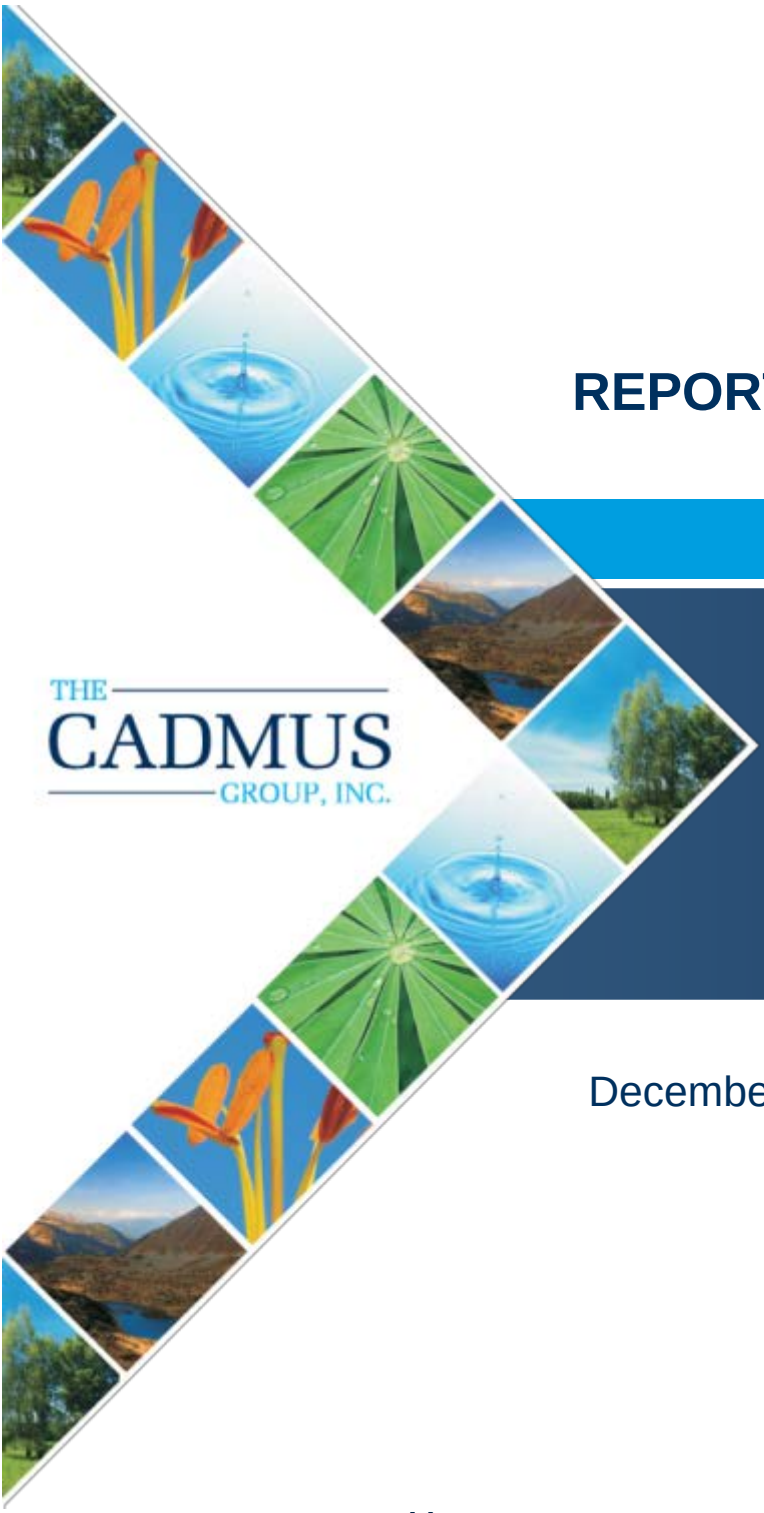

THE CADMUS GROUP, INC.

REPORT

Impact and Process Evaluation of Efficiency Maine Trust's Retro-Commissioning Pilot Program

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EXECUTIVE SUMMARY

Evaluation Overview

The Efficiency Maine Trust (the Trust) guides and administers energy-efficiency and alternative-energy programs for the State of Maine. Currently, the Trust administers a Retro-Commissioning Pilot Program (RCx Program), designed to encourage the implementation of projects that optimize nonresidential building systems by offering incentives. The RCx Program is funded by the American Recovery and Reinvestment Act (ARRA) State Energy Program (SEP) grant to the State of Maine.

The Trust contracted with Cadmus to evaluate the RCx Program. Cadmus' evaluation used a variety of techniques—stakeholder interviews (with the Trust, its delivery team, and the providers), participant surveys, building file engineering reviews, on-site audits, collection of trending data, spot measurements, metering, and engineering calculations—to conduct an impact and process evaluation of the Trust's RCx Program.

Program Design

Retro-commissioning (RCx) is a systematic process for investigating, analyzing, and optimizing the performance of building systems through the identification and implementation of low- and no-cost facility upgrades to improve and ensure continued performance. RCx can resolve issues that began during a building's design and construction, or developed over time, during a building's use. This process can generate ongoing energy and cost savings and lead to increased building efficiency.

The RCx Program targets small- to medium-sized commercial and institutional facilities, with existing building management systems and/or automated lighting controls that could potentially achieve cost-effective energy savings through system optimization.

The complete RCx Program offering (the Investigation and Implementation Track) has two steps:

1. **Step One—RCx Investigation:** An RCx provider conducts a systematic analysis of the participant's building systems, determines possible improvements, and assesses potential energy savings.
2. **Step Two—Implementation:** Eligible improvement measures, identified through the RCx Investigation (Step One), or in some cases by a mechanical system contractor, and approved for funding by the Trust, are implemented.

Participation in the RCx Program through the Investigation and Implementation Track involves successful completion of Steps One and Two, and requires preapproval from the Trust before the initiation of each step.

A building can also participate through another track, the Direct Implementation Track, whereby the participant completes only Step Two. This option is available for facilities where RCx improvements (i.e., mechanical system repairs and optimization) have been identified by mechanical system contractors through a process independent of the RCx Program.

Process Evaluation

The process evaluation reviewed program activity that occurred between April 2010 (when the pilot program was launched) and October 2012.

Cadmus' process evaluation examined the following:

- Effectiveness of program implementation over time, including changes in program offerings and incentives;
- Efficiency and quality of program operations and processes, including data tracking and documentation;
- Stakeholder response to and satisfaction with the program;
- Motivators and barriers to program participation and project completion;
- Key challenges and successes in program implementation; and
- Opportunities for strengthening and streamlining the program, should future funding become available.

Cadmus reviewed the RCx Program using multiple strategies including interviews with the Trust and its delivery team, RCx Providers, and program participants.

Findings

Participants reported high satisfaction with the program and with the delivery team and the Trust. A vast majority (86%) reported being "very satisfied" with the program; 14% reported being "somewhat satisfied." None reported dissatisfaction with the program or with the delivery ream or the Trust. Some of the participants reported having little interaction with the Trust.

Generally, commercial and industrial customers who were approached about the RCx Program were relatively unfamiliar with RCx. However, as Maine's market matures and more market actors offer RCx as a standard business service, the practice may become more commonplace, leading to more informed participants and greater knowledge about RCx, in general.

Interviewed participants' primary recommendation was to expand marketing and outreach to increase awareness about the program. Other suggestions for program improvement included:

- Provide contractors with more information about available incentives and eligible measures.
- Educate facility staff on measure persistence to ensure ongoing energy savings.
- Provide successful case studies from other businesses.
- Reduce the amount of application paperwork involved.
- Increase communication to participants about project stage, pending information, and next steps.
- Increase overall incentive amounts.

The participant survey captured data regarding how the program and its incentives influenced participants' completion of program-supported measures. Overall, the Trust's RCx Program

experienced low freeridership (3.7%). This estimation was consistent with expectations because the pilot program was Maine's first-ever RCx incentive program.

Cadmus identified some evidence of spillover during the site visits, including measures installed that were contained in the reports for which no incentives had been provided.

Impact Evaluation

The impact evaluation verified the energy savings achieved by the RCx Program for the 33 projects launched after program inception (April 2010), but before May 2012, that reported achieving energy savings. To complete the impact analysis, Cadmus:

- Selected a stratified sample of 24 sites for measurement and verification.
- Reviewed and assessed program energy savings estimates in the program's database through a desktop review.
- Conducted site visits to observe building operations, assess energy-efficiency improvements, perform spot measurements, and discuss the project with staff.
- Measured and verified achieved energy savings.
- Developed gross realization rates.
- Assessed program attribution, including freeridership and spillover.
- Calculated program cost-effectiveness using the Total Resource Cost (TRC) test.

During each of the site visits, Cadmus:

- Observed building characteristics and operation details to confirm that energy-savings calculations accurately characterized building shells, mechanical systems, lighting power density, and other parameters.
- Verified that measures for which program participants received an incentive payment were: (1) installed; (2) functioning; and (3) operating in accordance with the incentive paid.
- Collected data for further analysis including collecting spot measurements, or installing monitoring equipment (where applicable) to determine energy savings resulting from installed energy-conservation measures.
- Discussed installation of measures with building personnel.

After completing the site visits, Cadmus conducted an engineering analysis to verify energy savings estimates for the visited sites. Cadmus then calculated a realization rate for each site and the program. The program realization rate was applied to the entire program to obtain program-verified energy savings.

Findings

Cadmus' impact evaluation verified the energy savings achieved by the RCx Program.

Net-to-Gross

The Net-to-Gross (NTG) ratio reflects the percentage of gross program savings that are attributed to the program.

Based on participant survey responses, Cadmus estimated the RCx Program's freeridership (FR) to be 3.7%. The rate of spillover was not quantified as part of the evaluation, but is expected to be minimal based on Cadmus' observations in the field. Because spillover was low and additional measures installed were not all due to the program, spillover was set to zero, resulting in final NTG (1-FR) value of 96.3% for the program.

Gross and Net Savings

Overall, the RCx Program achieved verified gross savings of 9,980 MMBTU (gross realization rate of 78.2%) and verified net savings of 9,611 MMBTU (net realization rate of 75.3%), as shown in Table 1.

Table 1. Savings and Gross and Net Realization Rates

Savings	Electric Savings (kWh)	Fuel Oil Savings (Gallon)	Gas Savings (Therm)	Propane Savings (Gallon)	Gross Savings (MMBTU)	Net Savings (MMBTU)	Gross Realization Rate	Net Realization Rate
Reported Savings	1,186,433	42,217	26,599	1,407	12,764			
Verified Savings	702,159	42,342	15,337	1,901	9,980	9,611	78.2%	75.3%

While the Investigation and Implementation Track projects were more popular and achieved higher reported energy savings than the Direct Implementation projects, had higher verified energy savings per project (315 MMBTU vs. 282 MMBTU) and lower realization rates (60% vs. 161%), as shown in Table 2.

Table 2. Impacts by Program Track

Track	Number of Projects	Reported Savings (MMBTU)	Gross Verified Savings (MMBTU)	Realization Rate	Average Reported Savings per Project (MMBTU)	Average Gross Verified Savings per Project (MMBTU)
Investigation and Implementation	20	10,486	6,309	60%	524	315
Direct Implementation	13	2,279	3,671	161%	175	282
Total	33	12,764	9,980	78%	387	302

* Includes only projects implementing measures.

As of September 2012, the program had awarded $363,981 in incentives. Investigation and Implementation projects received the majority of incentives. Table 3 displays differences in total incentives by project type. Cadmus found Direct Implementation projects to be less expensive per project than Investigation and Implementation projects (probably because the Investigation and Implementation projects also included the Investigation component). Additionally, Direct Implementation projects had a lower cost per MMBTU saved, as shown in Table 3.

Table 3. Costs by Project Type

Track	Total Incentives Paid	Number of Projects	Average Incentive Cost per Project	Gross Verified Savings (MMBTU)	Cost per MMBTU Saved
Investigation and Implementation	$303,198.85	26	$11,661.49	6,309	$48.06
Investigation (Step 1)	$166,129.54				
Implementation (Step 2)	$137,069.31				
Direct Implementation	$60,781.93	13	$4,675.53	3,671	$16.56
Total	$363,980.78	39	$9,332.84	9,980	$36.47

* Includes projects that received program incentives.

Cadmus extrapolated the realization rates from the impact evaluation sample of 24 sites to the remaining, non-sampled sites in the overall program (by stratum) to determine the overall program-level verified energy savings. These values are reported by Fiscal Year (FY) in Table 4.

Table 4. Verified Gross Savings by Year

FY	Electric Savings (kWh)	Natural Gas Savings (MMBTU)	Propane Savings (MMBTU)	Fuel Oil #2 Savings (MMBTU)	Total (MMBTU)
2011	162,037	1,037	90	598	2,277
2012	508,795	497	85	5,198	7,516
2013	31,327	0	0	76	183
Total	702,159	1,534	174	5,872	9,976*

* This number is slightly different from 9,980 in other tables due to rounding differences.

Cadmus also estimated the program's verified lifetime impacts, using a weighted-average measure life of five (5) years. Lifetime savings are included in Table 5.

Table 5. Lifetime Savings

Savings	Electric Savings (kWh)	Fuel Oil Savings (Gallon)	Gas Savings (Therm)	Propane Savings (Gallon)	Savings (MMBTU)	Net Savings (MMBTU)
Reported Lifetime Savings	5,932,165	211,086	132,995	7,036	63,821	
Verified Lifetime Savings	3,510,793	211,711	76,686	9,503	49,902	48,055

Cost-Effectiveness

Cadmus calculated the RCx Program's cost-effectiveness using a Total Resource Cost (TRC) test, an industry-standard metric for evaluating program cost-effectiveness. Outlined in the

California Standard Practice Manual,[1] the TRC compares energy savings benefits (avoided costs) to program administrator and participant costs.

Table 3 shows TRC test results for verified costs and savings for all projects completed and verified from program inception, including partial data for FY 2013.[2] The TRC test result using verified savings from the evaluation is slightly lower than the program reported FY 2012 result. The program's verified results narrowly did not pass the TRC cost-effectiveness test (signified by a greater than 1.0 result), with a benefit-to-cost ratio of 0.96.

Table 6. TRC Results for Verified FY 2010-2013 and Trust Reported FY 2012

TRC Components	Cadmus Verified FY 2010-2013 YTD Values	Trust Reported FY 2012 Values
Net TRC Benefits	$962,468	$996,641
Net TRC Costs	$1,003,432	$947,743
TRC Ratio	0.96	1.05

Recommendations and Conclusions

Below, Cadmus outlines conclusions and recommendations regarding the program's design, process, and marketing techniques to be used should the Trust choose to convert it into a full-scale program.

Process Evaluation

The program design served the pilot program's needs, but a full-scale RCx Program would likely require modifications to increase program impacts. Recognizing the program's unique goals, due to ARRA grant funding, the pilot was designed largely for staff to accomplish the pilot's objectives. Flexible definitions of RCx projects, adaptable program guidelines, and the two-track design served the pilot program's particular goals to minimize delivery costs, move incentive money quickly, and build a provider network.

Freeridership for the program was low (3.7%), which is consistent with expectations as this was the first RCx incentive program in Maine and consistent with other RCx programs in other jurisdictions. Providing incentives for in-depth engineering analyses that provide new and valuable information to customers about how to improve the efficiency of their building systems may be one strategy to keep freeridership levels low in future years, if the program is developed into a full-scale offering.

A review of other full-scale RCx offerings indicated RCx can probably achieve significantly more energy savings than those realized by the pilot program. By making the following

[1] California Public Utilities Commission (CPUC). 2001. *California Standard Practice Manual Economic Analysis of Demand-Side Programs and Projects.* Sacramento, CA: Governor's Office of Planning and Research, State of California.

[2] The verified TRC results are the actual program results using actual expenditures and savings as verified by Cadmus. The Trust reported FY 2012 values are the program reported values based on the program data tracking system.

changes to program design, the Trust can improve the program's effectiveness, if funding becomes available to develop a full-scale RCx offering:

- Consider moving some measures under the Business Incentive Program umbrella to boost overall energy savings and lower the cost per unit of energy saved.
- Consider moving the Direct Implementation Track to the Business Incentive Program.

Consider instituting a requirement for minimum energy use per square foot, by building type, for eligible facilities. This would ensure that buildings in the program would have large opportunities for savings. A minimum energy-use intensity (energy use per square foot, or EUI) level could also be used as a cut-off as it can be less effective to achieve savings for projects with lower EUIs through an RCx program.

The program experienced high satisfaction levels, mainly due to clear instructions and communications from the Trust and its delivery team. Timely feedback, prompt decision making, and accessibility emerged as common themes reported by providers addressing their experiences with the program delivery team. Providers reported a clear understanding of the program and its expectations of them, which directly translated to positive participant experiences. Communication about the program probably increased providers' outreach to their customers, leading to a larger participant pool. If developing a full-scale offering, the Trust should continue to prioritize communications with providers and participants to facilitate high satisfaction.

The program's strategy to use providers as the main channel for promoting the program to building owners proved effective for a pilot, but may need to be modified for a full-scale program. Relying entirely on providers not only limits penetration, but also can result in varied products. Participants learned about the pilot program primarily through their providers or contractors. However, providers also said more marketing materials would prove helpful in promoting the program and explaining RCx to their customers. The Trust and the program delivery team said limited marketing probably resulted in fewer Direct Implementation projects than anticipated. If developing a full-scale offering, consider allocating additional budget to marketing to develop program brochures, one-pagers, and case studies for customers and providers.

