Minnesota Sustainable Building 2030

Phase One and Two/Year 1 - Final Report

Submitted on July 15, 2009 by
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Consultant's Report

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Executive Summary of Minnesota Sustainable Building 2030 for Phase 1 and 2 from June 2008-July 2009

1. BACKGROUND FOR MINNESOTA SUSTAINABLE BUILDING 2030:

In the summer of 2007, the Minnesota Climate Change Advisory Group recommended that to reduce greenhouse gas emissions in buildings, a similar approach to the national *Architecture 2030* should be adopted for Minnesota. *Architecture 2030* outlines specific performance targets for energy use in buildings until 2030. Every five years, the total energy use in buildings is to be reduced starting in 2010 by 60% and ending in 2030 as a 100% reduction (net zero carbon). The benchmark for these reductions in the national program is the energy use of the average building in 2003 found in the federal Commercial Building Energy Consumption Survey (CBECS) database.

- 2010 - 60% reduction in carbon producing fuel used for building energy.
- 2015 - 70% reduction in carbon producing fuel used for building energy.
- 2020 - 80% reduction in carbon producing fuel used for building energy.
- 2025 - 90% reduction in carbon producing fuel used for building energy.
- 2030 - 100% reduction in carbon producing fuel used for building energy.

In the spring of 2008, the Minnesota Legislature passed legislation designating the Center for Sustainable Research at the University of Minnesota to develop a Minnesota program reflecting the goals of *Architecture 2030.* This program was named *Sustainable Buildings 2030* (SB 2030). Highlights of the legislation (Minn. Stat. §216B.241, subd. __) include the following:

1) "The purpose of this subdivision is to establish cost-effective energy-efficiency performance standards for new and substantially reconstructed commercial, industrial, and institutional buildings that can significantly reduce carbon dioxide emissions by lowering energy use in new and substantially reconstructed buildings"

2) "The commissioner (of Commerce) and the Center for Sustainable Building Research shall, in consultation with utilities, builders, developers, building operators, and experts in building design and technology, develop a Sustainable Building 2030 implementation plan that must address, at a minimum, the following issues:
    a. training architects to incorporate the performance standards in building design;
    b. incorporating the performance standards in utility conservation improvement programs; and
    c. developing procedures for ongoing monitoring of energy use in buildings that have adopted the performance standards."

3) "Additional work may include
    a. research, development, and demonstration of new energy-efficiency technologies and techniques suitable for commercial, industrial, and institutional buildings;

b. analysis and evaluation of practices in building design, construction, commissioning and operations, and analysis and evaluation of energy use in the commercial, industrial, and institutional sectors;
c. analysis and evaluation of the effectiveness and cost-effectiveness of Sustainable Building 2030 performance standards, conservation improvement programs, and building energy codes;
d. development and delivery of training programs for architects, engineers, commissioning agents, technicians, contractors, equipment suppliers, developers, and others in the building industries; and
e. analyze and evaluate the effect of building operations on energy use."

In the summer of 2008, the Center for Sustainable Building Research assembled a team of experts to develop the *Sustainable Building 2030* program for new and substantially renovated buildings. The scope of work completed by June 30, 2009 consisted of the following tasks:

A) Establish and convene the SB 2030 steering committee consisting of the consulting team and key state employees to assist the consultant team in formulating SB 2030 policy.
B) Establish and convene the SB 2030 advisory committee consisting of organizations and building experts from Minnesota to review the SB 2030 project.
C) Create appropriate energy use benchmarks for Minnesota by investigating similar programs, generating modeling results, and comparing benchmark approaches. Recommend benchmarks for the Minnesota Sustainable Building 2030 program.
D) Create a case study database of exemplary Minnesota projects by establishing data collection protocol, identifying case studies, collecting data, and evaluating actual performance.
E) Assist in the development of utility conservation programs by identifying appropriate strategies, determining costs, analyzing cost effectiveness, and identifying program approaches.
F) Identify goals, options and barriers related to effective ongoing building operations. Develop recommendations for programs to ensure efficient operations.
G) Recommend a plan for tracking energy use in SB 2030 buildings.
H) Create a knowledge base that can become a comprehensive web site for case studies and educational material to assist the building community in implementing the SB 2030 program.

2. RESEARCH:

2a. Overall Findings:

After nearly a year of research and study, the Minnesota Sustainable Building 2030 Project Team found the following:

- Buildings can be and are being designed and constructed to meet the 2010 energy standard of the SB 2030 program and beyond.
- Meeting the SB 2030 energy standards is cost effective in essentially every building type.
- It is important to develop a benchmarking methodology for Minnesota that can be accepted as accurate, consistent, comprehensive and fair for all building types in this climate.
- Effective on-going operations is critical to ensure the lasting benefits of the building energy reduction design.
- Utility incentive programs that are perceived as cost effective and beneficial to the building owners are essential to the success of this program.
- Continued education and training programs for Minnesota designers, engineers and building operators are fundamental to the initiation of the SB 2030.
- With continued education, assistance, incentives, tracking and verifying results, Minnesota Sustainable Building 2030 can be a very effective program to reduce energy use and carbon emissions in buildings.

2b. Research Summary: Development of a Minnesota SB 2030 Benchmark by the Weidt Group:

The Sustainable Building 2030 legislation establishes a plan mirrored on the Architecture 2030 goals of reducing building energy consumption by establishing energy savings threshold goals over 5 year increments from now until 2030. The key element of this research section is to develop building specific energy benchmarks for use in measuring the savings goals over time, and to determine savings percentages over time that are cost-effective for buildings in the State of Minnesota.

Goals of an Energy Benchmarking System

Comprehensive energy consumption benchmarks must be established for new commercial and institutional buildings in the State of Minnesota to use as the baseline for measuring the energy performance goals established in the Sustainable Building 2030 legislation. The Benchmarking system requirements must be:

- Easy to use
- Accurate
- Consistent
- Comprehensive

Comparison of Different Benchmarking Systems

Four energy benchmarking systems were compared which included:

- Environmental Protection Agency's (EPA) Target Finder tool, derived from 2003 CBECS data
- Architecture 2030 National averages, representing 18 building types derived from 2003 CBECS data
- DOE energy benchmark models representing 16 building types using American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) 90.1 2004 code
- Minnesota B3 Building Energy Benchmark program representing over 50 building types using the different energy code types.

The qualitative and quantitative findings of these comparisons are summarized below:

- The Architecture 2030 program uses EPA's Target Finder and its own table of national average energy consumption to establish the benchmarks for the savings goals it has established over time. However, the national average energy consumption table has benchmarked energy use far lower than current building performance in Minnesota, since Minnesota does not have an average US climate. The national average table is not accurate.
- EPA's Target Finder results matched up fairly well with Minnesota B3 models using the ASHRAE 90.1 1989 models. However, the DOE ASHRAE 90.1 2004 benchmarks show energy consumption much lower than Target Finder, and it would be difficult to meet the savings targets established in the Architecture 2030 program.
- Both DOE and Target Finder building types are too limited to comprehensively and accurately establish benchmarks for all the buildings that will be built in Minnesota.

Recommended Benchmarking Method

Based on the benchmarking system comparison results we recommend setting the benchmark based on building type energy simulation models that meet the minimum requirements of the ASHRAE 90.1 1989 energy code. This method will provide:

- A very efficient analysis method for creating a comprehensive list of building types that represents the range of current building types being constructed. It will not require expensive data collection of existing building energy use for ALL building types that need to be added to create a comprehensive list. The code is a rule-based system that can be modeled consistently and accurately for all building types.

- The ASHRAE 90.1 1989 model data is closest to Target Finder results, the main benchmark metric used for the Architecture 2030 program.

- The ASHRAE 90.1 1989 has been the code in place until recently and closely follows the intent of the Architecture 2030 program that is based on 2003 CBEC data.

- Subsequent code improvements can be easily benchmarked to identify how they alone improve the energy use intensity (EUI) from the 1989 baseline. Again, the code is a rule-based system that governs the inputs into the model that achieve the results.

- Savings goal standards will need further study since it is known all building types do not have the economic or technical ability to reduce their energy consumption at the same savings level.

2c. Research Summary: Cost-Effectiveness Analysis & Utility Energy Efficiency Program Design & Development by the Center for Energy and the Environment:

Cost Effectiveness Analysis

The Center for Energy and the Environment (CEE) performed preliminary Conservation Improvement Program (CIP) program style cost-effectiveness analysis on a set of 115 buildings in the region that participated in similar design assistance programs and achieved savings of the same order of magnitude expected with the soon to be established Sustainable Buildings 2030 energy performance standard. Energy savings, estimated incremental costs and CIP program incentives were based on the design alternative chosen by the design team and all other assumptions were chosen to be as representative as possible of current CIP program analysis assumptions used in Minnesota. The estimated incremental costs are generally based on preliminary estimates rather than bid alternates, so are less precise than most of the other inputs. No potential building market value increase associated with recognition as a high performance building was considered. The analysis was performed using a spreadsheet based calculation tool developed by CEE.

All of the building projects across a wide variety of building types were found to have a net benefit over an assumed 20 year life when a conservative societal discount rate was assumed. When a discount rate that is more representative of businesses assumptions is used, 94% of the building projects are cost-effective over the same 20 year life-cycle analysis. The majority of projects have high enough cost-effectiveness to the building owner that they could be considered as reasonable alternatives to developers that use a long-term view in planning investments. However, certain types of buildings tended to have significantly lower cost-effectiveness than others—most notably religious buildings and sports facilities.

Results from looking at the standard CIP program definition of societal cost-effectiveness showed similar trends, with the energy saving upgrades for each of the building projects being cost-effective. This societal test is generally the most critical test in terms of review of CIP program plans proposed by utilities. The general cost-effectiveness demonstrated in terms of both the participant and societal tests suggests that the level of energy savings being considered for the SB2030 energy performance standard can be cost-effective for a wide range of building types. However, the self-selected nature of the data set and relatively low cost-effectiveness for specific types of buildings suggests that either the standards might need to be lower for specific building types, and/or that a method should be established to provide project-specific limits on the performance standard based on project-specific cost-effectiveness analysis.

A representation of CIP program cost-effectiveness for the above data set showed very good cost-effectiveness to the utility for a representative design assistance program and incentives. In fact the cost-effectiveness to the utilities appears to typically be much higher than for the building owners. This suggests that higher incentives to building owners could make the marketing of the programs more successful (and cost-effective to the building owners) while still maintaining an attractive cost-effectiveness to the utility. Therefore, efforts to encourage utilities to increase incentive levels are recommended.

Utility Program Design & Development

As the Sustainable Building 2030 energy performance standard is implemented, CEE will work cooperatively with utilities to develop and/or modify CIP programs to encourage new buildings to meet the SB2030 standards. The language of the legislation requires that utilities address these standards with their programs, and these efforts will help utilities to optimize their program designs and support their efforts. The first step in the program efforts was the review of innovative and effective new construction CIP programs from around the country to determine what program elements could be effectively applied in Minnesota. A number of innovative program elements were identified—such as a whole building performance standard for small buildings and higher per unit incentives tied to meeting a green building standard—and a list of these is being presented to utilities as a menu of possible options. The most critical CIP program aspects that will be encouraged and supported are comprehensive design assistance services, bonus incentives for achieving SB2030 standards, and establishing a comprehensive whole-building performance program for small buildings.

2d. Research Summary: Survey of Energy-Efficient Operations Programs by Herzog Wheeler:

1. Years of existing building energy use research, energy audits and recommissioning studies repeatedly show that existing buildings will use 10-20% more energy than necessary.
2. Survey of the "energy-efficient operation marketplace" was conducted to determine current best practices.
3. Energy efficiency is as much a management issue as it is a technical issue.
4. Managers at all level of the organization need to understand the benefits and commitment to energy efficiency.
5. Few institutions and businesses have ongoing programs or internalized energy efficiency into their everyday operations
6. Even with energy monitoring equipment installed in buildings, the management piece is missing.

7. Most energy related issues for building operators have to do with occupants comfort and equipment failure.
8. There are few well-documented procedures and schedules specifically focused on energy-efficient operations.
9. Most energy efficiency programs are capital cost based and not training or management based.
10. Training energy managers and operators to understand the magnitude of energy waste within each building component is essential.
11. Develop a model format for an "Energy-Efficient Operations Process" (EEOP) that can be adapted to individual buildings.

2e. Research Summary: Building Case Studies by LHB Architects:

The primary purpose of this case study was to collect data on approximately 10 buildings in Minnesota with a minimum of one year of operations, then apply the MN Sustainable Building 2030 energy standard and determine the ability of each building to reach the 2010 energy standard of 60% or better than its building benchmark.

The conclusion of our study indicates that, based on a select group of high performance buildings designed and constructed over 9 years between 1997 and 2006, the 2010 energy standard of 60% better that the benchmark is achievable. We recognize that these buildings may not be typical. Many are LEED certified or Green Communities demonstration projects and have technologies such as geothermal heating and cooling and photovoltaics.

3. IMPLEMENTATION PLAN FOR PHASE 3 OF MINNESOTA SUSTAINABLE BUILDING 2030:

1. **Notify all stakeholders that the SB 2030 program will be implemented on all projects beginning July 1, 2010.**

   All State agencies and other entities that receive state bonding for building projects will be notified that the SB 2030 standard will be required on all projects receiving bond funds except for projects that are either in Construction Documents Design Phase or in Construction on July 1, 2010.

   Date of notification: July 2009

2. **Develop an on-line tool for determining building benchmarks and energy standards for SB 2030 projects.**

   In the first phase of researching and developing benchmarks for the SB 2030 program, the development of a computer tool was recommended to enable accurate benchmarks to be established for each project based on location and building characteristics. This is a critical component; it is necessary to set accurate and fair targets for a wide range of projects in a Minnesota context. A system for ongoing tracking of SB 2030 projects will be established as well.

   Delivery of benchmarking tool: March 1, 2010

3. **Incorporate the SB 2030 standards and methodology into the Minnesota Sustainable Building Guidelines (B3) that are required in all state bonded projects.**

   The SB 2030 standards and methodology will be required effective July 1, 2010 for all state-bonded projects except for projects that are either in Construction Documents Design Phase or in Construction. The Minnesota Sustainable Building Guidelines will be amended for this purpose, in accordance with 16B.325 guidelines.

   Incorporation of amended language into Minnesota Sustainable Building Guidelines: April 1, 2010 (allowing review by State agencies before they become effective on July 1, 2010.

4. **Work with utilities and the Department of Commerce to incorporate the SB 2030 energy standards and methodology into utility conservation programs.**

   The project team will assist utilities in the development of CIP program elements that are based on the SB 2030 standards and support their implementation through pilot programs and new or modified CIP program filings.

   Pilot program introduction and CIP filings: January-June, 2010
   Comments to support elements in current CIP filings: August-December, 2009

5. **Continue to develop case studies and educational information that will support the implementation of SB 2030.**

Detailed information on exemplary buildings is useful to demonstrate that targets can be met with conventional technologies at reasonable costs. This information supports the training program development.

Case study development: Ongoing from July 2009 through June 2010.

6. Develop and deliver training for the design and construction community in the implementation of the SB 2030 program.

The training program curriculum for the design and construction community will be developed that includes the use of the benchmarking tool and related information to implement the SB 2030 program. The training will be developed in collaboration with key professional, academic, utility and building development representatives.

Completion of pilot training curriculum: January 1, 2010 Delivery of pilot training curriculum: January through June, 2010 Delivery of revised training curriculum: Ongoing after July, 2010

7. Develop and deliver training for the facilities management and building operations community to ensure effective operation of SB 2030 projects.

The training program curriculum for the facility management and building operation community will be developed to ensure effective ongoing operation of SB 2030 projects. The training will be developed in collaboration with key building owner and operator representatives, utilities, technical colleges and work force development stakeholders.

Completion of pilot training curriculum: January 1, 2010
Delivery of pilot training curriculum: January through June, 2010
Delivery of revised training curriculum: Ongoing after July, 2010

4. Work Plan for Minnesota Sustainable Building 2030—Phase 3: July 1, 2009—June 30, 2010

TASK 1: Management:

A) Convene steering committee
B) Coordinate meetings and agenda
C) Develop work plan and proposals for future phases
D) Review and contribute to work in progress on all tasks including reports
D) Report to Legislature
F) Prepare quarterly reports

TASK 2: Setting Benchmarks: (New Construction, Renovation and Existing Buildings)

A) Develop benchmarking tool for new and existing buildings
B) Refine existing building benchmarks
C) Develop and pilot metric for carbon
D) Prepare Reports

TASK 3: Case Study Data Base: (New Construction, Renovation and Existing Buildings)

A) Identify additional case studies and collect data
B) Collect and evaluate actual performance
C) Prepare Reports

TASK 4: Development of utility conservation programs: (New Construction, Renovation and Existing Buildings)

A) Continue to identify appropriate strategies, processes and technologies
B) Continue to determine costs
C) Continue to analyze cost effectiveness
D) Work with utilities to develop pilot program by January 2010
E) Work with utilities to develop CIP filing by January 2010
F) Prepare Report

TASK 5: Ongoing Operations:

A) Develop programs to ensure compliance with SB2030 during operations
B) Work with State Agencies and others to identify best options for training (Development of pilot training program is in Task 8)
C) Prepare Report

TASK 6: Tracking System:

A) Develop tracking system for SB2030 projects building on existing B3 Benchmarking Database
B) Prepare Report

TASK 7: Knowledge Base and Design Assistance:

A) Continue to develop a comprehensive web site
B) Provide assistance to building owners including State agencies and design teams in implementation of SB2030 standards

TASK 8: Training Programs and Education:

A) Develop curriculum and deliver pilot training program to designers in applying SB 2030 Standard and related Utility Programs

B) Develop curriculum and deliver pilot training program to facility managers and building operators on ongoing operations practices and data collection

C) Prepare report

TASK 9: Building Label:

A) Develop building label that is renewable annually for the SB 2030 Standard

B) Prepare report

Primary Responsibility: CSBR

Secondary Responsibility: All others

Deliverables: Building label report

Minnesota Sustainable Buildings 2030 Energy Benchmarks Report Phase 2

June 27, 2009

Prepared for:
Center for Sustainable Building Research
University of Minnesota

By:
The Weidt Group

1.0 Executive Summary

The Sustainable Building 2030 legislation establishes a plan mirrored on the Architecture 2030 goals of reducing building energy consumption by establishing energy savings threshold goals over 5 year increments from now until 2030. The key element of this research section is to develop building specific energy benchmarks for use in measuring the savings goals over time, and to determine savings percentages over time that are cost-effective for buildings in the State of Minnesota.

Goals of an Energy Benchmarking system

Establish comprehensive energy consumption benchmarks for new commercial and institutional buildings in the State of Minnesota to use as the baseline for measuring the energy performance goals established in the Sustainable Building 2030 legislation. The Benchmarking system requirements must be:

- Easy to use
- Accurate
- Consistent
- Comprehensive

Comparison of different benchmarking systems

Four energy benchmarking systems were compared which included:

- EPA's Target Finder tool, derived from 2003 CBECS data
- Architecture 2030 National averages, representing 18 building types derived from 2003 CBECS data
- DOE energy benchmark models representing 16 building types using ASHRAE 90.1 2004 code
- Minnesota B3 Building Energy Benchmark program representing over 50 building types using the different energy code types.

The qualitative and quantitative findings of these comparisons are summarized below:

- The Architecture 2030 program uses EPA's Target Finder and its own table of national average energy consumption to establish the benchmarks for the savings goals it has established over time.
- As expected, the national average energy consumption table has benchmark energy use far lower than current building performance in Minnesota, since Minnesota does not have an average US climate. The national average table is not accurate.
- EPA's Target Finder results matched up fairly well with Minnesota B3 models using the ASHRAE 90.1 1989 models.
- As expected, the DOE ASHRAE 90.1 2004 benchmarks show energy consumption much lower than Target Finder, and it would be difficult to meet the savings targets extablished in the Architecture 2030 program.
- Both DOE and Target Finder building types aretoo limited to comprehensively and accurately establish benchmarks for all the buildings that will be built in Minnesota.

Recommended benchmarking method

Based on the benchmarking system comparison results we recommend setting the benchmark based on building type energy simulation models that meet the minimum requirements of the ASHRAE 90.1 1989 energy code. This method will provide:

- A very efficient analysis method for creating a comprehensive list of building types that represents the range of current building types being constructed. It will not require expensive data collection of existing building energy use for ALL building types that need to be added to create a comprehensive list. The code is a rule-based system that can be modeled consistently and accurately for all building types.

- The ASHRAE 90.1 1989 model data is closest to Target Finder results, the main benchmark metric used for the Architecture 2030 program.

- The ASHRAE 90.1 1989 has been the code in place until recently and closely follows the intent of the Architecture 2030 program that is based on 2003 CBEC's data.

- Subsequent Code improvements can be easily benchmarked to identify how they alone improve the EUI from the 1989 baseline. Again, the code is a rulebased system that governs the inputs into the model that achieve the results.

- Savings goal standards will need further study since it is known all building types do not have the economic or technical ability to reduce their energy consumption at the same savings level.

Analysis to develop a building energy benchmark system

We have reviewed a sample of actual projects for two common building types that show a large variation in energy performance attributable to building characteristics not regulated by the energy code. These types of characteristics are specific requirements unique to the building owner's program requirements and include:

- Building geometry, such as number of floors and building shape.
- Type and percentage of space use, such as 75% office, 20% circulation, and 5% storage area.
- Operational schedules, such as how many hours the building is occupied daily, and seasonal schedules when the building is open or closed.

If an office building type used a benchmark EUI based on the average of all office buildings in the sample, 35% of the projects based solely on the building owner's program requirements would have energy consumption 20 to 30% lower than the benchmark. Conversely, 20% of the projects would have energy consumption over 20% greater than the benchmark.

This approach would unduly reward or penalize a building project's benchmark based on the owner's requirements for the amount and type of space they need to build, the number of hours they require to operate the building, and the number of floors the building requires to fit within the building site.

Dissemination of the Sustainable Buildings 2030 benchmarking system

To accommodate the wide variation in building characteristics that impact a specific project's energy consumption, we recommend developing a web based online tool for building designers to enter specific building design, operational and weather characteristics on their building design project in order to obtain a custom energy benchmark in kBtu/sf/yr for their project.

We recommend the tool be set up with standard defaults that are based on typical conditions to allow designers to quickly edit data specific to their unique program requirements. A table of building types and energy use intensity values will not provide the accuracy needed to accommodate a practical and consistent program.

2.0 INTRODUCTION

The Sustainable Building 2030 legislation establishes a plan mirrored on the Architecture 2030 goals of reducing building energy consumption by establishing energy savings threshold goals over 5 year increments from now until 2030. The key element of this research section is to develop building specific energy benchmarks for use in measuring the savings goals over time, and to determine savings percentages over time that are cost-effective for buildings in the State of Minnesota. The Architecture 2030 program prescribes three different methods for determining the benchmark based on Building type:

- EPA's Target Finder representing 15 building types
- National average energy consumption data by representing 18 building types published by the EPA
- Labs 21 benchmarking system for Lab building types

Data from these systems are based on 2003 CBEC data and establish the benchmark for which future savings goals will be measured from.

Additionally, in 2008 the United States Department of Energy (DOE) came out with stand-alone benchmark building models that include all building types in Target Finder.

There are serious technical drawbacks to using the benchmark system prescribed by the Architecture 2030 program. EPA's Target Finder has only 15 building types (11, really: 5 of 15 are different hotel types) and does not comprehensively cover the range in public or private sector building types for use as a Statewide program. The 18 additional building types based on national averages is not accurate due to Minnesota's specific climate.

The goal of this research project is to:
Establish comprehensive energy consumption benchmarks for new commercial and institutional buildings in the State of Minnesota to use as the baseline for measuring the energy performance goals established in the Sustainable Building 2030 legislation. The Benchmarking system requirements must be:

- Easy to use
- Accurate
- Consistent
- Comprehensive

The Benchmarking system will consider:

- Space usage type of the building
- Operational characteristics of the building
- Floor area of the building
- Special use conditions of the building (pools, data centers, etc.)
- Geographic location (weather determinants)
- Mixed-use building types
- Various Building/ meter relationships

3.0 Comparison of building energy benchmark methods and systems

3.1 Energy Benchmarking Methods
The creation of good quality benchmarks requires good quality data plus the use of normalization factors to separate operational issues from efficiency issues. 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 actual reported energy consumption of similar buildings in a population – the 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 – the B3 and DOE approach

Empirical benchmarking is a 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. The Target Finder application in the Energy Star Portfolio Manager is an example of the empirical approach. The empirical approach requires a properly selected random sample from each population of relevant building types to create the empirical model.

The empirical approach was not used for the Minnesota B3 Benchmarking system because of the need to have data for a much broader range of building types than statistically available (over 50 different building/space usage types were required.)The energy simulation model approach was developed and implemented in the Minnesota B3 Benchmarking process back in 2004. 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.

"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.

3.2 Benchmarking Metrics

Building energy benchmarks in the United States are expressed in a metric of Energy Use Intensity (EUI). The units of EUI are:

kBtu per building gross floor area in square feet in square feet per year.

Annual kBtu's are calculated by adding up all the energy and fuel sources the building consumes for one year.

In future phases of this work we will investigate using a carbon dioxide benchmark which will take into account the varying levels of carbon dioxide emissions based on the energy and fuel sources the building consume.

3.3 Current Energy Benchmarking Systems

Target Finder / Portfolio Manager

. This building energy benchmarking system, developed by the Environmental Protection Agency (EPA) Energy Star program, has been developed to help architects and building owners set energy targets and rate a building design's estimated energy use. Target Finder is a variation of EPA's Portfolio Manager tool, which is focused on existing buildings.

Target Finder uses the Department of Energy (DOE) Commercial Building Energy Consumption Survey (CBECS) data for its analysis. The CBECS is a sample survey conducted every four years that collects information on the stock of U.S. commercial buildings, their energy-related building characteristics, and their energy consumption and expenditures.

The internet based tool uses the basic user input (location, building type, area, energy consumption/ or desired rating etc.) to come up with a benchmark value based on similar buildings from the CBECS database. A rating of 50 indicates that the building, from an energy consumption standpoint, performs better than 50% of all similar buildings nationwide, while a rating of 75 indicates that the building performs better than 75% of all similar buildings nationwide. There are 15 Building types in the system.

Minnesota B3 Benchmarking system

The (Over 50) building/space usage types currently available in B3 Benchmarking were developed with DOE2 energy simulation models to match the public building stock in Minnesota. The large number of space usage types provides for a comprehensive range of buildings that can be benchmarked. The performance metric used in B3 Benchmarking is building annual energy use intensity (EUI). The units of the EUI is the annual Btu's (expressed in thousands) of energy consumed per square foot per year (kBtu/sf), 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 requirements of 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 90.1-1989 version and was adopted in 1993. The main variation is reduced lighting power densities where they range by space type somewhere between the ASHRAE 1989 code and the ASHRAE 2004 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), hours of use, and special use conditions such as buildings with pools, data centers, or parking lots. Currently, all indices are based on modeling results using the same Minnesota climate file. This will be changed to accommodate different weather regions within the State in the coming year.

New DOE Building Model Benchmarks

The Department of Energy and its three national labs have developed commercial building models with the EnergyPlus program. These models are organized by 16 commercial building types and 16 climate zone locations within the U.S. The 16 different types include office, hospital, retail, etc., representing around 70% of the commercial buildings in the U.S. Benchmarks will eventually include models for new construction, post-1980 buildings, and pre-1980 buildings. Currently only the new construction models are publically available, and these models have been created to meet ASHRAE 90.1-2004 requirements for building energy efficiency.

Architecture 2030 National averages

The Architecture 2030 program developed a list of national average benchmarks for additional building types to extend the number of building types beyond the 15 types in Target Finder. This list of buildings uses the Commercial Building Energy Consumption Survey (CBECS) 2003 database to calculate a national average energy use by building type. The website provides 18 additional building types with one national average site energy use intensities (KBTU/sq ft.) for each building type to be used as a benchmark.

The national averages are not adjusted for climate, operation, or any special use conditions. The system uses Energy Use Intensity (KBTU/ sq ft.) as a proxy for GHG emissions.

3.4 Compare characteristics and features of the different benchmarking methods and systems

We have made a comparison of the Benchmarking systems in use based on the program goals. Figure 1, below shows a comparison of features each system provides:

Figure 1: System Features

Benchmark Goals	DOE Benchmarks	Architecture 2030 EPA Target Finder	Architecture 2030 EPA National Averages	Minnesota B3 Benchmarking Program
Easy to use	Yes	Yes	Yes	Yes
Accurate	Yes, for the available building types	Yes, for the available building types	No	Yes
Consistent	Yes	Will vary based on new CBEC surveys	Will vary based on new CBEC surveys	Yes
Comprehensive	16 building types representing a mix of public and private sector types.	15 building types representing a mix of public and private sector types.	18 building types representing a mix of public and private sector types	Over 50 building/space types covering full range of public/ private sector types
Modify Benchmark based on operational use conditions for the building	static model can not modified	Yes	No	Yes
Modify Benchmark based on special use conditions of the building (pools, data centers, etc.)	No	Yes	No	Yes
Floor area of the building	Yes	Yes	Yes	Yes
Geographic location (weather determinants)	16 locations nationally	Yes	No	Currently only one location for the entire State
Mixed-use building types	No	Yes (within the available building types)	No	Yes
Various Building/ meter relationships	No	Yes	No	Yes

4.0 Comparison of energy use indexes for different benchmark systems

We have compared the energy use index results for a variety of building types using the different Benchmark systems. We have conducted three types of comparisons:

4.1 Comparison of energy use index for Architecture 2030 EPA Target Finder with different energy code models to determine the impact of selecting a code level based on meeting the Architecture 2030 savings goals.

4.2 Comparison of energy use index using the Architecture 2030 EPA National averages results with the B3 Model to determine the impact of selecting a code level based on meeting the Architecture 2030 savings goals.

4.3 Sensitivity analysis of operational characteristics to compare how Target Finder and the B3 Benchmarking system account for changes in building operation.

4.1 Comparison of Target Finder results for selected building types for different building benchmarking systems

We have reviewed the EUI for seven building types that are inclusive of types found in Target Finder, B3, and the DOE models. We have used the operational parameters found in the DOE models to normalize the B3 and Target Finder results so we can make the best apples-to-apples comparison possible. The 7 building types compared represent a range in building energy performance.

1. Warehouse
2. Small Hotel
3. Medium Office
4. Primary School
5. Retail
6. Hospital
7. Supermarket

Figure 2 identifies the Target Finder EUIs and the Architecture 2030 savings goal of 60 % to reach by 2010.

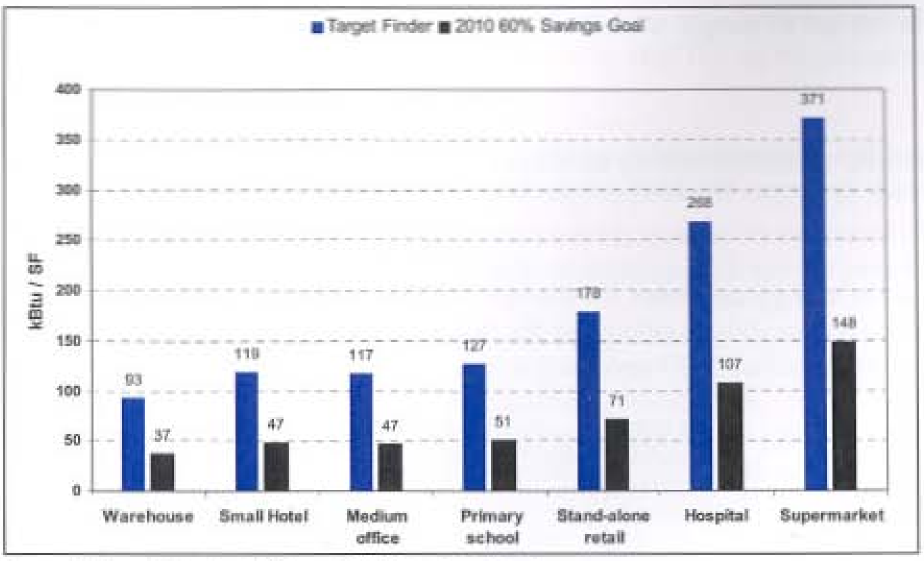


Figure 2: Target Finder EUI's and 60% Savings Goals

The graph shows the large range in EUI variation for different building types, ranging from 93 kBtu /sf for a warehouse to 371 kBtu/sf for a supermarket. This nearly 4 x consumption range identifies the need for a the SB 2030 benchmarking program to incorporate a wide range of building types that accurately and comprehensively accommodate all building projects.

In Figure 3, 4, and 5 show the EUI for each building type and Benchmark system based on the common operational parameters used in developing the DOE models.

- The ASHRAE 2004 DOE Model
- The ASHRAE 2004 B3 Model
- The MN1993 B3 Model
- Target Finder is the result of using the common parameters in the Target Finder system
- The 2010 60% Savings Goal is 60% less than the Target Finder value

	Annual kBtu / SF Benchmark EUI's					
Building Type Name	ASHRAE 2004 DOE Model	ASHRAE 2004 B3 Model	MN 1993 B3 Model	ASHRAE 1989 B3 Model	Target Finder	2010 60% Savings Goal
Warehouse	30	na	60	62	93	37
Small Hotel	110	113	na	125	119	47
Medium office	70	72	90	100	117	47
Primary school	114	95	116	119	127	51
Stand-alone retail	100	112	125	152	178	71
Hospital	114	200	198	206	268	107
Supermarket	225	278	na	316	371	148

Figure 3:EUI's of Various Models with Common Operational Parameters

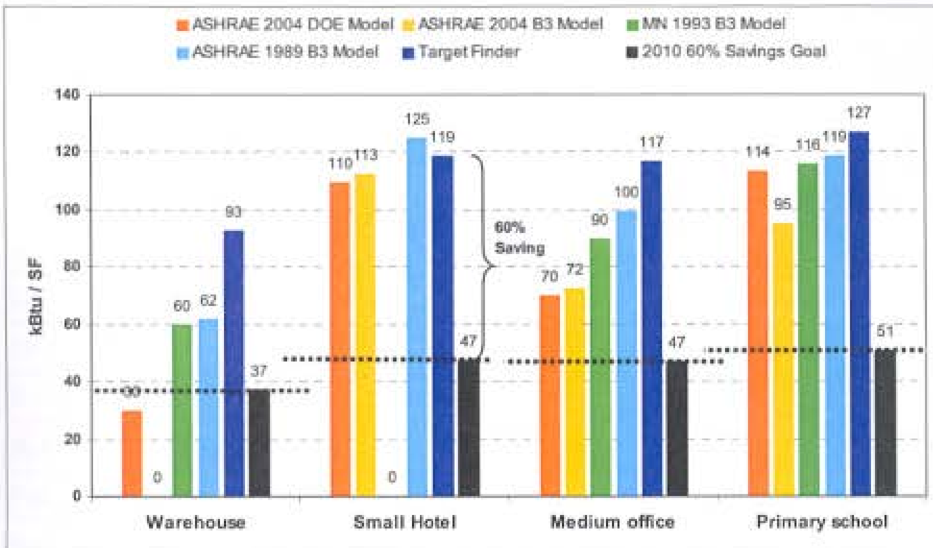
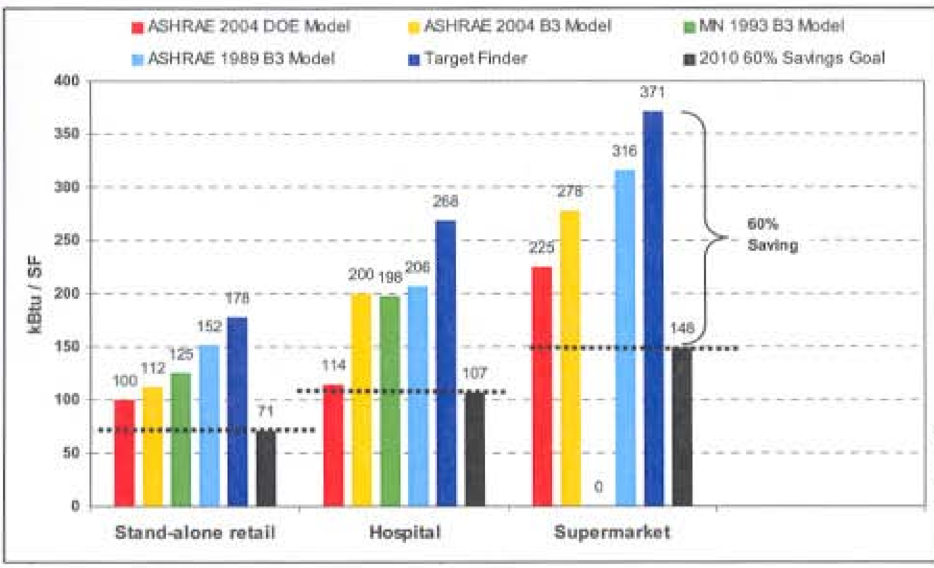


Figure 4: Comparative EUI's - Warehouses, Hotels, Offices, Schools



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Comparison of the ASHRAE 2004 DOE Model and ASHRAE 2004 B3 Models:
The DOE and B3 models produce similar results for about half of the building types studied. The DOE Primary school model is 16% higher than B3, 75% lower for Hospitals and 24% lower for Supermarkets. The DOE hospital result appears to be low and has an identical EUI as the primary school.

Building Type Name	ASHRAE 2004 DOE Model	ASHRAE 2004 B3 Model	Difference	% Change
Warehouse	30	na	na	na
Small Hotel	110	113	-3	-2%
Medium office	70	72	-2	-4%
Primary school	114	95	19	16%
Stand-alone retail	100	112	-12	-12%
Hospital	114	200	-86	-75%
Supermarket	225	278	-53	-24%

Figure 6: Comparison of ASHRAE 2004 DOE and B3 Models

Comparison of Target Finder and ASHRAE 90.1 1989 B3 Models:
Target Finder results and the ASHRAE 90.1 1989 model show similar results, although Target Finder results are generally higher.

Building Type Name	ASHRAE 1989 B3 Model	Target Finder	Difference	% Change
Warehouse	62	93	na	na
Small Hotel	125	119	6	5%
Medium office	100	117	-17	-17%
Primary school	119	127	-8	-7%
Stand-alone retail	152	178	-26	-17%
Hospital	206	268	-62	-30%
Supermarket	316	371	-55	-17%

Figure 7: Comparison of ASHRAE 1989 B3 Model and Target Finder

The 1989 B3 Model results for Medium office, Primary school, and Supermarkets are very proportional to the Target Finder results with an identical 17% lower EUI than the Target Finder. The Warehouse and Hospital Building type results are far apart, while Hotels and Primary schools results are less than 10% different.

Conclusions:
The ASHRAE 90.1 1989 B3 Benchmark model results and the Target Finder results are the best fit of data systems compared in this study.

4.2 Comparison of B3 Model results with the Architecture 2030 National Average EUI's

Figures 8 and 9 show the current B3 energy benchmark compared to the Architecture 2030 National average EUI's for six different building types.

Building Type Name	MN 1993 B3 Model	Arch 2030 National Average	2010 60% Savings Goal
College University	160	120	48
Fire Station	122	78	31
Police Station	123	78	31
Nursing Home/Assisted Living	136	124	50
Public Assembly	96	66	26
Service	86	77	31

Figure 8: Comparison of the Architecture 2030 EPA National Averages with the 1993 B3 Model. 2010 60% Savings Goal Based on the Architecture 2030 EPA National Averages

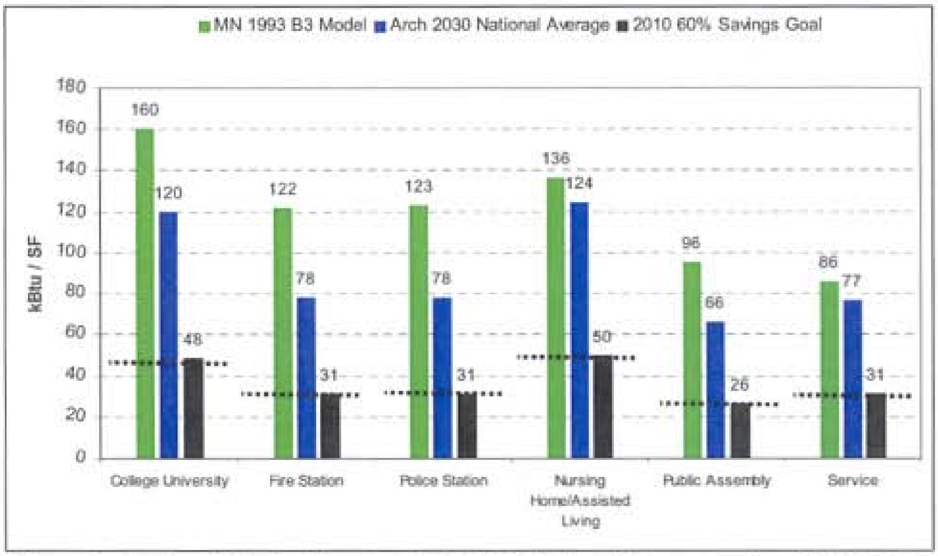


Figure 9: Graph of the Architecture 2030 EPA National Averages, the 1993 B3 Model. and 2010 60% Savings Goals Based on the Architecture 2030 EPA National Averages

Figure 10 compares the MN 1993 Model results with the Architecture 2030 national average indexes. The percentage change varies from -30% for College University Classrooms to +71% for Service buildings. Nursing home/Assisted Living is within 2%. In most cases the National average data does not appear to match up well with the MN 1993 B3 Model data.

