MINNESOTA SUSTAINABLE BUILDING GUIDELINES:

History, Effectiveness and Path for the Future.

Richard Graves[1] and Patrick Smith[2]

INTRODUCTION

The Minnesota Sustainable Building Guidelines is a progressive sustainability program for state funded buildings which serves as a model for sustainability in Minnesota buildings. The program was created by the State of Minnesota in 2001 and developed by a team led by the Center for Sustainable Building Research (CSBR) at the University of Minnesota. Unlike other green building programs, it focuses on measured performance improvements, using a list of required metrics instead of a menu of potential options. The program is structured to provide a feedback loop to the building design, construction and operations industry in the state. Elements of the program are used through all phases of the development of state-funded buildings in Minnesota from pre-design through design, and construction and for ten years of operations. It is continually updated and improved in collaboration with state agencies and industry stakeholders and could serve as a model for localized green building programs.

KEYWORDS

green building, rating systems, code, climate change, architecture 2030, emission reduction, actual performance, net zero, EUI, renewable

HISTORY

The Minnesota Sustainable Building Guidelines (MSBG) has roots as far back as 1976 when the state created its first energy code that applied to new and remodeled buildings. In 1980 the state required utilities to develop pilot conservation programs. Also in the 1980's the University of Minnesota started to develop green building prototype designs at the Regional Daylighting Center and the Minnesota Building Research Center. The University has continued to play a major role in sustainable building research and implementation, including work in the College of Design and the Center for Sustainable Building Research by John Carmody, Mary Guzowski, Richard Graves and others.

In 1995 the Minnesota Office of Environmental Assistance (OEA) funded the Hennepin County Sustainable Design Guide. Collaborators included HOK Architects, local architects and

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landscape architects, the University of Minnesota, and the Hennepin County Environmental and Facilities Management Departments. In 1999, The Hennepin County Guidelines were modified and transferred to the University of Minnesota where they became known as the Minnesota Sustainable Design Guidelines. These guidelines were adopted by several public agencies in Minnesota for use on public buildings and served as a precursor to national green building programs like LEED.

In 1997, John Carmody established the Building Research Group in the College of Architecture and Landscape Architecture. In 2001, the group was renamed the Center for Sustainable Building Research (CSBR) within the University of Minnesota College of Design. CSBR has become a leader in the design of sustainable guidelines and related data and research for the last 17 years.

Also in 1997 the Minnesota State Legislature passed legislation requiring the Departments of Administration and Commerce to develop sustainability guidelines for all new state buildings that receive state bond funding. This act required the Department of Administration to collect information and energy use for all public buildings in order to establish benchmarks and future conservation goals. The governor signed the bill into law on May 29, 2001. A team was selected to implement this program which included the Center for Sustainable Building Research, LHB Inc., and The Weidt Group acting as principal partners. CSBR led the development of the Minnesota Sustainable Building Guidelines and The Weidt Group led the development of the B3 Benchmarking part of the project.

The team developed Version 1.0 of the MSBG that went into effect on January 15, 2004, for all new buildings using State general obligation (GO) bonding. It was designed to be compatible with national guidelines such as LEED while maintaining regional relevance and impact. Adopting LEED was considered but it was decided to expand upon the existing Minnesota Sustainable Design Guidelines because they were more specific to Minnesota's needs and could go further than LEED in some areas, such as water issues and IAQ. The MSBG were also designed so that most of the elements are required, unlike LEED, which allows more selection between categories and a less targeted approach to reducing social and environmental impacts. Finally, the state desired and the team implemented a set of guidelines that is more performance than prescriptive based.

Based on the original legislation, Version 1.0 of the MSBG required buildings to achieve at least a 30% reduction from the existing energy code, achieve lowest possible lifetime cost for new buildings, encourage continual energy conservation improvements in new buildings, ensure good indoor air quality, create and maintain a healthy environment, facilitate productivity improvements, specify ways to reduce material costs and consider the long-term operating cost of buildings. The guidelines applied to new buildings of any size funded in whole or in part by the State of Minnesota General Obligation Bonds, the primary source of State capital funding. In 2006, an updated Version 2.0 of the MSBG became available.

The MSBG is not a certification program. Projects receiving bond money are required to comply by law and therefore the guidelines act much more like a stretch code. Projects are assessed to be compliant rather than certified and compliance is verified during the planning, design and operations phases and approved by the appropriate state agency that receives the funds. The guidelines are performance-based with recommended guidelines in some topic areas included as a way to encourage more rigorous requirements whenever possible.

In response to climate change, a significant development to the program occurred on May 25, 2007, when Minnesota Governor Tim Pawlenty signed into law the Next Generation

Energy Act. The legislation increased energy efficiency, expanded community-based energy development, and established statewide greenhouse gas (GHG) emission reduction goals of 15% by 2015, 30% by 2025, and 80% by 2050, based on 2005 levels. The bill charged the Minnesota Climate Change Advisory Group with developing a comprehensive GHG emission reduction plan to meet these goals. One of the policy recommendations was to "adopt green building guidelines for all commercial and residential buildings consistent with Architecture 2030 targets." (NGEA 2007)

In the spring of 2008, the Minnesota Legislature passed a bill 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 Building 2030 (SB 2030). It was created to demonstrate how state funded buildings could be a model for the creation of net zero carbon buildings by 2030. However, SB 2030 was also seen as a way to test the feasibility of transitioning the "lead by example" program into a code for all buildings to scale the GHG reductions. To become a code which would be integral to the climate change action plan for the state, SB 2030 needed to include some key aspects:

- The energy guideline needed to move from a relative performance improvement (30% better than code) to an absolute performance (net zero)
- A clear target that is tailored to the actual climate, building type and program must be set.
- Design targets need to be verified with actual performance over time to prove that real energy reduction is occurring.

