BetterBricks Energy Savings Protocol

Progress Report

PREPARED BY

HMG

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BetterBricks Energy Savings Protocol Progress Report

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1. EXECUTIVE SUMMARY

This is the first report on the development of savings estimates for NEEA's BetterBricks Initiative. While planning estimates were developed as part of the BetterBricks Board-approval process, this project represents the first attempt to use actual Initiative data as the source for savings estimates that are directly linked to Initiative activities.

The primary tasks for this initial effort were:

- to create a conceptual framework to guide the work,
- develop protocols that describe the steps needed to collect, validate and analyze the data, and then
- apply the savings protocols to as many completed projects as possible to determine if defensible savings estimates at the project level could be generated.

There is no attempt in this report to determine savings for BetterBricks overall and it would be inappropriate at this time to attempt to extrapolate the savings reported to any other projects. Future reports will expand on what has been learned here and will develop more broadly applicable savings estimates.

This report documents the steps that were taken to develop the framework and protocols and the results of applying the protocol for one type of project—design and construction projects in which BetterBricks contractors were directly involved—to actual projects to validate the approach. While broad conclusions cannot be drawn from our small sample of projects, the results do show that:

- energy savings are being achieved by the BetterBricks-influenced projects
- the protocol approach is able to calculate actual energy savings
- electric energy savings tend to result in an increase in gas usage as a result of less internal heat being generated by more efficient lighting. (Overall energy usage is reduced, however)
- there is a wide range of energy savings by project type and location (as anticipated).

While we were moderately successful in selecting sites, conducting site visits and developing savings estimates, the process did not go completely as planned. The lessons learned are:

- The BetterBricks Commercial Tracking System (CTS) needs to be fully populated with critical data to make it useful to this process and make our approach cost-effective.
- Implementers need to collect required project data for this approach to be cost-effective.
- BetterBricks may need to be more involved in each project through completion to verify installed recommendations. Project owners will need to see a value in the BetterBricks involvement.

- Determination of building energy savings is dependent on the baseline definition and approach. NEEA will need to make a policy-level decision on how/which baselines should be used before our protocols can be finalized.

The next steps are to:

- analyze additional projects
- test our Building Operations protocol
- analyze additional projects and identify measure bundles
- work with NEEA staff to prepare recommendations on baselines for policy adoption.

2. INTRODUCTION

2.1 BetterBricks Initiative

BetterBricks comprises all of NEEA's commercial sector activities. It seeks to:

> Make energy efficiency an integral part of business decision-making. Within targeted vertical markets, change energy-related business practices to achieve energy efficiency in design and construction, and in building and facility operations. Create natural market demand for related trade ally products and services[1].

Within BetterBricks, an "energy-related business practice" is defined as any consistent policy or action an organization applies that affects energy consumption in its buildings. The changes in business practices that BetterBricks is promoting will result in facilities that reduce energy-related capital and operating costs. In addition, there are potential non-energy benefits, such as occupant comfort and productivity, and an alignment of design and construction projects with industry best practices.

BetterBricks currently addresses three specific "vertical" markets (hospitals and health care, groceries, and commercial real estate) and two "cross-cutting" markets (design and construction, and building operations), as shown in Figure 1. In broad terms, the distinction is between companies that have a demand for services (vertical) and companies that supply services (cross-cutting). Services provided to these markets include technical support, business advice, education and training. Technical support can be provided for either specific projects or whole organizations, while business advice is always at the organizational level. The majority of these services are provided to a few selected partners within each market with whom NEEA has established a formal memorandum of understanding, and who have the potential to influence other organizations in those markets.

[1] Northwest Energy Efficiency Alliance. 2006. *Commercial Sector Initiative 2006-2008 Project Description (July 5, 2005).* Portland, Oreg.: Northwest Energy Efficiency Alliance, p. 6. See: http://www.nwalliance.org/proposals/rfps/CSIProjectDescriptionForRFP.pdf.

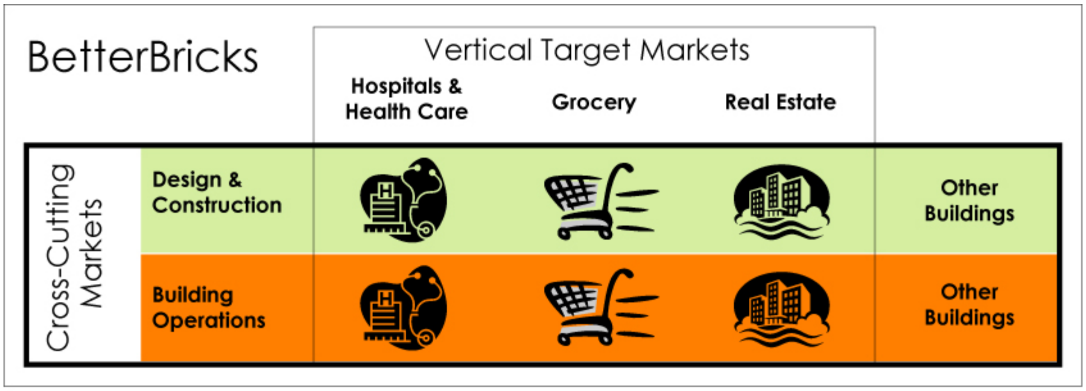

Figure 1. BetterBricks Targets

2.2 Description of this Project

The Heschong-Mahone Group, Inc. (HMG) was hired in 2005 to develop savings estimates for the BetterBricks Initiative. While planning estimates were developed as part of the Board-approval process, this project represents the first attempt to use BetterBricks projects as the source for savings estimates that are directly linked to Initiative activities. The primary tasks of this project were:

- to create a conceptual framework to guide the work,
- develop protocols that describe the steps needed to collect, validate and analyze the data, and then
- apply the results to generate Initiative-wide savings estimates. (2-3 years from now.)

The framework was completed in 2006 and is described in Chapter 3; the protocols, described in Chapter 4, were started in 2007 and continue to evolve.

In large part, this project is breaking new ground. While a multitude of well-established energy savings estimation techniques has been developed by the energy efficiency industry over the past twenty years, few of these approaches can be directly applied to BetterBricks because, as described in detail below, its emphasis on changing business practices means that there are no prescriptive lists of energy efficiency measures from which savings will be derived. Existing estimation techniques are being adapted and new ones are being developed for this project. In addition, there are several difficulties specific to BetterBricks itself that make this a challenging project.

