useful in this evaluation.

The projects were stratified first according to the size of estimated energy savings measured in MMBtu, with the smallest 3 percent of sites removed from consideration for the sample. The single site with two of the largest projects was designated as the "very large" stratum. All other projects with over either 200,000 kWh or 900 MMBtu total energy were placed in the "large" stratum. The remaining projects were divided up into four strata according to whether or not they had any electricity savings and whether or not they had any renewable savings. The sample stratification is shown in Table 2-1.

[5] R.L. Wright et al. "Double Ratio Analysis: A New Tool for Cost-Effective Monitoring." 1994 ACEEE Summer Study. http://eec.ucdavis.edu/ACEEE/1994-96/1994/VOL08/263.pdf.

[6] The coefficient of variation is defined as the standard deviation of a population divided by the mean of the population. It provides an estimate of the underlying variability in the population, which drives the overall sampling uncertainty.

Table 2-1: Sample Stratification

Strata	Annual Gross Reported Savings (Site MMBtu)	Number of Projects	Phone Verifications	On-Site Verifications
Very Large	9,954	2	2	2
Other Large	9,631	6	6	6
Renewable Electric	1,352	3	3	3
Non-Renewable Electric	2,443	5	5	3
Renewable Non-Electric	2,969	12	7	5
Non-Renewable Non-Electric	4,159	12	7	4
Other Very Small Projects (not sampled)	827	11	-	-
Total	31,335	51	30	23

Source: Navigant analysis.

Table 2-2 shows the types of projects that are contained in each of the strata. This information is useful for interpreting the stratum-level results found in Section 3 of this report.

Table 2-2: Project Types by Stratum

Strata	Number of Projects	Types of projects included
Very Large	2	HVAC, Controls
Other Large	6	Shell measures and HVAC upgrades (boilers and controls)
Renewable Electric	3	Vegetable Oil Cogen, Solar PV, Process Solar Thermal
Non-Renewable Electric	5	Lighting, HVAC, Controls
Renewable Non-Electric	12	Solar Thermal
Non-Renewable Non-Electric	12	Shell measures and HVAC upgrades (boilers and controls)
Other Very Small Projects (not sampled)	11	-

Source: Navigant analysis.

2.1.2 Impact Analysis Approach Overview

In order to calculate gross and net impacts, the evaluation team performed the following eight general tasks:

1. **A stratified sample of projects was drawn for document reviews, phone verification, and on-site data collection to verify the engineering-adjusted impacts.**
   a. The sample included two levels of analysis, using a double ratio estimation method
   b. An overall sample was drawn for performing *document reviews* and *phone verifications*
   c. An on-site subsample was drawn from within the overall sample for performing *on-site verification* of phone-verified savings

2. **Conducted detailed documentation review for the *overall sample of projects* (n=30).**
   a. Acquired all available project documentation from program staff.
   b. Determined the algorithm used to calculate program reported savings and determined if a different algorithm is more applicable or appropriate
   c. Identified the key assumptions used in the calculation of reported savings
   d. Identified places where a better source of an assumption may be available

3. **Interviewed facility staff by phone for *the overall sample of projects* (n=30).**
   a. Obtained additional project documentation
   b. Obtained available baseline data
   c. Obtained available interval meter data or EMS trend logs as available/needed
   d. Obtained details on other sources of project funding for attribution purposes
   e. Completed decision-maker surveys for attribution purposes
   f. Followed-up with facilities staff to determine the source and accuracy of assumptions

4. **For each project in the *on-site subsample*, developed a site data collection plan (n=23).**
   a. Identifed key sources of potential error in assumptions
   b. Determined appropriate International Performance Measurement and Verification Protocol (IPMVP) option for analysis
   c. Determined correct combination of spot measurements, field verification of assumptions, and data logging to be deployed at the site

5. **Collected field data from each project in the on-site subsample (n=23).**
   a. Performed on-site visit, including spot measurements, verification of baselines, and deployment of data loggers if necessary
   b. Performed a second retrieval site visit to pick up data loggers (if deployed)

6. **Analyzed document review and phone verification data and calculated phone verification rates for each stratum.**
   a. Used document review and phone verification data to refine assumptions and calculate phone-verified impacts for each site in the overall sample
   b. For each stratum, divided phone-verified impacts by reported impacts to derive a phone verification rate for each stratum

7. **Analyzed field data and calculate field verification rates for each stratum.**
   a. Used field data to refine assumptions and calculate field-verified impacts for each sampled site
   b. For each stratum, divided field-verified impacts by phone-verified impacts to derive a field verification rate for each stratum

8. **Calculated total program impacts and uncertainty.**
   a. Applied phone verification rates by strata to those projects not included in the overall sample
   b. Applied field verification rates by strata to projects not included in the on-site subsample

c. Where reported savings were unavailable, extrapolated site-verified results to total population using ratio of one verified impact to another verified impact (i.e., kW)
d. Summed field-verified impacts to derive the program total impact

2.1.3 Overall Site Energy

Site energy includes all energy consumed on site, converted into common thermal units (MMBtu). Site energy savings can be computed as the difference between total energy consumed at the site before and after the project's completion. In many cases for this evaluation, this computation was a direct conversion from how much fuel was used before and after the project's completion. The general algorithm for this is shown below.

where:

- is the thermal energy savings.
- is quantity of fuel consumed, in fuel-specific units
- *CF* is the conversion factor for units of fuel into thermal energy

2.1.4 Fossil Fuel Savings

Fossil fuel savings were determined based on the project type. In the cases of shell improvement and HVAC upgrade projects, the fossil fuel savings account for a change in efficiency resulting from upgraded controls, upgraded heating system or shell improvements. In the case of new renewable technologies, the fuel saved was determined by converting the amount of energy generated by the renewable system to the equivalent amount of fuel being displaced, taking into account the efficiency of the backup system. For example, a given solar system might produce 100 MMBtu of thermal energy in a year. If the backup water heating system had an efficiency of 80%, then the total fuel savings would be 100 MMBtu/ 80% = 125 MMBtu.

Projects which involve fuel conversion from one fossil fuel to another will have both positive and negative fuel savings. The replaced fuel will be positive savings and the new fuel will be negative savings. This accounts for the site still using fossil fuels.

2.1.5 Electric Energy and Demand Savings

Electrical energy savings were calculated for each sampled site with electricity savings and extrapolated to the total population. Because demand savings were not reported, demand savings had to be extrapolated using a multi-step process. First, summer and winter peak demand savings were calculated for each sampled site with electricity savings. The ratio of verified peak demand savings to verified electricity savings was calculated for summer and winter for each stratum. These ratios were then multiplied by the stratum-verified electricity savings to determine stratum and program peak demand savings.