MN 1993 B3 Model	MN 1993 B3 Model	Arch 2030 National Average	Difference	% Change
College University	93	120	-28	-30%
Fire Station	119	78	41	34%
Police Station	117	78	39	33%
Nursing Home/Assisted Living	127	124	3	2%
Public Assembly	178	66	112	63%
Service	268	77	191	71%

Figure 10: Comparison of the MN 1993 Model results with the Architecture 2030 EPA National Average Index

Conclusions:

The national average data is national average data; it occasionally resembles Minnesota data but usually does not. It is not a valid method for setting benchmarks for Minnesota buildings.

4.3 Sensitivity Analysis for Operational Characteristics

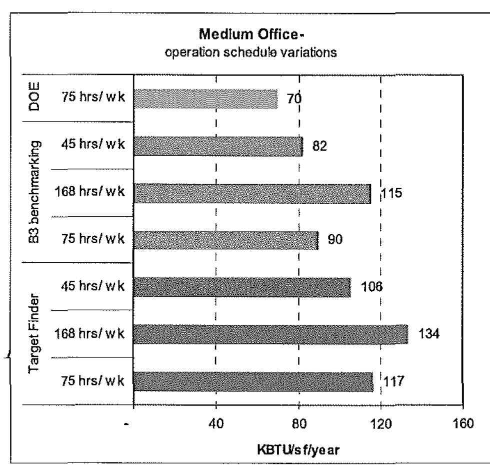
We compared EUI's using standard operational characteristics and conducted operational sensitivity testing to compare how each Benchmarking system handles operational changes. Using the DOE model operating assumptions as the common baseline, the Target Finder and B3 Benchmarking systems were modified to test the impact of changing operating hours and varying the heated and cooled areas within each building type. Four different building types were evaluated:

1. Medium Office, Primary School, Stand-alone Retail, Warehouse

The figures below on the left identify the change in energy use index when operating hours are varied for both the B3 and Target Finder Benchmarking systems. The figures below on the right show the impact of varying the heated and cooled areas within the building. In all cases the changes made each system yield proportional results.

The variation in operating hours has a significant impact on the EUI for all systems. It should be noted that the DOE Benchmarking model is static,--it is not a system that can be changed automatically.

Figure 11: Offices. Shows similar proportional changes for varying operating schedules and conditioned areas in both the B3 Benchmarking program and Target Finder.



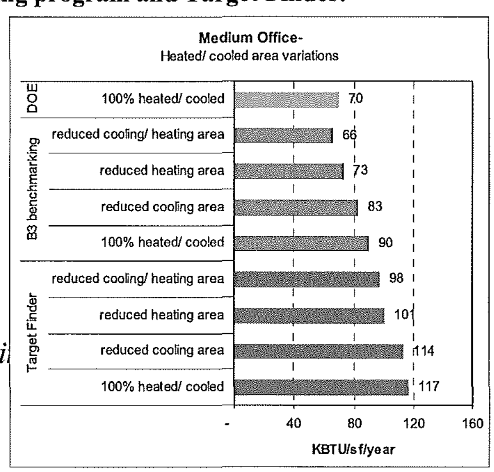


Figure 12: Primary Schools. Schools show lower absolute changes in varying operating schedules than offices. Schools show similar proportional changes for varying operating schedules and conditioned areas in both the B3 Benchmarking program and Target Finder.

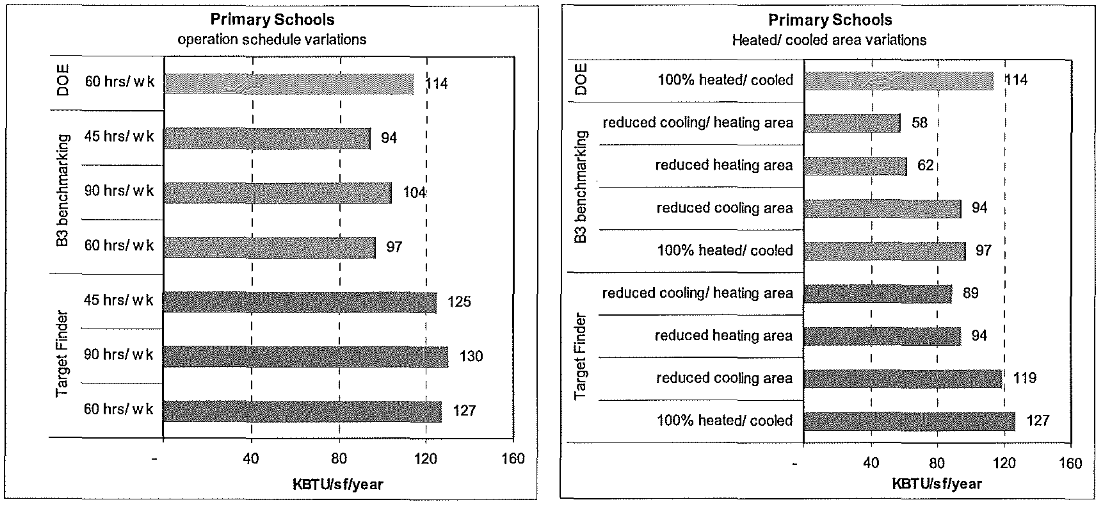


Figure 13: Retail. Shows similar proportional changes for varying operating schedules and conditioned areas in both the B3 Benchmarking program and Target Finder.

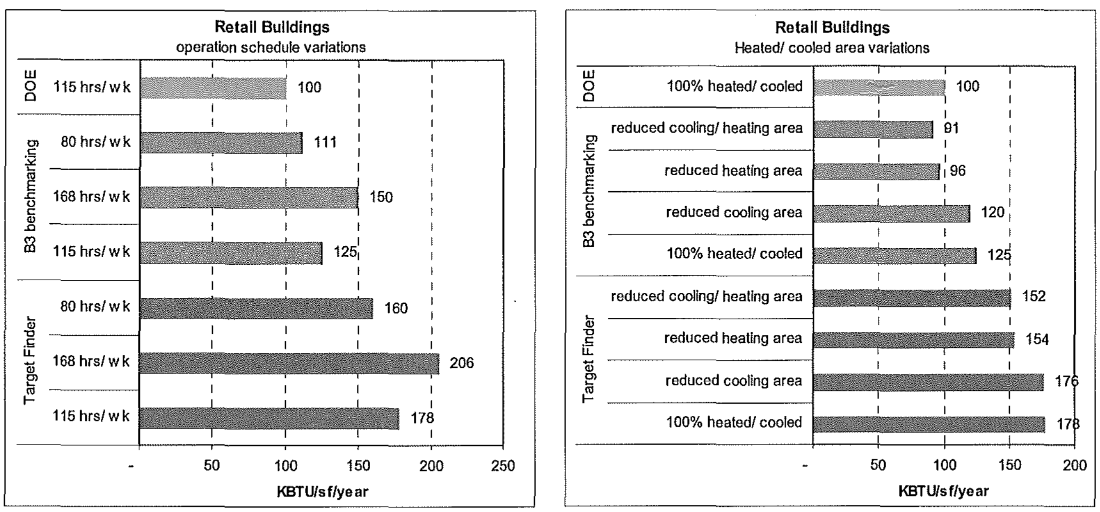
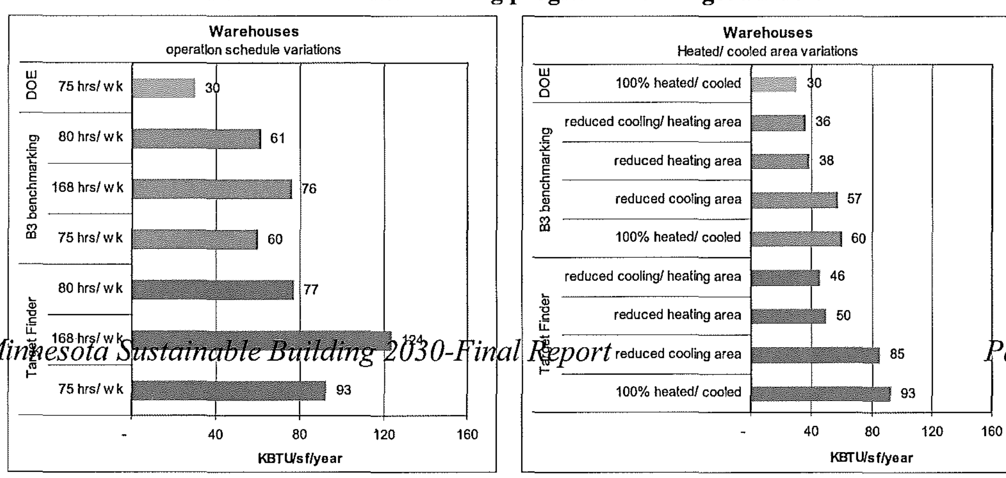


Figure 14: Warehouse. Shows similar proportional changes for varying operating schedules and conditioned areas in both the B3 Benchmarking program and Target Finder.



Conclusions:
Changes in operating hours and the conditioned area of the building have significant impacts on establishing the building's benchmark. Variations in the parameters studied show impacts of up to 25% . Both Target Finder and The B3 Benchmarking systems handle these changes and produce proportional results. We will need a system that accounts for these variations to develop an accurate Benchmark System.

5.0 Recommended Method for Developing Minnesota Benchmarks

Comparing Benchmarking systems identified broad variations in results. The 2030 EPA Target Finder statistical sample of existing buildings generally has much higher EUI than even the first and oldest national energy code developed in 1989. This is consistent given that there are many old buildings within the population that drive the existing buildings' averages higher. Thus, the Architecture 2030 benchmark will be higher than benchmarks based on relatively codes. Also, reviewing the 2030 EPA Target Finder and the 2030 EPA National Averages illustrates , in the case of Target Finder, that there are far too few building/space types, and in the case of National Averages they do not align well with buildings built in Minnesota. It is thus clear that we need to establish a Minnesota benchmarking system.

Since the benchmarking system will apply to new construction or major renovation projects that need to be built to the current energy code, it makes logical sense to use an energy code requirement to define the building parameters that establish the energy consumption for the Benchmark.

Based on the Benchmarking system comparison results we recommend setting the benchmark based on Building type energy simulation models that meet the minimum requirements of the ASHRAE 90.1 1989 energy code. This method will provide:

- A very efficient analysis method for creating a comprehensive list of building types that represents the range of current building types being constructed. It will not require expensive data collection of existing building energy use for ALL building types that need to be added to create a comprehensive list. The code is a rule-based system that can be modeled consistently and accurately for all building types.

- The ASHRAE 90.1 1989 model data is closest to Target Finder results, the main benchmark metric used for the Architecture 2030 program.

- The ASHRAE 90.1 1989 has been the code in place until recently and closely follows the intent of the Architecture 2030 program that is based on 2003 CBEC's data

- Subsequent Code improvements can be easily benchmarked to identify how they alone improve the EUI from the 1989 baseline. Again, the code is a rule-based system that governs the inputs into the model that achieves the results.

Since the ASHRAE 1989 Code results have lower benchmark EUI's as compared to Target Finder, applying the same savings percentages goal identified in the Architecture 2030 program will yield lower absolutes energy consumption targets for new buildings and major renovations. For the building types and operational characteristics studied, we have calculated the savings percentage needed using the 1989 Code Benchmark to meet the Target Finder Benchmark with a 60% savings goal by 2010.

Figure 15 shows the savings percentages that yield identical results to the Target Finder 60% savings goal using the 1989 Code Benchmarks as the starting point.

	Annual kBtu / SF Benchmark EUI's			
Building Type Name	**ASHRAE 1989 B3 Model**	**Target Finder**	**2010 60% Savings Goal**	**Equivalent ASHRAE 1989 B3 Savings % to meet target finder 60% goal**
Warehouse	62	93	37	40%
Small Hotel	125	119	47	62%
Medium office	100	117	47	53%
Primary school	119	127	51	57%
Stand-alone retail	152	178	71	53%
Hospital	206	268	107	48%
Supermarket	316	371	148	53%

Figure 15: Comparison of ASHRAE 1989 Model, Target Finder and Equivalent Savings Goals

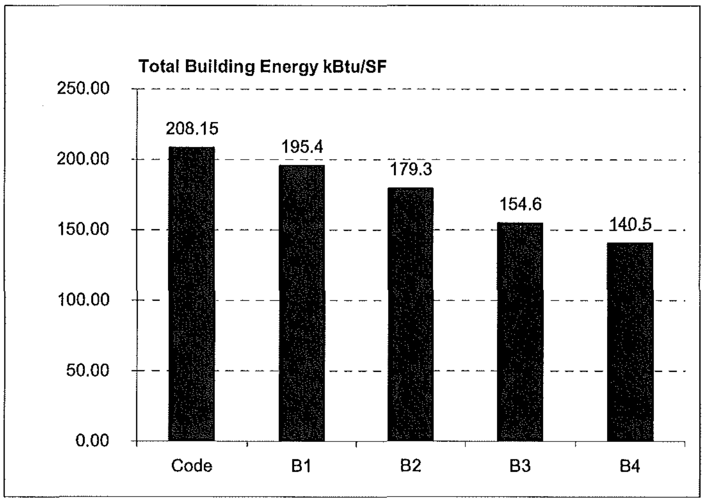
The equivalent percentage savings ranges from 62% for the Small Hotel to 40% savings for the Warehouse building type. This analysis raises the question of using a standard savings percentage for all building types or having it vary based on building type. From a program administration standpoint it would not be desirable to have a unique benchmark with its own savings goal per building type, however a simple range of savings goals, maybe 40%, 50%, and 60%, for a bracket of appropriate building types may be advisable. The next section reviews this question from a technical perspective versus a savings mandate approach.

6.0 Analysis of savings goals

The concept of setting uniform savings goals for all building types over time is very compelling and easy to understand - it is straightforward and simple. However, the reality that all building types have the same energy savings opportunities is simply not the case. Just as all building types do not have the same energy consumption footprint based on function and use, they also do not have the same technological savings opportunities. For a select number of building types we have studied the technological opportunities for savings and have found a significant savings range that is not consistent from one building type to the next.

At this time we evaluated the hospital building type using the ASHRAE 90.1 1989 code as the benchmark and have developed four different strategy bundles to understand what is technologically feasible. The hospital building type has many critical functions that place constraints on the opportunities to reduce energy consumption. Figure 16, using a graph and table, identifies a typical code level hospital and 4 energy savings bundles. Bundle 4 (B4) identifies the maximum range of current technological building energy efficiency and conversation opportunities available today.

Hospital: Gas Boiler/ Water-Cooled Chiller



	Code	B1	B2	B3	B4
1989 Code	208.15	195.4	179.3	154.6	140.5
1989 Savings		12.7	28.9	53.5	67.6
% Savings		6%	14%	26%	32%

Figure 16: Hospital energy savings for four levels of energy efficiency savings strategy levels.

The savings in Figure 16 ranges from a minimum of 6% for Bundle 1 to 32% for Bundle 4. To achieve greater savings within this building type with current technology would require a new design paradigm in health care function, organization, and comfort. It is unlikely this building type by 2010 would be able to achieve 60% saving from an ASHRAE 90.1 1989 Benchmark level.

Conclusion:

This level of investigation needs to be expanded in our current research plan for the next phase. We recommend doing a number of building types to this level of analysis so we develop reasonable savings standards that are achievable by building type. We believe the outcome of this research would develop 2 to 3 savings standards for different building types. The savings bracket analysis must consider both the baseline and the technology opportunities.

7.0 Analysis to develop a building energy benchmark system

To develop building energy benchmarks for different building types we have reviewed the energy performance and building characteristics not regulated by the energy code for hundreds of actual projects and the DOE models. The building characteristics not regulated by the energy code are specific requirements unique to the building owner's program requirements and include:

- Building geometry, such as number of floors, and building shape.
- Type and percentage of space use, such as 75% office, 20% circulation, and 5% storage area.
- Operational schedules, such as how many hours the building is occupied daily, seasonal schedules when the building is open or closed, etc.

We have found variation of these program requirements above can provide a significant range in energy consumption within a given building type. One case worth noting relates to addition and renovation projects. These projects typically focus on a limited set of space use within a typical building type. For example, an addition to an elementary school could be a new gym and storage area, or it could be a classroom wing addition. The gym and storage room addition would have significantly lower energy consumption than the classroom addition. Having only one average benchmark for an elementary school would make it easy to achieve the energy EUI goal for the gym and storage addition, but more difficult for the classroom wing addition.

To quantify and illustrate this range in energy performance we have examined the ASHRAE 90.1 1989 model results for real projects for two different building types, offices and schools. All projects use natural gas for heating and electricity for cooling, and include new construction, additions and renovation projects.

Figure 17 identifies the annual kBtu per square foot for 13 office projects. The results range from 66 to 211 kBtu/sf/yr where Project 1, an outlier in the sample, contains a large data center.

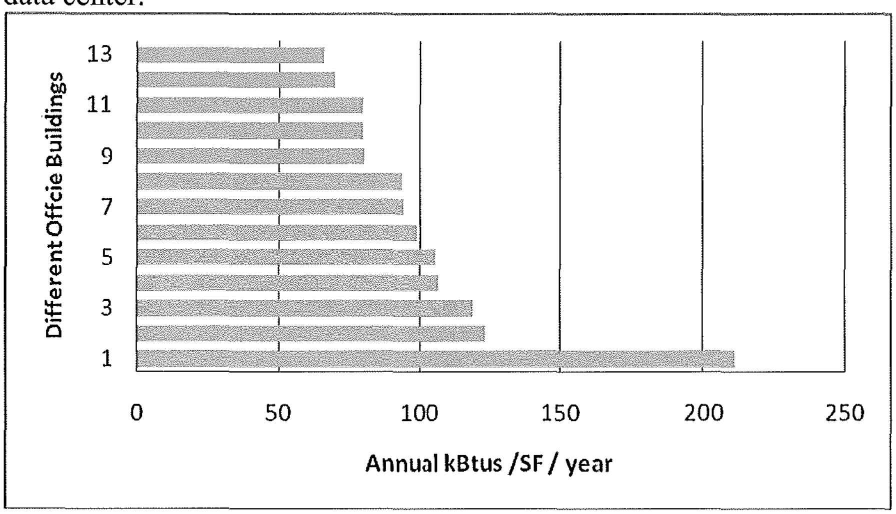


Figure 17: Range in energy consumption for 13 actual office buildings modeled using ASHRAE 90.1 1989 code requirements.

Figure 18 shows the percentage difference from the average performance within the sample.

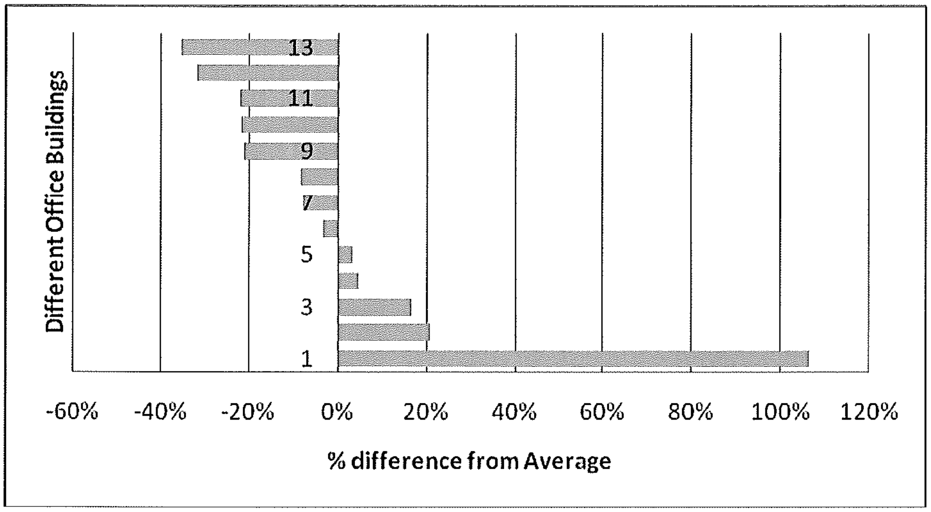


Figure 18: Percent difference from Average performance of 13 actual office buildings modeled using ASHRAE 90.1 1989 code requirements.

For this example, if the project with the average results were used to establish the benchmark for this building type, five projects based solely on the building owner's program requirements would have energy consumption 20 to 30% lower than the benchmark. Conversely, two projects would have energy consumption nearly 20% greater than the benchmark, and the outlier project with a data center would have energy consumption of 100% over the benchmark.
Figure 19 shows the range in energy consumption for a sample of 27 elementary schools. The results range from 60 to 189 kBtu/sf/yr.

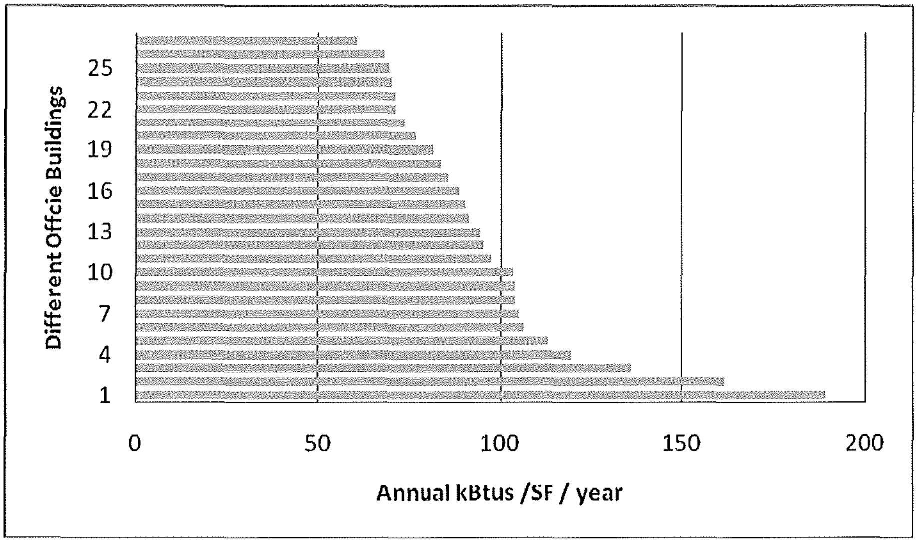


Figure 19: Range in energy consumption for 27 actual office buildings modeled using ASHRAE 90.1 1989 code requirements.

Figure 20 shows the percentage difference from the average results for the 27 elementary school projects. Eight projects have energy consumption 20 to 35% lower than the average, while five projects have energy consumption from nearly 20 to 90 % above the average, again solely based on the building owner's program requirements.

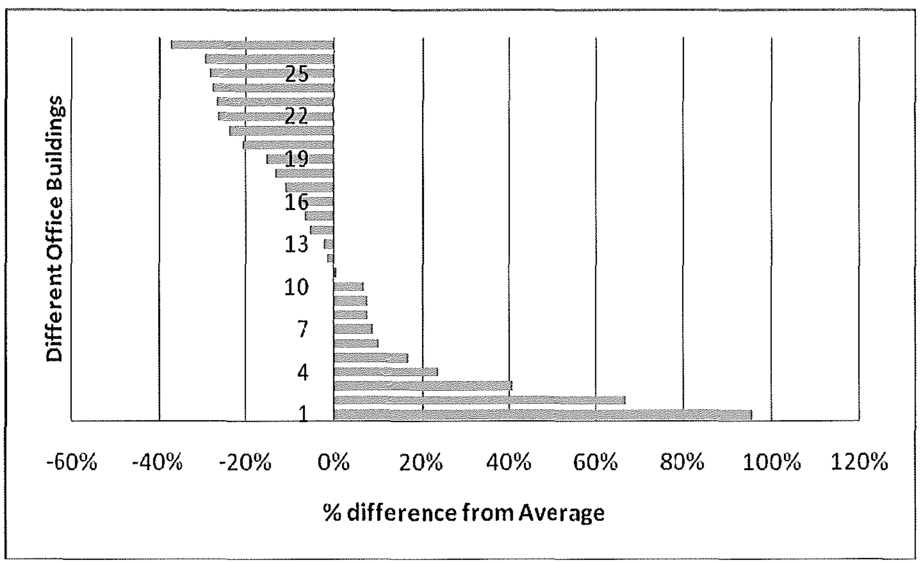


Figure 20: Percent difference from Average performance of 27 actual elementary school buildings modeled using ASHRAE 90.1 1989 code requirements.

Conclusion:

Based on the analysis results, it is our recommendation that a benchmarking tool be developed to account for the wide range in variables a specific building project may have within a given building type. As a result, building projects will not be rewarded or penalized based on the unique characteristics of the buildings owner's requirements for the amount and type of spaces they need to build, the hours they require to operate their building and the number of floors required to fit the building on their site.

We recommend the tool be set up with standard defaults that are based on typical conditions to allow designers to quickly edit data specific to their unique program requirements. A table of building types and energy use intensity values will not provide the accuracy needed to accommodate a practical and consistent program.

8.0 Dissemination of the Sustainable Buildings 2030 Energy Benchmark System

In Phase 3 we recommend developing a web-based online tool for building designers to enter specific building design, operational and weather characteristics on their building design project to obtain a custom energy benchmark in kBtu/sf/yr for their project. This approach will allow building owners and project designers the ability to establish a meaningful energy benchmark and savings standard based on the unique characteristics of the building they build.

The tool will provide the following features:

1. Collect designer contact and proposed building name information

2. Allow designer to enter:
    a. Building location (establishes weather via zip code)
    b. Building gross floor area
    c. Building type (if mixed use – allow for multiple type areas)
    d. Number of floors (for each building type)
    e. Space use type selection and floor area for up to 80 to 90 different space use types
    f. Operational schedule for each space use type
    g. Percent heated or cooled for each space use type
    h. Cooling and heating system type for each building type
    i. Fuel source for different energy end use systems

3. Automatically run an energy simulation for the designer building entry above and return:
    a. Total Energy Standard EUI kBtu/sf goal based on 2030 criteria.
    b. Fuel source end use in kBtu/sf/yr
    c. CO_2 Total and by fuel source per sf

The tool would provide standard defaults for building geometry, space use type and distribution, and operational use for each space type for a given building type. The user of the tool would be able to use these defaults or make modifications that represent the specific design characteristics of their building project.

Preliminary SB2030 Energy Benchmarks:
In the interim we have developed Figure 21, a table of Preliminary Building types, Benchmark EUI, percent fuel source, percent savings standard for 2010 and the 2010 Standard EUI. The data is based on the B3 energy model data for 44 different building types and calculations using the ASHRAE 90.1 1989 energy code. The benchmark EUI is based on using Minneapolis, MN weather data. The fuel source data assumes natural gas for heating end use.

The table is called preliminary at this time based on further work identified in the report to define the proper 2010 savings standards. The savings standards are only an estimate at this time. These preliminary savings standards will be updated in the tool after further analysis.

The preliminary SB2030 Energy Benchmark table will guide the development of standard defaults for use in the tool.

#	Building Type	Benchmark EUI kBtu/SF/YR	% Gas	% Electric	% Savings Standard 2010	2010 Standard EUI kBtu/SF/YR
	Preliminary SB2030 Benchmarks and Savings Standards Table Phase 2					
1	Administration	101.8	33%	67%	50%	50.9
2	Animal Shelter	433.8	65%	35%	35%	281.9
3	Auditorium	105.3	30%	70%	40%	63.2
4	City Hall	113.9	41%	59%	50%	56.9
5	Coliseum / Stadium	71.1	44%	56%	40%	42.7
6	College Classroom	172.5	55%	45%	50%	86.2
7	College Laboratory	433.8	65%	35%	40%	260.3
8	Community Center	97.0	52%	48%	45%	53.4
9	Computer Center	172.5	55%	45%	30%	120.7
10	Courthouse	101.8	33%	67%	50%	50.9
11	Data Center	721.5	0%	100%	20%	577.2
12	Dedicated Kitchen/Food prep	167.3	50%	50%	20%	133.9
13	Dental Lab	433.8	65%	35%	45%	238.6
14	Dormitory	142.5	66%	34%	50%	71.2
15	Elementary School	124.1	64%	36%	50%	62.0
16	Field House / Gym	130.8	61%	39%	40%	78.5
17	Fire Station	130.8	48%	52%	40%	78.5
18	Greenhouse	288.3	64%	36%	30%	201.8
19	High School	115.4	58%	42%	50%	57.7
20	Hospital	205.5	54%	46%	30%	143.9
21	Ice Arena	195.8	43%	57%	20%	156.6
22	Kitchen / Dining	136.2	50%	50%	35%	88.5
23	Library	126.0	48%	52%	40%	75.6
24	Machine Shop	153.1	31%	69%	35%	99.5
25	Maintenance Repair	93.1	62%	38%	35%	60.5
26	Mechanical	63.5	66%	34%	40%	38.1
27	Middle School	115.2	60%	40%	50%	57.6
28	Multi Family Housing	108.2	67%	33%	50%	54.1
29	Museum	214.0	42%	58%	35%	139.1
30	Nursing Home	141.9	51%	49%	40%	85.2
31	Office	101.8	33%	67%	50%	50.9
32	Park / Recreation	84.4	62%	38%	35%	54.9
33	Parking Garage	44.0	48%	52%	30%	30.8
34	Parking Lot	4.7	0%	100%	30%	3.3
35	Parts Assembly	143.1	33%	67%	35%	93.0
36	Police Facility	133.7	47%	53%	40%	80.2
37	Prison / Jail	101.7	51%	49%	30%	71.2
38	Prison Housing	184.9	67%	33%	30%	129.4
39	Retail / Store	142.1	39%	61%	50%	71.0
40	Retirement Home	79.7	49%	51%	35%	51.8
41	Student Union	113.9	41%	59%	45%	62.6
42	Swimming Pool	411.6	69%	31%	30%	288.1
43	Warehouse - Active	105.3	60%	40%	40%	63.2
44	Warehouse - Inactive	63.5	66%	34%	40%	38.1

Figure 21: Preliminary SB2030 Benchmark and Savings Standard Table. Savings Standard 2010 column is only an estimate at this time.

Appendix A: Conversion from kBtu to Carbon Dioxide Emissions Benchmarks

While the Phase 1 and 2 work plan scope is to develop a method for defining site energy consumption benchmarks for buildings, we also believe it will be valid to develop carbon dioxide benchmarks for buildings too. This section reports a preliminary investigation of issues that would need to be considered when establishing a method to develop a carbon dioxide benchmarking system. Further research in later phases will be needed develop a practical system.

There are important differences between energy consumption benchmarks using site energy in kBtu/SF versus carbon dioxide benchmarks. A carbon dioxide benchmark considers the emissions into the atmosphere based on the fuel sources used to heat, cool, ventilate, light and power the building. In most cases in Minnesota, commercial buildings use electricity to cool, light, ventilate and run equipment, and use natural gas to heat the building and its hot water supply. There are cases where heating can be done with conventional heat pump systems that use electricity to operate the heat pumps and require a boiler assist using gas or electricity, or a geo thermal heat pump system that entirely uses electricity as the fuel source and uses the ground exchange as the boiler back-up. There are also district heating systems which combust coal, bio-mass, or natural gas to produce steam.

The conversion of site energy consumption into carbon emissions is an easy calculation. All that is needed to be known is the CO2 emission factor or pounds of CO2 emitted by the fuel source type consumed at the building. For this analysis we use the Climate Registry Protocol version 1.1 for emission factors. The Climate Registry identifies an eGRID regional factor for electricity equal to 1.81 lbs CO2 per kWh, and for natural gas they define 117.1 lbs of CO2 per MMBtu.

Converting the emission factors into equivalent site energy consumption units, electricity produces 0.530 lbs of CO2 per kBTU, and natural gas produces 0.117 lbs of CO2 per kBTU, showing that electric consumption per equivalent site energy produces nearly 4.5 times more CO2 than natural gas consumption. One must also understand that electricity is a very refined source of energy at the site, far greater than natural gas. Typical gas boiler or furnace system efficiency range from 80 to 90%, while electric resistance heating is 100% efficient and if heat pump systems are used they can reduce heating consumption by 2 to 3 times over an electric resistance heating system.

The major question becomes, should the benchmark be set to a building that uses gas heat, or electric heat?

To illustrate the issues between kBtu's and Carbon we have reviewed two populations of building types, representing 41 office and 59 school projects. For each building type about half the projects use natural gas heating and the other half use electric heating. The energy code baseline for all projects is the ASHRAE 90.1 1989 code. The electric heated building code mechanical baseline is a conventional water loop heat pump with an electric boiler. We also have the proposed final design energy use for all projects. In nearly all cases the electric heated building final design utilizes a geothermal exchange heat pump system.

Figure A1 identifies the average Code and Design kBtu / SF for the office building population. The set of bars on the left shows the electric heated offices while the second set shows the natural gas heated projects.

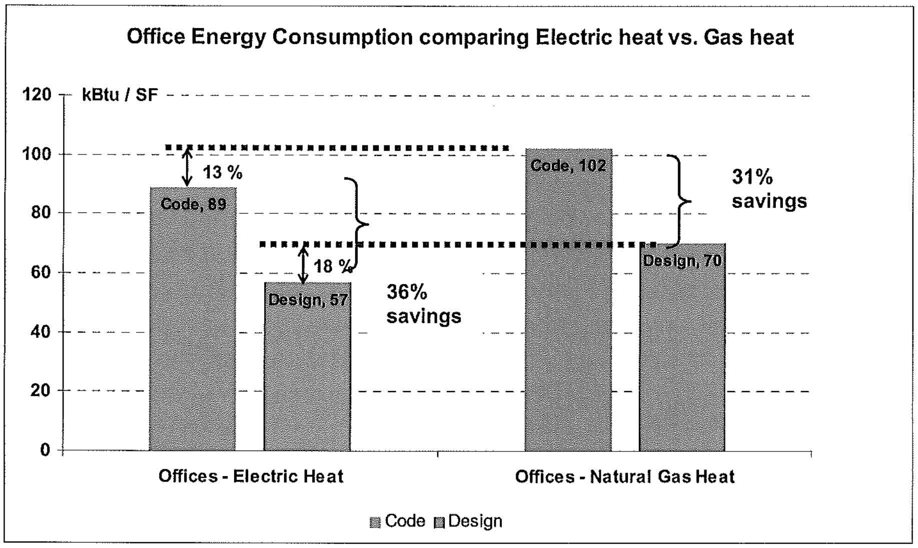


Figure A1: Average office building energy consumption from 41 offices for code and design levels and electric and natural gas heating.

The average kBtu/SF Code base for the electric heated office buildingsis 13% lower than the gas heated office buildings and the average design is 18% lower. This would be expected since electricity is a more refined energy source at the site level.

Figure A2 shows the average Code and Design CO2 pounds / SF for the offices. The first set of bars show the average for electric heated offices and the second shows natural gas heated offices.

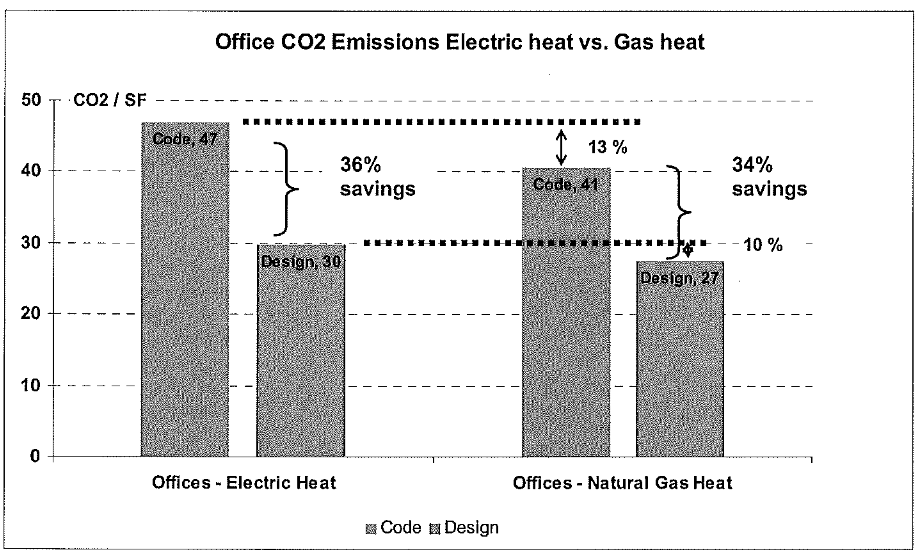


Figure A2: Average office building CO2 emissions from 41 offices for code and design levels and electric and natural gas heating.

Now, the results are reversed as compared to the kBtu graph. The Code base electric heated buildings have higher CO2 emission per square foot by 13% and an average design base that is 10% greater than the natural gas heated buildings. What is interesting is that the absolute final design averages show only a difference of 3 lbs of CO2 / SF between the two types.

Next we look at the school population in the same way. Figure A3 shows that the electric heated building average kBtu/SF is 23 % lower for the Code base and 42% lower for the Design as compared to the average data for the natural gas heated schools. The electric heated buildings from code to design save 52% on average while the natural gas heated buildings only save 36%.

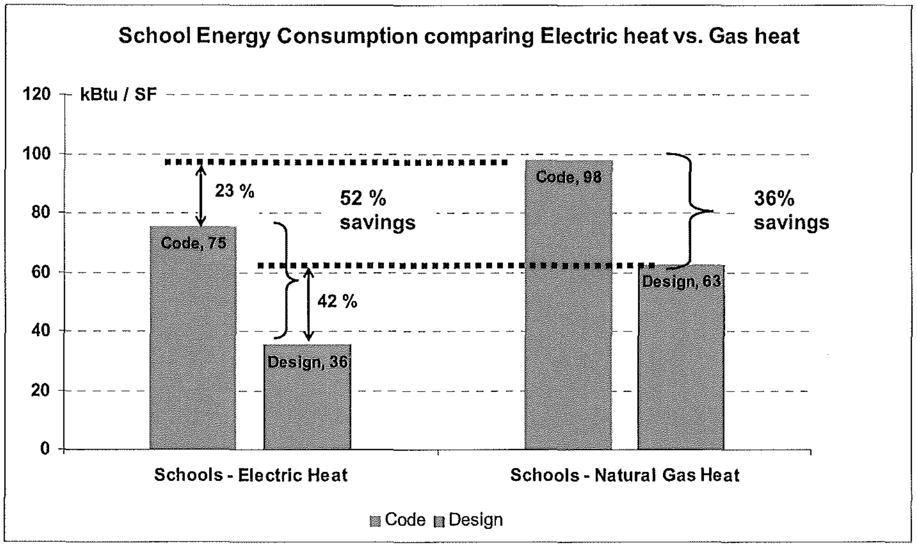


Figure A3: Average school building energy consumption from 59 schools for code and design levels and electric and natural gas heating.

Figure A4 shows the CO2 emissions results for this school population. Both the electric and natural gas heated schools start off at very different code base levels, 40 lbs CO2 / SF for the electric and 31 lbs CO2 / SF for the natural gas projects. However, their design CO2 levels are identical at 19 lbs CO2 / SF.

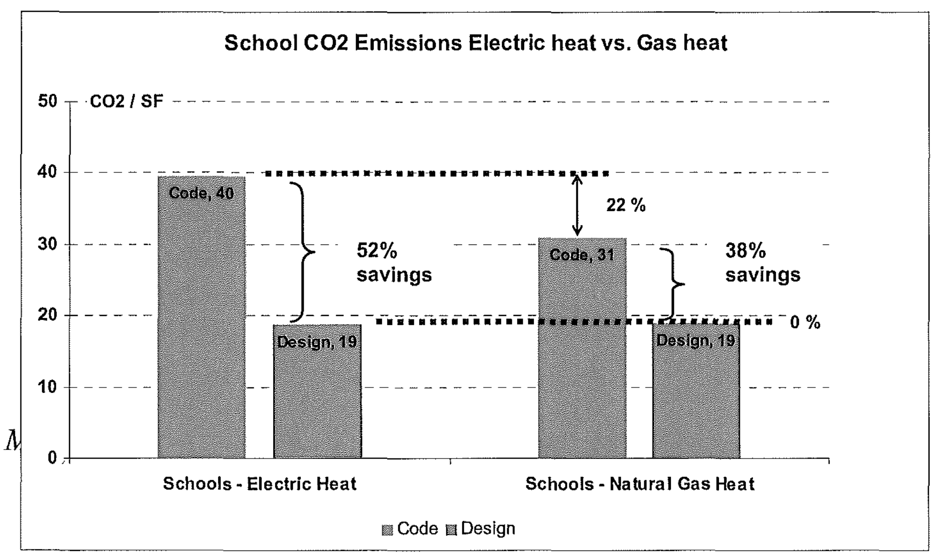


Figure A4: Average school building CO_2 emissions from 59 schools for code and design levels and electric and natural gas heating.

Conclusions:

From these examples we have learned that if we set a Carbon Dioxide Benchmark using an electric heated Code base building, both natural gas and electric heated buildings have the same opportunity within their design technology set to reach similar carbon emission goals.

Next Steps:

We recommend further testing on more building types in Phase 2 to understand the best methods for establishing a CO_2 Benchmark.

Sustainable Buildings 2030

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Contents

EXECUTIVE SUMMARY

Cost Effectiveness Analysis

CEE performed preliminary CIP program style cost-effectiveness analysis on a set of 115 buildings in the region that participated in similar design assistance programs and achieved savings of the same order of magnitude expected with the soon to be established Sustainable Buildings 2030 energy performance standard. Energy savings, estimated incremental costs and CIP program incentives were based on the design alternative chosen by the design team, and all other assumptions were chosen to be as representative as possible of current CIP program analysis assumptions used in Minnesota. The estimated incremental costs are generally based on preliminary estimates rather than bid alternates, so are less precise than most of the other inputs. No potential building market value increase associated with recognition as a high performance building was considered. The analysis was performed using a spreadsheet based calculation tool developed by CEE.