The team that created and currently manages the SB 2030 Tool and related B3 Programs includes CSBR at the University of Minnesota, The Weidt Group, LHB Inc., the Center for Energy and the Environment, and Herzog Wheeler Associates.

In 2009, Version 2.1 of the MSBG became available incorporating the SB 2030 Program as the new energy standard for State-funded projects. Version 2.1 also included other updates, expanded the B3 requirements to cover remodeling projects as well as new buildings, and launched an online project tracking tool. In 2013 Version 2.2. was released, including updates in Site and Water and performance management. In 2017, a new Version 3.0 was released with updated sections on project management, indoor environmental quality, and sustainable materials. Changes are forthcoming in site design, water, and indoor environmental quality.

During the first 8 years of aligning the energy portion of the MSBG with Architecture 2030, the approach has worked well and has been shown to be a cost effective (based on a 15 year payback) approach for GHG reductions. The development team is now looking at ways to modify the International Green Construction Code enable SB 2030 to be applied to all buildings. The code development is in the early stages, but shows promise and provides important details for a building code that integrates a pathway to net zero for new buildings and major renovations.

Structure of the Program

The Minnesota Sustainable Building Guidelines are also known as Buildings, Benchmarks or Beyond (B3 Guidelines), and yes, that is a Buzz Lightyear reference. They can be applied to the design of new buildings or renovations to meet sustainability goals for site, water, energy, indoor environmental quality, materials and waste. Guidelines are required on all projects that receive general obligation bond funding from Minnesota. The guidelines can also be used on a voluntary basis on any project. They are a pathway for many municipalities in Minnesota to comply with their green building standards. Cities such as St. Paul, St. Louis Park, and others have integrated the guidelines into their programs.

The MSBG incorporates the Sustainable Buildings 2030 (SB 2030) energy standard, as this has become the program's energy standard since 2009. After design and during the building occupancy, the project uses the B3 Benchmarking tool to track and compare actual energy use to design targets. In addition, projects during operations can use the B3 post occupancy evaluation (POE) to survey occupants on the indoor environmental quality of the building to ensure occupant satisfaction with indoor environmental quality.

The MSBG has the following five sections: performance management, site water, energy and atmosphere, indoor environmental quality, and materials and waste. Each section has a number of requirements that are tracked during five phases of a project life: pre-design, design, final design, closeout and occupancy. The occupancy tracking of actual performance related to projected performance is required by legislation to be submitted annually for 10 years to show actual compliance of a project. More information on all of the guidelines can be found at www.b3mn.org.

The performance management section of the guidelines has requirements for submissions during each phase of the project, including commissioning requirements. In addition, this section includes information and requirements for conducting Post Occupancy Evaluations in buildings that meet a certain threshold of occupants and available space types.

The objectives of the site and water section are to improve the ability of soil to maintain its structure against adverse impacts, restore and improve the hydrological cycle of water on the site to avoid adverse impacts on site and downstream, reduce consumption of potable water, improve biodiversity by introducing flora and fauna that will help contribute to the sustainability of the site over time, and reduce energy consumption and pollution related to site location and associated transportation requirements and to restore and improve outdoor environmental quality. Requirements range from typical green building guidelines, like stormwater management, light pollution reduction, and site and building water efficiency, to guidelines particular to the Minnesota program, like designing buildings to be safe for migratory birds.

The energy section of the guidelines incorporates SB 2030 and was inspired by the Architecture 2030 program created by Ed Mazria. The goals of the energy section of the guidelines are to achieve significant reductions in energy and energy usage in carbon emissions every five years, so that by 2025 buildings in the program have a 90% reduction over a typical building in 2003. This creates the potential for these buildings to achieve Net Zero by 2030 by incorporating increasing efficiency and on-site renewable energy generation. In addition, other objectives of the energy section are to provide building performance data for benchmarking activities, reduce plug loads, and process energy through energy smart operations practices, source at least 2% of the energy from on-site renewable sources, encourage the consideration of additional power supply from renewable energy, and insure that long-term operations meet or exceed the original design. Additional detail on SB 2030 will be covered later in the article.

The indoor environmental quality section of the guidelines is designed to have buildings provide exemplary indoor air quality and other interior environmental conditions to promote occupant health, well-being and productivity. Health is more than the absence of disease and well-being includes provision of physical comfort and psychological satisfaction with-in the physical environment. The provision of indoor environmental quality at levels that support productive human habitation both complements and supports the environmental and economic goals for sustainable building. There are eight requirements in the indoor environmental quality section and three recommended guidelines. The requirements range from typical green building program requirements for lower emitting materials, ventilation design, thermal comfort lighting and acoustics. More unique requirements like moisture control guidelines for exterior envelopes are also required. The recommended guidelines include elements like promoting health from physical activity that are starting to also emerge in programs like WELL and FitWell.

The materials and waste section of the guidelines hopes to reduce the embodied environmental impact and toxicity in building materials as well as reduce the contribution of construction and operations going into landfills. This section of the guidelines includes four requirements such as a whole building lifecycle assessment of the materials of construction, using environmentally preferable materials, waste reduction and management, and the impact of materials on human health. Materials and waste was updated in version 3.0 and released in 2017.

Architecture 2030

The original MSBG energy requirement was that buildings use 30% less energy than a code building. Starting in 2007, the state started seeking more aggressive requirements to integrate with the emerging climate change plans for the state. A review of the new Architecture 2030 program proposed very aggressive reductions starting at 50% and then increasing the reduction by 10% until buildings were targeting Net Zero in 2030. As a result, the Next Generation Energy Act expanded the state's sustainable building program to include development of green building guidelines mandatory for all major renovations receiving funding from the bond proceeds fund after January 1, 2009. The legislation defined major renovations as at least 10,000 square feet and included the replacement of the mechanical, ventilation, or cooling systems of the building or a section of the building. The energy efficiency requirement based on Architecture 2030 and adapted to Minnesota became Sustainable Building 2030 (SB 2030).

