Recommendations for BUILDING ENERGY MODELING EDUCATION IN CALIFORNIA

Prepared for SOUTHERN CALIFORNIA EDISON®

Prepared by sei

November 8, 2021

Table of Contents

Acknowledgements

This report was prepared with support from Southern California Edison (SCE), California Building Energy Modeling (CalBEM), and 2050 Partners. The following individuals provided their insight:

- Elise Wall and Alex Chase from 2050 Partners, Dave Intner from SCE, the members of CalBEM Working Group 2, and subject matter experts: Brian Selby, Erik Kolderup, Dimitri Contoyannis, Scott Blunk, and Ted Tiffany.
- Interviewees: Abhijeet Pande, Ben Johnson, Brendon Levitt, Frank Schwamborn, Gina Rodda, Glen Folland, Jayati Chhabra, Jill Marver, Kristen Cetin, Ladan Ghobad, Liam Buckley, Luke Morton, Matt Biesterveld, Mike Wilson, Mohammad Heidarinejad, Neil Bulger, Pablo La Roche, Roy Eads, Ryan McEvoy, Scott Schuetter, Stacey White, Stefano Schiavon, Steffen Peuker, Steve Kromer, Supriya Goel, and other interviewees who generously dedicated their time. We also thank Rhys Davis for his insights.
- Working Group 2 Reviewers: Gina Rodda, Jon McHugh, and Krishnan Gowri.
- SEI staff: Emily Courtney, Liz Fitzpatrick, Hannah Maryanski, Fernando Gil, Katrina Hagedorn, Meera Parthasarathy, and Lauren Azzola.

Executive Summary

Building Energy Modeling (BEM) is an essential tool for developing new energy-efficient buildings and renovating existing buildings in California and is growing increasingly important as the state moves to significantly reduce greenhouse gas emissions. A trained BEM workforce is needed to meet the demand for energy modeling. To support high-quality building energy modeling in California, this report aims to:

- Identify educational resources to increase awareness and the effective use of BEM in developing new buildings and improving the performance of existing buildings.
- Develop recommendations for creating and improving education programs on BEM, and facilitating resource sharing in California.
- Identify avenues for reaching new audiences to promote current and new BEM educational programs and resources.
- Assess the current educational landscape and identify areas to build upon existing efforts.

Given the range of BEM use cases, such as informing architectural design, predicting energy performance, modeling for energy code compliance and national green building standards (e.g., ENERGY STAR® and Home Energy Rating System [HERS] ratings), Heating, Ventilation, and Air Conditioning (HVAC) system sizing, and Mechanical, Electrical, Plumbing (MEP) engineering

applications, BEM professionals come from a variety of educational backgrounds and expertise areas.

Within the BEM workforce, on-the-job learners, including those who seek out training programs to start their BEM careers, and students enrolled in college and university programs, are the largest target audiences for BEM education and training. These two types of educational pathways are not mutually exclusive; on-the-job learning is common, even for BEM professionals who received exposure as students. Energy model users, such as architects and contractors, are an additional audience.

Existing BEM education and training offerings can be divided into four categories:

- **Industry resources**, varying significantly in format and depth and ranging from formal training courses (e.g., Energy Code Ace) to informal forums.
- **College and university programs** at the community college, undergraduate, and graduate levels in architecture/environmental design, engineering, HVAC, and related departments.
- **Practitioner certification programs**, which give professionals a baseline standard of BEM education and training that can be used to prove their competence to employers and grow their understanding of industry codes and standards.
- **Teacher training resources**, providing teachers with support in teaching BEM.

BEM uses diverse Knowledge, Skills, and Abilities (KSAs), and workers benefit from gaining exposure to them, both before joining the workforce and as incumbent workers. Interviewees identified the top KSAs for BEM professionals as building science, codes and standards, thermodynamics, design and construction knowledge, communication, software, HVAC principles, technical savviness, understanding how outside factors affect modeling results, and physics. The widespread nature of BEM use cases also means a single set of KSAs is not necessarily appropriate for all professionals who produce or consume energy models. This report identifies areas to grow KSAs among various types of BEM professionals and the broader BEM workforce.

Based on these findings, the following recommendations are given:

1. Inspire pursuit of BEM careers and participation in BEM educational programming by both engaging in outreach that raises awareness of BEM as a green career among high school and undergraduate students, as well as defining the BEM field, its potential career paths, and the personal and environmental benefits of these careers.
2. Advocate for and support targeted BEM education in fields that come into contact with BEM, including promoting curriculum ideating and sharing, institutionalizing BEM education, and integrating relevant BEM knowledge into current curricula.
3. Promote professional credentials among energy modelers.

These recommendations are provided to guide CalBEM Working Group 2 in further research, advocacy, and development related to BEM education and training in California.

Introduction

BEM is essential for energy code compliance, energy-efficient net-zero and high-performance building design, and improving existing building efficiency in California. A trained BEM workforce is needed to meet the growing demand for high-quality energy modeling. To support high-quality BEM in California, this report aims to:

- Identify educational resources to increase awareness and effective BEM use in designing new buildings and improving existing building performance.
- Develop recommendations for creating and improving BEM education programs and facilitating resource sharing in California.
- Identify avenues for reaching new audiences to promote current and new BEM educational programs and resources.
- Assess the current educational landscape and identify areas to build upon existing efforts.

Methodology

Overview

Primary research guided this report, and includes interviews with faculty and industry representatives, feedback sessions and interviews with Subject-Matter Experts (SMEs), and input from International Building Performance Simulation Association USA (IBPSA-USA), CalBEM Working Group 2, SCE, California Association of Building Energy Consultants (CABEC), and 2050 Partners representatives. Secondary research consisted of reviewing industry reports, syllabi, and other web-based data found in the bibliography at the end of the report.

Data Collection and Analysis

BEM is a broad field spanning across disciplines. It is used by architects, HVAC professionals, Mechanical, Electrical, and Plumbing (MEP) engineers, and energy consultants, among others. Given the interdisciplinary nature and significant span of BEM, it was crucial to represent a broad range of trades, industries, and programs in this assessment. This research used the following multifaceted approach:

- Conducting a series of 27 interviews with experts ranging across disciplines, including (but not limited to) architects, engineers, industry representatives, and faculty.
- Seeking input from SMEs and CalBEM Working Group 2.
- Performing additional secondary research.

Expert Interviews

Interviews were typically 45 minutes long. For each interview, a series of questions tailored to the interviewee's expertise were selected from a predetermined list, and follow-up questions were asked about promising topics. For a list of sample questions, please see Appendix 1.

Interviewees were selected based on referrals and independent research on academic program faculty. Of the 27 experts, 22 were in industry and 9 were faculty, with some representing both categories. Their professional BEM uses spanned residential and non-residential, design, code compliance, software, research, and green building certification consulting, among others.

Since the interviews were distinct based on the interviewees' diverse professional points of view, experts often spoke on different topics, but did not necessarily contradict or agree with each other. As such, conclusions in this report have consensus from at least three interviewees, and points where insights may have less-supported findings are notated. Where applicable, dissenting viewpoints are also noted. The findings do not necessarily reflect the opinion of every interviewee, and should not be interpreted as such.

SMEs and CalBEM Working Group 2

SMEs provided interviews and project feedback at the beginning, middle, and end of the project timeline. They have collective experience in industry, university/institutional instruction, training for existing professionals, residential BEM, and commercial BEM.

CalBEM Working Group 2 meeting attendees received an interim findings presentation in July 2021, and provided verbal feedback to researchers in small discussion groups. Three representatives from Working Group 2 served as reviewers. The findings do not necessarily reflect the opinion of every SME or Working Group 2 member, and should not be interpreted as such.

Secondary Research

While this report is driven by primary research, secondary web-based research was also conducted on BEM educational and training resources and publications. Most research was directed by referrals from interviewees, SMEs, Working Group 2 members, and existing research provided by CalBEM.

To create the list of existing college and university educational programs (found in Appendix 2) referrals were gathered from interviewees and SMEs. To capture programs unknown to interviewees and SMEs, web searches were conducted for BEM degree programs at four-year institutions and community colleges listed on the Building Efficiency for a Sustainable Tomorrow (BEST) Center's college and program directory.[1]

[1] "College & Program Directory," BEST Center: Building Efficiency for a Sustainable Tomorrow.

Analysis & Findings

Educational Pathways and Labor Market Data

Career Pathways Engaging in Energy Modeling

BEM can be used for multiple purposes, including building-level and broader scope analyses. Building-level uses include modeling for architectural and HVAC design/operation,[2] third-party building certification, code compliance, incentives and rebates, Measurement and Verification (M&V), and existing building improvements. Broader uses include policy development, standards development, and software development. Because energy modeling can be conducted for different projects and a variety of purposes, there is a range of career pathways engaged in energy modeling (listed in Appendix 6).

Engineers, specifically mechanical engineers, are dominant in the BEM workforce. A LinkedIn Recruiter search of members with "building energy modeling" in their profiles returned 3,600+ U.S. workers and 545 California workers. A mechanical engineering field of study topped both national and California lists, with three times as many results as the next-highest field of study (architecture). In the California context, architecture and environmental studies backgrounds returned near-equal results.[3]

There were some limitations to this approach: LinkedIn does not include the entire workforce; workers who use BEM in their professions may not have entered "building energy modeling" in their profiles; and individuals with little building energy modeling experience may have been included as a result of search parameters. However, at a high level, these results suggest the California BEM workforce has a large number of workers who are educated in mechanical engineering, architecture, and environmental studies. Conversations with interviewees and experts indicate degrees in these fields are not required to practice BEM, and certifications such as the Certified Energy Analyst (CEA) and HERS program also provide entry points.

