# Minnesota B3 Benchmarking Results: Prioritizing the Energy Savings Opportunity in Minnesota Public Buildings

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**ABSTRACT**

Minnesota initiated the "B3" building energy benchmarking program to guide effective allocation of energy conservation investments in existing buildings. The data collection process relies on a web-based tool through which building representatives of public buildings enter data, including building characteristics and utility bills. The users can see how their buildings compare to individualized benchmarks. B3 advances a unique approach to determine the benchmarks: a parametric model based on space-type simulations and prescriptive requirements in the current Minnesota energy code. The advantage of this modeling approach is precise knowledge of the underlying building characteristics associated with the current energy code. Buildings with actual energy use significantly above their benchmark are most likely to have a better return on investment for conservation improvements.

Participant response is highly positive, with representatives submitting and tracking data on 4,237 (74% of 5,746) public buildings and counting. Analysis of the data provides a picture of energy use with respect to building type, age, and size. Overall, there are 344 sites (29%) in the analyzable data set of 1,205 sites that exceed their specific benchmark. These sites represent an annual opportunity to save more than $10,000,000 in energy costs and 87,000 metric tons of carbon dioxide emissions. On average, schools, offices, and college classrooms/laboratories perform around the benchmark, but at least 10% of the sites in each category consume more than the benchmark. As the B3 Benchmarking program evolves and conservation improvements are implemented, future studies will look at the tracked performance of retrofitted buildings.

## Introduction

The B3 Benchmarking program started in 2004 as a coordinated effort to achieve advanced energy performance in the state of Minnesota's public buildings. The benchmarking program addresses the needs of existing buildings, and a complimentary effort, the B3 Guidelines (http://www.msbg.umn.edu/), supports the design process of new public buildings. As of January 4, 2008, the B3 Benchmarking initiative had over 4,000 public buildings in its database and several organizations using the benchmarking tool to identify and prioritize energy improvement opportunities. Data and lessons learned are emerging and ready for analysis.

In the B3 Benchmarking program, we provide a unique benchmark for each building. By comparing a building to its unique benchmark, the opportunity for energy savings can be determined. By then comparing opportunity across buildings, one can come up with a prioritized list of buildings that offer the highest potential for cost effective improvements to energy consumption. This systematic method of comparison will help managers justify and win the funds necessary to complete further analysis through energy audits and, ultimately, energy conservation upgrades.

While data collection is still in progress, the program is just at the point where an analyzable data set is available. The objectives of this study are twofold. First, we describe the process of carrying out a legislative directive to implement a state-wide benchmarking system and share our lessons learned. Second, we analyze data on the public building stock's energy consumption to answer questions such as how much energy savings opportunity is realistically available and where is the opportunity?

**Short History**

Legislation in 2001 and 2002 provided the framework for the creation of what is now the Minnesota B3 Benchmarking program. The language of the legislation (Laws 2002, Chapter 398, Section 8) requires the Department of Administration and the Department of Commerce of the State of Minnesota to maintain information on energy usage in all public buildings. The legislation stipulates that the operators of public buildings provide information to support these goals. It states that the purpose of the data collection is to establish benchmarks and energy conservation goals so as to develop a plan for energy conservation via strategies that have paybacks of 10-15 years. From this, we designed and developed a system to track and find cost effective energy savings opportunities in Minnesota public buildings.

The team that developed the B3 Benchmarking system includes:

- the Minnesota Department of Commerce and Minnesota Department of Administration,
- LHB, an architecture and engineering firm, and
- The Weidt Group, an energy design and software firm.

Together, the team translated the requirements of the program into the following list of objectives:

- Gather building data and energy consumption data on Minnesota public buildings.
- Evaluate ("benchmark") the performance of each building.
- Identify the short list of buildings that have the highest potential return on investment for energy conservation improvement dollars spent to be further analyzed with energy audits.

The approach and architecture behind the web-based software is based on the concept that, in order to meet the State's legislative goals, the system needed to be user friendly. This includes means of engaging the building representatives, or Stakeholders. The objective of this paper is to report on Minnesota's benchmarking experience and on the findings realized in the initial data collected for public buildings.

## Background

As energy costs and environmental impacts rise, opportunities for reducing energy use become increasingly important. In the public sector, money that is spent on energy bills reduces the available taxpayer funding that is available for other important services. Existing buildings are an important source of conservation opportunity, not only because they account for a much larger percentage of the building stock than new construction, but also because changes in a building's use and occupancy over time have adverse impacts on energy consumption.

Ultimately, when spending money to improve the performance of existing buildings, it is important to select the buildings that will most benefit from improvement dollars spent and to then select the measures that will provide the most energy conservation return on that investment.

## Commercial Building Benchmarking Systems Review

The creation of good quality benchmarks requires good quality data plus the use of normalization factors to separate operational issues from efficiency issues (Bannister and Hinge, 2006). The primary approaches to benchmarking the energy use of existing commercial buildings are as follows:

- Comparison to an empirical model derived from a sample of other similar buildings in a population – Energy Star approach
- Comparison to past energy bills – the "tracking" approach
- Comparison to the results of an energy simulation model with certain pre-defined baseline characteristics, such as meeting an energy code or standard – B3 approach

Empirical benchmarking, as relevant to this paper, is comparison of actual building performance against the broader building market. In creating such a benchmark, one has to be sure of the comparability of the building to the data set. This typically means that a range of normalization factors are required to provide a common basis for comparison. By this method, differences in climate, building size and hours of operation can typically be eliminated from the comparison (Bannister and Hinge, 2006). The Energy Star Portfolio Manager is an example of the empirical approach (EPA, 2007). The empirical approach requires a properly selected random sample from each population of relevant building types to create the empirical model. California, for example, expanded the Energy Star statistical benchmarking method based on the California End Use Survey (Matson and Piette, 2006). For Minnesota, the statistical approach was not used primarily because of the need to have data, which did not already exist, for 154 different building, or space usage, types.