The legislature passed the SB 2030 standards to create quantitative measures of total building energy use and associated carbon dioxide emissions for different building types that allow for accurate determinations of a building's conformance. The energy-efficiency performance standards must be updated every three or five years to incorporate all cost-effective measures and reflect the reductions in carbon dioxide emissions per square foot resulting from actions taken by utilities to comply with the renewable energy standards. New buildings must meet the following energy consumption reductions relative to an average building in 2003:

- 60 percent in 2010
- 70 percent in 2015
- 80 percent in 2020
- 90 percent in 2025

Renovation projects have reduction targets that are 50% of the new building targets.

According to the legislation, the guidelines for both new buildings and major renovations must:

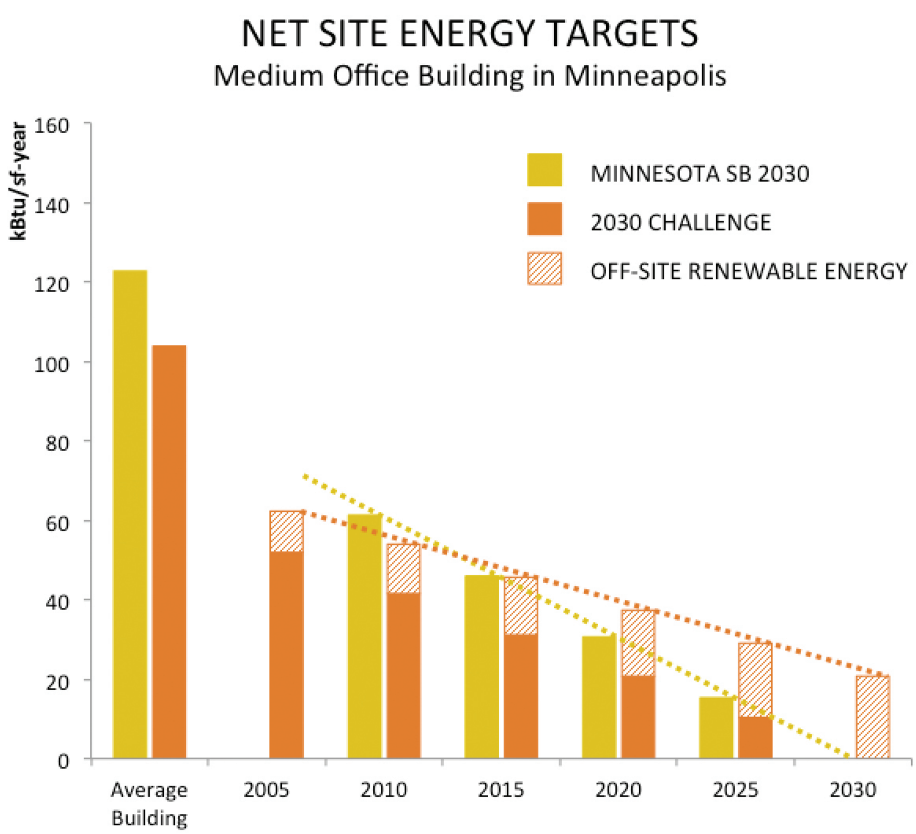
- Research, develop and demonstrate of new energy-efficiency technologies and techniques suitable for commercial, industrial, and institutional buildings.

- Analyze and evaluate practices in building design, construction, commissioning and operations that influence the energy use in the commercial, industrial, and institutional sectors.
- Analyze and evaluate the effectiveness and cost-effectiveness of Sustainable Building 2030 performance standards, conservation improvement programs, and building energy codes.
- Develop and deliver training programs for architects, engineers, commissioning agents, technicians, contractors, equipment suppliers, developers, and others in the building industries.
- Analyze and evaluate the effect of building operations on energy use.

Adaptation of 2030 to Minnesota

The Architecture 2030 program has galvanized interest in low energy design in the architecture and engineering industries. (Architecture 2030) The SB 2030 design team were tasked by the state of Minnesota in 2008 to revise the state green building guidelines to adapt Architecture 2030 to Sustainable Buildings 2030. It has been tailored to the needs of an enforceable guideline program for Minnesota buildings. ASHRAE and AIA have both adopted Architecture 2030, as well as hundreds of design firms. AIA has provided a reporting mechanism for design firms to report progress towards the goals. As all of these efforts have been voluntary, mandating the

FIGURE 1. Comparison of SB 2030 and Architecture 2030.



goals creates additional challenges that needed to be addressed. Architecture 2030 relies on EPA's Target Finder and the Commercial Building Energy Consumption Survey (CBECs) from 2003 to a national average baselines for different building types. Figure 1 compares the Net Site Energy Targets between Architecture 2030 and SB 2030.

Through benchmarking all public buildings in Minnesota, it was determined that only 20–25% of the building types in the public portfolio were eligible for Target Finder and Portfolio Manager scores. The team anticipated the mix of new construction projects would be similar to the existing building stock of public buildings. This meant that SB 2030 would either need to rely on national average Energy Use Intensity (EUI) goals that were not well adjusted for climate, fuel mix, hours of use, or occupancy, or on a percent reduction from the energy code. Many design attributes of a building are not regulated by the energy code and may be the same in the baseline as the design, which means that two design teams with the same owner requirements could have different EUI goals.