First is the sheer scope of BetterBricks. Savings must be estimated for both the new construction and existing building markets, for different market segments, for different climate zones, and, ultimately, must account for commissioning and operational changes in addition to building system efficiencies.

Second, the result of the non-prescriptive nature of BetterBricks is that, while certain measures and practices are being emphasized (e.g. daylighting), any one building may have an entirely different set of efficiency improvements than another building in the same vertical market. This is especially true in existing buildings where the focus is on operational improvements.

Third, and by far most challenging, the vast majority of the buildings affected by BetterBricks will have no contact with initiative staff or contractors. While initial activities are focusing on business owners and trade allies with whom BetterBricks has direct relationships, a fundamental part of the market transformation theory is that documented successes will inspire other businesses who do not have direct contact with BetterBricks to adopt the same business practice changes.

Of necessity, the development of energy savings estimates follows the implementation of the program. For the first few years, BetterBricks implementers have been focusing on laying the groundwork for changing business practices and completing individual projects that can be used as success stories and validation of the benefits that will result from adopting the business practices BetterBricks is promoting. During this first phase, evaluators will generate savings estimates based on information collected from individual buildings. Ultimately, however, the evaluation goal is to relate the changes in business practices directly to savings. For example, if an organization adopts integrated design as a policy, we would like to be able to say, without examining or analyzing each building that this will save some deemed percent of energy relative to baseline buildings. For such an approach to be credible it must be based on large amounts of empirical data; gathering such data will take several years, as both significant numbers of buildings and significant numbers of organizations adopting the new business practices will be needed to discern the quantitative relationship between the two.

The basic metric for BetterBricks energy savings estimates will be whole building energy use intensities (EUIs) using saved kilowatt-hours per square foot per year and normalized for factors appropriate to each market. Accurate EUIs, however, will need to be based on actual program results. The analytical starting point for this project, therefore, is to carefully track and analyze both baseline conditions and installed measures in buildings NEEA has worked on directly[1]. While it was noted above that BetterBricks is not a prescriptive program, a fundamental assumption of our approach is that we can determine representative bundles of measures with aggregate EUIs that reflect the projects that have been completed at any given time. We will do this by continuously examining the measures installed in individual projects and generating bundles that are statistically most common. The contents of the bundles may change over time as the Initiative emphasizes different technical strategies for saving energy. We will continue until sufficient confidence is gained that the savings of the tracked buildings are representative of what BetterBricks is expected to generate in all buildings over time. When that level of confidence is gained, the EUIs will be applied, going forward, as deemed savings.

[1] Throughout this document, any reference to installed measures connotes anything done to a building or building design that reduces energy consumption. A participating building is one for which NEEA provide direct support, such as design advice or modeling.

3. FRAMEWORK DEVELOPMENT

The initial task for this project was to create a conceptual framework that could be used to develop the analytical approaches for estimating savings. The first step, which directly addressed the challenges described in Section 2.2, was to use the BetterBricks initiative description to define three levels of program influence:

- ***Direct Involvement***. Meaning that BetterBricks has provided services directly to an individual project, and documentation exists that specifically identifies what changes were recommended. The BetterBricks market managers have responsibility for ensuring that documentation is collected by contractors and entered into the Commercial Tracking System (CTS). The source may be a BetterBricks contractor or the organization that participated in the project.
- ***Direct Influence***. Refers to organizations or buildings where a specific BetterBricks activity can be identified as having influenced a project, even though no direct BetterBricks technical or business service was received. One example of *direct influence* would be when a successful *direct involvement* project leads an organization to implement other energy efficiency practices or apply those practices that were recommended to other buildings where no direct help is received. Another example of *direct influence* would be when a customer attends a BetterBricks training session or talks to a colleague at *direct involvement* firm, which leads to implementation of some energy efficient practice or technology. The fundamental assumption is that a causal link can be established between BetterBricks activities and actions taken, and a reasonable estimate of the impact can be made (even though direct documentation may not be available).
- ***Indirect Influence***. Accounts for the remaining influence that all BetterBricks' activities will have on the rest of the market. This is the essence of the market transformation theory, in which organizations that change business practices, on both the demand- and supply-sides of the market, achieve success, leading other organizations to mimic them. These secondary effects cannot directly be linked to BetterBricks activities, because the people who implement them do not realize the origin of the change was BetterBricks. They are simply adopting a successful practice or technology they see in the market that makes sense to them.

After establishing these three levels of influence, we reviewed logic models of the individual BetterBricks vertical market initiatives and noted that BetterBricks can have influence at the project level, the business practice level, and the organizational level. For purposes of the savings framework and protocols, we use the following definitions:

***Project* –** Building-specific activity consisting of one or more measures.

***Measure* –** Any action resulting in measurable energy savings. Measures can include specific equipment, a procurement policy or a facility energy management plan.

***Business Practice Area* –**The four areas within a vertical markets organization that BetterBricks can influence to attain energy savings:

design and construction, building operations, procurement, and system upgrades.

Organization – Business entity operating in a BetterBricks market. Broadly split into demand-side (requiring products and services) and supply-side (supplying products and services). All have business practice areas and projects that can be influenced (directly or indirectly) by BetterBricks.

Market – A BetterBricks-defined piece of the commercial market.

When we combine these with the levels of influence we get the overall framework shown in Figure 2. The arrows in the figure indicate that, in general, BetterBricks activities and results move from individual projects to the entire market. For example, an organization receives direct help on an individual project; if the measures implemented in the project are successful it leads to them being implemented in other projects; if they are successful in a few of these other projects they are incorporated into a consistent business practice policy. Success with one or more measures can lead to comprehensive business practice changes that address all energy consumption. Through word-of-mouth, marketing, competitive pressures, and BetterBricks' supply-side efforts, these changes ultimately flow to the rest of the market on the far right of the figure. Organizations do not need to follow this entire sequence. They may take what they have heard about the results and immediately change individual business practices and proceed from there. Rarely, if ever, would we expect a company to start by adopting a comprehensive, organization-wide policy without previous experience.