2.1.6 Renewable Capacity and Generation

Renewable energy capacity is the thermal or electric nameplate capacity of a renewable system. This is the amount of energy that could theoretically be achieved with perfect efficiency and conditions. Renewable energy generation is the amount of energy actually produced from a system. Generation is calculated as:

where:

- *CF* is the capacity factor of the technology; the capacity factor is the average expected output of a generator expressed as a percentage of the nameplate capacity.
- η is the efficiency (assumed or proven) of the technology
- *t* is the amount of time the technology was in use.

The renewable energy generation for the solar thermal and solar photovoltaic projects included in the sample was calculated with a calibrated simulation in the National Renewable Energy Laboratory's System Advisor Model (SAM). The SAM allows users to enter the specific model numbers of the solar panels and inverters or solar collectors, the weather data for the specific location, tilt and azimuth, and other system details. Models for the solar thermal projects also include the hourly hot water draw, storage tank details, circulation pump and heat exchanger details and information about the auxiliary hot water heater. These methods are discussed further in Appendix B.1.1.

2.1.7 Greenhouse Gas Emissions Reductions

Greenhouse gas emissions reductions were determined by calculating the difference of the carbon dioxide equivalents (CO2e) for each fuel used before and after the project's completion. The total greenhouse gas emissions used in this evaluation include on-site combustion emissions as well as precombustion emissions associated with upstream extraction, refining, and transportation. For electricity, total emissions include all combustion and precombustion emissions associated with the production of a unit of electricity. The algorithm to determine carbon emissions reductions ( ) for each project is:

where

- *Fuel* is the amount of fuel or electricity used (in gallons, ft^3, or kWh)
- *CF* is the conversion factor between fuel units and lb of CO2e.

The conversion factors are shown in Table 2-3. Emissions were calculated using the sum of precombustion and combustion CO2e factors.

Table 2-3: Greenhouse Gas Emission Factors

Fuel Type	Precombustion CO2e	Combustion CO2e	Total CO2e
Electricity	-	-	1.166 lb/kWh
Natural Gas	0.0278 lb/ft^3	0.123 lb/ft^3	0.1508 lb/ft^3
Distillate Fuel Oil	4.1 lb/gal	22.8 lb/gal	26.9 lb/gal
Residual Fuel Oil	4.47 lb/gal	25.6 lb/gal	30.07 lb/gal
LPG	2.56 lb/gal	13.5 lb/gal	16.06 lb/gal
Propane	2.56 lb/gal	12.95 lb/gal	15.51 lb/gal

Source: Source Energy and Emission Factors for Energy Use in Buildings (Deru and Torcellini [7])
Note: Propane precombustion value is assumed to be the same as LPG. Combustion value from EIA[8]. Electricity CO2e includes CO2 only, from 2011 Synapse report.[9]

2.1.8 Job Creation

The Navigant team used the ACEEE Energy Stimulus Jobs Calculator[10] to estimate jobs created by Commercial Project Grants for DOE reporting. The ACEEE Calculator uses an input-output framework to evaluate the number of jobs created per dollar of stimulus funding invested in energy efficiency based on the following four inputs:

- **Investment** – Project investment in millions of dollars
- **Savings** – Annual energy bill savings in millions of dollars
- **Stimulus Period** – Number of years over which stimulus money is spent
- **Financing Shares** – Percent of total investment provided by federal, and out-of-pocket local and locally borrowed funds

To determine the input values, Navigant extrapolated savings and investment from the gross verified savings and incremental costs obtained from our phone verification (engineering review) sample. Financing shares were determined using participant responses to the attribution and cost-effectiveness survey.

2.1.9 Other Sources of Uncertainty

Throughout the evaluation, Navigant strove to reduce measurement error and/or bias. Sites were randomly selected for inclusion in the sample from within each stratum. All sites selected for the sample that had completed installation of energy-efficient equipment in time for evaluation were successfully recruited to participate in the evaluation, in some cases with recruiting assistance from EMT staff. With all sampled sites participating (100% response rate), there was no possibility for response bias in the results. For each sampled site, phone surveys and data collection plans were developed and reviewed for technical accuracy by experienced engineers before they were deployed. This ensured that the best

[7] Deru, Michael and Paul Torcellini [2007], *Source Energy and Emission Factors for Energy Use in Buildings*, National Renewable Energy Laboratory, Golden, CO. NREL/TP-550-38617.

[8] Carbon Dioxide Emissions Factors for Stationary Combustion, Energy Information Administration [2005]. http://www.eia.gov/oiaf/1605/coefficients.html

[9] Avoided Energy Supply Costs in New England: 2011 Report, Synapse Energy Economics, Inc.

[10] www.aceee.org/press/2009/07/aceee-releases-job-calculator-energy-saving-stimulus-pro

possible approach was used at each site, in order to minimize the amount of extrapolation and unverified assumptions that would be used in the analysis of results for each site.

2.2 Attribution Approach

The evaluation team used a self-report survey (the attribution survey) to quantify the degree of freeridership in the program. A simple, proven freeridership logic model (See Appendix B) was applied to the design of the survey and attribution analysis for this purpose. Spillover was not quantified as part of the attribution analysis because most spillover does not occur until well after the projects are completed. Given the timing of surveys occurring shortly after or before projects were completed, any assessment of spillover at this time would underestimate actual spillover. Instead, an explicitly conservative approach was used in the calculation of the program's net-to-gross ratio (NTG), taking into account only freeridership NTG = (1 – FR).[11]

2.3 Cost-Effectiveness Analysis Approach

Navigant conducted a benefit-cost analysis of the Commercial Projects Grant Program through the use of the EMT benefit-cost screening tool (Version 2.2). All relevant measure and project data were verified by Navigant engineers and entered in the tool. Project cost data was obtained from customer invoices, the EMT Commercial TRM, and other regional TRM documents as appropriate. Project data was input at the individual measure level (electric and fossil fuel savings, incremental cost, and measure life) to calculate measure level savings and cost effectiveness. In the benefit-cost model calculations, electricity and fossil fuel savings at the measure level are subtotaled for each project and finally for the program as a whole. At the program level, the model calculates cost effectiveness, program incentive and non incentive costs, total program costs, and cost of conserved energy. Benefit-cost results for the sampled projects were extrapolated to the population by stratum, using benefits and costs per annual site MMBtu in each sampled stratum. Both net and gross TRC results were calculated by applying the NTG factor.

The State Energy Program Recovery Act Cost (SEP RAC) Test is a metric for measuring the performance of the program calculated as the annual source MMBtu saved per $1000 of ARRA funds expended.