At the building level, energy models can be used to examine alternative designs and energy-efficiency measures as a way to observe and compare energy usage. In the non-residential space, SMEs suggest this type of work is often conducted by engineers or non-licensed individuals who completed specialized training such as Energy Code Ace courses. HVAC design and performance analysis is a common application of BEM in this context, and mechanical engineers are particularly well-suited for HVAC design work due to their technical training in overlapping concepts such as thermodynamics and heat transfer.

[2] "About Building Energy Modeling," U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.
[3] "Building Energy Modelers on LinkedIn," 2021, Alex Chase, 2050 Partners.

Modeling to meet codes and standards is another significant use of BEM in both the residential and non-residential contexts. Modelers may be contracted to provide energy code compliance analyses, conduct BEM for incentives and rebates, or to meet third-party certification standards (e.g., ENERGY STAR or Leadership in Energy and Environmental Design [LEED]). In this context, interviewees indicated BEM professionals can (but are not always required to) have advanced engineering or architecture degrees. For example, the CEA prepares modelers for work in this arena.

While less common than other use cases discussed above, BEM may be used for M&V modeling to compare actual building performance to expected performance.

In addition to new building design, BEM is used to make energy-efficiency improvements to existing buildings. An SME noted BEM practitioners who work on existing buildings combine BEM with energy auditing to assess potential savings, and as such, may need expertise in calibrating models to the building's true performance.

Some of the interviewed researchers and public-sector energy modelers focus on policy and code/standards development. While municipal and state governments and utilities drive this type of energy modeling, they may employ the expertise of consulting firms and research institutions to help develop energy policy and codes/standards. Some interviewees indicated energy modeling in support of research and policy development requires an advanced understanding of BEM.

Energy modelers may also work on the software itself. Interviewees from the software side identified job tasks such as debugging software, researching code, making software improvements, and investigating software features. However, software-focused modelers may also engage in public-facing tasks, such as providing training or resources on the energy modeling software, and assisting clients with questions.

While those who pursue education and training in BEM may find comfort in their skills being applicable to a range of job opportunities, the career pipeline is ultimately inconsistent. "Building Energy Modeler" is not a universal job title, likely due to the range of BEM applications. For example, Liam Buckley, an industry representative and faculty member, provided a list of job titles students enrolled in his course could pursue, as shown in Figure 1.

Figure 1: Career Titles in Building Energy Modeling

Other BEM job titles SMEs identified include (but are not limited to): Energy Analyst, Energy Consultant, Utility Engineering Consultant, Incentive Program Manager, City/Local Government Sustainability Staff or Project Manager, and Certified Energy Manager. As one interviewee expressed, the range of BEM careers can make job seeking more difficult for emerging professionals, and non-standardized titles make it harder for job seekers to determine the roles for which they are qualified.

Energy modeling team size and scope depends on the firm – it could be a dedicated team, a single employee, or outside consultants. BEM practitioners may spend all or only part of their time directly working on BEM projects. Despite differences in roles and backgrounds, any individual who does energy modeling in their role may be considered an energy modeler.

Labor Market Data

Labor market data specifically for Building Energy Modelers are not available, but information about the architecture and engineering labor markets can inform an assessment of the BEM labor market. This approach, however, does not account for the labor market for BEM practitioners with other backgrounds and roles discussed previously in this report. In California, the labor markets for architects[4] and mechanical engineers are expected to grow from 2018 to 2028, as shown in table 1. This data excludes the impact of the COVID-19 pandemic and response efforts.[5]

[4] For the labor market sections of this report, "architect" refers to the "architect, not landscape or naval" title.
[5] "Employment Projections," 2021, CA.gov (Employment Development Department).

Table 1: California Labor Market Projections, 2018 - 2028[6,7]

Profession	Current Employment (2018)	Expected Employment (2028)	Percent Change (2018 - 2028)	Number Change (2018 - 2028)
Architect[8]	18,400	20,000	8.7%	1,600
Mechanical Engineer	29,700	31,900	7.4%	2,200

Interviewees shared mixed perspectives on the market demand for BEM professionals, with several stating there is demand in California. In fact, two industry representatives currently hiring for BEM roles at sustainability consulting firms are struggling to find strong candidates. Three interviewees remarked that BEM professionals with several (three to five) years of on-the-job experience are especially difficult to find.

However, other interviewees expressed opposing viewpoints. Two out-of-state interviewees and two in California felt there was not enough demand for BEM from the marketplace and developers. They provided reasons such as a lack of understanding about sustainability and the inefficiencies of performing BEM on small projects.

While it is not a requirement for entry into the BEM field, BEM-related education can help place students in open jobs. Faculty interviewees in engineering said students who took their classes were able to find jobs that use their BEM skills, and in some cases, interviewees emphasized the rapid pace at which trainees were hired. These faculty teach at California colleges in the following departments: graduate combined architecture and engineering, mechanical engineering with HVAC, and graduate engineering in energy systems. Outside of California, where architectural engineering programs are more common, one faculty member shared a similar position as the California faculty members in that the hireability of his architectural engineering students is very high. One important consideration raised by another out-of-state faculty member and an SME is that employers need to know which universities are preparing students for BEM, otherwise strong fits may be left out of the recruiting process.

Labor Market Demographics

At the time of this report, demographic BEM labor market data were not readily available. Some limited insights can be drawn from U.S engineering and architecture labor market data, with the same caveats as stated previously. BEM's relatively small labor market means the data may be biased by more dominant industries, particularly mechanical engineering, where the majority of

[6] "Detailed Guide for Architects Except Landscape or Naval in California," 2021, CA.gov (Employment Development Department).
[7] "Detailed Guide for Mechanical Engineers," 2021, CA.gov (Employment Development Department).
[8] National data shows a steep decline in the architect labor market between 2018 and 2019. This context is relevant for interpreting California data that extends only through 2018.

the workforce is in either the "motor vehicles and motor vehicle equipment manufacturing" or "machinery manufacturing, n.e.c. (not elsewhere classified) or not specified" industry, with only 19.5% in the"architecture, engineering, and related services" industry as of 2019.[9]

In both fields, men were disproportionately represented in the U.S. labor force in 2019, as men constituted 72.6% of the architecture workforce and 91.3% of the mechanical engineering workforce.[10] In 2019, White, non-Hispanic architects and mechanical engineers made up almost 75% of the workforce and were disproportionately represented compared to their share of the overall U.S. workforce (61.3%).[11]

These figures indicate that White people and men dominate the mechanical engineering and architecture workforce and are disproportionately represented. Anecdotal evidence from interviewees suggests further exploration into the demographics of BEM professionals may produce different results. No interviewee felt confident assessing the entire California workforce, but they were willing to share their own perceptions of their circle. One BEM instructor noted his courses were male dominated, yet his energy code compliance courses tended to draw more women. Other interviewees thought the BEM field was becoming more diverse. A California faculty member noted women made up 50% of the HVAC concentration in the mechanical engineering department. Another interviewee said more than half of the San Francisco IBPSA-USA chapter meeting attendees were women, and others observed that the BEM industry was becoming increasingly diverse with more women and people of color represented, some with the caveat that the industry does not yet reflect the general population.

Further study is needed to produce a definitive description of BEM labor market demographics. Should the study find the BEM workforce is more diverse than the architecture and mechanical engineering industries by significant margins, BEM groups might consider leveraging that success and sharing insights with other industry groups interested in increasing their field's diversity.

Drivers of Demand for Energy Modeling in California

California is a leader in energy code advancement.[12] The state's building energy codes (Title 24, Part 6 Building Energy Efficiency Standards) apply to residential and non-residential new construction and upgrades to current buildings. These building energy-efficiency standards are one prong of a statewide strategy to decrease electricity and natural gas use through energy efficiency.[13] SMEs indicated the performance compliance approach is used more commonly in California than in other states. This, they stated, along with the flexible nature of design, drives the use of performance simulation. The increasingly-stringent nature of prescriptive requirements may continue to drive performance-based compliance approaches. California energy code compliance was noted by six out of eight interviewees asked about BEM demand drivers. As long

[9] "Architects, except landscape and naval & mechanical engineers," DATA USA.
[10] Binary gender divisions (male and female) are a further limitation of the dataset.
[11] "Architects, except landscape and naval & mechanical engineers," DATA USA.
[12] "State and Local Policy Database: California," 2020, American Council for an Energy-Efficient Economy.
[13] "California Energy Commission - Tracking Progress," 2018, State of California Energy Commissions.

as buildings continue to be developed and upgraded, code compliance will be a key driver of residential and non-residential BEM.