Project Type	**Individual Measures &Projects**	**Individual Business Practice Policies**	**Comprehensive Organization-wide Policy**	**Market**
Direct Involvement				
Direct Influence				
Indirect Influence				

Figure 2. Theoretical Framework for Overall BetterBricks Influence

Another layer of the conceptual framework addresses the BetterBricks' goal of influencing energy-related decision-making in targeted vertical markets. Initiative implementers have defined four business practice areas where changes could result in reduced energy consumption: Design & Construction (D&C), Building Operations, Procurement, and Systems Upgrades. BetterBricks works directly in the first three business practice areas. The last, Systems Upgrades, are retrofit activities currently supported by utility efficiency programs throughout the Northwest. Energy savings estimates will account for activities in all four business practice areas. Figure 3 presents the framework as it applies to these business practice areas. Each cell represents a separate section of the protocol. There will be similarities for each column and to a lesser extent across each row.

Project Type	**Business Practice Area**			
	Design & Construction	**Building Operations**	**Procurement**	**Systems Upgrade**
Direct Involvement				
Direct Influence				
Indirect Influence				

Figure 3. Theoretical Framework for BetterBricks Influence on Business Practices

Taken together, Figures 2 and 3 indicate all of the vectors through which impacts can result and all of the areas in which they can result. Defining this theoretical framework allows us to move more efficiently to the next step of quantifying savings.

4. PROTOCOL DEVELOPMENT

With the framework established, the next step was to develop protocols for estimating actual energy savings based on BetterBricks involvement and influence. In the context of this project, a protocol is defined as a process that includes sufficient detail on all the techniques, strategies, definitions and descriptions required to produce overall energy savings estimates for each aspect of a specific target market. A draft protocol has been developed for Hospitals & Healthcare; in 2008 protocols will be developed for each vertical market: Hospitals & Healthcare, Grocery, Real Estate, with separate sections that address each of the four business practice areas: design and construction, building operations, procurement and systems upgrades as illustrated in Figure 4. The completed protocols will also separately address each level of BetterBricks influence: Direct Involvement, Direct Influence, Indirect Influence. Each row represents one protocol, with each cell representing a section within the protocol. As with the Framework table (Figure 3), there will be similarities within each column. Given the evolving state of BetterBricks, a protocol will, of necessity, change over time to reflect additions and deletions in the energy savings activities of the BetterBricks market it addresses.

Vertical Target Market	**Business Practice Area**											
	Design & Construction			**Building Operations**			**Procurement**			**Systems Upgrade**		
	Dir. Inv.	Dir. Infl.	Indir. Infl.	Dir. Inv.	Dir. Infl.	Indir. Infl.	Dir. Inv.	Dir. Infl.	Indir. Infl.	Dir. Inv.	Dir. Infl.	Indir. Infl.
Hospitals & Healthcare												
Grocery												
Real Estate												

Figure 4. Protocol Structure

Protocols require a mix of broad approaches and techniques for determining whole building savings, as well as a list of specific approaches and techniques for determining the savings for specific energy efficiency measures. In broad terms, the protocols are intended to answer the following questions:

- What data are available for baseline and post-treatment conditions?
- How will data be collected?
- Who is responsible for collecting the data?
- What does the existing data tell us and how can it be used to estimate savings?
- What activities are needed to validate or calculate energy savings?

- What tools are required for in-field data collection?
- How will data be analyzed including methods, tools and expected outputs?
- What are the final savings?

The protocols provide clear procedures for collecting the data necessary to estimate savings, and specify the necessary precision in the data collection and measurement to result in acceptable levels of accuracy in the resulting savings estimates. The protocol defines what "acceptable level of accuracy" means, and will likely vary among the various elements and over time based on the BetterBricks priorities.

Figure 5 gives a general template for the protocols and illustrates the overall process. Each arrow represents one influence level: Direct Involvement, Direct Influence or Indirect Influence. On the right side of the figure, there is an arrow connecting the levels of Direct Involvement and Direct Influence to illustrate the idea that the results of the Direct Involvement savings analysis, for a given project type and measure bundle, can be applied directly (perhaps with an adjustment factor) to the Direct Influence projects. Since both levels have a documentable connection to Initiative efforts, we believe it is reasonable to assume that, at a broad level, the types of projects and resulting energy savings will be similar enough that they should be linked in the analysis. This assumption will be tested over the next year as we gather data on more projects at both levels and compare them.

Indirect Influence projects are much less tied to specific Initiative activities and we cannot therefore make an *a priori* assumption that the resulting projects will have any similarity to those we see in the Direct Involvement level. An approach has not yet been developed for Indirect Influence projects. It will be developed after the direct involvement/influence methodology has been more fully tested on additional projects.

For the direct involvement and direct influence levels we have defined a four-step process reflected in Figure 5:

- *Step One - Project Information Tracking and Gathering.* Provide the data for determining baseline and post-treatment conditions and outline how data are collected and by whom. Step One is based on the fundamental assumption that there is project data for us to review.
- *Step Two - Project Information Review.* Review existing data and determine how it can be used to estimate savings or defines additional data collection procedures.
- *Step Three – Validation and Site Visits.* Define the validation and calculation activities.
- *Step Four – Data Analysis.* Define the analysis methods and tools and develop the final savings estimates.

As the basis for this study, we assume that energy use intensities (EUI) or energy use per square foot can be calculated, measured or deemed, based on available data. The levels of data collection and savings analyses can range from simple to complex, and may include engineering estimates, energy simulations, analyzing metered data and billing analysis. (See Appendix A for complete description.)