The quality of investigation reports varied greatly by RCx provider. Providing RCx providers a template report and recommended set of measures could be helpful in focusing the program on the most cost-effective measures and reducing the costs of preparing the reports if a full-scale offering is developed.

Cadmus recommends that ***the Trust encourage follow-up with participants. Follow-up with participants would help the Trust identify program improvement opportunities.***

Cadmus recommends that ***the Trust establish greater brand recognition around this program***. While Cadmus understands this was not necessarily a goal of the pilot program, many participants interviewed did not understand the Trust's involvement in the program, and did not feel the Trust's "presence" throughout the process, as they primarily interacted with providers or contractors. This offers an opportunity for the Trust to promote its work.

Impact Evaluation

Establish standardized calculation methods and determine implementation rate and persistence of measures. Overall, the program achieved a gross realization rate of 78%, which is reasonable for a pilot project. However, one of the largest projects had a realization rate of over 200%, while the other projects had a combined gross realization rate of 65%. This lower rate was due in part to the fact that several reported measures either were not fully implemented, or did not persist through the evaluation period. Other measures, particularly air balancing, resulted in greater thermal comfort for occupants, but occasionally resulted in higher energy use than the baseline case. Fuel oil realization rates, in particular, varied widely. Training on and standardization of estimating fuel oil savings should be included in future programs.

Use simple quality control metrics. At a minimum, estimated energy savings should be compared to facility energy consumption as a reasonableness check. Estimated savings above a threshold (e.g., 10% of consumption) should be further reviewed.

Require verification inspections or trend data review six months after RCx measure installation for all projects with reported savings larger than a threshold (i.e., 1,000 MMBTU) to confirm measure installation and persistence. In our examination of the sampled sites, Cadmus often found that the reported RCx measures in program data files were either not fully implemented or were implemented for only a short time during the evaluation period. These issues reduced energy savings realized by projects.

Require all participants to have and use a building energy management system (EMS). The EMS system should have trending enabled for the relevant parameters associated with the RCx measures. The verification inspection could also obtain EMS trend data to confirm the performance of measures for which incentives had been provided. We found in some cases that the EMS was not controlling or monitoring the system addressed by the efficiency measure.

Screen buildings for opportunities. In addition to screening for high energy use intensity, the program will be most effective if it can also screen for buildings with large savings opportunities. We found that some RCx reports were actually energy audits with information that was too general, and which recommended relatively expensive measures. Rather than fund numerous larger RCx investigation studies, an alternative that we recommend is to fund lower-cost studies that rely on basic time series data to identify the larger savings opportunities: :

- **Obtaining interval data.** Interval data can be used to identify RCx and other opportunities at low initial cost.
- **Providing incentives for installation of a logging meter where interval data cannot be obtained.** Installing a permanent or semi-permanent logging meter on the service panel is relatively inexpensive (on the order of $2,000, or more if the meter is linked to the Internet). The resulting interval data can help identify energy savings opportunities, including high unoccupied energy use and poor response to temperatures.
- Providing incentives for provision of EMS trend data. Even limited trend data can diagnose building problems.

The Trust could then fund more comprehensive investigative studies on buildings presenting the largest opportunities.

Prioritize the most successful measures. Where a measure is simple, e.g. shutting off air handlers at night, it has the highest probability of success. In general, simple directly installed measures were the most reliable in terms of producing energy savings. These included:

- Pipe insulation
- Steam trap measures
- VFD installations
- Compressed air measures.

Some of the most cost-effective HVAC measures installed through the program eliminated over-conditioning during unoccupied hours and reduced introduction of excessive outside air. In larger buildings, however, control strategies to accomplish these outcomes can become complex. HVAC control measures varied in terms of actual installation rate and success. Successful measures included supply air temperature resets, fixing outside air problems, and improving VAV system response.

Remove from eligibility any measures that should result from routine maintenance (e.g. cleaning of a heat exchanger).

Claim credit for non-energy benefits (NEBs), or avoid measures that can increase energy use. In certain situations, fixing buildings can lead to increased energy use. Some RCx Program measures fixed building problems that allowed for improved occupant comfort, but increased resource consumption and did not save energy. These measures include replacing failed (closed) heating valves and ventilation air balancing.

If the pilot RCx Program is not continued as a standalone program, certain measures from the pilot can be incorporated in the Trust's business program offerings, as funding sources permit. Cadmus recommends the following measures:

- Small business direct installation: programmable thermostats and pipe insulation.
- Custom incentive, including comprehensive custom building assessment and combustion air damper repair.
- Prescriptive incentive:
  - Boiler reset controls
  - Boiler tune ups
  - Steam trap repair or replacement
  - Pipe wrap
  - Minor compressed air measures (i.e., zero-loss condensate drains, additional receiver capacity, low pressure drop filters, and cycling air dryers).

INTRODUCTION

The Efficiency Maine Trust (the Trust) guides and administers energy-efficiency and alternative-energy programs for the State of Maine. Currently, the Trust administers a Retro-Commissioning Pilot Program (RCx Program) that offers incentives to encourage the implementation of projects that optimize nonresidential building systems.

The Trust contracted with Cadmus to evaluate the RCx Program. Cadmus' evaluation used a variety of techniques—stakeholders interviews (with the Trust, its delivery team, and the providers), participant surveys, building file engineering reviews, on-site audits, trending data collection, spot measurements, metering, and engineering calculations—to conduct an impact and process evaluation of the Trust's RCx Program.

The Trust's RCx Program is a time-limited program offering made possible by funding through the American Recovery and Reinvestment Act (ARRA) State Energy Program (SEP) grant.

Program Overview

The retro-commissioning (RCx) process improves existing building equipment and system operation and performance. RCx is a systematic process for investigating, analyzing, and optimizing the performance of building systems through the identification and implementation of low- and no-cost facility improvements to improve and ensure their continued performance. RCx can resolve issues that began during a building's design and construction, or that developed over time during a building's use. This process can generate ongoing energy and cost savings and lead to increased building efficiency.

The RCx Program targets small- to medium-sized commercial and institutional facilities, with existing building management systems and/or automated lighting controls that could potentially achieve cost-effective energy savings through system optimization.

RCx typically involves several phases, including but not limited to:

- Project selection
- Scoping and planning
- Investigation of current operation building systems, and identification of deficiencies and opportunities for improvements
- Implementation of selected measures to address recommended improvements.

The RCx Program's time-limited offering is funded by a grant that the State of Maine received from the ARRA-SEP. The RCx Program launched in April 2010, and will terminate on December 31, 2012, coinciding with the end of ARRA-SEP grant funding availability. The program has a total budget of $900,000, including program delivery and incentives.

Overall program objectives include:

- Demonstrate that RCx is a viable energy-saving opportunity.
- Improve the ability of building operations' staff to identify wasteful energy use.
- Ensure that savings created through the program persist over the expected lifetime.

- Ensure that quality services are delivered to the building owner from a well-delivered RCx process.
- Provide insight to aid in developing a full-scale RCx Program (should future funding become available).

Program Delivery Strategy

The Trust contracted with a delivery team—Energy & Resource Solutions, Inc., (ERS) and its subcontractors GDS Associates, Inc., and Rocheleau Engineering—to launch and implement the RCx Program. The delivery team's initial activities included:

- Developing program materials;
- Identifying a core group of mechanical and control system contractors and providing training about the RCx Pilot Program structure and processes;
- Developing and implementing an application review process and evaluation criteria;
- Conducting outreach to potential program participants;
- Developing a list of RCx providers trained to participate in the RCx Pilot Program, and making the list available to potential participants.

In the program's ongoing implementation, the delivery team serves multiple roles, including (but not limited to):

- Application review and eligibility determination for program incentives;
- Oversight of RCx studies;
- Technical assistance for participants and RCx providers during implementation;
- Development and maintenance of program tracking data and documentation.

Program Design, Incentives, and Measures

The complete RCx Program offering includes two steps:

1. **Step One—RCx Investigation:** An RCx provider conducts a systematic of the participant's building systems, determines possible improvements, and assesses potential energy savings. At the investigation's close, the RCx provider delivers an RCx investigation report to the participant that outlines energy-efficiency findings and opportunities.
    a. After successful completion of the investigation, the program team reviews the recommended measures and determines whether the participant is approved for funding the selected measures.
2. **Step Two—Implementation:** This step implements eligible improvement measures, identified through the RCx Investigation (Step One), or in some cases by a mechanical system contractor, and approved for funding by the Trust.

Participants can pursue these steps through two different tracks:

1. **Investigation and Implementation**: Investigation and Implementation in the RCx Program involves successful completion of Steps One and Two, and requires preapproval from the Trust and its delivery team before the initiation of each step.
2. **Direct Implementation**: When participating via Direct Implementation, the participant completes only the program's second step, an option available for facilities where RCx improvements, such as mechanical system repairs and optimization, have been identified by mechanical system contractors through a process outside the RCx Program.

The Trust added the Direct Implementation track approximately six months after the program's launch, seeking to increase program participation and to facilitate implementation of previously identified RCx measures, thus removing additional investigation expenses.

The RCx Program provides cash incentives to decrease up-front costs of the RCx investigation and implementation of RCx improvements. Investigation incentive payments may be authorized after investigation presentation, and the RCx provider has invoiced the participant for the investigation. Implementation incentive payments may be authorized after implementation completion and participant submission of associated invoices.

Table 7 shows incentive levels offered by the program.

Table 7. RCx Program Incentives

Step	April 2010–March 2012	April 2012–Present
Investigation Incentive	50% of cost, up to $10,000	50% of cost, up to $10,000 (plus an additional 25% of cost, up to $5,000, upon implementation completion by 10/1/2012)
Implementation Incentive	50% of cost, up to $10,000	50% of cost, up to $20,000
Maximum Total Incentive	$20,000	$35,000

Program Measures

Measures funded under the RCx Program implementation incentive have included (but have not been limited to):

- Calibration, replacement, and repair of sensors, valves, actuators and dampers
- Optimization of set-back and reset schedules
- Balancing of air and hydronic delivery systems
- Demand control ventilation, with CO2 sensing
- Repairs to mechanical system insulation
- Lighting control updates
- Restoration of economizer operation
- Training for building owners/operators.

Though the RCx Program does not provide funding for equipment replacement or retrofits, participating facilities may take advantage of Efficiency Maine Business Program incentives for eligible replacement and retrofit measures.

EVALUATION OVERVIEW

To meet the Trust's RCx Program evaluation objectives, Cadmus conducted process and impact evaluations of the program. The evaluation project commenced with a kick-off meeting on August 29, 2012, followed by the development of an action-oriented work plan detailing the process and impact evaluation activities. The impact evaluation covered projects initiated between the RCx Program's launch in April 2010, through April 2012. The process evaluation examined program activity from April 2010 through October 2012.

To complete the impact evaluation, Cadmus completed the following:

- Estimated energy savings achieved—in MMBTU (converting heating energy from fuel oil, propane, and gas), and kWh—through the RCx Program for a sample of 24 projects, using a variety of techniques, which included:
  - Program data engineering review
  - Engineering calculations
  - Examination of trend data from building automation systems (BAS)
  - Metering (where applicable).
- Identified additional opportunities to save energy at these buildings, and how opportunities could be recognized by the program delivery team, providers, and building managers.
- Assessed measure lifetimes and persistence.
- Estimated the RCx Program's cost-effectiveness.

To complete the process evaluation, Cadmus:

- Developed an understanding of the program's operation and how it could be improved.
- Estimated freeridership and spillover.
- Summarized implementation strategies and achievements of other RCx programs.
- Reviewed results from past impact and process evaluations and program experiences to develop recommendations to transition the RCx Pilot Program to a full-scale initiative (should funding become available), and to continue certain program elements or measures within the Trust's Business Program.

PROCESS EVALUATION

Cadmus' process evaluation assessed the RCx Program's design and implementation, and offered recommendations to improve its implementation and success. The process evaluation reviewed program activity that occurred between April 2010 (when the pilot program was launched) and October 2012.

Cadmus' process evaluation addressed the following key issues:

- Effectiveness of program implementation over time, including changes in program offerings and incentives;
- Efficiency and quality of program operations and processes, including data tracking and documentation;
- Stakeholder response to and satisfaction with the program;
- Motivators and barriers to program participation and project completion;
- Key challenges and successes in program implementation; and
- Opportunities for strengthening and streamlining the program, should future funding become available.

To assess these key issues, Cadmus reviewed the RCx Program using multiple strategies. Table 8 shows essential process evaluation activities.

Table 8. Process Evaluation Data Collection Methods

Evaluation Activity	Total Population	Targeted Sample	Completed Sample
Interview the Trust and the program delivery team	5	4	5
Interview RCx providers	10	10	9
Survey participants who completed projects (surveys)	52	24	21
Review previous RCx evaluations (studies)	N/A	3	5

Methodology

Trust and Program Delivery Team Interviews

Cadmus interviewed the Trust and the program delivery team (ERS, GDS, and Rocheleau Engineering) during the evaluation's early weeks (October and early November 2012), allowing interview results to inform other process and impact evaluation activities.

The Trust is responsible for managing the RCx Program, in concert with the program delivery team, and overseeing and maintaining the program's quality. Interview goals with the Trust and the program delivery team sought to understand the following RCx Program components:

- Program history and design;
- Program vision and goals;
- Marketing and outreach efforts to target audiences and market partners;

- Key successes;
- Effectiveness of administrative processes;
- Data management efforts;
- Program delivery, including quality assurance;
- Program challenges and areas for improvements; and
- Quality control and assurance mechanisms.

The program delivery team works with the core group of RCx providers, teaching them about the program and program participation. This helps to drive participation and maintain overall program quality.

RCx Providers Interviews

In this program, an RCx Provider is an engineering firm or mechanical contractor that assists the program participant with the completion of the RCx investigation (Step One). Generally, the RCx Providers also assist with the implementation portion of the program (Step Two). RCx providers are integral to the RCx Program's success, as they remain in direct contact with the participants (end-use customers). In addition to providing system diagnoses and change recommendations, RCx providers often educate participants about the program processes, incentive levels, and actions required under program guidelines. Therefore, they must thoroughly understand RCx and the specific RCx Program offering.

Cadmus conducted in-depth interviews with nine providers, focusing on:

- Quality and helpfulness of program training;
- Knowledge about program procedures and requirements;
- Usefulness of program marketing and outreach activities;
- Ease with which program procedures can be navigated;
- RCx sales issues and market barriers;
- Perceptions of program influence with participants;
- Participants' overall satisfaction with participation; and
- Program changes sought by participants.

Participant Surveys

While performing site visits, Cadmus completed survey interviews with each project's "decision maker", that is, the individual most knowledgeable about the organization's participation in the RCx Program and the specific project. Cadmus' participant survey addressed the quality and helpfulness of the program and its providers, key drivers influencing program participation, perceptions of program procedures, overall customer satisfaction, and the program's influence on participants' energy efficiency actions within and outside of the program.

The interviewed decision makers could be found in multiple roles: building owners, building operation managers, or other building personnel.

Typically, building owners and operations managers have responsibility for instituting RCx or similar such projects and determining the extent of changes made to their buildings. Therefore, asking how well the program worked for this group provided useful insights into opportunities for continuing or expanding the program, should funding become available.

Freeridership and Spillover

Cadmus designed the participant survey to capture data about the program's influence on participants' completion of program-supported measures to estimate the level of freeridership—whether participants would have implemented energy-efficient measures had the program not existed. Additionally, the participant survey assessed whether participants' program experiences led them to complete energy-efficiency projects outside of the program's scope (spillover).

Findings

Program Goals and Intention

During interviews with the Trust, Cadmus gained further insight into the program's goals. The following goals were identified as the major drivers of the pilot initiative:

1. Address buildings that would have immediate impacts on energy use and greenhouse gas emissions.
2. Support development of a skilled workforce and RCx activity in Maine.
3. Build Efficiency Maine's network of qualified providers.
4. Inform full-scale program offerings with findings from the pilot.
5. Identify energy-savings opportunities in the market.
6. Achieve measurable results.
7. Develop a summary of RCx measures with energy saving potential that could be incorporated into the Trust's Business Program offerings.

The Trust did not set firm participation or energy-savings goals for the program due to its unique structure as a limited-time pilot.

Overall, the Trust emphasized the program's fluidity, allowing continual adaptation to market circumstances and findings, as demonstrated by several program design and delivery changes occurring throughout the pilot's life (see the Program Evolution and Timeline section).