[11] The typical approach includes spillover (SO), and is calculated using the equation NTG = 1 – FR + SO.

3. Impact Findings

The impact findings are summarized below in terms of gross savings and net savings. Gross savings refer to the entire savings realized at the customer site, while net savings consist of the savings that are attributable to the program after taking into account savings that would have occurred in the absence of the program (freeridership). In this evaluation, the estimate of net savings was calculated by subtracting estimated freeridership from gross savings, using NTG * gross savings. Because net savings and NTG were explicitly calculated for each site in the overall sample, the NTG value varies depending on the impact and level of aggregation.

3.1 Verified Gross and Verified Net Site Energy Savings

The overall site energy savings results for the Commercial Projects Grant program are summarized in Table 3-1. The site energy savings include all fuels saved in their thermal MMBtu equivalents.

Table 3-1: Site Energy Savings and Realization Rates

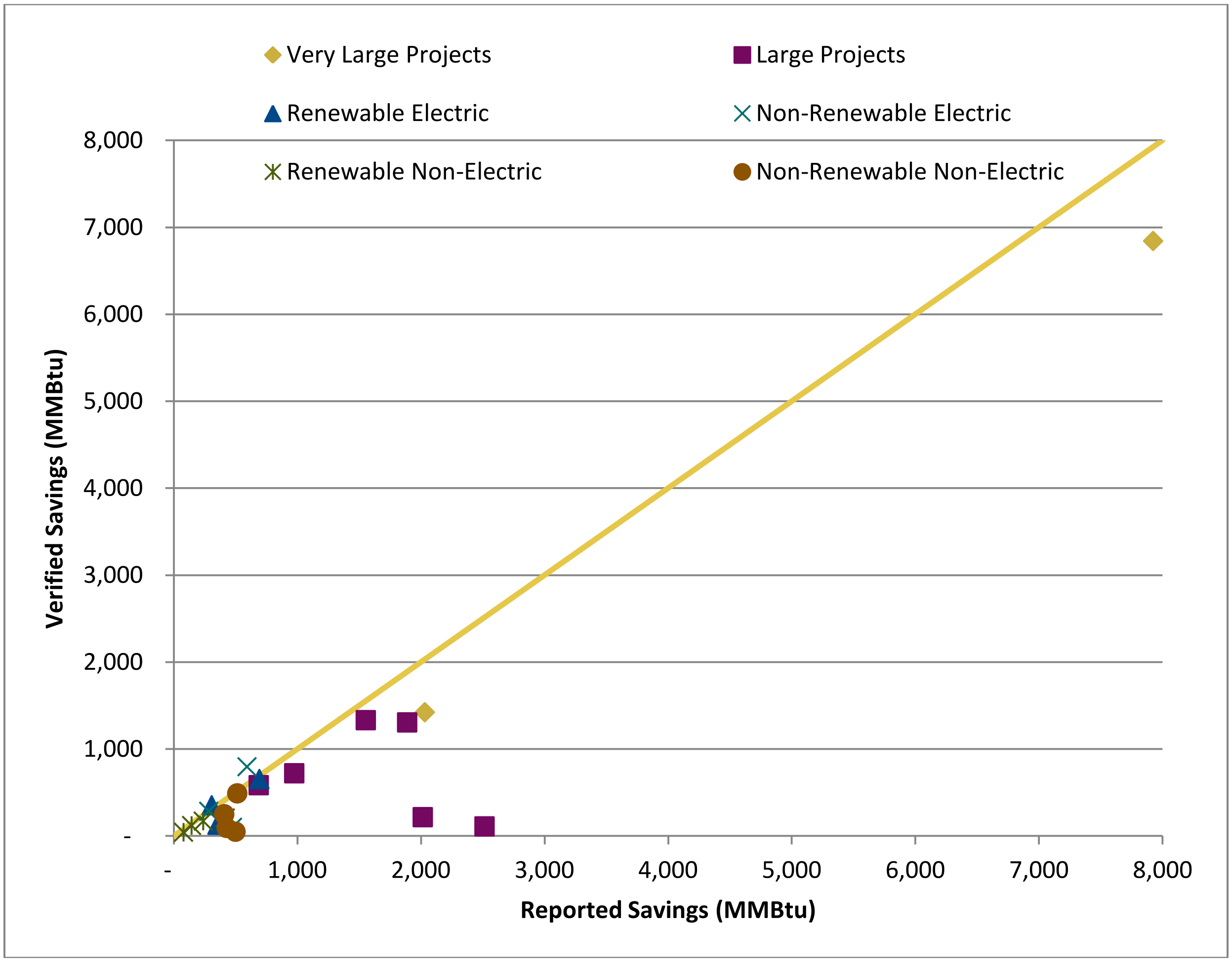
Metric	Reported Gross Savings (A)	Verified Gross Savings (B)	Gross Realization Rate (A/B)	NTG	Verified Net Savings (B*NTG)
Annual Site Energy Savings (MMBtu)	31,335	20,992	0.67	0.62	13,029
Lifetime Site Energy Savings (MMBtu)	N/A	442,181	N/A	0.61	269,966

Source: Navigant analysis.
Note: Values in this table are site energy savings. Source energy savings may be found in Section 3.2.5. The NTG values are not the same because variations in the lifetime cause the strata weights to change.

The resulting gross realization rate (verified gross savings/reported gross savings) is 0.67 and the NTG (1-freeridership) for annual site energy savings is 0.62. Applying the NTG to verified gross savings yields verified *net* savings of approximately 13,000 MMBtu for annual site energy savings and 270,000 MMBtu for lifetime site energy savings. Navigant believes these are good results given the context of the ARRA program's non-energy objectives and the relatively fast track grant approval process which was focused heavily on investing the money in the local economy consistent with the ARRA stimulus objectives. The relatively low gross realization rate is driven by a handful of project sites for which Navigant found very low verified savings relative to what was reported in program records; the difference was result of these projects not having being defined properly in program records for the calculation of energy savings.

Figure 3-1 shows a graphical comparison of verified site energy savings to reported site energy savings for each project that received a site visit. Sites with verified energy savings equal to reported energy savings, with a perfect realization rate (equal to 1) will lie along the solid diagonal line. Sites with low verified energy savings relative to reported energy savings lie well below the line. In the evaluation sample, most of the sites lie along or close to the perfect realization rate line, while there are a couple of outliers that bring down the overall realization rate.

Figure 3-1: Verified vs. Reported Gross Site Energy Savings



The outliers are accounted for by several specific problems in the reported savings for these sites, including using the wrong baseline (assuming retrofit in a replace-on-burnout situation), assuming full baseline fuel savings for a fuel switching project, and claiming savings for energy efficiency measures that happened before the grant.