To be able to set an EUI goal for all public buildings, the program needed to create a target calculation method that could be extended to additional building types. In order to provide a target calculation method for all buildings that accounted for local weather, occupancy, and did not vary based on the design solution, the SB 2030 team created the SB 2030 Energy Standard Tool. The goal of the tool was to match the Target Finder goals for the 16 building types supported by Target Finder, but with a method that was scalable to additional building types and available online. During a research phase of the project, the team discovered that the CBECs and Target Finder numbers were substantially similar to the energy consumption of a baseline building defined by ASHRAE 90.1-1989. Additional modifications were applied to develop single baselines for each building program, including baseline geometry for each building type. By having a single standard method, design teams have a single clear performance goal, and would not be able to compare multiple baselines to choose the least stringent target.

By basing the SB 2030 methodology on a modified ASHRAE 90.1 1989, the team could create a single EUI goal for each building's design criteria that was fuel neutral, but otherwise independent of the design decisions made. This meant that two different design teams with the same owner requirements would be held to the same target EUI. With the energy code, each unique design is compared to a unique baseline building derived from the design. Minnesota wanted an EUI goal that took into account the different opportunities for district heating and cooling (i.e. district energy, electricity, or natural gas), but was otherwise independent of the design decisions. That way there was a common standard for all projects.

By creating an online tool that calculated the EUI goal based upon building type, occupancy, and other factors, energy reduction targets could be consistently applied. A modeling approach which was design-agnostic allows each new building type to be added with incrementally less effort. The first version of the tool launched with 19 building types tailored to the anticipated project types that would be receiving state funding. The latest version of the tool uses nearly 50 building space asset types that can be combined into 100 building types. It is adjusted for local climate within the state, building types, type of occupancies, number of floors, time of day usage, ventilation rates, plug loads, fuel type and other special characteristics of the building. Each building energy use is modeled to estimate an average 2003 building and reduced by the appropriate percentage. Table 1 further compares Architecture 2030 and SB 2030.

The SB 2030 program also created supporting program elements, including a case study database to track building performance, a training program for design professionals, and an energy efficient operations program.

TABLE 1. Comparison of Architecture 2030 and SB 2030.

	Architecture 2030	SB 2030
Baseline(s)	CBECs 2003 Target Finder % Reduction from code	SB 2030 Standard Tool
Occupancy adjustments	Only available for Target Finder and % reduction from code buildings	Consistent for all buildings
Design or Operations Standard	Design Standard, no operational verification	Design and operational standard tracked over first 10 years of operations
Offsite renewables	Up to 20%	Not currently allowed

Source: Architecture 2030 *Source:* B3mn.org

Updates to the Program

In 2014, the B3 design team began a program to update the guidelines. Other than the energy requirements that transitioned to SB 2030, some of the other requirements had not been substantially revised since their creation in the early 2000's. The process the team used to update the guidelines is:

- Survey and conduct focus groups with stakeholders to get their recommendations on updates and program scope.
- Review the latest updates of other green building programs and codes like LEED, BREEAM, IGCC, Green Globes, ASHRAE 189 and others to see how their requirements have evolved.
- Perform a literature review of research in guideline topic areas to understand the latest thinking on impacts, metrics and other aspects.
- Draft proposed guidelines and review with stakeholders to optimize the balance between increasing the difficulty and potential benefits of the program, while minimizing the impact to initial capital costs and design time.
- Develop compliance methods that ensure that performance requirements are being met with minimal design team effort needed to complete reporting requirements.

The following guideline sections are anticipated:

- In 2018 final draft guidelines on Site and Water and Indoor Environmental Quality will be released, which will go into effect in early 2019
- In 2019 updated Energy and Atmosphere guidelines will be released to go into effect in 2020 concurrent with increase in the SB 2030 energy goal to 80% reduction compared to the average building in 2003.

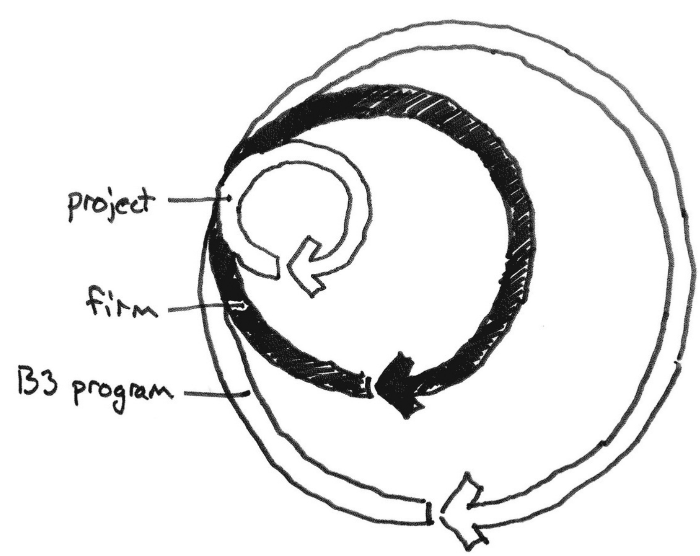
The Center for Sustainable Building Research was very fortunate to be selected by Minnesota to lead the B3 team that includes The Weidt Group, LHB, and the Center for

Energy and Environment. It is an interdisciplinary team made up of Minnesota-based expertise which has real advantages for the program. The local management creates connections to the building industry to get feedback on requirements, provide training to the industry and integrate the program with teaching and research at the University of Minnesota. The Center for Sustainable Building Research maintains and updates the guidelines, provides education programs, and works with project teams to clarify requirements and answer questions. The Weidt Group creates and maintains all of the software for setting energy targets and benchmarking of results. LHB manages the program with CSBR and provides feedback from their practice. The Center for Energy and the Environment (CEE) reviews designs for compliance with the energy requirements and collaborates with CSBR on the operations program which provides tools for buildings to fine tune their energy performance.

