# BetterBricks Energy Savings

## *Evaluation Report*

PREPARED BY

**The Cadmus Group, Inc**

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THE CADMUS GROUP, INC.

Final Report

# BetterBricks Energy Savings Evaluation Report

Prepared for:
Northwest Energy Efficiency Alliance
April 24, 2009

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# Executive Summary

The Northwest Energy Efficiency Alliance (NEEA) retained the Cadmus Group (Cadmus) to complete an initial evaluation of the projects and energy savings associated with BetterBricks, NEEA's commercial initiative. BetterBricks is a comprehensive commercial sector energy efficiency initiative designed to stimulate demand for energy efficiency within three vertical markets (Hospitals, Real Estate, and Grocery) and supply of energy efficiency services from two cross-cutting markets (Design and Construction, and Building Operations) which, respectively, focus on new and existing building stock. NEEA's cross-cutting activities also take place in buildings outside the three vertical markets such as schools, universities, and retail businesses.

The primary objective of this effort was to collect and review available data from BetterBricks activities between 2005 and 2008, develop a methodology to estimate those savings, and quantify the energy savings associated with those specific activities using a high level of rigor. A secondary objective was to develop recommendations to improve evaluability of the initiative's energy savings. It is important to note, however, that the estimates in this report do not include energy savings from the broader market impacts of BetterBricks. Future reports will examine this topic in detail.

This report includes findings from both Cadmus' own work as well as validation work from the Heschong Mahone Group (HMG). The total validated savings from the two evaluation efforts amounts to 2.08 aMW of electrical energy savings and 592,217 therms of natural gas savings. In addition, the evaluation contractors identified an additional 0.55 aMW and 97,088 therms of well-documented savings from efficiency measures already in place that are pending further review. Looking forward, evaluation contractors have identified plans and commitments for measures that amount to 5.74 aMW and 1,922,513 therms of additional savings that initiative staff expect to be realized in the next three to five years.

Tables 1 and 2 provide details of energy savings by vertical and cross-cutting markets.

**Table 1. Validated Electric Savings**

| | Hospitals (aMW) | Real Estate (aMW) | Grocery and Other (aMW) | Total (aMW) |
|---|---|---|---|---|
| Design & Construction (evaluated by Cadmus) | 0.66 | 0.40 | 0.30 | 1.36 |
| Design and Construction (evaluated by HMG) | 0 | 0.02 | 0.21 | 0.23 |
| Building Operations (evaluated by Cadmus) | 0.34 | 0.15 | 0 | 0.49 |
| Total: | 0.99 | 0.57 | 0..51 | 2.08 |

**Table 2. Validated Gas Savings**

| | Hospitals (therms) | Real Estate (therms) | Grocery and Other (therms) | Total (therms) |
|---|---|---|---|---|
| Design & Construction (evaluated by Cadmus) | 367,505 | 28,421 | 114,366 | 510,293 |
| Design and Construction (evaluated by HMG) | 0 | 16,447 | 1,729 | 18,176 |
| Building Operations | 47,130 | 16,618 | 0 | 63,748 |
| Total: | 414,635 | 61,486 | 116,095 | 592,216 |

Energy savings from planned efficiency measures and other energy goal/commitments are described in this report on pages 27 to 32.

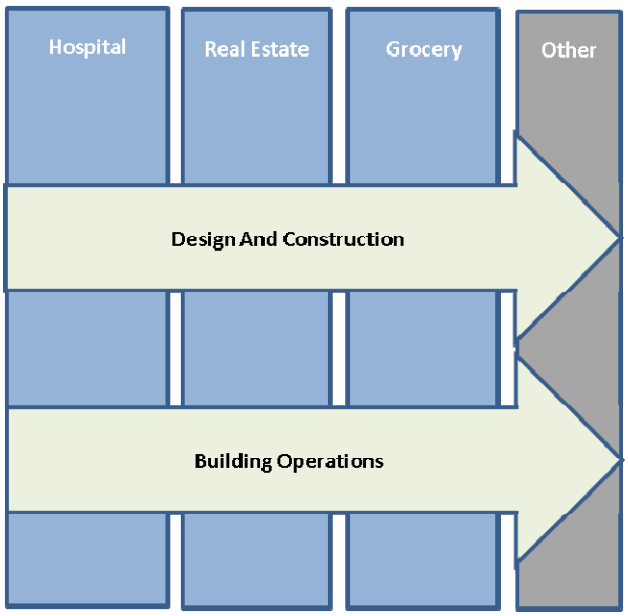
BetterBricks intends for its activities to result in secondary market effects, as market actors among the target audiences become more educated regarding potential energy-efficiency improvements. These stakeholders include architects, engineers, contractors, consultants, building owners, and facilities managers who may choose to implement similar measures in the future, even without direct support from BetterBricks. According to the initiative's theory of market transformation, high-profile BetterBricks projects should also serve as learning tools for a wider pool of stakeholders who do not engage in direct contact with BetterBricks. The effort to quantify these secondary market effects was outside the scope of this study, but will be examined in future reports.

In addition, Cadmus reviewed the evaluability of the BetterBricks project in terms of energy savings. Cadmus was unable to validate more than a small fraction of potential projects due to a lack of data. Comprehensive data collection on BetterBricks projects by Initiative staff combined with consistent follow-up would improve this situation. Furthermore, NEEA support of additional post-occupancy and post-installation evaluation would provide greater reliability in the calculation of realization rates for various projects and measures, which in turn would increase the accuracy of savings estimates for completed and in-process projects.

# 1. Introduction

The Northwest Energy Efficiency Alliance (NEEA) retained the Cadmus Group (Cadmus) to complete an initial evaluation of the projects and energy savings associated with BetterBricks, NEEA's commercial initiative. BetterBricks is a comprehensive commercial sector energy efficiency initiative approach to stimulate demand for energy efficiency within three vertical markets (Hospitals, Real Estate, and Grocery) and building supply of energy efficiency goods and services from two cross-cutting markets (Design and Construction, and Building Operations) which, respectively, focus on new and existing building stock. NEEA's cross-cutting activities also take place in buildings outside the three vertical markets such as schools, universities, and retail businesses (classified as "Other" for the purpose of this study).

**Figure 1. BetterBricks Target Markets Evaluated by Cadmus**




## Target Markets

The BetterBricks initiative provides support to a limited number of vertical and cross cutting markets, impacting each market as described below.

### Vertical Markets

- **Hospitals**: Assists hospitals to develop and implement Strategic Energy Management Plans (SEMP), a structured approach to improve energy efficiency throughout organizations and facilities. The SEMP focuses on best practices to achieve energy efficiency in capital improvements, design and construction, operations and maintenance, and purchasing.

- **Real Estate**: Supports companies in the development and implementation of a high performance portfolio framework, addressing best practices similar to those mentioned above, but within the business context of general office space.

- **Grocery**: Offers grocery store chains support in the development and implementation of energy action plans that primarily address refrigeration and lighting. Best practices, in this context, include benchmarking refrigeration systems, system optimization service and general energy awareness materials for employees.

### Cross Cutting Markets

- **Design and Construction**: Offers a number of tools, resources, advice and assistance to Northwest architects and engineers to assist in the design of energy efficient buildings. The five Integrated Design Labs (IDLs) provide educational and technical support that includes daylighting modeling, as well as support for "whole-building" integrated design. The main delivery method is through the Firm Focus (FF) approach, where program staff work closely with selected architecture firms, influencing their business practices and increasing their technical capabilities to deliver integrated design, specifically in the BetterBricks vertical markets.

- **Building Operations**: Provides technologies and consulting to building operators, in order to improve regional building performance by facilitating the adoption of improved operations and maintenance strategies, both on the demand and supply side of the market. BetterBricks activities towards this goal include (1) technical training and (2) business development support to select mechanical and controls service providers (i.e., the “Firm Focus” approach.) NEEA’s expectation is this will expand the breadth and quality of energy efficiency-focused building operations and maintenance services offered in the Pacific Northwest.

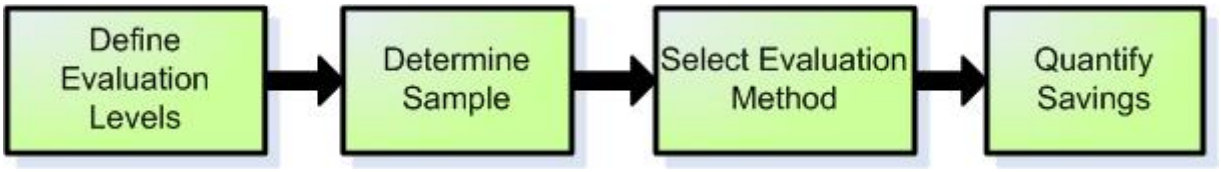
## Study Objectives

The primary objective of this study was to collect and review available data from the initiative activities between 2005 and 2008, and estimate the energy savings associated with those projects. A secondary objective was to develop recommendations to improve evaluability of the initiative’s energy savings impacts.

# 2. Energy Savings Evaluation Methodology

At the beginning of the study, Cadmus met with BetterBricks staff to define the evaluation levels, develop a sampling plan, and select appropriate evaluation methods. The study methodology is outlined in the four stages shown in Figure 2 below.

**Figure 2. Energy Savings Accounting Stages**




## Step 1: Define Evaluation Levels

Cadmus and HMG worked with BetterBricks staff to determine appropriate evaluation levels. The selected evaluation levels are consistent with those used by Cadmus to report savings for NEEA's Industrial Initiative. Cadmus defined the five levels as follows:

- **Validated**: Savings that have been evaluated through a site visit and a review of calculations or a professional assessment. Generally, the evaluation contractor reviews energy savings based on data and calculations provided by the implementation team. In many northwest service territories, NEEA's validation requirements are on par with utility measurement and verification (M&V).

- **Pending**: Savings quantified by the implementation team or end-user but not yet verified or validated by the evaluation contractor due to budget or time constraints.

- **Committed**: Savings the implementation team expects will be achieved within the next two years based on the schedule for construction or measure implementation. Projects are either in progress or have a defined budget allocated by the customer.

- **Planned**: Similar to committed savings above, except that the customer has not allocated a project budget, and the implementation team does not expect the project will be completed within two years.

## Step 2: Determine Sample

**Phase 1: Identify Universe of Potential Projects**

The first phase of the project involved collecting data on potential evaluation sites. These included all buildings contained in NEEA's Commercial Tracking System (CTS), as well as buildings participating in NEEA's Kilowatt Crackdown and HVAC Service Assistant programs. This resulted in an initial sample frame of 588 buildings.