Project Type

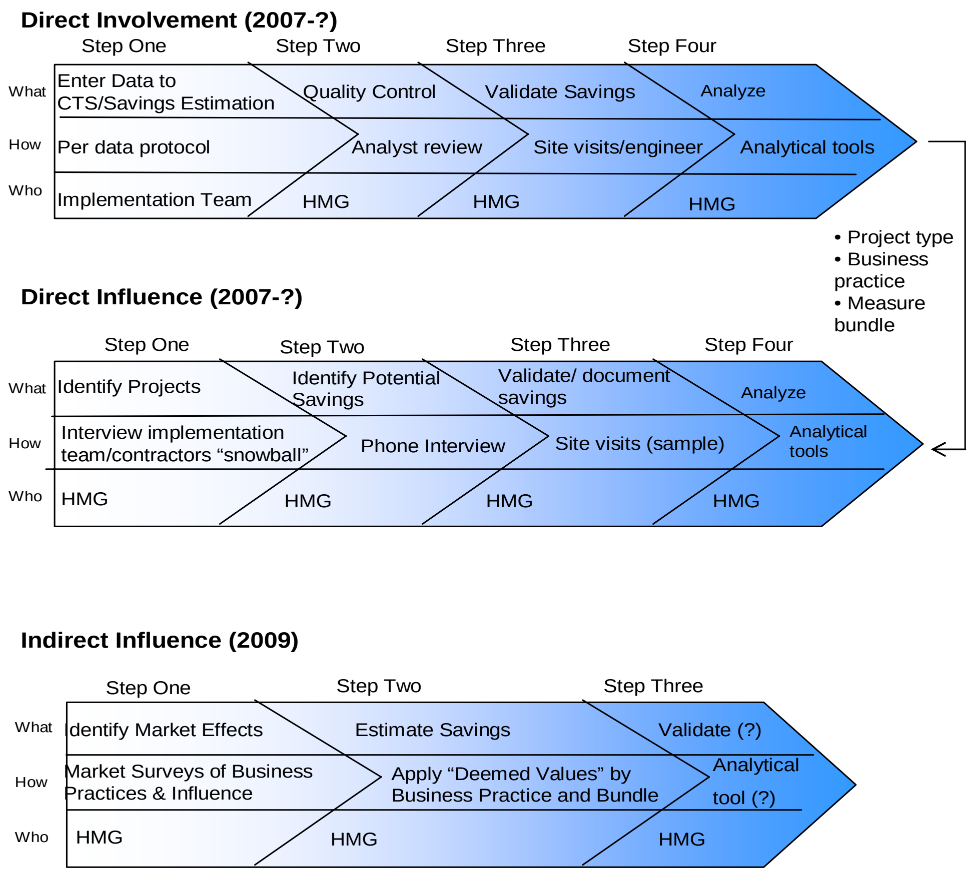

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Figure 5. General Template for BetterBricks Energy Savings Protocol

5. TEST PROTOCOL IMPLEMENTATION

To validate the concept represented in Figure 5, we developed and tested a limited protocol that addresses direct involvement design and construction projects. Other areas of the protocols have been written but have not been implemented pending both the results described in this report and availability of a greater number of projects from other business practice areas. The remainder of this chapter describes the steps that were taken to test the protocol. The steps are linked to those noted in Figure 4 and described in the previous chapter.

5.1 Step 1 - Project Information Tracking/Gathering

Figure 5 designates the implementation team as the responsible party for collecting and entering data into the Commercial Tracking System (CTS). However, at the time of our initial review in spring 2007, CTS was minimally populated and thus was not used extensively, though it is expected to be the primary data source for future research. Because the software systems and data requirements were still being developed as our research was being conducted, we were forced to take a more ad hoc approach to data collection. We worked directly with the BetterBricks D&C contractors, primarily the Integrated Design Labs (IDL) in Boise, Portland and Seattle, to develop lists of potential projects that were determined to be built and occupied. Since most commercial new construction projects take a minimum of 18 months to reach this stage, we were largely limited to projects the contractors worked on prior to 2006.

We eventually received names of 143 potential projects. We then eliminated projects that were either “old” (five years old or older) or still under construction. We focused on the building types of interest, primarily grocery, health care and office. These two screens left us with 58 projects. We further reviewed the projects to identify measures of interest and, most important, selected projects for which we were confident we could get access and documentation. Of the approximately 58 projects remaining, we focused on high priority sites first, exhausted those possibilities and moved on to others. We pursued projects that we thought would have documented energy savings and would be complete enough for us to visit and verify savings estimates. When we encountered a project that was not yet ready for the protocol test, we moved on to the next project. If at any point in the process a contact told us the project was not ready, we moved on to other projects.

This entire process ultimately led to ten documented projects (shown in Section 5.5), which we were able to visit by early October 2007. Ten was deemed to provide sufficient diversity to test the application of the protocol to real-life situations while maintaining costs at a reasonable level.

Additional information came from interviews with one or more of the following: NEEA staff, technical advisors, market specialists, business advisors, building owners, service providers and designers.

5.2 Step 2 - Project Information Review

In reviewing the most relevant projects (as determined by the BetterBricks Integrated Design Labs (IDL) directors and staff) we gained an understanding of the approach adopted by each Lab toward accomplishing the BetterBricks goals. Though the criteria for relevancy varied by Lab, the projects selected were typically those that were in the target markets, those that the Labs felt they had the most influence over and/or were most representative of their current activity. Through file reviews and interviews we were able to identify specific measures, and to determine the likelihood that the measure was installed as proposed and was achieving the estimated savings. For example, if a measure was proposed at the schematic design stage, and the IDL was not involved with further stages of the project, then the estimated savings would reflect possible savings, but not necessarily actual project savings. If the IDL provided energy savings estimates during the final design stages, the estimates are more likely to represent as-built conditions. Historically, the IDLs have rarely been involved in a project from early design through construction. This is changing rapidly with the new focus on in-depth integrated design, but little project data has yet been generated from the new approach.

We initially expected that NEEA staff and contractors would have relatively easy access to the project documentation of recommended energy savings strategies and measures, and the initial estimate of energy savings. This expectation turned out not to be true in many cases leading to additional effort to collect the documentation before going on-site, resulting in delays.

In some instances where the original energy savings reports did not exist or no energy simulation analysis was conducted to predict energy savings, we needed to collect supporting data such as ‘as-designed’ and ‘as-built’ plans and equipment spec sheets before and after the site visits in order to develop the energy savings analysis. While we were able to eventually gather enough documentation to complete our analysis, this is not a sustainable procedure for the longer-term evaluation effort because of the high cost.

5.3 Step 3 - Validation/Site Visit

In this first phase of protocol testing, we conducted on-site surveys of all ten sites to confirm information from CTS and other documentation. Prior to the site visit we reviewed the project files, to identify the recommended measures and to identify the original analysis approach. From a protocol perspective this approach is too labor-intensive to be sustainable. However, the detailed data collection and verification at this stage allows us to fully understand the BetterBricks initiative process, which will ultimately lead us to a less labor-intensive approach.