The team works very closely with agencies, design firms and builders in trainings for selected topics. In addition, CSBR holds focus groups with stakeholders to get feedback on the process and requirements to continually improve the program and identify future issues to research. These feedback loops are critical to keep the guidelines not only impactful, but also achievable within the tight constraints of state funded construction. Figure 2 shows a diagram of how the team views these multiple feedback loops. The program is seen as developing information streams within each project as metrics are evaluated and met; within each firm as multiple projects are completed under the program; and in the program overall as project information and performance is shared through the case study database.

At the University of Minnesota, CSBR is a research center within the College of Design that has programs in Architecture, Landscape Architecture, Interior Design and Graphic Design which all have had faculty and graduate student researchers contribute to the program. Student researchers have assisted with Post Occupancy Evaluations, analysis of the latest research in all areas of the guidelines, and compared the design intentions with actual results. The work provides great examples of the importance of performance feedback on practice.

FIGURE 2. Program intends several information feedback loops structured around guideline metrics and strategies.



Researchers at CSBR also teach in the Architecture program and use project examples as case studies and the guidelines as performance requirements in studios and other courses. This builds the performance driven design skills they need to be successful in practice. Many students from the program have gone on to become sustainable design leaders in firms and critical team members design successful buildings in the program.

Project Examples

The MSBG have been used for projects since 2004. Project types range from small camper cabins in state parks to the new US Bank Stadium for the Minnesota Vikings. The range of projects makes it a good proving ground for cost effective energy efficiency measures that could eventually become code and for the development of metrics that represent sustainable best practices that are achievable across a wide variety of project types. Hospitals are the only significant missing building types from the program. Three projects demonstrate some of the benefits of the program:

Higher Ground Saint Paul is the first phase of the redevelopment of a campus providing emergency and permanent supportive housing on the edge of downtown Saint Paul. Though constricted by a compact site with shallow bedrock that required ongoing problem-solving throughout the construction process, the project accommodates a sub-grade stormwater tank while including an appropriate volume of soil needed to support native plants and large-caliper trees.

The use of architectural precast panels for the exterior envelope combines desired exterior finishes with high insulation values and a durable interior finish that both meets programmatic

FIGURE 3. Rendering of Higher Ground Saint Paul, image credit: Cermak Rhoades Architects.

requirements to maximize material lifespan and minimize maintenance. During the design process, the project team explored and documented reduction in the embodied energy of the construction materials and made design decisions to limit the impact of glazing on birds through glazing layout and selection. Large windows and narrow floor plates enable daylight harvesting in major program spaces, UV-coated bird-safe glazing provides uninterrupted views to the surrounding context while meeting the bird-safety threshold specified by the program. A sustainably-harvested wood veneer ceiling in the lobbies and shelters provides warmth and character to the space.

The new area office for the Minnesota Department of Natural Resources in Glenwood, Minnesota is a 9,400 sf new building that was designed to achieve net-zero energy usage through an integrated set of passive and active design strategies.

The project team's decisions were informed by early energy modeling, which helped them find the optimal location and orientation to maximize solar gain while limiting glare, and revealed that triple pane windows and sealants to reduce air infiltration would be more impactful than adding more insulation.

The team also coordinated between the different building systems to improve energy efficiency. They removed all structural and electrical elements from the structural insulated panel

FIGURE 4. Higher Ground Saint Paul B3 Case Study project description.

HIGHER GROUND SAINT PAUL
New Construction | 2017

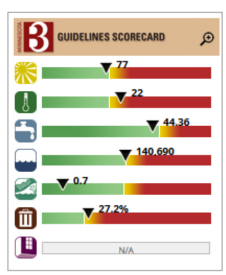
Higher Ground Saint Paul is the first phase of a campus providing emergency and permanent supportive housing on the edge of downtown Saint Paul. Though constricted by a compact site with shallow bedrock that required ongoing problem-solving throughout the construction process, the site accommodates a sub-grade stormwater tank in addition to the volume of soil needed to support native plants and large-caliper trees.

The use of architectural precast panels for the exterior envelope combines visually appealing exterior materials with high insulation values and a durable interior finish that meets programmatic requirements to maximize material lifespan and minimize maintenance. Large windows and narrow floor plates enable daylight harvesting in major program spaces, while UV-coated bird-safe glazing provides uninterrupted views to the surrounding context. A sustainably-harvested wood veneer ceiling in the lobbies and shelters provides warmth and character to the space.

This project is the winner of the 2017 Best of B3 Design Award.

PROJECT DETAILS

LOCATION	Saint Paul, MN
CONSTRUCTION TYPE	New Construction
BUILDING TYPE	Housing
ORGANIZATION	Grants to Local Governments
OWNER	Catholic Charities of St. Paul and Minneapolis
BUILDING AREA	112,750 sf
VEGETATED AREA	0.51 acres
NUMBER OF STORIES	5
YEAR OF OCCUPANCY	2017



DESIGN TEAM

ARCHITECT	Cermak Rhoades Architects
MECHANICAL ENGINEER	Emanuelson-Podas, Inc.
CIVIL ENGINEER	Pierce Pini + Associates
CONTRACTOR	Watson-Forsberg
COMMISSIONING AGENT	Emanuelson-Podas, Inc.
ENERGY MODELER	Emanuelson-Podas, Inc.
ELECTRICAL ENGINEER	Emanuelson-Podas, Inc.
LANDSCAPE ARCHITECT	Coen + Partners
BUILDING MANAGER	Catholic Charities of St. Paul and Minneapolis

FIGURE 5. Department of Natural Resources office in Glenwood, Minnesota. Photo credit Minnesota DNR

(SIP) exterior walls to maximize the thermal envelope, and coordinated the mechanical systems with the building structure to reduce the floor-to-floor height.