All of the building projects across a wide variety of building types were found to have a net benefit over an assumed 20 year life when a conservative societal discount rate was assumed. When a discount rate that is more representative of businesses assumptions is used, 94% of the building projects are cost-effective over the same 20 year life-cycle analysis. The majority of projects have high enough cost-effectiveness to the building owner that they could be considered as reasonable alternatives to developers that use a long-term view in planning investments. However, certain types of buildings tended to have significantly lower cost-effectiveness than others—most notably religious buildings and sports facilities.

Results from looking at the standard CIP program definition of societal cost-effectiveness showed similar trends, with the energy saving upgrades for each of the building projects being cost-effective. This societal test is generally the most critical test in terms of review of CIP program plans proposed by utilities. The general cost-effectiveness demonstrated in terms of both the participant and societal tests suggests that the level of energy savings being considered for the SB2030 energy performance standard can be cost-effective for a wide range of building types. However, the self-selected nature of the data set and relatively low cost-effectiveness for specific types of buildings suggests that either the standards might need to be lower for specific building types, and/or that a method should be established to provide project-specific limits on the performance standard based on project-specific cost-effectiveness analysis.

A representation of CIP program cost-effectiveness for the above data set showed very good cost-effectiveness to the utility for a representative design assistance program and incentives. In fact the cost-effectiveness to the utilities appears to typically be much higher than for the building owners. This suggests that higher incentives to building owners could make the marketing of the programs more successful (and cost-effective to the building owners) while still maintaining an attractive cost-effectiveness to the utility. Therefore, efforts to encourage utilities to increase incentive levels are recommended.

Utility Program Design & Development

As the Sustainable Building 2030 energy performance standard is implemented, CEE will work cooperatively with utilities to develop and/or modify CIP programs to encourage new buildings to meet the SB2030 standards. The language of the legislation requires that utilities address these standards with their programs, and these efforts will help utilities to optimize their program designs and support their efforts. The first step in the program efforts was the review of innovative and effective new construction CIP programs from around the country to determine what program elements could be effectively applied in Minnesota. A number of innovative program elements were identified—such as a whole building performance standard for small buildings and higher per unit incentives tied to meeting a green building standard--and a list of these is being presented to utilities as a menu of possible options. The most critical CIP program aspects that will be encouraged and supported are comprehensive design assistance services, bonus incentives for achieving SB2030 standards, and establishing a comprehensive whole-building performance program for small buildings.

COST EFFECTIVENESS ANALYSIS

Background & Analysis Tool Development

Reasons for Demonstration of Cost-Effectiveness

The legislation guiding the establishment of the SB2030 energy performance standards dictates that the standard be "…cost-effective based upon established practices used in evaluating utility conservation improvement programs." This requirement to demonstrate cost-effectiveness is not only important to ensure prudent use of public money in state-bonded buildings, but it is also critical to justify utility program support of the SB2030 energy performance standards and voluntary adoption of the SB2030 energy performance standards for commercial projects.

It is important that any additional up-front investment needed for public buildings to achieve the SB 2030 energy performance standard yield a long-term energy cost savings benefit that provides a life-cycle cost advantage. Otherwise, the mandate for higher energy performance would undercut the ability of state or local governments to provide their intended public service benefits and erode the support for energy performance improvements. Therefore, the cost-effectiveness of the preliminary SB2030 energy performance standards for state-bonded buildings will be verified (as required by the legislation) before the standards are finalized.

It is anticipated that the largest amount of funding for programs to support and reward the achievement of the SB2030 energy performance standards for commercial building projects will be utilities. Utility CIP design assistance programs for new construction projects have been cost-effective, and the cost-effectiveness of increased CIP program expenditures linked to the SB2030 energy performance standards will have a big impact on the amount of financial support that utilities will want to provide. Therefore, it is important that the cost-effectiveness of CIP program options that support the SB2030 standards be demonstrated. In addition to showing the cost-effectiveness to utilities, analysis of these potential programs will also evaluate the societal cost-benefit analysis, which is perhaps the most critical criteria in the Department of Commerce's review of CIP program plans. Utility program cost-effectiveness also includes an analysis of cost-effectiveness to building owners, which is important for making sure that the long-term economic benefits of meeting the SB2030 energy performance standards will be large enough that they afford to invest in higher performance buildings. While final analysis of formally proposed CIP program cost-effectiveness will be performed by each utility, preliminary analysis of potential programs will be an important tool both for helping evaluate different program options, and for encouraging utilities to include programs targeted to the SB2030 energy performance standards.

Background on Economic Evaluation of Utility Programs

When utilities first started considering load reduction programs as an alternative to building generating capacity more than two decades ago it required new models for evaluating the economic benefits. The California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Proejcts then emerged as the industry standard for evaluating the economics of these programs. The economic analysis of utility CIP programs in Minnesota generally follows the principles outlined in this document, which not only considers the economics from the utility perspective, but also from the perspective of participants and from a societal perspective.

Each of the different economic *tests* used to evaluate CIP program economics from a unique perspective is based on a life-cycle cost analysis of the energy saving improvement. Each test compares the long-term cost saving benefits against the near-term costs needed to achieve energy savings by converting both into a net present value at an assumed discount rate. Escalation rates for each of the numerous price factors are also assumed. The most commonly used metric of these tests in Minnesota is a benefit to cost ratio (ben-cost ratio) based on the ratio of these net present values. Benefit to cost ratios above one indicate an economic advantage over the life of the energy saving measures. Assumed life of the energy saving measures and escalation factors for energy and other costs are kept constant across the different tests, but different discount rates are applied for the various tests. The use of the specific tests based on the net present value benefit to cost ratios in Minnesota is overseen by the Department of Commerce's Office of Energy Security.

Participant Test

The participant test reflects the economics of a building owner that pays additional up-front costs to achieve savings, and then directly benefits from all of the reduction in retail energy costs. **Error! Reference source not found.** summarizes the characteristics of this test. Note that that for this test the financial incentives from a utility program are counted as benefits rather than a reduction in costs. Even though energy upgrades are often evaluated by customers in terms of simple payback, the primary results of this test is the lifetime sum of the net present value of benefits costs to the net present value of costs (ben-cost ratio). While any ben-cost ratio above one indicates favorable life-cycle costs for the participant, the economics alone are not a big motivator for most building owners unless the ben-cost ratio is significantly higher than one.

Table 1. Participant Test Summary

Benefits	Costs
Utility bill savings at retail rates Utility incentives (program rebate) Tax credits Any O&M cost savings	Initial added (incremental) cost Any O&M cost increase Removal cost (less salvage value)
Discount Rate for Calculating Net Present Value (NPV)	
Commercial Customers—Estimate of Businesses' Expected Rate of Return on Investments (High) Residential Customers—Estimate of Individuals' Expected Rate of Return on Investments (Low)	
Result to Look For	
Ben-Cost Ratio* >> 1 to achieve significant voluntary market penetration Ben-Cost Ratio* > 1 may be acceptable for governmental entities	

*Ben-Cost Ratio is the ratio of the net present value of benefits to the net present value of costs.

A separate discount rate for government buildings has not been defined specifically. While government buildings have generally been included in CIP programs that serve the commercial building sector (which are evaluated using a high discount rate), the nature of the public investment in government buildings may make a lower discount rate more appropriate for this building sector.

Utility Test

The utility test evaluates the economics of utility CIP program costs against the benefits of reduced energy generating, transmission and distribution costs. **Error! Reference source not found.** summarizes the characteristics of this test. Note that this test looks only at the cost of a CIP program against the utility's "internal" benefits of reduced costs, and ignores the potential utility revenue reduction that might result from preventing energy use with a CIP program (as opposed to allowing the use to occur).

Table 2. Utility Test Summary

Benefits	Costs
Avoided energy generating costs (at wholesale rates)	CIP program administration & project cost
Avoided infrastructure costs (e.g power plants, transmission & distribution)	Incentives to program participants (rebates)
Discount Rate for Calculating Net Present Value (NPV)	
Utility—utility's cost of capital from latest approved rate case (High)	
Result to Look For	
Ben-Cost Ratio* > 1 is beneficial to the utility	

*Ben-Cost Ratio is the ratio of the net present value of benefits to the net present value of costs.

The primary result of the utility test is the ben-cost ratio. From a regulator's standpoint, any ben-cost ratio of one or more is acceptable for the utility test, but having a higher ben-cost ratio with increase the likelihood of enthusiastic utility support. A secondary result that is also often considered by utilities is the program cost per unit of savings in the first year (e.g. $/kW, $/kWh or $/therm).

Societal test

The societal test is meant to include the overall net economic impacts of a CIP program on society as whole, including the utility, all of the utilities' customers, any government that supports the program through tax credits, and those who will eventually need to pay to deal with environmental impacts caused by energy use (environmental externalities). **Error! Reference source not found.** summarizes the characteristics of this test. Note that transfer payments between the above named groups are ignored (e.g. end-user utility bills, CIP program incentives [rebates], and tax credits). This test is typically the most critical test in Minnesota for determining whether or not CIP program will be considered for approval by regulators. A ben-cost ratio of at least one is needed for a project to be considered cost-effective based on the societal test.

Table 3. Societal Test Summary

Benefits	Costs
Avoided energy generating costs (at wholesale rates)	Initial added (incremental) cost
Avoided infrastructure costs (e.g power plants, transmission & distribution)	Any Participant O&M cost increase
Any Participant O&M cost savings	Removal cost (less salvage value)
Avoided environmental externalities costs	CIP program administration & project cost
Discount Rate for Calculating Net Present Value (NPV)	
Societal Discount Rate—Same as Residential Customers Discount Rate (Low)	
Result to Look For	
Ben-Cost Ratio* > 1 is acceptable to regulators	

*Ben-Cost Ratio is the ratio of the net present value of benefits to the net present value of costs

Software Tools for Economic Analysis of Utility Programs

Although the underlying equations remain essentially the same, various software packages are used for the economic evaluation of CIP programs. These include commercially available software and publicly available spreadsheets. A summary of the characteristics of a number of analysis tools appears in **Error! Reference source not found.Error! Reference source not found.**. After reviewing the capabilities and limitations of the available tools, CEE developed a new tool to provide a combination of transparency and capabilities that was not otherwise available.

Commercially available software packages are used by most electric utilities in Minnesota. DSManager is the legacy software that utilities have used in the past, but many Minnesota utilities are switching to the newer DSMore software. The primary advantage of the commercially available software packages is that they generally have the ability to combine detailed hourly "load shape" information about electric demand savings for an energy efficiency upgrade with similar detailed information about an electric utility's hourly marginal costs to generate electricity. The full benefit of this feature is only realized when accurate, detailed information about the timing of an upgrade's energy savings and about the utility system are available. The level and accuracy of this information is highest for programs that are targeted to specific energy saving technologies and/or specific building types. However, the advantages of load-shape analysis would be largely lost on programs that are primarily based on annual energy performance improvements that could be accomplished through a combination of a wide variety of different energy saving technologies—like the Sustainable Buildings 2030 energy performance standard.

Table 4. Summary of Utility Program Economic Analysis Tools

Analysis Tool	Developer	Electric kW and kWh	Combinted Fuels	Hourly Load Profiles	Transparent	Parametric Analysis	Non-Uniform Escalation	
DSManager	Electric Power Research Institute (product support discontinued)	✓		✓			✓	No longer available or supported, but still used because of familiarity & load-shape libraries
DSMore	Integral Analytics, Inc.	✓		✓		✓	✓	
ProCost	Northwest Power and Conservation Council	✓	✓	✓				Uses Total Resource Cost test instead of Societal Test
ElecBen	Minnesota Department of Commerce	✓			✓		✓	Not Actively Used
BenCost	Minnesota Department of Commerce		✓		✓			Minnesota Natural Gas Utilities are Required to Use
CEEtest	Center for Energy and Environment	✓	✓		✓	✓	✓	Newly developed for SB2030

The primary disadvantages of the commercially available software are that load-shape data must be obtained or generated for all energy savings technologies to be analyzed, and that key inputs are typically not transparently available for review by others. The detailed hourly information about savings load-shapes and utility costs can have a big impact on the results, but the load-shapes are typically obtained from a proprietary source (which does not allow their publication for public scrutiny) and the hourly information is generally very cumbersome to review (and has typically not been disclosed for public scrutiny). Moreover, the general percent savings nature expected in the SB2030 energy performance standards (and the limited data readily available from previous projects and utilities) means that many "educated guesses" about the hourly values would be incorporated into any analysis that did use the hourly profiles. Because of these disadvantages and the limited benefit of the detailed load-shape analysis capability for the SB2030 standard, commercial software packages were considered inappropriate for this project.

The more public ProCost spreadsheet based tool is similar in many respects to the commercial packages, with the advantage of being able to look at both electric and natural gas savings at the same time. However, it was also considered inappropriate for the reasons as the commercial software, plus the fact that it includes neither the societal test nor the capability to use non-uniform escalation rates.

Two spreadsheets maintained by the Minnesota Department of Commerce (ElecBen and BenCost) provide standard cost-benefit analysis and have the primary advantages of being transparent and using a simple annual average representation of utility costs per unit. However, each of these tools has limitations that prevent it from being a comprehensive tool for evaluating cost-effectiveness for this project. Each of these spreadsheets was designed primarily for one fuel (electricity or natural gas) and neither provides a complete enough representation of the other fuel to provide a comprehensive representation of the participant and societal benefits for projects that have impacts on both fuels. ElecBen lacks any inputs for natural gas savings and BenCost ignores the dual considerations of demand (kW) and energy use (kWh) that each have a big impact on electric costs. In addition, neither of the spreadsheets has any built-in parametric analysis capabilities. For the above reasons, the publicly available cost-benefit analysis tools were not considered adequate for the purposes of screening the cost-effectiveness of possible SB2030 energy performance standards and implementation programs.

Because of the absence of a pre-existing energy efficiency program cost-benefit analysis tool with the appropriate capabilities for this project, CEE developed a spreadsheet based program (CEEtest—Combined Energy and Environmental Transparent Economic Screening Tool) with these capabilities. The key capabilities built into the spreadsheet are: simultaneous evaluation of the impact of both electric and natural gas savings, transparency of assumptions, and simultaneous evaluation of ten different scenarios. The ability to use non-uniform escalation rates was also considered important for evaluating the impact of scenarios with step-wise cost variations such as: the consideration of individual power plant construction, and a future carbon value associated with a tax or cap-and-trade systems. Results from CEEtest were verified against ElecBen and BenCost. While some variable names and table layouts were incorporated from the publicly available spreadsheets, CEEtest it was built up with a structure that provides the ability to evaluate multiple scenarios with concise, transparent summaries of input assumptions and key results (and detailed tables that make every step of the calculations transparent for review). **Error! Reference source not found.** shows the general structure of the CEEtest spreadsheet and sample spreadsheet tables are shown in

Appendix A.

All of the inputs for up to ten parametric runs are summarized in one spreadsheet tab. Automatic formatting in the input summary clearly note which input assumptions change from one parametric one to the next. The only inputs not completely detailed in the input summary tab are annual cost increases for those costs that are treated as non-uniformly increasing each year. Nearly all costs can be treated as either uniform (fixed percentage increase each year) or non-uniform escalation. Uniform escalation rates are entered on the input summary tab and any yearly non-uniform escalation steps are entered in a separate escalation schedule tab for each applicable parametric run (10 separate tabs). The input summary tab indicates whether or not a uniform escalation is applied to each cost variable. Within the input tab, inputs are grouped according to whether they apply to a specific utility type (i.e. gas vs electric) or the customer directly, and whether or not they are fixed or change with CIP program design (e.g. retail rate structure vs number of buildings and/or the amount of financial incentive for a program). A number of macros were also created to allow for the batch resetting of: default assumptions, matching assumptions to the first run, and uniform escalation. The combination of input structure and macros provides great flexibility for changing assumptions in parametric runs while makes the definition and documentation relatively straightforward.

The cost-benefit calculations have every step shown in detail with a separate spreadsheet tab for each cost-benefit test and each of the ten parametric runs (a total of 40 calculation tabs). Each tab includes the detail of each year's calculation and the key summary results from the test. The

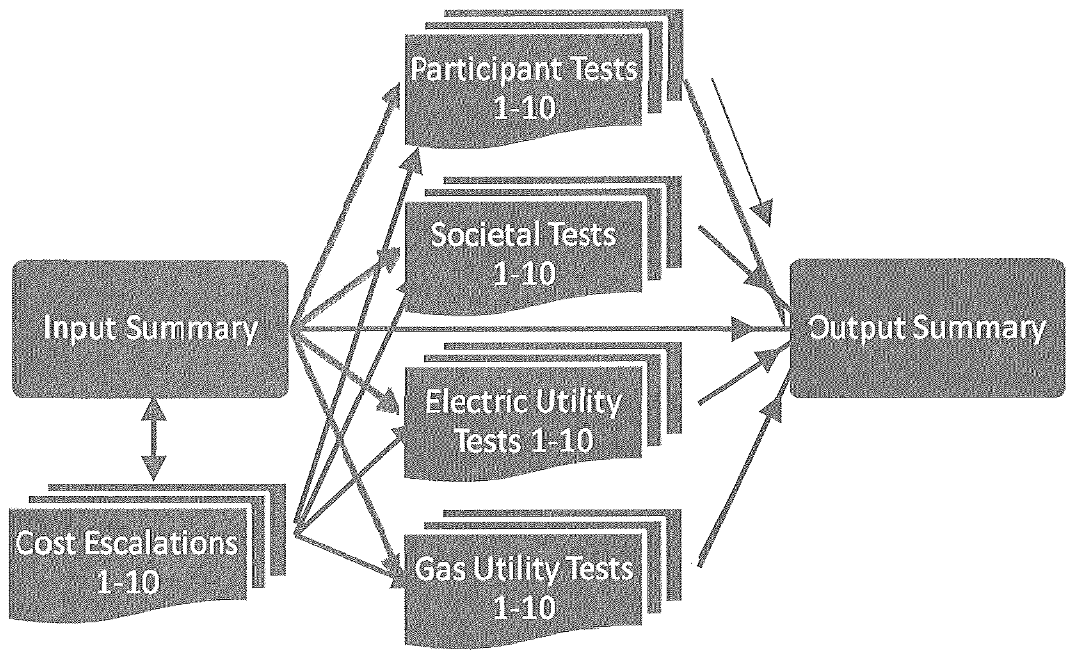

Figure 6. Organization of CEEtest Spreadsheet Tabs

electric utility and gas utility cost-effectiveness test results for each scenario are calculated in separate tabs. The 40 spreadsheets tabs provide detail that can be transparently reviewed, and the summary results are then fed into the output summary.

The output summary tab has both a table and chart that summarize the results. While the chart shows the benefit to cost ratios for the four cost-effectiveness tests and ten parametric runs, the table includes additional summary information that is also often of interest to program planners.

Analysis Inputs

Baseline values of inputs into the cost-effectiveness analysis were developed to be as representative as possible of upcoming and recent CIP program filings in the state. The Office of Energy Security (OES) within the Minnesota Department of Commerce generally gives utilities direction for each input regarding specific values to use or methods of calculating utility-specific values. The direction given to utilities for filings on June 1, 2009 (OES 2009) were used as the primary source of input assumptions for a number of variables. Where utility-specific values must be calculated, representative values were taken from recent CIP filings by the largest electric and gas utilities (Xcel Energy 2008 and CenterPoint Energy 2008). Likewise, the electric rate structure of Minnesota's largest electric utility was used as a representative indication. CEE also conducted independent research into a number of the inputs to gain insight into the appropriateness of the values being used in Minnesota, and reasonable alternate values that could be used in sensitivity analysis. However, all of the baseline values outlined in the next two sections and used for preliminary evaluation of cost-effectiveness were based on OES direction and/or contemporary CIP filings.

The analysis inputs generally fall into one of two categories: those that do and those that do not vary with CIP program design changes. The inputs that do not change reflect general conditions for a utility (e.g. retail rates and the wholesale cost of fuel to the utility). The following sub-section outlines the data sources and values for these inputs, which tend to have a significant impact on all of the cost-benefit analysis tests. A number of the inputs can change significantly between one individual utility CIP program and another (e.g. number of participants and CIP program cost), and the treatment of these inputs in the analysis is summarized in the **Error! Reference source not found.** subsection.

Representative General Conditions for Minnesota Utilities

CEE compiled a representative summary of utility and economic conditions for Minnesota to use as a basis for the economic analysis of Sustainable Buildings 2030 energy performance standards. Although some of these variable do vary from one utility to another (e.g. retail rate structure for electricity), they generally do not change significantly between one CIP program and another for the same customer class. The inputs that represent the general conditions for Minnesota utilities are described in more detail below, along with the base values assumed and data source for each input.

Electric utility general condition inputs are summarized in **Error! Reference source not found.**. Where possible, these inputs are based directly on representative values indicated by OES, and other inputs are based on values from an individual utility. The most notable input variation between utilities is the electric retail rate structure and level. A true Minnesota-wide weighted average electric rate is difficult to define because of the very different combinations of demand, energy use, and meter charges used in different electric utilities. Therefore, the most used electric rate structure for institutions and businesses—the A14 general service rate for Xcel Energy's commercial customers—was chosen as a representative input Variations from this rate structure and level for other utilities can have a big impact on the participant test, but do not impact the societal test which is the most critical test for policy setting. Wholesale electric generation and distribution costs are the key utility to utility variation that impacts the societal test. However, the establishment of a more open and active wholesale electric market in the region over the last several years has lowered the utility to utility variations in these costs. Representative values from MISO and recent CIP filings for design assistance programs that are performance based (rather than focused on a specific technology) were used to represent the energy and demand cost savings that can be achieved by buildings meeting the SB 2030 energy performance standards. Although the analysis tool is capable of taking more seasonal variations into account, lower than expected seasonal variation in electric energy costs seen in wholesale data from MISO and limited data availability for other items caused annual representative values to be used for most inputs.

Table 5. Representative Electric Utility Inputs for Cost-Effectiveness Analysis

Input Variable	Baseline Value	Data Source	Alternative Value(s) & Source
Marginal Energy Cost ($/KWh)	$0.0247	OES 2009	$0.05376 per MISO 2007 (includes effect of demand)
Escalation Rate	4.00%	OES 2009	
Avoided Capacity Cost ($/KW/Yr)	$135	Xcel 2007-9 CIP Escalated	
Escalation Rate	2.40%	Xcel 2007-9 CIP	
Variable Electric Operations & Maintenance Cost Saving	$0.0056	Xcel 2007-9 CIP Escalated	
Escalation Rate	4.00%	OES 2009	
Avoided Environmental Damage Costs ($/KWh Saved)	$0.0060	OES 2009	$0.012 to $0.064 per Roach & Mossburg 2008 Report to PUC
Escalation Rate	1.83%	OES 2009	
Retail Energy Rate ($/KWh)	$0.0422	Xcel A14 Rate in 2009	
Escalation Rate	1.76%	OES 2009	
Retail Demand Charge Summer ($/KW/Month)	$10.15	Xcel A14 Rate in 2009	
Escalation Rate	1.76%	OES 2009	
Retail Demand Charge Winter ($/KW/Month)	$6.81	Xcel A14 Rate in 2009	
Escalation Rate	1.76%	OES 2009	
Percent Line Loss	8%	OES 2009	6% Xcel 2009 Modification
# of Summer Months	4	Xcel A14 Rate in 2009	

Natural gas utility general condition inputs are summarized in **Error! Reference source not found.**. Where possible, these inputs are based directly on representative values indicated by OES, and other inputs are based on values from an individual utility.

Table 6. Representative Natural Gas Utility Inputs for Cost-Effectiveness Analysis

Input Variable	Baseline Value	Data Source	Alternative Value(s) & Source
Commodity Cost ($/MCF)	$9.13	OES 2009	
Escalation Rate	2.35%	OES 2009	5.41% NYMEX Futures (Feb 2009 - 2021); 6.56% EIA Historical Data for MN (1997-2007); 2.90% EIA Projection (2007-2030)

Demand Cost ($/Unit/Yr)	$100.91	Xcel 2009 Modification	$119.12 CenterPoint 2009 CIP
Escalation Rate	2.35%	OES 2009	1.29% CenterPoint 2009 CIP
Variable O&M ($/MCF)	$0.0692	CenterPoint 2009 CIP	
Escalation Rate	2.35%	OES 2009	
Gas Environmental Damage Factor ($/MCF)	$0.33	OES 2009	$0.48to $3.62 per Roach & Mossburg 2008 Report to PUC
Escalation Rate	1.83%	OES 2009	
Retail Rate ($/MCF)	$10.92	Commodity Cost Plus CenterPoint Energy's 2009 Delivery & Demand Charge	
Escalation Rate	2.35%	OES 2009	5.65% EIA Historical Data for MN (1997-2007)

Another key set of assumptions that has a significant impact on the cost-benefit analysis results are the discount rates used to de-value future cost savings when calculating net present value. The discount rates are summarized in **Error! Reference source not found. Error! Reference source not found.**. Note that OES directs the matching of the participant discount rate to the utility discount rate for commercial customers, and the lower societal discount rate for residential customers. These are meant to approximate the cost of capital for the different customer classes. The utility and commercial customer discount rates are based on a utility's cost of capital per its most recent rate case. Government customers and other public institutions have historically been in included in the commercial customer class. However, the assumption of a lower societal discount rate for state bonded buildings was deemed a reasonable policy alternative for the SB2030 energy performance standard analysis because of the longer-term building investment planning view that these institutions tend to have (compared to typical commercial customers) and their general interest in long-term societal benefit versus short-term investment return.

Table 7. Discount Rate Inputs for Cost-Effectiveness Analysis

Discount Rate	Baseline Value	Data Source
Participant Discount Rate (General Commercial)	7.14%	Weighted average of utility discount rates (2/3 electric and 1/3 gas)
Participant Discount Rate (Option for State-Bonded Buildings)	3.22%	See societal discount rate
Electric Utility Discount Rate	7.29%	Xcel 2009 CIP Modification
Gas Utility Discount Rate	6.83%	CenterPoint Energy 2009 CIP Filing
Societal Discount Rate	3.22%	20-Year Daily Treasury Long Term Rate as of 1/2/2009 (reported by OES)

Program and Project-Specific Inputs

A large number of program and project specific inputs vary significantly between different possible CIP programs and/or specific buildings for a given utility. These inputs are summarized in this subsection, along the values used for the preliminary cost-effectiveness analysis that has been performed. This cost-effectiveness analysis is generally based on buildings designed to have on-site energy usage at least 40 percent below energy code. Data for 115 such buildings was provided by the The Weidt Group, based on participants in CIP funded energy design assistance programs. The preliminary analysis assumes that buildings will be served by a CIP program similar in scope and per participant utility program delivery cost to Xcel Energy's Energy Design Assistance (EDA) Program. Future CIP programs that target the SB2030 energy performance standards are expected to have the same core characteristics as this program, with additional features. All of the sample building projects analyzed received incentives through this, or a similar, program and the actual incentive levels provided were used. While future efforts are expected to include more detailed evaluations of possible CIP program alternatives, the initial analysis focused on evaluating the different aspects of cost-effectiveness for a good representation of a current, comprehensive new construction CIP program that is focused on overall building performance.

Table 8. Electric Utility CIP Program/Project Specific Inputs for Cost-Effectiveness Analysis

Input Variable	Baseline Value	Data Source
Electric Utility Project Delivery ($/Participant)	$25,139	Xcel 2008 Status Report--2007 Actual
Electric Utility Administration ($/Participant)	$2,646	Xcel 2008 Status Report--2007 Actual
Electric Utility Incentive Costs ($/Participant)	Varies by Building	Data from The Weidt Group
Number of Participants in Electric Program	1	-
Average Energy Reduction/Participant Total (KWh)	Varies by Building	Data from The Weidt Group
Peak Coincidence Factor	0.928	Xcel 2008 Status Report—EDA
Target Group Diversity Factor	1	Assumed
Peak Monthly Load Reduction Summer (kW)	Varies by Building	Data from The Weidt Group
Avg Monthly Load Reduction Summer (kW)	70% of Peak	Assumed
Avg Monthly Load Reduction Winter (kW)	60% of Peak	Assumed

The electric utility CIP program specific inputs are detailed **Error! Reference source not found.** in **Error! Reference source not found.**. Note that actual utility program costs for admin and delivery were divided by the number of participants to yield a per participant program cost that can be used with individual buildings to provide representative ben-cost ratio results.

The natural gas utility CIP program specific inputs are detailed **Error! Reference source not found.** in **Error! Reference source not found.**. Gas utility project costs were only assigned to the small fraction of sample building projects that had received a natural gas energy savings incentive in connection with an electric utility's design assistance program.

Table 9. Natural Gas Utility CIP Program/Project Specific Inputs for Cost-Effectiveness Analysis

Input Variable	Baseline Value	Data Source
Gas Utility CIP Project Operating Cost ($/Participant)	$4,108	
Gas Utility Incentive Costs ($/Participant)	Varies by Building	Data from The Weidt Group
Number of Participants Gas	0 or 1	Data from The Weidt Group
Average MCF/Part. Saved	Varies by Building	Data from The Weidt Group
Peak Reduction Factor	1%	Xcel 2009 CIP Modification, CenterPoint 2009 CIP

The general and participant specific inputs are detailed **Error! Reference source not found.** in **Error! Reference source not found.**. Perhaps the most hard to determine key variable is the incremental cost for a higher performing building. Values in the analysis are generally based on preliminary cost-estimates generated by the design teams, which may or may not have had much history with the design upgrades. For utility program analysis in Minnesota, the maximum measure life is currently limited to 20 years based on direction from OES. While a number of energy saving measures incorporated into the design of a building will last for the life of the building, while other equipment-specific items (e.g. air conditioner) may have a shorter lifetime than the 20 years. The 20 year life assumed for the preliminary analysis is consistent with what has been used in CIP filings for new construction design assistance programs. Note that no potential increase in value based on recognition as a high performance building was considered in the analysis.

Table 10. General/Participant Project Specific Inputs for Cost-Effectiveness Analysis

Input Variable	Baseline Value	Data Source
Direct Participant Cost ($/Participant)	Varies by Building	Data from The Weidt Group
Other Participant One-Time Cost ($/Participant)	$0	Assumed
Measure Lifetime (Years)	20	Assumed, Xcel 2009 CIP Modification
Participant Non-Energy Savings (e.g. water or O&M)	$0	Assumed
Escalation Rate	2.50%	Assumed
Participant Non-Energy Costs (e.g. increased O&M)	$0	Assumed
Escalation Rate	2.50%	Assumed

Cost-Effectiveness Analysis Findings To Date

Public Building Developer/Owners

The participant and societal cost-benefit tests are the most critical to demonstrate that the Sustainable Buildings 2030 energy performance standards provide a net long-term benefit to both the institution that funds and operates a building, and to society at large. Preliminary analysis was conducted for a set of 115 buildings in the region that participated in CIP funded energy design assistance programs delivered by The Weidt

Group. Buildings were generally included in this data set if the chosen design was expected to achieve at least 40 percent savings compared to the local energy code at the time. Average site energy use savings for the buildings was projected to be 50 percent. The building data set is somewhat self-selected because any projects for which energy analysis showed poor economics for an aggressive energy saving design would have been less likely to have chosen the aggressive energy saving design and would have been subsequently excluded from inclusion. However, analysis of the reported upgrade costs and savings indicate that energy savings of the same order of magnitude that is expected in the SB 2030 standards can be cost-effectively achieved for a large number variety of buildings.

Twenty year life-cycle cost-effectiveness to an owner is demonstrated in **Error! Reference source not found.** by benefit to cost ratios that are above one. The left-hand axis and blue bars show the number of buildings of each type in the data set, and the benefit to cost ratios noted by the box and whisker plots are read from the right hand axis. The ends of the lines represent the highest and lowest values for the building type, while the ends of the boxes indicate where the middle 50% of sample buildings of each type fall. The values in this graph are based on the proposed use of the societal discount rate for government and quasi-governmental institutions that receive state bond funding. For the vast majority of buildings—except religious buildings—the benefit to cost ratios are significantly higher than one, indicating a net benefit to the building owner over 20 years. Even all of the religious buildings do have a cost-effectiveness of one or more.

The cost-effectiveness does go down somewhat for these projects when the utility's discount rate is applied to the future savings realized by the building owner (as has been traditionally done for CIP program analysis of commercial customers—including government entities). These results are shown in **Error! Reference source not found.**. Although the participant cost-effectiveness is lower with the higher discount rate, the values are below one for only 6 percent of the buildings in the sample. Although ben cost ratios just slightly above one can justify a public policy decision, voluntary recruitment of significant numbers of commercial projects will likely require ben-cost ratios of at least two.

The results of societal benefit to cost ratio analysis are similar to the participant test results, indicating that the energy savings provides a net economic benefit to society. The range of values by building type is shown in **Error! Reference source not found.**. None of the sample buildings show a benefit to cost ratio of less than one. The societal test is the most critical from a public policy decision standpoint, so these results strongly suggest that the level of energy savings expected as part the

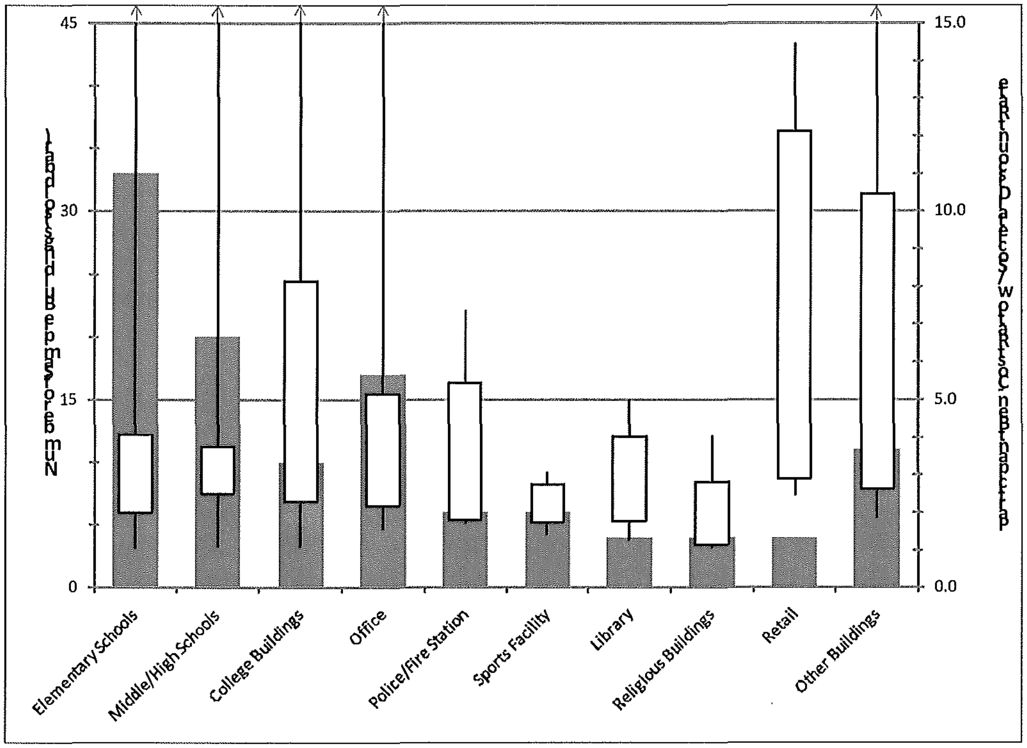

Figure 7. Participant Benefit to Cost Ratios by Building Type (at Societal Discount Rate)

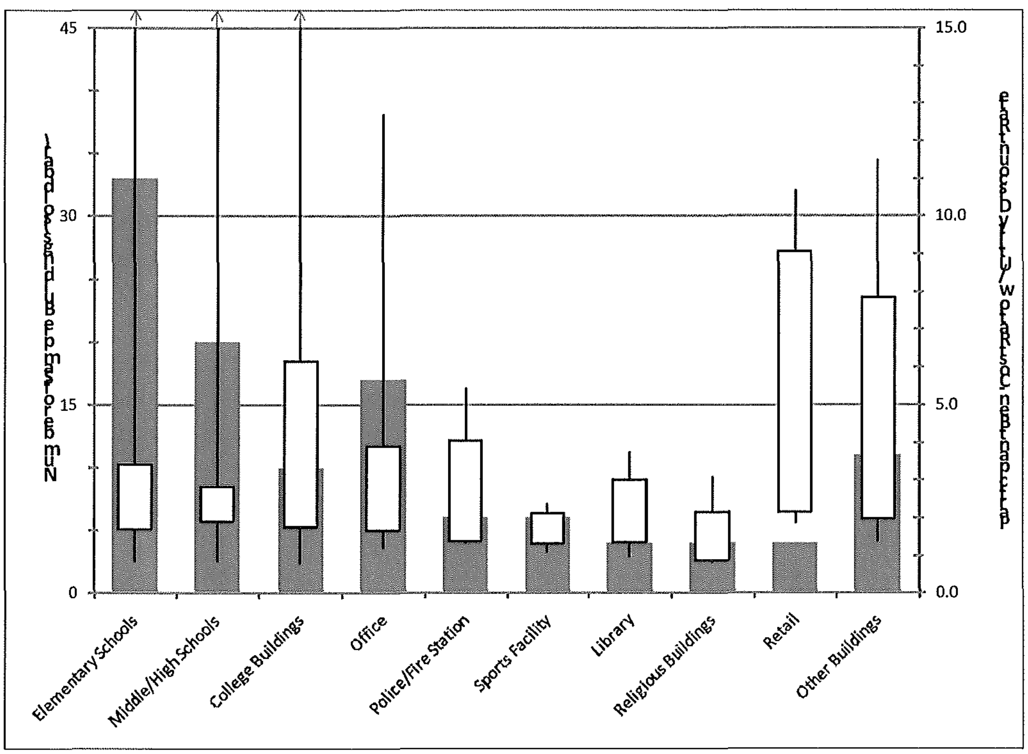

Figure 8. Participant Benefit to Cost Ratios by Building Type (at Uility Discount Rate)

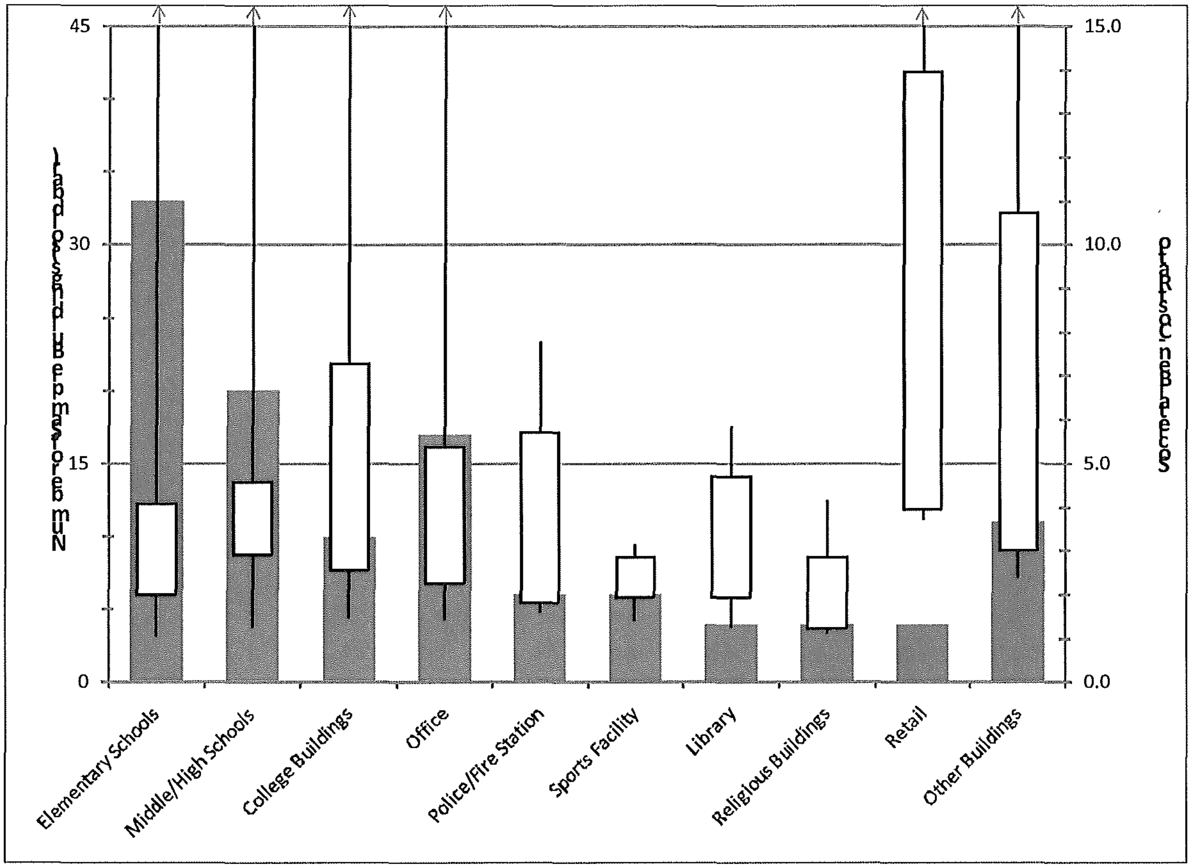

Figure 9. Societal Benefit to Cost Ratios by Building Type

SB2030 energy performance standard can be justified as a sound, cost-effective policy for for the majority of buildings. However, the relatively poor performance of all four religious buildings suggests that there may be some building types that are an exception to the general rule of cost-effectiveness.

In order to deal with the wide variations in cost-effectiveness by general building type, the project team will need to further evaluate the cost-effectiveness of various performance levels for a variety of building types and set the SB2030 performance standards below the Architecture 2030 savings goals for building types that generally are not able to cost-effectively achieve these goals. This approach requires significant up-front analysis, but then would provide clear up-front goals that are cost-effectively achievable by design and development teams. Therefore, this is recommended for common building types—especially those that represent a significant percentage of state-bonded building projects. However, this up-front analysis approach is limited in that it can foresee neither all design options that a design team might incorporate, nor all the building types for which the SB2030 energy performance standards could be applied.