On-site data collection included:

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

We used the survey and interviews to understand how the building is structured and to identify energy efficiency components including characteristics, services, practices, etc.

We made use of existing EMS or other metered data to the extent possible. We reviewed existing monitored energy performance data where it was available to verify and update the energy savings estimates. For a majority of the projects, existing monitored energy usage data was not available, so we installed our own data logging equipment to monitor the HVAC, lighting and/or ventilation systems. The intent of the data monitoring is to develop operational schedules for these systems as well as gather as-operated energy use data on these systems.

5.4 Step 4 - Data Analysis

To estimate actual energy savings we used a direct, engineering-based approach based on specific measures. The intent was to provide an estimate of the energy savings due to the 'as-built' (construction specs) or 'as-operated' (schedules, manual operation or overrides) conditions and compare these against the original savings estimates or relevant baselines.

For six (6) of the ten buildings we analyzed in this round, we were successful in getting copies of the original energy simulation input and output files for both the building 'as-designed' as well as the 'code-base' building. For these six projects, we updated the models to reflect the 'as-built' or 'as-operated' conditions based on the data collected from the file review and the site visit, or supplied later by the project contact. Thus we conducted our analysis following the original estimation approach described in the available documentation and energy models.

For the remaining four buildings, we had to develop an energy simulation model from scratch. For these buildings, we followed a similar approach of using energy simulation analysis to predict 'as-built' or 'as-operated' savings. Since there was no original energy savings analysis report or energy model, we generated both the 'as-built' or 'as-operated' models as well as the 'code-base' model based on data collected through our site surveys, and follow-up data collection on 'as-built' and 'as-operated' conditions through architect interviews and plan reviews.

Thus our final energy savings used the original approach (where available) with enhanced information from updated on-site data, monitored data and/or billing data. At this point in the overall process, the analysis focused on specific energy measures and the resulting energy savings. Because these are new construction projects, billing data comparisons of "pre" and "post" consumption data to estimate energy savings is not possible.

In future revisions, we may be able to make greater use of billing data or benchmarking data but it was more important here to validate project-specific data. Once we identify typical measure bundles by building type and their contribution toward energy savings we can apply the percent end-use savings to estimate savings directly from billing data. Billing analysis to estimate savings will only be useful once we have sufficient data on the measure bundles and savings by fuel type for each end use.

To calculate savings we needed to establish a baseline as the starting point from which energy efficient design alternatives are considered. For this test, the baseline was defined using building code requirements, where applicable, and standard industry practice typical of specific building construction and system design where building codes are not applicable. We were able to use the baseline assumptions from the original energy savings estimations [when we had them, otherwise we used code baseline assumptions] in our analysis. In the long-term we will not have the luxury of documented baseline assumptions. Baseline issues are discussed further in Section 6.4.

5.5 Energy Analysis Results

Following the four step process described above, we were able to use existing and new data applied to the established analysis approach to estimate energy savings.

Ten (10) projects are included in the first round of analysis. The baseline energy use and the energy savings in kWh or therms, unit energy savings (EUI, kWh or therms saved per year per sf) and percent savings for ten projects are shown in Figure 6. The table also shows average, minimum and maximum savings, both in terms of EUI and percent. Nine of the projects are Direct Involvement projects and one is a Direct Influence project[1].

The energy savings are calculated as the difference between the project base model and the as-built conditions model. Percent savings are the final energy savings as a percent of the code base model consumption presented as unit energy savings, kWh/sf or therms/sf, referred to as EUI in the table. In all cases energy savings are presented as a percent of total building energy use by fuel type, electric or gas. Baseline unit energy consumption values are shown to provide a reference for the relative energy savings. The electric (kWh) energy use and savings is comprised primarily of the lighting, HVAC (cooling, fans and pumps) and refrigeration end-uses. The gas (therms) energy is comprised of space heating and water heating end-uses. In most cases the negative therm savings were a secondary effect from reduced lighting consumption. The results are discussed below.

Bldg Type	BB Influence	kWh				therms			
		Baseline Energy Use (kWh/sf/yr)	Energy Savings			Baseline Energy Use (therms/sf/yr)	Energy Savings		
			kWh	per sf (EUI)	Percent		therms	per sf (EUI)	Percent
Grocery	Dir. Invl.	44.89	191,208	5.68	13%	1.23	4,203	-0.34	-28%
Grocery	Dir. Invl.	65.75	154,507	5.97	9%	-		-	-
Classroom/office	Dir. Invl.	12.05	609,980	5.39	45%	0.22	(8,698)	-0.08	-35%
Classroom/office	Dir. Invl.	8.41	100,170	4.74	56%	0.44	6,224	0.29	67%
Classroom/office	Dir. Invl.	9.82	5,260	1.53	16%	0.03		-	-
Office	Dir. Invl.	19.56	696,700	5.92	30%	0.23	5,116	0.04	19%
Office	Dir. Invl.	9.76	6,220	3.74	38%	0.01	0	0.00	1%
Office	Dir. Invl.	6.23	345,420	2.22	36%	0.18	12,082	0.08	43%
Office/Whse	Dir. Invl.	0.88	32,780	0.61	69%	0.02	(414)	-0.01	-38%
Office/Whse	Dir. Infl.	0.82	31,600	0.29	36%	0.01	(335)	0.00	-24%
Average Savings		-		3.61	35%	-		0.00	0.01
Unit Energy Savings	**Minimum**	-		0.29	-	-		-0.34	-
	Maximum	-		5.97	-	-		0.29	-
Percent Savings	**Minimum**	-		-	9%	-		-	-38%
	Maximum	-		-	69%	-		-	67%

Figure 6. Energy Savings for Sample of Ten Projects

[1] The test was intended to look only at direct involvement projects. This direct influence project is included because the building owner has two buildings on the same lot. He took what he learned from the first project (last Direct Involvement project in Figure 6) and applied it to the second. He plans to do so with future projects and to work with BetterBricks to continue improving energy efficiency. Energy savings for the Direct Involvement project were approximately twice that of the Direct Influence project.

The total savings for these ten projects are 2,173,845 kWh (0.25 aMW) and 18,176 therms.