Concerned that shrinkage and moisture issues may affect the long-term performance of the SIP walls, the team worked closely with the contractor to ensure proper installation and sealing, with a vented air space over the SIP roof providing air movement and inhibiting moisture issues. The effort yielded a building that exceeded air infiltration expectations and has shown energy usage running below the predicted total.

Washburn Center for Children is a children's mental health center that provides healing therapeutic services. Indoor environmental quality was discussed at the initial stages of the new facility design, and was written into the Owner's Project Requirement document.

Due to the nature of the facility, acoustic privacy was the highest IEQ priority. An external acoustician was brought onto the design team to ensure that there was no noise transfer from space to space. Duct penetrations through adjacent therapy areas were eliminated and all internal walls were built up to deck. Throughout this process the guidelines provided a framework to develop high-performance indoor environmental quality.

Another project goal was to achieve high levels of daylight and lighting control. The design allows 96% of regularly occupied spaces to be adequately illuminated by daylight, and glazing on interior walls enables borrowed daylight to enter internal spaces. Additionally, 92% of regularly occupied spaces, including all therapeutic spaces, have views to the outside.

Results from a recent post-occupancy survey revealed that employees felt that both the overall facility and their primary workspace enhance their work performance and health. Employees were satisfied with nearly every surveyed aspect of their work environment, with daylighting, view conditions, appearance, and cleaning and maintenance being cited most often.

FIGURE 6. Department of Natural Resources office in Glenwood, Minnesota B3 Case Study project description.

DNR AREA OFFICE, GLENWOOD

New Construction | 2017

This 9,400 sf new building serves as an office and information center for visitors to the Minnewaska Lake area. The project's sustainability goals were to achieve a net zero energy building that utilizes natural daylighting and maximizes the use of geothermal and solar potential on the site.

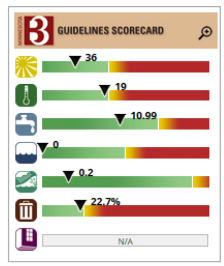
The project team's decisions were informed by early energy modeling, which helped them find the optimal location and orientation to maximize solar gain while limiting glare, and revealed that triple pane windows and sealants to reduce air infiltration would be more impactful than adding more insulation. The team also coordinated between the different building systems to improve energy efficiency. They removed all structural and electrical elements from the structural insulated panel (SIP) exterior walls to maximize the thermal envelope, and coordinated the mechanical systems with the building structure to reduce the floor-to-floor height.

Concerned that shrinkage and moisture issues may affect the long-term performance of the SIP walls, the team worked closely with the contractor to ensure proper installation and sealing, with a vented air space over the SIP roof providing air movement and inhibiting moisture issues. The effort yielded a building that exceeded air infiltration expectations, and has shown energy usage running below the predicted total.

This project is the winner of the 2017 Best of SB 2030 Award, and was a finalist for the 2017 Best of B3 Design Award.

PROJECT DETAILS

LOCATION	**Glenwood, MN**
CONSTRUCTION TYPE	**New Construction**
BUILDING TYPE	**Office**
ORGANIZATION	**Minnesota Department of Natural Resources**
OWNER	**MN DNR**
BUILDING AREA	**8,828 sf**
VEGETATED AREA	**4.97 acres**
NUMBER OF STORIES	**2**
YEAR OF OCCUPANCY	**2017**



DESIGN TEAM

ARCHITECT	**MN DNR**
MECHANICAL ENGINEER	**EEA**
STRUCTURAL ENGINEER	**Mattson Macdonald Young**
CIVIL ENGINEER	**MN DNR**
COMMISSIONING AGENT	**Hallberg Engineering**
ENERGY MODELER	**EEA**
ELECTRICAL ENGINEER	**EEA**
LANDSCAPE ARCHITECT	**MN DNR**
BUILDING MANAGER	**MN DNR**

FIGURE 7. Washburn Center for Children. Photo credit Washburn Center for Children and DLR group.

FIGURE 8. Washburn Center for Children B3 Case Study project description.

WASHBURN CENTER FOR CHILDREN

New Construction | 2014

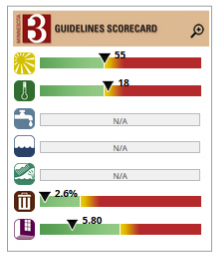
Washburn Center for Children is a children's mental health center that provides healing therapeutic services. Indoor environmental quality was discussed at the initial stages of the new facility design, and was written into the Owners Project Requirement document. Due to the nature of the facility, acoustic privacy was the highest IEQ priority. An external acoustician was brought onto the design team to ensure that there was no noise transfer from space to space. Duct penetrations through adjacent therapy areas were eliminated and all internal walls were built up to deck.

Another project goal was to achieve high levels of daylight and lighting control. The design allows 96% of regularly occupied spaces to be adequately illuminated by daylight, and glazing on interior walls enables borrowed daylight to enter internal spaces. Additionally, 92% of regularly occupied spaces, including all therapeutic spaces, have views to the outside. Results from a recent post-occupancy survey revealed that employees felt that both the overall facility and their primary workspace enhance their work performance and health. Employees were satisfied with nearly every surveyed aspect of their work environment, with daylighting, view conditions, appearance, and cleaning and maintenance rising to the top.

This project is the winner of the 2016 Best of B3 Indoor Environmental Quality - Workplace Award.