Since it is not possible or cost-efficient for the project team to fully anticipate and evaluate all possible building and space use types, there is also expected to be a need for a project-specific "waiver" system for building types that can not cost-effectively achieve the SB2030 general energy performance standard. This is expected to be a more flexible general procedure that can be used to reduce the percentage energy savings requirement for individual projects, but puts the burden on the design and development team to demonstrate that a specific project cannot cost-effectively achieve the SB2030 percentage savings goals. Such a system should require that analysis of a number of different aggressive energy saving design options be performed to both conclusively show that the percentage savings in the SB2030 standard cannot be achieved in a way that is cost-effective from both a societal and participant perspective (ben-cost ratios of one or higher), and to determine a lower percentage savings target that achieves the highest possible savings while still being cost-effective from both a societal and participant perspective.

Further investigation also found that the benefit to cost ratios did not seem to show any dramatic, systematic pattern of dropping off as the percentage energy savings increased. **Error! Reference source not found.** shows a scatter plot of the societal ben/cost ratio as a function of percent site energy savings compared to code. The absence of a strong trend in the data suggests that very large reductions in energy use can often be achieved as cost-effective as lower levels of energy savings. Similar analysis on subsets of the data (e.g. elementary schools) also did not show any clear tendency for the cost-effectiveness to drop off sharply with increasing percentage savings.

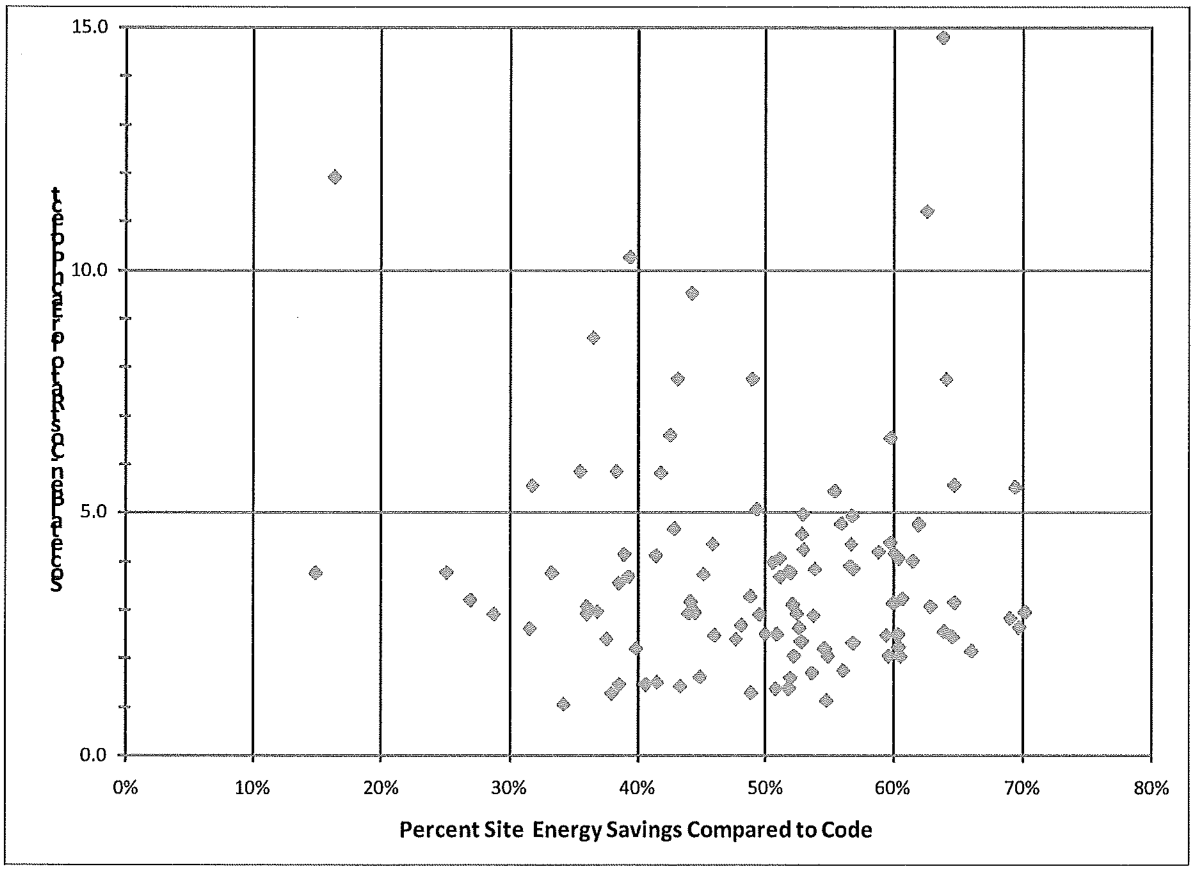

Figure 10. Cost Effectiveness Varition with Percent Energy Savings

Utility Programs

Preliminary analysis suggests that the cost-effectiveness to a large electric utility of a comprehensive design assistance program that achieves roughly the level of savings expected as part of the SB2030 standards is very good. These results are summarized in **Error! Reference source not found.**. The left-hand axis and blue bars in the graphs show the number of buildings of each type in the data set, and the benefit to cost ratios noted by the box and whisker plots are read from the right hand axis. The ends of the lines represent the highest and lowest values for the building type, while the ends of the boxes indicate where the middle 50% of sample buildings of each type fall. Note that the electric utility benefit to cost ratios tend to be much higher than the participant to cost ratios. This suggests that there is the potential to cost-effectively provide higher incentive levels that could make the participant economics more attractive while having only a modest reduction if overall program cost-effectiveness. Therefore, the SB2030 project team plans to support utility efforts to increase CIP program incentives for achieving energy savings consistent with the SB2030 standards.

Natural gas utility cost-effectiveness for those projects receiving incentives shown in **Error! Reference source not found.** indicates even higher cost-effectiveness than for electric utilities. A majority of the project delivery cost was assigned to the electric utility making the assumed gas program costs relatively low, and it appears that higher natural gas program costs could be incurred and still have the program easily justified as being cost effective to the natural gas utility.

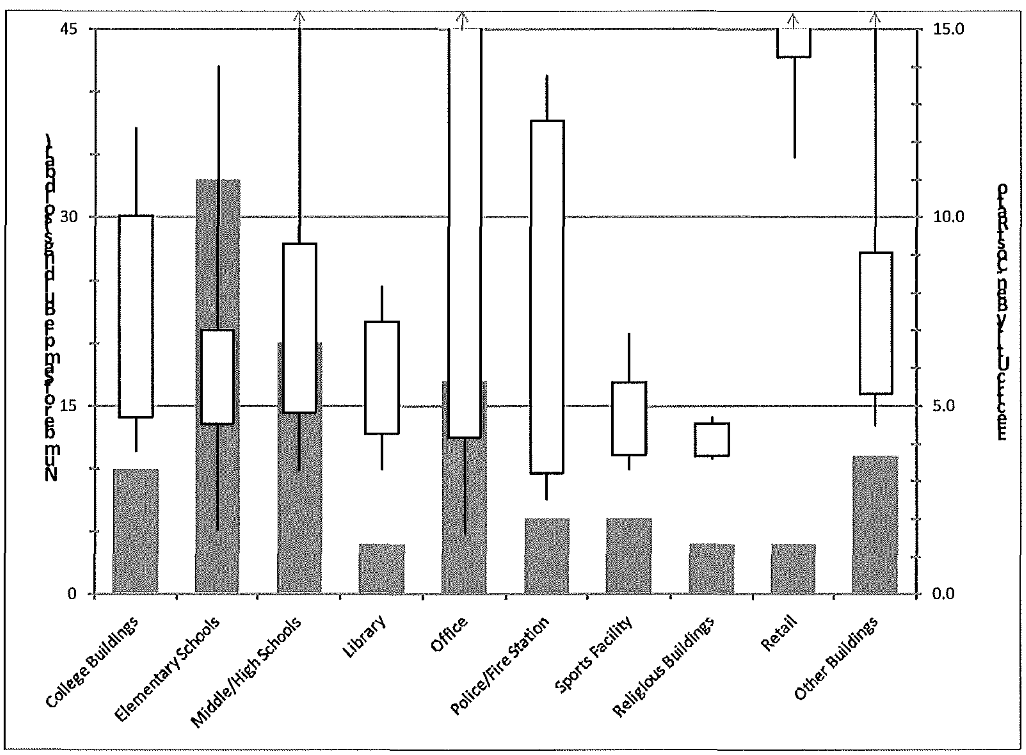

Figure 11. Electric Utility Benefit to Cost Ratios by Building Type

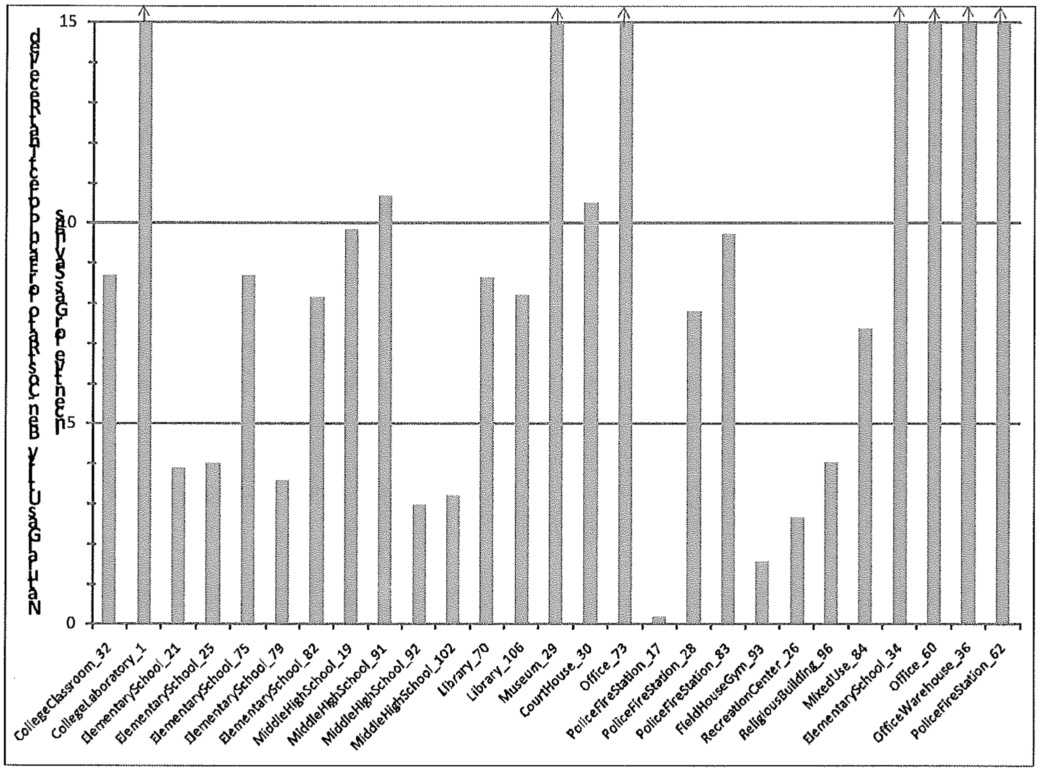

Figure 12. Natural Gas Utility Benefit to Cost Ratios by Building Type

UTILITY PROGRAM DESIGN & DEVELOPMENT

The biggest source of funding to encourage and support building designers, developers and owners in efforts to meet Minnesota's Sustainable Building 2030 standards is expected to be Conservation Improvement Programs (CIP programs) operated by utilities. Section 216B.241, Subd. 9e indicates that utilities will be required to develop CIP programs that incorporate certain minimum elements to help building achieve the SB2030 energy efficiency standards. At the same time, utilities in Minnesota are having their minimum requirements for energy savings from CIP programs increased substantially [polish & add reference per Sheldon]. Therefore, efforts to develop models of utility program approaches and to cooperatively work with utilities to encourage best practices and funding for CIP program represents a key aspect of the support for SB2030 standards and can be seen by utilities as an opportunity to meet increased CIP performance goals.

CEE identified model CIP program approaches based on examples of programs in Minnesota and from around the country, as the first step in developing effective programs. While utilities in Minnesota have operated successful CIP programs with some of the elements that will be needed to meet the above requirements, it will be a new challenge for many of Minnesota's utilities to comprehensively address all of the above requirements effectively. Minnesota's largest electric utility, Xcel Energy, has long been an industry leader in programs that have a number of the elements that will be required. Xcel Energy has worked with The Weidt Group since 1993 to operate an energy design assistance program for new construction projects that has received national recognition as an exemplary program (ACEEE 2007). This program was expected to provide a framework for much of an ideal model CIP program for SB2030,yet it needs to be updated to expressly incorporate the SB2030 standards. Minnesota's largest natural gas utility, CenterPoint Energy, has a program to support the development of LEED certified buildings that provides one example of several across the country that are linked to a specific sustainable building energy performance standard. These are two examples of various utility CIP and state public benefits programs that CEE examined against the future needs of Minnesota utilities to address the SB2030 energy performance requirements while developing model program features.

After developing model program features, CEE began efforts to work cooperatively with key staff from Minnesota utilities to have a positive impact on the development of their CIP programs. While these meetings educate them about the SB2030 standards and related CIP program requirements, the main goals of these meetings are to suggest model approaches that could be used to effectively meet the CIP program requirements for SB2030 energy standards, and to encourage high levels of utility funding for such programs that are simultaneously cost-effective to the utilities, society and the developer/owners.

Model Utility Program Features

Beyond requiring that utilities design CIP programs to achieve energy efficiency goals consistent with the Sustainable Buildings 2030 performance standards, the Sustainable Buildings 2030 legislation calls for the utility programs to have each of the following elements:

- Design assistance and modeling;
- Financial incentives; and
- Verification of the proper installation of energy-efficient design components

CEE reviewed CIP and state-wide public benefits programs to find examples of program features that could be used by utilities in Minnesota to simultaneously meet their CIP program requirements and effectively support the voluntary use of the Sustainable Buildings 2030 energy performance standards in buildings that are not state-bonded. The remainder of this section highlights examples of programs that can provide guidance for program design in Minnesota.

Rebates for Meeting Sustainability Building Guidelines

New construction CIP programs have traditionally provided rebates based on incremental energy (or demand) savings compared to a minimal standard of performance (typically the current energy code or minimum standard practice), so the SB2030 legislation's call to achieve a set level of performance that is dramatically higher than the energy code is a deviation from this approach. Fortunately, several utilities have already pioneered programs that provide examples of approaches to encourage projects to achieve specific sustainable building system target efficiencies that represent a dramatic "step" increase in performance—as opposed to proportionally rewarding any increase in performance.

Several utilities tie rebates or services to LEED-NC certification, while a limited number reference other sustainable building or energy performance standards. **Error! Reference source not found.** summarizes the key characteristics of several programs—two of which are in Minnesota—that tie services or financial incentives to specific standards that are significantly above code requirements. These programs are generally available as a separate tract or additional component of a more general new construction program.

While program features targeed to specific energy performance ratings in Minnesota have focused exclusively on providing technical assistance (directly or indirectly through rebates to engineers), a number of other programs have included incentives. Within Minnesota, Xcel Energy provides additional technical assistance in the form of energy simulations for projects that achieve 16% energy savings and intend to achieve LEED certification. CenterPoint Energy also provides technical assistance, but more indirectly through rebates to engineers for design work (rather than energy analysis activites). While We Energies in Wisconsin has similarly provided design team incentives related to LEED projects, programs in other parts of the country—especially the west coast—have also provided owner rebates for projects that meet specific green building or energy performance goals that are substantially better than the local energy code requirements.

Besides the LEED green building rating system, the Advanced Buildings Benchmark is referenced by multiple utilities for smaller building projects.

Table 11. Programs Tied to Sustainable Building or Stand-Alone Energy Performance Ratings

Organization(s)	Rating Referenced	Type of Support	Notes
Xcel Energy & The Weidt Group	LEED Registered with 16% Savings	Additional Technical Assistance	Additional energy analysis and support of energy performance credit certification
CenterPoint Energy	LEED	Engineering Assistance	Up to $5,000 for engineering design services; ½ up front and ½ after certification
We Energies	Submitting for LEED Silver or Better	Rebates for Design Team	Also design team rebates for integrated design process & simulations
Energy Trust of Oregon	LEED-NC or – CS EA credits 3 or 1&5	Rebates	Additional rebates tied to LEED credits for Enhanced Commissioning and/or On-Site Renewables plus Measurement & Verification
Long Island Power Authority	LEED-NC & 24% better than ASHRAE 90.1 2004	Rebates for Meaures & Services	Higher rebate cap, 100% of cost for simulation, fundamental & enhanced commissioning, and rebates for specific LEED credits
San Diego Gas & Electric	LEED, 20% Savings Vs Code & Evaluate On-Site Renewables	Rebates for Owner & Design Team	20% bonus above standard new construction rebates plus ½ of certification fees
Southern California Edison (Suatainable Communities Program)	20% Savings Vs Title 24 (CA code) [15% residential]	Technical Assistance & Rebates	Targeted to large mixed use and multi-building projects
Savings by Design (Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison Company, Southern California Gas Company and the Sacramento Municipal Utility Dist)	10% and 15% Savings Vs Title 24 (CA code)	Rebates for Owner & Design Team	Projects must achieve 10% savings to receive owner incentive and 15% to receive design team incentive
National Grid	Advanced Buildings Benchmark	Rebates	
We Energies	Advanced Buildings Benchmark	Rebates	This tract for buildings <80,000 sf
Energy Trust of Oregon	EnergyStar	Rebates	Much lower cap on rebates than LEED tract

Progressive Rebates

While CIP programs in Minnesota that provide new construction performance based rebates have traditionally had a fixed level of incentive (e.g. $/kW, $/kWh or $/therm) for savings compared to the state energy code (e.g. $/kW, $/kWh or $/therm), a number of programs in other Midwestern states and California use progressive rebates to strongly encourage larger "leaps" in efficiency over smaller incremental improvements. **Error! Reference source not found.** summarizes the characteristics of three such programs. Each of these programs has a minimum percent savings versus a baseline that must be achieved before any rebates are available. Then, the programs have a sliding or multiple step scale with rebate amount per unit of savings increasing as the percent savings increases.

Table 12. Sample Programs With Progressive Rebates

Organization(s) & Locations	Rebate Recipient	Reference for Energy Savings	Minimum Per Unit Rebate	Maximum Per Unit Rebate
Alliant Energy, Iowa	Owner	Iowa Code (~ASHRAE 90.1 2004)	5¢/kWh @ 5% savings	14¢/kWh @ 35% savings
Focus On Energy, Wisconsin	Owner	Wisconsin Code (~ASHRAE 90.1 2004) Plus Limited Program Requirements	@ 10% savings: $125/kW; 4¢/kWh; $0.40/therm	@ 30% savings: $200/kW; 6¢/kWh; $0.60/therm
Pacific Power, California & Washington	Owner	California Title 24	12¢/kWh @ 10% savings	18¢/kWh @ 30% savings
Savings by Design (Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison Company, Southern California Gas Company and the Sacramento Municipal Utility Dist), California	Owner	California Title 24	10¢/kWh @ 10% savings	25¢/kWh @ 25% savings
Savings by Design (Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison Company, Southern California Gas Company and the Sacramento Municipal Utility Dist), California	Design Team	California Title 24	5¢/kWh @ 15% savings	8.3¢/kWh @ 25% savings

While the above programs are not specifically linked to a sustainable building system target, they set examples for a progressive rebate structure that could be linked to the Sustainable Buildings 2030 performance goals. For example, an incentive program could have a base incentive level per unit of savings (e.g. $/kW) with a large step increase in the incentive level per unit of savings for projects that meet or exceed the SB2030 performance goals.

Design Team Incentives

Progressive building owners and developers may provide general direction to design an energy efficient building, but they are very dependent on the design team's expertise to determine what is efficient and may not fully appreciate the extra effort required by the design team to design a building that is dramatically more energy efficient that more "typical" designs.. The long-term staple of CIP programs has been incentives for the building owners, but many programs have recognized the critical role of the design professionals and provide at least one form of incentive or reimbursement. **Error! Reference source not found.** outlines the types of designer incentives that have been used, and highlights examples of some of the programs that have used each of the types.

Table 13. Design Team Rebate Approaches for New Construction Programs

Rebate Basis	Description	Program Examples
Fixed Design Services Rebates	Supports involvement in meetings to evaluate energy upgrades or for extra design work to incorporate upgrades	*Xcel Energy*—Incentives to design team are intended to offset the cost of involvement in the CIP design assistance program *Center Point Energy*—Incentives to engineers for the design of efficient equipment *Aiiant Energy (IA)*—Program participation to design team based on project square footage ($2,000 to $13,000) *We Energies*—Incentives to design team if integrated design process *Wisconsin Focus on Energy*—Paid to design team or owner to help offset the cost of developing an energy efficient design
Fixed Building Energy Simulation Rebates	Covers at least a portion of the cost of energy simulation performed by the design team	*We Energies*—Incentives to design team if simulation performed *Wisconsin Focus on Energy*—Fixed $3,000 to design team or owner to help offset the cost of simulation as part of developing an energy efficient design *Energy Trust of Oregon*—Engineering study (see below) often includes simulation (up to $25,000) *Long Island Power Authority*—Up to $50,000 for projects seeking LEED-NC certification
Savings Achieved	Provides a rebate proportional to the level of energy savings achieved by the design.	*Savings by Design (CA statewide)*—Additional 1/3 of project incentive to design team for projects with at least 15% savings VS California Title 24 (up to $50,000) *Northeast Utilities*—

		We Energies—Additional 10% of project incentive to design team *Energy Trust of Oregon*—Funds engineering study work up to ½ of project incentive or $25,000

To date, new construction CIP programs in Minnesota have generally limited designer incentives to low levels that offset incremental designer costs associated with CIP program participation or for traditional design work for energy upgrades. However, two additional approaches to design team rebates have the potential for cost-effectively increasing overall program savings.

First of all, providing an option for the design team to receive an incentive for performing the energy simulation that is typically used in new construction programs to estimate savings and determine incentive amounts (rather than limiting it to the utility staff and/or contracted consultants) provides flexibility for quickly increasing program participation. The specialized nature of simulations and issues with quality control of simulations performed by firms that are not under a large-scale program contract with the utility have made the reliability of this option dubious in the past. Over the last few years this option has become more tenable as the following has occurred:

- many more design firms are developing high level in-house capability to perform energy simulations;
- standard quality control is provided by a third party for many projects through USGBC's review of submittals for LEED-NC certification
- widespread use of a standard for energy simulations which compare the energy performance of a proposed design against a lower efficiency reference case (Appendix G of ASHRAE Standard 90.1) has taken hold due to requirements in the LEED-NC rating system and for new federal buildings

The stringent requirements for building energy simulation and its review for projects applying for LEED-NC certification provide the ability to use ability these results as a basis for determining incentive levels and compliance with the Sustainable Buildings 2030 energy performance goals. It is expected that a large percentage of projects choosing to achieve the SB2030 energy performance goals will also be applying for LEED-NC certification, so providing design team incentives to cover at least a significant part of the simulation cost could be a cost-effective and reliable way to document the energy performance of a large number of project designs in a CIP program incorporating SB2030 goals. This is especially true for utilities that do not have a history with comprehensive design assistance programs.

When providing rebates for simulation it is important to differentiate between the less rigorous evaluation of many alternatives early in the design process, and the more rigorous simulation needed to document energy savings of the final design against a standard. The early design phase modeling, which can have the biggest impact on the project, should generally not have as rigorous standards because the goal is preliminary evaluation of design options against each other. At this stage, having part of the design team perform the simulation provides the potential for a better fine-tuning of designs through more iterative feedback and design adjustment than can typically be achieved when the utility or a separate consulting firm performs the simulation. However, funding to support this should have minimum requirements for the evaluation of a number of options. On the other hand, the above referenced standard provides most of the guidance necessary for documenting savings of the final design (although the results may need to be scaled to reflect the difference between the current code and the SB2030 baseline).

The third approach to designer rebates rewards the design team in proportion to the level of savings. This can provide a powerful incentive to the individual professionals who make a multitude of decisions that drive the energy efficiency of the building design. While We Energies and the Energy Trust of Oregon programs have limited this incentive based on the equivalent design professional hourly fees, the Savings by Design program has a more open-ended reward for performance that provides design teams more flexibility in pursing different design options without committing to specific, minimal limitation on analysis and design hours for high performance projects that usually include a number of design features that are not "run of the mill". This type of open-ended design team rebate based on performance could be very effective at giving designers the extra motivation necessary to include energy efficient features that require more up-front work on their part.

Commissioning & Operator Training

Commissioning of buildings involves a third party reviewing the design and construction to verify that the building energy systems (primarily heating, ventilating and cooling) are are capable of meeting the owner's performance requirements. At the design stage, the plans are reviewed against the owner's project requirements, and during the construction and acceptance phase the systems are verified against the design documents. Another key aspect of commissioning is the support of ongoing operations through the verification of training and the preparation of a commissioning report that includes documentation and manuals for the HVAC systems and their components. While the main goal is make that things work properly, it is generally recognized that, on average, about 5% energy savings is achieved. In fact, the LEED-NC green building rating system has commissioning as one of its very few prerequisites, and categorizes this under the energy category. Although commissioning is generally an important item, it is especially important for innovative energy system designs with which designers and/or contractors may have limited experience.

For the reasons noted above, a large number of utilities strongly encourage commissioning of new construction projects through various combinations of incentives and education. A non-exhaustive list of utilities that provide financial incentives for commissioning is included in **Error! Reference source not found.**.

Examples of utility programs that specifically include design phase commissioning are noted in **Error! Reference source not found.**. Starting commissioning in the design phase is not only important to identify potential issues with the design meeting the owner's intended performance, but also to make sure that any items needed to ensure that systems can be reliably commissioned are included in the design documents (e.g.

pressure taps to measure pump performance). Because commissioning is sometimes interpreted to be limited to construction verification, it is important that any intent to include design phase commissioning and operator training be expressly stated in program materials. It should also be note that LEED-NC credit for Enhanced Commissioning includes design phase commissioning, while the Fundamental Commissioning required for all LEED-NC projects does not.

The importance of strict requirements for operator training (and their verification through commissioning) is hard to overemphasize. More information about the critical role of building operations can be found in a separate section of this project report. Even if building operators

Table 14. Utilities with Commissioning Incentives

Organization(s) & Locations	Design Phase	Additional Notes
Austin Energy, Texas		
Energy Trust of Oregon, Oregon	X	-Rebate for Enhanced Commissioning that meets LEED-NC EA credit 3; -Rebates of 1.5¢/kWh plus 10¢/kWh of savings; -Rebate capped at $20,000
Long Island Power Authority, New York	X	-Must use preselected commissioning agents; Rebates up to 50% of commissioning cost for typical projects; -Rebates up to 75% of rebate for savings; For LEED projects, rebates up to 100% of cost of Fundamental & Enhanced Commissioning
NV Energy, Nevada		
NYSERDA, New York		-Commissioning required for projects receiving rebate of $100,000 or more; -Commissioning incentive of additional 10% of project rebate up to $50,000
Puget Sound Energy, Washington State	X	-Standard commission rebate of 32¢/square foot; -Additional rebate if design-phase commissioning
Seattle City Light, Washington	X	Rebate of $5,000 to $10,000 requires design phase commissioning

start with a good level of HVAC knowledge, system specific training is important—especially for innovative systems.

Measurement of Performance Over Time

Many technologies and buildings end up having field performance that doesn't match expectations—often due to issues with improper installation and/or operation. Therefore, the measurement of actual energy performance over time is important both to help building owners identify operational problems that can be addressed, and to provide feedback to the utilities and designers about the actual performance of designs. While providing incentives for the measured performance over a long period of time can be logistically difficult, it provides a valuable resource for energy savings and information. Energy Trust of Oregon has two program features that specifically address the issue of long-term performance measurement, which are described in **Error! Reference source not found.** along with the measurement & verification systems they reference.

Table 15. Measure of Performance Items in Energy Trust of Oregon Programs

Provider & Tract	Description
Energy Trust of Oregon, EnergyStar Tract	Rebates are based on becoming an EnergyStar rated new construction building, which requires specific elements, plus one-year of post-occupancy metered data showing that the building uses less energy than 75 percent of similar, existing buildings in 2003
Energy Trust of Oregon, LEED-NC Tract	-Rebate for Measurement & Verification plan that meets LEED-NC EA credit 5, which requires a long-term plan for comparing expected energy use against actual performance and the installation of necessary sub-metering equipment; -Rebate of 1.5¢/kWh plus 10¢/kWh of savings; -Rebate capped at $20,000
Long Island Power Authority, Green Building Incentives	$1,000 Rebate for Measurement & Verification that meets LEED-NC EA credit 5, which requires a long-term plan for comparing expected energy use against actual performance and the installation of necessary sub-metering equipment

Comprehensive Prescriptive Criteria for Small Buildings

The CBECS 2003 data indicates that more than half of the commercial building area in the Midwest is in buildings smaller than 50,000 square feet, which has been the minimum building size minimum for the largest comprehensive design assistance program in Minnesota. Moverover, 38% of the commercial building area is in buildings smaller than 25,000 square feet. However, achieving the SB2030 energy performance goal in a cost-effective way can be especially challenging for small buildings where the costs of building energy simulation and additional design team meetings represent a relatively large fraction of the design costs. Moverover, the design-build process often used for smaller building projects makes it harder for traditional design-assistance services to be effective. Fortunately, a number of resources have emerged that each provide a comprehensive set of energy efficiency feature requirements for new buildings that are significantly higher than most building code requirements.

The most comprehensive and aggressive set of whole-building prescriptive requirements is the Core Performance Guide written by the New Buildings Institute. This is the latest version of the Advanced Buildings Benchmark referenced used by a number of programs. In addition to the base set of requirements, it has a second tier of requirements that is referred to as enhanced measures. A number of utilities in New England, as well as Wisconsin, have referenced this guide as a set of requirements for rebates in small buildings. It has also been recognized in the LEED-NC rating system and has been recognized by Architecture 2030 as meeting the initial 50% reduction goal when the base and enhanced measures are required. While it is still unclear exactly how well the guideline matches up against the 2010 60% reduction goal for Minnesota, it appears that it can provide the majority of the savings for a variety of small buildings. A precedent for making modification to create a state-specific version of Core Performance Guide has also already been set in Vermont.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has taken a different approach in developing a set of Advanced Energy Design Guides (AEDGs), each of which is focused on a different type building and vary the requirements based on climate zone.. The buildings addressed are:

- Small Retail Buildings (≤20,000 square feet)
- Small Office Buildings (≤20,000 square feet)
- Small Warehouse & Self Storage Buildings (≤50,000 square feet)
- K-12 School Buildings (any size)

The initial set of AEDGs was developed to provide 30% energy cost savings compared to ASHRAE Standard 90.1 1999 (the 2004 version was determined to be approximately 14% more efficient than this standard). Unfortunately, this level of energy savings is not as aggressive as the levels of energy savings targeted by the Architecture 2030 goal.

Similar to the ASHRAE design guides, Minnesota's sustainable building guidelines provide a comprehensive set of prescriptive criteria that together yield a substantial improvement beyond the current energy code for office buildings. However, Minnesota's guidelines provide more flexibility for designers to choose between three different sets of criteria that each emphasize more substantial improvements in specific systems (e.g. lighting or HVAC).

Finally, a more flexible and easy to apply performance-based method of demonstrating an overall percentage energy savings compared to ASHRAE 90.1 2004 has been put into place by the Minnesota Housing Financing Agency. MHFA's approach allows the use of COMcheck to document percentage improvements in the lighting and envelope and provides options for trading off the envelope savings level against various levels of HVAC equipment efficiency improvement. (COMcheck is a free software program that is developed and supported by the Department of Energy.) Since the design team generally performs COMcheck analysis to demonstrate compliance with the Minnesota Energy Code, this approach requires relatively little additional effort to demonstrate compliance compared to the level of effort typically undertaken to document energy performance either for LEED-NC certification or CIP-funded design assistance programs.

The different sets of prescriptive, whole-building requirements noted above provide an array of options for small building energy performance requirements that could be used as a basis for rebates. While the building-type specific guidelines may be useful for encouraging moderate energy performance improvements in certain building types, the Core Performance guide appears to be the most widely used, widely applicable, and aggressive guide. CEE recommends that further investigation into and promotion of small building program options focus on evaluating the possible use of the Core Performance Guide (and the possible need to make Minnesota-specific modifications) and the possible use of a system that combines a COMcheck performance rating of the envelope and lighting with trade-offs in HVAC equipment efficiency.

Assisting Minnesota Utilities with CIP Program Development

Suggested Design for MN Utilities by Type & Size

Large Electric & Combined Utilities

Large electric and combined utilities in Minnesota are generally already delivering (or have the capability to deliver) new construction programs that have key program elements needed for encouraging energy efficient new construction (e.g. prescriptive measure and whole building tracts). However, effectively encouraging energy performance at the SB2030 level will require new features in these programs. Key program features that should be considered as programs are designed to address the SB2030 goals as part of a larger new construction program are:

- Bonus rebates for reaching SB2030 energy performance standards (e.g. higher $/kW,$/kWh, $/therm for these projects)
- Rebates for commissioning (including design phase and operator training)
- Additional rebates based on one-year post-occupancy metered energy use
- Design team incentive based on savings
- An option of rebates for simulation performed by the design team
- A comprehensive "prescriptive" option for smaller buildings (such as Core Performance Guide or ASHRAE design guides)

Smaller Electric & Gas Utilities

Many smaller electric and natural gas utilities in Minnesota may not have the in-house resources to develop and implement the full-service, multi-tract design assistance program that is expected to be most effective for encouraging energy performance that strives for the SB2030 standards. (See the previous section for a more detailed outline of key features that would be part of a larger, multi-tract new construction program (e.g. similar to Xcel Energy's Energy Design Assistance program). Moreover, the small volume of projects running through such a project for a smaller utility would make the administrative costs to develop and operate such a program relatively high. Therefore, it is recommended that smaller utilities take one of the approaches outlined below:

- Partner with one or more other utilities of the same type to develop and implement a program that covers a wider service territory
- Partner with one or more utilities of a different type to provide a coordinated program
- Develop a utility specific program that either subcontracts the program design and implementation to an outside consultant or which provides substantial rebates to the design team for energy analysis of options and documentation of the final design's energy performance.

Work with Utilities on CIP Program Design & Implementation

CEE's key objective in working with utilities is to encourage and support their efforts to design and implement modified, expanded and/or new CIP programs that cost-effectively increase building performance in a way that is consistent with the Sustainable Buildings 2030 energy performance standard. To this end, CEE has had meetings and/or phone conversations with staff from three investor owned electric utilities about the above program elements and will initiate dialogue with the remaining investor owned utilities, as well as wholesale providers, and representatives of a number of cooperatives and municipal utilities in Minnesota this summer. Initial indications are that CIP plans and program development efforts already reflect some movement in the direction of many of the program elements suggested, and the project team will work to support utilities' plans with the key elements noted, and work cooperatively with utilities to encourage and assist their development of further steps in the direction of the goals of the Sustainable Buildings 2030 standard.

Support for Utilities With Established, Comprehensive New Construction Programs
The top priorities for working with utilities that already have fairly comprehensive design assistance programs will be to develop a comprehensive, practical program for small buildings and to encourage increased incentives for projects that achieve the SB2030 energy savings standards. Xcel Energy is already taking steps in both of these directions, but expressed keen interested in the further development of program options for small buildings. The project team intends to have in-depth discussions with utilities and building industry professionals involved in the design of small buildings about the two most promising small building program options. Based on the results of the discussions, the project team expects to further develop a small building program template that is consistent with Minnesota's SB2030 standard. Additional actions that will be taken to encourage and support utilities' CIP program development are expected to include assistance with future CIP program plan development, the submission of supportive comments through the formal CIP comment process, and support pilot projects.

Support for Utilities Without Established, Comprehensive New Construction Programs
Although the items noted in the previous subsection, will also be addressed with utilities that don't have established comprehensive design assistance programs, the top priority in working with these utilities will be to encourage and support their development of such a program.

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APPENDICES

Appendix A. Sample CEEtest Input, Output and Calculation Tables

Multiple Utility and Multiple Input Cost-Benefit Analysis Tool

INPUT DATA SHEET: All Inputs Except for Non-Uniform Time Series Escalation

Project Name	**SB2030: Sample of Projects As Designed**
Electric Utility	**MN Representative Per Gas CIP 2010/Xcel**
Gas Utility	**MN Representative Per Gas CIP 2010/CPE**
MultiRun Name	Sample Projects: Non MN Elementary 1
Date_Time	6/4/09 3:58 PM

Restore All Defaults on Input Tab

Restore Uniform Escalation for All Runs

Restore Default Runs 2-10 Input Tab Only

Reset Runs 2-10 Escalations to Follow Example of Run1

Inputs are in bold Blue.

Non-uniform escalation rate entries are in tables in sheets 'Escalation Schedule_1' to 'Escalation Schedule_2'.

Blank cells in Run2-10 are the same as in the next lowest # Run that has a value displayed.

Default is for each Run to match Run1 (e.g. a change in Run2 will NOT be carried to Run3 unless Run3 is edited).