Program Process

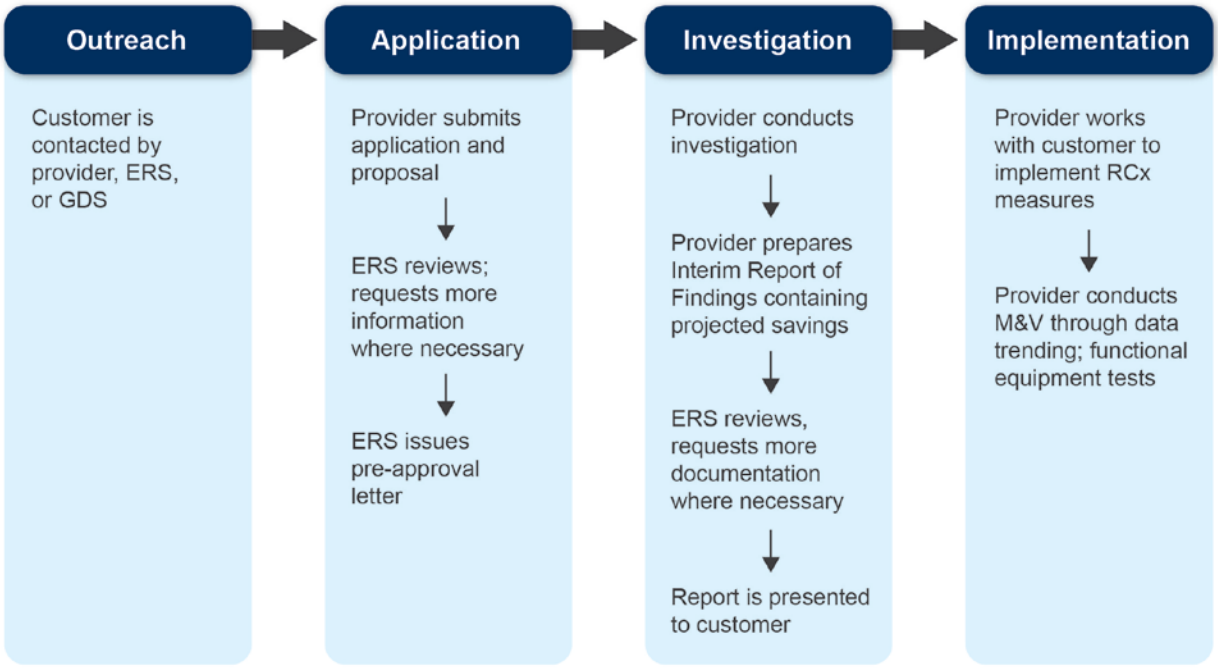
Participants can pursue two different tracks within the RCx Program:

1. **Investigation and Implementation**: Investigation and Implementation in the RCx Program involves the successful completion of an Investigation and Implementation, and requires the preapproval from the Trust and its program delivery team before the initiation of each step.
2. **Direct Implementation**: This option is available for facilities where RCx improvements, such as mechanical system repairs and optimization, have been identified by mechanical

system contractors. Under this track, the provider was still required to obtain approval from the Trust before implementation, the RCx Investigation step, was omitted.

Between initial contact and project completed, the delivery team and participants go through the following stages (see Figure 1):

Figure 1. Efficiency Maine Trust Process Flow Diagram



The RCx Program provides cash incentives to decrease up-front costs for the RCx investigation and the implementation of RCx improvements. Payment of implementation incentives are authorized after the installation of the RCx measures has been completed, the investigation report has been presented, and the participant has submitted associated invoices.

Program Design and Delivery

The Trust worked closely with its program delivery team, ERS and its subcontractor Rocheleau Engineering, to design the initial program. The Trust and the delivery team reported using four major guiding assumptions and priorities in the design of the program:

1. An initial limited budget of $500,000, with the majority ($350,000) paid as incentives.
2. The vision to award incentives quickly ("dollars on the street") to generate immediate impacts.
3. The need for market actor/provider education for successful program delivery.
4. The goal of benchmarking energy use in participating buildings.

Program Design Challenges

The program delivery team reported that the guiding assumptions and priorities for the program presented several challenges due to the nature of RCx programs and the particular setting, In particular:

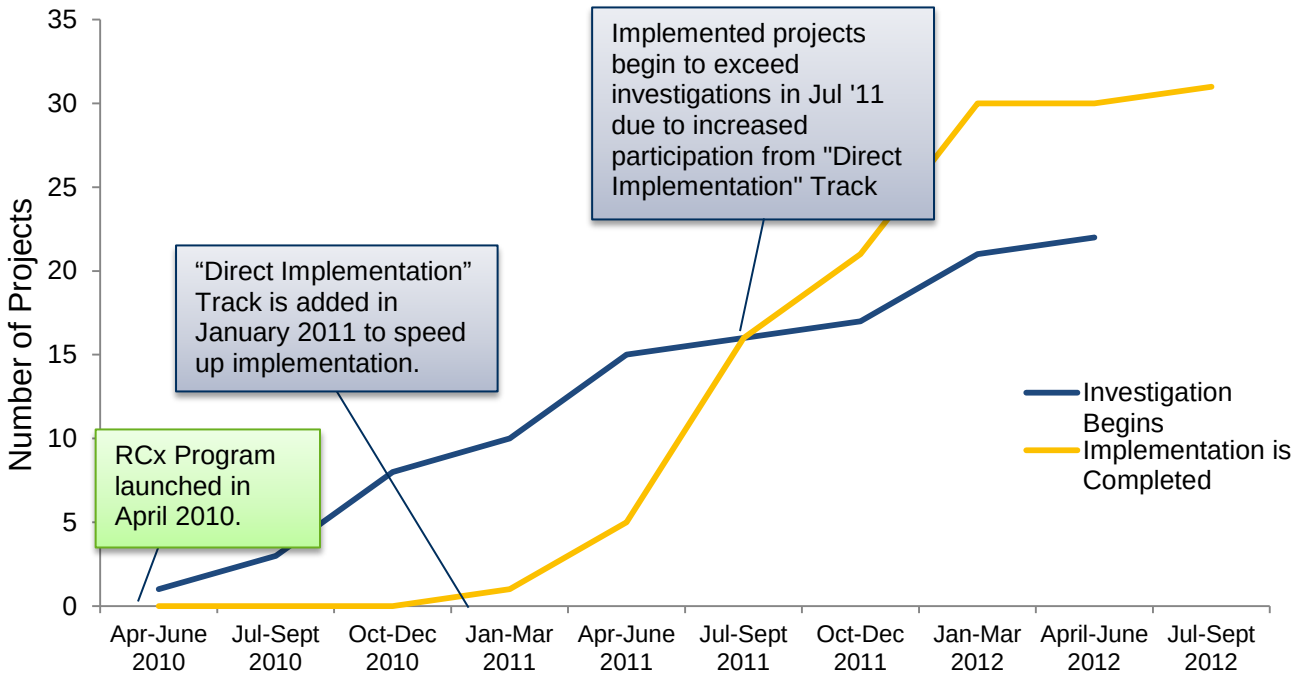
- RCx programs typically rely heavily on robust and often costly and time-consuming engineering analysis before realizing energy savings.
- RCx projects tend to span long periods, in some cases requiring 18 months to complete.
- Groundwork must be implemented to help providers and customers understand the RCx concept and the benefits it provides, as this was Maine's first RCx incentive program.

In some cases, these factors contradicted the need for fast implementation and immediate energy savings, thus requiring thoughtful and creative program design to work within the pilot's time and budget constraints.

Program Evolution and Timeline

As shown in Figure 2, projects generally did not complete implementation until several months after the initial RCx investigation, with the first projects not implemented until early 2011 (nine months after the program's inception).

Figure 2. Program and Participation Timeline



Note: Timeline reflects only projects that completed implementation (n=33).

To address the challenges of long project cycles and the need for faster implementation of energy-saving RCx measures, the Trust made the following changes to the Pilot Program:

- The pilot program period was extended to allow more projects to be completed.
  - Project completion deadlines were extended, first to March 2012 and then to November 2012.
- The RCx Program budget increased by reallocating more funds from the overall ARRA-SEP grant, for a total budget of $900,000.
- The initial cap of $20,000 per program participant was increased to facilitate completion of larger projects with higher energy savings.
- Initial program guidelines and requirements were modified in several cases to ease paperwork burdens on providers, minimize program delivery costs, or overcome customer barriers:
  - The requirement to use EPA Portfolio Manager to record baseline energy use and benchmark energy use over time was modified. Baseline energy use was reported through various means, including utility data.
  - The requirement to supply formal documentation of functional performance tests (post-installation verification) was modified to ease paperwork burdens on providers.
- The Trust and program delivery team expanded the program to include a "Direct Implementation" track, to increase participation and facilitate eligible projects to be completed under the program without the RCx investigation. According to the delivery team, this design modification was also in response to several projects that completed an investigation without implementing improvements.

Project Eligibility and Approval

To identify potential program participants, the program delivery team and providers used their knowledge of facilities, past energy usage, and personal relationships with targeted Maine building operators and organizations to reach out to buildings they thought would qualify for the program. Program eligibility requirements included:

- Submission of participant energy consumption data to establish baseline energy consumption.
  - Initially, participants and providers were required to use EPA's Portfolio Manager to input baseline data and benchmark energy consumption over time. However, according to the program delivery team, the requirement to use Portfolio Manager was relaxed due to participant barriers, including the fact that Portfolio Manager was not always an appropriate tool for benchmarking manufacturing and industrial facilities.
- Submission of reasonable evidence (by providers) to indicate that the project would result in energy savings (e.g., electric, natural gas, heating oil, or propane gas savings).
- Clear evidence that the project entailed optimization of existing building system performance, excluding equipment replacements or new equipment installations.

The pilot program did not set firm eligibility requirements for participating facilities (such as building square footage, vintage, or qualifying energy management systems), nor did it require projects to meet specific cost-effectiveness criteria to qualify.

For Investigation and Implementation track projects, preapproval for the implementation (Step Two) was based on the measure cost and scope described in the report of findings (Step One Investigation Report). For Direct Implementation projects, all applications included a scope of work that the program delivery team evaluated before approving the project.

The team reported that minimal participation requirements were put in place to facilitate participation and expedite the implementation of energy-saving measures. This approach appeared to work well for providers and participants, with the majority of providers reporting ease in developing project proposals and working with the Trust and its delivery team to facilitate efficient project approval and application processing times.

Project Documentation

The Trust developed standard application forms and templates for providers and participants, which required detailed information on facility types, ages, heated and cooled spaces, and energy use. Applications also required providers to submit information on facility control systems, HVAC, and lighting.

However, in some cases, the program's flexible eligibility requirements and the desire to minimize delivery costs resulted in limited project documentation. Cadmus found that the level and comprehensiveness of data and information within applications varied greatly by project, even though the delivery team sought to obtain the necessary baseline data and projected energy savings from applicants. The information contained in initial project proposals[3] also varied, while the Investigation Reports[4] contained more consistent and comprehensive information.

Cadmus found aspects of RCx project implementation and verification documentation to be missing more frequently than expected based on the program's intent and when compared to other RCx programs. Cadmus staff reported primarily relying on contractor invoices to determine project completion. Some projects lacked documentation on how the final energy savings were calculated. (In some cases, Cadmus was able to obtain this information through follow-up correspondence.) After the submission of a project proposal or an Investigation Report, no formal documentation or contract existed to describe the mutually agreed-upon measures that were to be implemented or their associated energy savings. Lastly, the pilot program did not require a post-installation verification report to ensure that measures were installed and functioning correctly.

Program Design Effectiveness

Overall, both the Trust and the program delivery team thought the program's design worked well, resulting in successful delivery, although opportunities for improvements were identified.

[3] Project proposals are submitted by the RCx provider prior to project implementation approval, and generally outline basic information (i.e., eligible building systems, preliminary assessment of potential energy savings).
[4] Investigation Reports are issued after the application is approved and the investigation is conducted. It should list recommended RCx measures and their associated energy and costs savings.

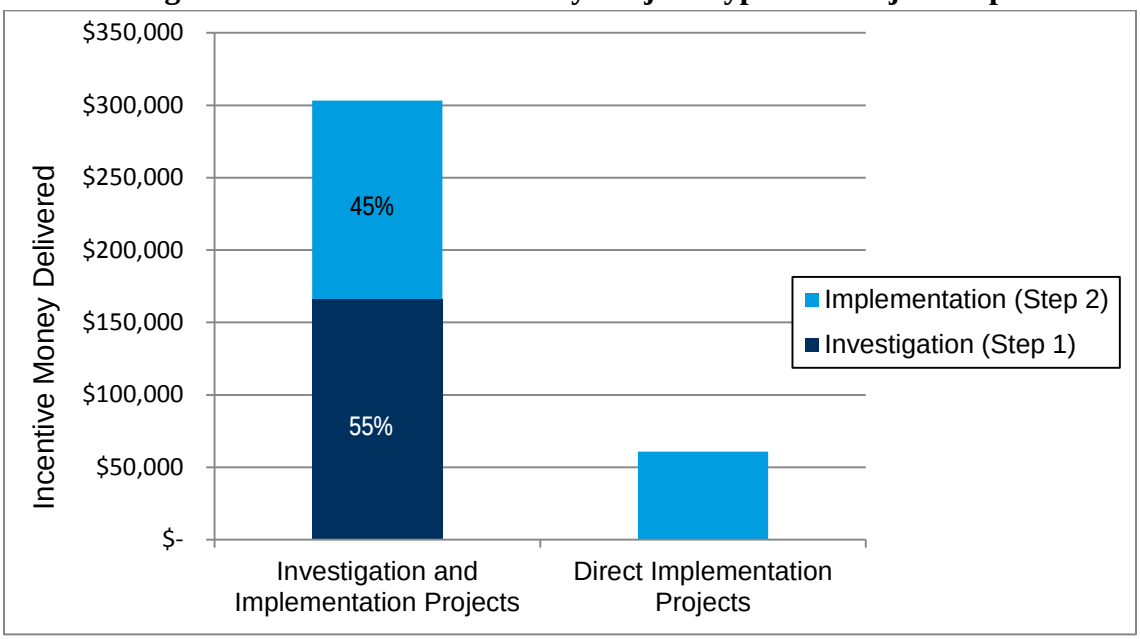
Overall, 13 projects participated in the program through Direct Implementation—fewer than anticipated. The program delivery team offered the following reasons for this track not proving as effective in recruiting projects as expected:

- Mechanical contractors' lack of understanding of the program;
- Contractors' unwillingness to fill out paperwork and conduct initial energy-savings calculations;
- Limited marketing to contractors for generating awareness about the available incentives.

Costs by Track

As of September 2012, the program delivered $363,981 in incentives. Investigation and Implementation track projects received the majority of incentives. Figure 3 displays differences in total incentives by project type. Within Investigation and Implementation projects, the program spent slightly more money on investigations (Step 1), likely due to several projects not following through with implementation following the investigation.[5]

Figure 3. Incentives Delivered by Project Type and Project Step



Investigation Value

Cadmus surveyed 21 participants, 11 of whom completed Investigation and Implementation projects, and 10 whom completed Direct Implementation projects. For the 11 participants who completed Investigation and Implementation, Cadmus asked about the value of the Investigation Report provided to them. Six participants reported having meetings in which providers explained or presented the findings. One participant reported they received the report via e-mail. Three

[5] As of September 2012, two projects had yet to decide which measures to implement, and five projects had conducted investigations without implementing measures.

respondents could not remember how they received the report, and one did not remember receiving it at all.

Of those that remembered receiving the report, (n=10), eight participants rated the information as somewhat valuable or very valuable in increasing their knowledge about their building systems and opportunities to improve efficiency or performance. Two respondents did not know the information's value.

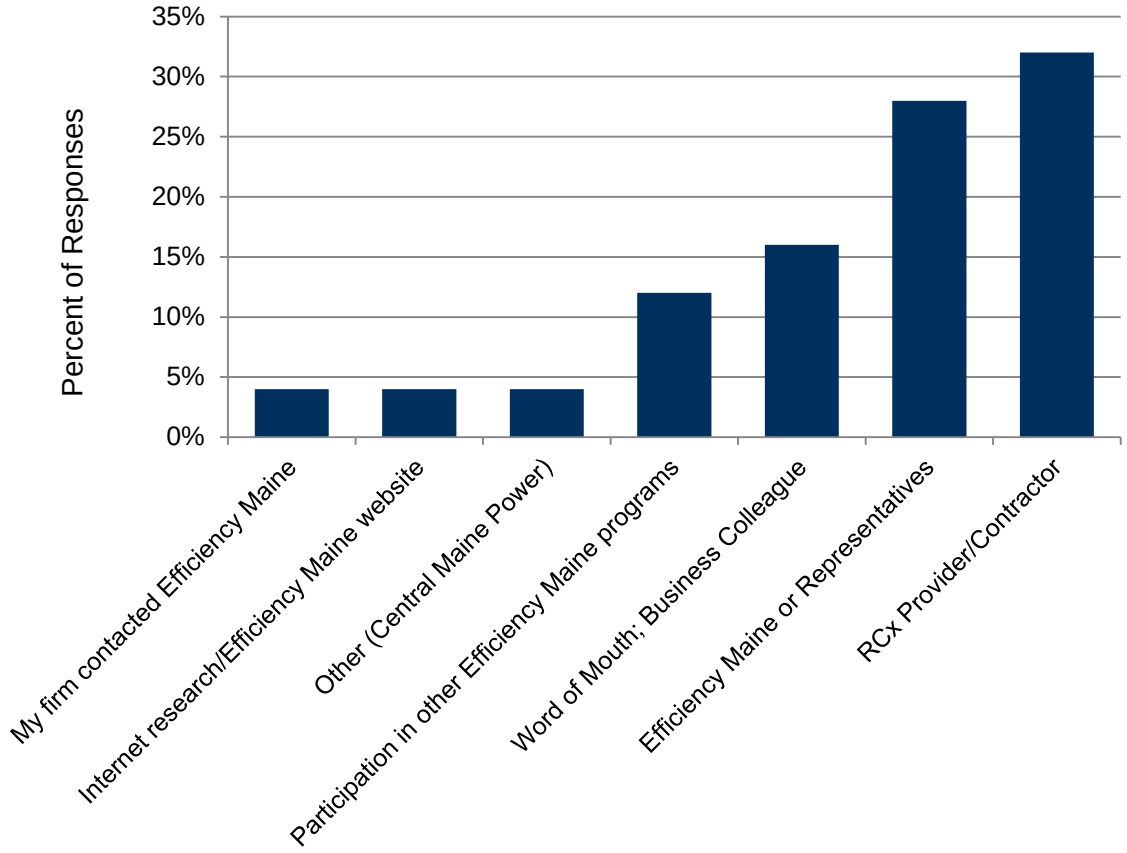
When asked how much the report influenced the participants' decision to implement measures, eight of 10 respondents reported it was "very influential." One respondent reported it was "somewhat influential," and one respondent reported the investigation report was "not very influential."