The two grocery projects gave relatively similar results. Additional grocery sites will be needed to verify that these values are representative. Energy savings for grocery projects are largely dependant on the operation of the refrigeration system. Understanding the operation of the refrigeration systems and making appropriate changes to the refrigeration settings is critical to achieving energy savings in these projects. For both of these projects, the on-site refrigeration control systems have data trending capabilities that can be accessed for continued data collection and analysis. If additional grocery stores have similar capabilities this may be a viable approach to collecting and analyzing data in the long term. However accessing and understanding the data requires the services of someone who has access to the site as well as knowledge of the control system programming.

The six office and office/classroom projects have a wide range of savings. The sites with the largest savings used integrated solutions that offer several building control options to the occupants. As such the actual energy savings depend on how the occupants make use of the features such as daylighting, lighting controls, and natural ventilation. Longer term monitoring of the buildings can provide excellent data on the building operation and the 'as-operated' energy savings for these projects. As expected, large savings were achieved for sites with adequate daylighting such that the lights remained off for most of the day.

The projects with an integrated design solution, in general resulted in higher percent energy savings. The first two Classroom/Office projects are excellent examples of the integrated approach to building systems and envelope. The buildings have passive building features such as thermal mass and occupant controls such as natural ventilation dampers.

Still these two projects have very high energy percent savings that caused us to review the measures and assumptions closely. The first project with 45% energy savings had very high lighting savings for the reasons mentioned above and had an efficient HVAC system that included a variable air volume (VAV) system and under-floor ventilation. The second project with 56% savings had very low lighting energy consumption. Additionally, the project used an Energy Recovery Ventilation (ERV) system in place of mechanical cooling. As a result, the cooling energy savings were very high.

The second project also has large therm savings. The heating system has a control strategy that utilizes manual operation by the facility manager. The manual heating system setting provides excellent opportunities for energy savings as it ensures that the heating system is only called for during the coldest periods of the year, and the building operates in passive mode for the majority of the year.

The energy usage of these facilities often depends on the intelligent operation of all the capabilities provided to the occupants, and as such the 'as-operated' energy savings can vary significantly by year or by user. Longer term monitoring of energy use is a better predictor of 'as-operated' energy savings than the annualized energy simulation analysis software that are not best suited for passive and manual controls.

The majority of buildings had large lighting energy savings due to sufficient daylight, but not necessarily due to automated daylighting controls. Most buildings that have daylighting controls also have manual switches that are used very regularly by occupants, resulting in very low lighting energy use. While we believe that the savings are being realized from the current operating strategy, we can not be sure that the savings are representative of future projects or that the savings will be sustained if the occupants change. We will continue to investigate this in future analysis. The Direct Involvement office/ warehouse is a good example of a building with very low lighting energy use . The building has large electric savings (69%) because the lights were off most of the time. The warehouse has good daylighting and the default operating strategy is to have the lights off.

While conclusions cannot be drawn from this small sample of projects, the results do show that:

1. The protocol approach is able to calculate actual energy savings
2. Energy savings are being achieved by the BetterBricks Influenced projects
3. Electric energy savings tend to result in an increase in gas usage as a result of less internal heat being generated by more efficient lighting. (Overall energy usage is reduced, however)
4. As expected, there is a wide range in energy savings by project type and location.

5.6 Measures Analyzed

Figure 7 shows the measures that were analyzed for the projects shown in Figure 6. They represent the initial step in gathering data that will eventually be used to create the representative bundles of measures discussed in Section 2.2.

Grocery	
Refrigeration/HVAC	**Lighting/Daylighting**
Upgraded Refrigeration Controls	Skylights
Upgraded HVAC Controls	Lighting controls
Upgraded Refrigeration System	
Efficient Rooftop Units	
Efficient Display Case Fan Motors	
Domestic Water Heat Reclaim	
Added Roof Insulation	
Office	
HVAC	**Lighting/Daylighting**
High efficiency HVAC system	Natural lighting: skylights/sidelighting
Underfloor ventilation system	Daylighting controls
Night flush ventilation	High efficiency lighting
Increased insulation	
High efficiency windows with shading	
Classroom/office	
HVAC	**Lighting/Daylighting**
High thermal mass	T-8 lamps with high efficiency ballasts
Energy management system	Direct/Indirect suspended fixtures
ERV's controlled by occupancy sensors	Automated window shades
Manually operated classroom louvers	Occupancy sensors
Groundsource heat pump	Daylighting: sidelighting/clerestories
Heat recovery through ERV's	Daylighting controls
High efficiency glazing	Skylights (w/ operable blinds)
	Exterior and interior light shelves
Office/Whse	
HVAC	**Lighting/Daylighting**
High efficiency glazing	Daylight Controls
	Skylights

Figure 7. Energy Saving Measures for Sample of Ten Projects

6. ISSUES/ LESSONS LEARNED

The purpose of this first round of analysis was to test the assumptions of the protocol. As such, in addition to reporting energy savings, we are reporting on the overall procedure in terms of what worked and what didn't worked.

6.1 Protocol Implementation Challenges

6.1.1 CTS Status & Review

As stated in Chapter 4, Step One of our protocol assumes that project data are available in CTS. This turned out not to be true in many cases, leading to a time-consuming process of identifying and obtaining project documentation

CTS includes both Completed and Active projects. We originally expected that for projects marked as "Complete" all necessary data would be in CTS. HMG conducted a comprehensive review of completed projects in CTS in March 2007 and again in October 2007 to determine both the quantity and the quality of data. We identified 20 fields that are critical to the success of our proposed savings estimate approach. As of October 2007, for any given project an average of seven (7) of the critical 20 fields (35%) were missing. Of the 20 critical fields, the data were missing on average 38% of the time for any given field.

Our CTS review indicates that while basic project information is being entered -- specifically four fields required by CTS in order to save the project -- the detailed information that we need is not. Critical information such as building type, building size, project overview, completion data and energy efficiency strategy summary were missing for well over half the projects. Absent this data, we were not able to use CTS as planned.

If CTS is not consistently and fully populated with project data, our energy savings analysis approach will require more time for collecting and reviewing documentation than we initially anticipated. The end result is that NEEA will spend significantly more money for additional evaluation time. While a minor portion of this cost may be offset by implementation contractors doing less data entry work, implementers have more knowledge of the projects and are thus better qualified to do the data entry. We recommend that NEEA make full use of CTS and implement more expansive requirements for saving a project in CTS. If that is not done, then we will need to rethink the basis of the protocol, because the cost of generating savings estimates will be higher and the quality slightly lower than originally assumed.