	IndividualRunName	Project 2	Project 4	Project 5	Project 6	Project 7	Project 8	Project 9	Project 11	Project 12	Project 21
	Project #	**2**	**4**	**5**	**6**	**7**	**8**	**9**	**11**	**12**	**21**

General Electric Utility Info

Original Label	ShtName	Run1	Run2	Run3	Run4	Run5	Run6	Run7	Run8	Run9	Run10
Marginal Energy Cost Summer ($/KWh) =	Marginal_kWhCost_Summer	$0.0247									
Simple Escalation Marginal Electric Energy Cost	SimpleEscal_Marginal_kWhCost_Summer	Yes									
Escalation Rate =	EscalRate_Marginal_kWhCost_Summer	4.00%									
Marginal Energy Cost Winter ($/KWh) =	Marginal_kWhCost_Winter	$0.0247									
Simple Escalation Marginal Electric Energy Cost	SimpleEscal_Marginal_kWhCost_Winter	Yes									
Escalation Rate =	EscalRate_Marginal_kWhCost_Winter	4.00%									
Avoided Capacity Cost Summer ($/KW/Yr) =	Avoided_kWCost_Summer	$135									
Simple Escalation Avoided Electric Capacity Cost	SimpleEscal_Avoided_kWCost_Summer	Yes									
Escalation Rate =	EscalRate_Avoided_kWCost_Summer	2.40%									
Avoided Capacity Cost Winter ($/KW/Yr) =	Avoided_kWCost_Winter	$0									
Simple Escalation Avoided Electric Capacity Cost	SimpleEscal_Avoided_kWCost_Winter	Yes									
Escalation Rate =	EscalRate_Avoided_kWCost_Winter	2.40%									
~~Avoided Capacity Cost SpringFall ($/KW/Yr) =~~	~~Avoided_kWCost_SpringFall~~	~~$0~~									
~~Simple Escalation Avoided Electric Capacity Cost~~	~~SimpleEscal_Avoided_kWCost_SpringFall~~	~~Yes~~									
~~Escalation Rate =~~	~~EscalRate_Avoided_kWCost_SpringFall~~	~~2.00%~~									
Variable Elec Operations & Maintenance Cost Saving	VariableOM_Cost_kWh	$0.0056									
Escalation Rate =	EscalRate_VariableOM_Cost_kWh	4.00%									
Avoided Environmental Damage Costs ($/KWh Saved) =	Externalities_Cost_kWh	$0.0060									
Simple Escalation Environmental Externalities Cost	SimpleEscal_Externalities_Cost_kWh	Yes									
AEC Escalation Rates =	EscalRate_Externalities_Cost_kWh	1.83%									
Percent Line Loss =	Elec_LineLossPercent	8.00%									
# of Summer Months	MonthsOfSummer	4									
Retail Energy Rate Summer ($/KWh) =	Retail_kWh_Summer	$0.0422									
Simple Escalation Electric Energy Charge	SimpleEscal_Retail_kWh_Summer	Yes									
Escalation Rate =	EscalRate_Retail_kWh_Summer	1.76%									
Retail Energy Rate Winter ($/KWh) =	Retail_kWh_Winter	$0.0422									
Simple Escalation Electric Energy Charge	SimpleEscal_Retail_kWh_Winter	Yes									
Escalation Rate =	EscalRate_Retail_kWh_Winter	1.76%									
Retail Demand Charge Summer ($/KW/Month) =	Retail_kW_Summer	$10.15									
Simple Escalation Electric Demand Charge	SimpleEscal_Retail_kW_Summer	Yes									
Escalation Rate =	EscalRate_Retail_kW_Summer	1.76%									
Retail Demand Charge Winter ($/KW/Month) =	Retail_kW_Winter	$6.81									
Simple Escalation Electric Demand Charge	SimpleEscal_Retail_kW_Winter	Yes									
Escalation Rate =	EscalRate_Retail_kW_Winter	1.76%									

Electric Project Info

Original Label	ShtName	Run1	Run2	Run3	Run4	Run5	Run6	Run7	Run8	Run9	Run10
Elec Utility Project Costs (Current Year)											
Elec Project Delivery	Elec_Utility_ProjectDelivery	$25,139									
Elec Utility Administration =	Elec_Utility_ProjectAdmin	$2,646									
Elec Incentive Costs =	Elec_Utility_IncentiveTotal	$315,404	$120,154	$83,500	$157,811	$85,633	$65,000	$149,000	$130,000	$101,600	$187,700
Total Elec Utility Project Costs =	Elec_Utility_ProjectCostTotal	$343,188	$147,938	$111,284	$185,595	$113,417	$92,784	$176,784	$157,784	$129,384	$215,484
Number of Participants Elec =	Elec_Participants	1									
Incentives Received/Participant ($) =	Elec_Incentive_PerParticipant	$315,404	$120,154	$83,500	$157,811	$85,633	$65,000	$149,000	$130,000	$101,600	$187,700
Percent Elec Energy Reduction =	Percent_kWhSavings	63.89%	59.84%	61.55%	64.81%	64.63%	60.75%	63.73%	62.58%	66.39%	66.55%
Average Consumption/Participant (KWh) =	Base_kWh_Per	3,526,186	1,434,326	970,992	1,739,234	946,416	1,198,592	1,627,420	1,488,924	1,094,183	2,014,542
Average Energy Reduction/Participant Summer (KWh) =	Savings_kWh_Summer_Per	901,153	343,296	239,046	450,887	244,665	291,277	414,869	372,682	290,553	536,309
Average Energy Reduction/Participant Winter (KWh) =	Savings_kWh_Winter_Per	1,351,730	514,945	358,569	676,331	366,998	436,915	622,304	559,022	435,829	804,464
Average Energy Reduction/Participant Total (KWh) =	Savings_kWh_Total_Per	2,252,883	858,241	597,615	1,127,218	611,663	728,192	1,037,173	931,704	726,382	1,340,773
Peak Coincidence Factor =	PeakCoincidenceFactor_Elec	93%									
Target Group Diversity Factor	TargetGroupDiversityFactor_Elec	100%									
Peak Monthly Load Reduction Summer (kW)	Peak_kW_Savings_Summer	1743.0	560.0	133.0	185.0	96.0	144.0	176.0	182.0	154.0	464.0
Avg Monthly Load Reduction Summer (kW)	Avg_kW_Savings_Summer	1307.3	420.0	99.8	138.8	72.0	108.0	132.0	136.5	115.5	348.0
Peak Monthly Load Reduction Winter (kW)	Peak_kW_Savings_Winter	1307.3	420.0	99.8	138.8	72.0	108.0	132.0	136.5	115.5	348.0
Avg Monthly Load Reduction Winter (kW)	Avg_kW_Savings_Winter	1045.8	336.0	79.8	111.0	57.6	86.4	105.6	109.2	92.4	278.4
Annual Total Load Reduction (kW)	SumMonthly_kW_Savings_Annual	13595.4	4368.0	1037.4	1443.0	748.8	1123.2	1372.8	1419.6	1201.2	3619.2

Discount Rates

Original Label	ShtName	Run1	Run2	Run3	Run4	Run5	Run6	Run7	Run8	Run9	Run10
Elec Utility Discount Rate (%)	DiscountRate_UtilityElec	7.29%									
Gas Utility Discount Rate (%)	DiscountRate_UtilityGas	6.83%									
Societal Discount Rate (%)	DiscountRate_Societal	3.22%									
Commercial Participant Discount Rate (%)	DiscountRate_Part_Commercial	7.14%									
Government Participant Discount Rate (%)	DiscountRate_Part_Government	3.22%									

General Project Information

Original Label	ShtName	Run1	Run2	Run3	Run4	Run5	Run6	Run7	Run8	Run9	Run10
Direct Participant Cost Participant =	Participant_Cost_Per	$396,129	$297,880	$179,634	$418,127	$280,142	$271,847	$506,262	$377,070	$437,404	$385,131
Other Participant Cost Participant (one-time) =	OtherParticipant_Cost_Per	$0									
Project Analysis Year =	ProjectYear	2010									
Measure Lifetime (Years) =	Measure_Life	20.0									
Participant Non-Energy Savings (e.g. water or O&M)	PartNonEnergySvgs	$0									
Simple Escalation Participant Non-Energy Savings	SimpleEscal_PartNonEnergySvgs	Yes									
Escalation Rate =	EscalRate_PartNonEnergySvgs	2.50%									
Participant Non-Energy Costs (e.g. increased O&M)	PartNonEnergyCosts	$0									
Simple Escalation Participant Non-Energy Costs	SimpleEscal_PartNonEnergyCosts	Yes									
Escalation Rate =	EscalRate_PartNonEnergyCosts	2.50%									

General Natural Gas Utility Info

Original Label	ShtName	Run1	Run2	Run3	Run4	Run5	Run6	Run7	Run8	Run9	Run10
Commodity Cost ($/MCF) =	GasCommodityCost	$9.1300									
Simple Escalation Commodity Cost	SimpleEscal_GasCommodityCost	Yes									
Escalation Rate =	EscalRate_GasCommodityCost	2.35%									
Demand Cost ($/Unit/Yr) =	GasAvoidedDemandCost	$100.91									
Simple Escalation Avoided Electric Capacity Cost	SimpleEscal_GasAvoidedDemandCost	Yes									
Escalation Rate =	EscalRate_GasAvoidedDemandCost	2.35%									
Variable O&M ($/MCF) =	VariableOM_Cost_MCF	$0.0692									
Escalation Rate =	EscalRate_VariableOM_Cost_MCF	2.35%									
Gas Environmental Damage Factor ($/MCF) =	GasEnvDamage_MCF	$0.3300									
Simple Escalation Gas Env Damage Factor	SimpleEscal_GasEnvDamage_MCF	Yes									
Escalation Rate =	EscalRate_GasEnvDamage_MCF	1.83%									
Retail Rate ($/MCF) =	Retail_MCF	$10.9200									
Simple Escalation Retail Rate ($/MCF)	SimpleEscal_Retail_MCF	Yes									
Escalation Rate =	EscalRate_Retail_MCF	2.35%									

Natural Gas Project Info

Original Label	ShtName	Run1	Run2	Run3	Run4	Run5	Run6	Run7	Run8	Run9	Run10
Gas Utility Project Costs (Current Year)											
Gas Project Operating Cost	Gas_Utility_ProjectAdminPlusOperating	$0									$4,108
Gas Incentive Costs =	Gas_Utility_IncentiveTotal	0									2,500
Total Gas Utility Project Costs =	Gas_Utility_ProjectCostTotal	$0									$6,608
Number of Participants Gas =	Gas_Participants	1									
Incentive Participant =	Gas_Incentive_PerParticipant	$0									$2,500
Percent GasEnergy Reduction =	Percent_MCFSavings	0.00%						20.51%	100.00%	0.00%	38.90%
Average Consumption Participant (MCF) =	Base_MCF_Per	0						468	45	15	473
Average MCF Part. Saved =	Savings_MCF_Per	0.00	0.00	0.00	0.00	0.00	0.00	96.00	45.00	0.00	184.00
Peak Reduction Factor =	PeakReductionFactor_Gas	1.00%									

Multiple Utility and Multiple Input Cost-Benefit Analysis Tool

ESCALATION SHEET: All Non-Uniform **Time Series Escalation**

Project Name: SB2030: Sample of Projects As Designed
Electric Utility: MN Representative Per Gas CIP 2010 Xcel
Gas Utility: MN Representative Per Gas CIP 2010 CPE
MultiRun Name: Sample Projects - Non MN Elementary 1

Individual Run: Project 2
Individual Run #: 1
Date Time: 6/4/09 4:29 PM

DO NOT EDIT ABOVE ROW 21--THESE ARE FORMULA CARRYOVERS FROM INPUT SHEET.

Table Values in gray are simple escalations from the previous year.

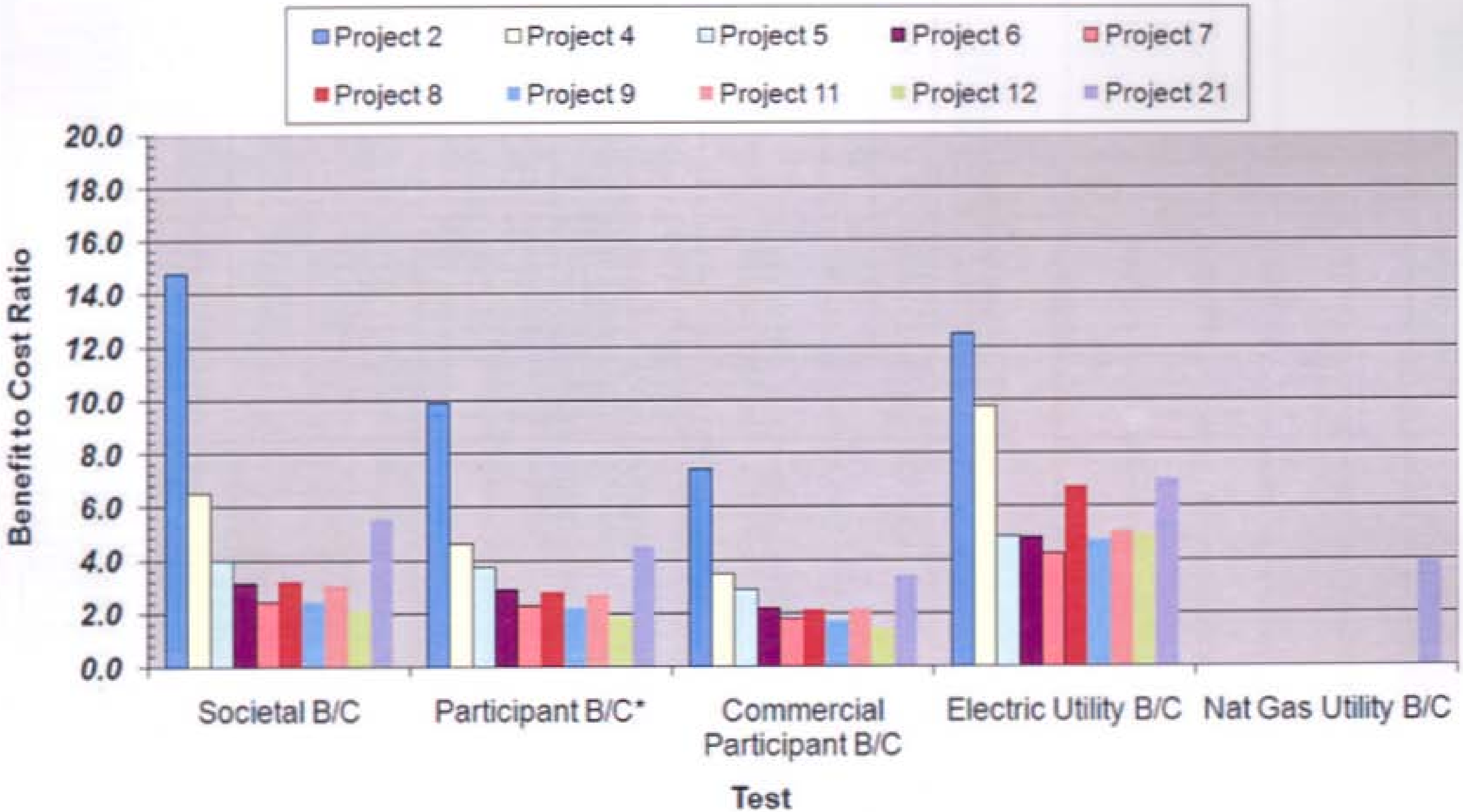
		Marginal_kWhCost_Summer_Run1	Marginal_kWhCost_Winter_Run1	Avoided_kWCost_Summer_Run1	Avoided_kWCost_Winter_Run1	Avoided_kWCost_SpringFall_Run1	VariableOM_Cost_kWh_Run1	Externalities_Cost_kWh_Run1	Retail_kWh_Summer_Run1	Retail_kWh_Winter_Run1	Retail_kW_Summer_Run1	Retail_kW_Winter_Run1	PartNonEnergySavings_Run1	PartNonEnergyCosts_Run1	GasCommodityCost_Run1	GasAvoidedDemandCost_Run1	VariableOM_Cost_MCF_Run1	GasEnvDamage_MCF_Run1	Retail_MCF_Run1
InitialValue		$0.025	$0.025	$135.313	$0.000	$0.000	$0.006	$0.0060	$0.0422	$0.0422	$10.1500	$6.530	$0.000	$0.000	$9.130	$100.910	$0.069	$0.350	$10.920
EscalationRate		4.00%	4.00%	2.40%	2.40%	2.00%	4.00%	1.85%	1.76%	1.76%	1.76%	1.76%	2.50%	2.50%	2.35%	2.35%	2.35%	1.85%	2.35%
~~Not Used Run~~																			
Simple Escalation		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
							Fixed @ Constant Escalation										Fixed @ Constant Escalation		
Nyear	CalYear	1a) Marginal Energy Cost Summer ($/KWh) =	1b) Marginal Energy Cost Winter ($/KWh) =	2a) Avoided Capacity Cost Summer ($/KW/Yr) =	2b) Avoided Capacity Cost Winter ($/KW/Yr) =	2c) Avoided Capacity Cost SpringFall ($/KW/Yr) =	5) Variable Elec Operations & Maintenance Cost Saving	4) Avoided Environmental Damage Costs ($/KWh Saved) =	17a) Retail Energy Rate Summer ($/KWh) =	17b) Retail Energy Rate Winter ($/KWh) =	18a) Retail Demand Charge Summer ($/KW Month) =	18b) Retail Demand Charge Winter ($/KW Month) =	Participant Non Energy Savings (e.g. water or O&M)	Participant Non Energy Costs (e.g. increased O&M)	3) Commodity Cost ($/MCF) =	4) Demand Cost ($/Unit/Yr) =	(6) Variable O&M ($/MCF) =	9) Gas Environmental Damage Factor ($/MCF) =	1) Retail Rate ($/MCF) =
0	2010	[illegible]	[illegible]	$100.00			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	2011	[illegible]	[illegible]	$150.00			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	2012	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	2013	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	2014	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	2015	[illegible]	[illegible]	$200.00			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	2016	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	2017	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	2018	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	2019	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	2020	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	2021	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	2022	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	2023	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	2024	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	2025	[illegible]	[illegible]	$300.00			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	2026	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	2027	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	2028	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	2029	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	2030	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	2031	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	2032	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	2033	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	2034	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	2035	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	2036	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	2037	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	2038	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	2039	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Project: SB2030: Sample of Projects As Designed
MultiRun: Sample Projects: Non MN Elementary 1

Run #	Run Name	% Elec Reduction	% Gas Reduction	Inc. Cost	1st Year Savings	Societal B/C	Participant B/C*	Commercial Participant B/C	Electric Utility B/C	Nat Gas Utility B/C	Utility Cost
1	Project 2	64%	0%	$396,129	$205,121	14.8	9.9	7.4	12.5	Infinite	$197/kW
2	Project 4	60%	0%	$297,880	$71,575	6.5	4.6	3.5	9.8	Infinite	$264/kW
3	Project 5	62%	0%	$179,634	$33,617	4.0	3.7	2.9	4.8	Infinite	$837/kW
4	Project 6	65%	0%	$418,127	$59,249	3.1	2.9	2.2	4.8	Infinite	$1,003/kW
5	Project 7	65%	0%	$280,142	$31,873	2.4	2.3	1.8	4.2	Infinite	$1,181/kW
6	Project 8	61%	0%	$271,847	$39,822	3.2	2.8	2.1	6.7	Infinite	$644/kW
7	Project 9	64%	21%	$506,262	$55,929	2.5	2.2	1.7	4.7	Infinite	$1,004/kW
8	Project 11	63%	100%	$377,070	$51,300	3.1	2.7	2.1	5.0	Infinite	$867/kW
9	Project 12	66%	0%	$437,404	$40,377	2.1	1.9	1.4	5.0	Infinite	$840/kW
10	Project 21	67%	39%	$385,131	$90,386	5.6	4.5	3.4	7.0	3.90	$464/kW

*Participant Benefit to Cost ratio is based on the government societal discount rate.

Project: SB2030: Sample of Projects As Designed
MultiRun: Sample Projects: Non MN Elementary 1



*Participant Benefit to Cost ratio is based on the government societal discount rate.

Multiple Utility and Multiple Input Cost-Benefit Analysis Tool

PARTICIPANT TEST SHEET

Project Name:	SB2030: Sample of Projects As Designed
Electric Utility:	MN Representative Per Gas CIP 2010/Xcel
Gas Utility:	MN Representative Per Gas CIP 2010/CPE
MultiRun Name:	Sample Projects: Non MN Elementary 1
Individual Run:	Project 2
Individual Run #:	1
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Benefits

T	Year	Retail Electric Energy Cost Savings Summer	Retail Electric Energy Cost Savings Winter	Retail Electric Energy Cost Savings Total	Retail Electric Demand Savings Summer	Retail Electric Demand Savings Winter	Retail Electric Demand Savings Total	Electric Incentives	Retail Gas Savings	Natural Gas Incentives	Non-Energy Participant Savings	Total Annual Benefits
0	2010	$ 38,029	$ 57,043	$ 95,072	$ 53,074	$ 56,975	$ 110,050	$ 315,404	$ -	$ -	$ -	$ 520,525
1	2011	$ 38,698	$ 58,047	$ 96,745	$ 54,008	$ 57,978	$ 111,986	$ -	$ -		$ -	$ 208,731
2	2012	$ 39,379	$ 59,069	$ 98,448	$ 54,959	$ 58,998	$ 113,957	$ -	$ -		$ -	$ 212,405
3	2013	$ 40,072	$ 60,108	$ 100,180	$ 55,926	$ 60,037	$ 115,963	$ -	$ -		$ -	$ 216,143
4	2014	$ 40,777	$ 61,166	$ 101,943	$ 56,911	$ 61,093	$ 118,004	$ -	$ -		$ -	$ 219,947
5	2015	$ 41,495	$ 62,243	$ 103,738	$ 57,912	$ 62,169	$ 120,081	$ -	$ -		$ -	$ 223,819
6	2016	$ 42,225	$ 63,338	$ 105,563	$ 58,931	$ 63,263	$ 122,194	$ -	$ -		$ -	$ 227,758
7	2017	$ 42,969	$ 64,453	$ 107,421	$ 59,969	$ 64,376	$ 124,345	$ -	$ -		$ -	$ 231,766
8	2018	$ 43,725	$ 65,587	$ 109,312	$ 61,024	$ 65,509	$ 126,533	$ -	$ -		$ -	$ 235,845
9	2019	$ 44,494	$ 66,742	$ 111,236	$ 62,098	$ 66,662	$ 128,760	$ -	$ -		$ -	$ 239,996
10	2020	$ 45,277	$ 67,916	$ 113,194	$ 63,191	$ 67,835	$ 131,027	$ -	$ -		$ -	$ 244,220
11	2021	$ 46,074	$ 69,112	$ 115,186	$ 64,303	$ 69,029	$ 133,333	$ -	$ -		$ -	$ 248,518
12	2022	$ 46,885	$ 70,328	$ 117,213	$ 65,435	$ 70,244	$ 135,679	$ -	$ -		$ -	$ 252,892
13	2023	$ 47,710	$ 71,566	$ 119,276	$ 66,587	$ 71,481	$ 138,067	$ -	$ -		$ -	$ 257,343
14	2024	$ 48,550	$ 72,825	$ 121,375	$ 67,759	$ 72,739	$ 140,497	$ -	$ -		$ -	$ 261,873
15	2025	$ 49,405	$ 74,107	$ 123,512	$ 68,951	$ 74,019	$ 142,970	$ -	$ -		$ -	$ 266,481
16	2026	$ 50,274	$ 75,411	$ 125,685	$ 70,165	$ 75,322	$ 145,486	$ -	$ -		$ -	$ 271,172
17	2027	$ 51,159	$ 76,738	$ 127,897	$ 71,400	$ 76,647	$ 148,047	$ -	$ -		$ -	$ 275,944
18	2028	$ 52,059	$ 78,089	$ 130,148	$ 72,656	$ 77,995	$ 150,652	$ -	$ -		$ -	$ 280,801
19	2029	$ 52,976	$ 79,463	$ 132,439	$ 73,935	$ 79,369	$ 153,304	$ -	$ -		$ -	$ 285,743
20	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
21	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
22	2032	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
23	2033	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
24	2034	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
25	2035	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
26	2036	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
27	2037	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
28	2038	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
29	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -
Raw Total =		$ 902,234	$ 1,353,351	$ 2,255,584	$ 1,259,194	$ 1,351,742	$ 2,610,936	$ 315,404				$ 5,161,924
NPVpartGovt =		$ 666,548	$ 999,821	$ 1,666,369	$ 930,261	$ 998,633	$ 1,928,893	$ 315,404	$ -		$ -	$ 3,910,665
NPVpartCmrcl =		$ 487,175	$ 730,763	$ 1,217,938	$ 679,922	$ 729,894	$ 1,409,816	$ 315,404	$ -		$ -	$ 2,943,159

Costs

T	Year	Direct Participant Costs	Other Participant Cost/Participant	Non-Energy Participant Costs	Total Annual Costs	Annual Benefits - Costs
0	2010	$ 396,129	$ -	$ -	$ 396,129	$ 124,396
1	2011	$ -		$ -	$ -	$ 208,731
2	2012	$ -		$ -	$ -	$ 212,405
3	2013	$ -		$ -	$ -	$ 216,143
4	2014	$ -		$ -	$ -	$ 219,947
5	2015	$ -		$ -	$ -	$ 223,819
6	2016	$ -		$ -	$ -	$ 227,758
7	2017	$ -		$ -	$ -	$ 231,766
8	2018	$ -		$ -	$ -	$ 235,845
9	2019	$ -		$ -	$ -	$ 239,996
10	2020	$ -		$ -	$ -	$ 244,220
11	2021	$ -		$ -	$ -	$ 248,518
12	2022	$ -		$ -	$ -	$ 252,892
13	2023	$ -		$ -	$ -	$ 257,343
14	2024	$ -		$ -	$ -	$ 261,873
15	2025	$ -		$ -	$ -	$ 266,481
16	2026	$ -		$ -	$ -	$ 271,172
17	2027	$ -		$ -	$ -	$ 275,944
18	2028	$ -		$ -	$ -	$ 280,801
19	2029	$ -		$ -	$ -	$ 285,743
20	2030	$ -		$ -	$ -	$ -
21	2031	$ -		$ -	$ -	$ -
22	2032	$ -		$ -	$ -	$ -
23	2033	$ -		$ -	$ -	$ -
24	2034	$ -		$ -	$ -	$ -
25	2035	$ -		$ -	$ -	$ -
26	2036	$ -		$ -	$ -	$ -
27	2037	$ -		$ -	$ -	$ -
28	2038	$ -		$ -	$ -	$ -
29	2039	$ -		$ -	$ -	$ -
Raw Total =		$ 396,129		$ -	$ 396,129	$ 4,785,795
NPVpartGovt =		$ 396,129	$ -	$ -	$ 396,129	$ 3,514,537
NPVpartCmrcl =		$ 396,129	$ -	$ -	$ 396,129	$ 2,547,030

NPVpartGovt =	$ 3,514,537
NPVpartCmrcl =	$ 2,547,030
Participant Ben/Cost Ratio Govt	9.87
Participant Ben/Cost Ratio Cmrcl	7.43

Multiple Utility and Multiple Input Cost-Benefit Analysis Tool

SOCIETAL TEST SHEET

Project Name	SB2030: Sample of Projects As Designed
Electric Utility	MN Representative Per Gas CIP 2010 Xcel
Gas Utility	MN Representative Per Gas CIP 2010 CPE
MultiRun Name	Sample Projects: Non MN Elementary 1
Individual Run	Project 2
Individual Run #	1
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		Benefits Electric	Electric	Electric	Electric	Electric	Electric	Electric	Electric	Electric	*Electric	Electric
t	Year	Marginal Energy Cost Savings Summer	Marginal Energy Cost Savings Winter	Marginal Energy Cost Savings Total	Avoided Demand Cost Summer	Avoided Demand Cost Winter	Avoided Demand Cost Total	Variable O&M Cost Savings	Line Loss Energy Cost Savings	Avoided Environmental Damage Electric	Participant Non-Energy Savings	Total Annual Benefits Electric
0	2010	$22,258	$33,388	$55,646	$237,901	$0	$237,901	$13,773	$4,639	$14,693	$0	$326,852
1	2011	$23,149	$34,723	$57,872	$243,611	$0	$243,611	$14,324	$5,032	$14,962	$0	335,801
2	2012	$24,075	$36,112	$60,187	$249,458	$0	$249,458	$14,897	$5,234	$15,235	$0	345,010
3	2013	$25,038	$37,557	$62,594	$255,445	$0	$255,445	$15,492	$5,443	$15,514	$0	354,489
4	2014	$26,039	$39,059	$65,098	$261,575	$0	$261,575	$16,112	$5,661	$15,798	$0	364,244
5	2015	$27,081	$40,621	$67,702	$267,853	$0	$267,853	$16,757	$5,887	$16,087	$0	374,286
6	2016	$28,164	$42,246	$70,410	$274,282	$0	$274,282	$17,427	$6,123	$16,382	$0	384,623
7	2017	$29,291	$43,936	$73,227	$280,864	$0	$280,864	$18,124	$6,368	$16,681	$0	395,264
8	2018	$30,462	$45,693	$76,155	$287,605	$0	$287,605	$18,849	$6,622	$16,987	$0	406,219
9	2019	$31,681	$47,521	$79,202	$294,508	$0	$294,508	$19,603	$6,887	$17,298	$0	417,497
10	2020	$32,948	$49,422	$82,370	$301,576	$0	$301,576	$20,387	$7,163	$17,614	$0	429,109
11	2021	$34,266	$51,399	$85,665	$308,814	$0	$308,814	$21,203	$7,449	$17,936	$0	441,066
12	2022	$35,637	$53,455	$89,091	$316,225	$0	$316,225	$22,051	$7,747	$18,265	$0	453,379
13	2023	$37,062	$55,593	$92,655	$323,815	$0	$323,815	$22,933	$8,057	$18,599	$0	466,058
14	2024	$38,544	$57,817	$96,361	$331,586	$0	$331,586	$23,850	$8,379	$18,939	$0	479,116
15	2025	$40,086	$60,129	$100,215	$339,544	$0	$339,544	$24,804	$8,714	$19,286	$0	492,564
16	2026	$41,690	$62,535	$104,224	$347,693	$0	$347,693	$25,796	$9,063	$19,639	$0	506,415
17	2027	$43,357	$65,036	$108,393	$356,038	$0	$356,038	$26,828	$9,426	$19,998	$0	520,683
18	2028	$45,092	$67,637	$112,729	$364,583	$0	$364,583	$27,901	$9,803	$20,364	$0	535,379
19	2029	$46,895	$70,343	$117,238	$373,333	$0	$373,333	$29,017	$10,195	$20,737	$0	550,519
20	2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
21	2031	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
22	2032	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
23	2033	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
24	2034	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
25	2035	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
26	2036	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
27	2037	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
28	2038	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
29	2039	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0
Raw Total =		$662,815	$994,222	$1,657,037	$6,016,307	$0	$6,016,307	$410,126	$144,090	$351,013	$0	$8,578,574
NPVsoc =		$478,624	$717,937	$1,196,561	$4,415,492	$0	$4,415,492	$296,156	$104,049	$259,132	$0	$6,271,389

Societal NPV Project Elec Utility Only =	$ 5,847,476
Societal Benefits/Cost Ratio Electric Utility Only	14.79

t	Benefits Natural Gas	Natural Gas	Natural Gas	Natural Gas	*Natural Gas	Natural Gas
	Gas Commodity Savings	Peak Gas Demand Cost Avoided	Variable O&M Cost Savings	Avoided Environmental Damage Nat Gas	Participant Non-Energy Savings	Total Annual Benefits Gas
0	$0	$0	$0	$0	$0	$0
1	$0	$0	$0	$0	$0	$0
2	$0	$0	$0	$0	$0	$0
3	$0	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0	$0
5	$0	$0	$0	$0	$0	$0
6	$0	$0	$0	$0	$0	$0
7	$0	$0	$0	$0	$0	$0
8	$0	$0	$0	$0	$0	$0
9	$0	$0	$0	$0	$0	$0
10	$0	$0	$0	$0	$0	$0
11	$0	$0	$0	$0	$0	$0
12	$0	$0	$0	$0	$0	$0
13	$0	$0	$0	$0	$0	$0
14	$0	$0	$0	$0	$0	$0
15	$0	$0	$0	$0	$0	$0
16	$0	$0	$0	$0	$0	$0
17	$0	$0	$0	$0	$0	$0
18	$0	$0	$0	$0	$0	$0
19	$0	$0	$0	$0	$0	$0
20	$0	$0	$0	$0	$0	$0
21	$0	$0	$0	$0	$0	$0
22	$0	$0	$0	$0	$0	$0
23	$0	$0	$0	$0	$0	$0
24	$0	$0	$0	$0	$0	$0
25	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0
27	$0	$0	$0	$0	$0	$0
28	$0	$0	$0	$0	$0	$0
29	$0	$0	$0	$0	$0	$0
Raw Total =	$0	$0	$0	$0	$0	$0
NPVsoc =	$0	$0	$0	$0	$0	$0

Societal NPV Project Natural Gas Utility Only =	$ (396,129)
Societal Benefits/Cost Ratio Natural Gas Utility Only	Infinite

Costs Electric: Utility Project Costs Less Rebates	Costs: Direct Participant Costs	Other Participant Cost/Participant	Non-Energy Participant Costs	Electric: Total Annual Costs	Electric	Electric: Benefits Minus Costs
$27,784	$ 396,129	$ -	$ -	$423,913		($97,061)
$0	$ -		$ -	$0		$335,801
$0	$ -		$ -	$0		$345,010
$0	$ -		$ -	$0		$354,489
$0	$ -		$ -	$0		$364,244
$0	$ -		$ -	$0		$374,286
$0	$ -		$ -	$0		$384,623
$0	$ -		$ -	$0		$395,264
$0	$ -		$ -	$0		$406,219
$0	$ -		$ -	$0		$417,497
$0	$ -		$ -	$0		$429,109
$0	$ -		$ -	$0		$441,066
$0	$ -		$ -	$0		$453,379
$0	$ -		$ -	$0		$466,058
$0	$ -		$ -	$0		$479,116
$0	$ -		$ -	$0		$492,564
$0	$ -		$ -	$0		$506,415
$0	$ -		$ -	$0		$520,683
$0	$ -		$ -	$0		$535,379
$0	$ -		$ -	$0		$550,519
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$27,784	$ 396,129		$ -	$423,913		$8,154,661
$27,784	$ 396,129	$ -	$ -	$423,913		$5,847,476
	$ 396,129	$ -	$ -			

Societal NPV Project Both Utilities =	$	5,847,476
Societal Benefits/Cost Ratio Both Utilities		14.79

Costs Natural Gas: Utility Project Costs Less Rebates	Costs: Direct Participant Costs	Other Participant Cost/Participant	Non-Energy Participant Costs	Natural Gas: Total Annual Costs	Natural Gas	Natural Gas: Benefits Minus Costs
$0	$ 396,129	$ -	$ -	$396,129		($396,129)
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ -		$ -	$0		$0
$0	$ 396,129		$ -	$396,129		($396,129)
$0	$ 396,129	$ -	$ -	$396,129		($396,129)
	$ 396,129	$ -	$ -			

Sum of Electric & Natural Gas Benefits: Total Annual Benefits Both	Costs: Total Annual Costs Both	Benefits Minus Costs
$326,852	$423,913	($97,061)
$335,801	$0	$335,801
$345,010	$0	$345,010
$354,489	$0	$354,489
$364,244	$0	$364,244
$374,286	$0	$374,286
$384,623	$0	$384,623
$395,264	$0	$395,264
$406,219	$0	$406,219
$417,497	$0	$417,497
$429,109	$0	$429,109
$441,066	$0	$441,066
$453,379	$0	$453,379
$466,058	$0	$466,058
$479,116	$0	$479,116
$492,564	$0	$492,564
$506,415	$0	$506,415
$520,683	$0	$520,683
$535,379	$0	$535,379
$550,519	$0	$550,519
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$8,578,574	$423,913	$8,154,661
$6,271,389	$423,913	$5,847,476

Multiple Utility and Multiple Input Cost-Benefit Analysis Tool

ELECTRIC UTILITY TEST SHEET

Project Name:	SB2030: Sample of Projects As Designed
Electric Utility:	MN Representative Per Gas CIP 2010/Xcel
Gas Utility:	MN Representative Per Gas CIP 2010/CPE
MultiRun Name:	Sample Projects: Non MN Elementary 1
Individual Run:	Project 2
Individual Run #:	1
Date_Time	6/8/09 3:09 PM

This test quantifies the incremental decreases and increase to revenue requirements as a direct result of the project

		Benefits									**Costs**		
t	Year	Marginal Energy Cost Savings Summer	Marginal Energy Cost Savings Winter	Marginal Energy Cost Savings Total	Avoided Demand Cost Summer	Avoided Demand Cost Winter	Avoided Demand Cost Total	Variable O&M Cost Savings	Line Loss Energy Cost Savings	Total Annual Benefits	Total Utility Project Costs	Total Annual Costs	Benefits Minus Costs
0	2010	$22,258	$33,388	$55,646	$237,901	$0	$237,901	$13,773	$4,839	$312,159	$343,188	$343,188	($31,029)
1	2011	$23,149	$34,723	$57,872	$243,611	$0	$243,611	$14,324	$5,032	320,839	0	0	320,839
2	2012	$24,075	$36,112	$60,187	$249,458	$0	$249,458	$14,897	$5,234	329,775	0	0	329,775
3	2013	$25,038	$37,557	$62,594	$255,445	$0	$255,445	$15,492	$5,443	338,975	0	0	338,975
4	2014	$26,039	$39,059	$65,098	$261,575	$0	$261,575	$16,112	$5,661	348,446	0	0	348,446
5	2015	$27,081	$40,621	$67,702	$267,853	$0	$267,853	$16,757	$5,887	358,199	0	0	358,199
6	2016	$28,164	$42,246	$70,410	$274,282	$0	$274,282	$17,427	$6,123	368,241	0	0	368,241
7	2017	$29,291	$43,936	$73,227	$280,864	$0	$280,864	$18,124	$6,368	378,582	0	0	378,582
8	2018	$30,462	$45,693	$76,156	$287,605	$0	$287,605	$18,849	$6,622	389,232	0	0	389,232
9	2019	$31,681	$47,521	$79,202	$294,508	$0	$294,508	$19,603	$6,887	400,200	0	0	400,200
10	2020	$32,948	$49,422	$82,370	$301,576	$0	$301,576	$20,387	$7,163	411,495	0	0	411,495
11	2021	$34,266	$51,399	$85,665	$308,814	$0	$308,814	$21,203	$7,449	423,130	0	0	423,130
12	2022	$35,637	$53,455	$89,091	$316,225	$0	$316,225	$22,051	$7,747	435,114	0	0	435,114
13	2023	$37,062	$55,593	$92,655	$323,815	$0	$323,815	$22,933	$8,057	447,459	0	0	447,459
14	2024	$38,544	$57,817	$96,361	$331,586	$0	$331,586	$23,850	$8,379	460,176	0	0	460,176
15	2025	$40,086	$60,129	$100,216	$339,544	$0	$339,544	$24,804	$8,714	473,278	0	0	473,278
16	2026	$41,690	$62,535	$104,224	$347,693	$0	$347,693	$25,796	$9,063	486,777	0	0	486,777
17	2027	$43,357	$65,036	$108,393	$356,038	$0	$356,038	$26,828	$9,426	500,685	0	0	500,685
18	2028	$45,092	$67,637	$112,729	$364,583	$0	$364,583	$27,901	$9,803	515,015	0	0	515,015
19	2029	$46,895	$70,343	$117,238	$373,333	$0	$373,333	$29,017	$10,195	529,783	0	0	529,783
20	2030	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
21	2031	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
22	2032	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
23	2033	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
24	2034	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
25	2035	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
26	2036	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
27	2037	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
28	2038	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
29	2039	$0	$0	$0	$0	$0	$0	$0	$0	0	0	0	0
Raw Total =		$662,815	$994,222	$1,657,037	$6,016,307	$0	$6,016,307	$410,126	$144,090	$8,227,561	$343,188	$343,188	$7,884,372
NPVutil =		$336,520	$504,779	$841,299	$3,166,378	$0	$3,166,378	$208,226	$73,156	$4,289,059	$343,188	$343,188	$3,945,871

Elec Utility NPV Project =	$ 3,945,871
Electric Utility Benefits/Cost Ratio	12.50

Sustainable Building 2030
Ongoing
Operation

Survey of Energy-Efficient Operating Practices

Peter H. Herzog

Final – June 24, 2009

Outline of Report:

I. Executive Summary

II. Overview - Energy Use and Cost Management in Buildings

III. The Value and Importance of Energy-Efficient Operation

IV. The Energy-Efficient Operation Survey

V. Survey Questions

VI. Interview Subjects

VII. Findings

VIII. Conclusions

IX. Recommendations

I. Executive Summary

Survey Objective

Years of existing building energy use research, energy audits and recommissioning studies repeatedly show that existing buildings will use 10-20% more energy than necessary unless there is an orderly ongoing process to prevent this waste.

The objectives of this study were to first define the characteristics of a model process to prevent excess energy use, and second to survey the "energy-efficient operation marketplace" to see how current practice compares to the model process.

The final goal is to draw conclusions regarding the potential for reducing building energy consumption through improved operating efficiency, and to identify what can be done to achieve the potential savings.

Survey Methods

The model process for achieving and sustaining energy-efficient operation in existing buildings was derived from reviews of "best practices" literature, along with interviews of energy managers, consulting engineers specializing in building energy use, and with persons experienced in managing analogous processes (i.e., managing outcomes for ongoing multi-variable processes).

Information on current energy-efficient operation practices was gathered through interviews with persons engaged in managing existing building energy use, both at the management level and at the task level, as well as with providers of energy-related services, such as energy audits, recommissioning, test and balance studies and energy management services.

Findings: Characteristics of Method to Sustain Energy-Efficient Operation

The model process that emerged for sustaining energy-efficient operation in existing buildings has the following key characteristics:

a) It must be supported by a management-led understanding that buildings will use 10-20% more energy than necessary unless there is an ongoing process in place specifically designed to prevent this waste.
b) It requires an institutionalized, ongoing management process as opposed to periodic engineering interventions.
c) The process must establish its priorities on knowledge of the annual energy consumption of each system or device, and on an understanding of the potential of each to consume excess energy.
d) It must make the energy performance of the most significant energy-consuming components measurable.

e) It must utilize trained people who periodically conduct performance measurements to verify that key energy-consuming devices are using only as much energy as is necessary.

f) The procedures and schedules for the measured verification of operating efficiency must be sufficiently documented to allow supervision of the activity.

Findings: Current Practices in Energy-Efficient Operation

The process of evaluating current practices in light of this energy-efficient operation management model resulted in the following findings:

1. Only a few of the largest institutions recognize that a focus on energy-efficient operation can achieve and sustain a significant energy use and cost reduction.

2. Almost no institutions have built into their normal operating and maintenance practices a process specifically designed to prevent excess energy use.

3. Only one institution interviewed had sufficient documentation of component energy use to establish operating efficiency process priorities.

4. Many facilities have the capability to measure some energy consuming component performance through their computerized control system. However, this capability is seldom utilized.

5. It is common for building operators to conduct performance measurements of various energy-conserving devices. However, these measurements are typically initiated to solve a comfort or maintenance problem, and almost never directed specifically at detecting excess energy consumption.

6. Buildings do not currently have well-documented procedures and schedules specifically focused on energy-efficient operation. As a result, building owners or managers cannot assign the appropriate tasks or supervise the work.
   In facilities where component energy performance is monitored, it is entirely dependent upon the capabilities and zeal of an individual employee, with little prospect for persistence when their employment ends.

7. Some energy use management efforts, particularly in K-12 schools, focus upon the energy-consuming components controlled by building occupants. Most activities undertaken to avoid operating energy waste are performed by operating and maintenance staff and are focused on the heating, ventilation and air conditioning equipment under their jurisdiction. Few examples were found where a cross-functional structure has been set up to coordinate the activities and behavior of all of the people who affect the operation of significant energy consumers.

8. Most facilities interviewed have at some time in the past engaged the services of specialists to conduct energy audits, and/or to perform recommissioning services. They typically study the operating efficiency of a limited portion of energy consumers, and they make no provision for the persistence of any operating improvements achieved. Only a portion of these efforts are directed towards identifying operating inefficiencies, and the equipment studied is limited.

Conclusions

a) The management of most buildings includes practices to minimize comfort complaints and to prevent the premature failure of equipment. However, few have routine practices in place intended to sustain energy-efficient operation. As a result, most buildings consume 10-20% more energy than necessary to perform their intended function.

b) The periodic employment of energy audits and recommissioning studies consistently uncover operations savings opportunities, demonstrating that buildings typically operate with undetected excess energy consumption. Not all operating malfunctions identified by these studies are corrected, and those that are corrected are likely to recur due to the lack of an orderly process to prevent recurrence.

c) While a number of programs and services have been directed at operating efficiency in existing buildings, the work of combining the best of these practices into a comprehensive energy efficient management process has yet to be done.

d) Building owners and facility managers must be made aware that sustained operating efficiency requires an ongoing management process (as opposed to a series of engineering projects), and provided with the following assistance in establishing an energy-efficient operations process in their facilities:

    1. A method for estimating the operations savings potential of their buildings
    2. A model to follow in setting up their "Energy-Efficient Operations Process"
    3. Technical assistance with setting up and documenting a process tailored to their building(s)
    4. Training for staff assigned to perform the process tasks

Recommendations

Develop materials to allow building owners and managers to recognize the operating efficiency savings potential of their facilities.

Develop a model format for an "Energy-Efficient Operations Process" (EEOP) that can be adapted to individual buildings.

Train specialists who can be hired by building owners to set up an EEOP specific to their facilities, while at the same time detecting and eliminating currently existing excess energy use.

Develop training for facility and maintenance managers specifically to supervise and manage the EEOP.

Develop training for building operators and contract maintenance providers in the specific EEOP tasks.