**Table 3. Composition of Sample Frame**

| | Design & Construction | Building Operations | | | |
|---|---|---|---|---|---|
| | All | Hospital | Real Estate | Grocery | Total |
| Buildings from CTS | 359 | 23 | 41 | 0 | 423 |
| Buildings from Kilowatt Crackdown | | | 47 | | 47 |
| Buildings from HVAC Service Assistant | | | 107 | | 107 |
| Buildings from BetterBricks staff, not in CTS | 3 | 4 | 0 | 4 | 11 |
| **TOTAL SAMPLE FRAME** | **362** | **27** | **195** | **4** | **588** |

**Phase 2: Filter Universe to Identify Those With Likely Savings and Sufficient Data**

Once the total sample frame was determined, Cadmus worked with BetterBricks staff and contractors to reduce the number of projects that would be evaluated as follows:

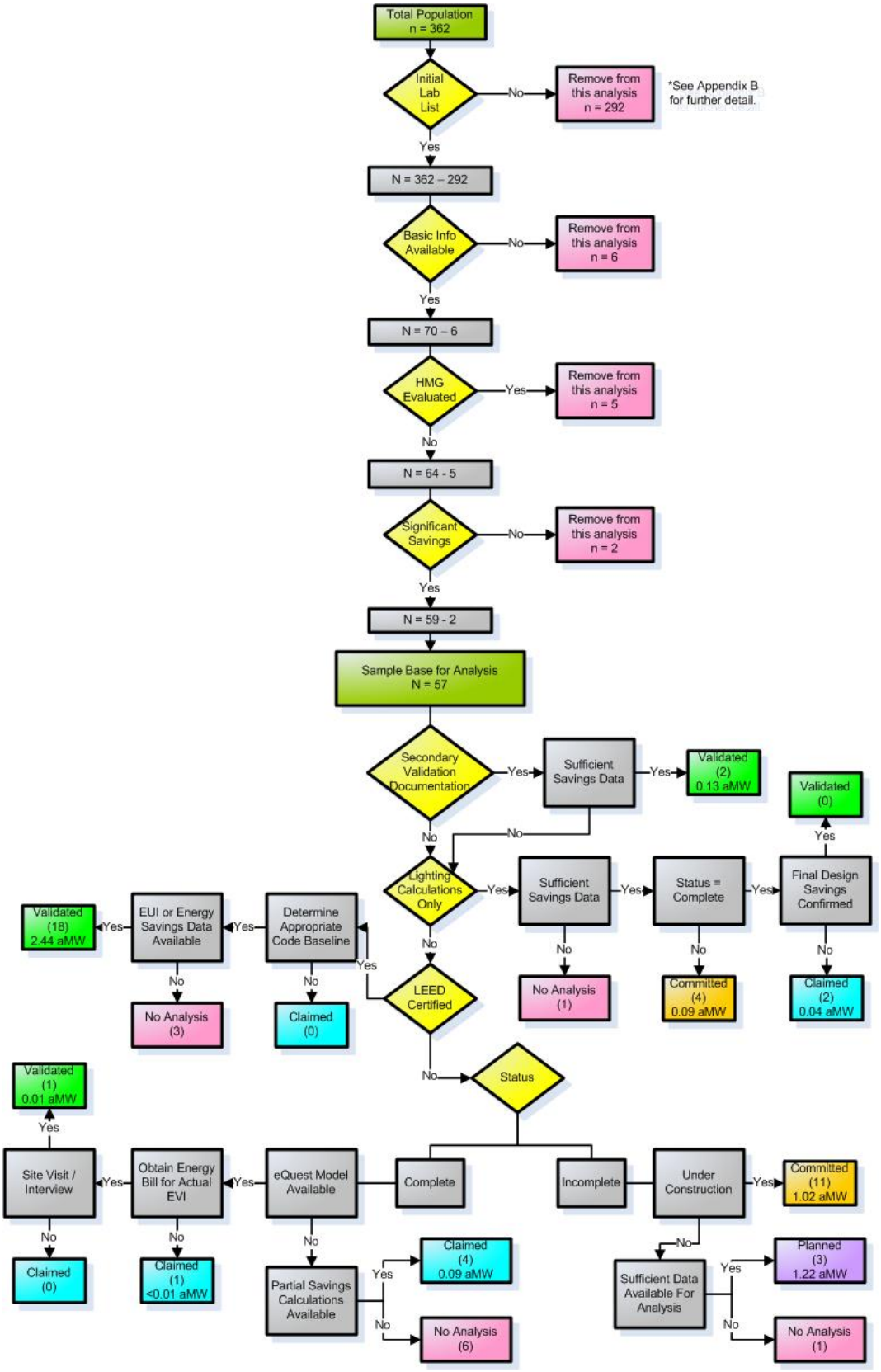
- ***NEEA staff or contractor selection:*** Cadmus coordinated with NEEA staff and contractors to identify design and construction projects that met the following criteria:
  1. Utilize the most comprehensive integrated design
  2. Have the highest savings potential (known actual or estimated).
  3. In the target markets.
  4. Have data available or data are easily obtainable.
  5. High profile (project has received, or will receive, publicity)." – i.e. good documentation.

  This exercise yielded 70 potential projects to evaluate out of the total of 362. This process is explained in greater detail in Appendix B.
- ***Data Sufficiency:*** Some sites chosen for evaluation were subsequently found to have insufficient data for Cadmus or HMG to conduct a savings analysis and were excluded from this analysis.
- ***Redundancy***: One project previously evaluated by the Heschong Mahone Group (HMG) was evaluated separately by Cadmus at the request of NEEA staff, and subsequently excluded to prevent redundancy. The project was a hospital designated WA-15.

NEEA's work with commercial design projects in the Northwest predates all other commercial sector interventions. However, BetterBricks has only recently begun to systematically collect energy savings data. As a result, Design & Construction projects constitute the largest number of both total projects and highest rate of attrition due to lack of sufficient data.

The complexity of Cadmus's decision making process related to our evaluation of the Design & Construction sites is shown below in Figure 3. Further detail about the process is located in Appendix B: BetterBricks Staff Design and Construction Project Selection Methodology. The decision making process for Building Operations projects was somewhat less complex, so no decision tree was developed.

**Figure 3. Design and Construction Decision Tree**



The following tables illustrate the filtering process from the sample frame to the final sample.

**Table 4. Filtering from Sample Frame to Preliminary Sample**

| | Design & Construction | Building Operations | | | |
|---|---|---|---|---|---|
| | All | Hospital | Real Estate | Grocery | Total |
| TOTAL SAMPLE FRAME | **362** | **27** | **195** | **4** | **588** |
| Buildings filtered due to self-selection/missing data | 292 | 9 | 27 | 0 | 328 |
| Preliminary Sample identified by Cadmus, HMG, and NEEA staff/contractors | 70 | 18 | 168 | 4 | 260 |

**Table 5. Filtering from Preliminary Sample to Final Sample**

| | Design & Construction | Building Operations | | | |
|---|---|---|---|---|---|
| | All | Hospital | Real Estate | Grocery | Total |
| Preliminary Sample identified by Cadmus, HMG, and NEEA staff/contractors | 70 | 18 | 168 | 4 | 260 |
| Buildings Cadmus or HMG unable to evaluate | 13 | 4 | 6 | 0 | 23 |
| Final number of buildings evaluated | **57** | **14** | **162** | **4** | **237** |

## Phase 3: Collect Data on Preliminary Sample and Determine Evaluability

After establishing a preliminary sample, Cadmus collected the necessary data to evaluate the selected sites. For the majority of the sites Cadmus collected information from CTS, data provided by NEEA staff and contractors, building energy models, billing data, lighting and engineering calculations, scoping reports, site visits, phone and email interviews with facility staff, Internet data related to each project, and data from architectural and engineering firms.

For each site, Cadmus reviewed the following:

- Type and quality of available data,
- Status of construction and occupancy, and
- Achievement of LEED certification.

Based on information available for the site and project, Cadmus then conducted:

- Analysis of building energy models,
- Site visits,
- Calculation review, or

- A phone or e-mail interview with a knowledgeable source regarding installed measures.

During this process Cadmus found a number of buildings unfit for further analysis and evaluation. Typically these projects had either not incorporated suggestions from IDL into their final design or lacked sufficient data for analysis. Therefore, the final number of buildings Cadmus reviewed was 237.

## Step 3: Select Evaluation Method

## Design and Construction

Evaluation of Design and Construction projects were based on the quality and quantity of available data, and applied one or more of five methods commonly used for evaluating commercial buildings. Specifically, Cadmus employed the following methods for all savings estimates, whether validated, pending, committed or planned:

- Third-party post-occupancy evaluations (n=3)
- Application of a calculated realization rate to LEED-certified projects and new construction(n=34)
- Cadmus post-occupancy evaluation (n=1)
- Review of lighting calculations (n=7)
- Analysis of building energy simulation models (fenestration model) developed by other contractors and IDLs. (n=1)

A brief description of each method follows.

### *Third-Party Post-Occupancy Evaluation*

The first evaluation method involved analysis of savings for three projects with post-occupancy evaluations (POE) performed by either Paladino & Associates, Berkeley Center for Built and Environment or Interface Engineering. These POEs were for Design and Construction projects that achieved LEED-certification. Cadmus reviewed the POE reports to determine if sufficient data had been obtained and the methodology was sound. In all three cases, Cadmus included the revised energy savings from the POEs as validated savings.

### *Calculated Realization Rate*

Energy savings estimates are initially determined by a contractor, engineer, architect, or consultant through engineering calculations and/or building energy simulations. In most, if not all, cases the predicted (or ex-ante) energy savings are different from that actually achieved (ex-post). The difference commonly results from a number of factors, including:

- Value engineering may eliminate measures or key components between the design phase and final construction
- Actual building characteristics may differ from final design
- Commissioning of building equipment may not achieve full operating potential
- Design changes may not be communicated to building modeler
- Occupant use or actual building operation may vary from original expectation

The ratio of the actual to predicted estimates of savings, known as the "savings realization rate" is commonly used in impact evaluations of energy efficiency and conservation programs to gauge their performance. It is standard practice in impact evaluations to calculate a savings realization rate for a sample of participants and apply it to the population of participants to estimate actual savings for a program.

Cadmus used as-designed estimates of savings as a basis for calculating savings realization rate, using the following steps:

1. Obtain the original energy efficient design model and one year of post-occupancy utility bills.

2. Modify the model to reflect as-built design and operating characteristics per available documentation.

3. Calibrate the original design model energy use to the actual, billed energy use by adjusting plug loads and other variables as appropriate.

4. Create a code model by removing energy efficient measures included in the design model and replacing them with the building code or standard practice equivalent, if applicable.

5. Calculate actual energy savings difference between code model (from step #4) and actual energy use.

6. Calculate the realization rate by dividing the actual energy savings by difference between the original design and code models.

Cadmus followed this procedure to calculate the savings at one new construction (not LEED certified) building. However, there were insufficient data to perform this analysis for all buildings because the "as built" information (e.g. actual installation data) was not available. Therefore, Cadmus used four buildings which had undergone POE's using the aforementioned process, to estimate a realization rate for other Design and Construction projects. These realization rates are shown below in Table 6. Further detail can be found in Appendix C: Realization Rate Development.

**Table 6. Realization Rate for Projects with Post-Occupancy Evaluation**

| Project ID | Actual Energy Savings (MBTU) | Modeled Design Energy Savings (MBTU) | Realization Rate |
|---|---|---|---|
| OR-07 | 34,417 | 43,463 | 79% |
| OR-08 | 1,281 | 13,176 | 10% |
| WA-07 | 2,600 | 4,455 | 58% |
| WA-11 | 8,100 | 12,062 | 67% |
| **Total:** | **46,399** | **73,156** | **63%** |

The realization rate observed in the above examples led Cadmus to apply a realization rate to all LEED projects in order to quantify validated energy savings when actual data was not available. Cadmus determined an average realization rate of 63% based on the ratio between the sum of

actual energy savings and modeled design energy savings for the four projects, as shown in Table 6. This average realization rate was applied to all LEED projects to validate savings.

In our judgment, four projects represent a very small a sample for developing program-level savings. To augment this calculation, Cadmus searched other sources to find additional POEs on other BetterBricks projects which had achieved LEED certification. This was unsuccessful, so Cadmus then searched for other secondary data regarding POEs on LEED-certified projects in general, but was unable to find additional information to further inform this rate.

Given the small sample size, additional data from energy-efficient building POEs will be required to develop a more comprehensive realization rate. While the rate of realization Cadmus calculated may be revised as additional data becomes available, it is important to note that the Idaho Integrated Design Lab reported[1] applying a 50% realization rate to expected energy savings for new construction projects. This realization rate was reported[2] as a conservative value based on anecdotal evidence, but is reasonably close to the value derived in this section.

