CalBEM Whitepaper - Building Energy Modeling Roles

CalBEM's Working Group 2 works to identify and address gaps in building energy modeling (BEM) education in California. During discussions, the group found that "building energy modeling" means different things to different people. We also found, of course, that in order to identify education priorities, we needed a common understanding of what we were talking about. Those discussions were the motivation for this whitepaper, which tries to do two things:

1. Define common uses for BEM
2. Identify of typical roles of people who perform BEM

The hope is that with a common understanding of the wide range of valuable uses for BEM, and with an appreciation for the diverse mix of professionals who perform BEM, that the building industry can more effectively take advantage of the value that BEM offers. Another hope is that a common understanding will help guide planning for investments in education and software development and may influence policy development.

Definition of BEM

For this discussion, BEM is the use of a physics-based software program to simulate whole-building energy use, most often looking at the building's performance over a full year using hourly weather data to represent typical environmental conditions. The building energy model used in the simulation contains information about features of the building such as the architectural design, envelope constructions, lighting, occupants, HVAC systems, water heating systems and other energy-using systems. Models sometimes also include renewable energy systems. Many models are developed to represent a design of a building yet to be built, others may represent an existing building that is being evaluated for savings opportunities.

Common uses for BEM in new building design

Potential uses for BEM are many, and this framework attempts to represent only the most common applications for new construction projects; other valuable uses for BEM listed at the end of this document. When considering BEM used for new buildings there are two main, and often overlapping, roles:

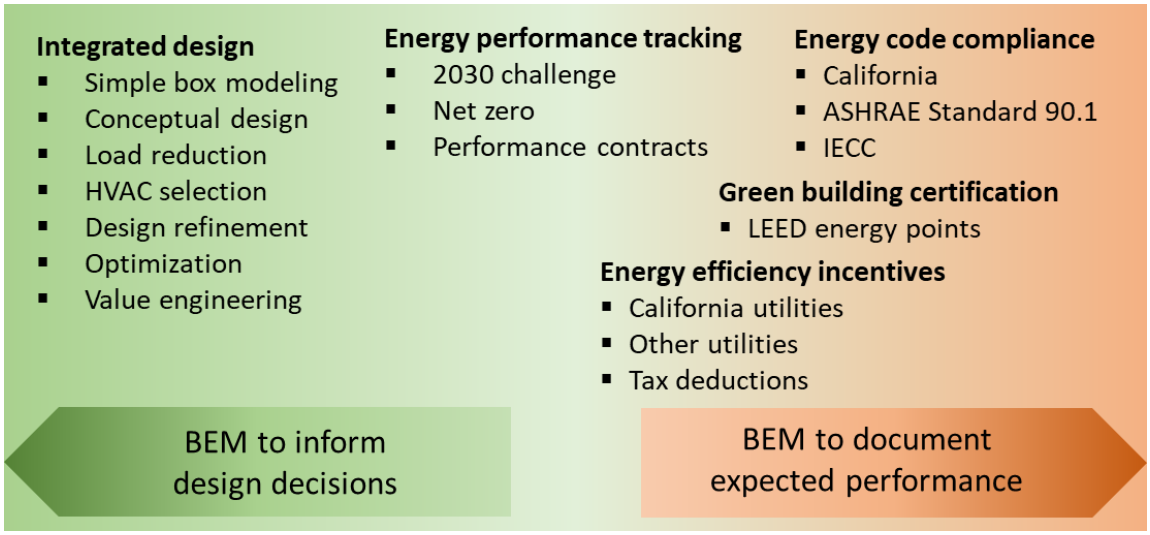
1. Inform design decisions
2. Document expected performance (e.g. energy code compliance)

When BEM is used for a new building project, it often serves a combination of those two roles. For example, BEM used for energy code compliance is performed to assess design performance for the purpose of compliance documentation. Sometimes these compliance models are developed strictly to document performance of an existing design, but other times these they are used to compare design options and inform design decisions. BEM used primarily to inform

design decisions, such as modeling of conceptual design alternatives, is typically performed to compare the relative performance of those alternatives or to assess cost effectiveness of potential efficiency strategies, but those models might also be used to document expected performance compared to goals such as energy use intensity targets set by the 2030 Challenge[1]. Five common uses for BEM in new building design are highlighted in this whitepaper, and the following figure subjectively locates each of these five uses in a space ranging between the roles "BEM to inform design decisions" and "BEM to document expected performance". Those five BEM uses are listed here and described in more detail below.