II. Overview - Energy Use and Cost Management in Buildings

A comprehensive process for minimizing energy use and cost in buildings consists of an ongoing involvement in the following activities:

Energy Purchasing:

The goal of Energy Purchasing management is to buy energy at the lowest unit cost. Example considerations in this sector include district energy versus owned boilers and chillers, interruptible versus firm gas use, electrical rate demand-limiting agreements and off-peak consumption agreements, as well as alternative energy sources such as wind and solar power. This sector is not directly concerned with how much energy is used, but rather how much it costs per unit.

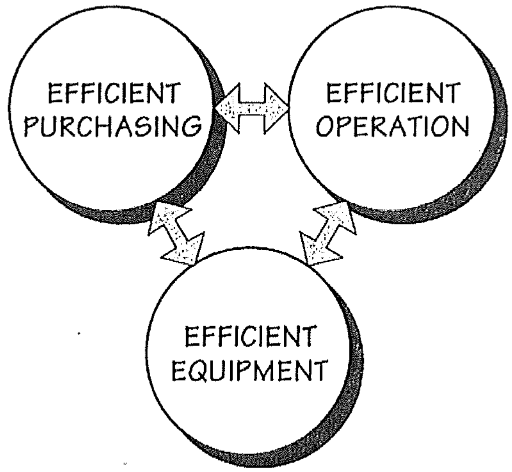
Acquisition of Energy-Efficient Equipment:

The goal of this activity is to make capital investments in more efficient energy-consuming equipment, with the intention of improving the energy-efficiency of buildings. In new construction, attention is paid to the design of the building envelope as well as the design and selection of efficient mechanical and electrical equipment. While all of these options can be considered in retrofits, the most common energy-efficient equipment improvements in existing buildings consist of upgrades to lighting, motors, controls, chillers and boilers.

Activity in this area is typically constrained by the availability of capital dollars, and the institution's return on investment criteria.

Energy-Efficient Operation:

The goal of energy-efficient operation is to ensure that the building, as currently designed and equipped, uses only as much energy as is necessary to perform its intended function. This is the most elusive of the three components of energy-efficiency in buildings.



III. The Value and Importance of Energy-Efficient Operation

The broad goal of the SB 2030 program is focused on encouraging ever more efficient equipment in buildings. (Component G). However, it is clear that the long-term benefit of investments in efficient buildings will depend heavily upon how efficiently these building are operated.

Years of research and analysis by building energy experts, and the nearly universal experience of persons who have performed recommissioning on existing buildings, clearly indicates that most buildings in the U.S. consume 10 to 20% more energy than they need to due to operating inefficiencies.

If these estimates of excess energy consumption are applicable to Minnesota, they suggest that optimizing the operating efficiency of commercial buildings could save Minnesotans between $260 and $530 million per year, and reduce non-residential building-related carbon emissions by 10 to 20%.

IV. The Energy-Efficient Operation Survey

The intent of this survey is to gather information on how efficiently non-residential building are presently operated, and to solicit recommendations on how to improve operating efficiency in areas where significant improvement is possible.

The information-gathering consists of interviews with a wide variety of people involved in building operating efficiency, representing a broad range of building types.

Prior to the interviews, information was assembled on the challenges presented in achieving and sustaining energy-efficient operation. The interview discussion topics were then directed towards how people addressed the following challenges in their facilities:

1. **The challenge of sustaining energy-efficient operation**
   A building's total energy consumption is the sum of the individual consumption of its many energy-consuming devices. How each device needs to operate can vary due to changes in occupancy, desired conditions and weather. How each device actually operates can change, due to changes in its condition and due to intentional or unintentional changes in how it is controlled.

   The challenge is to maintain a coincidence over time between how each device actually operates and how it needs to operate, recognizing that both "need" and "actual" are subject to change.

   The challenge of managing variable components over time suggests that achieving and sustaining energy-efficient operation requires an ongoing management process and cannot be achieved by a "moment in time" project.

2. **The challenge of managing multiple components**

   Buildings typically contain hundreds of energy-consuming devices, and ideally each of these would be monitored to verify that it is using only as much energy as is necessary to perform its intended function. Fortunately, experience has shown that the "80-20 rule" generally applies to building energy use, in that 80% of the energy is consumed by 20% of the energy-consuming devices. For this reason, it is practical to restate the definition of energy-efficient operation as:
   "A process to ensure that each significant energy-consuming device use only as much energy as is necessary to perform its intended function."

   All of this evidence suggests that a cost-effective energy-efficient operation process should be founded on a knowledge of which energy-consuming devices warrant the greatest management attention.

3. **How to manage multiple modes of operation**
   Energy-consuming devices in buildings are generally operated under one of the following three modes of operation:

   <u>Operating Mode A:</u>
   The criteria for operation and the control of the device are both decided by the occupants. Examples include switched lighting, computers, copiers, lab hoods, kitchen exhaust fans and miscellaneous plug loads.

Operating Mode B:
The criteria for operation are determined by occupants, but the control of the device is determined by the building operators. An example is air handler fans - the occupants determine what hours of the day their space is to be at "occupied", and the building operator sets up the controls to turn the fan on and off at times appropriate to maintain the "occupied" conditions.
Other examples are scheduled lighting control, space temperature and humidity setpoints, and ventilation air.

Operating Mode C:
The criteria for operation and the control of the device are determined by the building operator. Examples include boilers, cooling towers, chillers, pumps and the control of most components of air-handling systems.

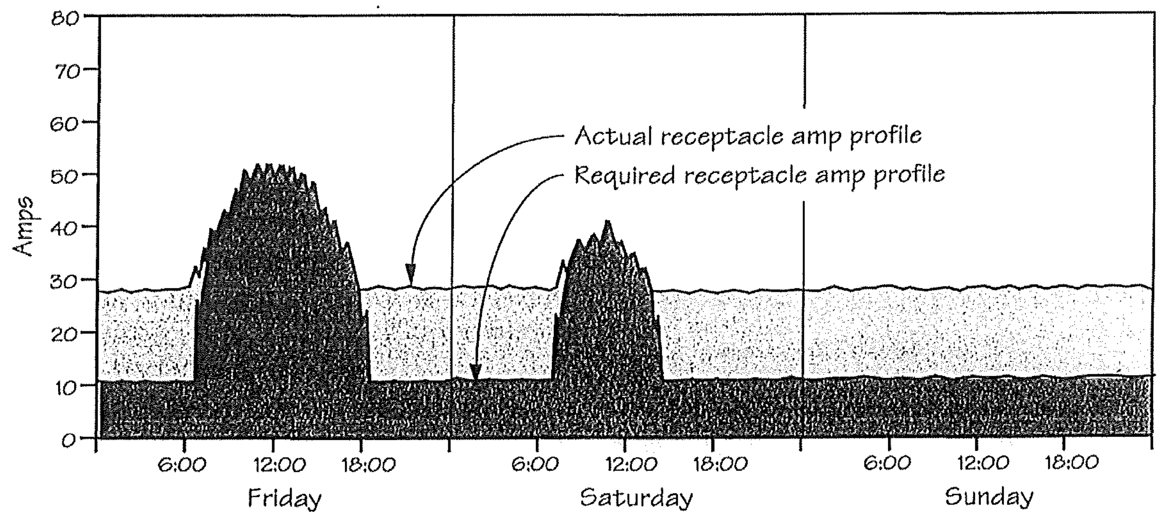
Responsibility for the energy-efficient operation of Mode A devices must be assigned to occupant managers, while Mode C responsibility resides with operations management. The energy-efficient operation of Mode B devices requires a cross-functional structure and shared accountability by occupants and operators (see Attachment A).

4. **How to make energy performance measurable**

All management systems require the ability to measure the actual outcome and to define an expected outcome to which the actual can be compared. To manage the operating efficiency of buildings it is necessary to manage the operating efficiency of each of its most significant energy-consuming components.

The desired outcome in buildings is that each significant energy-consuming device operates efficiently, and it is therefore necessary to develop the ability to measure the actual performance of each and to define what the desired performance is. As energy is the product of rate of consumption multiplied by time of operation, the measurement should be an expression of rate and time.

An "Operating Mode A" example is the management of electrical energy consumed by office equipment (computers, copiers, printers, task lights, etc.). A measurement over time (trend log) of the electrical use at the transformer serving this equipment will show the actual energy use profile. The required use profile can be determined by repeating this measurement after carefully verifying that equipment goes on and off coincident with need (see below). This component of energy use is now manageable, in that someone can be made accountable for managing a coincidence between the actual use profile and the required use profile.



5. **How to integrate "outside energy services"**
   There are a wide range of services available to the building owner that can affect how efficiently energy-consuming components operate. These range from periodic boiler and chiller tune-ups, to maintenance contracts for various equipment, to performance contracts that accept responsibility for energy use for the life of the contract. Other services include energy audits, recommissioning services and LEED certification for existing buildings.
   The building owner or manager has to decide if, when and how to integrate these sources of expertise into the process of sustaining energy-efficient operation.

V. Survey Questions

The data gathering consists of interviewing people responsible for building operations, both at the Management level and at the Task level. The questions asked were derived from the background information and challenges covered earlier in this report.

Example Questions at Management Level:

1. Estimate of the value of the "operating efficiency" component
2. What are current activities – projects versus process
3. How do you decide where to expend effort
4. What are current activities in each mode
5. Are key functions "measurable"
6. What outside resources do you employ

Example Questions at Task Level:

1. What specific operating efficiency tasks are performed (Mode A – Mode B – Mode C)
2. Are operating efficiency tasks "institutionalized" (assigned and managed)
3. Who performs operating efficiency tasks
4. What skills, tools and training are available for operating efficiency tasks
5. What time is available for operating efficiency tasks

VI. Interview Subjects

A total of 23 interviews were conducted with subjects representing both people engaged in managing and operating buildings, and people who provide energy-efficiency services to building owners and managers.

The interview subjects with direct energy management responsibilities represented 237 buildings, 44 million square feet, and a combined energy expenditure of $87.8 million annually.

Building Categories:

State Government
Large Office (managed)
Large Office (owner occupied)
University
K-12 schools
Large Retail

Provider Categories

Recommissioning
Energy Audit
LEED EB
LEED NC
Test & Balance
SEE (K-12 schools)
ReDirect (K-12 schools/offices)

VII. Findings

Value of Energy-Efficient Operation

Most participants in the energy management field do not conceive of energy-efficient operation as an activity separate from projects to upgrade equipment, and therefore have not considered its savings potential.

Many consider a building that generates few occupant comfort complaints to be operating "well", and therefore operating efficiently. They do not understand that persistent excess energy consumption can go undetected by typical operation and maintenance procedures.

In general, people do not believe significant energy use reductions are possible through improved operation of existing equipment.

Operating Efficiency Process

Most energy conservation activities involve upgrading existing equipment or controls and are characterized by a series of improvement projects. Few view operating efficiency as an ongoing, continuous process.

Places were found where operating efficiency activities are seen as a continual process, and performed with some regularity, resulting in considerable reductions in energy use. However, these activities usually result from someone's personal interest and zeal. Their activities are not recorded, understood by management or institutionalized. The operating efficiency and energy savings achieved are dependent upon one individual's continuing employment.

Deciding Where to Focus Operating Efficiency Efforts

Some well-trained and experienced energy managers have a relatively accurate intuitive understanding of which devices consume the most energy, how they can fail to operate efficiently and therefore how to prioritize their operating efficiency efforts. However, no one has a studied allocation of past energy use from which to establish well-documented priorities.

As one might expect, operators tend to pay the most attention to the energy consuming devices they happen to be most familiar with.

In general, energy managers have little or no information that guides them to the areas where operating efficiency management is most beneficial.

Current Activities in Operating Modes A-B-C
(See Section III.3 for an explanation of modes)

Operating Mode A:

Responsibility for energy use is typically given to building engineers. As they recognize that they have no control over the people who operate this equipment, Mode A operation is generally not attended to. Some K-12 schools, programs have been developed to specifically deal with Mode A energy use. They report energy savings of over 10% mostly from Mode A activities. One notable finding from those activities is the fact that it takes time and a persistent process to change the behavior that underlies Mode A energy waste.

Operating Mode B:
Larger institutions tend to have a capability to adjust schedules and setpoints to current occupant needs. However, in most facilities this activity is not a scheduled, assigned function and not performed on a frequency consistent with the possibility of a change in needs.
There is general agreement that this mode has a high potential for energy savings or energy waste.

Operating Mode C:
Some facilities pay considerable attention to Mode C operated equipment. In all such cases, this attention is the result of a highly capable and personally motivated individual. In most facilities, building engineers spend the vast majority of their time responding to comfort complaints, equipment failures or routine maintenance.
Few instances were found where proactive activities are performed specifically to ensure the energy-efficient operation of a device or system. It is assumed that routine maintenance achieves operating efficiency.

Ability to Measure Performance of Energy-Consuming Equipment

Most building operators have instruments with which to measure various operating characteristics of energy-consuming devices, such as temperature, electrical current and air flow. In addition, most buildings have some form of computerized energy management system that can report temperatures as well as the status of motors, valves and dampers. The primary use made of these measurement capabilities is to diagnose operational problems. While these capabilities could be used to proactively look for energy-wasting malfunctions, this is seldom done. Most building operators are not trained in measurement techniques specific to detecting energy-wasting malfunctions, and this work is not normally included in their job description.

The quantity of energy used by any energy-consuming device is a function of its rate of use over its time of operation. Therefore, the most useful measurement for assessing energy performance is a recording of a series of short-interval measurements (trendlog). While most building control systems can trendlog the points they control, this capability is seldom used to verify energy-efficient operation. Building operators are typically not trained in how to use the trending capability and/or in what to trendlog and how to interpret the data collected. Most buildings have a number of key energy users whose variables cannot be trendlogged by the existing control system. There are a large number of inexpensive portable dataloggers available in the marketplace, but few building operators have them or are trained in how to use them to detect operating inefficiencies.

In summary, the technology for measuring the actual performance of energy-consuming devices is available and affordable. However, this important capability is seldom utilized, in large part because building operators lack the necessary training, tools and accountability.

Use of Outside Resources

Introduction

In addition to in-house energy management capabilities, there are a number of outside resources available to building owners and managers that can affect the building's operating efficiency. While most of these are only partially directed at how buildings operate, they were each evaluated in light of their ability to contribute to the long-term, sustained energy-efficient operation. The key activities looked for in each resource or series are as follows:

1. Establish energy management priorities by identifying the key energy consumers, rank ordered by annual use and cost.
2. Verify, through measurements, that all key consumers are using only as much energy as is necessary to perform their current function.
3. Correct any significant energy-wasting malfunctions found.
4. Provide documentation and training designed to prevent the reoccurrence of the energy-wasting malfunction.

- Recommissioning:

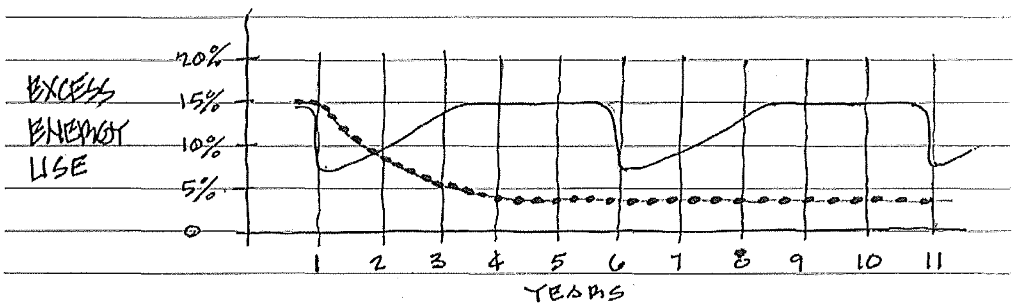
The most employed or considered outside resource is Recommissioning. The ability of these services to enhance operating efficiency is highly variable and depends upon what the building owner asked the recommissioning provider to do, and upon the skills and objectives of the provider.

The recommissioning reports reviewed showed that the providers' efforts are typically divided between identifying operating savings opportunities, evaluating equipment upgrade opportunities and considering improvements to correct chronic comfort or maintenance problems.

There appears to be no standardized format for recommissioning studies. The energy-consuming equipment that gets studied is determined by the intentions of the owner and the expertise and interest of the provider. As a result, few recommissioning projects can assure the owner that all of their significant energy-consuming systems are operating efficiently.

Some studies identify considerable opportunities to reduce energy consumption through the efficient operation of the existing equipment, thus supporting the thesis that significant energy waste can occur undetected.

Many of the energy-wasting malfunctions found and corrected are prone to recur, and the recommissioning process does not put in place processes designed to prevent these recurrences. The persistence of operating efficiency is dealt with by the recommendation that the recommissioning process be repeated every five years. This approach to operating efficiency will result in an excess energy use pattern as illustrated by Fig. 1 on page 13.



	OPERATING EFF. METHOD	10 YR AVG. EXCESS
	NO PROCESS	15%
—	PERIODIC INTERVENTION	12.5%
•-•-•	MANAGEMENT PROCESS	4.5%

Figure 1.

• LEED for Existing Buildings (LEED EB)
One section of the total LEED EB rating system deals with "Operation & Maintenance", and one portion of this section ("Energy and Atmosphere") addresses energy-efficient performance. Existing building recommissioning is called for, consisting of investigation and analyses, implementation, and ongoing recommissioning.

The requirements for this work include some form of all of the key energy management capabilities noted above. However, very little detail is provided, leaving it up to each provider to determine the method and quality of execution.

The provider is required to simultaneously evaluate the operating efficiency of the existing equipment and identify cost-effective opportunities for equipment upgrade and replacement. The allocation of limited project funds between optimizing operations and capital improvements tends to favor capital improvements as (1) the identification and cost/benefit analysis of capital improvements is very time-consuming and (2) the engineering people typically involved in this work have considerable experience with designing system upgrades and far less experience with existing equipment operation.

The LEED EB process recognizes the key activities necessary to achieve and sustain energy-efficient operation; however, consistently achieving the intent of each of these activities will require the development of procedures and formats to guide the providers. It is also critical that the projects be structured to ensure that "operations" portions receive the appropriate portion of the project time, skills and funding.

- LEED for New Construction and Major Renovations (LEED NC)

The "Energy and Atmosphere" section of the LEED NC rating system addresses energy performance.

The LEED NC rating system was reviewed to see how it ensures that a new building is using only as much energy as is necessary to perform its intended function, and what provision is made for the persistence of this operating efficiency.

The process calls for the "Fundamental Commissioning of the Building Energy Systems". Included in this commissioning is the verification of the installation and performance of HVAC and lighting systems. The focus of this work is to determine if they meet the "Owners Project Requirements" and the "Basis of Design". This process assumes operating efficiency will result from meeting these goals without specifically asking for verification that the systems are using only as much energy as necessary.

The "Optimized Energy Performance" credit specifies methods for determining how the total energy consumption compares to an energy-code based equivalent building. This process offers no assurance that each significant energy-consumer is operating at optimal efficiency.

The "Enhanced Commissioning" credit has two requirements that could make a significant contribution to sustain operating efficiency. Requirement #4 calls for the creation of a "System Manual" designed to provide operators with information on how to maintain and operate systems. The operating efficiency value of these manuals will depend upon how specifically they focus on identifying each system's vulnerability to excess energy use, and on proscribing methods to prevent the occurrence. The manual content called for in the "Reference Guide" is general, and the content specifically targeted to sustain energy-efficient operation will be entirely dependent upon the interest and experience of the provider.

Requirement #5 calls for training of building operators and occupants. Like the systems manual, training is an absolutely necessary component in achieving and sustaining energy-efficient operation. The content and delivery of the training is very generally described and its quality is totally dependent upon the particular provider.

The energy-efficient operation portion of the LEED NC process would benefit from the development of system manuals and training procedures specifically targeted at sustaining energy-efficient operation.

- <u>ASHRAE Procedure for Commercial Building Energy Audits</u>

The components of the ASHRAE Level I, II and III audit were reviewed in light of how each contributes to the goal of achieving and sustaining the energy-efficient operation of all significant energy consumers and if they encompass the key activities listed in the introduction above (page 8).

The breakdown of total annual energy use into end-use components is called for in Level I and refined in Level II. This information is very useful in setting priorities for an energy-efficient operation process.

The Level II audit calls for measuring key operating parameters, which is essential to verifying energy-efficient operation. There is little specificity in what is measured and how, leaving the quality and thoroughness of this work very provider-dependent. Also, there is no provision for identifying the measurements that should be incorporated into a process to sustain operating efficiency.

The ASHRAE audit process is designed to identify and analyze the cost/benefit of both capital improvements and operating improvements simultaneously, and it is up to the provider to determine what portion of the project budget will be devoted to these two categories of improvement opportunities. The design engineering expertise (as opposed to operating experience) of most providers, along with the extra rigor of documentation and analysis of capital improvements, tends to divert time and resources away from the operating efficiency analysis.

The product of these audits is a blended list of both operating and capital improvement opportunities. It is not in the proscribed scope to implement any of the opportunities identified. Also, it is not the goal of these audits to generate and organize information designed to ensure future energy-efficient operation. While these audits have the potential to identify the operating efficiency improvement opportunities, they are not designed to achieve energy-efficient operation of all significant energy consumers, nor are they designed to assist in their sustained operating efficiency

VIII. Conclusions

The most general conclusion of this survey is that operating efficiency in buildings presents a significant opportunity for energy conservation, with energy use reductions of 10-20% possible in most buildings. Numerous programs and services have been directed at this opportunity, but their success has been partial and temporary.

Participants in this survey agree that the complexity of design of our newest and most energy-efficient buildings make them even more susceptible to operational inefficiencies, indicating that all buildings, old and new, will continue to waste energy until we put processes in place to prevent it.

This is an opportune time to combine the best of current practices, supplemented with new practices where required, into a new management process designed specifically to achieve and sustain energy-efficient operation.

Few managers of facilities are well-informed about the energy savings that could be achieved through the improved operating efficiency of their existing equipment. Most of the voices encouraging increased energy-efficiency have a bias towards the upgrade or replacement of equipment, leading building managers to believe that the only means to reduce energy consumption is through capital projects.

Many managers believe that performing their regularly scheduled maintenance procedures will ensure operating efficiency, without considering that most of these procedures are designed to avoid comfort complaints or equipment failure, but few are specifically designed to detect and eliminate excess energy use.

Managers of facilities do not typically recognize that the forces that cause building to use more energy than necessary are varied, unpredictable and prone to reoccurrence over time. Because of this, an occasional engineering intervention (energy audit, recommissioning study, etc.) can offer only temporary improvement. It is evident that building managers would benefit from a clearer understanding that sustained operating efficiency can only be achieved by an ongoing management process.

Once aware of the need for an energy-efficient operational process, building managers will need a model upon which to organize a process appropriate for their facility. A survey of the available literature reveals numerous guides and suggested tasks, but work needs to be done to lay out a generic comprehensive process for facility managers to follow.

Building managers will need technical assistance in the initial setup of each building's energy-efficient operation process, and engineers will need some training to provide those startup services.

Building operators will require training in the process tasks and managers will need training in how to supervise the process.

IX. Recommendations

An analysis of this survey's findings has resulted in the following recommendations:

1. Develop information and/or training to inform building owners and managers regarding the energy-saving potential of an energy-efficient operation process.

2. Develop a self-assessment tool that will allow building managers to assess the status of their efficient operation management capability and estimate the savings potential.

3. Develop a model energy efficient operation process that can serve as a template for setting up the process in specific buildings. This work shall include a survey of current best practices, development of a draft process, one or more pilot projects and final process design.

4. Develop a service designed to assist building owners in setting up a process in their building(s), while at the same time identifying and correcting current inefficiencies.

5. Devise programs to assist in defraying the cost of the process setup.

6. Train technical personnel in providing these startup services.

7. Train building operators to perform the energy efficient operation process tasks

8. Train building managers to supervise and manage the energy-efficient operation process.

It is evident that the organizational structure under which building are occupied and managed vary widely. For example, the interrelationship between all of the people who operate energy-consuming equipment in K-12 schools is considerably different than in corporate office buildings or in a tenant-occupied suburban office building. It is possible that a number of training approaches may be required, tailored to the needs of defined categories of buildings and management structures.

There are a number of related services available to building owners that could be coordinated to contribute to a building's ongoing energy-efficient operation process. Toward that end, the following are recommended:

1. Train recommissioning practitioners to provide services and documentation useful to the setup of an energy-efficient operation process.

2. Train design engineers to include operating documentation and measurement techniques in operating manuals and LEED studies.

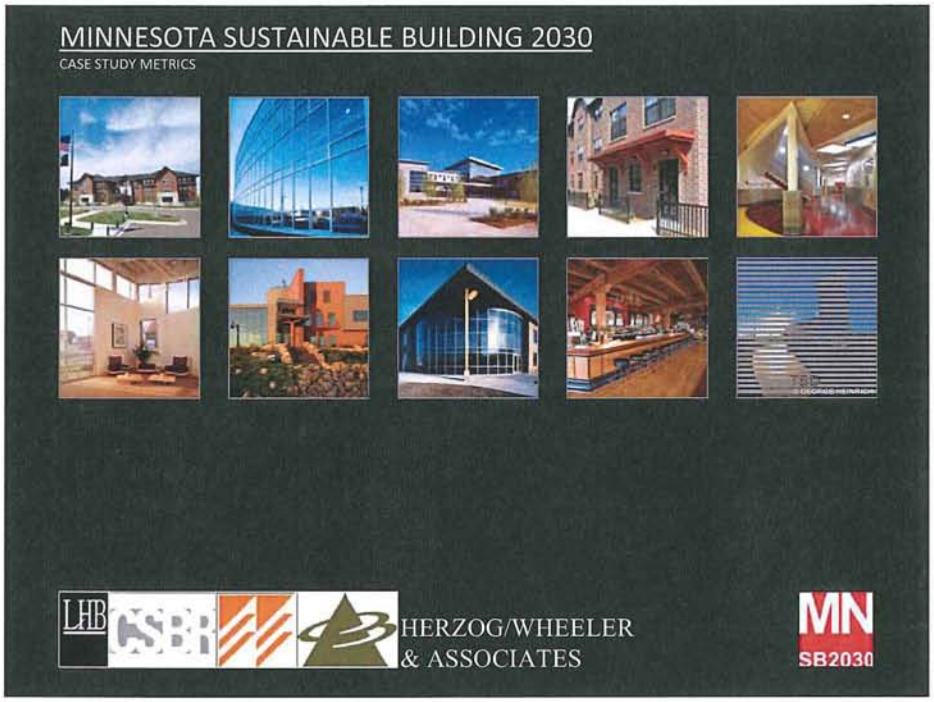
3. Train maintenance contractors to perform energy-efficient operation services; train building manager in how to request and manage these services.

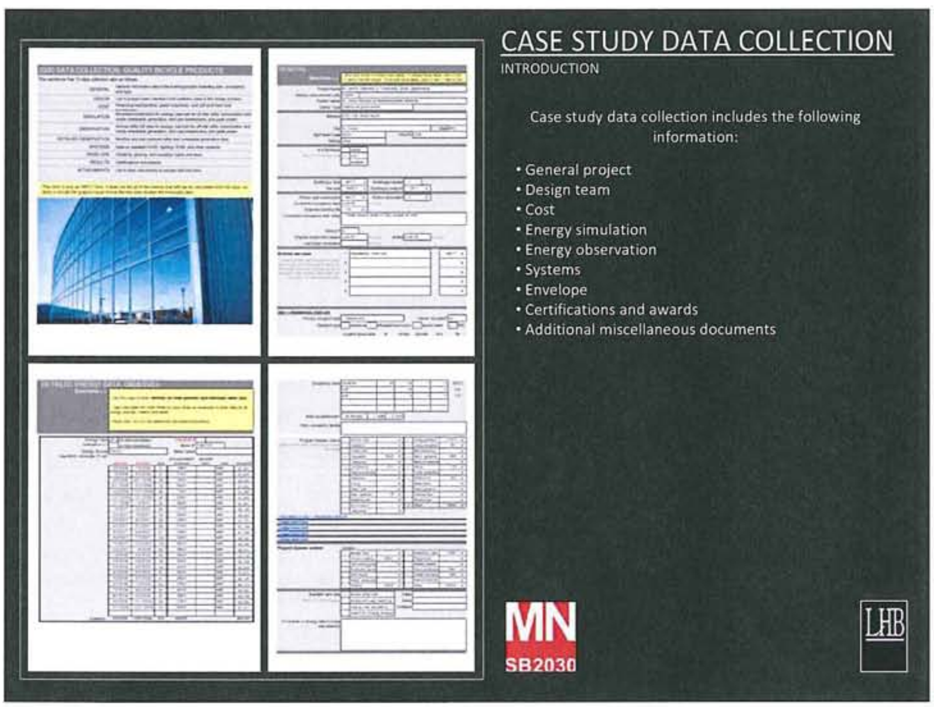
Attachment A

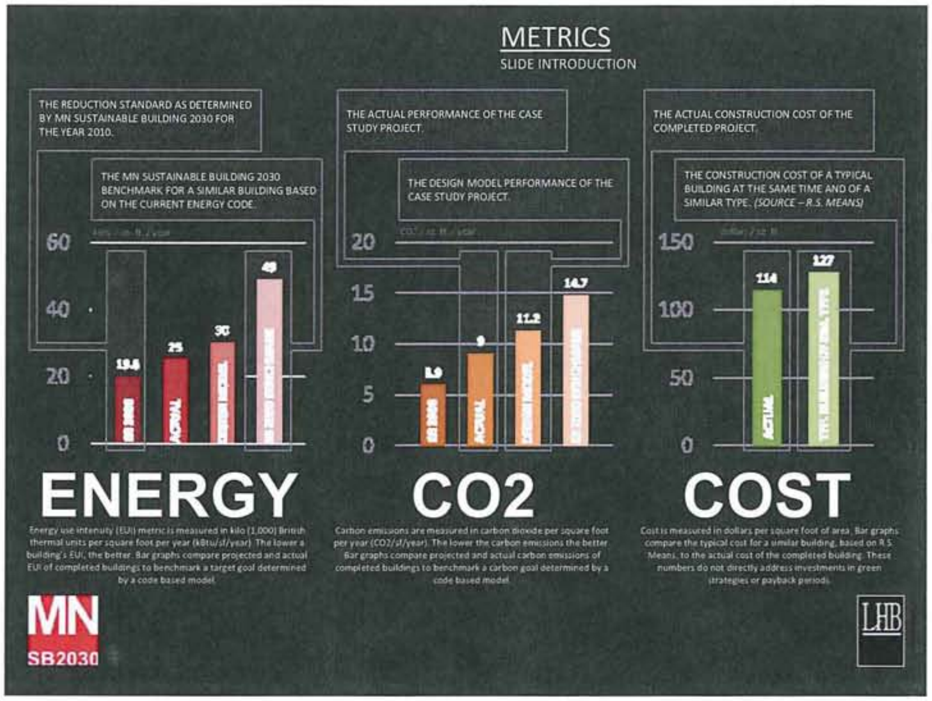
Managing the Efficient Operation of Energy-Consuming Equipment in Buildings

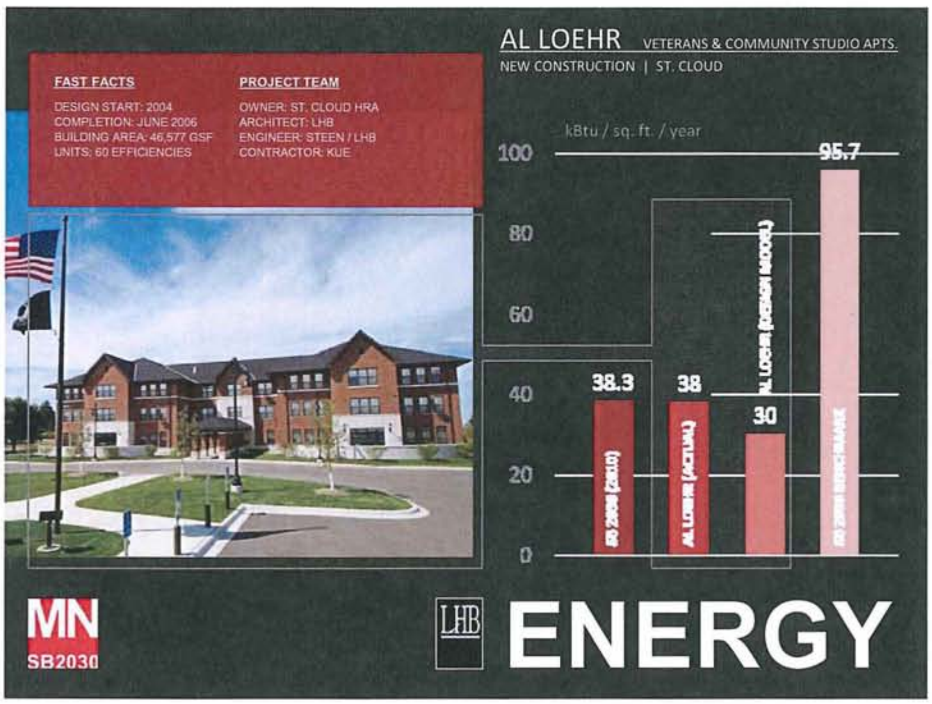
	DETERMINES CRITERIA	OPERATES EQUIPMENT	EXAMPLES
Mode A	Occupant	Occupant	Switched lighting Computers Copiers Misc. plug loads Lab hoods Kitchen exhaust Kitchen equipment
Mode B	Occupant	Building Engineer	Scheduled lighting control Occupancy sensor lighting control AHU occupied/unoccupied schedule Space temperature setpoints Ventilation air
Mode C	Building Engineer	Building Engineer	AHU: Outside air control Mixed air control Preheat temperature Cooling setpoint Reheat control Supply air temperature control Fan speed control Chiller Cooling tower Boiler Hydronic loop control Exhaust fans Domestic water heating Garage exhaust

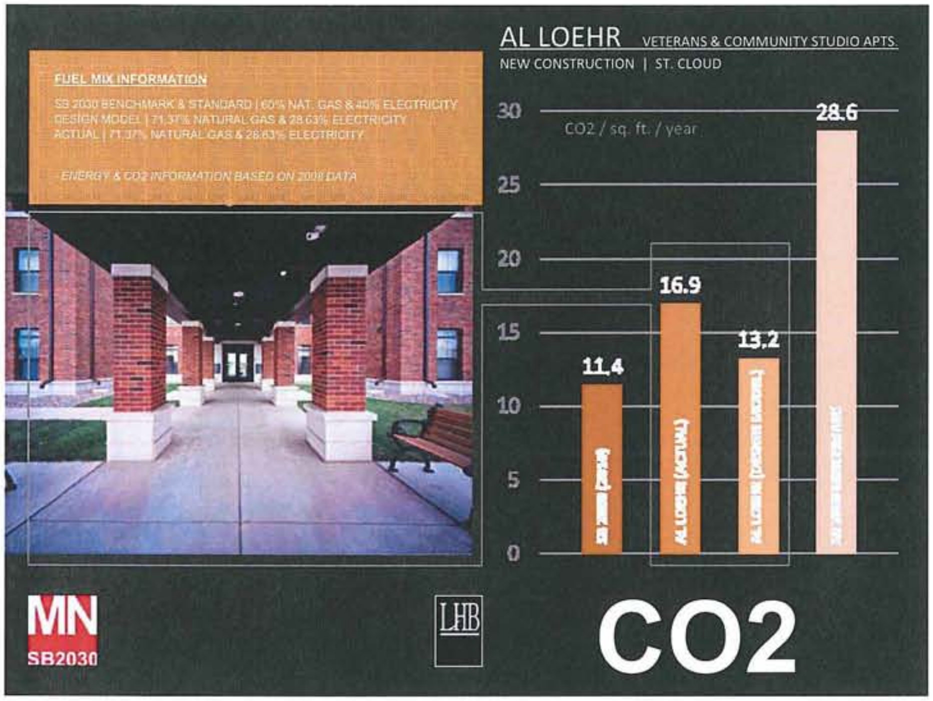
Case Studies

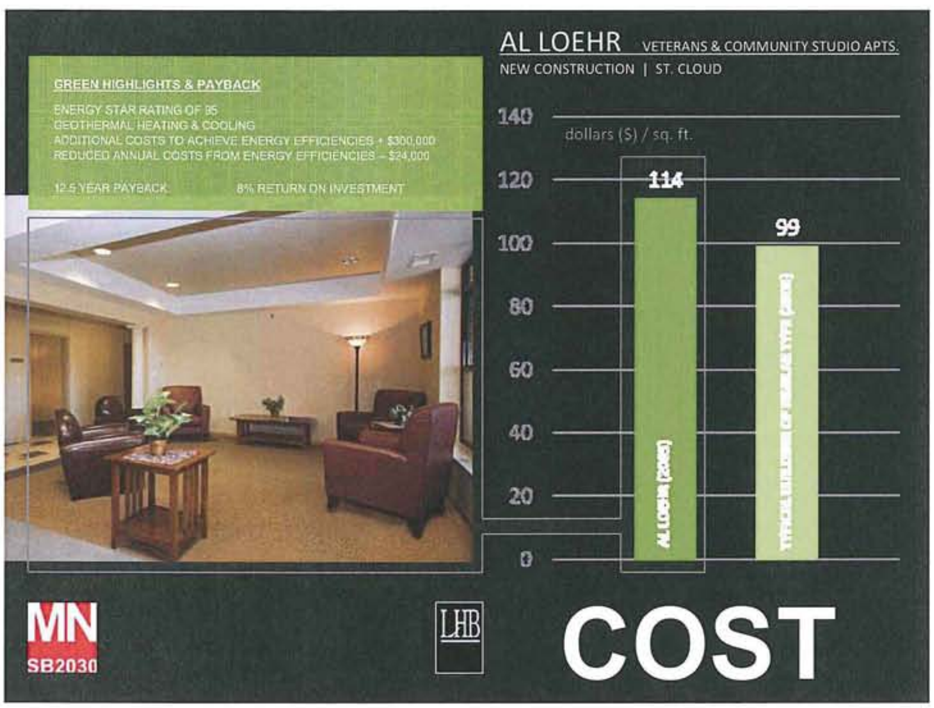





METRICS
SLIDE INTRODUCTION
THE REDUCTION STANDARD AS DETERMINED BY MN SUSTAINABLE BUILDING 2030 FOR THE YEAR 2010.
THE MN SUSTAINABLE BUILDING 2030 BENCHMARK FOR A SIMILAR BUILDING BASED ON THE CURRENT ENERGY CODE.
THE ACTUAL PERFORMANCE OF THE CASE STUDY PROJECT.
THE DESIGN MODEL PERFORMANCE OF THE CASE STUDY PROJECT.
THE ACTUAL CONSTRUCTION COST OF THE COMPLETED PROJECT.
THE CONSTRUCTION COST OF A TYPICAL BUILDING AT THE SAME TIME AND OF A SIMILAR TYPE. (SOURCE – R.S. MEANS)
60
40
20
0
19.6
25
30
49
20
15
10
5
0
5.9
9
11.2
14.7
150
100
50
0
114
127
ACTUAL
ENERGY
Energy use intensity (EUI) metric is measured in kilo (1,000) British thermal units per square foot per year (kBtu/sf/year). The lower a building's EUI, the better. Bar graphs compare projected and actual EUI of completed buildings to benchmark a target goal determined by a code based model.
CO2
Carbon emissions are measured in carbon dioxide per square foot per year (CO2/sf/year). The lower the carbon emissions the better. Bar graphs compare projected and actual carbon emissions of completed buildings to benchmark a carbon goal determined by a code based model.
COST
Cost is measured in dollars per square foot of area. Bar graphs compare the typical cost for a similar building, based on R.S. Means, to the actual cost of the completed building. These numbers do not directly address investments in green strategies or payback periods.
MN
SB2030
LHB


AL LOEHR VETERANS & COMMUNITY STUDIO APTS.
NEW CONSTRUCTION | ST. CLOUD
FAST FACTS
DESIGN START: 2004
COMPLETION: JUNE 2006
BUILDING AREA: 46,577 GSF
UNITS: 60 EFFICIENCIES
PROJECT TEAM
OWNER: ST. CLOUD HRA
ARCHITECT: LHB
ENGINEER: STEEN / LHB
CONTRACTOR: KUE
kBtu / sq. ft. / year
100
80
60
40
20
0
95.7
38.3
38
30
AL LOEHR (DESIGN MODEL)
MN
SB2030
LHB
ENERGY


