Architecture 2030 Goals Right Now: Minnesota's SB 2030 Tool to Set Goals and Track Performance for All Building Types

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ABSTRACT

In 2002, Architecture 2030, an independent non-profit organization, issued The 2030 Challenge to address climate change by establishing voluntary energy reduction goals for new buildings over time. In this program, the absolute energy consumption limit is a percentage reduction of the baseline established using Environmental Protection Agency's (EPA) Target Finder for applicable building types or using the Department of Energy's (DOE)/Energy Information Administration's (EIA) 2003 Commercial Buildings Energy Consumption Survey (CBECS) of U.S. national averages of site energy use for building types not found in EPA's Target Finder.

In 2008, the Minnesota Legislature adopted the Sustainable Building 2030 (SB 2030) energy conservation program, which mirrors the energy reduction goals of Architecture 2030, making it a mandatory program for all new or major renovation projects funded by State issued bonds. In addition to the mandatory requirements for State bond financing, the legislation encourages utility sponsored commercial new construction programs (funded through rate-payer dollars) to develop voluntary new construction programs to achieve these goals.

In order to make the SB 2030 program comprehensive, consistent, accurate and easy to use for all participants, an online, simulation-based Energy Use Intensity (EUI) goal setting tool was developed. The SB 2030 tool derives the absolute energy performance consumption goal as an annual EUI kBtu/SF that new and renovated building projects are required to achieve. This new tool allows users to derive a custom energy performance consumption goal based on the buildings' specific space type distribution, operational schedules, location, and unregulated energy code building attributes. The tool also provides a tracking system that allows design teams to archive and evolve the baseline characteristics for each design phase and each phase of building operations.

This paper will show how the goals of the Architecture 2030 program were operationalized in the SB 2030 tool, describe the methodology for the tool's development, identify how the Tool is used, and hypothesize about how the Minnesota SB 2030 program might also serve as a pilot for other regional and national programs.

BACKGROUND

Architecture 2030

In 2002, Architecture 2030, an independent non-profit organization, issued The 2030 Challenge to the global architecture and building community to slow down and then reverse the growth rate of greenhouse gas (GHG) emissions. The following targets were identified:

- All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 60% below the regional (or national) average EUI for that building type.
- At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 60% of the regional (or national) average for that building type.
- The fossil fuel reduction standard for all new buildings and major renovations shall be increased to 70% in 2015, 80% in 2020, 90% in 2025 and Carbon-neutral in 2030 (using no fossil fuel GHG-emitting energy to operate).

The Architecture 2030 Challenge indentifies two technical procedures to establish the regional (or national) average EUI for a building type, for which the percent savings reduction goals are calculated:

- Using the EPA's Target Finder, representing 15 different building types, or
- Using the 2003 CBECS data to calculate a national average site energy use for an additional 21 building types, when a building type is not defined within the Target Finder program.

Sustainable Buildings 2030

In 2008, the Minnesota Legislature passed a bill (M.S. Statute, Chapter 216B.241) requiring the state to develop a regionalized program based on the energy reduction schedule of the Architecture 2030 program. The program, called SB 2030, is mandatory for building projects receiving State bond funds. In addition, it encourages the voluntary incorporation of these standards in utility new construction conservation programs. The program also enables ongoing monitoring of energy use in buildings that have adopted the performance standards.

To operationalize the goals of the Architecture 2030 program to meet the requirements of the legislation, these key aspects of the program's framework were developed:

- A workflow tracking website of enrolled projects to record the energy consumption target, the as-designed EUI during various phases in the design process, and actual EUI during on-going occupancy.
- A region-specific method for calculating the target EUI based on program attributes specific to each building project, utilizing a web-based simulation tool.
- Verification of the as-designed energy model to the target standard's inputs.
- Ongoing tracking of actual energy consumption and comparison to the as-operated target.
- The end result of which is a building labeling system that shows the building project's design EUI and subsequent actual EUIs as compared to the target, on a continuum scale of net-zero to the "average building."

Project designers enter specific building attributes that include operational schedules, non-regulated energy code requirements, and location. A web service then conducts an energy simulation based on the user's entry and calculates the required target EUI. The system allows building attributes to be updated and modified as changes in design or operation occur. A performance label is created at the end of design and at the end of each year the building is in operation. The program has been operational since November of 2010 and is currently tracking the performance of over 30 enrolled projects. The preliminary results from buildings enrolled in the design phase show, on average, that building projects are on track to meet or exceed the performance goals, balanced by few building projects that are not.