Another form of performance-based modeling – for third-party building certification programs – emerges as a similar, prominent driver. Six out of eight interviewees who were asked about drivers noted third-party building certification as a key driver of BEM. For example, the LEED green building rating system can engage BEM in both performance and design modeling contexts, and BEM is used in performance modeling for residential GreenPoint ratings.[14]

To a lesser extent, three interviewees identified rebates and incentives as drivers of BEM in California, though specific rebates and incentives were not isolated. While these can vary by municipality and time period, examples of incentives that involve BEM include the Savings By Design program offered by California utilities,[15] the federal 179D commercial buildings energy efficiency tax deduction,[16] and the federal 45L residential tax credit.[17]

Individuals and small numbers of interviewees also identified several trends that could affect future BEM demand, including electrification, post-occupancy analysis, simplified energy modeling, and the growing push for net-zero-energy, high-performance, and carbon-neutral buildings.

Target Audiences for Energy Modeling Training

Target audiences for energy modeling training include on-the-job learners,[18] people entering the workforce through certification or industry training courses, college/university students preparing for careers in architecture, engineering, or building-related professions, energy model consumers, and people who would benefit from an introductory BEM education, such as high school students.

15 out of 21 interviewees who were asked confirmed BEM professionals learn BEM on the job. This type of learning could include asynchronous self teaching (e.g., YouTube videos and online resources), enrollment in training courses, active project work, and more. Interviewees shared a range of perspectives about the types and extent of on-the-job training, but this method of learning appears to occur across most (if not all) BEM use cases and professions.

15 out of 21 interviewees who were asked confirmed BEM professionals learn BEM on the job.

[14] "Build it Green's GreenPoint Rated Homes and Title 24," 2010, Kevin Beck.
[15] "Savings By Design encourages high-performance, non-residential building design and construction by providing financial incentives, design support, and detailed analysis," 2017, Savings By Design.
[16] "179D Commercial Buildings Energy-Efficiency Tax Reduction," 2020, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.
[17] "45L tax credit for energy efficient homes," CHEERS.
[18] An on-the-job learner is defined as someone receiving BEM training outside of a formal educational institution (e.g., a college or university) after they have started their career.

Several industry interviewees said California energy code education is a common type of on-the-job training, regardless of skill level. This is to be expected, given the triannual code cycle is shorter than the typical four-year degree. Four interviewees highlighted Energy Code Ace as a valuable tool for on-the-job code training, among its other robust offerings.

On-the-job training on the firm's chosen BEM software and tools is also common. In general, interviewees hiring for entry-level BEM roles expressed they are willing to hire employees with any BEM software experience, even if it is different from the firm's software, though this is not always the case. Training provided by software companies and utility-sponsored training centers, which have hosted CBECC-Com and CBECC-Res trainings, are particularly well-suited for employees who need support with a particular software application.

Interviewees shared a variety of perspectives about the extent of on-the-job training required or provided. Several said junior employees start with simpler modeling tasks. Two industry interviewees (one in performance modeling and one in multifamily housing) require (and in one case prefer) no prior BEM experience, but do require or recommend their energy analysts get their CEA during a specified time frame after starting work. Two interviewees representing small BEM teams at sustainability consulting firms provide in-house training, while another firm starts training energy consultants on residential projects before moving them to commercial projects. Even an internship program for college engineers can serve as an on-the-job training opportunity, as was described by an interviewee who works at a large firm focusing on non-residential projects. There was broad consensus among the interviewees that, while some firms might prefer BEM experience and those working in professions that require advanced BEM knowledge (like research or design) might enter the workforce with BEM experience, advanced BEM proficiency is not required, as some level of on-the-job training is expected for junior employees.

Interviewees said time and financial constraints can be barriers to pursuing on-the-job BEM education. An IBPSA-USA study noted this phenomenon is not unique to BEM, but identified that finding time for BEM training was a concern among a study group of architect interviewees from around the country.[19] Four interviewees for this report described the general time constraints associated with creating models, and two described the top-down pressure to conduct BEM quickly and minimize labor costs. A work environment with scant time allocated for pursuing formal training introduces challenges for modelers who want to develop skills beyond what they learn from working on projects or from their firm's in-house training.

People who choose to start their BEM careers through industry-based training resources are another key audience. For example, an SME highlighted that online training and certifications for residential BEM are an entry path for energy modelers. These models help make BEM careers more accessible to practitioners who may not have degrees in engineering, building science, or architecture.

[19] "The BEM Collaborative: Architect Outreach," 2019, Dimitri Contoyannis and Mike Wilson, IBPSA-USA.

California college and university students are receiving BEM education through two-year, four-year, and graduate programs. Classes offering BEM training tend to fall in architecture, building science, construction trades, and engineering departments,[20] corresponding with professions commonly using BEM in the industry. This suggests there is some degree of cohesion in the career pipeline between BEM education and industry.

In California's community colleges, students have access to BEM, building performance, and energy auditing courses through the construction trades. The accessibility of community college courses allows working professionals and full-time students to access this curriculum. Similar to four-year institutions, community college BEM coursework reaches both BEM practitioners and BEM consumers.

In California's four-year higher-education settings, BEM-focused courses are often populated with more senior students. In regard to engineering, one interviewee remarked that HVAC courses with BEM typically require knowledge of thermodynamics and heat transfer, a strong math and science foundation, and more, making HVAC courses with BEM better suited for engineering juniors and seniors. In this context, BEM and HVAC courses are typically offered as engineering electives or specializations. The audience is therefore self-selecting into BEM, making it important to increase undergraduate students' awareness of BEM courses and career pathways.

Two of California's public university bachelor of architecture programs, Cal Poly Pomona and Cal Poly San Luis Obispo, require undergraduate architecture students to take a course providing an introduction to BEM or building simulation over at least one lesson. These courses foster BEM awareness among a broad audience of architects. Several universities also offer advanced opportunities for architects to dive deeper into BEM later in their collegiate careers.

As with graduate programs in any subject, students who enroll in programs that include BEM education are generally being prepared for careers requiring advanced BEM knowledge, skills, and abilities.

In addition to the formal BEM education and training resources sought out by BEM professionals, interviewees also described informal methods of information sharing. These may be sponsored by organizations or individually driven, and include YouTube videos, listservs, online forums, and chat groups hosted in Slack and Discord.[21, 22] Interviewees said these methods are useful when modelers need assistance with specific BEM questions or topics. These informal channels may give BEM professionals answers more quickly than other peer-to-peer modes (such as conferences) and help work through questions not covered by other educational resources, but they have varying degrees of quality control.

[20] The exceptions are college programs that have titles more aligned with associate degrees and certificates, such as energy systems technology or construction technology.
[21] Discord is a digital distribution platform where users can communicate via voice or video calls or text messages either in private chats or in a 'server' (a group of individuals similar to a group chat or a conference call).
[22] Slack is a communication platform where users can communicate via voice or video calls or text messages either in private chats or in a 'workspace' (a group of individuals similar to a group chat or a conference call).

Finally, some evidence suggests high school programs, internships, and mentor relationships are additional methods of BEM education and training. While this report has limited research into BEM high school programs, industry interviewee Gina Rodda described a successful high school internship program offered by her firm every other year. Another industry interviewee who is involved with the Architecture, Construction, Engineering (ACE) national mentorship program recommended it as a new venue for BEM professionals to build awareness among high school students. Because of the national effort to boost Science, Technology, Engineering, and Math (STEM) outreach and education to high school students, leveraging existing program design and organizations (e.g., ACE or Project Lead the Way) is an efficient intervention.

Mentor relationships are not only a means of BEM education and training in themselves, but mentors can also build awareness among mentees about BEM education and training resources. One SME noted mentors can provide the bridge between theory and practice needed to complement theory-heavy university education. Formal mentorship programs are available, such as the California Association of Building Energy Consultants (CABEC) Mentorship program, which connects mentors with mentees who "are new to the Energy Industry or looking to advance [their] current training and direct experience by becoming a Mentee and moving towards becoming a CEA (Certified Energy Analyst)."[23] This mentorship program is for those in the residential sector, but CABEC plans to launch a non-residential mentorship program.

Architects and contractors are key consumers of energy models who benefit from BEM education. Several interviewees discussed the importance of having project stakeholders understand basics of BEM so they can understand the potential and limitations of BEM, as well as the importance of using BEM early in the design phase. Outside of the formal education programs already discussed, there has been some effort from architecture professional organizations, such as the American Institute of Architects (AIA), to provide BEM fundamentals to architects. While contractor training resources are available, three interviewees suggested BEM training for contractors is less widely known than other forms of BEM training.

Current Educational Resources

BEM education, training programs, and resources can be divided into four categories: industry resources, college and university programs, energy modeling certifications (e.g., CEA and Building Energy Modeling Professional [BEMP]), and teacher training. A detailed list of college and university programs is found in Appendix 2, industry resources in Appendix 3, certifications in Appendix 4, and teacher training resources in Appendix 5. A broad assessment is included here.

The industry resources category is vast, and includes knowledge databases, job boards, online and in-person trainings, single guides and documents, informational web pages, tools, and organization-supported forums. Industry organizations, such as CABEC, IBPSA-USA, AIA, and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) are

[23] "Mentorship Program," CABEC.

prominent in this category, as are Investor-Owned Utility (IOU)-supported resources, software companies, and university research centers. Interviewees expressed praise for the industry resources made available to them.

Industry organizations, such as CABEC, IBPSA-USA, AIA, and ASHRAE, are prominent in this category, as are IOU-supported resources, software companies, and university research centers.