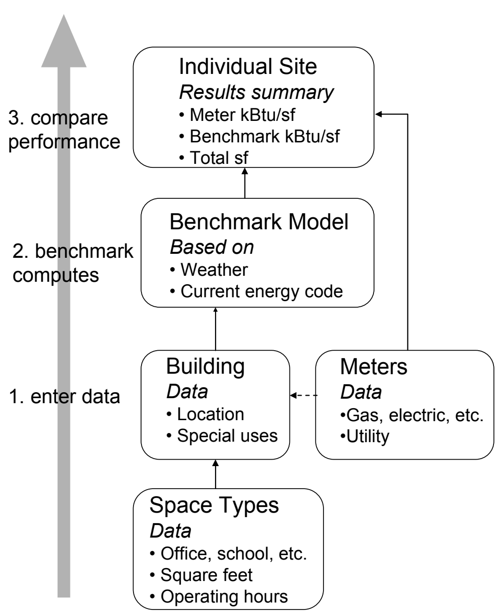
"Tracking" benchmarking, or comparing a building to itself over time, is useful in identifying changes in building performance. Alarms raised by unexpected changes in consumption can prompt an operator to analyze and act quickly to save energy. Tracking benchmarking is useful for trend analysis, but does not show the baseline efficiency with which a building is operating. Thus, tracking benchmarking is generally accompanied by one of the other two forms of benchmarking.

The energy simulation model approach was developed and implemented in the B3 Benchmarking process. With a model based approach, the B3 program can evaluate the performance of a small population of buildings, or even a single building because creating a model is more efficient than gathering data for a large population of a particular building type. The 154 space usage types currently available in B3 Benchmarking were developed with DOE2 energy simulation models to match the public building stock in Minnesota.

The performance metric used in B3 Benchmarking is a building annual energy use index (EUI). The units of the EUI is kBtu/sf/year, and it includes the energy to heat, cool, ventilate, light, and run typical equipment inside a building, as if the building were built to the current Minnesota energy code. This allows for known inputs on the parameters that affect heating, cooling, lighting and other energy end-uses as based on a current standard. The current Minnesota energy code for commercial buildings is a variant of the ASHRAE 90.l-1989 version. When a new building code is adopted, the B3 Benchmark can likewise be moved to match the increased stringency of an improved code. A unique index is generated for each building. The index can account for different fuel types, such as whether the building is heated by natural gas or district steam. For this data set, all indices are based on modeling results using the same Minnesota climate file.

Figure 1 shows the process for collecting data, computing the benchmark, and displaying the information to the system user. The model weighs the base benchmark for a given space type by changes in key input variables, such as fuel source, number of operating hours per day; number of days of operation per week; number of months of operation per year; and percent heated or cooled. Other special use conditions that a user may select and thereby adjust the benchmark model include the presence of a pool, data center, parking lot, or kitchen. As shown in Figure 2, the tool prompts users to enter information on those factors in addition to their monthly utility bill data, in both energy and cost units.

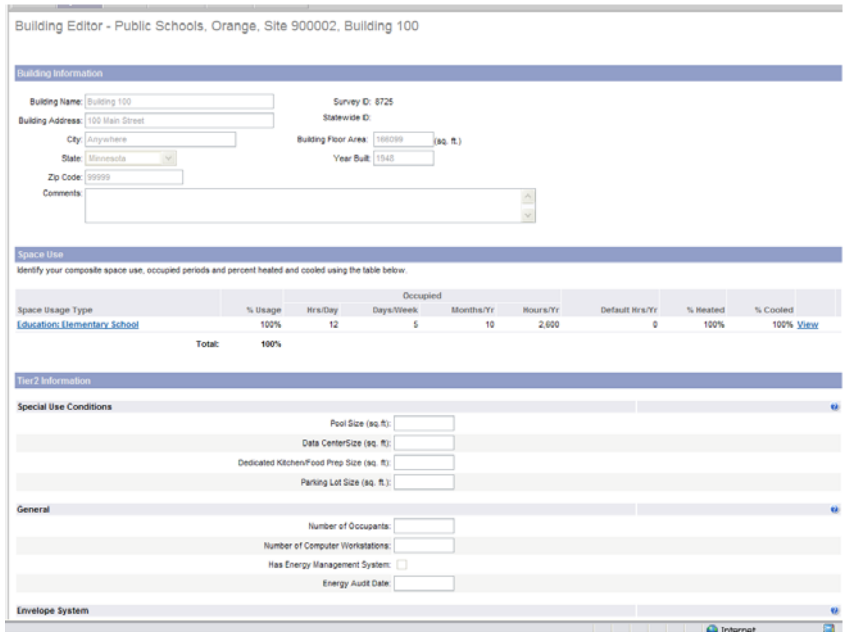
**Figure 1. Diagram of Data Relationships in the B3 Benchmarking Tool**




Users can compare their building site's benchmark index to the site's actual metered consumption. This approach provides Stakeholders with a meaningful representation of their own building's performance without comparing it to other Stakeholders' buildings. Driven by the goal of prioritizing funding opportunities as opposed to comparing one group's buildings to another's, the energy use index approach achieves a non-defensive method of assessing performance.

Despite the differences between the empirical and modeling approaches, the same inputs are generally needed for the different management systems, and similar results are obtained from each. Building managers can use both to determine their best performers as well as to identify the buildings most likely to provide cost effective return on energy conservation investment, to be further investigated with energy audits. For any benchmarking effort, the follow-up step is to perform additional investigations to ascribe causes and implement energy savings measures. For example, California's plans for its benchmarking system include developing an expert system that leads the user through a series of building and end-use specific questions and suggests possible retrofits or operational changes to reduce energy use (Matson and Piette, 2006; LBNL, 2008). The B3 Benchmarking tool also queries the user for retrofit and audit information such as the dates of replacements for heating or lighting systems, or when the last energy audit was conducted. This aspect of the benchmarking tool is designed to aid the process of carrying out energy audits.