1. Integrated design analysis
2. Energy performance tracking
3. Energy code compliance documentation
4. Green building certification energy performance documentation
5. Energy efficiency incentive documentation

Common BEM uses in new building design



Integrated Design Analysis

BEM for integrated design analysis may be performed at any point during design process but is often most valuable during early design stages. BEM is especially useful for comparing the performance of design options and captures the integrated impact of variations in features such as the building form, envelope component performance, HVAC systems, lighting and other building systems. The BEM software chosen for integrated design analysis may be different than software used for energy code compliance, depending on the needs of the project. ASHRAE Standard 209 defines seven types of BEM analysis that may be useful during design, and they are listed in the figure above as examples.

[1] Architecture 2030. https://architecture2030.org/2030_challenges/2030-challenge/

Design Performance Tracking
BEM is sometimes used to evaluate the performance of a building design in terms of metrics such as energy cost, site energy consumption and carbon emissions. The 2030 Challenge, established by the American Institute of Architects, sets an energy use intensity target (kBtu/ft^2-yr) that depends on the location and type of building occupancy[2]. Some projects target net zero energy or carbon emissions, and BEM is used to estimate the energy consumption that will need to be offset with renewable energy generation. BEM may be used at several points during the design process to verify that the design is on track to meet its performance targets.

Energy Code Compliance
The most common use of BEM is probably energy code compliance. The California Energy Code and most other energy codes provide a performance compliance path based on the use of BEM, where the performance of the proposed design is compared to a standard design. In California, this analysis is performed using software that is certified by the California Energy Commission (CEC), and the calculations follow rules established by the CEC. There are two other energy codes that are used in much of the rest of the country, ASHRAE Standard 90.1 and the International Energy Conservation Code, which use different sets of calculation rules.

Green Building Certification
LEED is one example of a green building certification system for which BEM is used to calculate points for energy performance, and LEED certification is also a very common use of BEM. LEED calculation rules are based on ASHRAE Standard 90.1. There are options to use results from California energy code compliance calculations for LEED credit, though consultants sometimes perform Standard 90.1 calculations for LEED even when the project is in California if the building has features not supported by California software.

Energy Efficiency Incentives
California utilities and many other utilities offer incentives for energy efficient new buildings which are based on BEM calculations, and the calculation rules vary in different regions. Another potential incentive is Federal tax deductions based on savings calculated using BEM.

People who perform BEM for new buildings

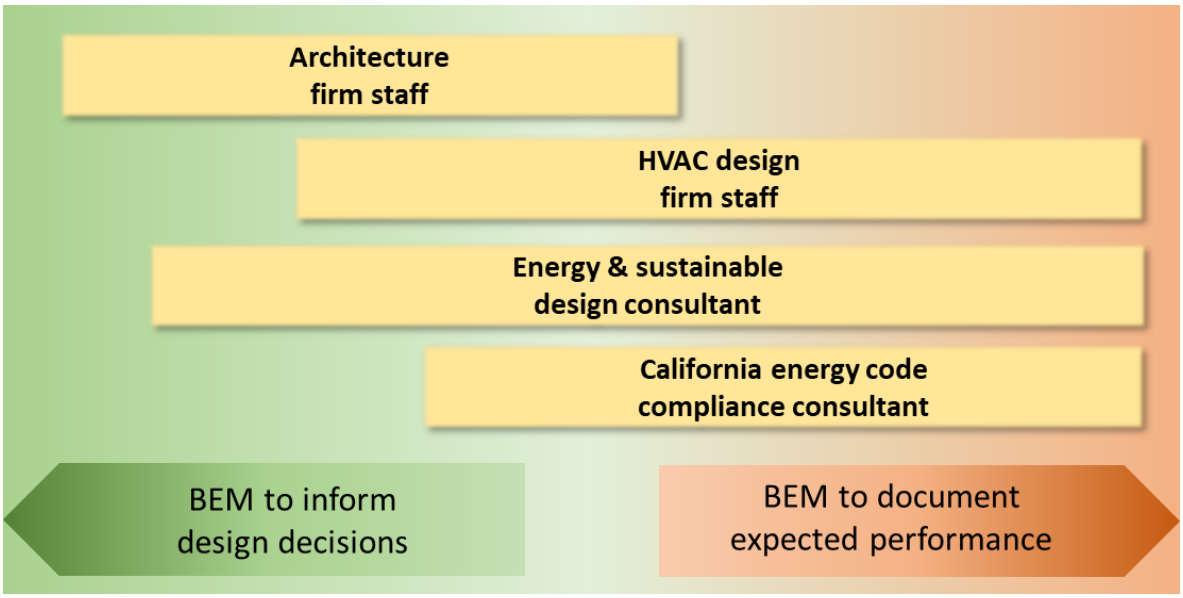
Energy modelers who work on new building projects in California commonly fit into one the following categories, though it is important to note that these descriptions of typical roles are rough generalizations and not all-inclusive.