Methodology: Developing a Method for Region Specific Architecture 2030 Target Goals

The first phase of development established criteria for creating a region specific EUI target method, which was then used to evaluate the features of various benchmarking methods/systems currently in use. The second phase quantitatively compared Benchmark EUI's for different energy code compliance versions used in the benchmarking system evaluated to the prescribed method used by the Architecture 2030 Challenge (Target Finder 50^{th} percentile ranking and CBEC National Averages). The Phase 2 goal was to identify an energy code compliance version that would emulate the energy EUI calculated using the Target Finder 50^{th} percentile ranking.

Phase 1

Criteria established by the SB 2030 working group identified a system that is: easy to use, provides accurate regional results, uses a consistent analysis method for all buildings, and can comprehensively be applied to all types of buildings. A benchmarking system was also needed to account for variations in a number of building attributes unique to a project's program to ensure projects with different programmatic requirements of space type floor area (i.e. an office building with 35% circulation floor area versus a building with 15% circulation floor area) would derive different target values.

Four energy benchmarking type methods were selected for evaluation:

1. **DOE Energy Benchmarks** are simulation models created by the DOE and its three national labs which use EnergyPlus. These models are organized by sixteen commercial building types and sixteen climate zone locations within the U.S. The building types include office, hospital, retail, etc., stated to represent 70% of the commercial buildings in the U.S. These models have been created to meet ASHRAE 90.1-2004 requirements for building energy efficiency.
2. **Target Finder** is a building energy benchmarking system developed by the EPA's ENERGY STAR® program. The system was developed to help architects, engineers, 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 DOE's/EIA's CBECS data for its analysis and can analyze 15 different building types. [1]

3. **The 2030 Challenge Targets** is an approach developed by Architecture 2030 to extend the number of building types found in Target Finder for use in the Architecture 2030 Challenge. This data utilizes U.S. National Averages developed by the DOE's EIA. This list of buildings uses the 2003 CBECS database to calculate a national average energy use by building type. The Architecture 2030 website provides 21 additional building types with one national average site EUI (in 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.
4. **Minnesota B3 Benchmarking Program** established in 2004, (Greden 2008, ACEEE Paper) is a building energy benchmarking system that has collected building characteristics, actual energy consumption, and expenditures on over 6,400 public buildings in Minnesota including those of public schools, cities, counties, and state agencies. Buildings are benchmarked using DOE-2 energy simulation models set to the current Minnesota energy code using over 50 typical building/space usage type descriptions. Space type allocation, hours of use, % heated and % cooled, and location are key parameters entered into the program to identify the operational benchmark EUI and compared to the actual operational EUI. The large number of space usage types provides for a comprehensive range of buildings that can be benchmarked in this building type portfolio. [2]

The features for each of the four benchmarking methods were compared to the criteria developed as well as baseline EUI comparisons for a select set of building types for

[1] The CBECS is a survey, historically conducted every four years collecting information on a sample of the stock of U.S. commercial buildings, their energy-related building characteristics, and their energy consumption. In 2011, EIA reported that the 2007 CBECS had not yielded valid statistical estimates of building counts, energy characteristics, consumption, and expenditures. Because the data did not meet EIA standards for quality, credible energy information, neither data tables nor a public use file will be released. In the interim, As reported in the EIA Press Release, "Immediate Reductions in EIA's Energy Data and Analysis Programs Necessitated by FY 2011 Funding Cut" (http://www.eia.gov/pressroom/releases/press362.cfm), work on the 2011 CBECS was suspended throughout 2011, but has been resumed.

[2] The B3 Energy Benchmarking program launched in 2004 and has collected both simulation-based models and actual consumption data on more than 6.400 buildings in Minnesota and 1,200 buildings in Iowa. The scope of buildings served includes all public building sectors: state; cities; counties; and public school districts. The B3 Benchmarking program collects information on the design, operation and energy performance of existing public buildings so that the State and its political subdivisions can direct energy conservation improvements where they are most needed, most cost-effective, and where the return on investment for a capital expenditure is greatest. Information on design and operations is used to create engineering baseline models for the specific space uses in their locations.

The data collection process relies on a web-based tool through which building representatives of public buildings enter data, including building characteristics and utility bills. The users can see how their buildings compare to individualized benchmarks. B3 advances a unique approach to determine the benchmarks: a parametric model based on space-type simulations; and prescriptive requirements in the current Minnesota energy code. By comparing a building to its unique benchmark, the opportunity for energy savings can be determined.

each method and energy code version. Figure 1 identifies a summary matrix of features as compared to the criteria established.