**Figure 2. View of a Building Site's Page in B3 Benchmarking**



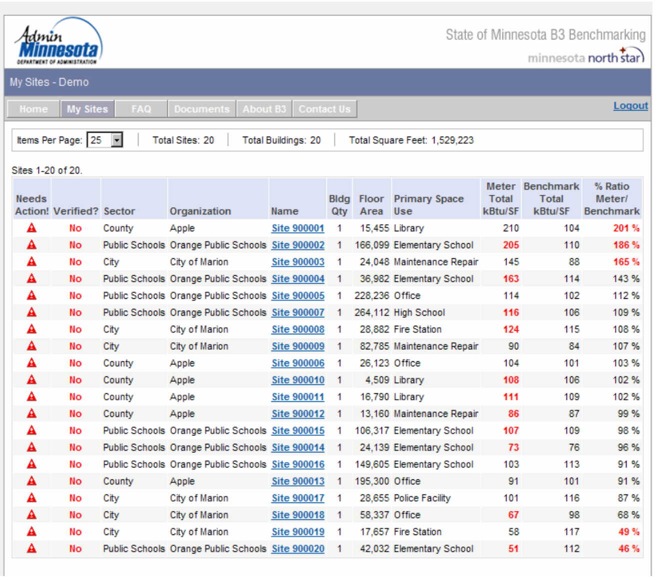

## Methodology

The following section describes the design of the data store behind the B3 Benchmarking system.

### Data Description

Any analysis of building consumption is limited by the arrangement of meters and the buildings they serve. It is not uncommon for a single gas or electric meter to measure consumption for several buildings. Such an arrangement does not allow analysis down to the building level, but rather to the *site* level, which is defined as the smallest set of buildings that has a unique set of meters. In many cases, benchmarking analysis would be more accurate if sub meters were added to each building, or even to individual circuits within buildings. The B3 system can accommodate increasing granularity of analysis if submeters or additional meters are added.

**Figure 3. Sample Page in B3 Benchmarking Showing the Stakeholders All the Sites in Their Management with Summary Benchmarks for Each Site**



Admin Minnesota DEPARTMENT OF ADMINISTRATION

State of Minnesota B3 Benchmarking

minnesota north star

My Sites - Demo

Home | My Sites | FAQ | Documents | About B3 | Contact Us | Logout

Items Per Page: 25 | Total Sites: 20 | Total Buildings: 20 | Total Square Feet: 1,529,223

Sites 1-20 of 20.

| Needs Action! | Verified? | Sector | Organization | Name | Bldg Qty | Floor Area | Primary Space Use | Meter Total kBtu/SF | Benchmark Total kBtu/SF | % Ratio Meter/ Benchmark |
|---|---|---|---|---|---|---|---|---|---|---|
| | No | County | Apple | Site 900001 | 1 | 15,455 | Library | 210 | 104 | 201 % |
| | No | Public Schools | Orange Public Schools | Site 900002 | 1 | 166,099 | Elementary School | 205 | 110 | 186 % |
| | No | City | City of Marion | Site 900003 | 1 | 24,048 | Maintenance Repair | 145 | 88 | 165 % |
| | No | Public Schools | Orange Public Schools | Site 900004 | 1 | 36,982 | Elementary School | 163 | 114 | 143 % |
| | No | Public Schools | Orange Public Schools | Site 900005 | 1 | 228,236 | Office | 114 | 102 | 112 % |
| | No | Public Schools | Orange Public Schools | Site 900007 | 1 | 264,112 | High School | 116 | 106 | 109 % |
| | No | City | City of Marion | Site 900008 | 1 | 28,882 | Fire Station | 124 | 115 | 108 % |
| | No | City | City of Marion | Site 900009 | 1 | 82,785 | Maintenance Repair | 90 | 84 | 107 % |
| | No | County | Apple | Site 900006 | 1 | 26,123 | Office | 104 | 101 | 103 % |
| | No | County | Apple | Site 900010 | 1 | 4,509 | Library | 108 | 106 | 102 % |
| | No | County | Apple | Site 900011 | 1 | 16,790 | Library | 111 | 109 | 102 % |
| | No | County | Apple | Site 900012 | 1 | 13,160 | Maintenance Repair | 86 | 87 | 99 % |
| | No | Public Schools | Orange Public Schools | Site 900015 | 1 | 106,317 | Elementary School | 107 | 109 | 98 % |
| | No | Public Schools | Orange Public Schools | Site 900014 | 1 | 24,139 | Elementary School | 73 | 76 | 96 % |
| | No | Public Schools | Orange Public Schools | Site 900016 | 1 | 149,605 | Elementary School | 103 | 113 | 91 % |
| | No | County | Apple | Site 900013 | 1 | 195,300 | Office | 91 | 101 | 91 % |
| | No | City | City of Marion | Site 900017 | 1 | 28,655 | Police Facility | 101 | 116 | 87 % |
| | No | City | City of Marion | Site 900018 | 1 | 58,337 | Office | 67 | 98 | 68 % |
| | No | City | City of Marion | Site 900019 | 1 | 17,657 | Fire Station | 58 | 117 | 49 % |
| | No | Public Schools | Orange Public Schools | Site 900020 | 1 | 42,032 | Elementary School | 51 | 112 | 46 % |

## Data Collection Process

No central data repository existed for Minnesota's population of public buildings, so the B3 Benchmarking initiative first set out to make a list of public buildings. First we collated, merged and purged multiple building lists (e.g. from state agencies, insurance companies, utilities, etc) to create a beginning list of buildings. Then we found the Stakeholders of the obviously large collections of buildings with a single Stakeholder (e.g. City of Minneapolis or the Minnesota Department of Administration). A Stakeholder is defined as someone who is able to supply building and consumption data. This may be an owner, operator, manager, or agency.

Figure 3 shows an example summary page that a Stakeholder would see if they had multiple sites in the B3 Benchmarking tool. Throughout the process, we found that the most effective way to gather data for B3 Benchmarking was to first, gather a minimum amount of data to identify potential candidates for the best improvement in energy consumption. While it is tempting to ask for all sorts of information about buildings, there is a trade-off between the amount of information that could be acquired and the willingness of participants to invest the time to supply the data.

The B3 Benchmarking team decided to gather very basic (Tier 1) information about each building, limited to space usage types, operation hours, and area, and then use those data to create a shorter list of buildings for which we would collect deeper information (Tier 2), such as special uses and history of retrofits. Tier 2 information is used to refine the comparison model and pinpoint buildings that are candidates for energy audits.