The site energy results at a stratum level are shown in Table 3-2. The variability between stratum-level results in driven primarily by the frequency of negative outliers within the stratum. The electric projects and renewable projects generally had higher NTG and realization rates, than the other strata. The high NTG for these strata means that the projects funded in these strata generally would not have happened without the program. The overall NTG is driven by a very low NTG for the Very Large stratum, which reflects a large project that was already far along before program funds became available.

Table 3-2: Stratum-Level Site Energy Results

Strata	Reported Annual Site Energy Savings (MMBtu)	Verified Annual Gross Site Energy Savings (MMBtu)	Fraction of Reported Savings	Realization Rate of Stratum	NTG	Explanatory Notes
Very Large	9,954	8,268	32%	0.83	0.43	
Other Large	9,631	4,275	31%	0.44	0.65	1 project claimed larger project than covered by grant, 1 project claiming full fuel savings for fuel conversion
Renewable Electric	1,352	1,140	4%	0.84	0.93	
Non-Renewable Electric	2,443	2,702	8%	1.11	0.83	
Renewable Non-Electric	2,969	1,964	9%	0.66	0.87	
Non-Renewable Non-Electric	4,159	2,089	13%	0.50	0.66	1 project with wrong baseline, 1 project claiming full fuel savings for fuel conversion
Other Very Small Projects (not sampled)	827	554	3%	0.67	0.62	
Total	31,335	20,992	100%	0.67	0.62	

Source: Navigant analysis.

3.2 *Other Verified Gross and Net Impacts*

3.2.1 Fossil Fuel Savings

The computation and verification of fossil fuel savings posed a significant evaluation challenge. Savings were frequently reported for the wrong fuel or otherwise incorrectly reported for fuel switching installations. As a result, the fuel-specific realization rates could be misleading. In light of this the fossil fuel savings realization rates are reported in total rather than by fuel (Table 3-3).

Table 3-3: Fossil Fuel Savings and Realization Rates

Metric		Reported Gross Savings	Verified Gross Savings*	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)*
Annual Savings	Fuel Oil (gallons)	157,819	152,063	n/a	0.61	93,385
	Natural Gas (MMBtu)	3,589	(1,009)	n/a	0.53	(535)
	Propane (gallons)	28,259	(9,793)	n/a	0.57	(5,599)
	Total Fossil Fuel (MMBtu)	**28,134**	**18,639**	**0.66**	**0.60**	**11,170**
Lifetime Savings	Fuel Oil (gallons)	3,313,121	3,202,150	n/a	0.60	1,934,583
	Natural Gas (MMBtu)	85,838	(11,480)	n/a	n/a	(1,792)
	Propane (gallons)	611,835	(173,969)	n/a	0.58	(100,481)
	Total Fossil Fuel (MMBtu)	**602,919**	**398,468**	**0.66**	**0.59**	**234,956**

*Values shown in parentheses indicate negative savings.
Source: Navigant analysis.

3.2.2 Electric Energy and Demand Savings

Gross annual electricity savings were calculated using the data collected through document reviews, phone verification surveys, and field visits for the sample of sites. The peak electric demand savings were calculated using load factors calculated for the sample strata and extrapolated to the total population. Because demand impacts were not reported in program records, there are no peak demand realization rates available. The results of this analysis in Table 3-4 show a gross realization rate of 0.76 for annual electricity savings.

Table 3-4: Electricity and Peak Demand Savings and Realization Rates

Metric	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)
Annual Electricity Savings (MWh)	938	712	0.76	0.79	565
Summer Peak Demand (kW)	N/A	109	N/A	0.79	86
Winter Peak Demand (kW)	N/A	85	N/A	0.81	69
Lifetime Electricity Savings (MWh)	N/A	13,222	N/A	0.80	10,624

Source: Navigant analysis.

3.2.3 Renewable Capacity and Generation

Grant recipients installed a variety of renewables projects. These included two vegetable oil cogeneration systems, a solar PV system, and a number of solar hot water systems. These systems produced or offset both electricity and thermal energy savings. The results in Table 3-5 show both electricity and thermal energy savings (does not include electricity) for these systems.

Table 3-5: Renewable Generation and Realization Rates

Metric		Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)
Annual Savings	Installed Electricity Generation Capacity (kW)	N/A	33	N/A	0.89	30
	Electricity Generation (MWh)	228,772	154,537	0.68	0.93	143,606
	Thermal Energy Generation (MMBtu)	2,969	1,482	0.50	0.87	1,290
Lifetime Savings	Electricity Generation (MWh)	N/A	3,855,267	N/A	0.93	3,582,557
	Thermal Energy Generation (MMBtu)	N/A	37,100	N/A	0.87	32,304

Source: Navigant analysis.
Note: Thermal energy generation refers to non-electric thermal energy produced by renewable systems such as solar hot water or biomass

3.2.4 Greenhouse Gas Emissions Reductions

The verified greenhouse gas emissions reductions are higher than the amount reported by the program, with a gross realization rate of 0.84, as shown in Table 3-6. This difference between reported and verified gross emissions reductions is driven by three reasons. First, the verified energy savings were lower, which translates into lower greenhouse gas emissions. Second, Navigant used different greenhouse gas emissions factors for electricity, reflective of the updated values found in the latest Avoided Energy Supply Costs in New England Report, which are slightly lower than the values that were reported.[12] Third, Navigant used both combustion and precombustion emissions to account for the complete lifecycle emissions reductions associated with fuel savings in the program, which increases savings. Fourth, the program reported greenhouse gas emissions included only carbon dioxide, while the verified greenhouse gas emissions include other greenhouse gases, which also increases savings.

[12] *Avoided Energy Supply Costs in New England: 2011 Report*. Synapse Consulting.

Table 3-6: Greenhouse Gas Emissions Reductions and Realization Rates

Metric	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)
Annual Greenhouse Gas Reductions (metric tons CO2e)	2,444	2,058	0.84	0.64	1,312
Lifetime Greenhouse Gas Reductions (metric tons CO2e)	N/A	42,839	N/A	0.63	26,878

Source: Navigant analysis.
Note: Savings are in CO2-equivalent metric tons and only include total emissions of all greenhouse gases.

3.2.5 Source Energy Savings

Source energy savings include all of the upstream and downstream energy consumption savings associated with energy consumption savings within a facility or building, including upstream combustion and thermodynamic conversion efficiency, extraction and refining energy, and transmission and distribution losses. Source energy savings were not explicitly reported by EMT, so Navigant calculated them using the reported savings by fuel and a standard set of source energy conversion factors. As a result, the source energy realization rate is the same as the site energy realization rate, 0.67, as shown in Table 3-7. The NTG ratio is slightly higher than for site energy because of the slightly different weights among the strata used when extrapolating from the sample to the program.