Figure 1. SB 2030 Criteria Compared to Four Benchmarking Methods

Benchmark Method Criteria	1. DOE Benchmark	2. Architecture 2030 EPA Target Finder	3. 2030 Challenge Targets: U.S. National Averages	4. 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, for the available building types
Consistent	YES Baseline is energy code based and will not change over time	NO Underlying baseline will change when CBECS survey is updated	NO Underlying baseline will change when CBECS survey is updated	YES Baseline is energy code based and will not change over time
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.	21 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	Stand alone models designed for research, not programmatic edits	Yes, simple variations	No	Yes, simple variations
Space type floor area percentage	No	No	No	No
Space type attributes: plug load, ventilation rate, temperature set points, etc.	No	No	No	No
Floor area of the building	Yes	Yes	Yes	Yes
Climate Zones	16 Climate Zones for the entire U.S	All U.S. climate zones	No	5 Climate Zones only in MN
Mixed-use building types	No	Yes (within the available building types)	No	Yes

Results of the feature comparison shows that all methods evaluated did not entirely meet the criteria established for developing the SB 2030 program. The DOE simulations and B3 are energy-simulation based systems. The Target Finder and Architecture 2030 Challenge are based on CBECS and, by definition, suffer the limitations of a statistically representative sample. Using SB 2030, we have the ability to come up with a target finder for any different building that isn't represented in CBECS using a modeling system.

Phase 2

Next, baseline EUI results were compared for a variety of building types using the different benchmark methods surveyed and different energy code compliance parameters. The goal of this quantitative evaluation was to find out how different energy code model EUIs compared to the 50th percentile Target Finder results, to determine which rule-based energy code could best emulate the Target Finder results. The Target Finder 50^{th} percentile ranking is used as the "average building" baseline from which the 2030 Challenge energy reductions over time are calculated. Using a code baseline approach would allow any building to calculate a target goal based on its specific operation and programmatic requirements and by setting envelope, lighting, and HVAC attributes to the energy code values. This concept was supported in 2008 by Architecture 2030's release of a white paper entitled "Meeting the 2030 Challenge Through Building Codes." Table A, entitled "2030 Challenge Interim Code Equivalents," identified 8 energy codes and their equivalent percentage savings reduction to comply with the target EUI goals established by the 2030 Challenge.

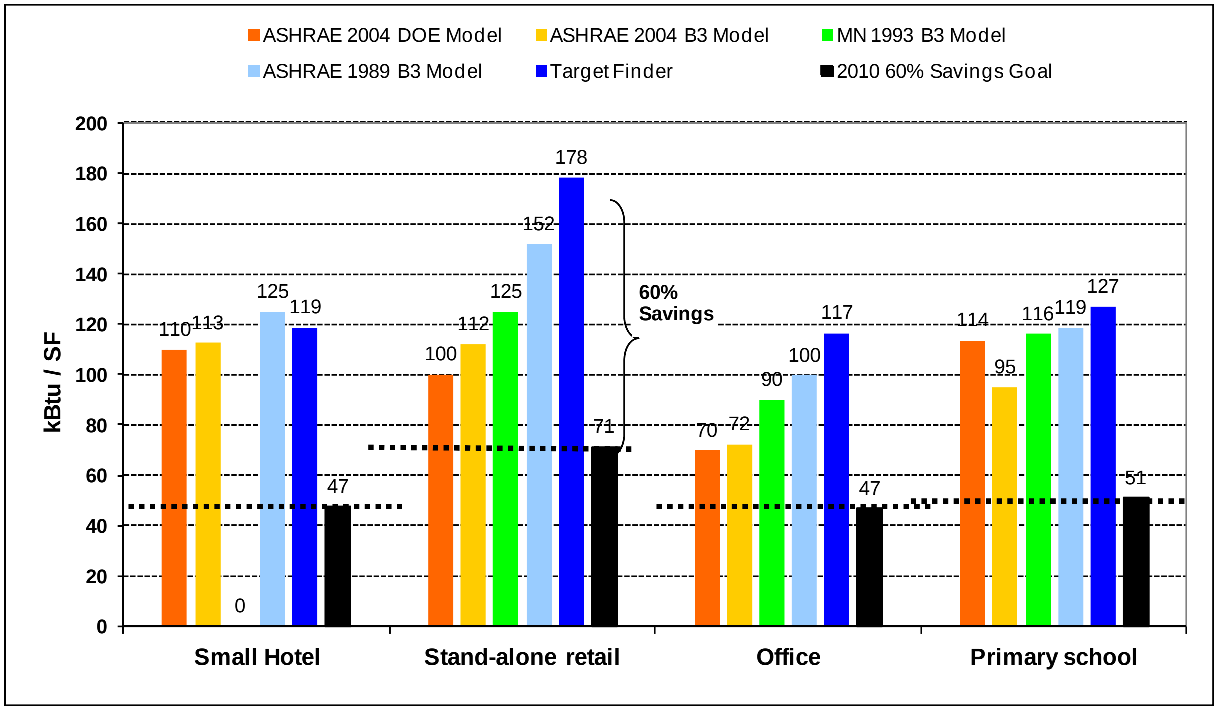
Two types of technical comparisons were conducted for selected building types:

1. Comparison of the 50th percentile ranking EUI for Target Finder and different energy code models using the B3 Benchmarking and DOE Benchmark models to determine which energy code level is similar to the EUI performance found in Target Finder.

2. Comparison of EUIs using the 2030 Challenge Targets: U.S. National Averages results with the B3 Benchmarking Model EUIs.

A sample of EUI comparison of 4 of the 12 building types evaluated found in Target Finder, B3, and the DOE models are shown in Figure 2, comparing different energy codes versions with Target Finder and energy code baselines listed, for ASHRAE 2004 DOE and B3 models, ASHRAE 1989 B3 models, MN 1993 B3 Models, Target Finder EUI results and the Architecture Challenge 60% target based on the Target Finder results.

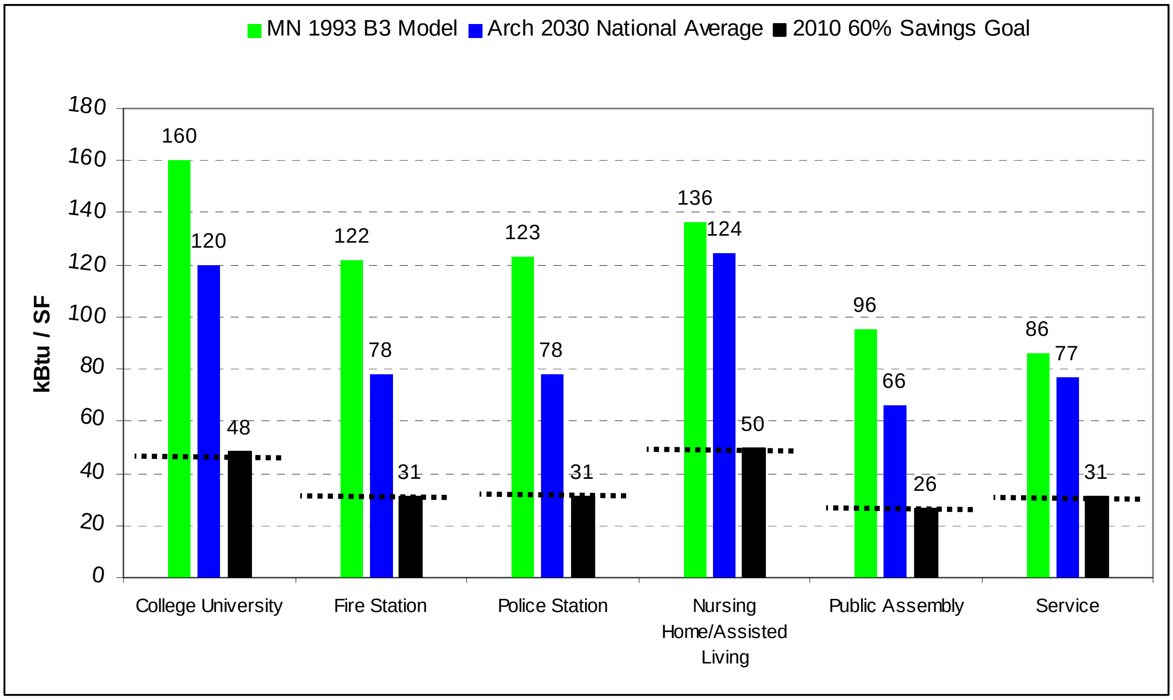
Figure 2. EUI Comparison of Four Building Types



The Weidt Group: Collaboration Analysis Research PPT presentation from June 15, 2009 to the SB 2030 Advisory Group Meeting

Figure 3 compares the MN 1993 Model results with the Architecture 2030 national average indices. The percentage changes are significant and vary from -30% for College University Classrooms to +71% for Service buildings. Nursing home/Assisted Living is within 2%. The National average data does not appear to match up well with the MN 1993 B3 Model data and may be partially due to the fact Minnesota climate is not representative of average weather conditions in the United States.