The Benchmarking tool's services and data acquisition functions are delivered via the Internet. We ran pilot tests using paper, email, and the Internet, and found the Internet to be most effective in gathering data for the following capabilities:

- Provide instant feedback to the data entry process for validation.
- Reward the Stakeholder immediately for their efforts.

- Provides interaction with the data repository in which the Stakeholder can manage their building data.

To manage the stakeholders and building sites, we divided Minnesota public buildings into four sectors: State, City, County, and Public Schools.

Data is only gathered for buildings larger than 5,000 square feet. One exception to this rule is the case of a building less than 5,000 square feet sharing a meter with a building greater than 5,000 square feet. In that case we must account for the energy used by the small building in evaluating the performance of the larger. At this point we are aware of 5,746 public buildings in Minnesota.

## Results and Discussion

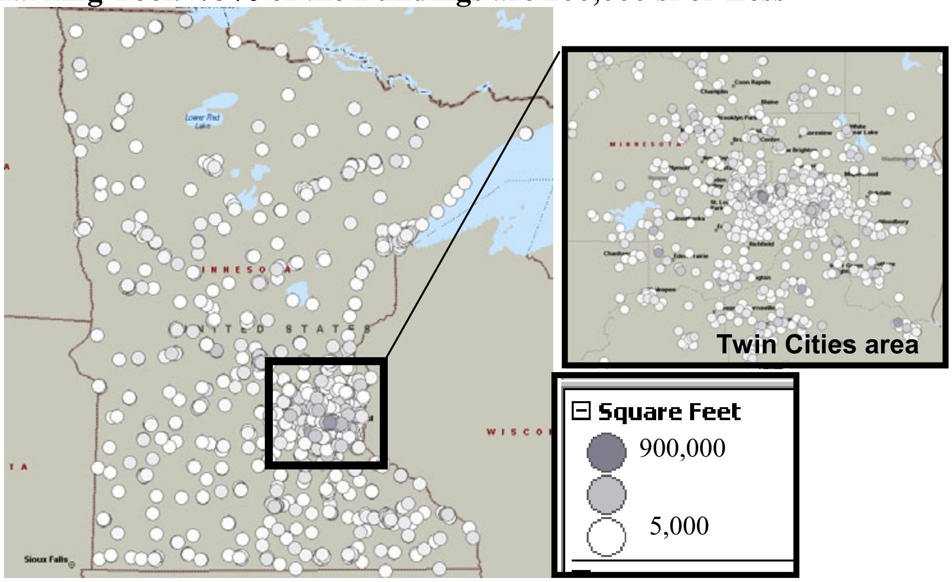
The following questions are answered in this section:

- How many building sites are in and using the B3 Benchmarking tool?
- What is the current snapshot of energy use in public buildings?
- Where is the opportunity for energy savings in Minnesota public buildings?
- Does the benchmarking process improve return on investment?

### Participant Response

As of January 4, 2008, stakeholders were using the B3 Benchmarking tool for 4,237 (74% of 5,746) buildings and counting. **Figure 4** shows the geographic distribution of public buildings across the state of Minnesota. Approximately 75% of the buildings are 100,000 sf or less. The shading of the dots in **Figure 4** indicates the square feet in each building. The buildings correspond to 2,342 sites. Of this total number of sites, 38% are schools, 26% are state sites, 25% are city sites, and 11% are county sites. A large concentration of the buildings is in the Twin Cities metropolitan area. State buildings are mostly located in the Twin Cities area and on the various State university campuses throughout the state. The other sectors have buildings throughout the state, and most buildings in the other sectors are less than 50,000 sf. Schools are the exception, with one-third of sites less than 60,000 sf, another one-third in the range 60,000-110,000 sf, and the last one-third in the range of 110,000-650,000 sf.

**Figure 4. A Map of the Location and Size of the 4,237 Buildings in the Minnesota B3 Benchmarking Tool. 75% of the Buildings are 100,000 sf or Less**

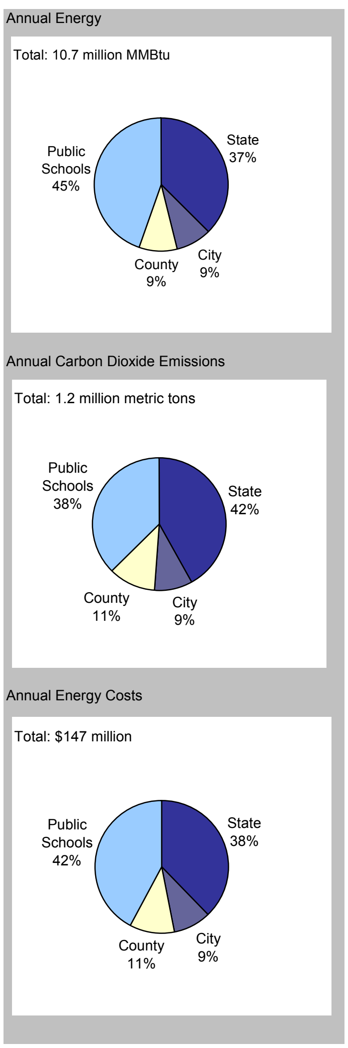



Because stakeholders are still in the process of entering data into the tool, several filters are placed on the data for further analysis of energy use and conservation opportunity:

- twelve consecutive months of meter data,
- space usage type(s) selected with data for area (square feet) entered, and
- actual usage not more than 300% of the model prediction

Of these filters, the most common reason for a site to be excluded from the analyzable data set is that data entry is still in progress, so either meter data or space type data is missing. This is expected due to the work in progress nature of the effort. The filter for valid entry of space usage and corresponding area is required for the model to calculate the baseline energy use. The third filter excludes sites that are more than 300% above the model prediction because it is likely that an outlier has a data problem. These outlier data points are not analyzed in the scope of this study, but will be of special interest for the program going forward. If the result is correct, meaning energy use is three or more times higher than the benchmark, those sites would represent large potential opportunities for energy savings.