Marketing and Outreach

The RCx Program used limited marketing, primarily due to budget restrictions. The program's strategy was to empower participating RCx providers to allow them to contact their own customers about RCx opportunities and the program, rather than use incentive dollars to market the program directly.

This strategy proved effective: eight of nine RCx providers reported recommending the program to customers, and the majority of participants reported hearing about the program through their providers or contractors (32%). In addition to RCx providers, participants also learned of the program through several other channels summarized in Figure 4. "Efficiency Maine or representatives" could include the Trust or the delivery team (ERS, or GDS, a subcontractor to ERS for both the RCx Program and the Business Incentive Program).

Figure 4. How Participants Learned about the RCx Program (n=21)



The Trust reported a desire to continue to use market actors as the main channel for promoting the program if it were to evolve into a full-scale offering. Both the Trust and the delivery team agreed that spending more of the budget on program marketing and outreach, whether that was directed at the potential participant or the provider, would be necessary for a full-scale program.

Marketing Materials

The Trust developed a factsheet for the RCx Program, although several providers reported that additional program brochures, factsheets, eligible measure lists, or case-studies and testimonials would be helpful in promoting the program to their customers. One provider also suggested making industry guidelines available to both providers and customers who had questions, including those published by the Building Commissioning Institute (BCI) and PECI (formally known as the Portland Energy Conservation Institute).One engineering firm that completed nine projects under the program created its own factsheet about the program as well as a list of businesses with which they had worked, and reported that this helped their credibility. See Appendix B for these materials.

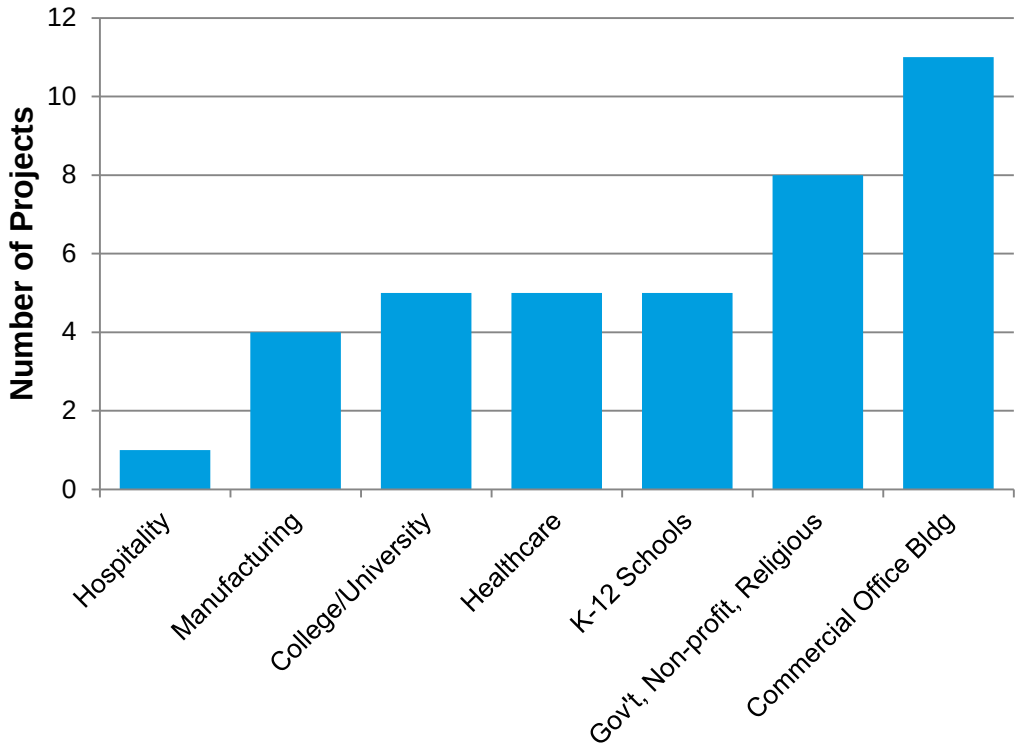
Target Market and Participating Market Segments

The target market for the program was mid-sized buildings, 10,000-100,000 square feet. Since funding was initially capped at $20,000 for each project, large facilities were not appropriate candidates. In two cases, however, RCx was conducted for only part of the building or one

building system, which allowed for the accommodation of larger customers. The most common participants were commercial office buildings.

Figure 5 provides a summary of the participants by market segment.

Figure 5. Program Participation by Market Segment



Provider Recruitment, Training, and Feedback

Provider Recruitments

In general, potential RCx providers heard about the RCx Program from the program delivery team, other RCx firms, or because they had previous experience with interested participants. Interested firms had to receive one-on-one training, or demonstrate (through documentation) their capabilities before becoming involved with the program.

Effectiveness of Training

The program delivery team offered initial training for potential RCx providers—predominantly in-state engineering firms capable of completing the RCx investigation and overseeing implementation. The training included an overview of the program and eligible measures, and guidelines and expectations about energy savings calculations. While a number of firms expressed initial interest, few followed through and completed the training.

Of the nine RCx providers interviewed by Cadmus, only three reported that they received training for the RCx Program. One provider said that they thought there was a training offered to them but they did not attend; another recalled attending program sessions for The Trust's business programs as a whole, but did not recall specific training about the RCx Program. Three

others did not recall training at all, or thought they may have received some guidelines but did not classify their experience as a training.

While training recall was relatively low, the majority of RCx providers interviewed reported that there were no additional topics on which they would have liked to receive more training or information. One provider suggested more training on how to calculate the energy savings, and one provider thought that training on relevant software, such as Portfolio Manager, would have been helpful.

When the Direct Implementation Track was introduced, a second round of training was offered for mechanical contractors. Many of the contractors attending this training completed RCx projects subsequent to the training.

Effectiveness of Communications

Despite low attendance in training sessions, RCx providers overwhelmingly reported high satisfaction with all communications from the Trust. Common feedback was that expectations were clear, and there were few challenges or confusions with the program.

Overall Program Satisfaction

The majority of providers were "very satisfied" with the program overall and with the Trust. When asked about their experiences, providers mentioned the following:

> "[Efficiency Maine] was very responsive. The communication was very good."
>
> "Very easy to get a hold of. If I had any questions, [ERS] was always available. And [they] provided a lot of good follow-up."
>
> "Everyone was very accessible and responsive. The beginning stages certainly required more communication. There were several policy decisions that had to be made on the fly; they had to be flexible with their policy and guidance and they were always very fast."
>
> "We have had dealings with other programs [in other geographic areas; these other RCx programs are] not as streamlined as Efficiency Maine."

Challenges with the Process

Cadmus asked providers about challenges that they encountered with the program as well as barriers that their participants experienced. Two providers reported that lack of understanding about the program and the benefits of RCx presented challenges from a participant perspective. An additional two cited that prospective participants were often skeptical about the potential for energy savings. No providers reported that up-front costs were a barrier to participants, but several commented that the incentive eliminated the cost barrier for participants.

Four providers reported that there was more work necessary to participate than was anticipated, particularly during the investigation phase of a project. One provider mentioned that completing the investigation did not align with his company's business model, which seeks to divide incoming projects evenly among the 27 contractors employed by this company. Another reported that it felt the program was overly focused on up-front analysis rather than on the actual implementation of energy-efficiency measures.

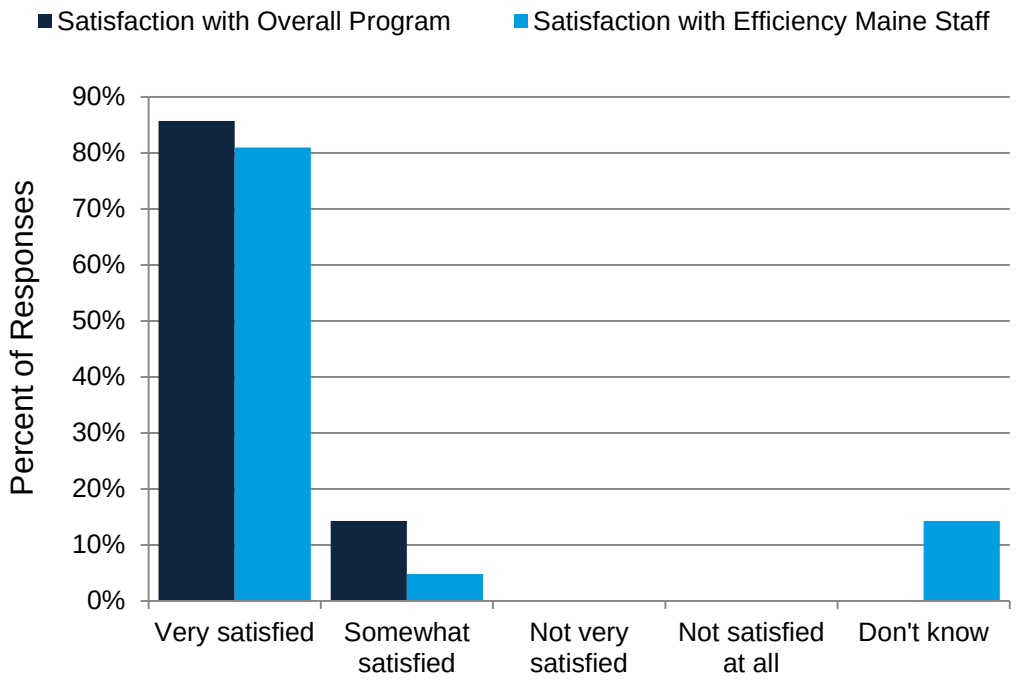
Participant Feedback

While performing site visits, Cadmus interviewed each project's decision maker (the staff most knowledgeable about the RCx Program and the specific project). Interviewed decision makers included building owners, facilities managers, and building staff that instituted and oversaw each project. These interviews examined participant satisfaction, challenges and barriers and identified opportunities for continuing or expanding the program, should funding become available.

Satisfaction

Participants reported extremely high satisfaction with the program and with the Trust and its delivery team. A vast majority (86%) reported being "very satisfied" with the program; 14% reported being "somewhat satisfied." None reported dissatisfaction with the program, the delivery team, or the Trust. Three participants reported not having very much contact with the Trust, so they did not know how to rank their satisfaction.

Figure 6. Participant Satisfaction (n=21)



Participant Challenges and Barriers

When Cadmus asked participants about challenges experienced, most (n=16) reported they did not experience challenges. Five participants cited difficulties in the following areas:

- Collecting baseline data;
- Tracking the project's status (the project's position in the incentive approval process, and information they needed to provide to move the project forward);
- Internal budgetary problems resulting in implementation of only some of recommended measures, not all;

- Scheduling site visits, building assessments, and meetings during the program; and
- Gathering necessary building data and conducting necessary tests for a healthcare facility, due to its 24-hour operation.

Suggestions for Improvement

When asked what the Trust could change about the program to improve its effectiveness, nine participants recommended expanding marketing and outreach to increase awareness about the program. One participant reported some confusion occurring among building owners about why some participants were contacted about the program while others were not. Other suggestions for program improvement included:

- Provide contractors with more information, so they know about available incentives and measures eligible under the program.
- Provide education for facility staff on measure persistence to ensure ongoing energy savings.
- Provide successful case studies from other businesses.
- Reduce the amount of application paperwork involved.
- Provide more communication or a way for the customer to track their project's stage, pending information, and next steps.
- Increase overall incentive amounts.

Perceived Impact on Utility Bills

Cadmus asked customers whether they saw differences in their utility bills or their building's energy consumption since completing the RCx project. As shown in Table 9, results were mixed. Most respondents (n=10) did not know if they realized a difference, or said it was too early to detect differences. Some building owners in this group said they would not know financial impact until going through the winter, as their buildings had yet to reach peak heating demand. Some answering "No" reported that, while they were sure RCx improved energy consumption; too many other factors impacted utility bills on a monthly basis to clearly attribute variations in utility costs to the program. Other factors included things like outdoor air temperatures or other operations within the facility.

Table 9. Have you seen a difference in your utility bills, or your building's energy consumption? (n=21)

Choice	Response Percent	Response Total
Yes	33%	7
No	19%	4
Too soon to tell; Don't know	48%	10
Total	100%	21

Market Impacts

Freeridership

Cadmus designed the participant survey to capture data regarding how the program influenced participants' completion of program-supported measures. Where the program had little influence on the customer's decisions to retro-commission their buildings, or where customers reported they would likely have conducted the same activities without the program incentive, a participant could be considered a freerider. Cadmus estimated that 3.70% of program participants were freeriders. Appendix A contains Cadmus' full freeridership methodology and analysis for the RCx Program.

Overall, the Trust's RCx Program experienced low freeridership, a finding consistent with expectations, as the pilot program was the first-ever RCx incentive program in Maine. The program revealed general low awareness among commercial and industrial customers regarding RCx, but, as the market matures and more Maine market actors offer RCx as a standard business service, the practice may become more commonplace for informed customers.

Spillover

The participant survey included a series of questions to determine the program's influence on participants' decisions to purchase and install energy-efficient equipment or engage in other activities to improve their buildings' energy performance.

Cadmus identified some evidence of spillover during the site visits, including measures installed that were contained in the reports but for which no incentives had been offered. These are discussed in the Impact Evaluation section of this report.

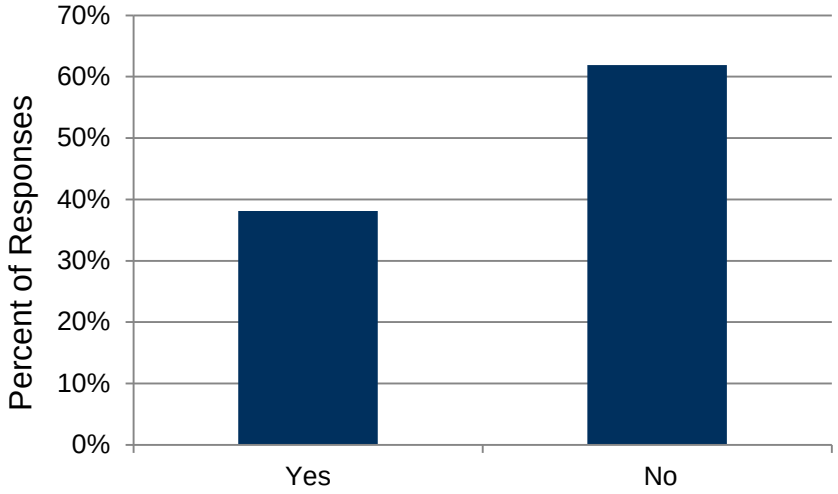
Market Transformation

Cadmus asked several questions in participant surveys and provider interviews to .assess the RCx Program's influence on the market. As the program sought to increase overall market awareness and knowledge about RCx, understanding the knowledge baseline before the program's inception proved important in understanding its influence.

Participant Knowledge of RCx

Cadmus found that most participants did not know what RCx was before participating in the program. Of 21 respondents, 12 reported they had not been familiar with RCx (62%), while nine reported they did know what RCx was (38%), and shown in Figure 7.

Figure 7. Did you know what RCx was before participating in the Efficiency Maine program? (n=21)



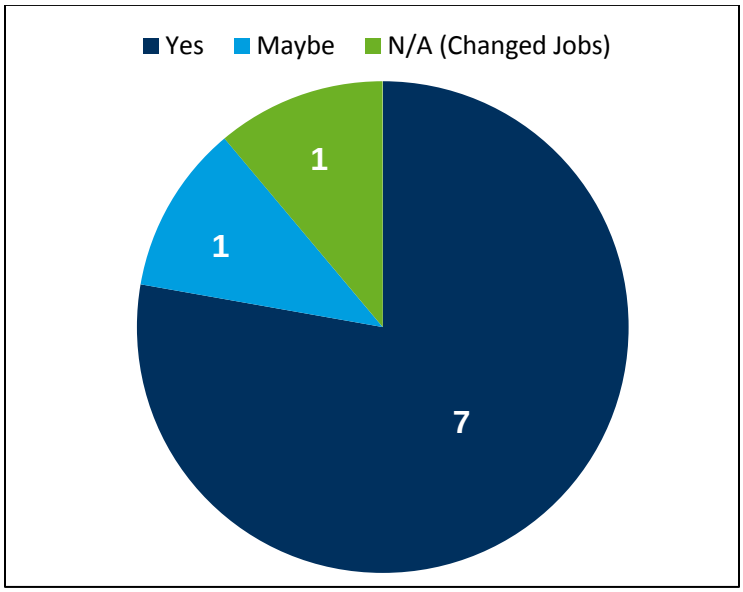
Provider Knowledge and Services

When asked, most providers (n=6 out of 9) said they had significant experience with RCx before participating in the program. Two providers reported they had some experience, while only one provider reported having little experience. When asked if they offered RCx to customers before the program, six providers said yes and three said no, although two respondents said, while they offered the service prior to the pilot program, they did not do so to the same extent. One provider said:

> *"Yes we offered it, but [the program] has reinforced our methodology…. We are paying more attention to RCx as a business model."*

The majority of providers (n=7) stated they would continue offering RCx as a service to customers despite an incentive's absence (see Figure 8), but several stated skepticism regarding demand for RCx among building owners without assistance to cover the costs.