To further augment the process, Cadmus reviewed a number of studies which examined a savings "realization rate" by comparing actual energy savings to that from the initial, uncalibrated code model (which may or may not reflect additional design changes during construction), as listed in Appendix D. However, none of these studies reflected the previously discussed methodology acceptable for determining a net realization rate. The need for post-occupancy evaluations with accurate net realization rates represents a significant opportunity for NEEA to explore the issue and better determine energy savings in the region.

### *Applying the Realization Rate to Calculate Savings*

Once the realization rate for buildings with limited data was established, Cadmus needed to collect sufficient information to calculate energy savings. The information required to determine savings includes:

- Square footage
- Total Building Energy Use Intensity (EUI)
- Establishment of the baseline used in the LEED analysis and point system, which could be either ASHRAE Standard 90.1 or local energy codes.

Cadmus obtained information on total building energy use intensity (EUI), and square footage from the architecture and engineering firms involved in the project. Where Cadmus could not obtain this data from the firms involved in the original project, Cadmus utilized secondary data sources on square footage and savings relative to energy code.

For the purpose of this analysis, the baseline for energy savings is local energy code. However, sometimes LEED certification uses ASHRAE Standard 90.1 as the baseline, and other times the local code. Cadmus found that neither LEED certification documents nor information from the

[1] Integrated Design Lab – University of Idaho 2007 Annual Progress Report, page 8

[2] Email from Kevin Van Den Wymelenberg, Integrated Design Lab – Boise, Director, March 24, 2009

IDLs provided definitive data on whether an energy code or ASHRAE Standard 90.1 was applied as the baseline. Therefore, Cadmus reviewed secondary sources for each project to determine the relevant baseline. Where Cadmus found that ASHRAE Standard 90.1 was the baseline, Cadmus engineers adjusted the savings percentages from those certified by the LEED points to reflect the greater stringency in local codes. In the case where an Internet search did not produce information on the relevant baseline, the baseline was assumed to be the state or local code.[3]

LEED certification requires the adjustment of energy models throughout the design process to reflect any changes. The percentage difference in energy use between code and design determines the amount of energy savings and corresponds to a certain number of points in the LEED system. Cadmus did not have access to these LEED building simulation models and therefore could not examine them for savings and accuracy. Therefore, Cadmus calculated the energy savings using the percentage savings from each project's LEED certification and data supplied to the Integrated Design Labs by architects and engineering firms who performed the building energy modeling. That information included either the building's modeled baseline EUI or modeled energy savings in terms of kilowatt-hours and therms. Cadmus applied the previously calculated realization rate to the LEED project energy savings to determine validated savings.

In addition, Cadmus applied the same realization rate to new and recently occupied buildings that could not have savings validated (meaning they were categorized as pending, committed or planned). For those projects, it was unclear which energy efficiency measures had been implemented or might be included in the final as-built design. This meant Cadmus could apply a conservative estimate of savings via the derived realization rate.

NEEA also requested that energy savings be provided in terms of kilowatt-hours and therms. This information could not be accurately determined for those projects where only EUI data (in kBTU per square foot) was available. NEEA supplied the following conventions to apply to the energy savings[4], as shown in more detail in Appendix D:

- Office buildings: 70% electric, 30% gas
- Hospitals: 40% electric, 60% gas
- Schools: 40% electric, 60% gas

[3] December 8, 2008, e-mail from the University of Washington IDL Director: "We asked what the code base was for the data that they sent us, and I believe in every case they used the state or municipal code as baseline, which as you referenced is a bit more stringent than the appropriate ASHRAE 90.1 per date of project permitting. I'm sure that there is some individual variability there, but generally the question we asked them was, 'What was the code baseline, and what was the as designed baseline?' Without doing a great deal of checking, we have assumed they answered our questions to the best of their ability."

[4] This convention was derived by NEEA staff and contractors from the 2003 *Commercial Buildings Energy Consumption Survey* and *the Baseline Characteristics of 2002 - -2004 Nonresidential Sector*. This derivation is currently under review by NEEA and its evaluation contractors.

### *Cadmus Post-Occupancy Evaluation*

Cadmus conducted a post-occupancy evaluation for one building, ID-03, to verify installation of proposed energy-efficient measures and determine actual operating schedules and building control system settings. The University of Idaho Integrated Design Lab provided code and design eQuest models of the facility. The site visit findings were combined with actual energy use from billing data to modify the proposed design eQuest model to represent the as-built design and operation of the facility. The code model was adjusted to reflect the correct baseline usage, which allowed derivation of the validated energy savings.

### *Lighting Calculations*

Seven buildings had lighting projects with energy savings calculations performed by either the local utility or the University of Oregon Energy Studies in Buildings Laboratory (ESBL). Those calculations were reviewed for sufficient data to achieve savings validation, completion or design status, and amount of savings based on EUI and square footage. Cadmus could not obtain sufficient data from building owners to validate any of these projects. ESBL estimated savings for the project design that assumed all recommended measures would be implemented. As with new construction, Cadmus expected not all measures will be installed as designed. Therefore, Cadmus chose to apply the derived energy savings realization rate noted in previous subsections because a lighting savings realization rate was not available.

### *Fenestration Model Review*

Cadmus performed adjustments to a fenestration model developed by the Montana State University Integrated Design Lab for MT-02. The IDL provided code and design models for MT-02, for which they had conducted a study of energy savings related to various types of windows. Cadmus contacted the project architect to determine which window was actually installed, and also received the specification sheet for that window type. Specifications were entered into the design model to determine the improvement over baseline, which yielded less than 0.01 aMW of savings. Cadmus only reviewed this one fenestration model because the window replacement was the only measure implemented through this project, and no other design and construction project had this specific scope.

## Building Operations

The evaluation of Building Operations projects followed some of the same methods as Design and Construction, although the details are not portrayed in a graphical decision tree.

### *Hospitals*

Hospital projects typically involved the adoption of a strategic energy management plan (SEMP), installation of energy conservation measures, commissioning or retro-commissioning, and HVAC system tune-ups. Cadmus applied the following principle evaluation methods:

- Conduct site visits to confirm measure installation and facility operating hours.

- Review of engineering calculations employed by implementation contractors.
- Analyze scoping reports with projected savings.

### *Real Estate*

Cadmus used two methods to evaluate savings for real estate projects:

- Review of on-line HVAC tune-up data, which was automatically uploaded by the HVAC Service Assistant tool following a site visit by one of the BetterBricks contractors.
- Analysis of scoping reports with projected savings.

## HMG Evaluation Methodology

The Heschong Mahone Group (HMG) previously evaluated elements of the BetterBricks initiative, including samples of Design and Construction, Building Operations, Grocery Store, and Real Estate kW Crackdown projects. HMG later provided the relevant findings to the Cadmus Group, along with methodologies, data, and calculations. Cadmus lacked sufficient time to analyze all the submitted data prior to the completion of this report, but has included many of HMG's findings where appropriate.

In this process, HMG worked with BetterBricks personnel to determine evaluation samples and obtain data. HMG then developed and applied appropriate evaluation methods for four target markets. The methodology was reported to NEEA in four separate memos in December 2008, which are summarized below.

### *Summary of Design and Construction Memo*

For Design and Construction projects, HMG conducted on-site surveys and data collection at fifteen sites to confirm information from CTS and other documentation sources. HMG obtained sufficient data to analyze nine of those fifteen projects. On-site data collection included:

- Equipment and building characteristics
- Interviews with building operators
- Installation of data loggers for end-use metering

HMG collected billing data and, where available, existing energy efficient measure monitoring data. They also obtained the original energy simulation input and output files for both the code and proposed design conditions. HMG then modified the energy simulation models for each project to reflect as-built conditions, and recorded the resulting energy savings. These savings are included under "Pre-2008 Validated Savings."

### Summary of Real Estate Memo

HMG validated energy savings for 47 Real Estate projects as part of the BetterBricks Kilowatt Crackdown program. HMG obtained total site energy use for all the buildings from January 2007 through August 2008, which represents one full year before the Kilowatt Crackdown program and two-thirds of the implementation period. HMG analyzed the energy use data, examined energy use intensity comparisons, and conducted surveys with building managers. Through this effort, HMG was able to validate the difference in annual energy use through August 2008 as a lower bound for energy savings.

### Summary of Building Operations Memo

HMG attempted to evaluate eleven Building Operations projects through billing analysis. They examined electric and natural gas bills, when available, for projects both before and after project implementation, and considered any differences to result from installed measures. HMG reported savings on seven projects. This method of evaluation has limitations, particularly when measure installation occurs at the same time as substantial changes in building size or use. Energy savings less than 10% of total building load are often difficult to discern from the normal ebb and flow of energy use. This is particularly true with hospitals, and HMG reported that all four hospital Building Operations projects could not be analyzed because no quantifiable improvement was observed in billing data or insufficient information was available. Cadmus recommends that NEEA provide funding to examine these projects in further detail to obtain additional information and complete analyses where necessary.

### Summary of Grocery Stores Memo

Grocery Store refrigeration tune-ups were evaluated through billing analysis by examining electric utility bills both before and after project implementation. The resulting consumption differences were considered as energy savings attributed to the installed energy efficient measures. Mechanical service contractors also performed short-term metering to predict energy savings, which was available for two of the four projects. This analysis possesses the same limitations outlined above for Building Operations. In addition, the projects had less than one year of billing data, which Cadmus views as the minimum for a higher degree of accuracy. In mid-2008, HMG sought to offset concerns about the length of monitoring by developing a weather-normalized correction to the data based on projected statewide differences in heating degree days. However, a review of full 2008 weather data for the installation region indicated no correction was actually necessary. Cadmus recommends that NEEA provide funding to examine these projects in further detail to obtain additional billing information and refine analyses where necessary.

# 3. Findings

Cadmus reviewed all projects not only for validated savings, but also for those that met pending, committed, and planned criteria. This section first presents the total current and potential savings, before offering detailed findings for the validated, pending, committed, and planned savings, in that order.

## All Energy Savings

Based on our analysis, this report accounts a total of:

- 2.63 aMW in validated and pending electric savings and 689,147 therms in validated gas savings. (Table 7 and Table 8).
    - 2.08 aMW validated (1.85 aMW validated by Cadmus plus 0.23 aMW validated by HMG).
    - 592,217 therms validated (574,041 validated by Cadmus plus 18,716 therms validated by HMG).
    - 0.55 aMW in pending electric savings
    - 97,388 therms in pending gas savings
- 0.99 aMW in committed electric savings and 224,890 therms in committed gas savings (Table 9 and Table 10).
- 4.74 aMW in planned electric savings and 1,697,623 therms in planned gas savings (Table 9 and Table 10).

The total of 8.36 aMW in electric savings and 2,613,531 therms in gas savings quantifies only the realized savings and conservation opportunity that could be identified to date. These savings do not include broader market effects. Note that totals below reflect the effects of rounding, and therefore may differ slightly from the summation of results presented in tabular form.