**Figure 5. Annual Energy Use of Analyzable Sites Using B3 Benchmarking**




After applying the data filters, the analyzable data set consisted of 1,205 sites, or just over half of the total number of sites currently in use in the B3 Benchmarking tool. Figure 5 presents an annualized snapshot of energy use in these sites by sector: State (including public universities), Public Schools, County, and City. The annualized data is calculated using the most recent consecutive 12 months of data for a site. Stakeholders are not necessarily, nor currently required to, continuously update the data for their sites, so the range of years for the energy snapshot is 2004-2007. For these 1,205 sites, a total of 10.7 million MMBtu are consumed, representing $147 million in energy costs and 1.2 million metric tons of carbon dioxide emissions.

The breakout by sector shows that the State Buildings, including public universities, and Public Schools are the largest sectors of energy consumption. They are also the largest sectors by area: 28% State and 50% Public School. The State buildings use steam as a source of heat, and this is the main reason for slight variation in that sector's percentage share of carbon dioxide emissions as compared to energy use and costs: energy is reported at the site while emissions are reported for the source.

General characteristics of this data set, including size, age, and space usage type, are shown in Figure 6. The first graph shows the breakdown in area of the sites. The total is 106 million square feet. Looking at the tails, 15% of the sites are less than 10,000 sf and 11% of the sites are greater than or equal to 200,000 sf. There are 436 sites, or 36% of the total, in the range of 10,000-50,000 sf. Overall, 75% of the sites in the analyzable data set are less than 100,000 sf.

A total of 1131 sites included data for age of buildings in the site. For sites that included more than one building, the age of the site is calculated as the area-weighted average of buildings in the site. The distribution in Figure 6 shows that 367 (32%) of the 1131 sites have buildings that are more than 50 years old on average. Only 115 sites, or 10%, of the 1131 sites are less than 10 years old.

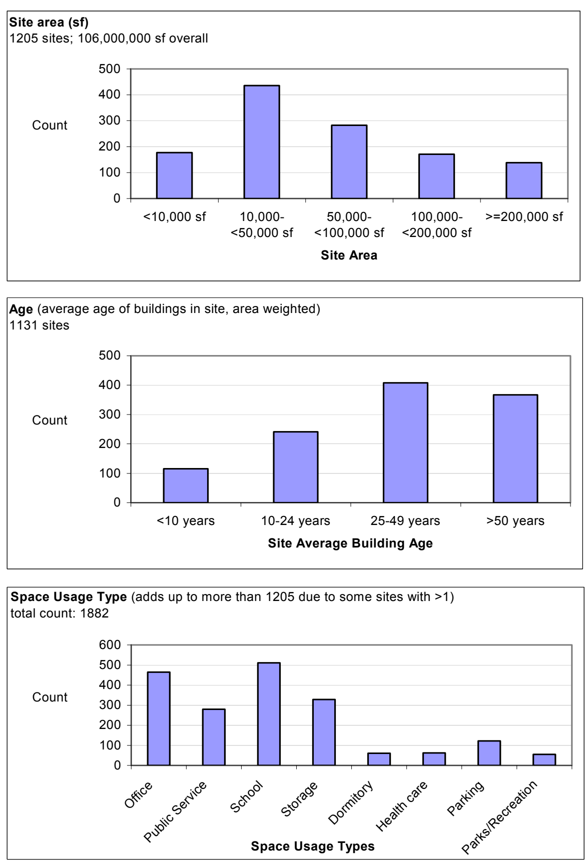



**Figure 6. Characteristics of the Analyzable Data Set, Including Size, Age, and Space Usage Type**

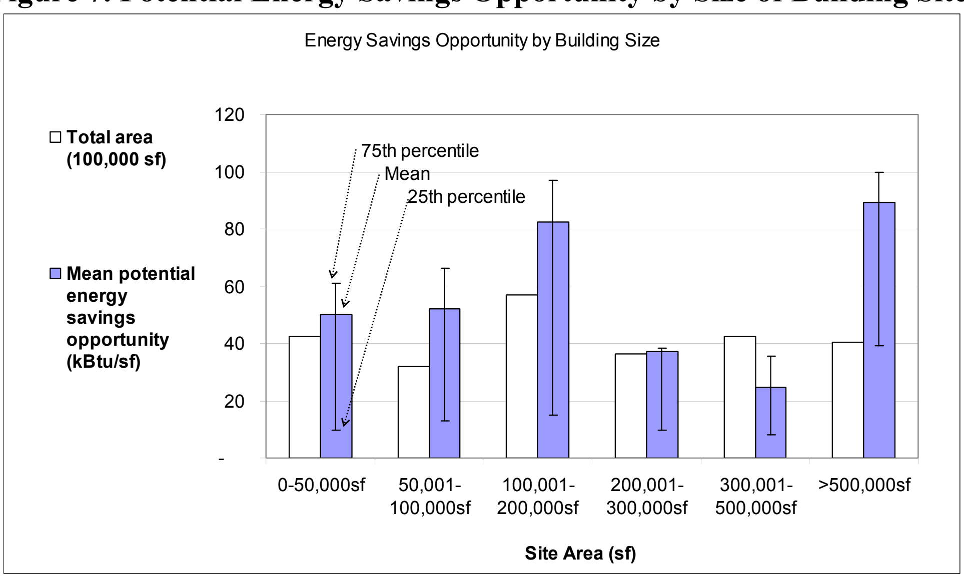
The third graph in Figure 6 shows the number of sites with the various space usage types. Even though not all space usage types are reported in this figure, the total still adds up to more than 1,205 sites because some sites have multiple buildings and some buildings have multiple space usage types. For example, a site may have 80% of its area as hospital and 20% as office. Another site may include 50% school and 50% public service. The space types of office and school are the most common in the data set, accounting for 114 million and 57 million square feet respectively.

### Potential Energy Savings Opportunity

The next step in the B3 Benchmarking process is to identify the sites with the highest potential for energy savings opportunity. Because the benchmark does not normalize for different uses within a given building type, it should be stressed that the screening performed with the benchmarking tool is a first step towards getting a good list of buildings with potential for savings. The next step is to do site visits and energy audits to identify the specific opportunities for savings in any given building. For the following analysis, "opportunity" is defined as any site that uses more than the model benchmark predicts, but less than 300% per the filter definitions for the data set. Of the 1,205 sites in the data set, 344 (29%) are over the benchmark. If each of these 344 sites' energy use was brought down to the benchmark level, this would mean an annual opportunity to potentially save more than $12,000,000 in energy costs and 55,000 metric tons of carbon dioxide emissions. The following analysis looks at the energy savings opportunity by size of the site, by age of buildings in the site, and by space usage types. All reported averages are area-weighted.