Figure 8. After the pilot program ends and there are no more incentives, will you continue to recommend RCx to your customers? (n=9)



RCx Programs from Other Jurisdictions

Cadmus reviewed evaluation reports and program materials for five other RCx incentive programs to understand how the Efficiency Maine RCx Pilot Program compared in terms of program impacts as well as program design.[6] Four of these other programs were offered by electric utilities, and one program was offered by a gas and electric utility. In contrast, the Trust's RCx Program is not run by a utility and addresses additional fuel types.

Program Impact

The annual energy savings from the reviewed utility RCx programs ranged from 14,300 to 40,700 MMBTU/year, higher than the Trust's program (see Table 10). Savings reflect electricity savings only, except where otherwise noted (Efficiency Maine and San Diego Gas and Electric).

[6] All information in this section derived from impact or process evaluation reports, or from public documents such, as online program manuals and Website information.

Table 10. Impact Summary of Other RCx Programs

Utility	Verified Gross Annual Savings, All Offered Fuels (MMBTU)	No. of Installed Projects per Program Year	Net-to-Gross Ratio
Efficiency Maine*	9,980	~19	96.3%
Southwest Utility	(reported) 14,354	7	N/A
ComEd (Illinois)	26,771	14	91%
Xcel Energy (Colorado)	21,544	20	89%
Rocky Mountain Power (Utah)	30,385	17	84%
San Diego Gas and Electric (California)**	40,767	8	75%

* Includes electric, natural gas, propane, and fuel oil savings.

** Includes electric and natural gas savings.

Incentive Structure

Four of the five electric utility programs reviewed (the Southwest Utility, Rocky Mountain Power, ComEd, and San Diego Gas and Electric) provide an up-front RCx investigation at no cost to customers. Such programs are designed so that the customer enters into a contractual agreement to invest in all or the majority of the RCx implementation costs, and the utility shoulders the cost of the facility investigation and analysis.

Utilities increase the likelihood that some level of energy savings will be achieved by structuring the incentive program to require customers to spend a certain amount of money on implementation of RCx measures with short payback periods. The Southwest Utility and ComEd programs offer "service rebates," which means they offer *only* the free RCx investigation and no additional incentive for measures installed. Rocky Mountain Power and San Diego Gas and Electric offer additional incentives after investigation completion, which are based on energy savings.

Similar to the Trust's program, Xcel Energy covers a portion of investigation and implementation costs, but Xcel Energy has higher caps on the incentive amounts as a portion of costs (75% of the investigation, up to $25,000, and 60% of implementation).

Program Process and Project Eligibility

The reviewed RCx programs followed a program process that included planning, implementation, and verification phases, similar to the Trust's RCx Program. All programs recruited participants using qualified service providers or the utility's key account managers.

Table 11 compares project eligibility requirements across the reviewed programs.

Table 11. Eligibility Criteria of Other RCx Programs

Utility	Building Size Requirement	Customer Obligation
Efficiency Maine	None	50% of implementation costs*
Southwest Utility	75,000 square feet	$10,000 on implementation
ComEd (Illinois)	Peak Demand of 500 kW	$10,000 for small projects; $20,000 for large projects
Xcel Energy (Colorado)	50,000 square feet	None
Rocky Mountain Power (Utah)	75,000 square feet, or peak demand of 300 kW	$10,000 on implementation
San Diego Gas and Electric (California)	100,000 square feet	Up to 5% of the building's annual electric cost on implementation

*Customer is also obligated to pay for implementation costs exceeding the incentive cap ($20,000 early in the program and $40,000 later in the program).

Cadmus' review of the other RCx programs indicated that their processes and protocols were more rigorous than the Trust's, but the other programs also entailed more time and cost for documentation, review, and quality control. Comprehensive RCx investigations and enhanced energy-savings calculations in the other programs helped ensure anticipated energy savings delivered for each project, but the more rigorous and time intensive process also generated a certain dissatisfaction level among qualified providers. While program providers appreciated the value the programs presented to their customers, Cadmus found that across most programs, overall feedback indicated a cumbersome, time-consuming, duplicative process (which, could have been enhanced if streamlined).

IMPACT EVALUATION

To complete the impact evaluation, Cadmus:

- Selected a stratified sample of 24 sites for measurement and verification.
- Reviewed and assessed program energy savings estimates in the program's database and files through a desktop review.
- Conducted site visits to observe building operations, assess energy-efficiency improvements, perform spot measurements, and discuss the project with staff.
- Measured and verified energy and demand savings achieved:
  - Analyzed gross energy savings and demand reduction—in MMBTU (converting heating energy from fuel oil, propane, and gas), kWh, and kW—achieved through the RCx Program.
  - Tailored the verification process and analysis to each individual project and measure list.
- Developed gross realization rates.
- Developed recommendations for improving energy-savings calculations.
- Quantitatively assessed program attribution, including freeridership and spillover.
- Calculated program cost-effectiveness for each program year using the Total Resource Cost (TRC) test.
- Summarized types of customers participating (using available data, such as rate class, size, and customer segment) and RCx activities at each site.
- Calculated and compared site energy use intensity (EUI) results to benchmark building performance. For each building, Cadmus used site visit data, reported program values, or secondary sources to determine square footage. Then, using evaluated energy savings, Cadmus determined each project's energy use intensity, and compared these data to building type results from previous studies. The analysis documented trends in building performance, and offered potential explanations for outliers.

Methodology

Sample Design

To design and select the sample, Cadmus reviewed the tracking spreadsheet containing information for all RCx projects.

All RCx Program participants must submit baseline energy usage data prior to preapproval of applications by the delivery team. Once submitted, these data are entered into a program tracking summary file (a tracking spreadsheet) in Microsoft® Excel, containing key fields for each participant.

The tracking spreadsheet review identified types and qualities of data tracked, helping to identify a representative sample of projects for review to estimate *ex post* energy savings.

Cadmus designed a sample to estimate total program savings within 10% (relative precision) with 90% confidence. Project-level predicted savings values provided by the Trust showed a wide range of project sizes. To account efficiently for the size variability, Cadmus estimated the program's realization rate using a ratio estimator, with sampling stratified by energy savings and participant groups.

Based on the population size of projects that installed measures (33) and using an error ratio of 0.5, estimating program savings to within 10% precision with 90% confidence required a sample of size of 28 projects. However, because the RCx Program served a relatively small number of participants, we applied a finite population correction to the final precision estimates. Also, predicted savings data indicated a large concentration of savings in a small number of large projects. Therefore, evaluation efficiency could be improved by grouping the largest projects into a "certainty stratum." Projects in this stratum could be sampled with certainty, with the remaining projects randomly selected. The final sample included four projects with savings greater than 1,000 MMBTU, fitting into the "certainty stratum." Using the certainty stratum increased precision to achieve 90/10 with a smaller sample size. Cadmus randomly sampled 10 projects each from the Investigation and Implementation subset and Direct Implementation subset to achieve a total sample of 24 projects for the impact evaluation, as shown in Table 12.

Table 12. Sample Strata Sizes

Stratum	Projects
Certainty	4
Investigation and Implementation	10
Direct Install	10
Total	24

Desktop File Review

The RCx Program participant documentation included program tracking spreadsheet, applications, correspondence, RCx investigation reports, and invoices. These data were submitted in both electronic and hard copy formats.

For the desktop file review, Cadmus requested baseline energy-usage data and individual participant documentation for each of the 24 sampled projects prior to conducting site visits to analyze baseline energy consumption and better understand each project's program participation. The desktop review helped Cadmus understand the following:

- The project plan;
- Participants' energy savings calculations and methodology for the calculations;
- Assumptions and formulae used to determine customer-estimated (*ex ante*) savings;
- Reasons for measures not selected for implementation, and respective missed savings opportunities.

Additionally, Cadmus examined each project file to obtain the following key information in preparation for the site visits:

- ***Building characteristics***, including details about shells, mechanical systems, control sequences, lighting systems, tenant types, operational schedules, and other parameters needed to verify accuracy of energy-savings calculations.
- ***Building operation information***, which proved useful in verifying savings assumptions, revising engineering calculations, and determining data monitoring requirements.
- ***Component measure data***, such as model numbers, baseline conditions, and appropriateness and validity of calculations. Baseline conditions of each sampled building were assessed by reviewing available pre-commissioning data captured by the Trust. Component measure data include:
  - Reported energy-savings estimates
  - Input parameters used in engineering calculations and models
  - Trend or meter logging
  - Pre-commissioning energy consumption data
  - ENERGY STAR® Portfolio Manager Profiles, including post-implementation billing entries
- ***Additional data*** required for collection during the site visits.

During the desktop file review process, Cadmus communicated with the delivery team to better understand proposed measures, measures actually installed, and associated savings analysis spreadsheets and documentation. After reviewing the RCx Program file documentation, Cadmus designed a site-specific data collection form to capture measures information while on site.

Site Visits

When scheduling site visits with the 24 sampled participants, Cadmus informed participants about the evaluation's nature, and requested information that would aid in the evaluation (e.g., trending or interval data).

During site visits, Cadmus gathered and verified post-implementation RCx data, such as operating schedules, trend data, and other building characteristics and parameters. Field staff also confirmed equipment was operating as expected following modifications. To calculate associated savings impacts, Cadmus collected data about installed efficiency measures.

During each of the site visits, Cadmus:

- ***Observed building characteristics and operation details*** to confirm energy-savings calculations accurately characterized shells, mechanical systems, lighting power density, and other parameters. If savings calculations did not include building-specific factors, the validity of assumptions used to calculate savings was assessed.
- ***Verified component measures***, where possible, confirming that measures for which program participants received an incentive payment were (1) installed; (2) functioning; and (3) operating in accordance with the specific incentive paid. For example, Cadmus reviewed the following measure types:
  - Calibration, replacement, and repair of sensors, valves, actuators and dampers
  - Optimization of set-back and reset schedules

- Balancing of air and hydronic delivery systems
- Demand control ventilation with CO_2 sensing
- Repairs to mechanical system insulation
- Updates to lighting controls
- Restoration of economizer operations

- ***Collected data for further analysis*** to determine energy savings resulting from installed energy-conservation measures. Cadmus determined pertinent data to collect from each site, based on the in-depth review of site project files, including EMS trend data, where available.
- ***Conversed with facility personnel involved with installation of conservation measures*** to obtain details and to verify the accuracy of submitted assumptions in determining energy-savings calculations.
- ***Performed spot measurements (where applicable)*** to verify that operating system conditions would not vary significantly with time. Such parameters may have included interior or process temperatures, pressure, voltage, amperage, power factor, and true power.
- ***Installed monitoring equipment (where applicable)*** to support verification of energy-savings calculation and to gather trend data over a two-or-more-week period for parameters varying with time. Site-monitoring efforts used data from direct digital control systems, EMS, or other computerized control forms, where available and appropriate. Monitoring data could then be extrapolated to annual usage through calibration to production or usage data. Such monitoring applied to measures such as:
  - Fan and pump motor operations
  - Lighting areas (simple loggers or power panel metering)
  - HVAC package and central plant equipment
  - Refrigeration systems.

One site visit was terminated early by the participant. Therefore, Cadmus did not have an opportunity to obtain the necessary documentation to support the energy savings analysis for that site. As a result, Cadmus removed the site from the evaluation sample, leaving a final sample size of 23 projects, but 24 locations because one project encompassed two locations.

Verified Energy Savings

The methodology and procedures used for verifying energy savings from different measure types varied by project based on the end-use measure types installed and the provided and collected data's availability and precision.

Gross Savings

Cadmus compared the assumptions and methodology of the original analysis, where available, to information collected while on site. Cadmus explored differences between reported and verified savings, determining whether customer action drove these differences (such as overriding a schedule) or if they arose from project provider and program delivery team analysis. A

comprehensive assessment of the gross verified energy savings calculations was presented to the Trust in as a separate submission.

Cadmus then calculated realization rates for each project. A realization rate (RR) is the ratio of the *ex-post* savings (evaluated savings) to the *ex-ante* savings (reported savings) for each project.

$$RR_{ij} = \frac{Evaluated\ Savings_{ij}}{Reported\ Savings_{ij}};\ for\ project\ j\ in\ stratum\ i$$

Net Savings

Net savings result from implemented efficiency improvements attributed to the program. To compute net savings, one adjusts gross savings to account for the likelihood that some participants would have pursued an RCx activity without the program incentive (freeridership) and, in some cases, because of the program; participants pursued other energy efficiency measures outside the program (spillover). The Net-to-Gross (NTG) ratio reflects the percentage of gross program savings that are attributed to the program, and can be calculated as follows:

$$NTG = 1\text{- }Freeridership\ Ratio\ (FR) \pm Spillover\ Ratio$$

For the RCx Program, freeridership was assessed through the participant survey, as described in the Process Evaluation section. Spillover was assessed through the participant survey and during the site visits, but was not quantified, reducing the NTG equation to:

$$NTG = 1\text{- }FR$$

Cadmus then calculated net verified energy savings for each sampled side by applying the NTG ratio to the site's gross verified energy savings.

Extrapolation to Population for Program-Level Savings

As described earlier, the measurement and verification process involved sampling projects with a sample large enough to provide 90/10 confidence and precision for each program track. Cadmus calculated realization rates to extrapolate to the remaining, non-sampled sites.

Stratum-Specific Ex-post Energy Savings

The *ex-post* savings for each stratum are calculated by applying the realization rate for the sampled projects within each stratum to the *ex-ante* savings for the entire stratum. The realization rate for each stratum is calculated as the ratio of the sum of the *ex-post* savings to the sum of the *ex-ante* savings for the sampled projects within that stratum.

$$RR_i = \frac{\sum_j Evaluated\ Savings_{ij}}{\sum_j Reported\ Savings_{ij}};\ for\ stratum\ i\ across\ all\ sampled\ projects \quad (1)$$

The total *ex-post* savings for each stratum is the product of the realization rate for the stratum and the total *ex-ante* savings for the stratum, assuming the estimated realization rate for the stratum can be applied across all projects in the stratum.

$$Evaluated\ Savings_i = RR_i \times \sum_j Reported\ Savings_j;\ for\ all\ projects\ in\ stratum\ i \quad (2)$$

Total Program Ex-post Energy Savings

The total *ex-post* savings for the program is the sum of the *ex-post* savings for each stratum.

$$Evaluated\ Program\ Savings = \sum_i Evaluated\ Savings_i \quad (3)$$

The program realization rate is the quotient of the *ex-post* program savings to the *ex-ante* program savings.

$$RR_{Program} = \frac{Evaluated\ Program\ Savings}{Reported\ Program\ Savings};\ for\ the\ population \quad (4)$$

Lifetime Savings

Cadmus evaluated the lifetimes of measures installed under the RCx Program. We assigned a weighted average measure life of the measured installed under the RCx Program. This measure life was then multiplied to the program-level savings to understand the persistence of the program savings. We also examined the persistence of measures installed by interviewing participating customers. Interviews sought to determine changes customers made subsequent to measure installation that could affect energy savings (i.e., customers could change temperature setpoints and operating schedules to less-efficient settings than those established during participation).

Cost-Effectiveness

Cadmus calculated the RCx Program's cost-effectiveness using a Total Resource Cost (TRC) test, which serves as an industry-standard metric for evaluating program cost-effectiveness. Outlined in the California Standard Practice Manual,[7] the TRC compares energy savings benefits (avoided costs) to program administrator and participant costs.

A cost-effectiveness assessment using the TRC test involves a valuation of a program's total resource benefits, as measured by energy avoided costs; and its total resource costs, as measured by incremental installed measure costs and program costs. In applying the TRC, costs and benefits are analyzed in Net Present Value (NPV).[8] A program can be deemed cost-effective if its ratio of total resource benefits to total resource costs is greater than 1.00. This is calculated as:

$$\frac{Total\ Resource\ Benefits}{Total\ Resource\ Costs} \geq 1$$

Where,

[7] California Public Utilities Commission (CPUC). 2001. *California Standard Practice Manual Economic Analysis of Demand-Side Programs and Projects.* Sacramento, CA: Governor's Office of Planning and Research, State of California.

[8] Program lifetime effects are discounted to their equivalent value during the base fiscal year; in this case, FY2011.

$$Total\ Resource\ Benefits = \text{NPV}\left(\sum_{year=1}^{measure\ life}\left(\sum_{i=1}^{8,760}\left(\text{Net Impact}_{i,j} \times \text{Avoided Cost}_{i,j}\right)\right)\right)$$

And,

$$Total\ Resource\ Costs = \text{NPV (Net Incremental Measure Costs + Program Administrator Costs)}$$

In the TRC calculation, electric kWh savings are calculated at the system level (at generation), taking into account line losses (energy lost through transmission and distribution). Energy savings from other fuel types do not include line losses.