Furthermore, BEM practitioners have made an effort to streamline and consolidate industry resources. For example, Energy Code Ace provides extensive resources across different learning modalities for a host of BEM use cases and roles, and was described as a go-to resource by many interviewees. Another example is BEMcyclopedia, a project funded by the U.S. Department of Energy (DOE) and led by Model Efficiency, which aims to further online BEM education by creating a wiki-style website.[24] BEMcyclopedia is currently looking for feedback on the beta version of their site, presenting one opportunity for CalBEM to engage with the development of educational resources. While these are just two examples, industry resources in general are well suited for on-the-job training, as they do not require enrollment in a degree program and are often free.

California colleges and universities also offer BEM education and training from the community college to graduate level. Evidence suggests that BEM offerings have increased over the past decade. As part of the BEM Innovation Summit, the Rocky Mountain Institute identified higher education institutions teaching BEM in 2011, and only two California institutions, Stanford and UC Berkeley, were noted.[25] These two universities continue to offer robust BEM coursework and are now joined by more colleges and universities. While the most up-to-date course information available was used to prepare the list for this report, it is possible that due to the commonly-elective nature of BEM courses, BEM training may not be offered annually at a particular college or university. In other cases, attempts to contact faculty to verify BEM coursework were unsuccessful. Appendix 2 provides further information about courses that could be verified.

One robust California community college offering identified for BEM is College of the Desert, which hosts a Building & Energy Systems Professional program, including both a certificate and an associate degree that include residential BEM training. The program not only offers specific BEM training, but also supporting curriculum in codes and building science,[26] two topics highlighted by interviewees as important knowledge areas for BEM professionals. Other California community colleges offer BEM coursework in HVAC, construction, and technology departments. Interviewees remarked that community college training can be particularly well-suited for BEM professionals interested in code compliance and/or residential BEM.

[24] "BEMcyclopedia: The Energy Modeling Knowledgebase," BEMcyclopedia.
[25] "BEM Summit Pre-Read," 2011, Kendra Topper, Stephanie Hodgin, Coreina Chan, Rocky Mountain Institute.
[26] "Building and Energy Systems Professional," College of the Desert.

One robust California community college offering identified for BEM is College of the Desert, which hosts a Building & Energy Systems Professional program, including both a certificate and an associate degree that include BEM training.

As described earlier, California four-year colleges and universities offer undergraduate programs with BEM coursework. In California, undergraduate BEM coursework is taught frequently, though not exclusively, in mechanical engineering and architecture departments. Generally, one or two undergraduate BEM training courses are offered in a given department. Graduate-level coursework is also available, but is not required of BEM practitioners unless they are conducting advanced or specialized BEM.

There is some evidence to suggest industry groups may want to devote attention to the sustainability of the BEM faculty pipeline. The future of BEM instruction at colleges and universities may be jeopardized, if BEM instruction is driven by individual faculty members. Three California faculty members felt BEM instruction was individually-driven at their institutions; however, this is not a universal concern, as one California faculty member in engineering said the curriculum had been institutionalized.

Beyond the courses offered, enrollment is another key element in understanding the BEM landscape. In conversations held with faculty, enrollment was varyingly described as being full to under-enrolled. While no common enrollment trends could be identified, five interviewees said BEM should be presented as more exciting and appealing to students, and four interviewees said it needed to be positioned as a green career (with one interviewee who said both). Creative projects included comparing regional weather differences for an outdoor shelter for people experiencing homelessness using building simulation (described by faculty member Pablo La Roche at Cal Poly Pomona).

A variety of BEM certification programs is available, but the Certified Energy Analyst (CEA) offered by CABEC and Building Energy Modeling Professional (BEMP) offered by ASHRAE emerged as popular certification options.

A variety of BEM certification programs is available, but the Certified Energy Analyst (CEA) offered by CABEC (both residential and non-residential) and Building Energy Modeling Professional (BEMP) offered by ASHRAE emerged as popular certification options. In September 2021, Brian Selby of CABEC noted that there were 80 residential and 23 non-residential CEAs for the 2019 code cycle and 188 residential and 65 non-residential CEAs for the 2016 code cycle. In a report published in November 2020, the DOE reported that the BEMP certificate was underperforming on enrollment, citing around 370 U.S. certifications.[27] Certification signifies a certain level of knowledge surrounding BEM (e.g., energy efficiency concepts, application of codes

[27] "Innovations in Building Energy Modeling," 2020, Amir Roth, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

and standards, troubleshooting models); therefore, on-the-job learners may seek out educational resources and training to help them prepare for and achieve their certificates. Furthermore, both the CEA and the BEMP credentials require continuing education hours – nine hours annually for CEAs[28] and 45 professional development hours every three years for the BEMP.[29] These are included in this report's assessment of educational and training resources.

There is also a small set of teacher training and curriculum resources, designed to support BEM instructors. These resources provide everything from building science educator instructional videos to a full curriculum for commercial energy auditing and analysis. Live collaboration opportunities are also a valuable way for educators to network and learn about the curriculum landscape. For instance, one interviewee noted the value of the IBPSA-USA Education committee session, in which faculty members shared syllabi, asked questions, and gave each other feedback. Interviews revealed an interest among both California and out-of-state faculty members in supporting collaborative instructional enhancement activities, such as resource sharing and training. Resources for instructors can be especially valuable, as they encourage further adoption of best practices, innovation, and ongoing instructor collaboration.

Interviews revealed an interest among both California and out-of-state faculty members in supporting collaborative instructional enhancement activities, such as resource sharing and training.

Knowledge, Skills, and Abilities (KSAs) for BEM

27 interviewees and SMEs (19 industry experts and eight faculty) discussed KSAs throughout the course of their interviews. While KSAs for BEM vary based on use case, the most popular KSAs are:

- Building science
- Thermodynamics
- Building codes and standards
- Design and construction knowledge: knowing that modeling doesn't save energy, design decisions and construction practices do, and being able to integrate BEM into design
- Communication: technical report writing, breakdown of complex topics into easily-digestible information, presentation skills, etc.
- Deep intuition for the software
- HVAC knowledge, including vapor compression cycles, protocols, and HVAC system modeling
- Technical savviness (e.g., 3D modeling experience and advanced Excel abilities)

[28] CEUs (Continuing Education Units)," CABEC.
[29] "BEMP - Building Energy Modeling Professional Certification," ASHRAE.

- Understanding how outside factors (e.g., daylighting, weather, human behavior) will affect your results
- Physics (separate from building physics/science)

Some of the categories overlap with one another and have prerequisites themselves. For example, having an intuition for BEM software requires technical savviness.

Having "deep intuition for the software" is a complex KSA encompassing a broad spectrum of understanding the software enough to be able to troubleshoot when performing BEM and to know how different data entries will affect results. Interviewee insights on what this KSA entails include:

- The data entered
- The reason the software requires certain data entries
- How alterations to data entries will affect the modeling result and level of impact on the result (i.e. sensitivity analysis)
- Practicality of proposed changes resulting from the model
- The reasoning behind the software design (i.e. why it is how it is, and why it does what it does)

The findings outlined above are consistent with the results of previous studies.[30] The IBPSA-USA Education Survey Report published in November of 2019 surveyed 113 of its members about the importance of potential education topics. The results of the IBPSA-USA Education Survey Report rated "communication and presenting modeling results" as the top education priority, and "integrating early design phase modeling" as the second-highest education priority.[31]

The results of the IBPSA-USA Education Survey Report rated "communication and presenting modeling results" as the top education priority, and "integrating early design phase modeling" as the second-highest education priority.[32]

Gaps in Teaching Knowledge, Skills, and Abilities

In general, interviewees expressed praise for the existing BEM education and training resources and their ability to teach BEM KSAs. Positive feedback was provided for industry organizations (e.g., AIA, CABEC, and IBPSA-USA), online educational tools (e.g., Energy Code Ace), IOU workshops, individual faculty members and university programs, software-focused training programs, and more. No extremely urgent or concerning gaps in teaching KSAs were unearthed; rather, interviewees expressed ideas for new resources, or additions to existing resources, that could build on the existing effective landscape.

[30] More studies were located, however, only non-citable, draft versions were found.
[31] "IBPSA-USA Education Report," 2019, IBPSA-USA.
[32] "IBPSA-USA Education Report," 2019, IBPSA-USA.

The gaps in teaching BEM knowledge, skills, and abilities vary based on the industry in which BEM is being used. Therefore, this is not a comprehensive list of every possible KSA gap for each industry; instead, the priority gaps uncovered by interviewees are discussed in this section.

Five interviewees indicated building science/building physics knowledge is a KSA gap, making building science/building physics one of the most common gaps identified in this research. These interviewees represented a spectrum of BEM sectors — research, commercial, residential, building performance engineering, green building, undergraduate-focused architecture faculty, and an architecture faculty member referencing engineering degree programs — indicating addressing building science knowledge gaps could be an effective focus area for multiple BEM career pathways. This is not to say that building science training does not exist, nor that the existing offerings require improvement. In fact, some interviewees praised university programs and industry resources in building science unprompted. Rather, CalBEM could explore whether these existing resources are reaching all industries and educational levels of BEM practitioners.

Three interviewees stated continuing education (outside of university degree programs) for complex modeling problems and new building technologies is an opportunity for further training resource development or increasing awareness of training resources. One interviewee offered translucent walls and radiant flooring as examples of complex modeling challenges.