6.1.2 Coordination with BetterBricks Implementers

Several of our first assumptions regarding Design & Construction projects were wrong, primarily that detailed energy analysis reports would be available for our review at the start of the process. For many projects, reports and detailed energy savings calculations were not readily available from BetterBricks implementers prior to the site visits. Lack of up-front documentation resulted in additional efforts by HMG staff to collect alternate sources of information from project designers, engineers, consultants and owners. While HMG was able to collect all needed data, the time and effort involved in getting the information from these sources make it an inefficient strategy. BetterBricks implementers need to play a greater role in collecting this documentation on an on-going basis and storing it for future use.

Our near-term evaluation strategy is to conduct site visits to verify measure installation and operation. We expected that we would get support from BetterBricks staff, technical advisors, market advisors and market partners in gaining access to the sites. The Lab staff were supportive, however they have other obligations and goals that take priority over our energy savings work. We were moderately successful in coordinating project reviews and site visits with the Labs. However there were often scheduling challenges that slowed down our process, particularly the site visits, increasing both the time and the cost to conduct the evaluation. In the short-term, if we want this process to work efficiently, we will need more support from the implementers.

6.2 BetterBricks Implementation Challenges

BetterBricks technical advisors state that it would be extremely difficult to require the project contacts (typically building owners) to provide documented energy savings even if they were given an incentive. In the current market structure, the majority of building owners do not see the benefit of this additional step, which they perceive as costing them time, even if they are not paying for the analysis. If BetterBricks needs documented energy savings (which they do for this protocol approach) it will probably have to provide a mechanism to encourage project owners to require it from their designers. On the other hand, it appears that the initiative has been extremely hesitant to require anything in return for the services being provided, services which have a very real value to both designers and owners. We think the initiative should explore being more aggressive in what they require when providing their services. We believe there is a good chance modest requirements would be accepted provided they are tightly defined and presented in advance. There is also a possibility that requiring some ‘payment’ will add to the perceived value of what the initiative is offering.

An alternative is for BetterBricks implementers to complete the analysis on their own (even if they don’t provide the owners with the documentation) but this runs counter to the goals of the initiative. The key point is that if documented energy savings are not going to be routinely developed then the basis for our energy savings protocol disappears.

BetterBricks staff and contractors also face challenges in knowing whether what they recommend is ultimately installed. They are generally unaware of the ultimate influence or implementation of their recommendations; this is even more true when their involvement is limited to the initial design stages of a project with informal meetings and no formal analysis reports. They also have no way of knowing whether their recommendations have influenced other projects. If BetterBricks needs to stay involved in the project until completion to verify installed recommendations, then the contractor needs to be told to do so and the project owner needs to see a value in the BetterBricks involvement. Again, this could become an initiative requirement for providing services.

6.3 Building Operations Approach

While this evaluation reports only on design and construction projects, we had initially thought that we would include building operations projects as well. This idea was dropped when we discovered that testing of the building operations protocol was more difficult than we anticipated.

Our initial thought was to conduct in-depth site analyses similar to our approach for design and construction. In practice, it was very difficult for us to get access to the right person for the projects. To get to the building engineer we worked through the BetterBricks' technical advisors, the service providers with whom BetterBricks has formal agreements and the business owners. However, because the service provider's primary relationship is with the owners rather than with BetterBricks we had difficulty using BetterBricks as leverage to gain access to buildings. Additionally, neither the building owners and operators nor the service providers have an incentive for assisting us. They indicated that they do not have the time to talk to us or want to be compensated for their time.

In the few cases where we managed to get site visits approved the process was extremely time-consuming and put negative pressure on important relationships that implementers are trying to develop. One possibility is for BetterBricks to modify its agreements with service providers to include provisions requiring tracking of specific fixes and pre- and post-conditions. This data could then be used directly for the energy savings analysis.

In addition to the protocol implementation difficulties, the Building Ops projects were also more challenging than the D&C projects in terms of collecting documentation. Data on the fixes implemented, and on pre- and post-conditions have been more difficult to obtain from the participants than anticipated.

The challenges faced by BetterBricks service provider partners are similar to those faced by BetterBricks staff and contractors. Their influence point and level are limited by the access and time given them by the building owners and operators and they need to be cognizant of the customers needs. Because of this business relationship, the service providers will always defer to the requests of the clients at the expense of BetterBricks requests. The issue of energy savings documentation is a good example. The NEEA logic model states that customers will be willing to pay for the additional documentation because it validates the proposed energy savings. In reality, the customers often do not feel the documentation is worth the additional time and expense, and therefore do not want the service. In the interest of customer service, the service provider will follow the customers' request and provide recommendations without providing detailed energy savings documentation.

The service provider provides a scoping study to the owner indicating the energy savings opportunities and total potential for multiple fixes and upgrades, but the implementation of these recommendations is up to the owner. The service provider (firm focus or otherwise) has limited leverage to get the owner to commit to their services. In one instance, the owner decided to do most of the easy fixes in house, leaving the more costly measures for the service provider.

We are currently re-thinking our approach to building operations projects and will pursue a revised approach in 2008.

6.4 Determining Baseline

The calculation of energy savings is dependent on the selection of a baseline. There are several different baselines that could be used for the BetterBricks initiative activity. These include:

- *Project /building specific.* A relatively simple approach that calculates the difference between how the building was originally planned to be built and operated (prior to any BetterBricks influence) and how the building actually operates. Assumes that documentation of an initial plan exists.
- *Code.* Uses standard code requirements to estimate the original or baseline conditions
- *Market.* Assumes the baseline building follows 'standard practice', meaning what is typically being done in the market of equivalent buildings. This approach is harder to quantify, particularly in the short term. However, many of the BetterBricks staff and contractors feel this is a better approach.

In this report we used project-specific baselines for those projects where such baselines were generated by BetterBricks staff and consultants. It should be noted that the project-specific baseline often has elements of the code and standard practice baselines. For example, the building envelope baseline might be the code mandated insulation levels, but where no code base exists such as refrigeration systems, market baseline or 'standard practice' is included in the project-specific baseline. Ensuring comparability of HMG's analysis with the original project analysis was the primary benefit of, and motivation for, using the project-specific baseline for the first round analysis.