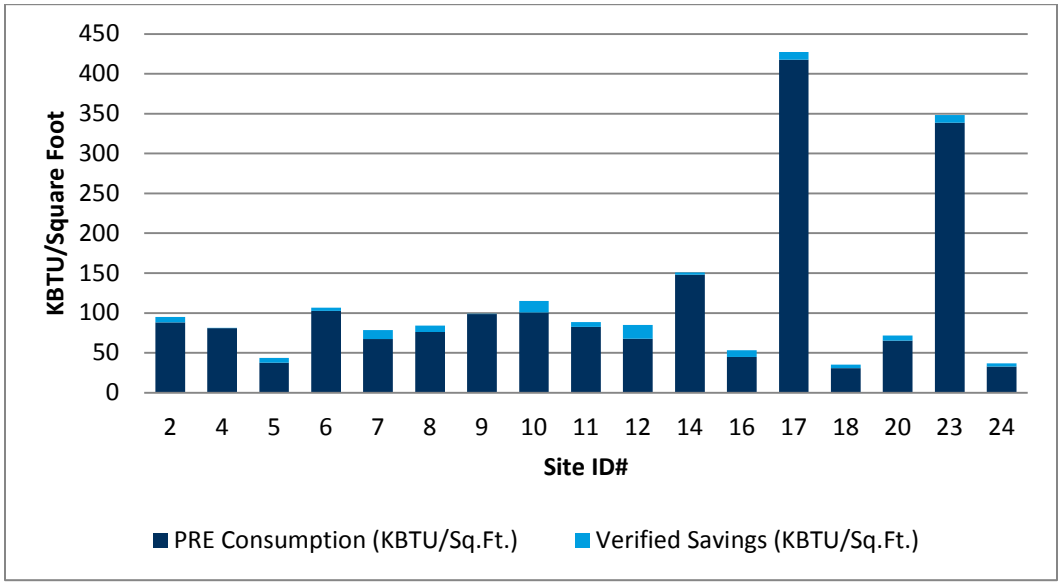
The TRC calculation uses net benefits and costs, as determined by applying the NTG ratio to gross values.

Findings

Characteristics of the Sampled Sites

Energy use intensity (EUI) reflects the energy used by a building relative to its size, measured in KBTU per square foot. EUI is useful to consider in the context of RCx programs because it can be less effective to pursue savings through an RCx measures for facilities with a relatively low EUI for its building type. Within the RCx Program, the EUI varied considerably for both the Investigation and Implementation and Direct Implementation Track projects. Figure 9 shows a distribution of energy use intensity (EUI), where EUI could be calculated.[9] Cadmus found that the RCx Program sites with the largest EUIs were hospitals.

Figure 9. EUI for Projects within Evaluation Sample



[9] The EUI was calculated for sites within the sample that had energy consumption and square footage data.

Where possible, Cadmus also calculated the breakdown of savings by measure in the RCx Program. [10] Figure 10 and Figure 11 show the savings by measure type (both reported and verified) for the sampled sites.

Figure 10. Reported Savings (by Measure)

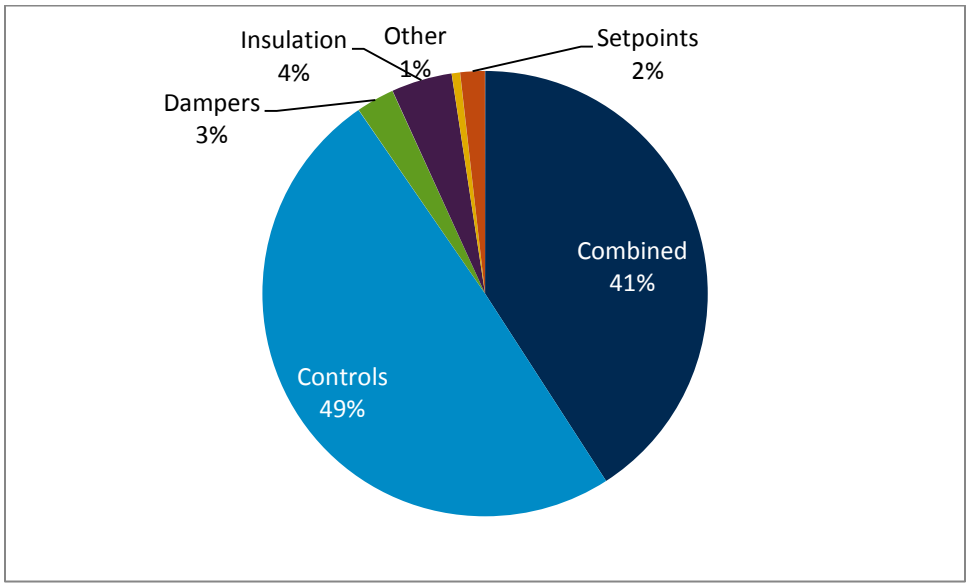
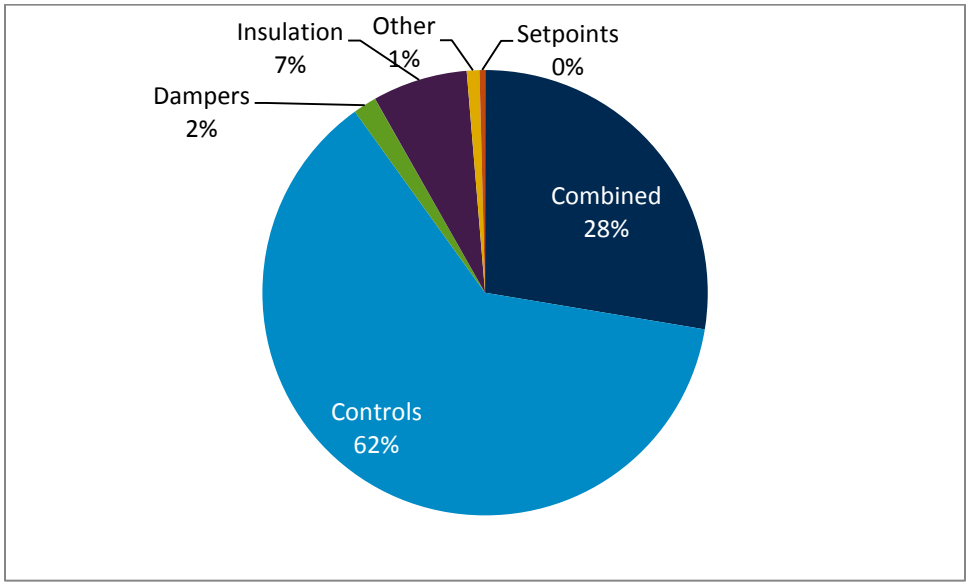


Figure 11. Verified Savings (by Measure)



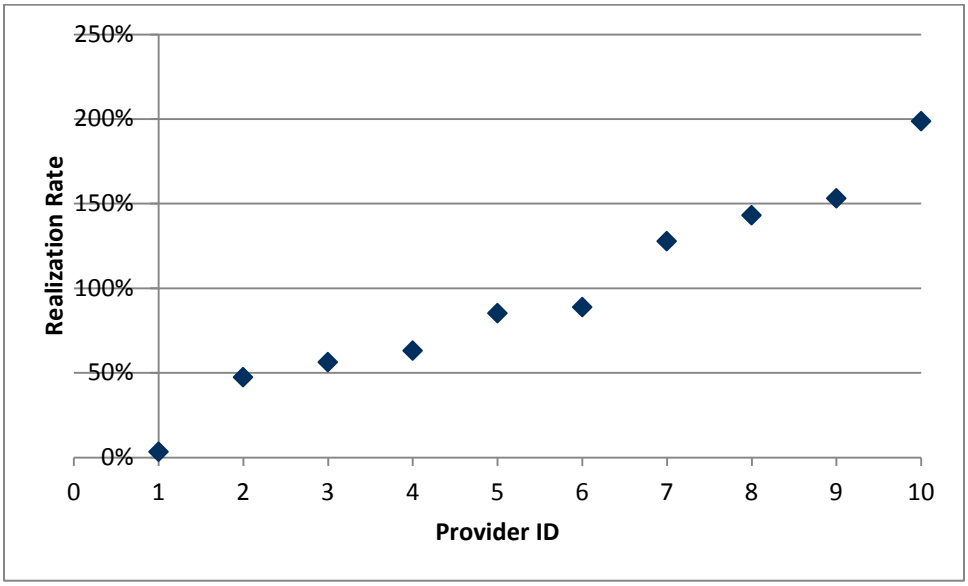
In both the reported and verified scenarios, control measures achieved the highest percentage (49% and 62%, respectively) of program savings. It is important to note that VFD installations were also included within the controls category. "Combined," the category that was unable to be

[10] Measure-level savings could not be assessed at all sites. In instances where it could not be broken out, site savings fell under the "combined" category, or were not able to be included in the measure-level calculation.

broken out, was the next-highest energy saving measure. Finally, dampers, insulation, other, and setpoints achieved small amounts of savings in the program.

Cadmus also calculated energy savings realization rates for each RCx Provider. Figure 12 shows the range of realization rates (between 3% and 198%). This large variation indicates a lack of standardization in savings calculations methods, but may also indicate variation in the quality of the providers. Providers 5 through 10 have high rates, from near 100% to 198%, indicating that verified savings were at or above the project's estimated savings.

Figure 12. Realization Rates by Provider



In conjunction with this Final Report, Cadmus provided the Trust with detailed site-level analyses and summaries. The summaries include detailed observations, savings calculations, and realization rates.

Gross and Net Energy Savings

The engineering reviews and verified gross energy savings calculations estimated savings by fuel type for the RCx Program, which are shown in Table 13.

Table 13. Reported and Verified Energy Savings (by Fuel Type)

Site ID	Reported Electric Savings (kWh)	Verified Electric Savings (kWh)	Reported Fuel Oil Savings (Gallon)	Verified Fuel Oil Savings (Gallon)	Reported Gas Savings (Therm)	Verified Gas Savings (Therm)	Reported Propane Savings (Gallon)	Verified Propane Savings (Gallon)
Investigation and Implementation Projects								
2	3,200	3,300			1,585	900		
3	127,312	114,933			10,650	8,790		
4	82,051	10,228			8,146			
5	13,689	4,200	2,098	1,664				
6	201,601	52,197			3,293	2,268		

Site ID	Reported Electric Savings (kWh)	Verified Electric Savings (kWh)	Reported Fuel Oil Savings (Gallon)	Verified Fuel Oil Savings (Gallon)	Reported Gas Savings (Therm)	Verified Gas Savings (Therm)	Reported Propane Savings (Gallon)	Verified Propane Savings (Gallon)
7	6,304	1,100	2,145	3,605				
8	3,982	3,800	5,740	2,884				
10	32,110	13,415			318	1,208		
12	7,626	2,200	5,284	2,019				
13	180,850	70,971						
15	75,493	31,167	7,142	3,830				
16	62,445	62,445	2,824	1,388				
17			3,278	4,310				
19	59,790	42,900						
Direct Implementation Projects								
1		0	200	311				
9		0	1,248	1,333				
11	10,000	468	400	351				
14	14,513	19,300	1,400	590				
18	460	861					675	851
20	3,608	4,500					341	655
22	3,771		500	822				
23	49,981	59,665	7,840*	16,533				
24	2,772	16					11	127

*Reported value amended to correct for Provider calculation error.

Note: Does not include savings from Site 21.

Net-to-Gross

Cadmus estimated the Program's NTG to be 96.3%, based on a freeridership rate of 3.7% and relatively low rates of spillover.

One project reported spillover. Cadmus was not able to quantify spillover savings associated with this project, but estimates that it was around 1%. Even if Cadmus did quantify spillover, it is likely that this spillover value (the additional energy savings) would add less than 1/10 of 1% to the NTG ratio so would not alter verified savings.

This final NTG value of 96.3% was applied to the gross verified energy savings to determine the net verified energy savings.

Table 14 shows each sampled project's reported and verified energy savings, and its gross and net realization rates.

Table 14. Reported and Verified Energy Savings

Site ID	Reported Savings (MMBTU)	Verified Gross Savings (MMBTU)	Verified Net Savings (MMBTU)	Gross Realization Rate	Net Realization Rate
Investigation and Implementation Projects					
2	169	101	98	60%	58%
3	1,499	1,271	1,224	85%	82%
4	1,095	35	34	3%	3%
5	338	245	236	73%	70%
6	1,017	405	390	40%	38%
7	319	504	485	158%	152%
8	810	413	398	51%	49%
10	141	167	160	118%	113%
12	759	288	277	38%	36%
13	617	242	233	39%	38%
15	1,248	638	614	51%	49%
16	605	406	391	67%	65%
17	455	598	576	131%	127%
19	204	146	141	72%	69%
Direct Implementation Projects					
1	28	43	42	156%	150%
9	173	185	178	107%	103%
11	90	50	48	56%	54%
14	244	148	142	61%	58%
18	63	81	78	128%	123%
20	44	75	73	173%	167%
22	82	114	110	139%	134%
23	1,258	2,497	2,404	198%	191%
24	10	16	15	153%	147%

*Site 21 was eliminated from the analysis because Cadmus was unable to verify the installation of the measure(s).

*Reported value amended to correct for Provider calculation error.

During the engineering reviews, Cadmus uncovered a unit conversion error that greatly altered the reported energy savings of Site 23 with respect to fuel oil (which was initially reported as 789 gallons). To decrease the sensitivity of the analysis to Site 23, Cadmus revised the reported savings estimate to eliminate the calculation error (ultimately, calculated to be 7,840 gallons). What is reported in the table above is the reported savings estimate without the unit conversion error.

Estimated gross realization rates for each sampled site varied greatly. Overall, the RCx Program achieved a gross realization rate of 78.2% and a net realization rate of 75.3%, as shown in Table 15.

Table 15. Savings and Gross and Net Realization Rates

Savings	Electric Savings (kWh)	Fuel Oil Savings (Gallon)	Gas Savings (Therm)	Propane Savings (Gallon)	Gross Savings (MMBTU)	Net Savings (MMBTU)	Gross Realization Rate	Net Realization Rate
Reported Savings	1,186,433	42,217	26,599	1,407	12,764			
Verified Savings	702,159	42,342	15,337	1,901	9,980	9,611	78.2%	75.3%

Energy Savings by Track

Adding the Direct Implementation Track helped boost the total number of implemented projects. While the Investigation and Implementation Track projects were more popular and achieved higher reported energy savings than the Direct Implementation projects, had higher verified energy savings per project (315 MMBTU vs. 282 MMBTU) and lower realization rates (60% vs. 161%), as shown in Table 16.

Table 16. Impacts by Program Track

Track	Number of Projects	Reported Savings (MMBTU)	Gross Verified Savings (MMBTU)	Realization Rate	Average Reported Savings per Project (MMBTU)	Average Gross Verified Savings per Project (MMBTU)
Investigation and Implementation	20	10,486	6,309	60.2%	524	315
Direct Implementation	13	2,279	3,671	161.1%	175	282
Total	33	12,764	9,980	78.2%	387	302

*Note: Includes only projects implementing measures.

As can be expected, Cadmus found Direct Implementation projects to be less expensive per project than Investigation and Implementation projects, which include the cost of the study. Additionally, Direct Implementation projects resulted in a lower cost per MMBTU saved, as shown in Table 17.

Table 17. Costs by Project Type

Track	Total Incentives Paid	Number of Projects	Average Incentive Cost per Project	Gross Verified Savings (MMBTU)	Cost per MMBTU Saved
Investigation and Implementation	$303,198.85	26	$11,661.49	6,309	$48.06
Investigation (Step 1)	$166,129.54				
Implementation (Step 2)	$137,069.31				
Direct Implementation	$60,781.93	13	$4,675.53	3,671	$16.56
Total	$363,980.78	39	$9,332.84	9,980	$36.47

Sampling Precision

Cadmus calculated the sampling precision to determine whether it was acceptable, based on standard statistical levels of rigor, to extrapolate sample energy savings to the overall program

population. Cadmus determined the confidence interval (precision) for a 90% confidence level, and found the sample achieved 90/11.[11] This result was slightly less precise than the intended sample design value of 90/10; this was primarily due to attrition in which one sample site had to be removed after the contact truncated the visit. We believe this level of precision is still reasonable to allow meaningful extrapolation of the sample results to the overall program population.

Program-Level Savings

Cadmus extrapolated the realization rates from the impact evaluation sample to the remaining, non-sampled sites in the overall program (by stratum) to determine the overall program-level verified energy savings. These values are reported by FY in Table 18.

Table 18. Verified Fiscal Year Gross Savings

FY	Electric Savings (kWh)	Natural Gas Savings (MMBTU)	Propane Savings (MMBTU)	Fuel Oil #2 Savings (MMBTU)	Total (MMBTU)
2011	162,037	1,037	90	598	2,277
2012	508,795	497	85	5,198	7,516
2013	31,327	0	0	76	183
Total	702,159	1,534	174	5,872	9,976*

*This number is slightly different from 9,980 in other tables due to rounding differences.

Lifetime Savings

Cadmus assessed the measure-weighted lifetime average to be five years. As a result, the verified lifetime gross savings for the RCx Program are 49,902 MMBTU. These data are listed in Table 18.

Table 19. Lifetime Savings

Savings	Electric Savings (kWh)	Fuel Oil Savings (Gallon)	Gas Savings (Therm)	Propane Savings (Gallon)	Savings (MMBTU)	Net Savings (MMBTU)
Reported Lifetime Savings	5,932,165	211,086	132,995	7,036	63,821	
Verified Lifetime Savings	3,510,793	211,711	76,686	9,503	49,902	48,055

Cost-Effectiveness

Data

To calculate the RCx Program's cost-effectiveness, Cadmus took the verified net savings of completed projects, and made adjustments to account for changing baseline consumption associated with the installed efficiency measures. Incremental participant measure cost was calculated from information provided by the Trust. Additionally, program administrative cost information, discount rate and line loss factors were provided by the Trust. Table 20 shows key

[11] The confidence level and interval determine precision. This value indicates Cadmus can be 90% certain, based on sampling error, the correct falls within ± 11% of evaluated savings.

model inputs and assumptions used to calculate the TRC. Cadmus estimated the program's NTG Ratio and program measure life from verified data. Avoided energy costs used in the analysis are shown in Appendix D.