## Table 7. Number of Validated and Pending Projects and Electric Savings (in aMW) by Market

| | Evaluation Level | Hospitals | | Real Estate | | Grocery | | Other | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | total projects | aMW | total projects | aMW | total projects | aMW | total projects | aMW | total projects | aMW |
| Design & Construction | Validated (Cadmus) | 2 | 0.66 | 9 | 0.40 | 0 | 0 | 10 | 0.30 | 21 | 1.36 |
| | Validated (HMG) | 0 | 0 | 5 | 0.13 | 2 | 0.02 | 3 | 0.08 | 10 | 0.23 |
| | Pending | 0 | 0 | 3 | 0.06 | 0 | 0 | 4 | 0.04 | 7 | 0.11 |
| Building Operations | Validated | 5 | 0.34 | 154 | 0.15 | 0 | 0 | 0 | 0 | 159 | 0.49 |
| | Pending | 3 | 0.20 | 4 | 0.16 | 4 | 0.07 | 1 | 0 | 12 | 0.44 |
| **Total:** | | **10** | **1.21** | **175** | **0.90** | **6** | **0.09** | **18** | **0.42** | **209** | **2.63** |

Note: Due to rounding, total values may appear to differ from the sum of components

## Table 8. Number of Validated and Pending Projects and Gas Savings (in therms) by Market

| | Evaluation Level | Hospitals | | Real Estate | | Grocery and Other | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | total projects | therms | total projects | therms | total projects | therms | total projects | therms |
| Design & Construction | Validated (Cadmus) | 2 | 367,505 | 9 | 28,421 | 10 | 114,366 | 21 | 510,293 |
| | Validated (HMG) | 0 | 0 | 5 | 16,447 | 5 | 1,729 | 10 | 18,176 |
| | Pending | 0 | 0 | 3 | 3,366 | 4 | 3,677 | 7 | 7,043 |
| Building Operations | Validated | 5 | 47,130 | 154 | 16,618 | 0 | 0 | 159 | 63,748 |
| | Pending | 3 | (9,141) | 4 | 3,192 | 1 | 96,294 | 12 | 90,345 |
| **Total:** | | **10** | **405,494** | **175** | **68,046** | **24** | **216,066** | **209** | **689,607** |

Note: Due to rounding, total values may appear to differ from the sum of components

## Table 9. Number of Committed and Planned Projects and Electric Savings (in aMW) by Market

| | Evaluation Level | Hospitals | | Real Estate | | Grocery | | Other | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | total projects | aMW | total projects | aMW | total projects | aMW | total projects | aMW | total projects | aMW |
| Design & Construction | Committed | 2 | 0.12 | 7 | 0.35 | 1 | 0 | 5 | 0.11 | 15 | 0.58 |
| | Planned | 2 | 0 | 0 | 0.00 | 0 | 0 | 1 | 0.00 | 3 | 0.47 |
| Building Operations | Committed | 2 | 0.41 | 0 | 0.00 | 0 | 0 | 0 | 0 | 2 | 0.41 |
| | Planned | 13 | 4.16 | 5 | 0.12 | 0 | 0 | 0 | 0 | 18 | 4.27 |
| **Total:** | | **19** | **5.16** | **12** | **0.47** | **1** | **0** | **6** | **0.11** | **38** | **5.74** |

Note: Due to rounding, total values may appear different from the sum of components

**Table 10. Number of Committed and Planned Projects and Gas Savings (in therms) by Market**

| | Evaluation Level | Hospitals | | Real Estate | | Grocery | | Other | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | total projects | therms | total projects | therms | total projects | therms | total projects | therms | total projects | therms |
| Design & Construction | Committed | 2 | 53,763 | 7 | 44,338 | 1 | 4,113 | 5 | 47,447 | 15 | 149,660 |
| | Planned | 2 | 211,302 | 0 | 0 | 0 | 0 | 1 | 1,425 | 3 | 212,727 |
| Building Operations | Committed | 2 | 75,230 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 75,230 |
| | Planned | 13 | 1,472,771 | 5 | 12,125 | 0 | 0 | 0 | 0 | 18 | 1,484,896 |
| **Total:** | | **19** | **1,813,066** | **12** | **56,463** | **1** | **4,113** | **6** | **48,872** | **38** | **1,922,513** |

Note: Due to rounding, total values may appear different from the sum of components

# Validated Energy Savings

Validated energy savings represent those confirmed with a site visit, a calculation review, and/or a professional savings assessment. For the BetterBricks study, Cadmus validated savings of 1.85 aMW in electric savings and 574,041 in gas savings.

## Design and Construction

### *Design and Construction Validated Savings*

Cadmus calculated energy savings for the majority of validated Design and Construction projects by applying a realization rate, as discussed in the previous chapter and Appendix C: Realization Rate Development. Cadmus applied the average realization rate of 63 % to 17 of the 21 projects, summarized in the table below. Cadmus used POE data to validate savings for the other four projects. Design and Construction projects accounted for validated annual electric savings of 1.36 aMW and 510,293 therms of gas savings, as shown in Table 11. Under the "Source of Savings" column, the LEED percentage refers to design energy savings above the relevant state or local building energy code. More detailed information is available in Table 25 in Appendix D:

**Table 11. Validated Energy Savings for Design and Construction Projects**

| Project ID[5] | Source of Savings (% Above Code) | Total Realized Electric Savings (aMW) | Total Realized Gas Savings (therms) |
|---|---|---|---|
| ID-01 | LEED (35%) | 0.001 | 960 |
| ID-02 | LEED (45%) | 0.07 | 8,866 |
| ID-03 | Cadmus POE | 0.00 | 3,450 |
| OR-01 | LEED (40%) | 0.09 | 12,071 |
| OR-02 | LEED (39%) | 0.04 | 18,031 |
| OR-03 | LEED (30%) | 0.01 | 1,744 |
| OR-04 | LEED (30%) | 0.02 | 10,266 |
| OR-05 | LEED (45%) | 0.13 | 56,953 |
| OR-06 | LEED (28%) | 0.03 | 4,082 |
| OR-07 | Secondary POE | 0.64 | 359,819 |
| OR-08 | Secondary POE | 0.02 | 7,686 |
| WA-01 | LEED (26%) | 0.04 | 5,322 |
| WA-02 | LEED (42%) | 0.003 | 1,376 |
| WA-03 | LEED (45%) | 0.001 | 72 |
| WA-04 | LEED (38%) | 0.01 | 5,443 |
| WA-05 | LEED (18%) | 0.02 | 3,190 |
| WA-06 | LEED (10%) | 0.03 | 4,355 |
| WA-07 | Secondary POE | 0.12 | (8,400) |
| WA-08 | LEED (27%) | 0.02 | 9,318 |
| WA-09 | LEED (36%) | 0.005 | 586 |
| WA-10 | LEED (43%) | 0.04 | 5,103 |
| **Total:** | | **1.36** | **510,293** |

# Building Operations

## *Hospitals*

Cadmus validated energy savings for six BetterBricks hospital projects. The resulting validated annual electric savings are 0.34 aMW and annual gas savings equal 47,130 therms, as shown in Table 12. More detail on the specific energy savings can be found in Table 26 in Appendix D: For the most part, the validated measures involved the installation of energy conservation measures (ECMs) as capital projects undertaken as part of the Strategic Energy Management Plan. Retro-commissioning or tune-up projects were implemented at two sites. Cadmus validated most sites through site visits that verified measure implementation and recorded relevant operating parameters. This site visit data enabled us to develop or verify energy savings calculations.

[5] Project codes represent the state where the building is or will be constructed, along with a numeric identifier.

Cadmus employed a different validation method for OR-09. In that case, the Market Specialist provided calculations to Cadmus from the facility and installation contractor. Cadmus validated these calculations through an e-mail interview.

**Table 12. Validated Energy Savings for Hospitals**

| Project ID | Source of Savings | Total Realized Electric Savings (aMW) | Total Realized Gas Savings (therms) |
|---|---|---|---|
| OR-09 | Capital Projects (ECMs) | 0.07 | 25,150 |
| OR-10 | Capital Projects (ECMs) | 0.05 | 5,525 |
| OR-11 | Capital Projects (ECMs) | 0.02 | 0 |
| OR-12 | Capital Projects (ECMs) | 0.05 | 16,455 |
| ID-07 | Capital Projects (ECMs) / Retro-Commissioning | 0.16 | 0 |
| **Total:** | | **0.34** | **47,130** |

Note: Due to rounding, total values may appear different from the sum of components

## *Real Estate - HVAC Service Assistant*

The HVAC Service Assistant by Field Diagnostic Services, Inc. identified energy savings opportunities and documented improvements for rooftop commercial HVAC units. BetterBricks provided support to train three service contractors. Data from 107 sites were recorded by the Service Assistant tool and automatically uploaded to the Internet. The resulting validated annual electric savings equal 0.02 aMW, as shown in Table 13. Each Project ID may represent multiple sites for each client. More detail on the specific energy savings can be found in Table 27 in Appendix D:

**Table 13. Validated Energy Savings for HVAC Service Assistant Projects**

| Project ID | Total Realized Electric Savings (aMW) |
|---|---|
| FDSI-01 | 0.004 |
| FDSI-02 | 0.002 |
| Miscellaneous | <0.001 |
| FDSI-03 | 0.002 |
| FDSI-04 | 0.001 |
| FDSI-05 | <0.001 |
| Miscellaneous | 0.000 |
| FDSI-06 | 0.001 |
| FDSI-01 | 0.006 |
| **Total:** | **0.02** |

Note: Due to rounding, total values may appear different from the sum of components

The results represent a large number of diagnostic checks and minor improvements to HVAC systems during the first summer of this tool's implementation. Increased savings are expected to be achieved during summer 2009 by following up on these initial results.

## *Real Estate – Kilowatt Crackdown*

HMG evaluated energy savings for 47 real estate projects through the Kilowatt Crackdown program. This program was implemented jointly by NEEA and the Building Owners and Managers Association (BOMA) of Seattle, and represented a contest for energy efficiency achievements among office buildings run by BOMA members.

HMG obtained total site energy use for all the buildings from January 2007 through August 2008, which represents one full year before the Kilowatt Crackdown program and two-thirds of the implementation period. HMG analyzed the energy use data, examined energy use intensity comparisons, and conducted surveys with building managers. Through this effort, HMG was able to validate the difference in annual energy use through August 2008 as a lower bound for energy savings. The lower bound of savings represent 0.13 aMW in electric savings and 16,618 therms in gas savings.

### *Grocery Stores*

No completed projects were available for evaluation under this category.

## Savings Validated by HMG

Prior to 2008, HMG evaluated 15 sites to determine Design and Construction savings and obtained data through data logging, billing analysis, and existing metering on energy efficient measures. Using this data, HMG either modified existing building energy simulation models or developed new ones. HMG reported validated savings for nine of the 15 sites. The resulting electric savings are 0.23 aMW with 19,589 therms in gas savings, as shown in Table 14. More detail on the specific energy savings can be found in Table 28 in Appendix D:.

**Table 14. Pre-2008 Validated Savings for Design and Construction Projects**

| Project ID | Total Realized Electric Savings (aMW) | Total Realized Gas Savings (therms) |
|---|---|---|
| HMG-WA-01 | 0.02 | 4,203 |
| HMG-OR-01 | 0.07 | (8,698) |
| HMG-OR-02 | 0.01 | 6,224 |
| HMG-ID-01 | 0.001 | 0 |
| HMG-WA-02 | 0.08 | 5,116 |
| HMG-ID-02 | 0.04 | 12,082 |
| HMG-ID-03 | 0.004 | (414) |
| HMG-ID-04 | 0.001 | 0 |
| HMG-ID-05 | 0.00 | 1,076 |
| **Total:** | **0.23** | **19,589** |

Note: Due to rounding, total values may appear different from the sum of components

## Pending Energy Savings

Pending energy savings are those quantified by the implementation team, which could not be validated. These savings involved primarily Hospitals and Design and Construction projects, resulting in 0.26 aMW of electric savings and 15,202 therms of gas savings.