Figure 3. EUI Comparison of MN 1993 Model Results with Architecture 2030 National Average Indices



The Weidt Group: Collaboration Analysis Research PowerPoint presentation from June 15, 2009 to the SB 2030 Advisory Group Meeting

Based on the analytical comparisons described above and the data gleaned in our research, comparison of different energy codes and benchmarking methods identified a variation in results.

The EPA Target Finder statistical sample of existing buildings generally has higher EUIs for most building types shown than the ASHRAE 90.1 1989 national energy code. This is consistent given there are many older buildings within the population that likely increase the existing building consumption average as compared to buildings built in the last 20 years. The major drawback of the EPA Target Finder method is that it is limited to only 15 different building types and does not consider important programmatic variables such as the space type floor area percentage, plug load requirements, ventilation requirements, and temperature set-point requirements. All of these building programmatic requirements impact the amount of energy a building will consume.

The B3 Benchmarking system provides many more building types but also does not consider variations in programmatic variables within a building type as identified above in Target Finder.

The 2030 Challenge U.S. National Averages EUI is a “one number fits all” approach per building type that cannot be modified based on programmatic or operational attributes and is simply not appropriate in climates zones that do not represent the national climate average, such as the State of Minnesota.

Of all the energy models compared, the ASHRAE 90.1 1989 code best emulates the Target Finder 50th Percentile EUI results.

Based on results compared, it was decided to establish the SB 2030 regional EUI targets using a building energy simulation model system that would allow custom input of building operation and programmatic attributes, and use the ASHRAE 90.1 1989 energy code to establish all physical design assets for envelope parameters, lighting power density and HVAC efficiencies and control sequences. The simulation EUI results from this input are then increased by 15 percent to account for the average variation found between the ASHRAE 90.1 1989 code models as compared to Target Finder 50th percentile EUI results studied at the time. The 2030 Challenge percent energy reduction per time period is then applied to the baseline EUI described above. We plan to revisit this calculation method to determine if some building types will require a change in the standard 15 percent increase based on the review of actual projects using the SB 2030 program.

This process will:

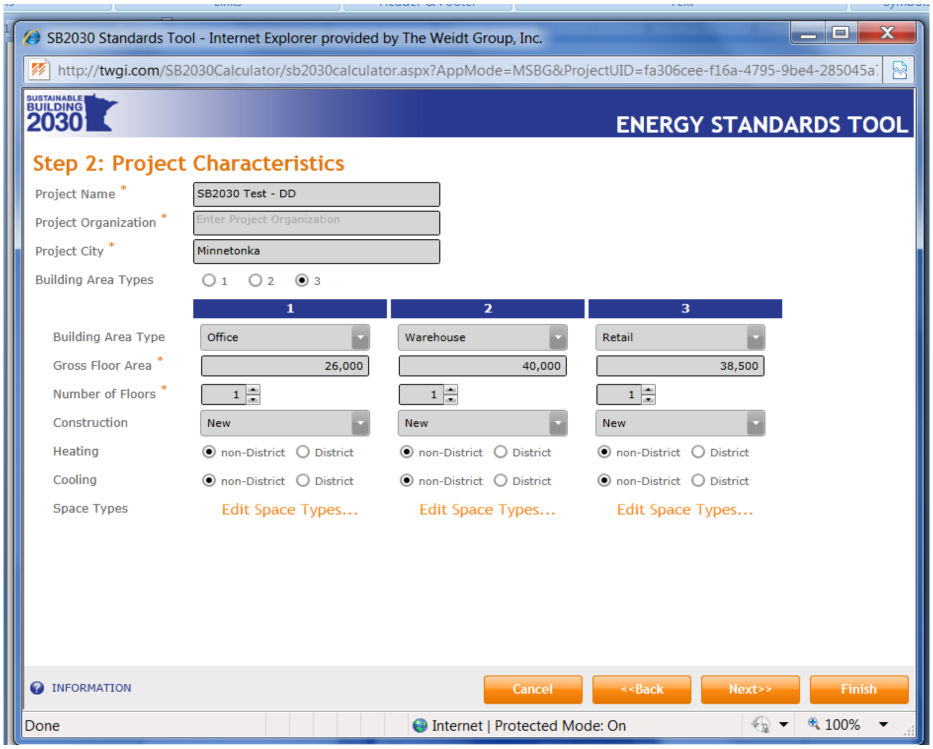
- Provide an analysis framework for creating a comprehensive list of building types that represents the range of current building types being constructed.
- Not require data collection of existing building energy use for ALL building types that need to be added to create a comprehensive list. The code is a rule-based system that can be modeled consistently and accurately for all building types.
- Allow projects to use specific operational and programmatic requirements to develop a custom EUI target goal and be capable of changing the target goal when changes occur to the buildings' operation and space use activities in the future.