As described in the educational resources section of this report, California colleges and universities are teaching students about BEM, but considering the number of colleges and universities in the state, BEM instruction in university programs is not widespread. This presents an opportunity to fill a gap early in the career pipeline. The existing and effective higher education courses and programs can serve as a framework to advocate for increased BEM coursework adoption. The diverse nature of existing educational program offerings is an advantage in this context. Depending on the interest of the target college or university, something as large as a course sequence and as small as a unit within a course could be proposed and supported with an existing success story.

Growing early-career education resources in the higher education setting (particularly for undergraduate and community college students) gives the advantage of targeting education to people who have the time, and who have set aside years of their lives to focus on education over other competing factors. For example, one interviewee in the architecture field noted it can be difficult to find time for ongoing skill development when hours must be spent on project billing.

A potentially powerful education leverage point is educating BEM consumers, who may be architects, developers, or contractors. Interviewees said BEM implementation timing and the project resources dedicated to BEM affect the model's ability to influence energy efficiency. Three interviewees thought contractor and architect BEM education would increase the quality of BEM in the market by building understanding of first, the value of BEM (which might encourage investment in more robust project BEM) and second, how to work with the energy modeler to

integrate BEM during the design phase. Secondary research also supports the investment in educating BEM consumers. In 2017, the DOE published an article on the potential for BEM to support energy efficiency, and aimed to build awareness of BEM among architects and their clients by "documenting the return on investment associated with BEM" since "BEM is typically a small part of overall project budget and can disproportionately improve both construction and operating costs."[33] Therefore, growing understanding of the value proposition among consumers can help improve the quality of BEM in California.

Architects with a working knowledge of BEM will be able to communicate more effectively with the design team and engineers to create high-performing building designs. Furthermore, an AIA interview with the AIA Chief Economist highlighted that architects are in a unique position to advocate for increased adoption of building energy technology with clients.[34] One SME also noted the integrated design framework can help bridge the gap between engineers and architects with respect to BEM. Efforts to increase the use and understanding of BEM among the architecture workforce are already underway. Leading architecture programs in the state are educating their undergraduates on BEM and building energy concepts, and one interviewee said efforts have already been made to increase knowledge of BEM in the current workforce through the American Institute of Architects (AIA). This is aligned with the AIA 2030 Commitment, which promotes the use of BEM to support the 2030 Challenge for the global architecture community to design more sustainable, less fossil fuel-dependent buildings.[35] [36] The U.S. Department of Energy is also an advocate for the integration of BEM into the architectural field by "working to further reduce the associated effort and cost by promoting integration of advanced BEM, lighting, and façade analysis capabilities with the design tools that architects already use."[37]

Contractors tend to be engaged in later project stages. As BEM consumers, contractors have an important role in creating budgets and timetables and hiring energy modelers for demonstrating code compliance, so it is essential that they have an understanding of the scope of BEM and its potential uses for energy efficiency and cost-saving measures. In design-build projects, contractors are more attuned to market forces, and with clients increasingly seeking high-performance design, BEM is a way for contractors to differentiate themselves. Three interviewees remarked there are opportunities to increase BEM knowledge among contractors, particularly an understanding of BEM and its use cases for that profession. Interviewees did not critique the existing resources for contractors to learn BEM, and there are several, ranging from directed resources provided by Energy Code Ace to a guide offered by the Rocky Mountain Institute. As such, a first approach to addressing this KSA gap could be to build awareness around existing resources so the information disseminates to contractors who would benefit from it.

---

[33] "Building Energy Modeling 101: Architectural Design Use Case," 2017, Amir Roth, U.S Department of Energy, Office of Energy Efficiency and Renewable Energy.
[34] "Adoption of Building Performance Tech at Firms Sputters without Business Rationale," William Richards, American Institute of Architects.
[35] "The 2030 Challenge," Architecture 2030.
[36] "The 2030 Commitment," American Institute of Architects.
[37] "Building Energy Modeling 101: Architectural Design Use Case," 2017, Amir Roth, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

Recommendations

A series of recommendations that aim to improve BEM education in California are provided based on these findings. With these recommendations, this report also aims to reflect CalBEM's education goal to **"support California's long-term climate action goals by encouraging, training, and educating on the use of BEM tools."**[38]

Recommendation 1

Inspire pursuit of BEM careers and participation in BEM educational programming by engaging in outreach that raises awareness of BEM as a green career among high school and undergraduate students and defines the BEM field, its potential career paths, and the personal and environmental benefits of these careers.

One problem in BEM education is that not enough people know about the BEM industry, from the people involved in the building process to professionals deciding on their career paths. Additionally, five interviewees stated BEM needed to be presented as more appealing to students to generate interest in learning more about BEM's applications for sustainable design. To remedy this issue, it is recommended that CalBEM raise awareness of BEM among potential incoming practitioners, such as high school students, college students, and future workers, by highlighting the labor market growth in this field, salaries for entry-level and experienced professionals that engage in BEM, and the essential role high-quality BEM plays in addressing the climate crisis. Outreach and marketing efforts may include, but are not limited to:

- Participating in green career fairs or job fairs; college events could target engineering and environmental science students looking for internships or entry-level jobs, while events for adults looking to start work without degrees could advertise online training programs.
- Hosting campus talks, seminars, and events open to high school and undergraduate students, including classroom guest lectures, leveraging chapters of campus student organizations (particularly those that aim to increase diversity in STEM), and career center talks.
- Reaching out to career counselors with information on BEM careers and continuing education opportunities.
- Engaging with existing mentorship programs for incumbent workers and undergraduate students.
- Engaging with existing STEM high school outreach programs (e.g., Project Lead the Way or the ACE Mentorship program) or replicating the BEM high school outreach efforts described in this report in other geographies.
- Educating the following career technical education leaders in the K-12 and community college systems about BEM careers:

[38] "About CalBEM," CalBEM: California Building Energy Modeling.

    - California Department of Education CTE leaders in these industries: Energy, Environment, and Utilities; Building and Construction Trades; Engineering and Architecture; and Information & Communication Technologies
    - Community College Regional Consortia Leaders
    - Regional K-14 coordinators
    - Regional Directors for Energy, Construction and Utilities; Agriculture, Water, and Environmental Technologies; and Information & Communication Technologies
- Supporting career pipelines between colleges/universities and employers who hire BEM practitioners by building awareness among employers of California universities and colleges that teach BEM.

In addition to these outreach opportunities, faculty members are also receptive to sharing career and continuing education resources in their classrooms. Most faculty interviewees for this report engage in the practices below, and these can be emphasized as a best practice:

- Encourage faculty who teach BEM to share examples of job titles, certifications, labor market growth projections, and salary data for career pathways students can pursue with their newly-acquired BEM skills.
- Encourage faculty to share opportunities for continuing education with their students, particularly training they can use on the job (e.g., professional organizations, online courses, and certifications).

To successfully raise awareness of BEM careers, the field and its potential career paths should be defined and differentiated. A solution is to create simple, well-designed communications materials that any lay audience member can understand, which describes (a) the necessary skills required for BEM; (b) the training available to help people qualify for these careers; (c) how to use BEM in each highlighted career pathway (e.g., residential energy analyst, mechanical engineer, architect, construction); and (d) exciting aspects of BEM (e.g., salary data, growth projections, problem solving, and climate impacts). To describe the necessary skills required for BEM, the essential KSAs highlighted above should be used as a guide.

In these communications materials, BEM should be positioned as a green career option. The green workforce is growing, so it is strategic to position BEM as a tool for climate protection, to generate interest in sustainability-minded high school and university students who want to lead the shift toward a net-zero future.[39] Studies show today's youth are passionate about fighting the climate crisis and want to have careers in the green economy.[40, 41] One 2019 survey even showed that

[39] "Green growth: Employment projections in environmentally focused occupations," U.S. Bureau of Labor Statistics, 2018.
[40] "Gen Z, Millennials Stand Out for Climate Change Activism, Social Media Engagement with Issue," Pew Research Center, 2021.
[41] "A survey of 1,000 people aged 18 to 34 found 50 percent wanted a job in the green economy," The Ecologist, 2020.

~25% of 629 teenagers surveyed had participated in climate activism, such as a rally/walkout or writing to a public official.[42]

The green workforce is growing, so it is strategic to position BEM as a tool for climate protection to generate interest in sustainability-minded high school and university students who want to lead the shift toward a net-zero future.

Using these communications materials to raise awareness among high school students and undergraduate students can help CalBEM inspire young students to pursue BEM education and excite them about using BEM in their future careers. Additionally, these practices can generally raise awareness of BEM among students who do not choose BEM as a field, but may come into contact with it in their careers (e.g., contractors).

The awareness-raising method has both strengths and weaknesses. One strength is that marketing and outreach activities can typically be developed and implemented more quickly than designing new courses or training programs. Raising awareness can also have the spillover effect of reaching people who will be in BEM decision-making positions. However, one weakness is the absence of clear data about the future of the BEM labor market and concerns about recruiting and training people for jobs that don't exist. To address this, partnering and communicating with the industry may help ensure accurate representation of the labor market during outreach, and be a means for establishing pathways from education and training to careers.

Recommendation 2

Advocate for and support targeted BEM education in fields that come into contact with BEM, including promoting curriculum ideating and sharing, institutionalizing BEM education, and integrating relevant BEM knowledge into current curricula.