Cadmus noted areas in which further analysis could potentially improve the accuracy of energy savings on projects previously evaluated by HMG. These include projects for Building Operations and Grocery refrigeration tune-ups. The additional information and analysis necessary to perform additional evaluation of these projects was outside the scope of this study. Cadmus categorized these HMG results as “pending” until further evaluation can be performed.

The pending electric savings from HMG projects is equivalent to 0.28 aMW, with gas savings of 82,186 therms.

## Cadmus Design and Construction

Pending energy savings for the Cadmus Design and Construction accounting resulted in electric savings of 0.11 aMW and 7,043 therms in gas savings. The energy savings data is detailed in Table 15 for these 7 projects. More detail on the specific energy savings can be found in Table 28 in Appendix D:.

**Table 15. Pending Energy Savings for Design and Construction Projects**

| Project ID | Source of Savings | Total Projected Electric Savings (aMW) | Total Projected Gas Savings (therms) |
|---|---|---|---|
| ID-05 | Model | 0.03 | 18 |
| ID-06 | Model | 0.001 | 0 |
| MT-01 | Lighting Calculations | 0.04 | 0 |
| MT-02 | Fenestration Model | <0.001 | 40 |
| OR-13 | Model | 0.01 | 3,659 |
| WA-12 | Model | 0.03 | 3,326 |
| WA-13 | Lighting Calculations | 0.002 | 0 |
| **Total:** | | **0.11** | **7,043** |

Note: Due to rounding, total values may appear different from the sum of components

Four projects involved new construction and have only recently been occupied. These buildings are still in the process of commissioning systems and installing significant measures. Cadmus applied the LEED realization rate derived in the Energy Savings Accounting Methodology section to these LEED-registered projects, which Cadmus expect to achieve certification.

Two buildings possessed lighting calculations for installed projects. However, Cadmus could not get confirmation of installation details from either the facilities manager at MT-01 or the architect for WA-13. The calculations for MT-01 were performed through the local electric utility, and included sufficient detail for fixtures and operating hours that a realization rate was deemed unnecessary. The calculations for WA-13 only included design EUI information, not final installation details. Due to the uncertainty regarding final installation, Cadmus applied a realization rate equal to the 63% LEED realization rate.

## Cadmus Building Operations

### *Hospital*

Two hospitals reported energy savings for implemented measures that could not be validated by Cadmus. The savings resulted from installation of ECM capital projects and HVAC tune-ups, as shown in Table 16. Facility or installation contractors reported savings to the relevant Market Specialist, but Cadmus could not obtain calculations or sufficient data to validate those savings. These pending savings are 0.15 aMW in electric savings and 8,159 therms. More detail on the specific energy savings can be found in Table 30 in Appendix D:.

**Table 16. Pending Energy Savings for Hospitals**

| Project ID | Source of Savings | Total Projected Electric Savings (aMW) | Total Projected Gas Savings (therms) |
|---|---|---|---|
| ID-07 | Capital Projects (ECMs) | 0.09 | 0 |
| WA-15 | Capitals Projects (ECMs) / Tune-Ups | 0.07 | 8,159 |
| **Total:** | | **0.15** | **8,159** |

Note: Due to rounding, total values may appear different from the sum of components

### *Real Estate*

No completed projects were available for evaluation under this category.

### *Grocery Stores*

No completed projects were available for evaluation under this category.

## HMG Pending Savings

HMG submitted four memos to NEEA in December 2008 that detailed preliminary evaluation results for Design and Construction, Building Operations, Grocery Stores, and Kilowatt Crackdown. NEEA provided the memos to Cadmus so results could be incorporated into the BetterBricks energy savings accounting. Cadmus reviewed HMG's methodology for each program and analyzed the resulting data. The savings from the Kilowatt Crackdown are included under the Validated Building Operations category of this study. HMG's evaluation of Design and Construction savings is included under the "Savings Validated by HMG" section. Cadmus noted areas in which further analysis could potentially improve the accuracy of energy savings on Building Operations and Grocery refrigeration tune-up projects previously evaluated by HMG. The additional information and analysis necessary to perform additional evaluation of these projects was outside the scope of this study.

### *Building Operations*

#### *Real Estate and Hospitals*

HMG attempted to perform billing analyses on eleven Building Operations projects in the Real Estate and Hospitals vertical. HMG reported savings on seven projects. This method of evaluation has limitations, particularly when measure installation occurs at the same time as substantial changes in building size or use. Energy savings less than 10% of total building load are often difficult to discern from the normal ebb and flow of energy use. This is particularly true with hospitals, and HMG reported that all four hospital Building Operations projects could not be analyzed because no quantifiable improvement was observed in billing data or insufficient information was available.

Of the projects analyzed by HMG, Cadmus had conducted a site visit at one hospital project, WA-15. That project was therefore excluded from this accounting to prevent double counting, particularly since HMG noted they were unable to complete their analysis on this project. The resulting savings for the remaining projects which HMG could evaluate are 0.21 aMW in electric

savings and 82,186 therms, as shown in Table 17. More detail on the specific energy savings can be found in Table 31 in Appendix D:. Cadmus recommends that NEEA provide funding to examine these projects in further detail to obtain additional information and complete analyses where necessary.

**Table 17. HMG Pending Savings for Building Operations Projects**

| Project ID | Total Realized Electric Savings (aMW) | Total Realized Gas Savings (therms) |
|---|---|---|
| HMG-OR-03 | 0 | 96,294 |
| HMG-OR-04 | 0.05 | (17,300) |
| HMG-WA-03 | 0.02 | (1,102) |
| HMG-WA-04 | 0.02 | 0 |
| HMG-WA-05 | 0.01 | 4,294 |
| HMG-WA-07 | 0.11 | 0 |
| **Total:** | **0.21** | **82,186** |

Note: Due to rounding, total values may appear different from the sum of components

### *Grocery Stores*

HMG performed billing analyses on four refrigeration tune-up projects in the Grocery Store vertical market. This analysis possesses the same limitations outlined above for Building Operations. In addition, the projects varied in the amount of post-installation billing data available, including three months for two projects, seven months for another, and more than one year for a fourth project. At least one year of post-installation data is recommended for a higher degree of accuracy. In mid-2008, HMG sought to offset concerns about the length of monitoring by developing a weather-normalized correction to the data based on projected statewide differences in heating degree days. However, a review of full 2008 weather data for the installation region indicated no correction was actually necessary. The electric savings are 0.07 aMW, as shown in Table 18. More detail on the energy savings can be found in Table 32 in Appendix D:. Cadmus recommends that NEEA provide funding to examine these projects in further detail to obtain additional billing information and refine analyses where necessary.

**Table 18. HMG Pending Savings for Grocery Stores**

| Project ID | Total Realized Electric Savings (aMW) |
|---|---|
| HMG-OR-04 | 0.04 |
| HMG-OR-05 | 0.01 |
| HMG-OR-06 | 0.01 |
| HMG-WA-06 | 0.01 |
| **Total:** | **0.07** |

Note: Due to rounding, total values may appear different from the sum of components

## Committed Energy Savings

Committed energy savings involve projects to be implemented within the near future, usually in the next two years. These projects are either in the construction or final design process, or have a

defined budget allocation. Cadmus found 17 Design and Construction and Hospital projects with committed energy savings, which should result in electric savings of 0.99 aMW and gas savings of 224,890 therms.

## Design and Construction

Committed energy savings for Design and Construction generally involved projects under construction with available projected savings data, as shown in Table 19. Resulting electric savings are estimated to be 0.58 aMW with 149,660 therms in gas savings, estimated generally by applying a realization rate. More detail on the specific energy savings can be found in Table 33 in Appendix D:

Projects with committed savings were evaluated similarly to those described in previous subsections, particularly buildings evaluated using building energy model data. Cadmus also analyzed several incomplete projects that employ lighting calculations developed by the University of Oregon ESBL. Most of these projects are not expected to achieve their full projected savings, as outlined in the Energy Savings Accounting Methodology section. Therefore, Cadmus applied the 63% realization rate derived in the Validated Savings subsection to all the projects, except two from Montana. Those two projects possessed comprehensive data and were further along in progress; Cadmus determined full savings were likely to be achieved.

**Table 19. Committed Energy Savings for Design and Construction Projects**

| Project ID | Source of Savings | Total Projected Electric Savings (aMW) | Total Projected Gas Savings (therms) |
|---|---|---|---|
| MT-03 | Model | 0.001 | 329 |
| MT-04 | Lighting calculations | 0.01 | 0 |
| OR-14 | Lighting calculations | 0.01 | 6,116 |
| OR-15 | Lighting calculations | 0.01 | 2,635 |
| OR-16 | Model | 0.001 | 4,113 |
| OR-17 | Model | 0.04 | 19,278 |
| OR-18 | Lighting calculations | 0.01 | 5,821 |
| WA-14 | Model | 0.03 | 3,682 |
| WA-16 | Model | 0.04 | 17,380 |
| WA-17 | Model | 0.03 | 13,597 |
| WA-18 | Model | 0.02 | 2,268 |
| WA-19 | Model | 0.21 | 26,847 |
| WA-20 | Model | 0.01 | 1,005 |
| WA-21 | Model | 0.08 | 36,383 |
| WA-22 | Model | 0.08 | 10,206 |
| **Total:** | | **0.58** | **149,660** |

Note: Due to rounding, total values may appear different from the sum of components

## Building Operations

### *Hospital*

For Hospitals, two facilities had energy savings for budgeted projects. Savings will result from installation of ECM capital projects and HVAC commissioning, as shown in Table 20. More detail on the specific energy savings can be found in Table 34 in Appendix D:. Cadmus reviewed the savings estimates, which appear reasonable. The committed projects should result in electric savings of 0.41 aMW and gas savings of 75,230 therms. Cadmus lacked sufficient data to determine whether it would be appropriate to apply a realization rate to these committed estimates or what that rate would be. Cadmus chose not to apply a realization rate at this time.

**Table 20. Committed Energy Savings for Hospitals**

| Project ID | Source of Savings | Total Projected Electric Savings (aMW) | Total Projected Gas Savings (therms) |
|---|---|---|---|
| WA-15 | East Tower Commissioning | 0.35 | 0 |
| OR-12 | Capital Projects (ECMs) | 0.06 | 75,230 |
| **Total:** | | **0.41** | **75,230** |

Note: Due to rounding, total values may appear different from the sum of components

### *Real Estate*

No completed projects were available for evaluation under this category.

### *Grocery Stores*

No completed projects were available for evaluation under this category.

# Planned Energy Savings

Planned energy savings involve projects expected to be implemented over a longer time frame, typically more than two years. These projects usually have a defined plan associated with them, often a final design or measure implementation strategy, but no specific budget allocation. The Design and Construction cross-cutting market had projects with sufficient data to evaluate for planned energy savings, as well as the Hospital and Real Estate vertical markets. Planned electric savings are expected to total 4.75 aMW with gas savings of 1,697,623 therms.

## Design and Construction

The Design and Construction sample base for evaluation included several projects early in their conceptual design phases, as shown in Table 21, which were evaluated under the Planned category. More detail on the specific energy savings can be found in Table 35 in Appendix D:.

Cadmus does not expect that most of these projects will achieve their full projected savings, as outlined in the Energy Savings Accounting Methodology section. Therefore, Cadmus applied the 63% realization rate derived in the Validated Savings subsection to all the projects. These projects should result in annual electric savings of 0.47 aMW and gas savings of 212,727 therms.