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 achieve the results.

The SB 2030 Application and Process

Project design professionals select and enter specific building characteristics based on their project's building program, operational characteristics, non-regulated energy code requirements, and building location. A Web-based service then conducts a DOE2 energy simulation based on the user's entry and calculates the required SB 2030 Standard EUI the owner and design team is required to achieve for their project.

Figure 4. Screen Capture of Project Characteristics

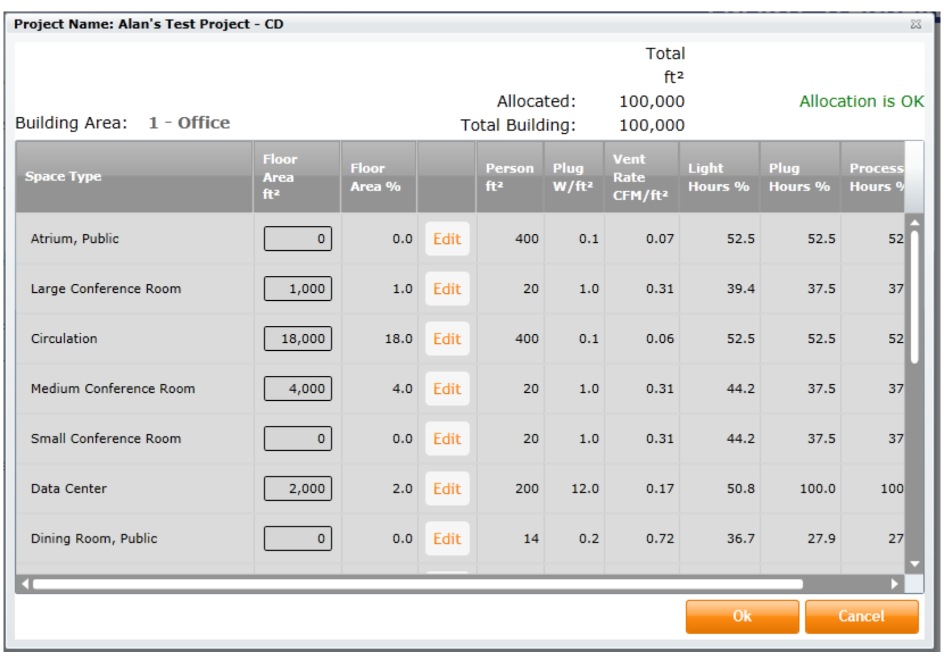


SB2030 Website

Figure 4: With minimum inputs for Project Name, Organization, Building type, Gross Floor Area and Number of Floors, both the Energy Standard (kBtu/SF/Yr) and the Carbon Footprint (CO2e/SF/Yr) are generated in the tracking tool.

Multi-use buildings may be generated by specifying the number and type associated with each project.

Figure 5. Screen Capture of Inputs



SB2030 Website

Figure 5: Default space types are generated based on the building type chosen. These may be customized to the building design. Numerous options are available within the Energy Standard Tool that allows significant customization within each of the available building types. Operational characteristics and unregulated energy end-uses for each space type may be customized depending on the information available at each design phase.

The SB 2030 EUI Standard is calculated using the minimum requirements for envelope, lighting, and HVAC system parameters identified by the ASHRAE Standard 90.1 1989 energy codes to establish the baseline EUI that the Architecture 2030 percent savings goals are applied to. From 2010 to 2015, the Architecture 2030 savings goal indentifies a 60% reduction in site energy EUI from the baseline for new construction and additions. Because renovation projects have constraints on the scope of building systems that can be altered and improved, they have a 30% reduction in site energy EUI applied to the baseline.