Figure 7 breaks the sites into bins by square footage in the site. While all bins have energy savings opportunity, the mean potential opportunity per square foot is highest in those sites larger than 500,000 sf (89 kBtu/sf savings) and lowest in the range of 300,001-500,000 sf (25 kBtu/sf savings). The second highest group is 100,001-200,000 sf (83 kBtu/sf mean savings). The bin for 100,001-200,000 sf has the largest total area; its 38 sites include 16 school sites and 18 state sites. Three-quarters of the total energy savings opportunity (kBtu) is in sites of size 100,000 sf or more (71 sites)

**Figure 7. Potential Energy Savings Opportunity by Size of Building Site**

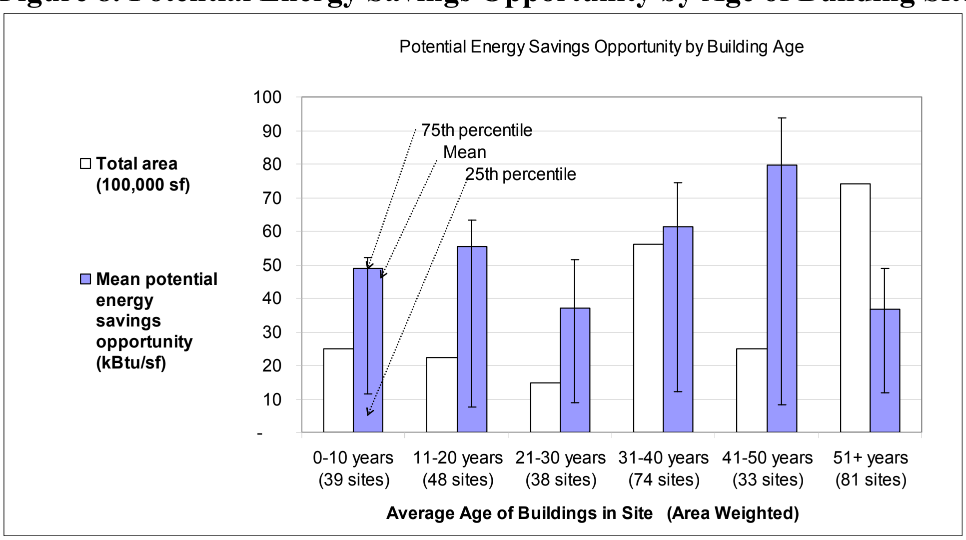



Analysis of the energy savings opportunity by age of the buildings in the site is given in Figure 8. Average age of the buildings in the site is an area weighted calculation, and the potential energy savings opportunity is the mean of the kBtu/sf for each group's data set.

Looking at the data by age reveals that newer buildings (0-10 years) that perform above the benchmark are on average higher above the benchmark (49 kBtu/sf opportunity) than older buildings (more than 50 years) at 37 kBtu/sf of opportunity. However, the area of buildings in the 51+ year bracket is much larger than in the less than 10 year bracket. The largest potential opportunity for energy savings, on a kBtu/sf basis, is in the age brackets of 31-40 and 41-50 years, with 61 kBtu/sf and 80 kBtu/sf of mean potential savings opportunity respectively. The age brackets of 31-40 years and 51+ years have the largest square footage with energy savings opportunity, at 5,500,00 sf (74 sites) and 7,400,000 sf (81 sites) respectively. In this data set, the age group of 21-30 years apparently has the lowest potential opportunity for energy savings, at an average of 37 kBtu/sf. This age group also has the lowest number of sites, 38, compared to the highest number of sites of 81 in the 51+ year group.

The result that newer buildings have roughly the same average energy savings opportunity as the older age group is counterintuitive against the argument that newer technology and newer building codes reduce a building's energy use. This is not a unique finding in this study alone, but it is worth mention. The counterbalancing effect of higher performance demand for comfort and safety in newer buildings, such as increased ventilation rates, tighter control of thermal environments, and air-conditioning results in higher energy use despite the potential use of more efficient technologies. Kodet and McDougall (1998) noted a similar finding in a study that compared energy performance of new and old schools. In the B3 data set, both the newer and older age groups have similar distributions in building types, including schools, health care, and laboratory type buildings. This data also supports the idea that operation of newer and older buildings alike requires attention and refinement over time, as building uses, occupants, and facility managers change.

**Figure 8. Potential Energy Savings Opportunity by Age of Building Site**



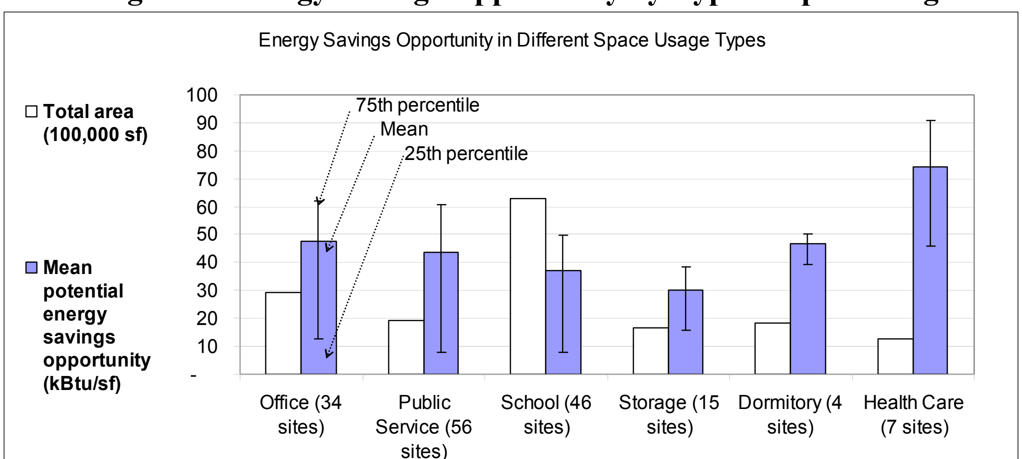

We limit the analysis of savings opportunity by space usage type to those sites with only a single space usage so as to not introduce other dependent variables. This reduces the data set to 162 sites, from the 344 total sites with energy savings opportunity in the 1,205 site set of filtered data. Figure 9 shows the energy savings opportunity for the following space usage types: office, public service, school, storage, dormitory, and health care. The public service type includes individual models for library, community center, fire station, jail, courthouse, and thus represents the most varied of the space type categories in the analysis.