PROJECT DETAILS

LOCATION	**Minneapolis, MN**
CONSTRUCTION TYPE	**New Construction**
BUILDING TYPE	**Healthcare**
ORGANIZATION	**Minnesota Department of Administration**
OWNER	**Washburn Center for Children**
BUILDING AREA	**76,720 sf**
VEGETATED AREA	**0.82 acres**
NUMBER OF STORIES	**3**
YEAR OF OCCUPANCY	**2014**



DESIGN TEAM

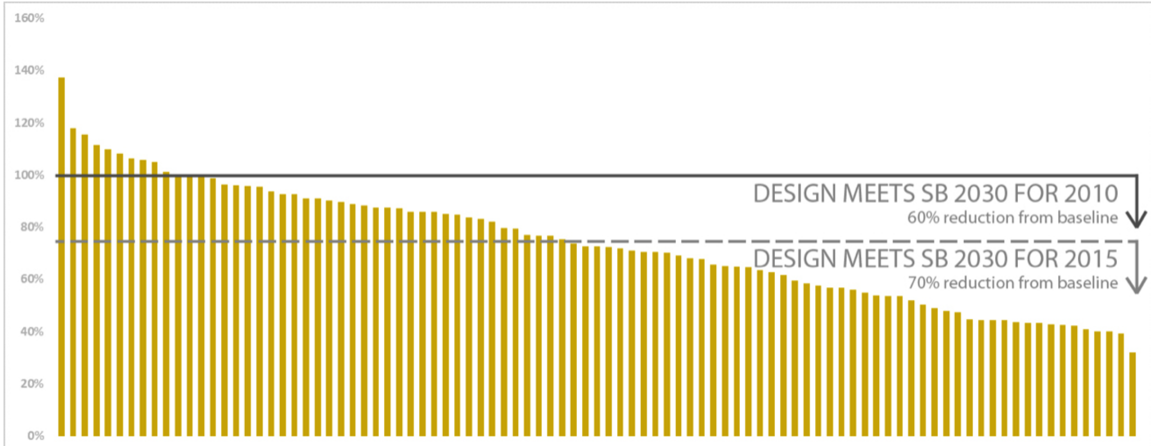
ARCHITECT	**LSE Architects, Inc./DLR Group**
MECHANICAL ENGINEER	**DLR Group**
STRUCTURAL ENGINEER	**Clark Engineering Corporation**
CIVIL ENGINEER	**Clark Engineering Corporation**
CONTRACTOR	**M.A. Mortenson Company**
COMMISSIONING AGENT	**Dunham Associates, Inc.**
ENERGY MODELER	**The Weidt Group**
ELECTRICAL ENGINEER	**DLR Group**
LANDSCAPE ARCHITECT	**Oslund and Assoc.**
BUILDING MANAGER	**Washburn Center for Children**

Results of Projects in Design and Operations

The SB 2030 program relies on a third-party review of information submitted from the design team during early design and the Construction Documents design team compares three main items: 1) the inputs to the Energy Standard Tool, which creates an estimate of a 2003 building given certain project characteristics such as schedule, space types, certain equipment and lighting loads, etc.; 2) the documentation of the energy simulation, which may be outputs from a number of types of allowed software; and the 3) construction documents, which verify that the building characteristics are identical to those modeled in the Energy Standard Tool and the design model. This approach allows flexibility for the design teams to work with the tools that they are the most comfortable with. This approach also builds capacity among energy modeling professionals; their outputs are validated for appropriate methods, completion of simulation and for accuracy in comparison to the construction documents.

In operations the SB 2030 project is required to verify that the SB 2030 Standard is being met annually. The energy consumption data is compiled through the B3 Benchmarking program (an online water and energy tracking and benchmarking tool) and data is automatically reported to the annual operations portion of the Tracking Tool. If the project has any changes to operation or other building characteristics, these can be reflected in changes to the SB 2030 Standard Tool, which will result in a change to the Target EUI and may trigger a brief review by

FIGURE 9. Designs of 93 projects to meet SB 2030.



the SB 2030 Review Team. The SB 2030 Standard is weather normalized to remove variations due to annual changes. If the project is not meeting the SB 2030 Standard in Operation, there are a set of steps to remediate the project including verification of equipment, validation of the standard and eventual participation in the Energy Efficient Operations program.

Project information is also accessible on the B3 Case Study Database. Annual energy and water consumption is displayed for projects, alongside the weather normalized SB 2030 standard to document that notes which projects are achieving compliance with the program in operation.

SB 2030 has been used by a wide variety of projects from the new stadium for the Minnesota Vikings to camper cabins in state parks for the Minnesota Department of Natural Resources. This is challenging for the program to create tools and strategies to achieve very aggressive energy efficiency targets across diverse building types, design teams, programs and occupancy. However, this diversity of building types is representative of the broader building industry.

From 2010 through the end of 2015, 93 projects had submitted design models indicating compliance with the 60% energy reduction goal.[3] (Figure 9) All but nine of the projects had design models that were better than the SB 2030 Energy Standard target. In fact, over half (53) of the projects beat the target by over 25% and would comply with a 70% reduction.[4] These projects are transitioning into operations and the program is tracking actual energy use. Forty-two projects have reported at least one year of actual operations data to compare to the SB 2030 and design model.

First year operations are averaging below the design predictions, but are increasing in the second and third year of operations. Tracking the actual operation data has uncovered a number of important questions and challenges:

- Inconsistent data between the design and the benchmarking software is entered for things like the area of building that could lead to inaccuracies in the EUI comparisons.

3. Projects beginning schematic design after January 1, 2015 are targeting a 70% reduction.
4. These results are much better than the AIA 2030 commitment nationally that has only 40% of the projects submitting energy models and only 14% achieving the goal. (USDOE)

- Program changes occur that modify the occupancy or operational character of the building and therefore change the energy use. These changes require rerunning the SB 2030 standard for the building.
- Operations data needs to be normalized for the weather.
- Renovation projects easily meet the energy goals that are half of new projects and may assume incorrectly that aggressive targets are hard to hit in renovations. The program may need to adjust the target and treat them like new projects in the future.