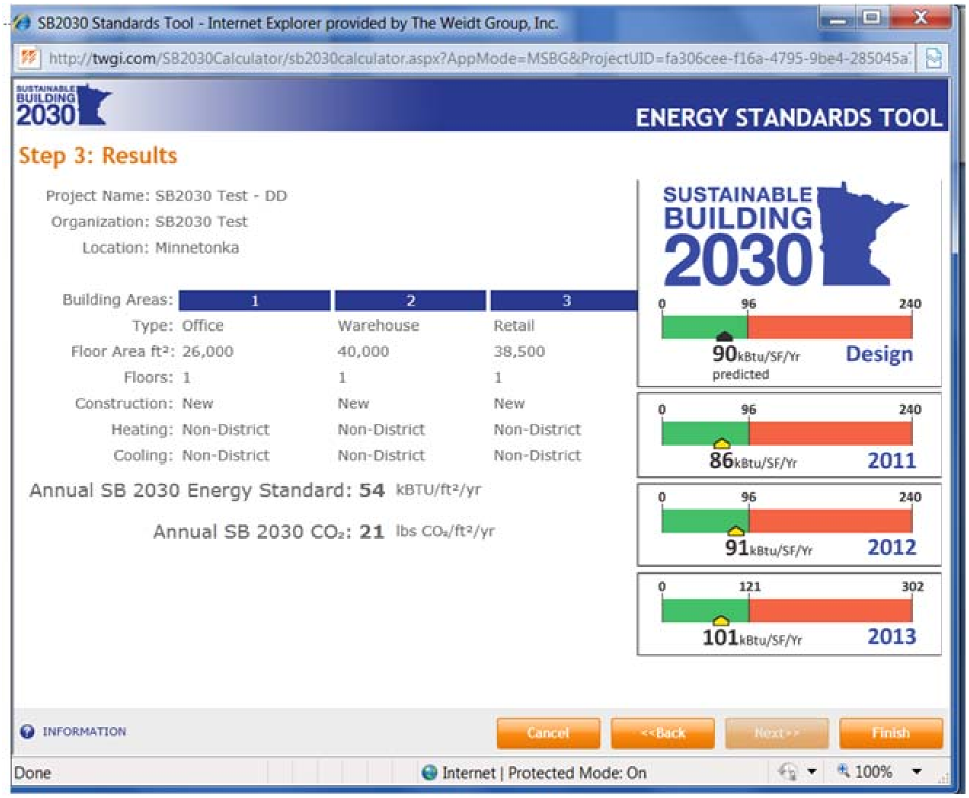
Building characteristics that are established inside the program include:

- Dynamic building type geometry, equally oriented on all facades based on the floor area for different space types and the number of floors entered
- Envelope, lighting, and HVAC parameters identified by the ASHRAE Standard 90.1 1989 Energy Code
- Window area set to a maximum of 40% window-to-wall area ratio
- Fan static pressure and pump head based on building floor area

Building characteristics that are established by building owner requirements include:

- Space types and floor area
- Annual operating schedules for lights, people, process and plug loads
- Ventilation requirements by space type
- Temperature set-points
- Plug loads
- Process loads
- People density