Table 20. Model Inputs and Assumptions

Analysis Assumptions	Value
Discount Rate	4.51%
Electric Line Loss	6.50%
NTG Ratio	0.963
Weighted Average Measure Life (years)	5

Results

Table 21 is a summary of verified program results used as inputs in the TRC test. Verified energy savings are listed by fuel type.

Table 21. Cadmus Verified Program Results FY 2010-2013

Category	2011	2012	2013
Annual Gross kWh Savings (at generation)	172,569	541,866	33,363
Annual Net kWh Savings (at generation)	166,184	521,817	32,129
Lifetime Net kWh Savings (at generation)	830,922	2,609,086	160,644
Annual Gross MMBTU Natural Gas Savings	1,037	497	0
Annual Net MMBTU Natural Gas Savings	998	479	0
Lifetime Net MMBTU Natural Gas Savings	4,991	2,394	0
Annual Gross MMBTU Propane Savings	90	85	0
Annual Net MMBTU Propane Savings	86	81	0
Lifetime Net MMBTU Propane Savings	432	407	0
Annual Gross MMBTU Fuel Oil Savings	598	5,198	76
Annual Net MMBTU Fuel Oil Savings	576	5,006	74
Lifetime Net MMBTU Fuel Oil Savings	2,878	25,030	368
Net Incremental Measure Costs	$183,413	$619,721	$18,210
Technical Support Costs	$99,573	$48,454	$32,712
Administrative Costs	$9,170	$10,192	$77,743
Evaluation and Research	$0	$0	$13,768

Table 22 shows TRC test results for verified costs and savings for all projects completed and verified from program inception, including partial data for FY 2013. The verified results are the actual program results using actual expenditures and savings as verified by Cadmus. The Trust reported FY 2012 values are the program-reported values based on the program tracking system data provided to Cadmus.

The TRC test result using verified savings from the evaluation is slightly lower than the program-reported FY 2012 result. The program's verified results narrowly did not pass the TRC cost-effectiveness test, with a benefit to cost ratio of 0.96.

Table 22. TRC Results for Verified FY 2010-2013 and Trust Reported FY12

TRC Components	Cadmus Verified Values FY 2010-2013 YTD	Trust Reported FY 2012 Values
TRC Benefits	$962,468	$996,641
TRC Costs	$1,003,432	$947,743
TRC Ratio	0.96	1.05

Table 23 compares the program's verified results for the entire program period with the program reported results for FY12. Several aspects account for the difference between the two:

- Overall program administrative costs for the multi-year period (FY10-FY13 YTD) were higher ($210,368) than the FY12 administrative costs ($58,646).
- Total verified electric savings over the evaluation period (FY10-FY13 YTD) were approximately 39% lower than the FY2012 reported electric savings (702,159 kWh instead of 1,160,208 kWh).
- The Trust reported that program FY12 TRC test results are based on gross savings, equivalent to a NTG ratio of 1.00. Cadmus estimated an NTG ratio of 0.963, which is applied in the TRC calculation. That change in the NTG ratio accounts for a 0.01 decrease in the verified TRC ratio from 0.97 to 0.96.

Table 23. TRC Results Comparison

Program Data Summary	Cadmus Verified FY 2010-2013 YTD Values	Trust Reported FY 2012 Values
Present Value of Total Program Costs	$1,003,432	$947,743
Present Value of Total Measure Costs	$793,064	$889,097
Present Value of Administrative Costs	$210,368	$58,646
Present Value of Total Benefits	$962,468	$996,641
Present Value of Electric Benefits	$267,198	$398,648
Present Value Non-Electric Benefits	$695,270	$597,993
Total Electric Savings (kWh)	702,159	1,160,208
Total Oil Savings (MMBTU)	5,872	4,354
Total Gas Savings (MMBTU)	1,534	2,586
Total Propane Savings (MMBTU)	174	66

RECOMMENDATIONS AND CONCLUSIONS

Below, Cadmus outlines conclusions and recommendations regarding the program's design, process, and marketing techniques to be considered, should the Trust choose to roll it into a full-scale program, if funding becomes available.

Process Evaluation

The program design served the pilot program's needs, but a full-scale RCx Program would probably require modifications to increase program impacts. Recognizing the program's unique goals, due to ARRA grant funding, the pilot's design largely allowed the Trust to accomplish objectives. Flexible definitions of RCx projects, adaptable program guidelines, and the two-track design served the pilot program's particular goals to minimize delivery costs, move incentive money quickly, and build a provider network.

Freeridership for the program was low (3.7%), which is consistent with expectations as this was the first RCx incentive program in Maine and consistent with other RCx programs in other jurisdictions. Offering incentives for in-depth engineering analyses that provide new and valuable information to customers about how to improve the efficiency of their building systems may be one strategy to keep freeridership levels low in future years, if the program is developed into a full-scale offering.

A review of other full-scale RCx offerings indicated RCx can achieve significantly more energy savings than those realized by the pilot program. By making the following changes to program design, the Trust can improve the program's effectiveness, if funding becomes available to develop a full-scale RCx offering:

- Consider moving some measures under the Business Incentive Program umbrella to boost overall energy savings and lower the cost per unit of energy saved.
- Consider moving the Direct Implementation Track to the Business Incentive Program.
- Consider instituting a requirement for minimum energy use per square foot, by building type, for eligible facilities. This would ensure that buildings in the program would have large opportunities for savings. A minimum energy use intensity (energy use per square foot, or EUI) level could also be used as a cut-off as it can be less effective to achieve savings for projects with lower EUIs through an RCx program.

The program experienced high satisfaction levels, mainly due to clear instructions and communications from the Trust and its delivery team. Timely feedback, prompt decision making, and accessibility emerged as common themes reported by providers addressing their experiences with the Trust and its delivery team. Providers reported a clear understanding of the program and its expectations of them, which directly translated to positive participant experiences. Communication about the program likely increased providers' outreach to their customers, leading to a larger participant pool. If developing a full-scale offering, the Trust should continue to prioritize communications with providers and participants to facilitate high satisfaction.

The program's strategy to use providers as the main channel for promoting the program to building owners proved effective for a pilot, but may require a modified approach for a full-scale program. Relying entirely on providers not only limits penetration, but also can result in varied products. Participants primarily learned about the pilot program through their providers or contractors. However, providers also indicated more marketing materials would prove helpful in promoting the program and explaining RCx to their customers. Program staff said limited marketing probably resulted in fewer Direct Implementation projects than anticipated. If developing a full-scale offering, consider allocating additional budget to marketing for developing program brochures, one-pagers, and case studies for customers and providers.

The quality of Investigation reports varied greatly by RCx provider. Providing RCx providers a template report and recommended set of measures could be helpful in focusing the program on the most cost-effective measures and reducing the costs of preparing the reports if a full-scale offering is developed.

Cadmus recommends that ***the Trust encourage follow-up with participants. Follow-up with participants would help the Trust identify program improvement opportunities.***

- One interviewed facility manager wanted data collected by the RCx provider to be supplied to the site. Unfortunately, he never received the gathered data. Ensuring that providers share data they have been paid to collect provides value to participants as well as evaluators.
- At a separate site, in particular, the participant expressed dissatisfaction with the contractor's work, and might consider redoing it. While an evaluation provides such feedback to program implementers and administrators, providing responses resulting in a closer-to-real-time understanding of program satisfaction would be beneficial.

Cadmus recommends that ***the Trust establish greater "brand recognition" around this program***. While Cadmus understands this was not necessarily a goal of the pilot program, many participants interviewed did not understand the Trust's involvement in the program, and did not feel the Trust's "presence" throughout the process, as they primarily interacted with providers or contractors. This offers an opportunity for the Trust to promote its work.

Impact Evaluation

Establish standardized calculation methods and determine implementation rate and persistence of measures. Overall the program achieved a gross realization rate of 78%, which is reasonable for a pilot project. However, one of the largest projects had a realization rate of over 200%, while the other projects had a combined gross realization rate of 65%. This lower rate was due in part to the fact that several reported measures either were not fully implemented, or did not persist through the evaluation period. Other measures, particularly air balancing, resulted in greater thermal comfort for occupants, but occasionally resulted in higher energy use than the baseline case. Fuel oil realization rates in particular varied widely. Training on and standardization of estimating fuel oil savings should be included in future programs.

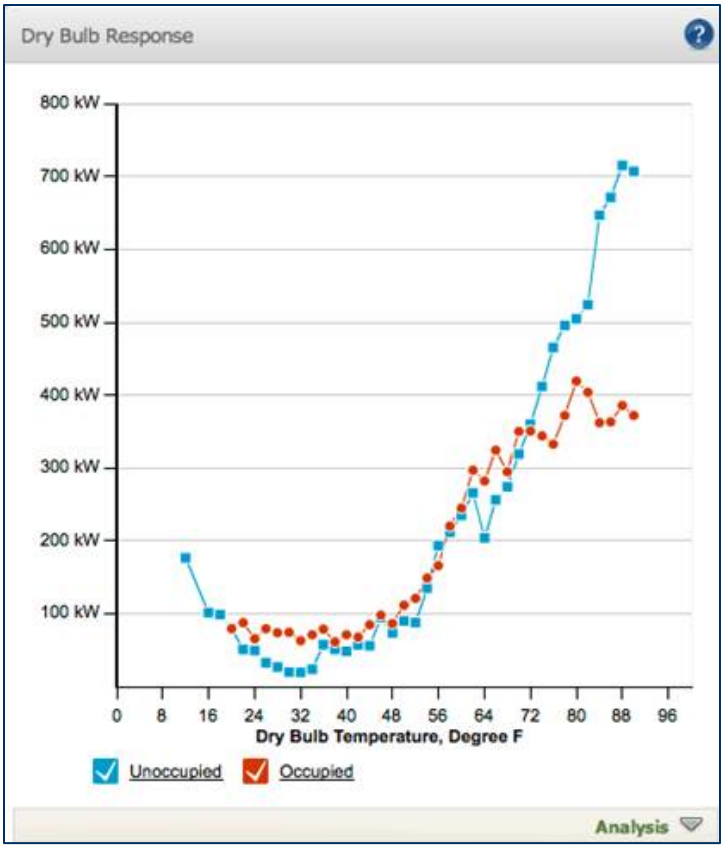
Use simple quality control metrics. At a minimum, estimated energy savings should be compared to facility energy consumption as a reasonableness check. Estimated savings above a threshold (e.g., 10% of consumption) should be further reviewed.

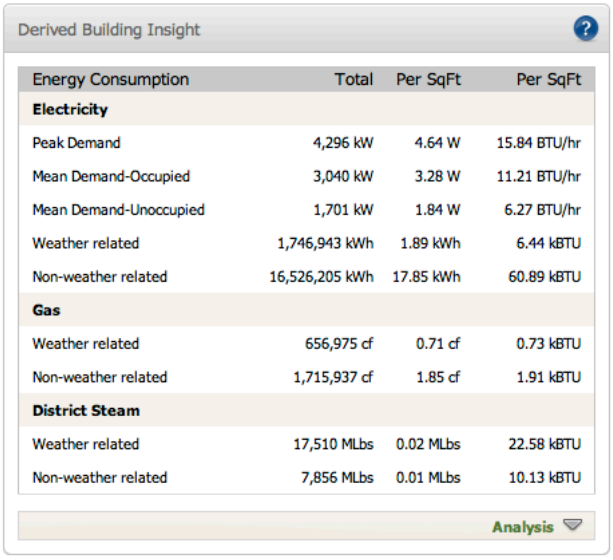
Require verification inspections or trend data review six months after RCx measure installation for all projects with reported savings larger than a threshold (i.e., 1,000 MMBTU) to confirm measure installation and persistence. In its examination of the sampled sites, Cadmus often found that the reported RCx measures in program data files either were not fully implemented by participants or were implemented only for a short amount of time during the evaluation period. These issues resulted in reduced overall energy savings for each fuel type realized by projects (and verified by Cadmus) relative to the *ex ante* project savings values in the program data.

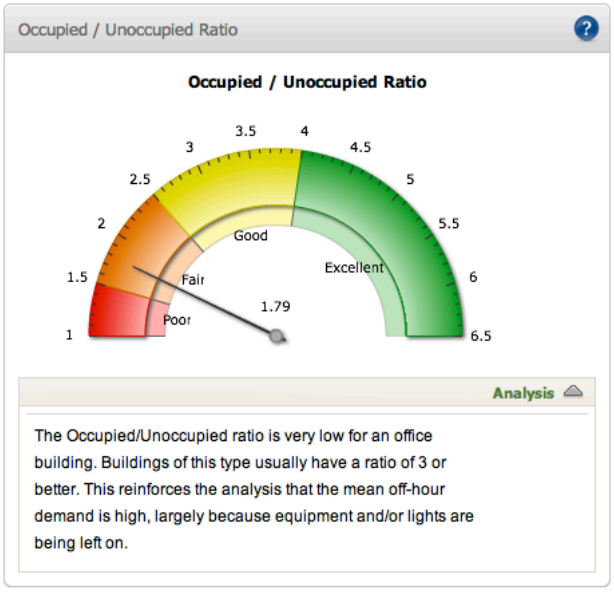
Require all participants to have and use a building energy management system (EMS). The EMS system should have trending enabled for the relevant parameters associated with the RCx measures. The verification inspection could also obtain EMS trend data to confirm the performance of measures for which incentives were offered. We found in some cases that the EMS was not controlling or monitoring the system addressed by the efficiency measure.

Screen buildings for opportunities. In addition to screening for high energy use intensity, the program will be most effective if it can also screen for buildings with large savings opportunities. We found that some RCx reports were actually energy audits with information that was too general, and which recommended relatively expensive measures. Rather than fund numerous larger RCx investigation studies, an alternative that we recommend is to fund lower cost "studies" that rely on basic time series data to identify the larger savings opportunities. Efficiency Maine could then fund more comprehensive investigative studies on buildings presenting the largest opportunities by:

- **Focusing on larger buildings.** There seemed to be lower success in smaller buildings where there is less system control over space temperature and system operations.
- **Obtaining interval data.** Interval data can be used to identify RCx and other opportunities at low initial cost. Examples of interval data analysis are shown below:







- **Providing incentives for installation of a logging meter where interval data cannot be obtained.** Installing a permanent or semi-permanent logging meter on the service panel is relatively inexpensive (on the order of $2,000, more if the meter is linked to the Internet). The resulting interval data can help identify energy savings opportunities including high unoccupied energy use and poor response to temperatures.

- **Providing incentives for provision of EMS trend data.** Even limited trend data can diagnose building problems.

Prioritize the most successful measures. Where a measure is simple (e.g. shut-off air handlers at night) it has the highest probability of success. In general, simple directly installed measures were the most reliable in terms of producing energy savings. These included:

- Pipe insulation
- Steam trap measures
- VFD installations
- Compressed air measures.

Some of the most cost-effective HVAC measures eliminate over-conditioning during unoccupied hours and reduce introduction of excessive outside air. In larger buildings, however, control strategies to accomplish these outcomes can become complex. HVAC control measures varied both in terms of actual installation rate and success. Successful measures included supply air temperature resets, fixing outside air problems, and improving VAV system response.

Remove, from eligibility, any measures that should result from routine maintenance (e.g. cleaning of a heat exchanger).

Claim credit for non-energy benefits (NEBs), or avoid measures that can increase energy use. In certain situations, fixing buildings can lead to increased energy use. Some RCx program measures fixed building problems that allowed for improved occupant comfort, but increased resource consumption and did not save energy. These measures include replacing failed (closed) heating valves and ventilation air balancing.

If the pilot RCx Program is not continued as a standalone program, certain measures from the pilot can be incorporated in the Trust's business program offerings. Cadmus recommends the following measures:

- Small Business Direct Installation: Programmable thermostats and pipe insulation.
- Prescriptive Incentive:
  - Boiler reset controls,
  - Boiler tune ups,
  - Steam trap repair or replacement,
  - Pipe wrap, and
  - Minor compressed-air measures (i.e., zero-loss condensate drains, additional receiver capacity, low pressure drop filters, and cycling air dryers).
- Custom Incentive, including comprehensive custom building assessment and combustion air damper repair.

APPENDIX A. FREERIDERSHIP METHODOLOGY AND ANALYSIS

For estimating freeridership, Cadmus conducted surveys with 21 participant decision makers. Cadmus used these customer self-report data to calculate net savings attributed to the program. Questions sought to determine why customers retro-commissioned their facilities, the program's influence over those decisions; and what decision makers might have done in the program's absence. Cadmus developed a scoring matrix to weight participant responses and to calculate net-to-gross (NTG).

Freeridership Survey Questions

The survey relied on various "skip patterns" to customize the question battery, based on initial responses. The following survey questions addressed FY 2012 program freeridership:

- FR0a. First, did your organization have specific plans to retro-commissioning the building ***before*** learning about the Efficiency Maine program?
- FR0b. Prior to participating in the Efficiency Maine Retro-commissioning Program, were funds for retro-commissioning activities included in your organization's capital or operating budget?
- FR1. Would you have retro-commissioned the building without the Efficiency Maine program incentive?

If a participant answered "yes," or "don't know," to a combination of the above questions, the following confirmatory questions assessed their freeridership level:

- FR1a. Would you have made some retro-commissioning improvements without the program incentive?
- FR2. Let me make sure I understand. Would you have made exactly the same type of retro-commissioning improvements without the incentive?
- FR3. And would you have made the same number of improvements without the incentive?
- FR4. And, without the incentive, when would you say you would have conducted the retro-commissioning… [Choices reflect 1 year, 2 years, etc.]
- FR9. Before participating in the Efficiency Maine retro-commissioning program, had you ever retro-commissioned this building or another [COMPANY NAME] facility?