Table 3-7: Source Energy Savings and Realization Rates

Metric	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)
Annual Source Energy Savings (MMBtu)	44,439	29,789	0.67	0.65	19,430
Lifetime Source Energy Savings (MMBtu)	N/A	614,360	N/A	0.64	394,728

Source: Navigant analysis.

3.2.6 Job Creation

Table 3-8 below presents the estimated number of net jobs created or retained by the program based on the ACEEE Stimulus Jobs Calculator. Net jobs refers to net of hirings and firings with the program compared to without the program. The jobs created or retained as a result of this program were primarily in the engineering and construction sectors and the largest impact is seen in Year 2.

Table 3-8: Jobs Created or Retained

Type of Jobs	Year 1	Year 2	Year 3	Year 5	Year 10
Net Jobs Created	1	14	3	3	2.5
Net Jobs Retained	1	14	3	3	2.5

Source: Navigant analysis using ACEEE Stimulus Jobs Calculator.

3.3 DOE SEP Attribution Findings

As part of the SEP-ARRA evaluation requirements, the DOE requires a calculation of the proportion of project savings that are specifically attributable to SEP-ARRA funds as opposed to other funding sources for the energy efficiency projects, such as EMT's Business Incentive Program. The "Fraction Attributable to SEP-ARRA Funds" shown in Table 3-9 can be multiplied by any of the net impacts in the report to determine the net impacts attributable to the SEP-ARRA funding. Navigant's survey attribution research with the Commercial Projects Grant program participants found that 91% of the project benefits are attributed to the SEP-ARRA matching grant funding.

Table 3-9. SEP-ARRAGrant Funding Attribution

Component	Number
SEP ARRA Funds – Sample ($)	$ 1,101,560
Non-SEP Funds – Sample ($)	$ 113,908
Total -- Sample ($)	$ 1,215,467
Fraction Attributable to SEP-ARRA Funds	91%

Source: Navigant Analysis

3.4 Confidence and Precision of Key Impacts

The confidence and precision of the evaluation results for the program are much better than the initial evaluation target of 90/10 (see Table 3-10). This occurred because the number of sites included in the evaluation dropped, so that a large proportion of the program projects in the evaluation frame were included in the sample (accounting for over 70 percent of program savings).

Table 3-10: Confidence and Precision of Gross Savings

Metric		Verified Gross Savings	Confidence / Precision of estimates
Overall Program Annual Savings	Site Energy Savings (MMBtu)	20,992	90/6
	Greenhouse Gas Savings (metric tons CO2e)	2,058	90/5
Annual Electricity Savings	Energy (MWh)	712	90/3
Annual Fossil Fuel Savings	Total Fossil Fuel Savings (MMBtu)	18,639	90/6

Source: Navigant analysis
Note: See Appendix for additional confidence and precision data on source energy.

The confidence and precision of net savings estimates in Table 3-11 are very similar to the confidence and precision of verified gross savings estimates, which is indicative of there generally being more variability in the site realization rates than in the site NTG values used to obtain net savings.

Table 3-11: Confidence and Precision of Net Savings

Metric		Verified Net Savings	Confidence /Precision of estimates
Overall Program Annual Savings	Site Energy Savings (MMBtu)	13,029	90/6
	Greenhouse Gas Savings (metric tons CO2e)	1,312	90/6
Annual Electricity Savings	Energy (MWh)	565	90/3
Annual Fossil Fuel Savings	Total Fossil Fuel Savings (MMBtu)	11,170	90/7

Source: Navigant analysis.
Note: See Appendix for additional confidence and precision data.

3.5 *Cost-Effectiveness Analysis Findings*

Total program costs through the end of calendar year 2011 are $1,719,000, of which $1,569,000 was spent on grants and $150,988 spent on administration.

3.5.1 Results of the Maine TRC Test

Results of the TRC benefit-cost test used by EMT were calculated on both a gross and net basis, with the NTG value applied to program savings and incremental costs for the net calculations. The results are very good overall, 2.85 for gross TRC and 2.35 for net TRC, as shown in Table 3-12.

Table 3-12: Maine TRC Test Results

Metric	Verified Gross Value	Verified Net Value
NPV of Lifetime Benefits	$ 7,575,912	$ 4,550,149
NPV of Lifetime Costs	$2,660,624	$1,939,715
TRC	2.85	2.35

Source: Navigant analysis.

The stratum-level TRC results are shown in Table 3-13 and Table 3-14. The stratum-level results are surprisingly consistent across the various strata. All of the strata have TRC results higher than one, even the renewable projects. The renewable electric stratum has a higher overall TRC than would be expected; this is generated by the very strong cost-effectiveness performance of two vegetable oil cogeneration systems that create both electricity and hot water. The rest of the renewable electric stratum had low

TRC scores in comparison. The renewable non-electric projects that include oil and propane savings create the bulk of the benefits within that stratum. The highest TRC is found at the very large projects stratum where a single, very successful project strongly influenced the overall results. The lowest TRC is for the renewable non-electric stratum, which consists primarily of solar hot water projects.

Table 3-13: Stratum-Level Maine TRC Test Results – Gross

Strata	Field Verified Gross Site Energy Savings (MMBtu)	Benefits ($)	Costs ($)	TRC Result
Very Large	8,268	$ 3,248,019	$ 382,410	8.49
Other Large	4,275	$ 1,129,807	$ 517,080	2.18
Renewable Electric	1,140	$ 612,335	$ 292,857	2.09*
Non-Renewable Electric	2,702	$ 776,720	$ 433,349	1.79
Renewable Non-Electric	1,964	$ 654,642	$ 519,187	1.26
Non-Renewable Non-Electric	2,089	$ 953,573	$ 299,100	3.19
Other Very Small Projects (not sampled)	554	$ 200,817	$ 65,653	3.06
Total	20,992	$ 7,575,912	$ 2,660,625	2.85

Source: Navigant analysis.
Note: The total costs include an additional $150,988 of program administration costs.
**The renewable electric stratum is primarily made up of two vegetable oil cogeneration systems, which have high cost-effectiveness.*

Table 3-14: Stratum-Level Maine TRC Test Results – Net

Strata	Verified Net Site Energy Savings (MMBtu)	Benefits ($)	Costs ($)	TRC Result
Very Large	3,516	$ 1,299,559	$ 164,949	7.88
Other Large	2,797	$ 753,878	$ 339,339	2.22
Renewable Electric	1,059	$ 573,057	$ 259,381	2.21
Non-Renewable Electric	2,231	$ 632,339	$ 314,634	2.01
Renewable Non-Electric	1,712	$ 568,536	$ 455,811	1.25
Non-Renewable Non-Electric	1,371	$ 601,772	$ 207,612	2.90
Other Very Small Projects (not sampled)	344	$ 121,007	$ 47,004	2.57
Total	13,029	$ 4,550,149	$ 1,939,716	2.35

Source: Navigant analysis.
Note: The total costs include an additional $150,988 of program administration costs.