Figure 6. Screen Capture of Results Page and Label



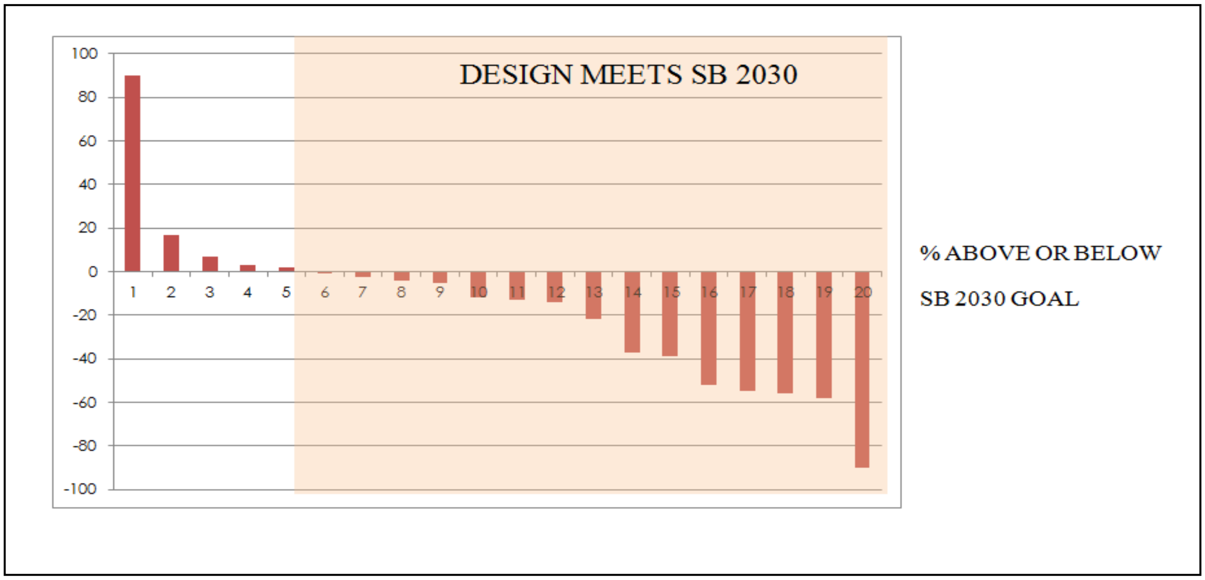
SB2030 Website

Figure 6: The SB2030 tool allows the user to derive an energy performance consumption goal and provides a dynamic baseline that evolves with the development of the building design and into building operation. Compliance with SB2030 will be transparent as ratings will be posted on a public website starting in 2012 as projects come online. There will be an operational assistance method to help owners bring non-compliant buildings into compliance. The label that is generated as a result of both the design inputs and the operational performance provides both a design and operational rating that is being used by 30 enrolled projects, 20 of which have sufficient data to analyze as of the writing of this paper.

SB 2030 Case Study Metrics

In a study on projects that have completed the SB2030 program, the mean EUI of 20 projects, weighted by area, were calculated. The projects types include office buildings, recreational centers, laboratories, student centers and multifamily housing.

Figure 7. Performance Metrics of 20 Projects in the SB 2030 Program



SB2030 Case Study Metrics

Figure 6: The design models show that 15 of the 20 projects meet or exceed the Minnesota SB 2030 Energy Standard. The remaining 10 projects of the current total of 30 are too recently enrolled to have data for analysis.

Project number 1 in Figure 6 wasn't aware that they were enrolled, as their building was not financed via state bond. They agreed to participate on a voluntary basis once it became clear they had been enrolled and project team has worked with them to try to get their building into compliance but awareness occurred too late to inform design choices; hence the outlier.

CONCLUSIONS

The benchmarking research was undertaken to inform the framework of the SB 2030 program and to assess what tools and resources were viable to enable a mandatory program. The comparative analysis was completed to ascertain how responsive each resource was to variables that were likely to be encountered in real-world examples of projects. The SB2030 tool was built to resolve the issues identified in both research exercises.

The drawback of Target Finder and 2030 Challenge Targets: U.S. National Averages is they are both based on CBECS and thus suffer the statistical sampling limitations of not comprehensively measuring all buildings that could be built. Modeling and energy simulation allow for any number of buildings to be quickly and inexpensively created and analyzed. Modeling and simulation provide a means to scientifically test that which has not yet been built and to forecast what would happen if different variables were modified. It also provides mechanisms to measure that which is difficult or impossible to measure in the physical world. Energy modeling was used in the SB 2030 project because it had the potential to overcome the limitation that statistical samples suffer by calculating EUI goals based on custom building attributes like:

- Space type and floor area percentage
- Operational characteristics of the building
- Geographic location (climate accuracy)
- Mixed-use building types

The SB2030 Application was created to resolve those issues by: 1) using an energy simulation-based model to create program specific energy consumption targets for new building projects; 2) providing a static yardstick for measuring the 2030 Challenge percentage reductions over time; and 3) warehousing data and energy simulations so that as inputs change in the design process, targets change as well, and all the data is captured for analysis.

Although the application was developed in order to deliver consistent 2030 target standards, as part of a program designed to meet Minnesota's 2030 Challenge commitments, the research undertaken and the application itself have a number of potential implications. It is feasible that using the methodology established in Minnesota and applying it to other states and regions could both serve those regions and begin to populate a tool with more diverse climate data and design choices. The tool could be customized to create region-specific pilot projects, collect data for analysis, or to inform and empower the current pilots that are moving forward—for example in Massachusetts and California. It would be interesting to see how the national average numbers that did not work for Minnesota fare in the northeast and on the west coast.

As adoption of rating, labeling and disclosure ordinances continues to grow, the need for energy simulation-based modeling tools that can produce asset ratings, conduct ongoing performance ratings, and benchmark existing buildings also grows.

The Minnesota pilot is a first step in researching the gap that needed to be filled, designing and deploying a version-one tool that could provide consistency in a mandatory process, and implementing the policy and warehousing outputs for purposes of compliance and enforcement. The Authors hope this paper begins a dialogue to expand the use of simulation-based models and tools to meet the goals of the Architecture 2030 program and that this research builds upon the knowledge in the industry.

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