AL LOEHR VETERANS & COMMUNITY STUDIO APTS.
NEW CONSTRUCTION | ST. CLOUD
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 60% NAT. GAS & 40% ELECTRICITY
DESIGN MODEL | 71.37% NATURAL GAS & 28.63% ELECTRICITY
ACTUAL | 71.37% NATURAL GAS & 28.63% ELECTRICITY
ENERGY & CO2 INFORMATION BASED ON 2008 DATA
CO2 / sq. ft. / year
30
25
20
15
10
5
0
11.4
16.9
13.2
28.6
MN
SB2030
LHB
CO2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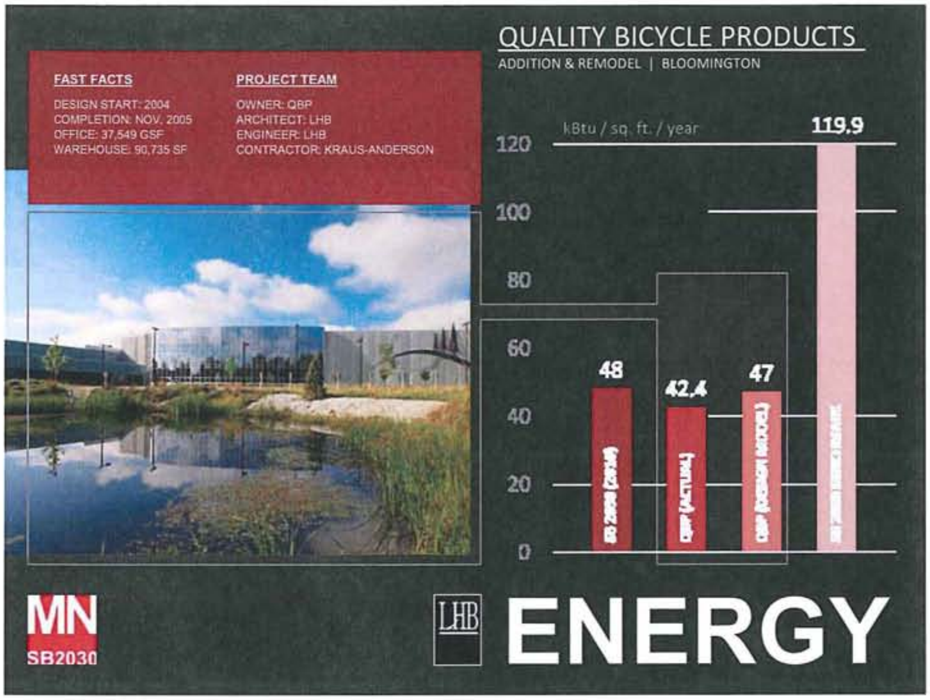
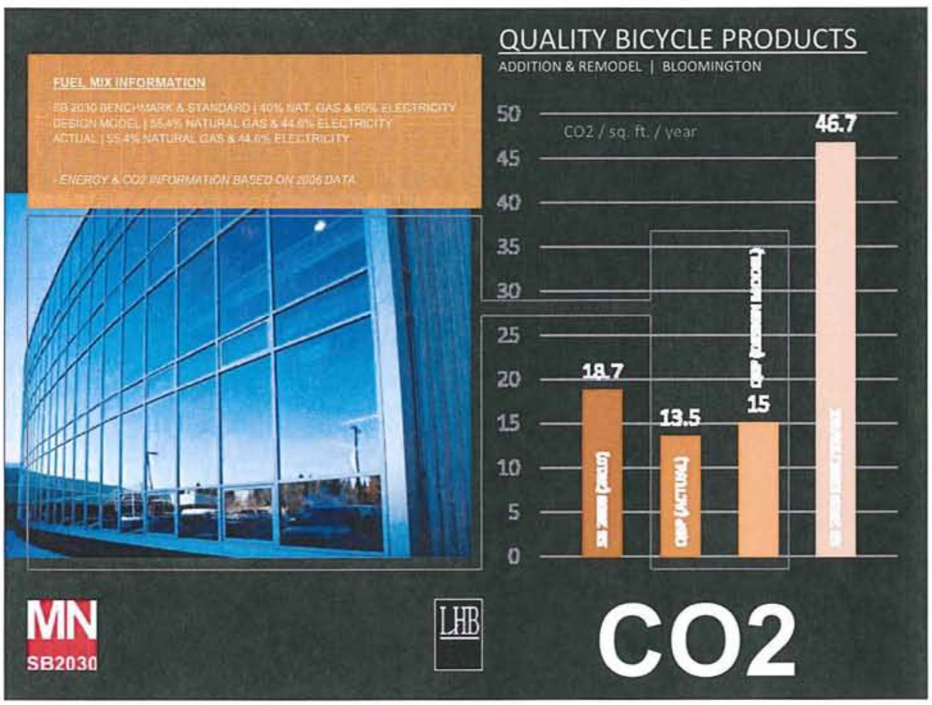
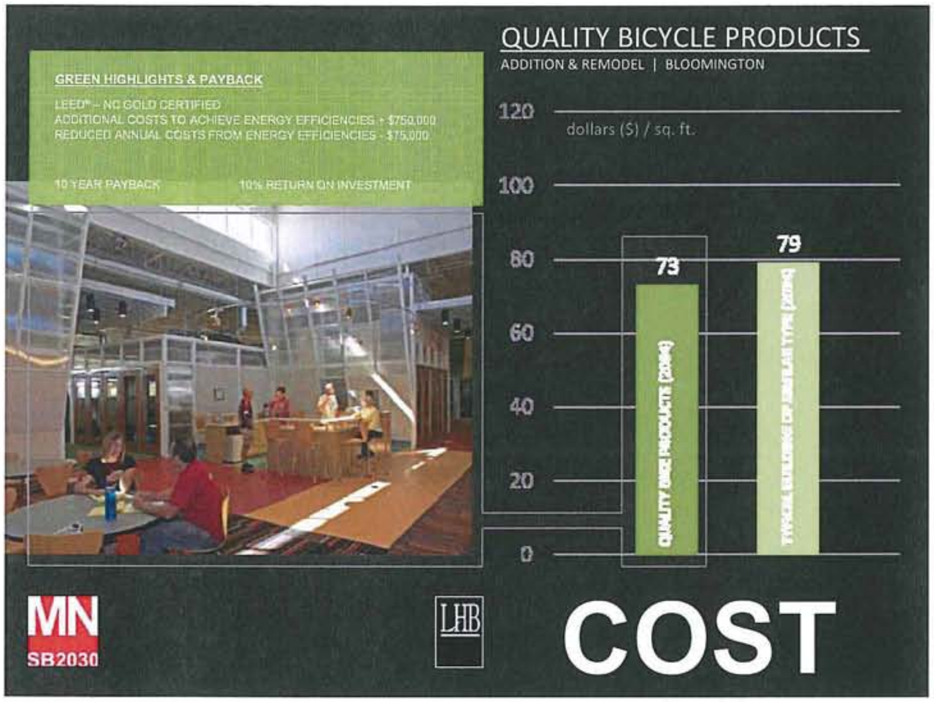
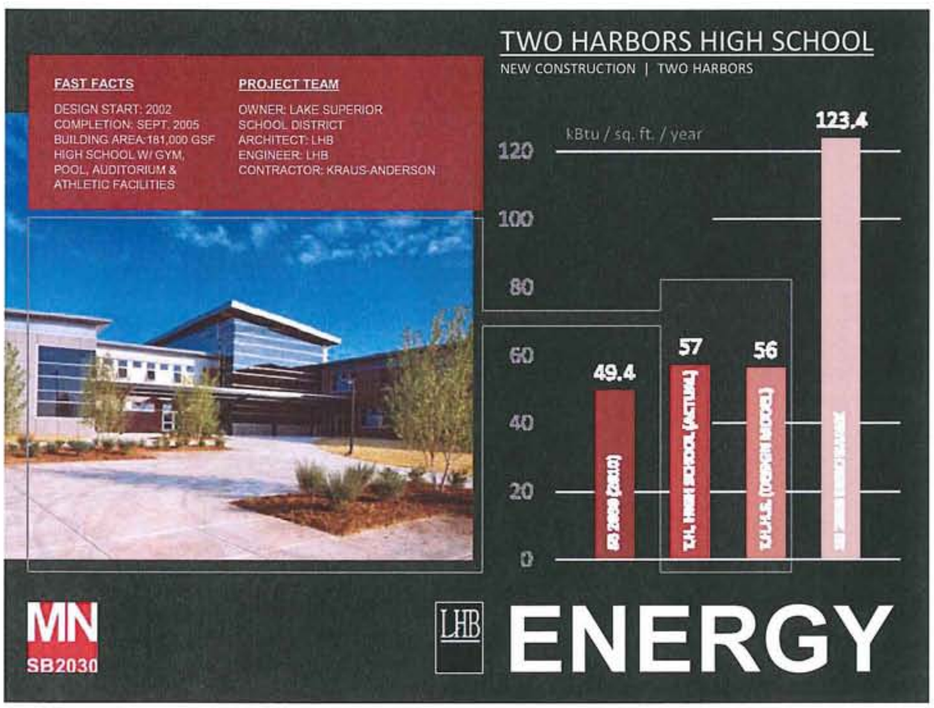
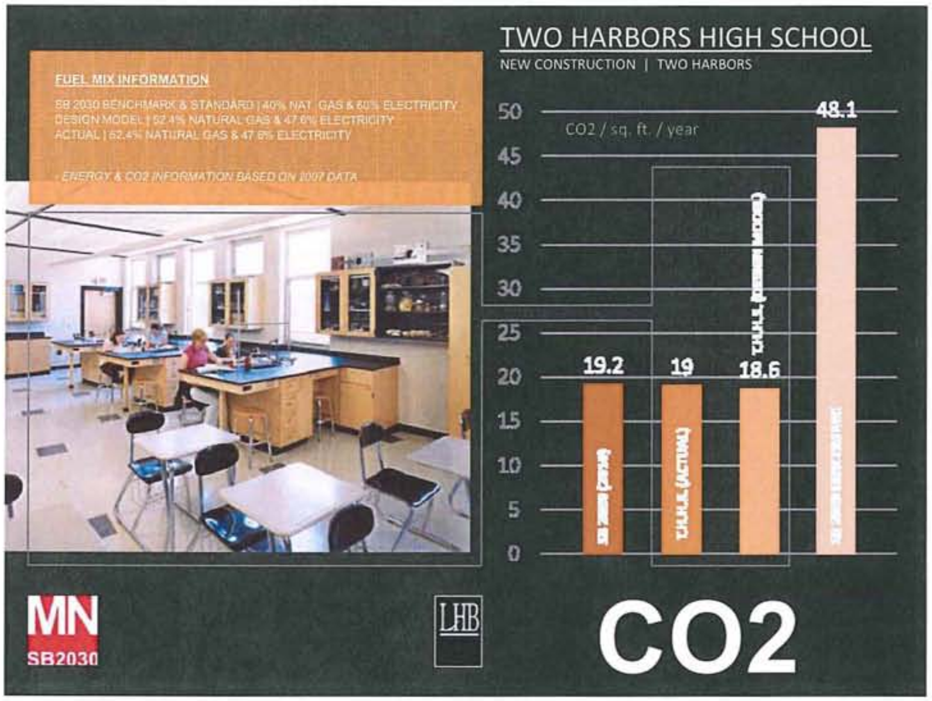
NEW CONSTRUCTION | ST. CLOUD
GREEN HIGHLIGHTS & PAYBACK
ENERGY STAR RATING OF 95
GEOTHERMAL HEATING & COOLING
ADDITIONAL COSTS TO ACHIEVE ENERGY EFFICIENCIES + $300,000
REDUCED ANNUAL COSTS FROM ENERGY EFFICIENCIES – $24,000
12.5 YEAR PAYBACK
8% RETURN ON INVESTMENT
dollars ($) / sq. ft.
140
120
100
80
60
40
20
0
114
99
MN
SB2030
LHB
COST

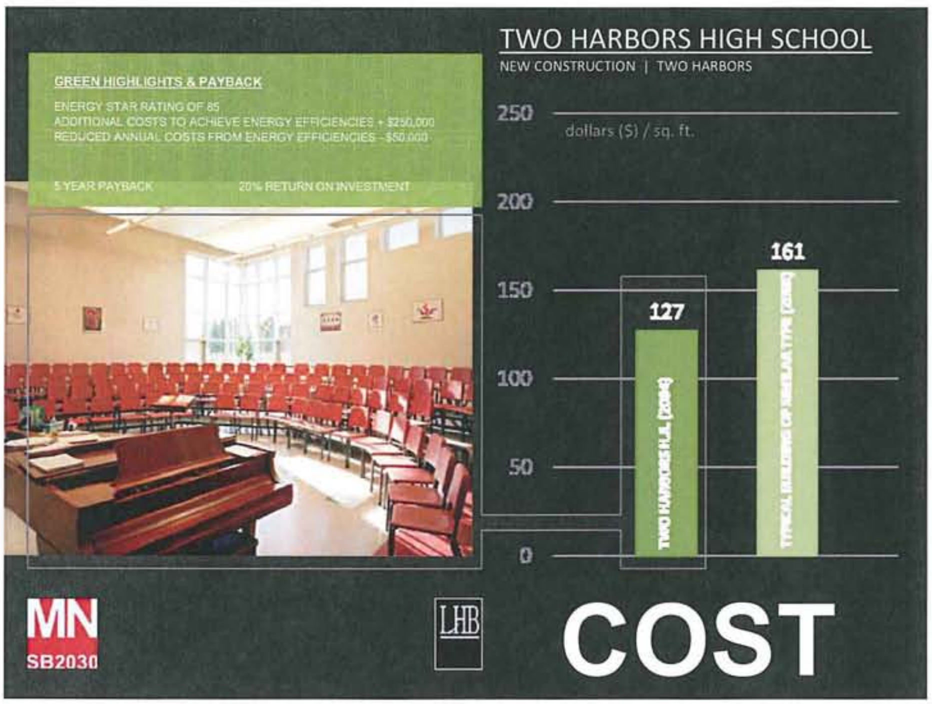

QUALITY BICYCLE PRODUCTS
ADDITION & REMODEL | BLOOMINGTON
FAST FACTS
DESIGN START: 2004
COMPLETION: NOV. 2005
OFFICE: 37,549 GSF
WAREHOUSE: 90,735 SF
PROJECT TEAM
OWNER: QBP
ARCHITECT: LHB
ENGINEER: LHB
CONTRACTOR: KRAUS-ANDERSON
kBtu / sq. ft. / year
120
100
80
60
40
20
0
48
42.4
47
119.9
MN
SB2030
LHB
ENERGY

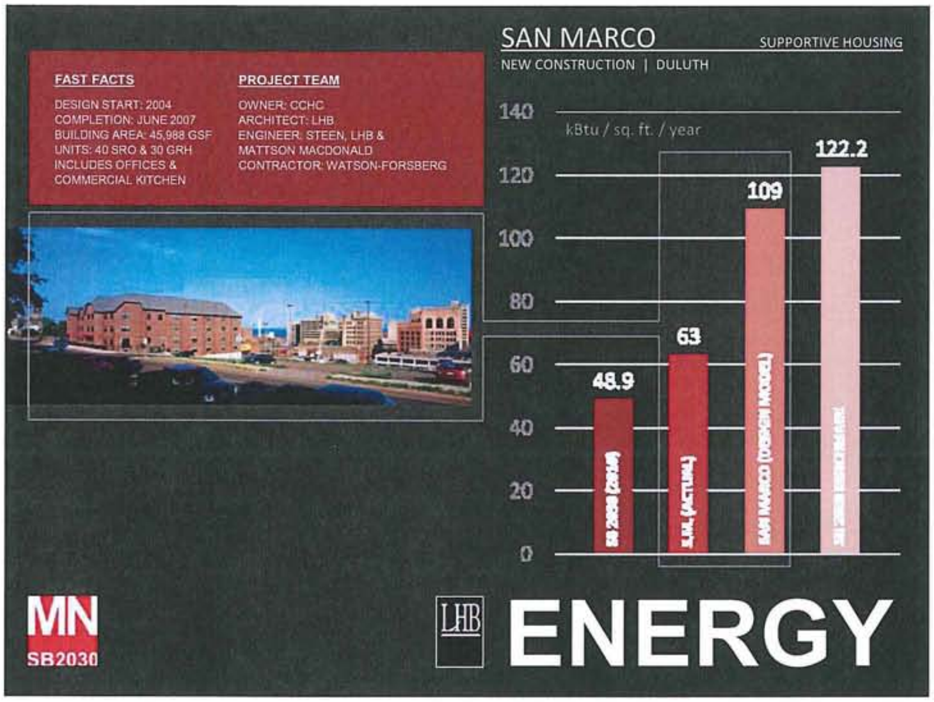

QUALITY BICYCLE PRODUCTS
ADDITION & REMODEL | BLOOMINGTON
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 40% NAT. GAS & 60% ELECTRICITY
DESIGN MODEL | 55.4% NATURAL GAS & 44.6% ELECTRICITY
ACTUAL | 55.4% NATURAL GAS & 44.6% ELECTRICITY
- ENERGY & CO2 INFORMATION BASED ON 2006 DATA.
CO2 / sq. ft. / year
50
45
40
35
30
25
20
15
10
5
0
18.7
13.5
15
46.7
MN
SB2030
LHB
CO2

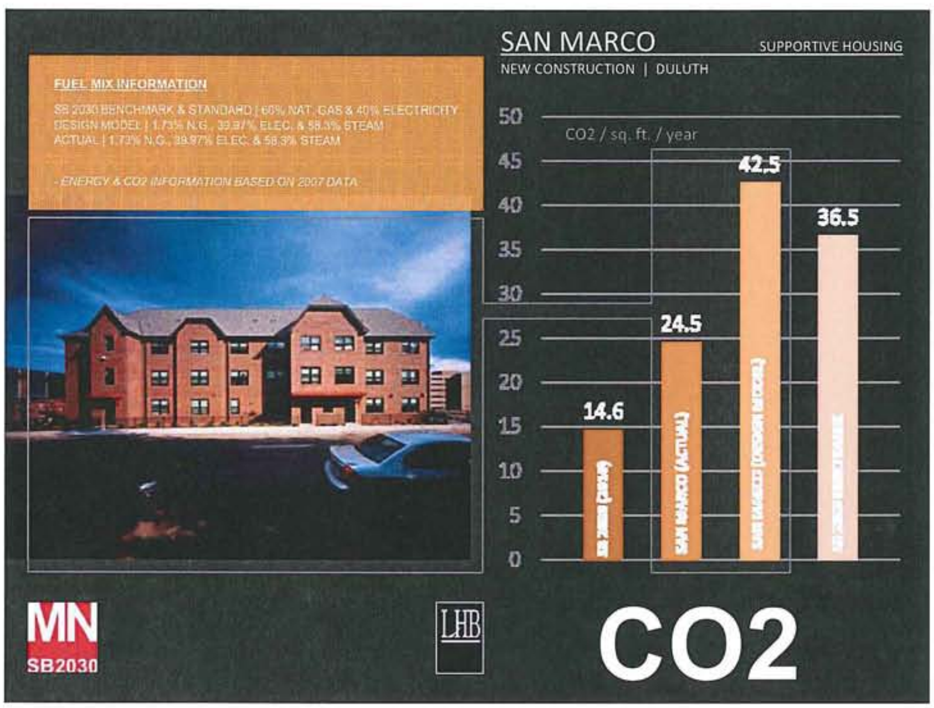

QUALITY BICYCLE PRODUCTS
ADDITION & REMODEL | BLOOMINGTON
GREEN HIGHLIGHTS & PAYBACK
LEED® – NC GOLD CERTIFIED
ADDITIONAL COSTS TO ACHIEVE ENERGY EFFICIENCIES + $750,000
REDUCED ANNUAL COSTS FROM ENERGY EFFICIENCIES - $75,000
10 YEAR PAYBACK
10% RETURN ON INVESTMENT
dollars ($) / sq. ft.
120
100
80
60
40
20
0
73
79
MN
SB2030
LHB
COST

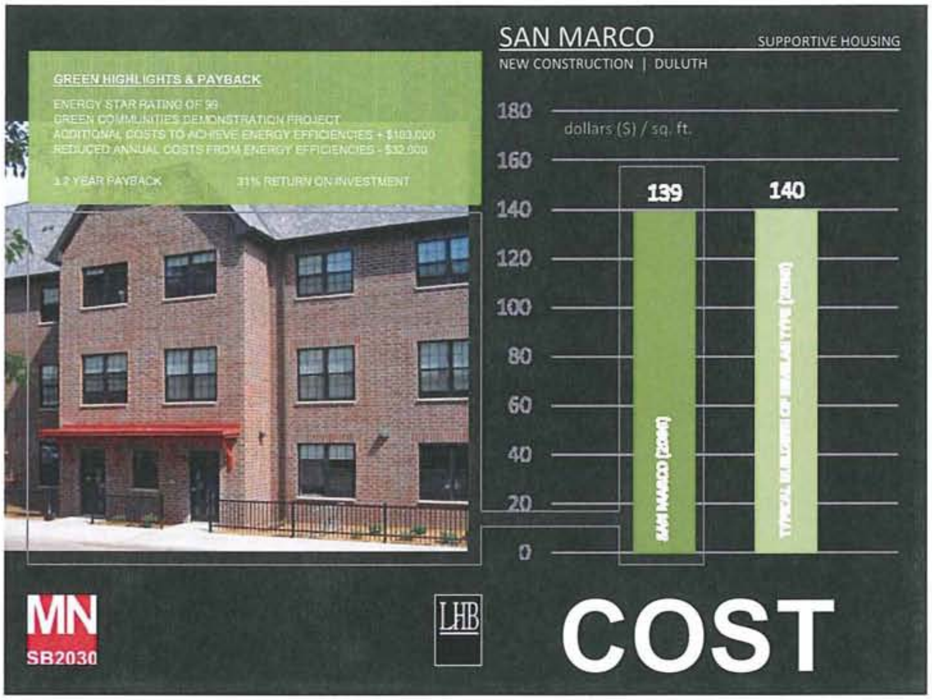

TWO HARBORS HIGH SCHOOL
NEW CONSTRUCTION | TWO HARBORS
FAST FACTS
DESIGN START: 2002
COMPLETION: SEPT. 2005
BUILDING AREA:181,000 GSF
HIGH SCHOOL W/ GYM,
POOL, AUDITORIUM &
ATHLETIC FACILITIES
PROJECT TEAM
OWNER: LAKE SUPERIOR
SCHOOL DISTRICT
ARCHITECT: LHB
ENGINEER: LHB
CONTRACTOR: KRAUS-ANDERSON
kBtu / sq. ft. / year
120
100
80
60
40
20
0
49.4
57
56
123.4
MN
SB2030
LHB
ENERGY

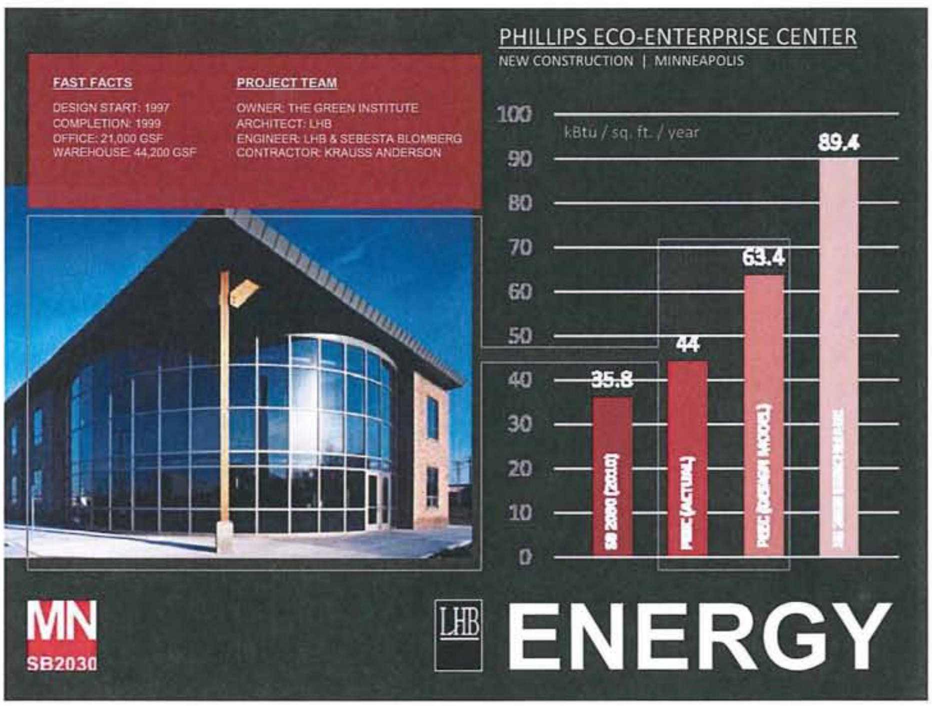

TWO HARBORS HIGH SCHOOL
NEW CONSTRUCTION | TWO HARBORS
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 40% NAT. GAS & 60% ELECTRICITY
DESIGN MODEL | 62.4% NATURAL GAS & 47.6% ELECTRICITY
ACTUAL | 62.4% NATURAL GAS & 47.6% ELECTRICITY
- ENERGY & CO2 INFORMATION BASED ON 2007 DATA
CO2 / sq. ft. / year
50
45
40
35
30
25
20
15
10
5
0
19.2
19
18.6
48.1
T.H.H.S. (ACTUAL)
MN
SB2030
LHB
CO2

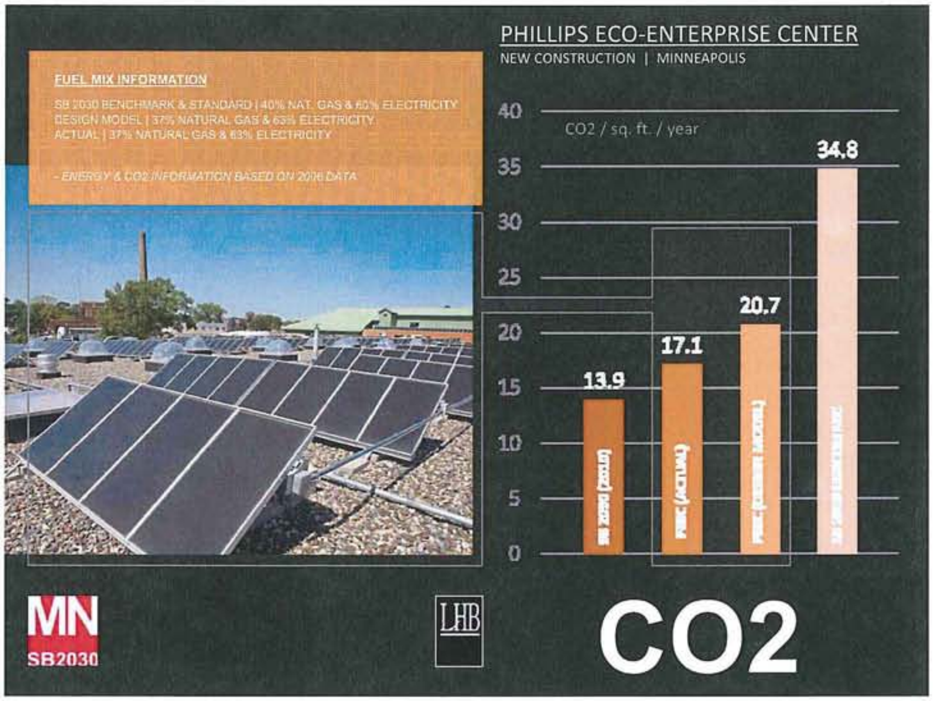

TWO HARBORS HIGH SCHOOL
NEW CONSTRUCTION | TWO HARBORS
GREEN HIGHLIGHTS & PAYBACK
ENERGY STAR RATING OF 85
ADDITIONAL COSTS TO ACHIEVE ENERGY EFFICIENCIES + $250,000
REDUCED ANNUAL COSTS FROM ENERGY EFFICIENCIES - $50,000
5 YEAR PAYBACK
20% RETURN ON INVESTMENT
dollars ($) / sq. ft.
250
200
150
100
50
0
127
161
MN
SB2030
LHB
COST


SAN MARCO
SUPPORTIVE HOUSING
NEW CONSTRUCTION | DULUTH
FAST FACTS
DESIGN START: 2004
COMPLETION: JUNE 2007
BUILDING AREA: 45,988 GSF
UNITS: 40 SRO & 30 GRH
INCLUDES OFFICES &
COMMERCIAL KITCHEN
PROJECT TEAM
OWNER: CCHC
ARCHITECT: LHB
ENGINEER: STEEN, LHB &
MATTSON MACDONALD
CONTRACTOR: WATSON-FORSBERG
kBtu / sq. ft. / year
140
120
100
80
60
40
20
0
48.9
63
109
122.2
MN
SB2030
LHB
ENERGY

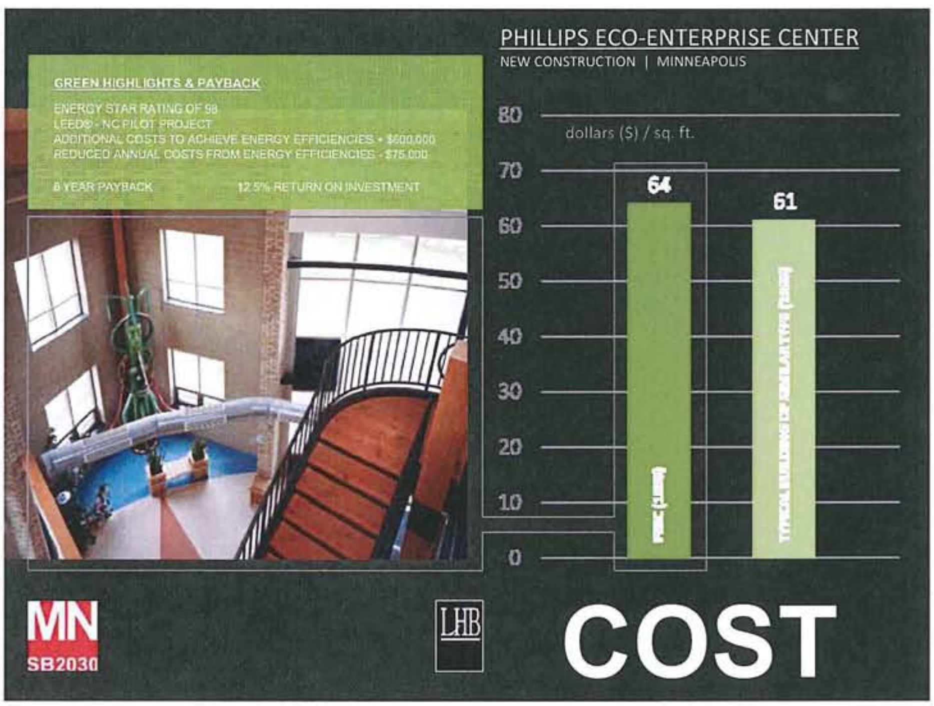

SAN MARCO
SUPPORTIVE HOUSING
NEW CONSTRUCTION | DULUTH
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 60% NAT. GAS & 40% ELECTRICITY
DESIGN MODEL | 1.73% N.G., 39.97% ELEC. & 58.3% STEAM
ACTUAL | 1.73% N.G., 39.97% ELEC. & 58.3% STEAM
- ENERGY & CO2 INFORMATION BASED ON 2007 DATA
CO2 / sq. ft. / year
50
45
40
35
30
25
20
15
10
5
0
14.6
24.5
42.5
36.5
MN
SB2030
LHB
CO2


SAN MARCO
SUPPORTIVE HOUSING
NEW CONSTRUCTION | DULUTH
GREEN HIGHLIGHTS & PAYBACK
ENERGY STAR RATING OF 99
GREEN COMMUNITIES DEMONSTRATION PROJECT
ADDITIONAL COSTS TO ACHIEVE ENERGY EFFICIENCIES + $103,000
REDUCED ANNUAL COSTS FROM ENERGY EFFICIENCIES - $32,000
3.2 YEAR PAYBACK
31% RETURN ON INVESTMENT
dollars ($) / sq. ft.
180
160
140
120
100
80
60
40
20
0
139
140
MN
SB2030
LHB
COST

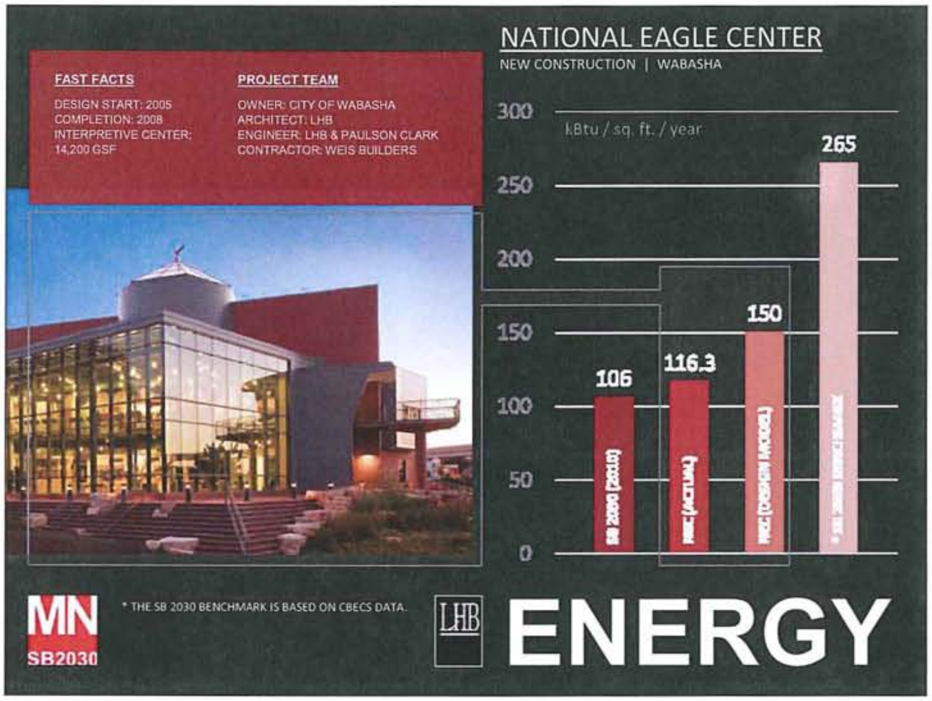

PHILLIPS ECO-ENTERPRISE CENTER
NEW CONSTRUCTION | MINNEAPOLIS
FAST FACTS
DESIGN START: 1997
COMPLETION: 1999
OFFICE: 21,000 GSF
WAREHOUSE: 44,200 GSF
PROJECT TEAM
OWNER: THE GREEN INSTITUTE
ARCHITECT: LHB
ENGINEER: LHB & SEBESTA BLOMBERG
CONTRACTOR: KRAUSS ANDERSON
kBtu / sq. ft. / year
100
90
80
70
60
50
40
30
20
10
0
35.8
44
63.4
89.4
MN
SB2030
LHB
ENERGY

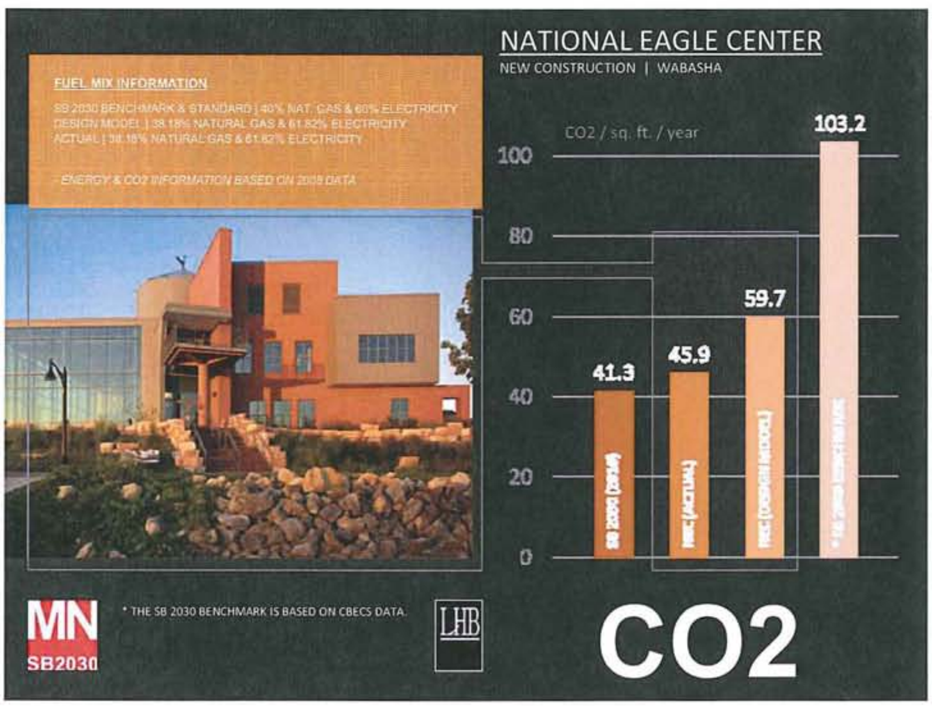


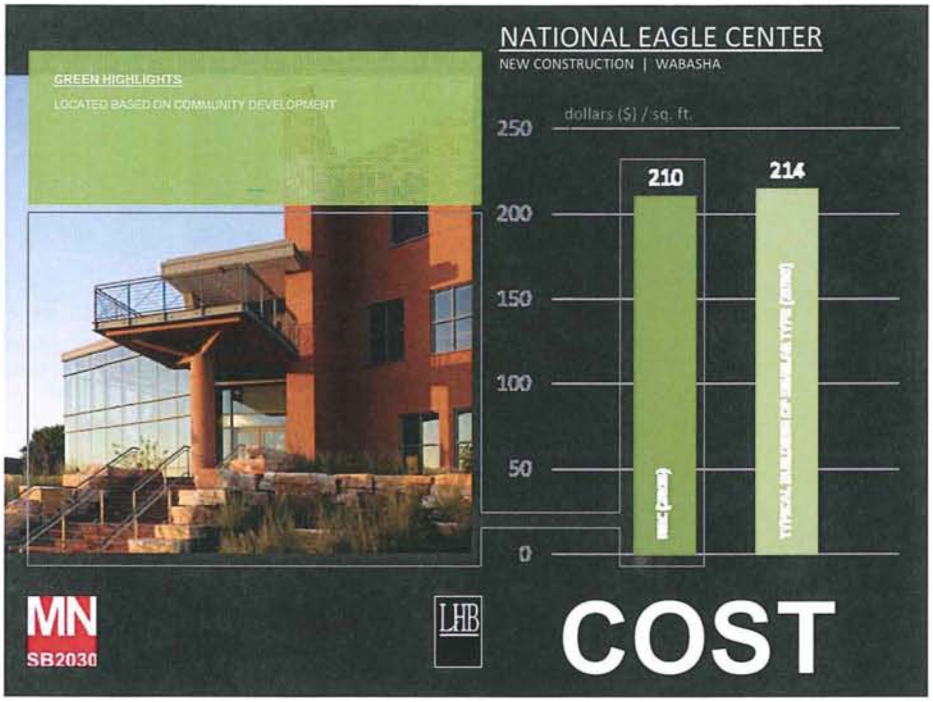
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 40% NAT. GAS & 60% ELECTRICITY
DESIGN MODEL | 37% NATURAL GAS & 63% ELECTRICITY
ACTUAL | 37% NATURAL GAS & 63% ELECTRICITY
- ENERGY & CO2 INFORMATION BASED ON 2006 DATA
PHILLIPS ECO-ENTERPRISE CENTER
NEW CONSTRUCTION | MINNEAPOLIS
CO2 / sq. ft. / year
40
35
30
25
20
15
10
5
0
13.9
17.1
20.7
34.8
MN
SB2030
LHB
CO2

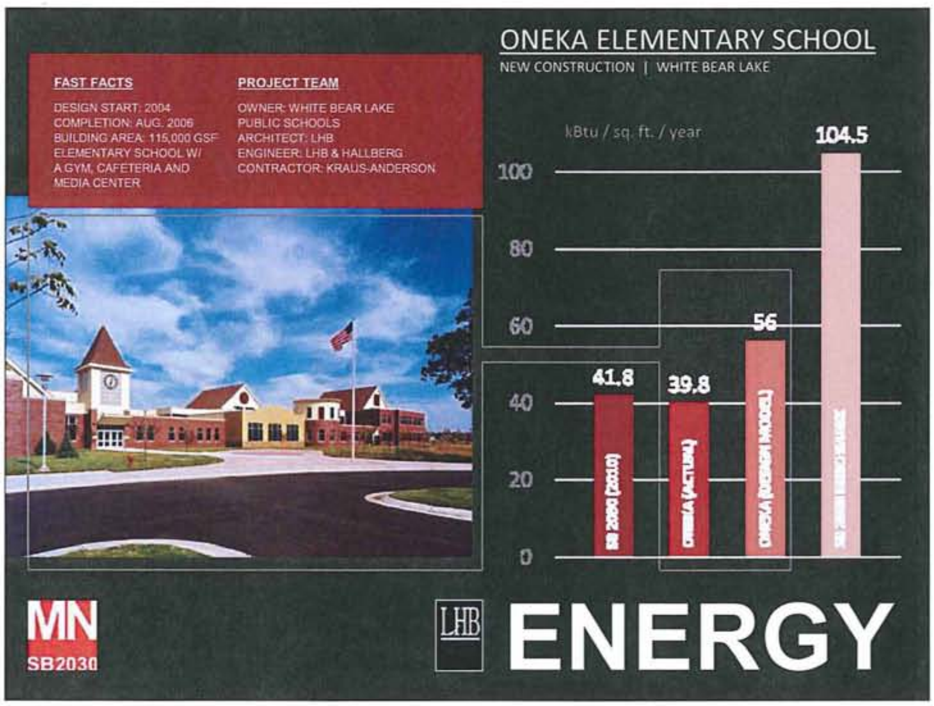


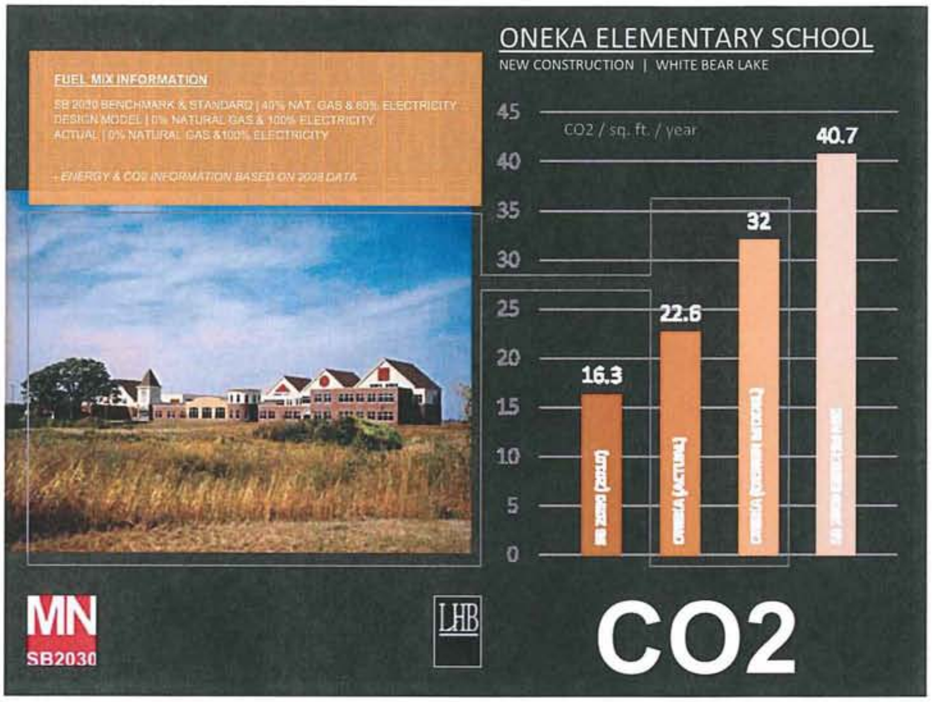
GREEN HIGHLIGHTS & PAYBACK
ENERGY STAR RATING OF 98
LEED® - NC PILOT PROJECT
ADDITIONAL COSTS TO ACHIEVE ENERGY EFFICIENCIES + $600,000
REDUCED ANNUAL COSTS FROM ENERGY EFFICIENCIES - $75,000
8 YEAR PAYBACK
12.5% RETURN ON INVESTMENT
PHILLIPS ECO-ENTERPRISE CENTER
NEW CONSTRUCTION | MINNEAPOLIS
dollars ($) / sq. ft.
80
70
60
50
40
30
20
10
0
64
61
MN
SB2030
LHB
COST