3.5.2 Results of the SEP Recovery Act Cost Test

The SEP Recovery Act Test computes the simple ratio of annual source energy savings compared to program dollars spent. The program results and stratum results are shown in Table 3-15 and Table 3-16. The SEP Recovery Act Test results should be compared to the DOE ARRA goal of at least 10 MMBtu annual source energy savings per $1000 of ARRA funds spent. The Commercial Projects Grant program falls short of this goal, due to the poor performance of the smaller projects (see Table 3-16) in terms of this metric.

Table 3-15: SEP Recovery Act Cost Test Results

Metric	Value
Annual Net Source Energy Attributed to ARRA (MMBtu)	11,808
Program ARRA Costs ($)	$1,580,951
SEP Recovery Act Cost Test (MMBtu/$1000)	7.5

Source: Navigant analysis.

Table 3-16: DOE SEP Recovery Act Cost Test Results by Stratum

Strata	Verified Net Source Energy Savings Attributed to ARRA (MMBtu)	Program Incentives ($)	SEP RAC Test (Net Source MMBtu/$1000 Incentive)
Very Large	3,186	$86,750	36.7
Other Large	2,535	$249,736	10.2
Renewable Electric	960	$111,373	8.6
Non-Renewable Electric	2,022	$173,809	11.6
Renewable Non-Electric	1,551	$414,144	3.8
Non-Renewable Non-Electric	1,242	$398,713	3.1
Other Very Small Projects (not sampled)	312	$134,407	2.3
Total	11,808	$1,568,934	7.5

Source: Navigant analysis.

4. Conclusions and Recommendations

In conclusion, the key findings for the program impact evaluation are:

- Gross site energy realization rate = 0.67
- Site energy NTG ratio = 0.62
- Gross TRC test = 2.85

The program's energy savings results are very good when placed in the context of the program objectives, which included significant non-energy objectives, namely quickly disbursing ARRA funds to create jobs. Given the short timeline and very limited amount of bidder guidance and project technical review, the site energy realization rate of 0.67 is surprisingly good. Further, the realization rate deviation from 1.0 is due primarily to a handful of sites with very poor realization rates due to mistakes that were made in defining the project or baseline.

The NTG ratio result is driven primarily by some very large sites at which a large degree of freeridership was estimated due to these very large projects being far along in the planning stages before the Commercial Projects Grant money became available. Given the program objectives, the 0.62 NTG compares favorably with the EMT Business Incentive Program NTG of 0.66.[13]

The Commercial Projects Grant Program TRC was the most surprising result for the evaluation team. The 2.85 gross TRC result and 2.35 net TRC result are both very strong, on their own and in comparision to the 1.9 TRC result for the Business Incentive Program. This high TRC for the Commercial Projects Grant Program was driven by significant fuel oil and propane savings in the program. Both of these fuels have very high costs at the current time and generate large dollar savings for participants.

Navigant makes the following recommendations for this program.

- **Continued funding for this program is worthwhile.** This program generated a very strong TRC result in addition to having high energy saving impacts. Participants were anecdotally pleased with the program. Everything is in place for a successful program going forward except for an on-going funding source.
- **Provide additional guidance to potential grant applicants.** Projects had very low verified savings relative to reported savings most often because the project application used the wrong baseline, the wrong project definition, or the wrong fuel and/or quantity for fuel-switching projects. Additional guidance and/or technical assistance for grant applicants should improve the quality of the applications and improve the program realization rate.
- **Implement additional technical review, similar to the Business Incentive Program review of custom projects.** EMT should perform a brief technical review, specifically focused on the project definition, assumed baseline, and fuel savings type. This should include a follow-up call to discuss technical aspects of the project with the applicant.

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[13] *Evaluation of the Efficiency Maine Business Incentive Program*, prepared for Efficiency Maine Trust, Opinion Dynamics Corporation, 2011.

Appendix A. Appendix A: Additional ARRA Reporting Metrics

A.1 Savings by Year

The net energy savings impact for each year over the effective useful life of the actions attributable to the projects supported by the SEP Recovery Act funds are shown in the three tables below. Savings degrade over time due to the varying lifetimes of the measures within the projects. The savings degradation schedule was developed using project-specific estimates of lifetime for the overall sample, then applied to the first year annual net energy savings. Common lifetimes are 30 years for boilers, 25 years for solar domestic hot water systems and 13 years for lighting fixtures.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Savings Degradation Factor	1.00	1.00	1.00	1.00	1.00	0.98	0.98	0.98	0.98	0.97
Annual Net Energy Savings (MMBtu)	13,029	13,088	13,088	13,088	13,088	12,782	12,782	12,782	12,782	12,633

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Savings Degradation Factor	0.72	0.72	0.72	0.71	0.69	0.67	0.67	0.67	0.67	0.67
Annual Net Energy Savings (MMBtu)	9,367	9,367	9,366	9,227	8,985	8,732	8,732	8,732	8,732	8,732

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Savings Degradation Factor	0.58	0.58	0.58	0.58	0.58	0.14	0.14	0.14	0.14	0.14
Annual Net Energy Savings (MMBtu)	7,576	7,576	7,576	7,576	7,576	1,779	1,779	1,779	1,779	1,779

A.2 Confidence and Precision on Source Energy

The confidence and precision on gross source energy is 90/5. The confidence and precision on net source energy is 90/6.

Appendix B. Engineering Methods

B.1 Engineering Methods

Different engineering methods were used based on project types. Several of these are listed below. Assumptions for individual sites are given in each site report (under separate cover). Note that the individual site reports used a different method of calculating greenhouse gas emissions for electricity savings. These were corrected in aggregate form for inclusion in the final report.

B.1.1 Solar Domestic Hot Water Projects

For the eight solar domestic hot water projects included in the document review sample, the National Renewable Energy Laboratory's System Advisor Model (SAM) was used to determine energy savings. SAM is based on an hourly simulation engine that interacts with performance models to calculate energy output. The model provides options for parametric studies, sensitivity analysis, optimization, and statistical analyses. SAM models system performance using the TRNSYS software combined with customized components. TRNSYS is a validated, time-series simulation program that can simulate the performance of renewable energy systems using hourly resource data.