As a percentage of the overall sites with 100% of a given space usage type, 58% of healthcare sites have potential energy savings opportunity, followed by 38% of public service, 35% of office, 29% of dormitory, 21% of storage, and 11% of school sites.

Despite their low percentage on the basis of number of sites, the largest overall area of opportunity is in schools, at over 6,000,000 sf in 46 sites. Schools have an average potential energy savings opportunity of 37 kBtu/sf (above the benchmark), with a 75$^{th}$ percentile value of 50 kBtu/sf (above the benchmark) and 90$^{th}$ percentile value of 96 kBtu/sf (above the benchmark). The model, or benchmark, EUI value for schools is approximately 107 kBtu/sf of energy consumption, with variation depending on elementary, middle, or high school; number of operating hours per day; number of days of operation per week; number of months of operation per year; percent heated or cooled; and special use conditions such as a pool, data center, parking lot, or kitchen. It is possible, however, that the person entering the data has not included a special use condition when in fact one exists. For this reason, we designed the benchmarking tool to facilitate recording of such details to further refine the site's score compared to the benchmark after further investigation. It is important to verify that all of a site's data are correct and complete before using the information to make decisions on where to provide funding for energy conservation improvements.

The space types with the highest average potential energy savings opportunity on a per square foot basis are office buildings and health care buildings, with the opportunity to save 48 kBtu/sf and 74 kBtu/sf respectively. There are 34 and 7 sites in each of these groups, accounting for 2,900,000 sf of office space and 1,300,000 square feet of health care space. There are far fewer sites in the health care category so attention to any one site will address a larger square footage as compared to any single site in the public service sector.

**Figure 9. Energy Savings Opportunity by Type of Space Usage**




| Benchmark EUI (kBtu/sf) | 94 | 90-120 | 107 | 54-97 | 147 | 80-195 |
|---|---|---|---|---|---|---|

**Space Usage Type (Number of Sites)**

Note: Benchmark values shown are *typical* values for that space type.

**Return on Investment Analysis**

The following return on investment (ROI) analysis relates the actual building data in the B3 database to scenarios of conservation improvement budgets to demonstrate how benchmarking improves the cost effectiveness of energy conservation investments. The analysis is a demonstration of the process that would lead stakeholders to determining which buildings to further assess energy savings opportunities through detailed energy audits.

The analysis breaks the 1,205 building sites in the analyzable data set into three performance groups:

- those using "less than or equal to the benchmark,"
- those using "0-50% more energy than the benchmark," and
- those using "more than 50% above the benchmark."

The results for "all" sites, as if benchmarking had not taken place, are also shown. The ROI analysis is then performed for two cases. First, the budget for energy retrofits, in terms of $/sf, is held constant and the payback is examined in terms of sensitivity of *achievable energy savings* in each group. Second, the energy savings goal is held constant at 15% while the *budget* is varied in the sensitivity analysis.

Table 1 illustrates a single calculation. For each of the performance groups, Table 1 shows the number of sites from the database in that group, their average energy cost per square foot, and their total energy consumption. Next, the total annual energy cost savings are calculated *assuming* a goal of 15%. As shown in Table 1, there are approximately $11.6 million of costs savings at a 15% level in those below the benchmark, and $5 million and $4.2 million in the 230 and 114 sites respectively in the two groups above the benchmark.

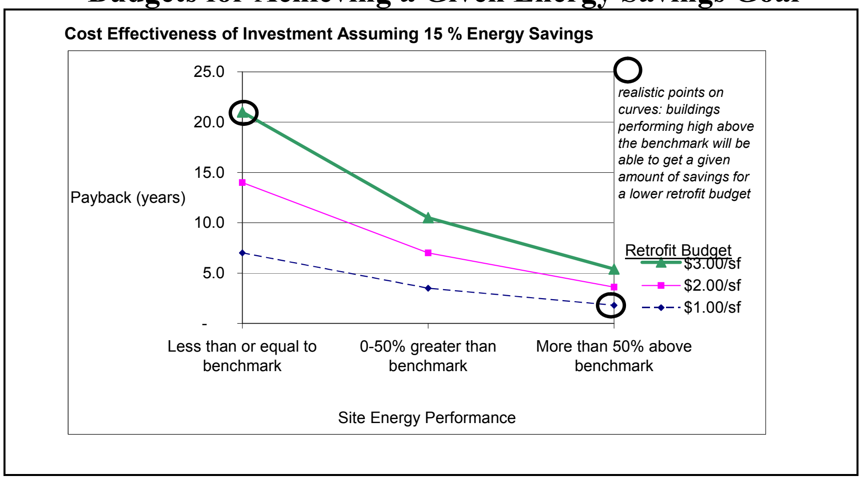
**Table 1. Analysis of Effectiveness of Investment with Benchmarking**

| | *Data From B3 Benchmarking* | | | *Apply Assumption to B3 Data* | | *Result* |
|---|---|---|---|---|---|---|
| **Approach** | **Number of Sites** | **Average Energy Cost Per SF ($/sf)** | **Total Energy Cost ($)** | **Total annual energy cost savings for goal of 15 % savings** | **Total investment assuming budget of $1 per sf** | **Payback (years)** |
| All | 1,205 | $ 1.31 | $ 138,633,000 | $ 20,795,000 | $ 106,083,000 | 5.1 |
| Less than or equal to benchmark | 861 | $ 0.95 | $ 77,246,000 | $ 11,587,000 | $ 80,977,000 | 7.0 |
| 0-50% greater than benchmark | 230 | $ 1.90 | $ 33,234,000 | $ 4,985,000 | $ 17,509,000 | 3.5 |
| More than 50% above benchmark | 114 | $ 3.71 | $ 28,153,000 | $ 4,223,000 | $ 7,596,000 | 1.8 |

Assuming we have an available budget of $1.00/sf to achieve those 15% savings – an *assumption* that will be revisited later - the next column calculates the total investment. Finally, the simple payback, or ratio of investment to annual energy cost savings, is calculated. As shown in Table 1, the average payback period for those sites already performing better than the benchmark is 7.0 years. However, the average payback drops dramatically for those sites using more energy than the benchmark. The average payback period is 3.5 years for those up to 50% over the benchmark and just 1.8 years for those more than 50% above the benchmark. This is because there is a larger amount of savings to be gained *per square foot* in those sites that are performing above their benchmark, so a larger absolute amount of savings are gained for a given energy savings goal expressed as a percentage. This demonstrates one element of the economic rational of performing benchmarking to guide investment for energy conservation projects.