**Table 21. Planned Energy Savings for Design and Construction Projects**

| Project ID | Source of Savings | Total Projected Electric Savings (aMW) | Total Projected Gas Savings (therms) |
|---|---|---|---|
| ID-08 | Model | 0.33 | 147,042 |
| WA-23 | Lighting Calculations | 0.003 | 1,425 |
| WA-24 | Model | 0.14 | 64,260 |
| **Total:** | | **0.47** | **212,727** |

Note: Due to rounding, total values may appear different from the sum of components

# Building Operations

## *Hospital*

For Hospital projects, Cadmus identified 13 existing facilities with significant potential energy savings through scoping reports. The savings will result from installation of ECM capital projects, HVAC commissioning or retro-commissioning, and operations and maintenance improvements, and are shown in Table 22. More detail on the specific energy savings can be found in Table 36 in Appendix D:. Cadmus reviewed the savings estimates in various scoping reports and studies and concluded the projects to have a reasonable payback. Projects resulting from Hospitals could result in electric savings equal to 4.16 aMW and gas savings of 1,472,771 therms.

Cadmus lacked sufficient data to determine whether it would be appropriate to apply a realization rate to these committed estimates or what that rate would be. Because of this, Cadmus chose not to apply a realization rate at this time. Additionally, much of the proposed savings may involve measures or processes that impact the same end use. The resulting measure interaction will further reduce potential savings. For example, a new boiler can be specified that would produce a certain percentage of energy savings to the hospital's hot water end use. Additional measures, such as pipe insulation, might also have savings estimates, but the final energy savings will not be additive among all measures applied to each end use. In the future, it might be possible to further analyze the projected savings reports for each hospital and provide a rough estimate of reduced savings due to measure interaction, but that falls outside the scope of this evaluation.

**Table 22. Planned Energy Savings for Hospitals**

| Project ID | Source of Savings | Total Projected Electric Savings (aMW) | Total Projected Gas Savings (therms) |
|---|---|---|---|
| MT-05 | Capital Projects (ECMs) | 0.30 | 191,250 |
| | O&M/Tune-up | 0.20 | 127,500 |
| MT-06 | Capital Projects (ECMs) | 0.13 | 38,150 |
| | O&M/Tune-up | 0.07 | 21,800 |
| | Retro-Commissioning | 0.40 | 103,100 |

| | | | |
|---|---|---|---|
| OR-10 | O&M/Tune-Up | 0.14 | 24,800 |
| | Retro-Commissioning | 0.21 | 37,200 |
| OR-19 | Capital Projects (ECMs) | 0.21 | 96,306 |
| | O&M/Tune-Up | 0.19 | 34,720 |
| | Retro-Commissioning | 0.20 | 90,642 |
| OR-12 | Capital Projects (ECMs) | 0.03 | 0 |
| OR-11 | Capital Projects (ECMs) | 0.01 | 0 |
| OR-09 | Capital Projects (ECMs) | 0.03 | 0 |
| WA-15 | Capital Projects (ECMs) | 0.03 | (398) |
| ID-09 | Capital Projects (ECMs) | 0.57 | 241,900 |
| | Commissioning / Retro-Commissioning | 0.21 | 180,500 |
| ID-04 | Lighting | 0.06 | (7,167) |
| | O&M / Retro-Commissioning | 0.16 | 140,347 |
| WA-27 | O&M/Tune-up | 0.77 | 65,029 |
| WA-26 | O&M/Tune-up | 0.18 | 10,344 |
| WA-25 | O&M/Tune-up | 0.04 | 76,748 |
| **Total:** | | **4.16** | **1,472,771** |

Note: Due to rounding, total values may appear different from the sum of components

## Real Estate

For the Real Estate market, Cadmus identified five buildings with potential energy savings through Building Operations scoping reports. Savings will result from HVAC commissioning or retro-commissioning, as well as operations and maintenance improvements. Energy-saving projections are shown in Table 23. More detail on the specific energy savings can be found in Table 37 in Appendix D:. Cadmus reviewed the savings estimates in the various scoping reports and studies, which appeared to have appropriate payback periods. The planned projects should result in electric savings of 0.12 aMW with 12,125 therms in gas savings.

**Table 23. Planned Energy Savings for Real Estate Projects**

| Project ID | Source of Savings | Total Projected Electric Savings (aMW) | Total Projected Gas Savings (therms) |
|---|---|---|---|
| ID-10 | O&M / Tune-up | 0.01 | 375 |
| ID-11 | O&M / Tune-up | 0.01 | 0 |
| WA-28 | O&M / Tune-up | 0.02 | 11,750 |
| WA-29 | O&M / Tune-up | 0.01 | 0 |
| WA-30 | O&M / Tune-up | 0.07 | 0 |
| **Total:** | | **0.12** | **12,125** |

Note: Due to rounding, total values may appear different from the sum of components

## Grocery Stores

Cadmus could not account for planned energy savings for any grocery store projects under the Building Operations cross cutting market because no buildings with planned savings were evaluated under this category.

# 4. Conclusions and Recommendations

Based on the available data, Cadmus was able to validate 1.85 aMW in electric savings and 574,041 therms associated with NEEA's Better Bricks initiative as of December 2008. HMG validated 0.23 aMW in electric savings and 19,589 therms in gas savings prior to 2008. Another 0.55 aMW in electric savings and 97,388 therms in gas savings are expected based on documentation for which validation is pending. End users, particularly hospitals, have goals and projects in development expected to achieve an additional 5.74 aMW in electric savings and 1,922,513 therms in gas savings.

## Data Collection and Quality

Cadmus found that only a small portion of projects in the CTS database included energy savings and measure data. Types of data that were frequently missing from CTS include measure information, baseline and design EUIs, square footage information, scoping reports, contact information, and sometimes entire projects. As a result, Cadmus was only able to evaluate a limited number of projects associated with BetterBricks activites. The savings cited in this study likely represent a small fraction of the total savings that could be linked to the BetterBricks initiative.

## Recommendations for Future Study

Cadmus found several areas requiring additional study that could strengthen the BetterBricks program and reporting of savings. These include:

- **Development of a realization rate for Hospitals**: Hospitals represent a large portion of projected BetterBricks energy savings. Most of these projected savings rely on implementation of recommendations from scoping reports. Cadmus notes that those recommendations either may not be implemented or partially implemented, and therefore the full projected savings may not be achieved. BetterBricks may want to determine a realization rate based on the energy savings implemented compared to the amount projected in scoping reports.

- **Creation of a methodology to determine savings for Hospitals resulting from changes in purchasing decisions**: Cadmus noted that there was no methodology available to adequately capture savings based on future purchasing decisions, such as a policy to only purchase Energy Star equipment. These savings could substantially impact the Buildings Operations savings rate in the future.

- **Improving the realization rate for LEED Projects**: Cadmus estimated a realization rate for LEED and new construction projects based on two post-occupancy evaluations (POE), which indicated that 63% of the projected savings were achieved. The availability of publicly-available POE data is very limited, but obtaining further data would improve the confidence of realization rates calculated for LEED projects. Currently LEED for

New Construction relies on modeling data to estimate energy savings, and no publicly-available studies have been undertaken to evaluate the actual realization rate of a large number of projects. Appendix E: provides more information on related studies of new construction project savings.

- **Post-Occupancy Evaluations**: POE data are a valuable tool for building owners to continuously improve system operation. For example, the project identified as OR-08 received a LEED rating based on 26% modeled savings over code and was projected to have an EPA Portfolio Manager score greater than 75. The building owner commissioned a POE which indicated actual savings only 3% above code and a Portfolio Manager score of 25. The POE data provided sufficient feedback on building system issues that the owner was able to improve operations and increase the Portfolio Manager score to 39, as of November 2008. The owner's representative projected continued improvement in the future.

- **Secondary Market Effects**: BetterBricks support will most likely result in secondary market effects as practitioners become more educated regarding potential energy efficiency improvements. These practitioners include architects, engineers, contractors, consultants, building owners, and facilities managers who may choose to implement similar measures in the future, even without direct support from BetterBricks. A number of high-profile BetterBricks projects also serve as learning tools for a wider pool of stakeholders who do not engage in direct contact with BetterBricks. Efforts could be made in the future to quantify these secondary market effects.

- **Attribution**: Due to time and budget considerations, Cadmus did not engage in the complex process of determining proper attribution of energy savings, particularly in Design and Construction projects. The design and construction process involves architects, engineers, consultants, and contractors who could potentially provide elements of their previous energy efficiency design experience. Therefore, it's possible that BetterBricks support is not directly responsible for all energy savings in these projects, although the secondary market effects cited previously could impact decision-making. Building owners and facilities managers for projects in the Building Operations markets may also have previous experience with energy efficiency measures that they would choose to install even without BetterBricks support.

## Recommendations for the Current Program

Cadmus offers the following recommendations:

1. **Improve data quality**: Two items were observed in need of additional attention to detail by NEEA staff and contractors: detailed completion of data collection requirements as outlined in the CTS database, and consistent follow up to record project implementation and as-built details.

2. **Develop refined methodology for capturing Hospitals savings**: As Hospitals savings account for much of BetterBricks savings, Cadmus recommends refining the

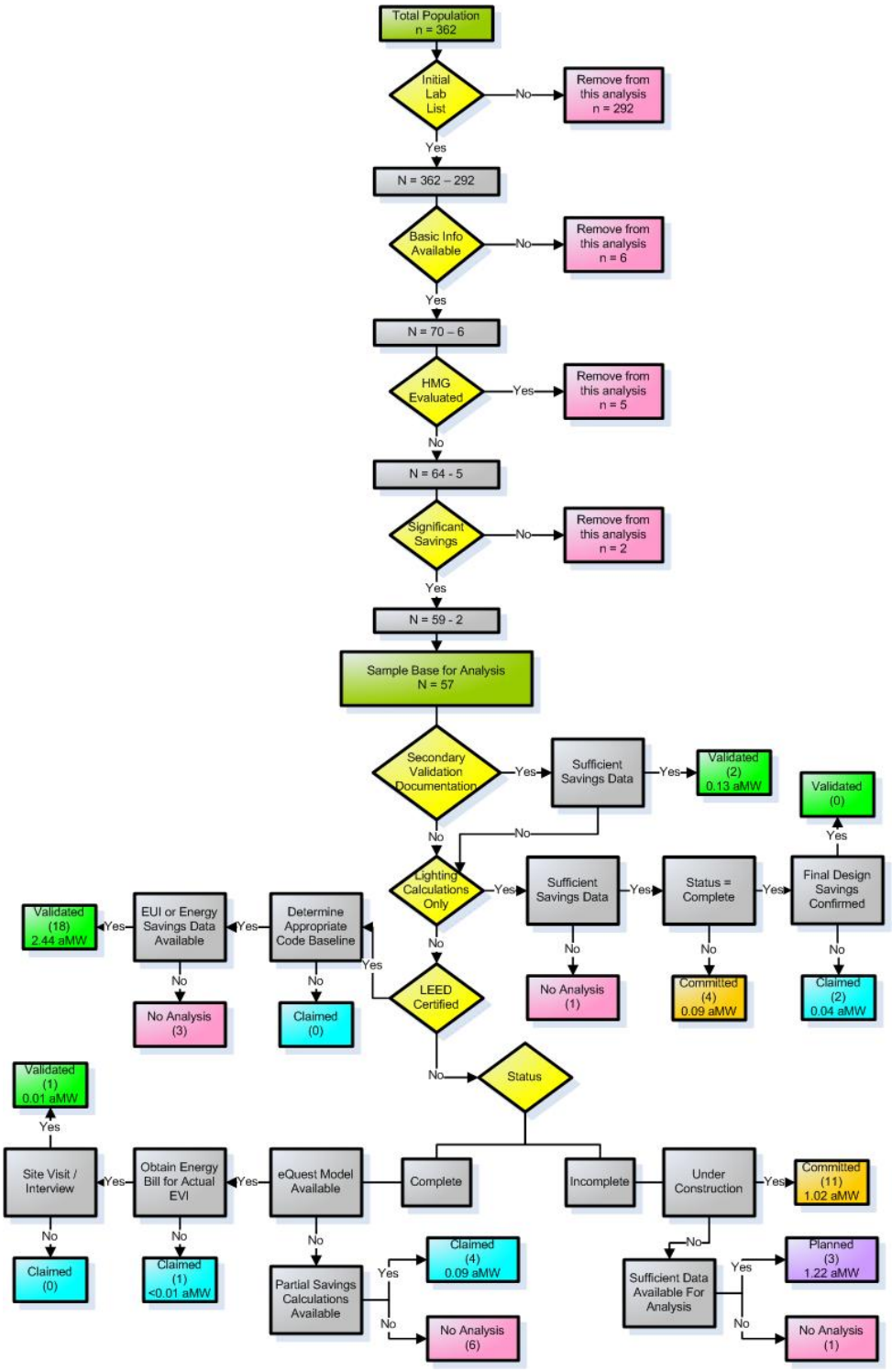
methodology for determining these savings. Specifically, estimating a realization rate would increase the accuracy of planned and committed savings estimates, as would developing a method for integrating changes in purchasing decisions of energy consuming products.