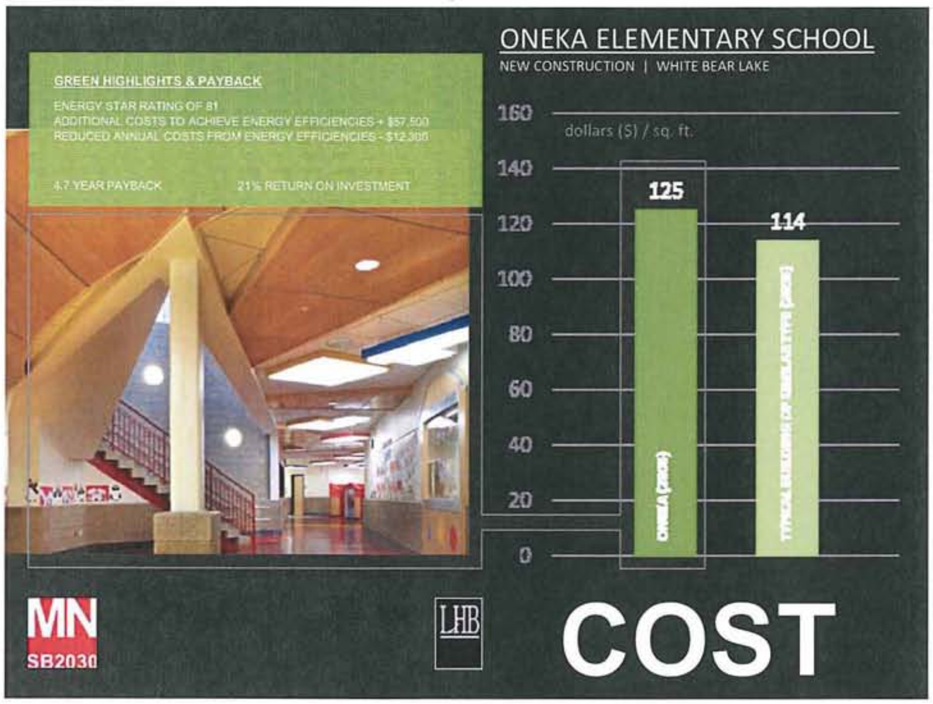

NATIONAL EAGLE CENTER
NEW CONSTRUCTION | WABASHA
FAST FACTS
DESIGN START: 2005
COMPLETION: 2008
INTERPRETIVE CENTER: 14,200 GSF
PROJECT TEAM
OWNER: CITY OF WABASHA
ARCHITECT: LHB
ENGINEER: LHB & PAULSON CLARK
CONTRACTOR: WEIS BUILDERS
kBtu / sq. ft. / year
300
250
200
150
100
50
0
106
116.3
150
265
MN SB2030
* THE SB 2030 BENCHMARK IS BASED ON CBECS DATA.
LHB
ENERGY

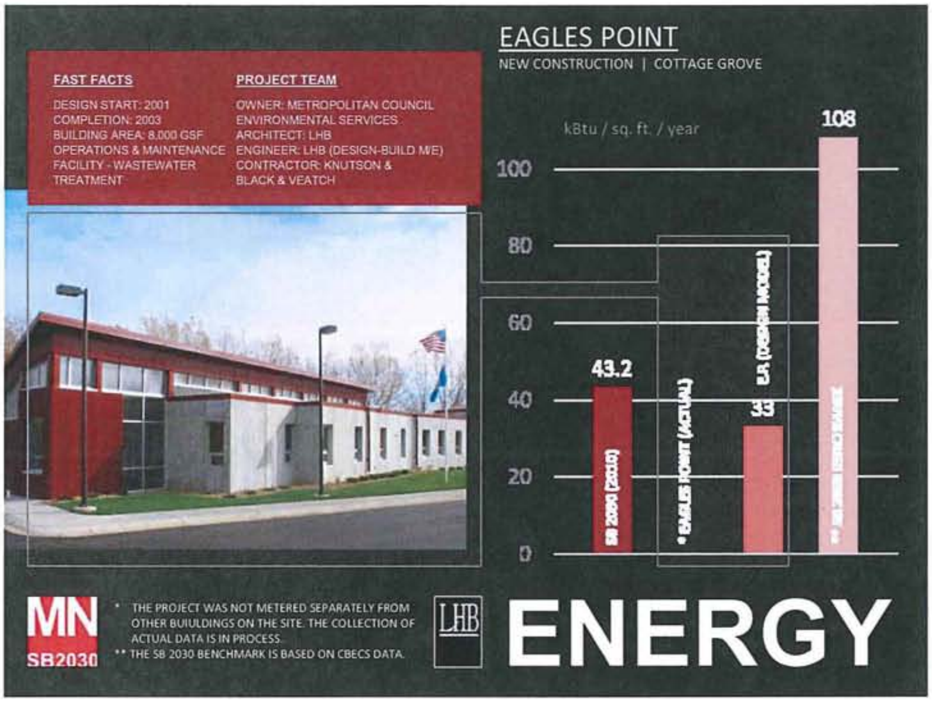

NATIONAL EAGLE CENTER
NEW CONSTRUCTION | WABASHA
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 40% NAT. GAS & 60% ELECTRICITY
DESIGN MODEL | 38.18% NATURAL GAS & 61.82% ELECTRICITY
ACTUAL | 38.18% NATURAL GAS & 61.82% ELECTRICITY
- ENERGY & CO2 INFORMATION BASED ON
CO2 / sq. ft. / year
100
80
60
40
20
0
41.3
45.9
59.7
103.2
MN SB2030
* THE SB 2030 BENCHMARK IS BASED ON CBECS DATA.
LHB
CO2

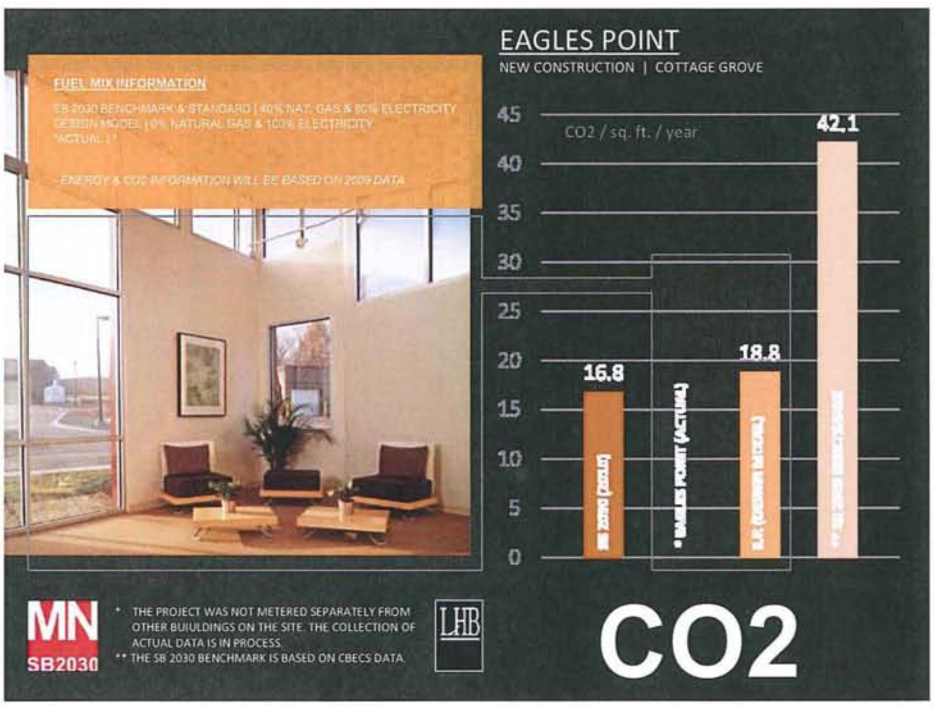

NATIONAL EAGLE CENTER
NEW CONSTRUCTION | WABASHA
GREEN HIGHLIGHTS
LOCATED BASED ON COMMUNITY DEVELOPMENT
dollars ($) / sq. ft.
250
200
150
100
50
0
210
214
MN
SB2030
LHB
COST

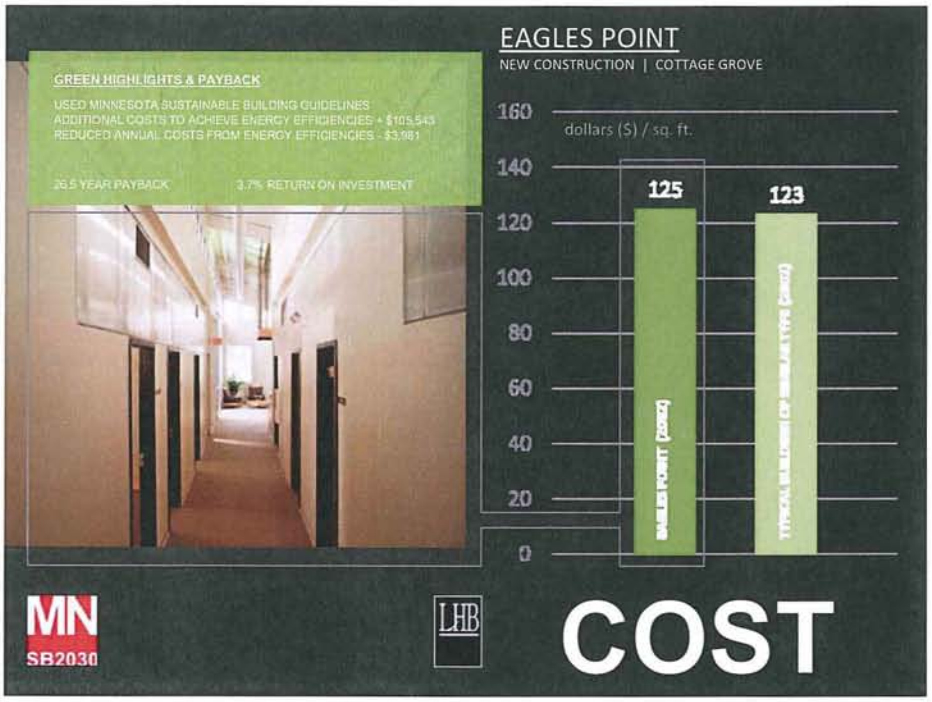

ONEKA ELEMENTARY SCHOOL
NEW CONSTRUCTION | WHITE BEAR LAKE
FAST FACTS
DESIGN START: 2004
COMPLETION: AUG. 2006
BUILDING AREA: 115,000 GSF
ELEMENTARY SCHOOL W/
A GYM, CAFETERIA AND
MEDIA CENTER
PROJECT TEAM
OWNER: WHITE BEAR LAKE
PUBLIC SCHOOLS
ARCHITECT: LHB
ENGINEER: LHB & HALLBERG
CONTRACTOR: KRAUS-ANDERSON
kBtu / sq. ft. / year
100
80
60
40
20
0
41.8
39.8
56
104.5
SB 2030 (2010)
ONEKA (ACTUAL)
ONEKA (DESIGN MODEL)
MN
SB2030
LHB
ENERGY

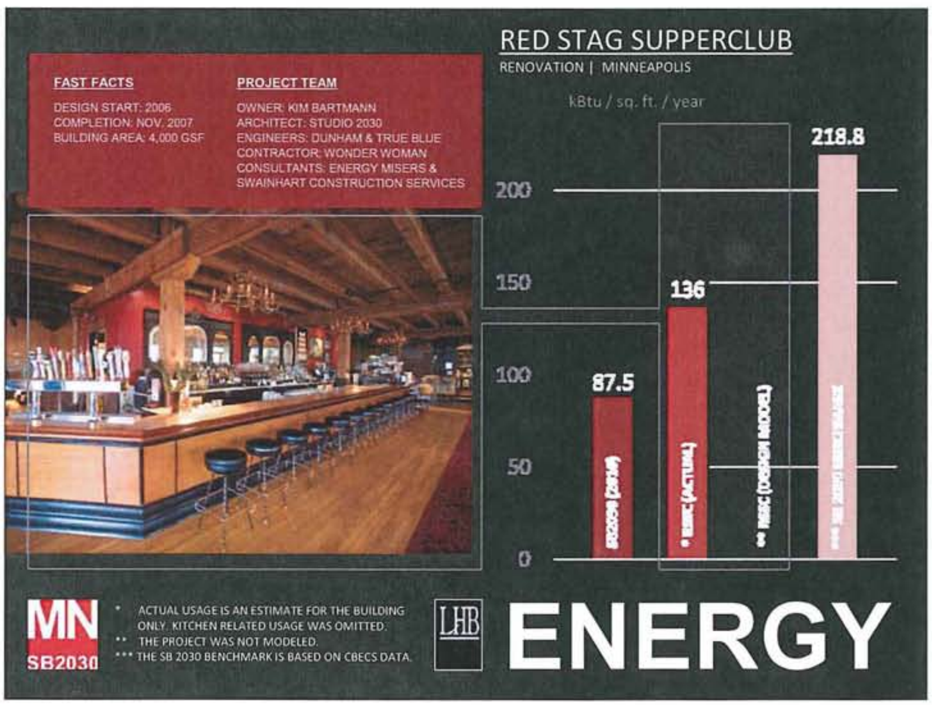

ONEKA ELEMENTARY SCHOOL
NEW CONSTRUCTION | WHITE BEAR LAKE
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 40% NAT. GAS & 60% ELECTRICITY
DESIGN MODEL | 0% NATURAL GAS & 100% ELECTRICITY
ACTUAL | 0% NATURAL GAS &100% ELECTRICITY
- ENERGY & CO2 INFORMATION BASED ON 2008 DATA
CO2 / sq. ft. / year
45
40
35
30
25
20
15
10
5
0
16.3
22.6
32
40.7
MN
SB2030
LHB
CO2

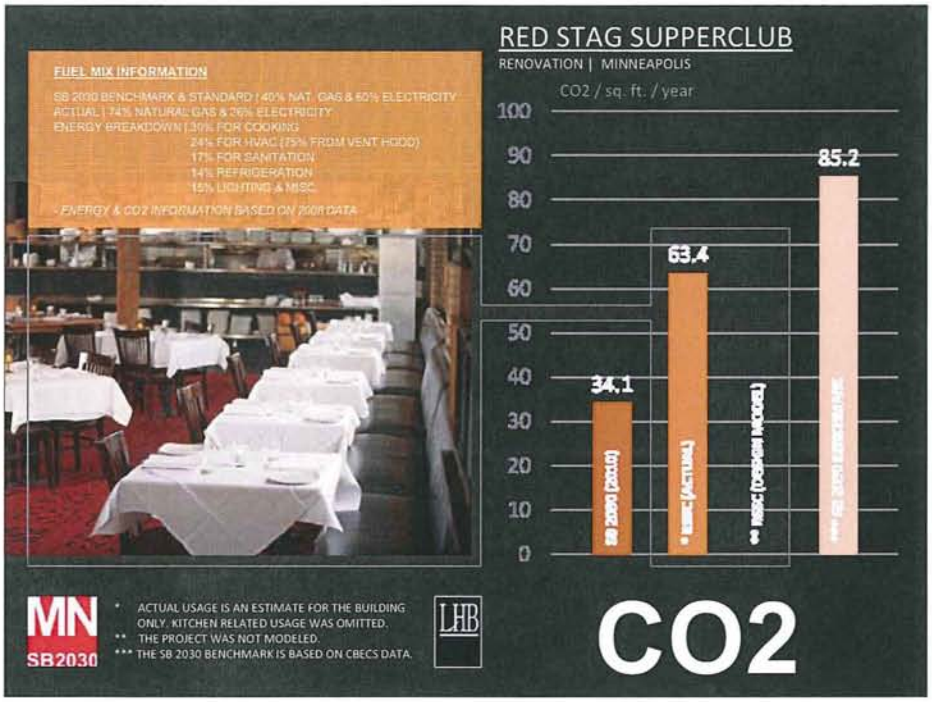

ONEKA ELEMENTARY SCHOOL
NEW CONSTRUCTION | WHITE BEAR LAKE
GREEN HIGHLIGHTS & PAYBACK
ENERGY STAR RATING OF 81
ADDITIONAL COSTS TO ACHIEVE ENERGY EFFICIENCIES + $57,500
REDUCED ANNUAL COSTS FROM ENERGY EFFICIENCIES - $12,300
4.7 YEAR PAYBACK
21% RETURN ON INVESTMENT
dollars ($) / sq. ft.
160
140
120
100
80
60
40
20
0
125
114
MN
SB2030
LHB
COST

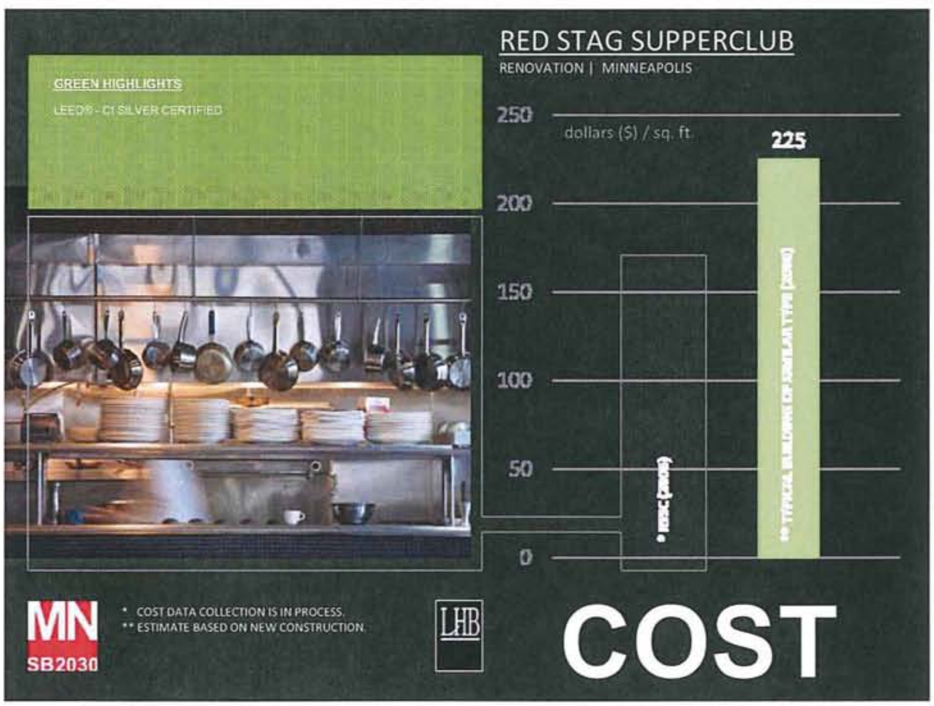

EAGLES POINT
NEW CONSTRUCTION | COTTAGE GROVE
FAST FACTS
DESIGN START: 2001
COMPLETION: 2003
BUILDING AREA: 8,000 GSF
OPERATIONS & MAINTENANCE FACILITY - WASTEWATER TREATMENT
PROJECT TEAM
OWNER: METROPOLITAN COUNCIL ENVIRONMENTAL SERVICES
ARCHITECT: LHB
ENGINEER: LHB (DESIGN-BUILD M/E)
CONTRACTOR: KNUTSON & BLACK & VEATCH
kBtu / sq. ft. / year
0
20
40
60
80
100
43.2
33
108
SB 2030 (2010)
* EAGLES POINT (ACTUAL)
E.R. (DESIGN MODEL)
MN
SB2030
* THE PROJECT WAS NOT METERED SEPARATELY FROM OTHER BUIULDINGS ON THE SITE. THE COLLECTION OF ACTUAL DATA IS IN PROCESS.
** THE SB 2030 BENCHMARK IS BASED ON CBECS DATA.
LHB
ENERGY

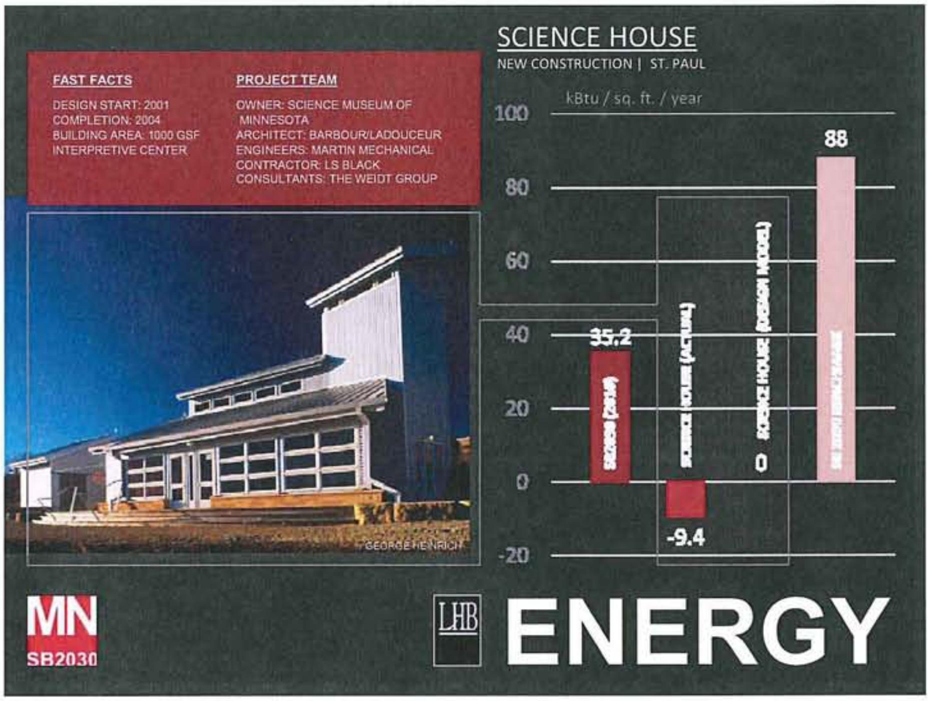

EAGLES POINT
NEW CONSTRUCTION | COTTAGE GROVE
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 40% NAT. GAS & 60% ELECTRICITY
DESIGN MODEL | 0% NATURAL GAS & 100% ELECTRICITY
ENERGY & CO2 INFORMATION WILL BE BASED ON 2009 DATA
CO2 / sq. ft. / year
0
5
10
15
20
25
30
35
40
45
16.8
18.8
42.1
* EAGLES POINT (ACTUAL)
MN
SB2030
* THE PROJECT WAS NOT METERED SEPARATELY FROM OTHER BUIULDINGS ON THE SITE. THE COLLECTION OF ACTUAL DATA IS IN PROCESS.
** THE SB 2030 BENCHMARK IS BASED ON CBECS DATA.
LHB
CO2

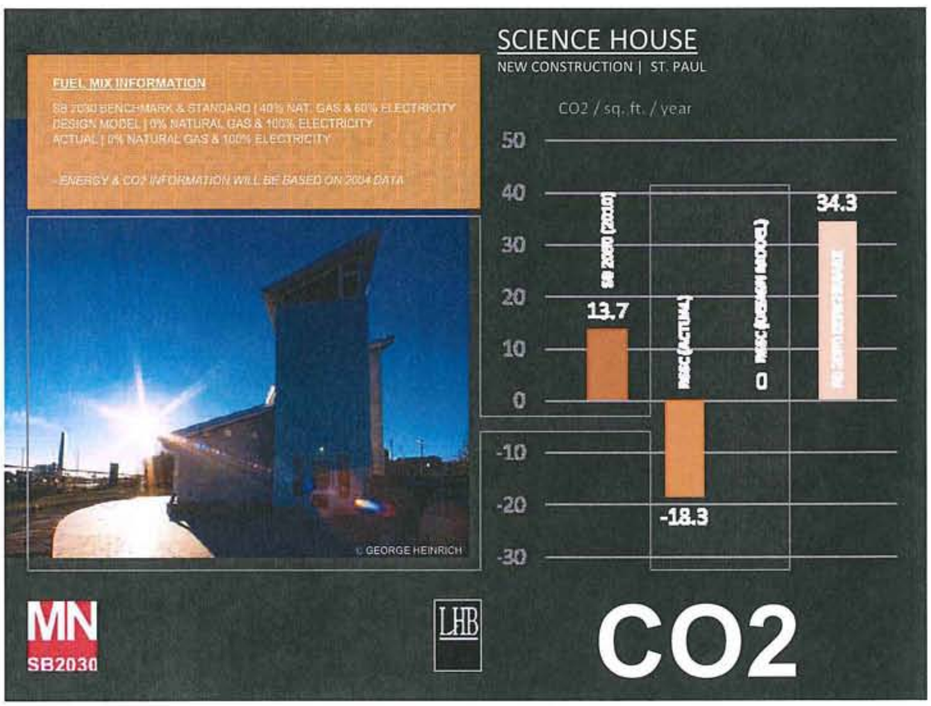

EAGLES POINT
NEW CONSTRUCTION | COTTAGE GROVE
GREEN HIGHLIGHTS & PAYBACK
USED MINNESOTA SUSTAINABLE BUILDING GUIDELINES
ADDITIONAL COSTS TO ACHIEVE ENERGY EFFICIENCIES + $105,543
REDUCED ANNUAL COSTS FROM ENERGY EFFICIENCIES - $3,981
26.5 YEAR PAYBACK
3.7% RETURN ON INVESTMENT
dollars ($) / sq. ft.
160
140
120
100
80
60
40
20
0
125
123
MN
SB2030
LHB
COST

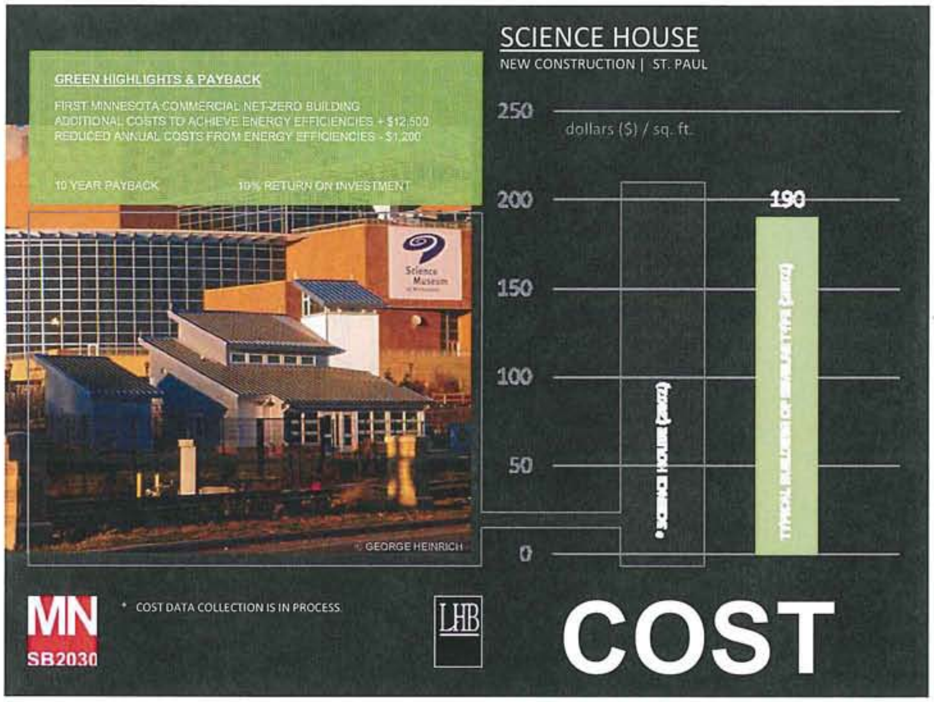

RED STAG SUPPERCLUB
RENOVATION | MINNEAPOLIS
FAST FACTS
DESIGN START: 2006
COMPLETION: NOV. 2007
BUILDING AREA: 4,000 GSF
PROJECT TEAM
OWNER: KIM BARTMANN
ARCHITECT: STUDIO 2030
ENGINEERS: DUNHAM & TRUE BLUE
CONTRACTOR: WONDER WOMAN
CONSULTANTS: ENERGY MISERS & SWAINHART CONSTRUCTION SERVICES
kBtu / sq. ft. / year
200
150
100
50
0
87.5
136
218.8
MN
SB2030
* ACTUAL USAGE IS AN ESTIMATE FOR THE BUILDING ONLY. KITCHEN RELATED USAGE WAS OMITTED.
** THE PROJECT WAS NOT MODELED.
*** THE SB 2030 BENCHMARK IS BASED ON CBECS DATA.
LHB
ENERGY

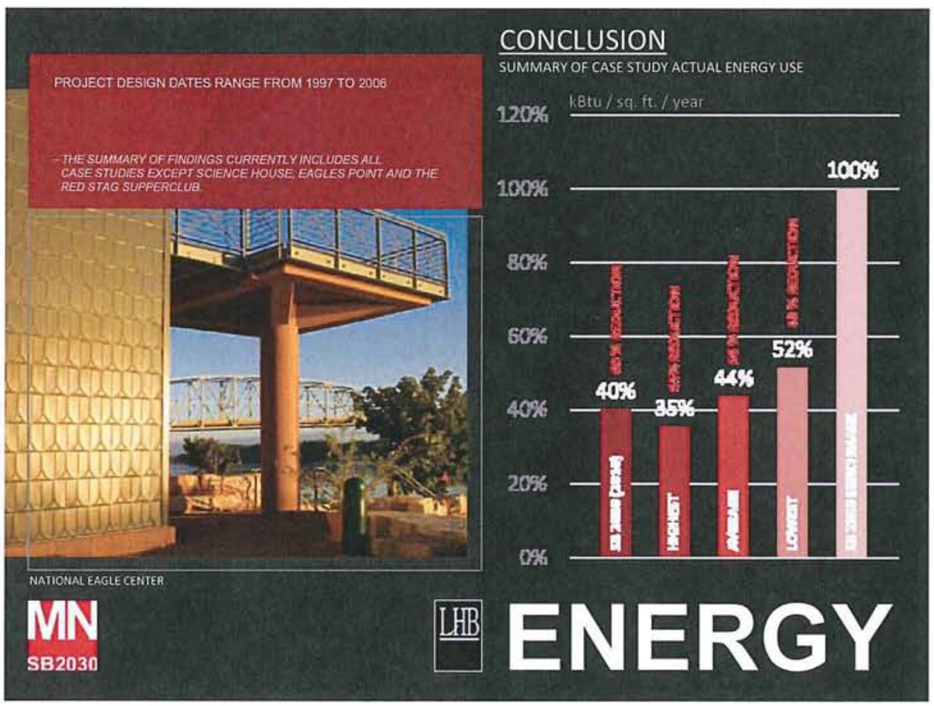

RED STAG SUPPERCLUB
RENOVATION | MINNEAPOLIS
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 40% NAT. GAS & 60% ELECTRICITY
ACTUAL | 74% NATURAL GAS & 26% ELECTRICITY
ENERGY BREAKDOWN | 30% FOR COOKING
24% FOR HVAC (75% FROM VENT HOOD)
17% FOR SANITATION
14% REFRIGERATION
15% LIGHTING & MISC.
- ENERGY & CO2 INFORMATION BASED ON 2008 DATA
CO2 / sq. ft. / year
100
90
80
70
60
50
40
30
20
10
0
34.1
63.4
85.2
SB 2030 (2010)
* RSSC (ACTUAL)
** RSSC (DESIGN MODEL)
MN
SB2030
* ACTUAL USAGE IS AN ESTIMATE FOR THE BUILDING ONLY. KITCHEN RELATED USAGE WAS OMITTED.
** THE PROJECT WAS NOT MODELED.
*** THE SB 2030 BENCHMARK IS BASED ON CBECS DATA.
LHB
CO2

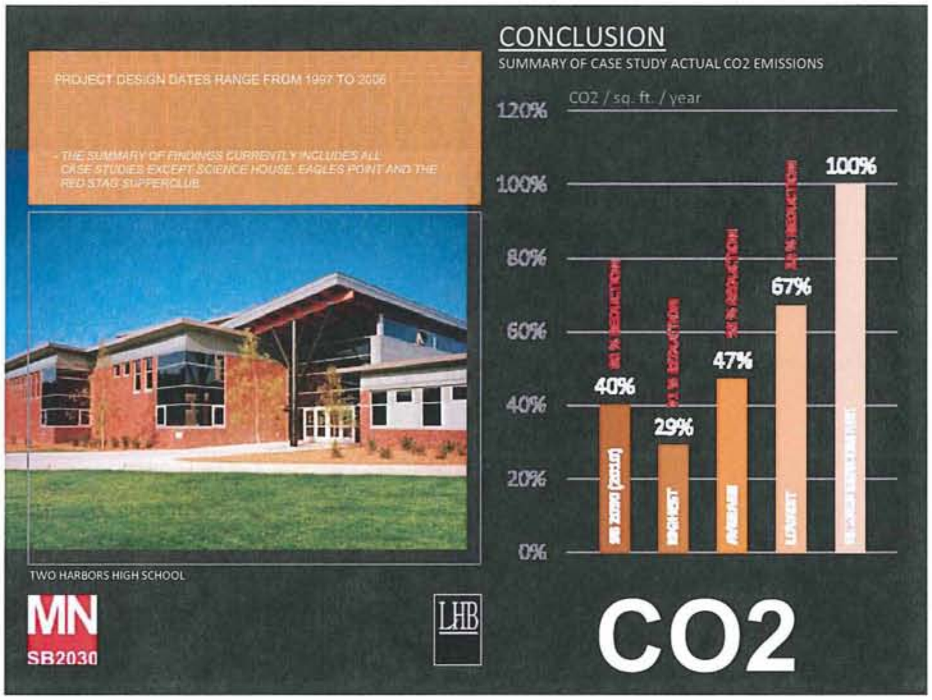

RED STAG SUPPERCLUB
RENOVATION | MINNEAPOLIS
GREEN HIGHLIGHTS
LEED® - CI SILVER CERTIFIED
dollars ($) / sq. ft.
250
200
150
100
50
0
225
MN
SB2030
* COST DATA COLLECTION IS IN PROCESS.
** ESTIMATE BASED ON NEW CONSTRUCTION.
LHB
COST

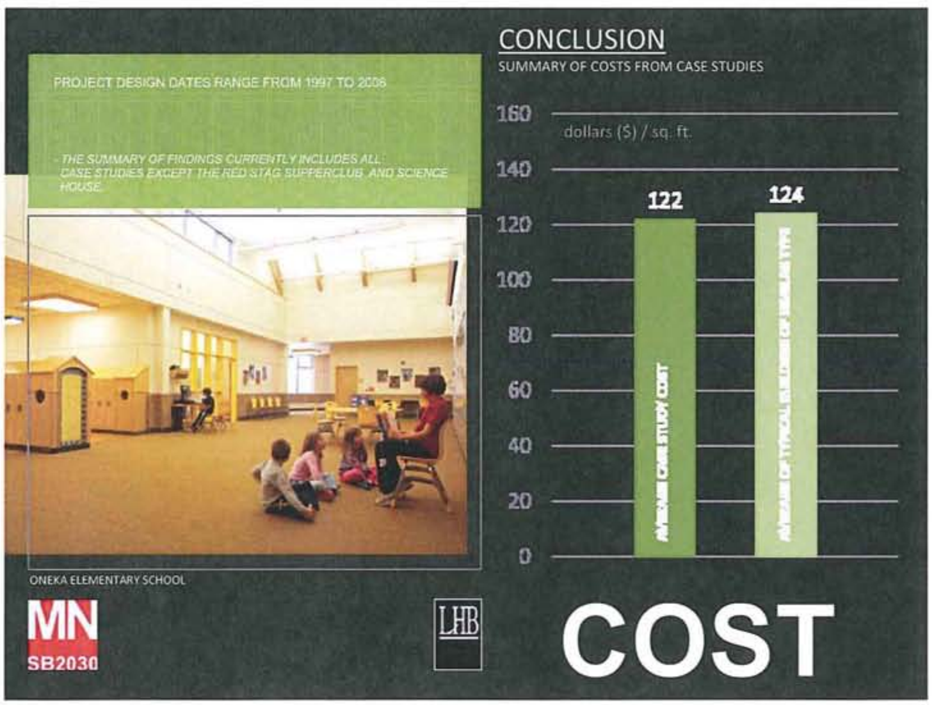

SCIENCE HOUSE
NEW CONSTRUCTION | ST. PAUL
FAST FACTS
DESIGN START: 2001
COMPLETION: 2004
BUILDING AREA: 1000 GSF
INTERPRETIVE CENTER
PROJECT TEAM
OWNER: SCIENCE MUSEUM OF MINNESOTA
ARCHITECT: BARBOUR/LADOUCEUR
ENGINEERS: MARTIN MECHANICAL
CONTRACTOR: LS BLACK
CONSULTANTS: THE WEIDT GROUP
© GEORGE HEINRICH
kBtu / sq. ft. / year
100
80
60
40
20
0
-20
35.2
-9.4
0
88
MN
SB2030
LHB
ENERGY


SCIENCE HOUSE
NEW CONSTRUCTION | ST. PAUL
FUEL MIX INFORMATION
SB 2030 BENCHMARK & STANDARD | 40% NAT. GAS & 60% ELECTRICITY
DESIGN MODEL | 0% NATURAL GAS & 100% ELECTRICITY
ACTUAL | 0% NATURAL GAS & 100% ELECTRICITY
- ENERGY & CO2 INFORMATION WILL BE BASED ON 2004 DATA
© GEORGE HEINRICH
CO2 / sq. ft. / year
50
40
30
20
10
0
-10
-20
-30
13.7
-18.3
0
34.3
MN
SB2030
LHB
CO2


SCIENCE HOUSE
NEW CONSTRUCTION | ST. PAUL
GREEN HIGHLIGHTS & PAYBACK
FIRST MINNESOTA COMMERCIAL NET-ZERO BUILDING
ADDITIONAL COSTS TO ACHIEVE ENERGY EFFICIENCIES + $12,500
REDUCED ANNUAL COSTS FROM ENERGY EFFICIENCIES - $1,200
10 YEAR PAYBACK
10% RETURN ON INVESTMENT
© GEORGE HEINRICH
dollars ($) / sq. ft.
250
200
150
100
50
0
190
* COST DATA COLLECTION IS IN PROCESS.
MN
SB2030
LHB
COST


CONCLUSION
SUMMARY OF CASE STUDY ACTUAL ENERGY USE
PROJECT DESIGN DATES RANGE FROM 1997 TO 2006
- THE SUMMARY OF FINDINGS CURRENTLY INCLUDES ALL CASE STUDIES EXCEPT SCIENCE HOUSE, EAGLES POINT AND THE RED STAG SUPPERCLUB.
kBtu / sq. ft. / year
120%
100%
80%
60%
40%
20%
0%
40%
35%
44%
52%
100%
HIGHEST
LOWEST
NATIONAL EAGLE CENTER
MN
SB2030
LHB
ENERGY


CONCLUSION
SUMMARY OF CASE STUDY ACTUAL CO2 EMISSIONS
PROJECT DESIGN DATES RANGE FROM 1997 TO 2006
- THE SUMMARY OF FINDINGS CURRENTLY INCLUDES ALL CASE STUDIES EXCEPT SCIENCE HOUSE, EAGLES POINT AND THE RED STAG SUPPERCLUB.
CO2 / sq. ft. / year
120%
100%
80%
60%
40%
20%
0%
40%
29%
47%
67%
100%
TWO HARBORS HIGH SCHOOL
MN
SB2030
LHB
CO2


CONCLUSION
SUMMARY OF COSTS FROM CASE STUDIES
PROJECT DESIGN DATES RANGE FROM 1997 TO 2006
- THE SUMMARY OF FINDINGS CURRENTLY INCLUDES ALL CASE STUDIES EXCEPT THE RED STAG SUPPERCLUB AND SCIENCE HOUSE.
dollars ($) / sq. ft.
160
140
120
100
80
60
40
20
0
122
124
AVERAGE CASE STUDY COST
ONEKA ELEMENTARY SCHOOL
MN
SB2030
LHB
COST

Red Stag Supperclub

CASE STUDIES

SUMMARY

The following is a summary of case studies in this presentation:

1. Al Loehr | LHB
2. Quality Bicycle Products | LHB
3. Two Harbors High School | LHB
4. San Marco | LHB
5. Phillips Eco-Enterprise Center | LHB
6. National Eagle Center | LHB
7. White Bear Lake Schools | LHB
8. Eagles Point | LHB
9. Red Stag Supperclub | studio 2030
10. Science House | Barbour/LaDouceur

MN SB2030

LHB