As discussed previously, KSA gaps exist specific to certain careers. As such, it is recommended that these gaps be addressed by advocating for or offering resources to:

Architects

- Integrate BEM into sustainable and environmental architecture courses/sessions (e.g., what is BEM, what can it be used for, and what questions should architects ask energy modelers). Leverage the success of California faculty who have incorporated BEM into undergraduate architecture courses required for accreditation.

Architects, Contractors, and Developers

- Partner with professional organizations for energy model consumers, to determine ways to best incorporate BEM concepts into their materials and disseminate them to the workforce, such as offering BEM courses for continuing education credits to maintain

[42] "Most American teens are frightened by climate change, poll finds, and about 1 in 4 are taking action," Washington Post, 2019.

professional certification, presenting at conferences, and offering short workshops (e.g., lunch-and-learns) that minimize time and financial barriers to participation. Using BEM in the design phase and the BEM value proposition are potential focus areas. For continuing education models, one faculty member highlighted the importance of bringing in people from different backgrounds to create training materials, including contractors, architects, and energy modelers who use BEM for different use cases. Perspectives from different focus areas can help provide use case and industry-specific insight, while illuminating diverse approaches to BEM problem solving.

All BEM Practitioners

- Explore methods to increase awareness and uptake of existing building science/building physics training resources within the incumbent workforce.

Energy-Efficient Design Consultants and Engineers

- Develop further resources or raise awareness of existing resources for complex modeling problems and new building technologies.

Engineers

- Explore ways to integrate architectural design principles into existing industry on-the-job training resources to reach the current BEM workforce.
- Integrate education on BEM for energy efficiency into relevant HVAC courses/sessions.

Higher Education (Non-Career-Specific)

- In the long term, support faculty efforts to institutionalize BEM into the approved course outlines, certificates, and degree programs where currently offered.
- Facilitate communication among BEM faculty (including those out of state) to discuss and share ideas and resources. In particular, CalBEM should consider partnering with and leveraging existing educator collaboration resources.
- Provide grants and staff support to teachers and faculty for documentation of curriculum and instructional resources for dissemination, to increase the number and quality of related academic projects and programs. This model has previously worked well with SEI, which offers staff support and grants of up to $5,000 for academic project/program design, documentation, and dissemination.

Recommendation 3

Promote professional credentials among energy modelers, and advocate for employers to lean on these certifications to standardize competency among hired energy modelers.

Professional certifications, such as CEA and ASHRAE's BEMP, ensure a baseline level of knowledge to increase the quality of BEM among entry-level energy modelers. Furthermore, continuing education requirements for these certifications incentivize the continuous use of quality education resources. Requiring certification is a complicated topic; however, further promotion of certifications without advocating for their requirement may still result in increased

adoption of these certification programs. The benefits of certification, especially for entry-level energy modelers, are significant. Though certification may be time-consuming, especially for those less familiar with the subject matter, it provides evidence of competence, and can be attractive to potential employers by demonstrating existing knowledge required for quality BEM. Thus, increasing the number of energy modelers who have certifications would not only promote a baseline level of education, and therefore the baseline quality of BEM, but it would also build confidence in BEM applicants among the industry.

One interviewee aptly noted that certification alone isn't a panacea; a person with the right background and curiosity could be an equally-strong (or stronger) hire. Many people are successful and well-established without certifications, but promoting certifications remains a way to improve the quality of BEM. The "Innovations in Building Energy Modeling: Research and Development Opportunities Report" published last year and sponsored by the DOE argues that "without credential requirements, cost pressures can lead firms to assign BEM tasks to junior staff with little experience in BEM or specific analyses, workflows, and tools," which leads to software misuse, careless errors, and misinterpreted results.[43] More widespread certification could help remedy this issue.

An SME for this report, Brian Selby, has identified a correlation between CEAs and BEM accuracy when compared to non-CEAs. This is based on his current research to evaluate the effectiveness of the CEA program. He elaborated by saying that even though CEAs represent a very small portion of individual BEM practitioners, they are responsible for a much higher project frequency. In other words, CEAs are completing BEM compliance projects more frequently, are in classes more frequently, and are doing more projects.

Certification promotion could be accomplished by including information on the benefits of professional certifications in outreach initiatives to industry leaders, BEM firms, contractors, relevant faculty members (e.g., architecture, civil engineering, mechanical engineering, HVAC, and environmental design professors), career counselors, and emerging energy modelers (see Recommendation 1 for specific examples of increasing awareness and outreach). One expert suggested this promotion also make clear which KSAs are covered by each professional certification; for example, the two primary certifications, CEA and BEMP, test for different competencies, and one or the other may be more relevant for specific career paths.

[43] "Innovations in Building Energy Modeling," 2020, Amir Roth, p. 77, U.S. Department of Energy.

Discussion

In addition to the insights and recommendations about California BEM education and training presented above, there are topics relevant to education and training that would benefit from additional research and discussion. One such topic is growing community college BEM offerings to provide more entry points into the workforce. Existing training programs, such as College of the Desert's degrees and certificates, the CEA certification, and HERS rater training demonstrate that BEM professionals do not need four-year degrees in engineering or architecture to secure jobs and training in the residential and energy analyst fields. There is a lingering question as to whether community college programs could be expanded and developed to train learners for other BEM use cases.

Interviewees expressed a range of opinions on further development and adoption of associate degrees for BEM, with the intention of hiring entry-level professionals directly out of two-year degree programs. Of the 16 interviewees who discussed community college programs, most (but not all) concurred BEM could be implemented at the community college level. There was some disagreement, particularly from interviewees who specialize in advanced BEM use cases. There was a general consensus that a community college program could be a good fit for modeling projects focused on compliance or residential modeling, but other interviewees said community college training could be a fit for multiple use cases.

Those against offering a BEM-focused associate degree at the community college level mostly had concerns about whether the industry had enough demand for energy modelers, particularly those with associate degrees, and if associate degree holders could compete in the hiring process with modelers who have more advanced degrees. On the other hand, some interviewees suggested that, if taught BEM, community college graduates would be more attractive, since four-year degrees typically do not teach BEM. In addition to this, community college graduates could use self-guided continuing education and professional credentials to get an entry point into the field. Certification programs with educational requirements often accept associate degrees, but several require more years of work experience for associate degree holders compared to other degrees. One interviewee said community college programs could increase diversity in the BEM field by providing a clear path to entry that doesn't require a four-year degree.

An interviewee with experience advocating for community college programs also proposed existing programs such as HVAC, construction, building science, and drafting be leveraged to promote professional certifications and BEM careers. This could prepare students for CEA or Associate Energy Analyst credentials, and seed the industry with professionals who have the foundational knowledge to perform well in BEM careers.

In conclusion, community college graduates can be successful in BEM, but it is still unclear as to whether there is enough industry demand for increasing the number of associate degree holders and significantly expanding BEM training at community colleges to other use cases.

Other BEM research areas should be further explored. First, it would be beneficial to further research the demand for BEM practitioners (including the demand for specific use cases and types of energy modelers) to ensure the field can handle an influx of BEM professionals that would result from increased educational and awareness efforts. Furthermore, CalBEM could explore whether existing resources are reaching all industries and educational levels of BEM practitioners and how these existing efforts can be more easily incorporated into the busy schedules of current BEM practitioners and BEM consumers.

References

"179D Commercial Buildings Energy-Efficiency Tax Reduction," 2020, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

"45L tax credit for energy efficient homes," CHEERS.

"A survey of 1,000 people aged 18 to 34 found 50 percent wanted a job in the green economy," The Ecologist, 2020.

"About Building Energy Modeling," U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

"About CalBEM," CalBEM: California Building Energy Modeling.

"Adoption of Building Performance Tech at Firms Sputters without Business Rationale," William Richards, American Institute of Architects.

"Architects, except landscape and naval & Mechanical engineers" DATA USA.

"BEM Summit Pre-Read," 2011, Kendra Topper, Stephanie Hodgin, Coreina Chan, Rocky Mountain Institute.

"BEMcyclopedia: The Energy Modeling Knowledgebase," BEMcyclopedia.

"BEMP - Building Energy Modeling Professional Certification," ASHRAE.

"Build it Green's GreenPoint Rated Homes and Title 24," 2010, Kevin Beck.

"Building and Energy Systems Professional," College of the Desert.

"Building Energy Modelers in LinkedIn," 2021, Alex Chase, 2050 Partners.

"Building Energy Modeling 101: Architectural Design Use Case," 2017, Amir Roth, U.S Department of Energy, Office of Energy Efficiency and Renewable Energy.

"Building Energy Modeling 101: HVAC Design and Operation Use Case," 2017, US Department of Energy.

"Building Energy Modeling 101: Inherent Performance Modeling Use Case," 2017, US Department of Energy.

"Building Energy Modeling 101: Stock-Level Use Case," 2017, US Department of Energy.

"Building Energy Modeling for Owners and Managers," 2013, Ellen Franconi, Kendra Typper, Blake Herrschaft, Craig Schiller, and Robert Hutchinson, Rocky Mountain Institute.

"CEUs (Continuing Education Units)," CABEC.

"California Energy Commission - Tracking Progress," 2018, State of California Energy Commissions.

"College & Program Directory," BEST Center: Building Efficiency for a Sustainable Tomorrow.

"Detailed Guide for Architects Except Landscape or Naval in California," 2021, CA.gov (Employment Development Department).

"Detailed Guide for Mechanical Engineers," 2021, CA.gov (Employment Development Department).