3. **Collect additional data in order to improve accuracy of the LEED realization rate:** The current realization rate is based on two data points from post occupancy evaluations. Accuracy could be improved by collecting additional data on LEED buildings through future post occupancy evaluations.

4. **Improve support of Post-Occupancy Evaluations:** BetterBricks is well positioned to assist building owners with POEs, ensuring expected savings are realized.

5. **Complete evaluation of results reported by HMG:** Cadmus noted areas in which further analysis could potentially improve the accuracy of energy savings on Building Operations and Grocery refrigeration tune-up projects previously evaluated by HMG. A comprehensive follow-up review to obtain additional information and validate the pending savings is recommended.

# Appendix A: Design and Construction Sampling and Evaluation Methodology



# Appendix B: BetterBricks Staff Design and Construction Project Selection Methodology

There are now over 400 projects in the CTS database. In an effort to keep the level of work of the labs to a manageable level, the number of projects selected for detailed data gathering had to be limited. The process to select a set of projects followed the outlined sequence below and used the criteria identified:

1. Assembled preliminary lists for each lab from the CTS database

2. Requested labs to review and add any missing or correct key identifying data

3. Requested each lab to highlight the top 10-15 projects in terms of highest savings potential

*Rationale and Criteria for Selecting Projects for Savings Analysis*

Message to the Labs early October:

"We need the project savings data for several reasons:
1) to generate some data on energy savings for a manageable set of projects (instead of all your projects).
2) to help determine what the highest level of energy efficiency we can deliver is.

Criteria for selection, in priority order, are:
1. Projects that utilize the most comprehensive integrated design
(i.e., the full wheel and addresses both lighting and mechanical systems).
2. Have the highest savings potential (known actual or estimated).
3. Projects in target markets.
4. Have a lot of data available or data are easily obtainable.
5. High profile (project has gotten, or will get, a lot of publicity)." – i.e. good documentation.

For the selected subset:
4. Determine key data to collect for each project

5. Assemble data from CTS on top projects

6. Return to labs to fill in missing data

7. Add or subtract projects based on new information:
- limited lab involvement
- limited measures (one small measure or small area)
- limited or no data on savings
- difficult to obtain data (unwilling architect or owner)

8. Suggest to Cadmus to move projects to definite or to estimation group
    - to estimation if not complete yet
    - to definite if complete.

Note: In addition to these steps, Cadmus has its own method of project selection or removal - see project decision tree.

# Appendix C: Realization Rate Development

Cadmus calculated energy savings for the majority of validated Design and Construction projects (17 out of 21) by applying a realization rate, as discussed in the previous chapter. This realization rate was also applied to a variety of new construction projects, whether pending, committed, or planned. The projects that formed the basis of this realization rate are described below:

- In the case of OR-07, the initial LEED design model indicated savings of 49% above code. A recently-completed POE for this building indicated ongoing work to bring the heat recovery system up from 1/3 of its projected potential. The POE provided two estimates for system performance, based on no and full heat recovery, as indicated in Table 24 below. Cadmus conservatively assumes the repair work will be at least partially successful and achieve 50% of full heat recovery. Therefore, the evaluation team applied gas energy savings halfway between the two values proposed in the POE. The resulting energy savings equal 34,417 MBtu, 79% of the 43,463 MBtu savings originally predicted and 38% above code.

- For OR-08, the POE indicated a 3% savings above Oregon energy code, but only 9.7% of the value predicted by the LEED modeling. An examination of reasons behind the low realization rate was outside the scope of this evaluation.

- In the case of WA-07, the POE revealed a 17% savings with respect to Seattle energy code and only 57% of the savings predicted by the LEED modeling.

- POE data were also available for WA-11, which did not receive support from the Integrated Design Lab and therefore no program energy savings were associated with this project. WA-11 is a LEED-certified building with a POE performed contemporaneously with WA-07, by the same firm. It is included to provide an additional data point upon which to base a realization rate.

**Table 24. Energy Savings for OR-07 Building Simulation Permutations**

| Model | Gas Usage (therms) | Electric Usage (kWh) | Total Energy Usage (MBtu) | Total Energy Savings (Mbtu) | Percent of Energy Saved |
|---|---|---|---|---|---|
| Calibrated LEED Baseline | 491,614 | 11,845,774 | 89,591 | - | - |
| Calibrated Design with no Heat Recovery | 416,023 | 5,623,104 | 60,794 | 28,797 | 32% |
| Calibrated Design with Full Heat Recovery | 303,615 | 5,623,104 | 49,553 | 40,038 | 45% |
| Calibrated Design with 50% Full Heat Recovery | 359,819 | 5,623,104 | 55,174 | 34,417 | 38% |

# Appendix D: Detailed Savings Tables

**Table 25. Detail for Validated Savings for Design and Construction Projects**

| Project ID | Source of Savings | Square Footage | Electric Savings (kWh) | Gas Savings (therms) | Energy Savings (MBTU)[6] | Total Realized Energy Savings (MBTU)[7] |
|---|---|---|---|---|---|---|
| ID-01 | LEED (35%) | 11,000 | 12,820 | 960 | | 140 |
| ID-02 | LEED (45%) | 174,000 | 619,290 | 8,866 | | 3,000 |
| ID-03 | Site Visit / Model | 240,000 | 559 | 3,450 | | 347 |
| OR-01 | LEED (40%) | 212,888 | 825,276 | 12,071 | 6,387 | 4,024 |
| OR-02 | LEED (39%) | 265,000 | 352,195 | 18,031 | 4,770 | 3,005 |
| OR-03 | LEED (30%) | 41,000 | 119,263 | 1,744 | 923 | 581 |
| OR-04 | LEED (30%) | 97,000 | 200,537 | 10,266 | 2,716 | 1,711 |
| OR-05 | LEED (45%) | 153,000 | 1,112,477 | 56,953 | 15,067 | 9,492 |
| OR-06 | LEED (28%) | 120,000 | 279,098 | 4,082 | 2,160 | 1,361 |
| OR-07 | LEED (61%) | 400,000 | 5,623,104 | 359,819 | | 55,174 |
| OR-08 | Secondary Evaluation | 183,000 | 150,132 | 7,686 | 1,281 | 1,281 |
| WA-01 | LEED (26%) | 185,269 | 363,861 | 5,322 | 2,816 | 1,774 |
| WA-02 | LEED (42%) | 9,453 | 26,876 | 1,376 | 364 | 229 |
| WA-03 | LEED (45%) | 1,700 | 4,910 | 72 | 38 | 24 |
| WA-04 | LEED (38%) | 60,000 | 106,323 | 5,443 | 1,440 | 907 |
| WA-05 | LEED (18%) | 125,000 | 218,110 | 3,190 | 1,688 | 1,063 |
| WA-06 | LEED (10%) | 360,000 | 297,704 | 4,355 | 2,304 | 1,452 |
| WA-07 | Secondary Evaluation | 198,000 | 1,013,000 | (8,400) | | 2,617 |
| WA-08 | LEED (27%) | 170,000 | 182,004 | 9,318 | 2,465 | 1,553 |
| WA-09 | LEED (36%) | 10,000 | 40,056 | 586 | 310 | 195 |
| WA-10 | LEED (43%) | 50,000 | 348,872 | 5,103 | 2,700 | 1,701 |
| **Total:** | | **3,066,310** | **11,896,466** | **510,293** | **47,428** | **91,632** |

[6] This energy savings column typically refers to differences in End Use Intensity (EUI) between the design and baseline building energy models, usually presented in kBtu/ft$^2$. These energy savings were not differentiated between electric and gas savings.

[7] This column contains the summation of the previous three columns for electric, gas, and undifferentiated energy savings, multiplied by the applicable realization rate.

**Table 26. Detail for Validated Savings for Hospitals**

| Project ID | Source of Savings | Electric Savings (kWh) | Gas Savings (therms) | Total Realized Energy Savings (MBTU) |
|---|---|---|---|---|
| OR-09 | Capital Projects (ECMs) | 642,000 | 25,150 | 4,706 |
| OR-10 | Capital Projects (ECMs) | 403,416 | 5,525 | 1,929 |
| OR-11 | Capital Projects (ECMs) | 143,676 | | 490 |
| OR-12 | Capital Projects (ECMs) | 400,295 | 16,455 | 3,012 |
| ID-07 | Capital Projects (ECMs) / Retro-Commissioning | 1,413,000 | | 4,823 |
| **Total:** | | **3,002,387** | **47,130** | **14,960** |

**Table 27. Detail for Validated Savings for HVAC Service Assistant Projects**

| Project ID | Contractor | Realized Electric Savings (kWh) | Realized Energy Savings (MBTU) | Potential Remaining Electric Savings (kWh) |
|---|---|---|---|---|
| FDSI-01 | Contractor 1 | 38,574 | 132 | 22,601 |
| FDSI-02 | Contractor 1 | 21,270 | 73 | 16,814 |
| Miscellaneous | Contractor 1 | 410 | 1 | 21,402 |
| FDSI-03 | Contractor 1 | 21,632 | 74 | 39,949 |
| FDSI-04 | Contractor 2 | 6,270 | 21 | 21,939 |
| FDSI-05 | Contractor 2 | 1,705 | 6 | 31,862 |
| Miscellaneous | Contractor 2 | 1,920 | 7 | 123,809 |
| FDSI-06 | Contractor 2 | 5,045 | 17 | 36,128 |
| FDSI-01 | Contractor 3 | 53,563 | 183 | 84,793 |
| **Total:** | | **150,389** | **513** | **399,296** |

**Table 28. Detail for Pre-2008 Validated Design and Construction Projects**

| Project ID | Electric Savings (kWh) | Gas Savings (therms) | Total Realized Energy Savings (MBTU) |
|---|---|---|---|
| HMG-WA-01 | 191,208 | 4,203 | 1,073 |
| HMG-OR-01 | 609,980 | (8,698) | 1,212 |
| HMG-OR-02 | 100,170 | 6,224 | 964 |
| HMG-ID-01 | 5,260 | | 18 |
| HMG-WA-02 | 696,700 | 5,116 | 2,889 |
| HMG-ID-02 | 345,420 | 12,082 | 2,387 |
| HMG-ID-03 | 32,780 | (414) | 70 |
| HMG-ID-04 | 6220 | | 21 |
| HMG-ID-05 | 21,410 | 1,076 | 181 |
| **Total:** | **1,948,738** | **18,927** | **8,816** |