The following input parameters are allowed in SAM:

- Climate/Location
- Hourly Hot Water Draw
- Number of Collectors
- Collector Tilt
- Collector Azimuth
- Collector Make and Model Number
- Solar Tank Storage Volume
- Solar Tank Height/Diameter Ratio
- Solar Tank U-Value
- Circulation Pump Power
- Heat Exchanger Efficiency
- Auxiliary Energy Factor
- Auxiliary Volume
- Auxiliary Set Temperature
- Auxiliary Max Power

The hourly hot water draw was established based on a combination of the customer interviews, data that had been taken on site about how many people were served at the facility, ASHRAE hot water demand data for different building types and engineering assumptions.

Because SAM is only equipped to deal with auxiliary systems that are fueled by electricity, the auxiliary information was negated to have no effect on the results of the model. After running SAM with the desired inputs and negating the auxiliary water heater, the efficiency and fuel type of the auxiliary were taken into account with a simpler model in Excel that was developed by Navigant staff. This model also allowed for a change in auxiliary water heater efficiency to accompany the solar hot water system installation – which occurred at two of the reviewed sites.

B.1.2 Boiler Upgrades and Fuel Conversions

For projects that include an upgrade to a higher efficiency boiler, the change in efficiency from the old boiler (η_{old}) to the new boiler (η_{new}) is used to calculate the saved energy and fuel, as shown in the algorithms below. The energy saved (ΔE) is calculated by

where F_{old} is the amount in volume (ft^3 or gallons) of the old fuel and $CF_{BTU,old}$ is the conversion factor between the volume of fuel to the fuel's heat content (higher heating value). The amount of fuel used historically is usually determined from billing data and adjusted based on heating degree days for the location of the boiler change. The amount of fuel used after the retrofit (ΔF_{new}) is calculated by

where $CF_{BTU,new}$ is the heat content of the new fuel if a fuel change accompanies the upgrade. If there is no fuel change, this conversion factor will be the same for both the old and new fuel. If the boiler upgrade occurs as an early retirement (discussed in section __ of Appendix __), the retrofit savings compare the new efficiency to the old efficiency while the replace on burnout savings compare the new efficiency to the standard efficiency of the efficient equipment ($E_{base,eff}$). These savings values are multiplied by the remaining life of the replaced equipment and the rest of the new boiler's lifetime, respectively, to achieve lifetime energy savings. The two energy savings algorithms are shown below.

, and

Other HVAC efficiency upgrades to furnaces, air conditioners and heat pumps are treated similarly with the same algorithms.

B.1.3 Shell Upgrades

Shell upgrades include any high efficiency insulation, window or door installations. The total energy savings from shell upgrades is the sum of the energy savings from the new measure and the reduced infiltration that results from the insulation:

.

To determine a percent energy savings from insulation, the following equation was be used for each distinct section of the building that will have shell upgrades (i) and for heating and cooling (j).

In this equation, R_{old} and R_{new} are the thermal resistances for the baseline and the new installed insulation, respectively. These R-values were given in the application and confirmed during the phone or onsite verification for the project. The ΔT term in this algorithm is given by the equations below for heating and cooling energy saved, respectively. The heating and cooling degree days are based on the specific city in which the retrofit takes place.

The energy savings from the increased infiltration is calculated with the following algorithm:

In the infiltration equation, V is the volume of the building and Q is the volumetric flow of the building. The LBL factor is a factor based on climate region, number of stories of a building, and sheltering from wind which is used to convert to estimated air changes in a building by natural means, without a fan. These factors are found in common tables.

B.1.4 Lighting Upgrades

Lighting upgrades result in saving electrical energy and demand. To determine demand savings (ΔD), the following algorithm is used:

where n is the number of fixtures installed and W is the wattage of each fixture. The energy savings are determined by multiplying each term by the number of usage hours (h) of the area:

The number of fixtures and fixture types are given in the grant application. Wattages of specific fixtures can be found in lighting fixture tables, such as in the Pennsylvania Technical Resource Manual. Hours of use are determined by a customer interview.

B.2 Baselines

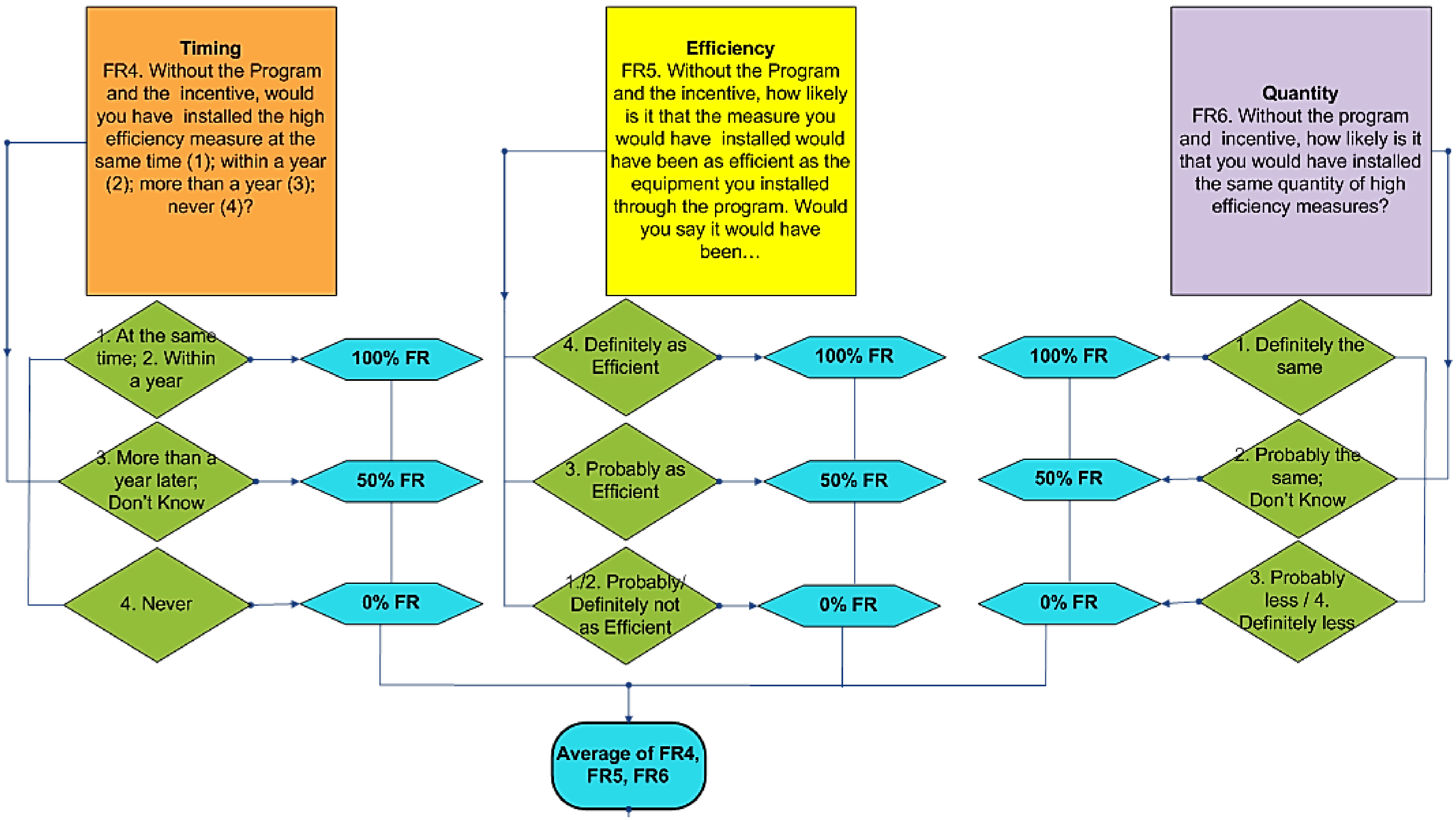
For each project that was reviewed, the engineer chose the proper baseline to determine energy savings against based upon the company's lowest labor and equipment cost to meet their required output. The baseline types are retrofit, early retirement, and replace on burnout.