"Employment Projections," 2021, CA.gov (Employment Development Department).

"Gen Z, Millennials Stand Out for Climate Change Activism, Social Media Engagement With Issue," Pew Research Center, 2021.

"Green growth: Employment projections in environmentally focused occupations," U.S. Bureau of Labor Statistics, 2018.

"HERS Raters," RESNET.

"Hiring an Energy Consultant," CABEC.

"IBPSA-USA Education Report," 2019, IBPSA-USA.

"Innovations in Building Energy Modeling," 2020, Amir Roth, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

"Mentorship Program," CABEC.

"Most American teens are frightened by climate change, poll finds, and about 1 in 4 are taking action," Washington Post, 2019.

"Savings By Design encourages high-performance, non-residential building design and construction by providing financial incentives, design support, and detailed analysis," 2017, Savings By Design.

"State and Local Policy Database: California," 2020, American Council for an Energy-Efficient Economy.

"The 2030 Challenge," Architecture 2030.

"The 2030 Commitment," American Institute of Architects.

"The BEM Collaborative: Architect Outreach," 2019, Dimitri Contoyannis and Mike Wilson, IBPSA-USA.

Appendices

Appendix 1: List of Potential Interview Questions

General Questions

- Inquire about interviewee's background – how did you get into Building Energy Modeling and how does it play a role in your current position?
- How would you characterize the current quality of BEM education in California? If you are not familiar with the California BEM educational landscape, what about the United States as a whole?
- What do you see as the greatest challenges to high quality BEM in California? If you are not familiar with California, what about the United States as a whole?
- How do you think BEM could be improved in California? If you are not familiar with the California BEM educational landscape, what about the United States as a whole?
- Are there any programs, instructors, or resources that are doing great work on BEM education in California? If you are not familiar with the California BEM educational landscape, what about the United States as a whole?
- What are the greatest needs and opportunities for improvement in BEM education in California? If you are not familiar with the California BEM educational landscape, what about the United States as a whole?
- At what level do people typically begin their careers involving energy modeling (e.g., two-year, four-year, graduate school, post-higher education, on-the-job training)?
- What would you say are the essential knowledge, skills, and abilities for building energy modeling?

Questions for Faculty

- Are your BEM classes at maximum capacity?
    - Do you feel that students are typically unaware of these programs/opportunities?
- Are there any strategies you have implemented to make the program more attractive? Have they worked? Why or why not?
- Do students that take classes in your program find job opportunities fairly quickly?

Questions for Industry Partners

- What is the greatest driver of BEM (e.g., compliance modeling, third party certification, or ratepayer incentives)? Are there any other drivers that should be considered?
- Do employers typically offer BEM training, or is it required to be known prior to employment?
- Are junior employees typically the ones doing BEM related tasks at your firm?
- What would you say is the most popular modeling software?
    - What software is best for beginners?

- What percentage of a typical building energy modeler's job tasks are devoted to BEM?

Wrap-Up Questions

- Who else should we talk to about BEM education in California?
- Do you have any other thoughts? Is there anything I should have asked that I haven't yet?
- Do you know of any reports or resources that we should review?

Questions Sent Via Email Post-Interview (industry)

- Generally, what BEM knowledge, skills, and abilities (KSAs) should be further developed among BEM practitioners? What existing education and training resources teach the KSA(s) you identified?
- Does your organization require any BEM certifications for employees? If so, which one(s)?

Questions Sent Via Email Post-Interview (faculty)

- Does your department have an industry advisory board, and if so, does that industry advising include BEM?
- Generally, are there enough faculty to meet the demand for BEM instruction?
- Is BEM instruction institutionalized at your university? In other words, if the current BEM faculty were to leave, would BEM instruction persist?
- As an instructor, would you be willing to share information on BEM continuing education resources with students (e.g., certifications they can pursue, online training they can take)? Is this information sharing a common practice among faculty?
- As an instructor, would you be willing to share information on BEM career paths with students? Is this information sharing a common practice among faculty?

Appendix 2 – Existing College and University Educational Programs

This list includes contributions from Working Group 2 members.

Name of Educational Institution	Type of Institution	Degree Type	Name of Program / Department	Short Description/BEM Courses	Research Links	Verified with an interviewee or contact?
California College of the Arts	Private University	BArch, MArch	Master of Architecture	Required course for BArch and MArch students in Building Energy, which covers heat transfer and comfort (ARCHT 4340/MARCH 6340). Have offered architecture electives with BEM in Parametric Design for Energy Autonomy, Luminous Space, and High Performance Facades (ARCHT 540/MARCH 640).	CCA Course Schedule	Yes
California Polytechnic State University Pomona	Public University	BArch, MArch, MS	College of Environmental Design: Architecture & Lyle Center for Regenerative Studies	BArch, MArch, and MS in Regenerative Studies all include some degree of BEM coursework. BArch and MArch both have a required course (ARC 3310 Environmental Controls) that involves introductory building sim and building physics. Both programs also offer advanced electives and topic studios that incorporate simulation, design, and/or passive systems. Regenerative studies program includes a course that does climate analysis (RS 5350 Regenerative Environments). Solar class open to all majors includes passive systems, codes, and some energy modeling (RS 4300 Solar Energy Systems).	MArch Catalog	Yes
California Polytechnic State University SLO	Public University	BS, MS	Mechanical Engineering Department	BS in Mechanical Engineering with HVAC&R specialization includes BEM elective; MS degree with BEM elective. Courses: ME 455: Introduction to Building Energy Modeling, ME 454: Benchmarking and Assessment of Building Energy Performance.	Mechanical Engineering Course Descriptions	Yes
		BArch	Architecture Department	BArch includes 2 weeks of introductory BEM (daylight and energy modeling) in required coursework, Architectural Systems Integration, and knowledge is expected to be applied throughout the year.		Yes
College of the Desert	Community College	AS, Certificate	Building & Energy Systems Professional program	Includes AS degree and Building Energy Consultant Certificate, among others. Courses: ESYS 021: Residential Energy Modeling, ESYS 022: Residential Energy Modeling Design Project; Prerequisite is a course on Building Energy Codes.	BESP AS Degree Course List	Yes

Cosumnes River College	Community College	Courses	Construction Technology Program	CONST 161: Intermediate Residential Building Performance and Energy Auditing, CONST 163: Advanced Energy Auditing and Energy Modeling; Certificate in Green Buildings includes Energy Efficiency code standards elective (BIT 150).		No
DeAnza College	Community College	AS, Certificate	Energy and Facilities Management	AS and Certificate in Energy Management and Building Science. BEM is an integral part of the course and lab curriculum and certificate/degree program. The campus and its buildings act as a learning laboratory. They have a VMI Student Energy Database that allows students to model, analyze, and manipulate real-time energy data from buildings across the campus.	EMBS Degree Requirements	Yes
Laney College	Community College	Certificate, AS	Department of Environmental Control Technology (HVACR)	Residential and commercial HVAC programs offer ECT 28, Certificate in Building Performance and Energy Efficiency is currently inactive; Courses: ECT 28: Energy Management and Efficiency in Building Systems, ECT 38: Measurement of Building Energy Efficiency, ECT 39: Energy Auditing and Computer Analysis of Energy Efficiency (residential).	ECT Course Descriptions	No
Sacramento City College	Community College	Certificate	Mechanical -Electric Technology	Commercial Building Energy Auditing and Commissioning Specialist Certificate. Courses: MET 393: Commercial Building Energy Audits and Calculations ("Students will perform a detailed energy audit of a state-of-the-art commercial building design using energy modeling simulation software and develop energy conservation strategies...")	Mechanical-Electrical Technology Course Descriptions	No
San Francisco State University	Public University	BS, MS	School of Engineering	BS in Mechanical Engineering with HVAC elective; MS in Engineering, concentration in Energy Systems with building electives. Courses: ENGR 465: Principles of HVAC, ENGR 865: Energy Efficient Buildings, ENGR 867: Energy Auditing, Measurement, and Verification	MS Energy Systems Degree Requirements	Yes
Sonoma State University	Public University	BS	Department of Geography, Environment, and Planning	Formerly offered a BS in Environmental Studies with focus in Energy, Management, and Design. Current offering is GEP 476 Energy Systems and Efficiency, which may include BEM ("You'll use mathematical models to estimate the energy use, cost, and carbon emissions for insulated buildings, heating and cooling, electric motors, and refrigeration. We'll use analytical and numerical methods for estimation and measurement").	GEP Course Descriptions	No