**Table 29. Detail for Pending Savings for Design and Construction Projects**

| Project ID | Source of Savings | Square Footage | Projected Electric Savings (kWh) | Projected Gas Savings (therms) | Projected Energy Savings (MBTU) | Total Projected Energy Savings (MBTU) |
|---|---|---|---|---|---|---|
| ID-05 | Model | 56,689 | 284,048 | 18 | | 971 |
| ID-06 | Model | 20,000 | 7,413 | | | 25 |
| MT-01 | Lighting Calculations | | 324,317 | | | 1107 |
| MT-02 | Fenestration Model | 28,320 | 2,570 | 40 | | 13 |
| OR-13 | Model | 80,000 | 71,473 | 3,659 | 968 | 610 |
| WA-12 | Model | 40,000 | 227413 | 3,326 | 1,760 | 1109 |
| WA-13 | Lighting Calculations | 15,213 | 14952 | | 81 | 51 |
| **Total:** | | **240,222** | **932,186** | **7,043** | **2,809** | **3,886** |

**Table 30. Detail for Pending Savings for Hospitals**

| Project ID | Source of Savings | Projected Electric Savings (kWh) | Projected Gas Savings (therms) | Projected Energy Savings (MBTU) | Total Projected Energy Savings (MBTU) |
|---|---|---|---|---|---|
| ID-07 | Capital Projects (ECMs) | 744,600 | | | 2,541 |
| WA-15 | Capitals Projects (ECMs) / Tune-Ups | 609,762 | 8,159 | | 2,897 |
| **Total:** | | **1,354,362** | **8,159** | | **5,438** |

**Table 31. Detail for HMG Pending Savings for Building Operations Projects**

| Project ID | Electric Savings (kWh) | Gas Savings (therms) | Total Realized Energy Savings (MBTU) |
|---|---|---|---|
| HMG-OR-03 | | 96,294 | 9,629 |
| HMG-OR-04 | 430,000 | (17,300) | -262 |
| HMG-WA-03 | 179,150 | (1,102) | 501 |
| HMG-WA-04 | 214,750 | | 733 |
| HMG-WA-05 | 66,292 | 4,294 | 656 |
| HMG-WA-07 | 979,059 | | 3,342 |
| **Total:** | **1,869,251** | **82,186** | **14,598** |

**Table 32. Detail for HMG Pending Savings for Grocery Store Projects**

| Project ID | Electric Savings (kWh) | Total Realized Energy Savings (MBTU) |
|---|---|---|
| HMG-OR-04 | 366,700 | 1,252 |
| HMG-OR-05 | 58,500 | 200 |
| HMG-OR-06 | 84,700 | 289 |
| HMG-WA-06 | 101,050 | 345 |
| **Total:** | **610,950** | **2,085** |

**Table 33. Detail for Committed Savings for Design and Construction Projects**

| Project ID | Source of Savings | Square Footage | Projected Electric Savings (kWh) | Projected Gas Savings (therms) | Projected Energy Savings (MBTU) | Total Projected Energy Savings (MBTU) |
|---|---|---|---|---|---|---|
| MT-03 | Model | 28,320 | 9,250 | 329 | | 64 |
| MT-04 | Lighting calculations | 75,000 | 64,145 | 0 | | 219 |
| OR-14 | Lighting calculations | 200,000 | 119,466 | 6,116 | 1,618 | 1,019 |
| OR-15 | Lighting calculations | 57,000 | 51,463 | 2,635 | 697 | 439 |
| OR-16 | Model | 158,500 | 5,606 | 4,113 | | 429 |
| OR-17 | Model | 255,000 | 376,560 | 19,278 | 5,100 | 3,213 |
| OR-18 | Lighting calculations | 338,000 | 113,706 | 5,821 | 1,540 | 970 |
| WA-14 | Model | 47,500 | 251,705 | 3,682 | 1,948 | 1,227 |
| WA-16 | Model | 65,868 | 339,495 | 17,380 | 4,598 | 2,897 |
| WA-17 | Model | 109,000 | 265,586 | 13,597 | 3,597 | 2,266 |
| WA-18 | Model | 40,000 | 155,054 | 2,268 | 1,200 | 756 |
| WA-19 | Model | 947,000 | 1,835,454 | 26,847 | 14,205 | 8,949 |
| WA-20 | Model | 76,000 | 68,741 | 1,005 | 532 | 335 |
| WA-21 | Model | 175,000 | 710,665 | 36,383 | 9,625 | 6,064 |
| WA-22 | Model | 270,000 | 697,744 | 10,206 | 5,400 | 3,402 |
| **Total:** | | **2,842,188** | 5,064,640 | **149,660** | **50,060** | **32,250** |

**Table 34. Detail for Committed Savings for Hospitals**

| Project ID | Source of Savings | Projected Electric Savings (kWh) | Projected Gas Savings (therms) | Total Projected Energy Savings (MBTU) |
|---|---|---|---|---|
| WA-15 | East Tower Commissioning | 521,225 | 75,230 | 9,302 |
| OR-12 | Capital Projects (ECMs) | 3,066,386 | | 10,466 |
| **Total:** | | **3,587,611** | **75,230** | **19,768** |

**Table 35. Detail for Planned Savings for Design and Construction Projects**

| Project ID | Source of Savings | Square Footage | Projected Electric Savings (kWh) | Projected Gas Savings (therms) | Projected Energy Savings (MBTU) | Total Projected Energy Savings (MBTU) |
|---|---|---|---|---|---|---|
| ID-08 | Model | 500,000 | 2,872,195 | 147,042 | 38,900 | 24,507 |
| WA-23 | Lighting Calculations | 66,780 | 27,836 | 1,425 | 377 | 238 |
| WA-24 | Model | 200,000 | 1,255,201 | 64,260 | 17,000 | 10,710 |
| **Total:** | | **766,780** | **4,155,231** | **212,727** | **56,277** | **35,455** |

**Table 36. Detail for Planned Savings for Hospitals**

| Project ID | Source of Savings | Projected Electric Savings (kWh) | Projected Gas Savings (therms) | Projected Energy Savings (MBTU) | Total Projected Energy Savings (MBTU) |
|---|---|---|---|---|---|
| MT-05 | Capital Projects (ECMs) | 2,636,250 | 191,250 | | 28,123 |
| | O&M/Tune-up | 1,757,500 | 127,500 | | 18,748 |
| MT-06 | Capital Projects (ECMs) | 1,130,500 | 38,150 | | 7,673 |
| | O&M/Tune-up | 646,000 | 21,800 | | 4,385 |
| | Retro-Commissioning | 3,465,000 | 103,100 | | 22,136 |
| OR-10 | O&M/Tune-Up | 1,213,000 | 24,800 | | 6,620 |
| | Retro-Commissioning | 1,819,500 | 37,200 | | 9,930 |
| OR-19 | Capital Projects (ECMs) | 1,881,160 | 96,306 | 16,051 | 16,051 |
| | O&M/Tune-Up | 1,698,200 | 34,720 | | 9,268 |
| | Retro-Commissioning | 1,770,524 | 90,642 | 15,107 | 15,107 |
| OR-12 | Capital Projects (ECMs) | 290,775 | 0 | | 992 |
| OR-11 | Capital Projects (ECMs) | 127,378 | 0 | | 435 |
| OR-09 | Capital Projects (ECMs) | 254,053 | 0 | | 867 |
| WA-15 | Capital Projects (ECMs) | 240,150 | (398) | | 780 |
| ID-09 | Capital Projects (ECMs) | 4,974,000 | 241,900 | | 41,166 |
| | Commissioning / Retro-Commissioning | 1,840,000 | 180,500 | | 24,330 |

| Project ID | Source of Savings | Projected Electric Savings (kWh) | Projected Gas Savings (therms) | Projected Energy Savings (MBTU) | Total Projected Energy Savings (MBTU) |
|---|---|---|---|---|---|
| ID-04 | Lighting | 504,315 | (7,167) | | 1,005 |
| | O&M / Retro-Commissioning | 1,437,099 | 140,347 | | 18,940 |
| WA-27 | O&M/Tune-up | 6,742,714 | 65,029 | | 29,516 |
| WA-26 | O&M/Tune-up | 1,610,707 | 10,344 | | 6,532 |
| WA-25 | O&M/Tune-up | 377,333 | 76,748 | | 8,963 |
| **Total:** | | **36,416,159** | **1,472,771** | **31,158** | **271,565** |

**Table 37. Detail for Planned Savings for Real Estate Projects**

| Project ID | Source of Savings | Projected Electric Savings (kWh) | Projected Gas Savings (therms) | Total Projected Energy Savings (MBTU) |
|---|---|---|---|---|
| ID-10 | O&M / Tune-up | 76,000 | 375 | 297 |
| ID-11 | O&M / Tune-up | 45,000 | | 154 |
| WA-28 | O&M / Tune-up | 215,000 | 11,750 | 1,909 |
| WA-29 | O&M / Tune-up | 61,403 | | 210 |
| WA-30 | O&M / Tune-up | 626,984 | | 2,140 |
| **Total:** | | **1,024,387** | **12,125** | **4,709** |

# Appendix E: Additional New Construction Studies

As noted previously, Cadmus experienced difficulty determining a reliable realization rate for energy savings associated with LEED-certified new construction projects. Cadmus could only acquire four POEs performed to our standards of accuracy. The Cadmus procedure follows impact evaluation standard practice to determine the realization rate, which is a ratio of actual savings determined by the evaluation contractor to initial savings projected by the design model. Cadmus recommends the following process to develop the realization rate for an occupied new construction building:

- Obtain the original energy efficient design model and one year of post-occupancy utility bills.
- Modify the model to reflect as-built design and operating characteristics.
- Calibrate the as-built model to the POE billed energy use by adjusting plug loads and other variables as appropriate.
- Develop an adjusted baseline model by replacing data values used for the installed energy efficient measures with associated data values from the appropriate state energy code or standard practice equivalent, as applicable.
- Determine actual energy savings as the difference between the adjusted baseline model energy use and actual energy use.
- Calculate the realization rate by dividing the actual energy savings by the savings as claimed through a utility program or as projected by the design team.

A number of studies and evaluations have examined savings associated with LEED new construction projects. However, several of those studies determine savings by comparing actual energy use from billing data with the original model built to code. One study author provided a cautionary note that claims "the comparisons in this report between actual energy usage and initial baseline modeling give only a very approximate initial estimate of energy efficiency savings[8]." As a result, Cadmus did not consider these study results for use in determining a realization rate to validate or estimate savings in this study.

Studies that provide approximate estimates cited above include:

- "Energy Performance of LEED® for New Construction Buildings," by Cathy Turner and Mark Frankel, New Buildings Institute, March 4, 2008[9]

[8] "LEED Building Performance in the Cascadia Region: A Post Occupancy Evaluation Report" by Cathy Turner for the Cascadia Region Green Building Council, January 30, 2006.

[9] <www.newbuildings.org/downloads/Energy_Performance_of_LEED-NC_Buildings-Final_3-4-08b.pdf>

- "LEED Building Performance in the Cascadia Region: A Post Occupancy Evaluation Report" by Cathy Turner for the Cascadia Region Green Building Council, January 30, 2006
- "Operating Experiences at the CK Choi and Liu Centre Buildings at the University of British Columbia," by Blair McCarry and Rosamunde Hyde

Cadmus recommends NEEA provide funding to perform more extensive post-occupancy evaluations, similar to those described in Section 3 of this study. The POEs will produce additional information on the performance of LEED-certified buildings, provide more accurate realization rate data for predicting future building and program performance, and determine the validity of approximations developed in the above studies.