If a piece of equipment was at the end of its useful life and must be replaced for the business to continue, then it is a replace on burnout (ROB) situation. Because there is no choice about whether the equipment must be purchased, the opportunity market is lost and the new efficient equipment is compared against the standard version of the new measure. The efficiency of standard equipment is found in the applicable standard document. A new construction project is also considered in this category due to the lost opportunity market.

A retrofit is a situation in which the equipment did not need to be replaced in order for operations to proceed, but the business has opted to upgrade to a higher efficiency despite the existing equipment having several years of useful life left. In this case, the savings and costs are measured against a no-change baseline. This means that the full invoice costs are the costs, the lifetime of the new equipment is the lifetime used in evaluation, and the savings are calculated against the existing equipment.

If the business would be required to update their equipment in the future and is installing a high efficiency piece of equipment to replace an existing piece of equipment before the existing equipment has reached the end of its useful life, then it is an early retirement. In these situations, the new equipment is compared against the existing equipment for the remainder of the existing equipment's useful life. Past the existing equipment's useful life, the new equipment is measured against the standard efficiency of the new measure.

B.3 Freeridership Logic Model



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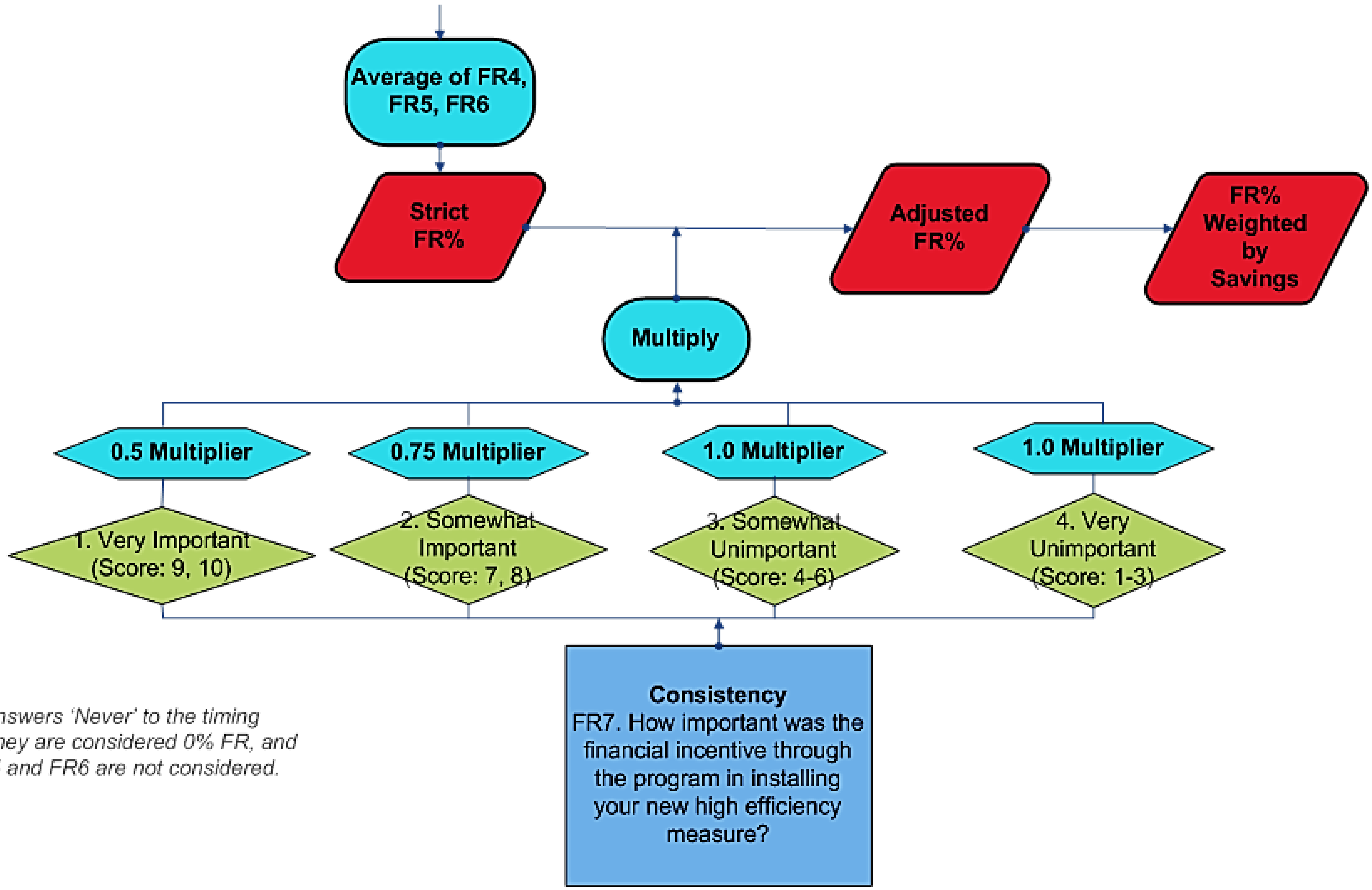

Note: If respondent answers 'Never' to the timing question, FR4, then they are considered 0% FR, and their response to FR5 and FR6 are not considered.