Impact of the Program to Date

154 buildings with an area of 13,246,802 sf have documented designs compliant with the SB 2030 Energy Standard and are predicted to save approximately 867 million kBtus/year. Ninety-four percent of all buildings enrolled in the SB 2030 program have designs that have reported meeting or exceeded the SB 2030 Energy Standard. These projects are expected to save the building owners $12.6 million per year and 107,000 tons of CO2e annually. Savings to-date from the 109 SB 2030 projects that are currently in operation are estimated at 1,700 million kBtu, 216,000 tons of avoided carbon at an aggregate cost savings of $25.7 million.

SB 2030 as a Stretch Code

One goal of the SB 2030 program since its beginning was to use the pilot program of state funded buildings to develop a pathway to Net Zero Energy for all buildings in Minnesota using the building code. In 2014, the Center for Climate Strategies, analyzed the cost and potential impact of transitioning the SB 2030 program into a code for residential, commercial and industrial buildings. (CSEO) A SB 2030 energy code would potentially save over 10 million metric tons of annual CO_2e savings in 2030 with about 58 million metric tons of CO2e savings between 2015 and 2030. The costs of implementing the program were determined to be less than the direct economic benefits in avoided energy and other costs.

Merging the SB 2030 program with the Minnesota Energy Code requires the development of specific code language, mechanisms and other support. Initial data on costs for achieving SB 2030 show that it is competitive with building less efficient buildings. The primary concern for the architecture, engineering and building construction industries is over-delivering high-performance buildings. Further analysis is needed on the cost of buildings and delivery to meet the standard at higher levels of the program, the availability of technology and designs to meet the performance requirements, training for the building industry and measurement, verification and enforcement for the code.

The team has looked at a number of options to integrate SB 2030 with the Minnesota Energy Code. One option is to modify the International Green Construction Code (IGCC). IGCC 2015 includes an outcomes based compliance path based upon the Zero Energy Performance Index zEPI (Eley et al) with EUI goals by climate zone and building type. Code compliance is determined by achieving in operations an EUI at least 50% below the reference EUI. This code compliance path is in many ways similar to the Architecture 2030 and SB 2030 EUI reduction requirements. The SB 2030 team proposed replacing Table 612.1 in the IGCC with the SB 2030 As-designed Tool. This would allow the EUI to reflect occupant density, unique plug loads, and schedules. An EUI metric that does not account for those measures would unfairly benefit lightly used buildings such as libraries with limited open hours, or office buildings with large private offices and few occupants.

FIGURE 10. Representative excerpt from the 2015 IGCC Table 612.1

TABLE 612.1
REFERENCE ANNUAL ENERGY USE INDEX (EUI_r)

CLIMATE ZONE	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A
Use and Occupancy[a]	Reference EUI_r skBtu/sf/yr									
	Business (B)									
Office	154	159	154	151	140	137	167	144	152	179
Bank	154	159	154	151	140	137	167	144	152	179
Medical office (non-diagnostic)	115	118	115	113	104	102	125	108	114	134

Another option would be to use the SB 2030 As Designed Tool directly as the stretch code. Development of this code path for Minnesota is still in the early stages, but the work to date on the SB 2030 buildings has provided important guidance on adjustments for the code to be successful.

Future Of The Minnesota Sustainable Building Guidelines

The Minnesota Sustainable Building Guidelines are gaining momentum in Minnesota:

- As more state funded projects are designed and completed, design teams are improving their skills and transferring the knowledge to private sector projects.
- More municipalities are incorporating the program into their green building incentive programs
- Private sector projects have started to use the program as an alternative to LEED.

The creation of the SB 2030 As-Designed Tool to adapt the broad goals of Architecture 2030 to a specific climate, building type and program is critical to setting a challenging but achievable target for buildings. This approach could be a model for climate change and energy codes outside of Minnesota. In addition, integration with operations and benchmarking programs to track the performance of completed designs and provide a feedback loop to policy makers and the building industry is essential. Designs of energy efficient buildings set the stage for potential energy savings in the future, but they must be informed and integrated with the demand, variability and complexity of future occupancy, and the range of expertise and skill level of management and operations.

As of 2015 all new construction in the SB 2030 program is targeting a 70% reduction from the baseline 2003 building. As this target increases to an 80% reduction in 2020 the next five years of research and program management are critical. The next generation of SB 2030 projects will need to incorporate integration of on-site renewable energy, improved efficiency and resource management and coordination with a renewable and smarter grid. These changes bring up several areas of future research:

- What is the limit of energy efficiency within the limits of a 15-year payback requirement of the program?

- How do you ensure that buildings that are designed to perform at an SB 2030 target achieve this in operation, with potentially changing operating parameters and operations staff?
- Can the cost of solar in Minnesota come down and the efficiency increase fast enough to provide the power required to achieve net zero?
- Once the limit of demand reduction is met, how do these distributed renewable energy systems integrate with the design and operations of existing institutions, and what opportunities exist with changes brought about by bringing these SB 2030 projects on-line?
- How should the requirement of all energy to be generated on-site be modified to allow for a variety of building sites and types? (Pless and Torcellini)
- Can all building types achieve net zero and is it the right goal for all projects? Should some projects be targeting net positive to make up for more challenging building types? (Griffith et al.)

Other areas of the Minnesota Sustainable Building Guidelines will continue to research ways the requirements can increase impact, connect more directly to socio-ecological factors and create the capacity within Minnesota for high-performance buildings to meet sustainability goals for site, water, energy, indoor environment, materials and waste.

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