In the long-term, as we start analyzing Direct Influence and Indirect Influence projects, we will not have the luxury of documented project baseline assumptions. NEEA therefore needs to decide which baseline will best serve its needs at the aggregate market level. The best baseline may vary depending on whether the market is for new construction or building operations. As protocol development proceeds, we will continue to investigate the various baseline approaches. Ultimately NEEA will need a policy-level decision on baseline in order for us to finalize our protocols.

6.5 Persistence of Savings

The protocols we have developed calculate savings at a specific point in time which may not always represent an ideal, average, "steady-state" operation. Building consumption, and therefore savings, can shift over time for reasons connected to persistence, commissioning and normal variation in consumption over time due to changing number of occupants, building use, etc. There is no single correct solution to this problem but the protocol needs to use a consistent way/time to measure energy use and estimate saving. As we work through the building operations protocol we will propose an approach for identifying and defining steady-state, or will propose a strategy for addressing non-steady-state conditions.

6.6 Scope of Analysis

With one exception, the projects analyzed for this report fell only into the design and construction/direct involvement category of the framework. In 2008, we will be expanding our analysis to include the level of direct influence as well as the categories of building operations and procurement. Some information on direct influence projects was gathered during the course of preparing this report; this information will be pursued in more detail and followed with site visits to begin understanding if there are systemic differences between direct involvement and direct influence projects. HMG will also attempt to identify additional projects through interviews with BetterBricks staff, BetterBricks contractors, service providers and market actors – essentially anyone who may be able to connect the actions that an organization took to information they received from or experiences they had with BetterBricks.

7. NEXT STEPS

This year we reported on ten Design & Construction projects. Next year we expect to have more projects and perhaps a revised protocol. Specifically, we will be following up on additional Direct Involvement projects and Direct Influence projects. We will also re-contact some of our initial interviewees to identify new projects that were potentially influenced by BetterBricks.

In 2008, we will test our Building Ops protocol, revising the data collection approach and working with staff to develop a long-term workable strategy. We will modify our approach by conducting an initial broad analysis of fuel consumption data to establish individual site trends and program patterns that will help formulate new Building Ops protocols. This approach aligns with the original intentions of the Building Operations program.

As we analyze additional projects, we will begin to identify measure bundles and the associated savings. For all projects, we will decide when site visits are necessary and develop an alternative data collection approach.

We will work with NEEA staff to prepare recommendations on baselines for policy adoption.

8. APPENDIX. ENERGY SAVINGS APPROACHES

Once the measures are defined in each protocol, we can estimate energy savings associated with the measures that will lead to widely accepted, defensible EUIs. EUIs can be calculated, measured, or deemed, based on available data. We need to have building level details that impact energy use and energy efficiency components including characteristics and services. The levels of data collection can range from simple to complex:

1. Most Simple: Self-reports by building operators
2. Fairly Simple: Telephone interviews with building design engineers/architects and installers
3. Less Simple: Engineering reviews of energy reports on the buildings
4. Less Complicated: On-site surveys of building systems and characteristics
5. Fairly Complicated: DOE-2 simulations of as-built and base case buildings
6. More Complicated: On-site end-use metering of equipment energy demand and operational profiles
7. Building Science Research: Detailed performance measurements for equipment and systems, such as refrigerant charge, air flow, time-of-use metering, etc.

We will start with available data and then try to develop other sources that will increase accuracy or confidence. The energy savings estimates and data collection approaches will be refined as we improve the methodology. We start with a list of techniques developed by the Integrated Design Labs. The techniques are:

***Expert Judgment*:** In circumstances where the building or space is similar to those analyzed on past projects, expert judgment is by far the fastest technique. Quite often it is used in conjunction with rule of thumb or simple calculations (described below). Any other more complex technique also relies on the past experience and judgment of the modeler for its accuracy.

***Default Path*:** We assume that if the building is designed to a certain standard it will achieve a certain level of savings. For instance, if the building is an Oregon State Energy Efficiency Design (SEED) program building, it will save X%. If the building is designed to the Oregon code, it will be y% better than ASHRAE/IESNA 90.1-2004. The effort to use this technique is the work required to define the expected savings by building type. If the buildings are of a limited number of types, this technique will be relatively inexpensive. As the number of types increases, the effort required for this technique increases. It does not predict the actual savings.

***Rule-of-Thumb*:** Quickly predict savings based on empirical and/or theoretical data. For example, past studies have shown that a type of building saves from x% to y% when measures a, b, and c are included. This technique is similar to the Default Path in terms of effort required, although it will need a modest amount of additional effort to apply the rules-of-thumb for each building.

Simple Calculations: Savings are predicted by system or component using simplified algorithms. For example: daylighting saves 60% annually (based on previous experience/data) on electric lights, electric lights are 40% of the baseline energy use, so the building saves 24% (60% x 40%).

Prescriptive Path: A savings percentage is calculated/assigned to each energy design strategy on a list for various building types. This could also be done for bundles of strategies, based on documentation of generic building types, either empirical or theoretical. For example:

Energy Design Strategy	**Done?**	**Savings**
Windows designed for daylighting	X	**15%**
Exterior operable shades		15%
Exterior fixed shades	X	**3%**
Interior operable shades	X	**10%**
On/off photo-controlled switching		10%
Stepped photo-controlled switching	X	**15%**
Dimming photo-controlled switching		20%
Total		**43%**

Example Prescriptive Path Savings Prediction

This technique would require a significant amount of effort to develop the predictions but would be relatively easy to use.

Simple Computer Model: A software program such as Energy Scheming can be used to show how design improvements affect loads/systems: for instance, to show that changing the R-value by x reduces the loads y%, and reducing the loads y% saves z% annually. The simple tradeoff in Oregon's CodeComp software could be used in this fashion. This technique would require a moderate investment per project, although this would be reduced somewhat by creating template files for various energy codes.

Elaborate Computer Model: A complete DOE2 or other simulation can be built for the building. This is the most time-consuming technique.

The techniques may be combined as appropriate for a particular project. Simpler techniques will reasonably predict energy savings as well as more complex ones as long as the characteristics of the building or space lie within the assumptions of the technique.