The assumption of a constant retrofit budget used in Table 1 assumes that it would be possible to get 15% energy savings in all performance groups, both those above and below the benchmark, for the same budget of $1.00/sf. In reality, it would actually cost more to get a given percentage of energy savings in those buildings that are already performing well. This concept is illustrated in Figure 10, where the payback is calculated for the 15% energy savings goals for three levels of retrofit budgets: $1.00/sf, $2.00/sf, and $3.00/sf. As marked in the graph, it is more realistic that the buildings in the group performing better than the benchmark would require a higher budget. If that budget is $3.00/sf to achieve 15% savings, the payback period is three times higher than with the original assumption of $1.00/sf, or 21 years.

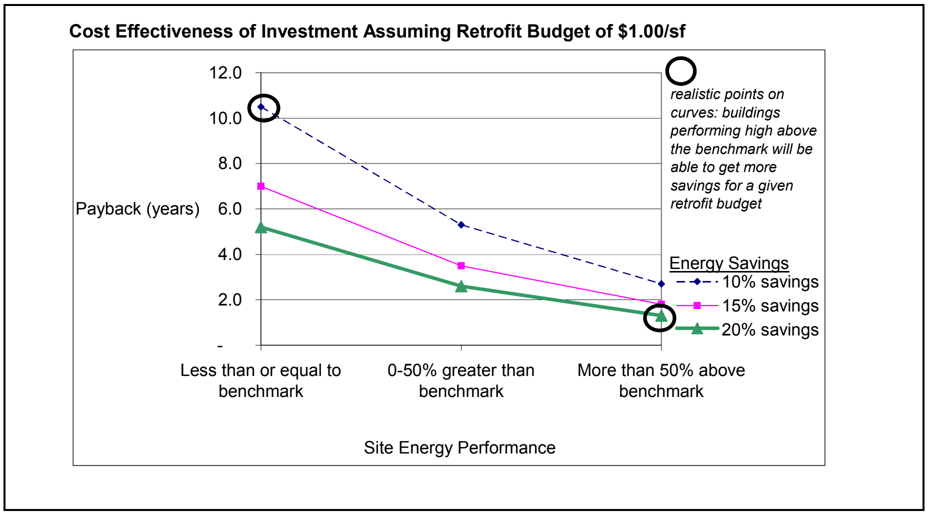
**Figure 10. Cost Effectiveness of Energy Conservation with Benchmarking: Alternative Budgets for Achieving a Given Energy Savings Goal**




If the building owner or organization has a fixed budget for making energy conservation improvements, provides the relevant analysis. Here, we keep the retrofit budget fixed at $1.00/sf while the level of energy savings is varied. Results are shown of energy savings levels of 10%, 15%, and 20%. For the performance groups above the benchmark, it is likely that a larger percentage of savings will be achievable for a given budget, per square foot, than for those buildings that are already better than the benchmark. For example, as illustrated in

Figure 11, the buildings in the performance group “more than 50% above the benchmark” may be able to achieve 20% energy savings for a $1.00/sf investment while those that are “less than or equal to the budget” may only achieve a 10% savings level. The payback periods are 1.3 and 10.5 years respectively, all for the same budget of $1.00/sf.

**Figure 11. Cost Effectiveness of Energy Conservation with Benchmarking: Alternative Energy Savings Levels for a Set Budget**




In summary, this section demonstrates two of the fundamental value propositions of benchmarking using the actual data collected through the B3 Benchmarking process. First, the down-sloping curves in Figures 10 and 11 exist because benchmarking identifies buildings that have more energy to be saved. Second, the realistic points for the different performance groups in Figures 10 and 11 show the improved payback periods for first targeting those buildings that have the highest potential opportunity for energy savings with further detailed energy audits to determine more accurate assessments.

## Conclusion

The B3 Benchmarking initiative is engaging public building managers in the process of managing the State of Minnesota's public building energy use for 4,237 buildings to date. It continues to be a work in progress as data collection, verification, and development tracking capabilities continue. Stakeholders will soon be able to see their Energy Star score along with their B3 performance metrics. Stakeholders are using the tool to help justify funding and target energy audit candidates. The program is now at the stage where the collected data can provide preliminary insight into where the energy savings opportunities are across the building stock, as we investigated in this study.

Through the analysis, it is clear that there are potential energy savings opportunities in buildings of all ages, sizes, and types. No one sector emerged as the clear target for initial action (i.e., site visits and energy audits to further identify specific retrofit opportunities). Rather, the process will help individual managers and administrators of public buildings identify, on a first order, and track their particular buildings that offer the most potential for cost effective opportunity for conservation. As the Return on Investment analysis shows, the payback period of investments to improve the set of buildings identified through benchmarking may be substantially reduced as compared to the cost of fixing buildings at random.

The process of engaging stakeholders in the B3 Benchmarking process is designed to give stakeholders immediate feedback for their data entry efforts. Working with single entities that have large populations of building sites has proved successful in forming a partnership in the process. Ongoing work to coordinate with the remaining stakeholders is most challenged by finding an empowered data owner. For those organizations that have fully engaged, the B3 program gets requests frequently to work with them to provide data and process management support for their efforts to advance energy conservation projects.

One area of future research to support benchmarking is to improve normalizations based on occupancy and plug load equipment in the building. Improvements in this area will further help users of benchmarking systems better target buildings that are the best candidates for more in-depth energy audits.

## Acknowledgements

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