If a participant responded "no" to FR1, Cadmus staff followed up with a question battery to confirm the participant was not a freerider:

- FR5. So, without the program incentive, you would **not** have retro-commissioned the building **at all.** Is that correct?

- FR6. Again, help me understand. Would you have made some general improvements to operations and maintenance, but not made the same **type** of improvements that you made with the program incentive?
- FR7. Without the incentive, would you have made some improvements, but fewer of them?
- FR8. And, without the incentive, when would you say you would have would you have retro-commissioned the building… [Choices reflect 1 year, 2 years, etc.]
- FR9. Before participating in the Efficiency Maine retro-commissioning program, had you ever retro-commissioned this building or another [COMPANY NAME] facility?

Cadmus assigned scores by using the "yes/partial/no" matrix shown in Table 25, below.

Freeridership Analysis

Placing the survey question results into a decision-making matrix allowed determination of each participant's freeridership score. This matrix assigned a score between a 0% freerider to a 100% freerider for each project. Table 25 and Table 26 illustrate the scoring mechanism associated with questions included in the freeridership survey. These tables have been presented for illustration purposes, and do not include all permutations of responses and scoring.

If participants had no plans to retro-commission their facilities, they could not be considered freeriders. At the other end of the spectrum, customers classified as 100% freeriders had previous plans to improve their building systems, and would have implemented the measures without the program.

As the Table 25 matrix illustrates, participants could be partial freeriders (more commonly than 100% freeriders). Customers received partial scores if they had plans to perform upgrades, but were influenced by the program in making that decision. The participant received a higher freeridership score if the program had less influence over their decisions, and they were highly likely to implement the measures.

The team independently evaluated each survey question response to assess participants' freeridership levels, with each survey response converted into values of: "yes" (indicative of freeridership); "no" (not indicative of freeridership); or "partial" (partially indicative of freeridership).

Table 24, below, lists 12 freeridership survey question numbers, their corresponding response options, and the value to which they were converted (in parentheses).

Table 24. Assignments of Retro-Commissioning Program Freeridership Response Options into Matrix Terminology

FR0a	FR0b	FR1	FR1a	FR2	FR3	FR4	FR5	FR6	FR7	FR8	FR9
Yes (Yes)	Yes (Yes)	Yes (Yes)	Yes, would have made some improvements (Yes)	Yes (Yes)	Yes (Yes)	Within the same year? (Yes)	Yes/correct, would not have made any improvements without the program incentive (No)	Yes (No)	Yes (No)	Within the same year? (Yes)	Yes (Yes)
No (No)	No (No)	No (No)	No, would NOT have made any improvements/installed anything (No)	No (No)	No (No)	Within one to two years? (Partial)	No/not correct, would have done something without the rebate (Yes)	No (Yes)	No (Yes)	Within one to two years? (Partial)	No (No)
Don't Know (Partial)	Don't Know (Partial)	Don't Know (Partial)	Don't Know (Partial)	Don't Know (Partial)	Don't Know (Partial)	Within three to five years? (No)	Don't Know (No)	Don't Know (Partial)	Don't Know (Partial)	Within three to five years? (No)	Don't Know (Partial)
Refused (Partial)	Refused (Partial)	Refused (Partial)	Refused (Partial)	Refused (Partial)	Refused (Partial)	In more than five years? (No)	Refused (No)	Refused (Partial)	Refused (Partial)	In more than five years? (No)	Refused (Partial)
						Don't Know (Partial)				Don't Know (Partial)	
						Refused (Partial)				Refused (Partial)	

Table 25. Retro-commissioning Program Freeridership Scoring Matrix—Initial Battery

FR0a	FR0b	FR1	FR1a	FR2	FR3	FR4	FR5	FR6	FR7	FR8	FR9	FR Score
Yes	Yes	Yes	x	Yes	Yes	Yes	x	x	x	x	Yes	100%
Yes	Yes	Yes	x	Yes	Yes	Yes	x	x	x	x	Partial	100%
Yes	Yes	Yes	x	Yes	Yes	Yes	x	x	x	x	No	75%
Yes	Yes	Yes	x	Yes	Yes	Partial	x	x	x	x	Yes	75%
Yes	Yes	Yes	x	Yes	Yes	Partial	x	x	x	x	Partial	75%
Yes	Yes	Yes	x	Yes	Yes	Partial	x	x	x	x	No	50%
Yes	Yes	Yes	x	Yes	Yes	No	x	x	x	x	x	0%
Yes	Yes	Yes	x	Yes	Partial	Yes	x	x	x	x	Yes	75%
Yes	Yes	Yes	x	Yes	Partial	Yes	x	x	x	x	Partial	75%
Yes	Yes	Yes	x	Yes	Partial	Yes	x	x	x	x	No	50%
Yes	Yes	Yes	x	Yes	Partial	Partial	x	x	x	x	Yes	50%
Yes	Yes	Yes	x	Yes	Partial	Partial	x	x	x	x	Partial	50%
Yes	Yes	Yes	x	Yes	Partial	Partial	x	x	x	x	No	25%
Yes	Yes	Yes	x	Yes	Partial	No	x	x	x	x	x	0%
Yes	Yes	Yes	x	Yes	No	Yes	x	x	x	x	Yes	50%
Yes	Yes	Yes	x	Yes	No	Yes	x	x	x	x	Partial	50%
Yes	Yes	Yes	x	Yes	No	Yes	x	x	x	x	No	25%
Yes	Yes	Yes	x	Yes	No	Partial	x	x	x	x	Yes	25%
Yes	Yes	Yes	x	Yes	No	Partial	x	x	x	x	Partial	25%
Yes	Yes	Yes	x	Yes	No	Partial	x	x	x	x	No	12.5%
Yes	Yes	Yes	x	Yes	No	No	x	x	x	x	x	0%

Table 26. Retro-commissioning Program Freeridership Scoring Matrix—Confirmatory Battery*

FR0a	FR0b	FR1	FR1a	FR2	FR3	FR4	FR5	FR6	FR7	FR8	FR9	FR Score
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Yes	Yes	Yes	25%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Yes	Yes	Partial	25%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Yes	Yes	No	13%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Yes	Partial	Yes	13%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Yes	Partial	Partial	13%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Yes	Partial	No	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Yes	No	x	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Partial	Yes	Yes	13%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Partial	Yes	Partial	13%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Partial	Yes	No	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Partial	Partial	Yes	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Partial	Partial	Partial	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Partial	Partial	No	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	Partial	No	x	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	No	Yes	Yes	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	No	Yes	Partial	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	No	Yes	No	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	No	Partial	Yes	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	No	Partial	Partial	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	No	Partial	No	0%
Yes	Yes	Partial	No	x	x	x	Yes	Yes	No	No	x	0%

*Cadmus asked this battery if the response to FR1 or FR1a was "No."

Freeridership Results

Table 27 presents freeridership scoring results, along with weighted evaluated savings for all projects. Table 28 shows total weighted average freeridership rates by stratum.

Table 27. Freeridership Results by Project

Participant	Evaluated Energy Savings	Freeridership Score	Reduction to Savings, Based on FR Score (kWh)	Stratum
1	1,094.6	50%	547.3	Census
2	1,017.2	0%	0.0	Census
3	1,271.7	0%	0.0	Census
4	169.4	0%	0.0	I&I Projects
5	344.6	0%	0.0	I&I Projects
6	828.7	13%	103.6	I&I Projects
7	141.4	0%	0.0	I&I Projects
8	617.1	0%	0.0	I&I Projects
9	614.1	0%	0.0	I&I Projects
10	465.5	0%	0.0	I&I Projects
11	204.0	0%	0.0	I&I Projects
12	28.4	25%	7.1	D.I. Projects
13	177.2	13%	22.2	D.I. Projects
14	90.9	0%	0.0	D.I. Projects
15	248.3	75%	186.2	D.I. Projects
16	62.3	13%	7.8	D.I. Projects
17	43.0	75%	32.3	D.I. Projects
18	29.1	25%	7.3	D.I. Projects
19	83.9	0%	0.0	D.I. Projects
20	281.9	0%	0.0	D.I. Projects
21	10.4	0%	0.0	D.I. Projects

Table 28. Weighted Average Freeridership by Stratum

Stratum	Evaluated Energy Savings (kWh)	Freeridership Score	Adjusted Savings (kWh)
Census	3,383.5	16%	2,836.2
Investigation and Implementation	10,508.4	3%	10,186.8
Direction Implementation	1,317.7	25%	989.6

Cadmus applied the weighted average freeridership score for the randomly selected Investigation and Implementation and Direct Implementation projects to total evaluated energy savings for each stratum. This resulted in a 6% freeridership score.

Overall, the RCx Program experienced low freeridership, a finding consistent with expectations, as the pilot program was the first retro-commissioning incentive program in Maine. The program revealed general low awareness among commercial and industrial customers regarding retro-commissioning, but, as the market matures and more market actors in Maine begin to offer retro-

commissioning as a standard business service, the practice may become more commonplace for informed customers. Providing incentives for in-depth engineering analyses, providing new and valuable information to customers about how to improve the efficiency of their building systems, may offer a strategy to maintain low freeridership levels in future years, if the program develops into a full-scale offering.

Appendix B. Marketing Materials (Examples)

CORDJIA

RETRO-COMMISSIONING

Efficiency Maine QUALIFIED PARTNERS

Efficiency Maine Retro-Commissioning Provider and Partner

CEM®

Certified Energy Manager

What is Retro-Commissioning?

Retro-commissioning is a process that seeks to optimize how existing building equipment and systems function together. Depending on the age of the building, retro-commissioning can often resolve problems that occurred during design or construction, or address problems that have developed throughout the building's life. In all, retro-commissioning improves a building's operations and maintenance ("O&M") procedures to enhance overall building performance.

Why is Retro-Commissioning Important?

Buildings frequently undergo operational and occupancy changes that challenge the mechanical, electrical and controls systems, hindering optimal performance. Additionally, in today's complex buildings, systems are highly interactive with sophisticated control systems that can create a trickle-down effect on building operations – small problems have big effects on performance.

Unfortunately, most buildings have never gone through any type of commissioning process, and even well-constructed buildings experience performance degradation over time. No matter how well building operators and service contractors maintain equipment, if it operates inefficiently or more often than needed, energy waste and reliability problems can occur.

What are the Benefits of Retro-Commissioning?

Everyone benefits from retro-commissioning.

The many documented benefits resulting from retro-commissioning include:

- Improved system operation – beyond preventive maintenance
- Improved equipment performance
- Increased O&M staff capabilities and expertise
- Increased asset value
- Energy savings
- Improved occupant comfort
- Improved indoor environmental quality
- Improved building documentation

Cost Savings: Retro-commissioning can produce significant cost savings in existing buildings. Savings vary depending on the building type, its location, and the scope of the retro-commissioning process. Generally, a comprehensive study will deliver an average cost savings of 20% on energy bills.

Efficiency Maine QUALIFIED PARTNERS

Efficiency Maine Retro-Commissioning Provider and Partner

How Does the Retro-Commissioning Process Work?

The retro-commissioning process typically involves two steps:

Step No. 1 – Diagnosis with a Study

- Develop an objective business case for efficiency project approval by Efficiency Maine
- Detail how best to run your current building's mechanical systems at peak efficiency
- Identify energy savings, cost estimates and corresponding rebate amounts for individual energy conservation opportunities
- Identify other considerations for improvement that will require additional design and engineering

Step No. 2 – Implementation

- Optimize your HVAC equipment
- Update lighting controls
- Identify, update or optimize system controls
- Adjust equipment to reduce long-term wear and tear
- Restore economizer operation

How Does Efficiency Maine Help Offset Retro-Commissioning Costs?

Efficiency Maine incentives help offset retro-commissioning costs:

Investigation Phase

- Efficiency Maine will fund 50%, up to $10,000, of the Investigation Phase cost
- The investigation must be completed, and an interim report of findings delivered by September 14, 2012, in order to be eligible for funding

Implementation Phase

- Efficiency Maine will fund 50%, up to $20,000, of the Implementation Phase cost
- Implementation of qualifying measures must be completed by November 1, 2012 in order to be eligible for funding
- For projects with all of the qualifying measures fully implemented prior to October 1, 2012, a bonus incentive representing an additional 25% of the Investigation Phase cost will be awarded

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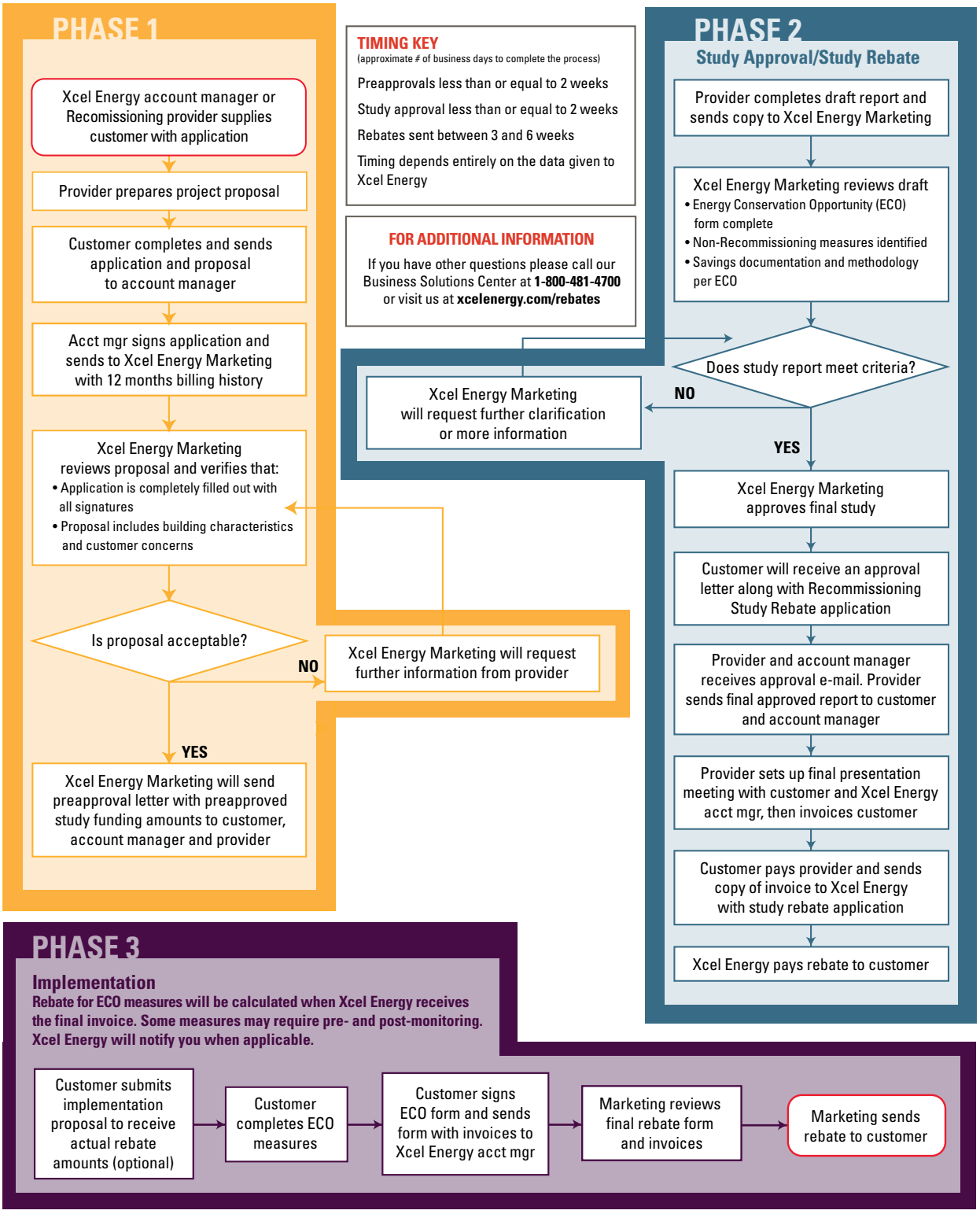
Appendix C. Process Flow Diagrams of Other RCx Programs

INFORMATION SHEET
COLORADO | MINNESOTA

Recommissioning Process

FLOW CHART



Appendix D. Cost-Effectiveness

Table 29 shows the avoided energy costs by year, which were used in the cost-effectiveness test.

Table 29. Avoided Energy Costs

Avoided Energy Costs	2011	2012	2013	2014	2015	2016	2017	2018
Electric Energy, Winter Off Peak ($/kWh)	0.046	0.048	0.051	0.052	0.058	0.058	0.061	0.069
Electric Energy, Winter On Peak ($/kWh)	0.052	0.055	0.057	0.059	0.065	0.067	0.069	0.077
Electric Energy, Summer Off Peak ($/kWh)	0.042	0.046	0.049	0.050	0.056	0.058	0.059	0.067
Electric Energy, Summer On Peak ($/kWh)	0.054	0.060	0.060	0.063	0.069	0.073	0.074	0.083
Electric Demand, Winter ($/KW)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Electric Demand, Summer ($/KW)	52.621	44.593	44.229	39.010	39.790	16.666	25.012	35.625
Transmission and Distribution ($/KW)	80.000	81.600	83.232	84.897	86.595	88.326	90.093	91.895
Natural Gas (MMBTU)	6.950	7.579	7.949	8.479	9.179	9.396	9.561	9.787
Propane (MMBTU)	25.029	24.792	24.536	24.289	24.263	24.707	24.992	26.237
Fuel Oil #2 (MMBTU)	41.280	40.147	39.296	38.787	38.545	38.356	38.368	39.836