1. **California energy code compliance consultants**. Primarily produce California *Energy Code compliance documentation*. May also perform *green building certification* and *energy efficiency incentive* calculations.

[2] 2030 Challenge. https://architecture2030.org/2030_challenges/2030-challenge/

2. **Energy and sustainable design consultants**. May also produce *energy code compliance documentation*, but typically performing *integrated design* analysis, *green building certification* and *energy efficiency incentive* calculations. May also work on projects outside of California and perform ASHRAE Standard 90.1 or International Energy Conservation Code (IECC) energy code compliance.
3. **HVAC design firm staff**. Plays an in-house role similar to energy and sustainable design consultants.
4. **Architecture firm staff**. Most likely to be performing *integrated design* analysis and *design performance tracking*, less often performing *energy code compliance* calculations.

Typical categories of energy modelers working on new building projects



Other uses and users of BEM

The descriptions above focus on using BEM to support new building projects. As noted earlier, there are many other valuable applications of BEM:

- Existing building retrofit design
- Building commissioning and recommissioning
- Measurement and verification
- Urban planning
- District energy systems design and optimization
- Electricity grid research and development
- Optimized building operation and model predictive control
- Primary research related to any of these topics
- Policy development, such as energy codes, often with prototype models
- Energy efficiency incentive program development and evaluation
- Education

- Product development

There are also additional categories of BEM users, such as the following.

- Staff of consulting firms focusing on existing building retrofits
- Energy performance contracting firm (ESCO) staff
- Policy development consultants
- Researchers
- BEM software developers
- Educators and students

References

These references provide additional useful perspectives on the roles of BEM.

- AIA. *Architects Guide to Building Performance, Integrating Performance Simulation into the Design Process*. https://www.aia.org/resources/6157114-architects-guide-to-building-performance
    - Provides a good summary of BEM uses in building design and a good summary of the requirements of ASHRAE Standard 209-2018

- ASHRAE. *Standard 209-2018, Energy Simulation Aided Design for New Buildings Except Low-Rise Residential Buildings*. https://www.techstreet.com/standards/ashrae-209-2018?product_id=2010483
    - Defines minimum standards for use of BEM in building design. Requires at least two "modeling cycles" selected from seven defined modeling cycles. Also requires several activities such as climate analysis, design charrette, benchmarking and setting of energy performance goals.

- Rocky Mountain Institute. *Building Energy Modeling for Owners and Managers, A Guide to Specifying and Securing Services*, August 2013. https://rmi.org/insight/building-energy-modeling-for-owners-and-managers-a-guide-to-specifying-and-securing-services.
    - Describes the purpose for BEM as either comparison, compliance or prediction:
        - Integrated design assistance - comparison
        - EEM evaluation - comparison
        - Building asset rating - comparison
        - LEED certification - compliance
        - Code compliance - compliance
        - Commissioning/retrocommissioning - prediction
        - Operations check - prediction
        - Measurement and verification - prediction
        - Performance rating - prediction
        - Outcome-based performance - prediction

        - Integrated project delivery – prediction

- USDOE. *Innovations in Building Energy Modeling Research and Development Opportunities Report for Emerging Technologies*. November 2020. https://www.nrel.gov/docs/fy21osti/77835.pdf
    - Describes two categories of BEM use cases:
        - Specific-building use cases
            - Performance documentation. Code and green certification
            - Integrated design
            - Integrated operation. Model predictive control
            - Measurement and verification
        - Prototypical building use cases
            - Prescriptive codes and guidelines
            - Program and product design