Southwestern College	Community College	AS, Certificate	Sustainable Energy Studies	AS/Certificate in Sustainable Energy Studies. Courses: SES 205: Building Energy Analysis using BIM required for both programs. Further discussion with faculty is needed to verify BEM presence.	SES Course Descriptions	No
Stanford University	Private University	MS	Department of Civil and Environmental Engineering	BS in Civil Engineering with building system elective, MS in Sustainable Design and Construction with Energy Track with required coursework in building systems; Courses: CEE 159/256: Building Systems (covers HVAC, lighting, and envelope systems for commercial and institutional buildings, with a focus on energy efficient design. Assignments include engineering problems, energy simulation exercises and a lighting design task).	Energy Concentration Program Sheet	Yes
University of California Berkeley	Public University	MS	Department of Architecture	MS in Architecture with emphasis in Building Science, Technology, and Sustainability is intended to supplement a professional Architecture degree. College of Environmental Design offers graduate-level coursework in energy modeling (ARCH 249 Building Energy Simulations) that includes enrollment from MS in Building Science Sustainability Technology, Civil and Environmental Engineering Masters students, and Architecture students. Daylighting and building performance modeling also taught at UC Berkeley. Undergraduates also get exposure to building performance in the Architecture and Sustainable Environmental Design programs through the Energy and Environment course. ARCH 149 Special Topics (Zero Energy Building) summer course includes BEM.	BSTS Course Descriptions	Yes
University of California Davis	Public University	Course	Program for International Energy Technologies	Multidisciplinary graduate course sponsored by facilities management office. "Over the duration of the course, student groups work on client-based energy projects, ranging from audits, behavioral studies, energy modeling, and more." Project-based, simple/spreadsheet BEM may be taught but is project- and guest-speaker contingent depending on the term.	ZNE Course Page	Yes

University of California Irvine	Public University	MEng	Master of Engineering - Mechanical and Aerospace	M. Eng with Energy Systems concentration. Course: ENGR 209P: Energy Efficiency in the Built Environment: Energy and power for the built environment; building energy modeling; heat transfer and losses; heating and cooling cycles; control hardware and software; carbon neutrality, optimization.	MAE Course Descriptions	No
University of California San Diego	Public University	BS	Department of Mechanical and Aerospace Engineering	BS in Mechanical Engineering with upper-division elective in BEM. Course: MAE 125: Building Energy Efficiency includes a design project using BEM software. Class not offered in 2021-22 school year.	MAE Course Descriptions	No
University of Southern California	Private University	MS	School of Architecture	Masters in Building Science includes required coursework and electives that cover BEM topics but further discussion with USC faculty is needed to provide more detail on BEM instruction. Program has been recommended as including BEM from interviewees.		No

Appendix 3 – Existing Educational Industry Resources

This list includes contributions from Working Group 2 members.

Name of Resource	Type of Resource	Organization / Institution	Short Description[44]
AEE: Association for Energy Engineers	Organization	AEE	AEE offers a full array of informational outreach programs including seminars (live and online), conferences, journals, books, and certification programs. Offers include: • BESA: Building Energy Simulation Analyst Certification (not accepting new applications) • CEM: Certified Energy Manager Certification
AIA: American Institute of Architects	Organization	AIA	AIA is a group of architects and related professionals seeking to advance their skills through the provision of resources and networking. Offers include: • A course Catalog of courses provided from other orgs • Some courses (for members)
Architect's Guide to Building Performance	Guide	AIA	"This guide's primary goal is to help architects use building performance simulation to inform decisions throughout the architectural design process. Use it as a roadmap to harness architectural experience and apply analysis and metrics to design better high-performance buildings for the 21st century and beyond." (page 5)
ASHRAE: American Society of Heating, Refrigerating, and Air-Conditioning Engineers	Organization	ASHRAE	ASHRAE is a group seeking to advance the level of HVAC and related fields through research, standards writing, publishing, and continuing education. Offers include: • BEMP Certification • ASHRAE Learning Institute • ASHRAE Bookstore • Job Portal • Membership Benefits
BemBook Wiki	Learning Center	IBPSA-USA, ASHRAE, RMI	"For building energy modeling to be fully known as a legitimate discipline, it is important to achieve consensus on a core body of knowledge... The purpose of the wiki is to describe what portion of the Body of Knowledge is generally accepted, to organize that portion, and to provide topical access to it."
BEMcyclopedia	Resource Tool/Sharing	IBPSA-USA, LBNL, Sustainable IQ	BEMcyclopedia is a wiki-style BEM education and information portal with two sections: Learn Fundamental Concepts (KSAs) and Learn by Design Task (i.e., learn how BEM can inform different parts of the design process). BEMcyclopedia is funded by the US DOE and "technical efforts are led by Model Efficiency, with the support of Lawrence Berkeley National Laboratory (LBNL), Sustainable I.Q., and IBPSA-USA."

[44] Quotation marks indicate a direct quotation from the resource.

Building Energy Modeling for Owners and Managers	Guide	RMI	This guide provides an overview of BEM for building professionals who may not be familiar with BEM. It includes resources such as a template RFP.
Building Energy Software Tools (BEST)	Resource Tool/Sharing	IBPSA-USA, (formerly DOE)	This is a list and comparison functionality for BEM software. It allows ratings and reviews of BEM software.
Building Simulation Users Group (BSUG)	Support Group	University of Idaho College of Art and Architecture	"The Building Simulation Users Group (BSUG) was created in 2009 to help to start a community centered around architecture and engineering-focused building simulation. Three years later, BSUG secured funding for another three years from the Idaho Power Company, which also provided funding for the first three years. Dubbed "BSUG 2.0", the second cycle of the group made some tweaks to its mission and aspired to provide more value to its members than just a static lecture series. Users groups are in unique positions to generate content that draws upon the diverse expertise of its members and guest lectures. This content has the potential to help support and add value to the established simulation community. The goals of BSUG 2.0 include: • Continue to procure a lecture series from internal speakers, local experts, and regional/national/international • Create a website to house newly archived sessions and serve as a gateway of knowledge concerning building simulation • Create a living document that outlines the simulation protocols used by the UI-IDL on projects • Conduct market assessments of the market penetration of building simulation in the local market"
CABEC Learning Center	Learning Center	CABEC	This is a resource from CABEC that provides online courses and webinars covering topics of building science, career learning pathways, and innovative products.
CABEC ShareSource	Resource Tool/Sharing	CABEC	This is a tool that allows you to upload new sources, search existing sources, and provide feedback on existing resources.
CABEC: California Association of Building Energy Consultants	Organization	CABEC	Purposes of CABEC include: furthering "technical expertise and ethics through certification" and fostering "professional development through training, information, and peer exchange/networking." Offerings include: • CEA: Certified Energy Analyst (Certification) • AEA: Associate Energy Analyst (Accreditation) • Learning Center with recording • A share tool

California Efficiency & Demand Management Council (CEDMC)	Organization	CEDMC	"The California Efficiency + Demand Management Council (the Council) is a statewide trade association of non-utility companies that provide efficiency, demand response and data analytics products and services in California."
California Energy Alliance (CEA)	Organization	CEA	"CEA works to bring beneficial, equitable change to energy standards, policies and programs by developing consensus among diverse and engaged stakeholders."
California Energy Efficiency Coordinating Committee (CAECC)	Organization	CAECC	"The California Energy Efficiency Coordinating Committee (CAEECC) provides a venue for stakeholders to discuss energy efficiency matters under the purview of the California Public Utilities Commission (CPUC) while ensuring transparent access to information and opportunities to get involved."
Consulting and Private Training	Learning Center	Various	Consulting companies and online education platforms offer BEM training for individuals and organizations, generally for a fee.
Center for Built Environment	Research Center	UC Berkeley	"CBE is a place where prominent industry leaders and internationally recognized researchers cooperate to produce substantial, holistic, and far-sighted research on buildings. Together we work to improve the performance of buildings by providing timely, unbiased information on building technologies and design and operation techniques." "CBE is developing tools and criteria for evaluating facade performance in terms of occupant comfort and energy efficiency."
COMNET	Learning Center	COMNET	"COMNET's mission is to build consensus among software developers, rating authorities and energy modelers, and through this process, develop and maintain a quality assurance program for evaluating the energy performance of new and existing non-residential buildings."
Education on Demand	Learning Center	IBPSA-USA	A library containing recordings of webinars, trainings, and presentations.
Energy Code Ace	Learning Center	Energy Code Ace	Energy Code Ace is a website that has "a portfolio of on-demand, and live in-person and online training alternatives on California's Energy Code and Title 20 regulations, tailored to a variety of industry professionals and addressing key measures." Training includes on-demand videos and webinars. Tools include different tools to help with specifics. Resources include downloadable guidance and compliance materials.
Green Building Certification Institute (GBCI)	Organization	GBCI	"GBCI drives implementation of the LEED green building program" (source). "The U.S. Green Building Council (USGBC) is a mission-driven, membership-based nonprofit organization that created the LEED rating system and is responsible for maintaining it" (source). "Together, USGBC and GBCI have created an organizational ecosystem that provides real-time adaptability and a future-proofing LEED development and implementation process" (source).

GreenBuildingXML	Open Schema	gbXML	"The Green Building XML schema, or 'gbXML,' is the language of buildings. It was developed to facilitate the transfer of building information stored in CAD-based building information models, enabling interoperability between disparate building design and engineering analysis software tools. This is all in the name of helping architects, engineers, and energy modelers to design more energy efficient buildings."
IBPSA: International Building Performance Simulation Association	Organization	IBPSA-USA	"The mission of IBPSA-USA is to advance and promote the science of building simulation in order to improve the design, construction, operation, and maintenance of new and existing buildings in the United States." Offerings include: • BEM Book Wiki • Education on Demand, videos/training on demand • BEM Library • BEMCyclopedia • BEST Directory
Institute for Market Transformation (IMT)	Resource Library	IMT	"IMT's resources provide clear guidance and insights into the most vital building performance issues facing local governments and businesses across North America. Whether you are a building owner or tenant taking first steps to control energy use, or a Mayor or city sustainability director looking to take the next leap in harnessing the benefits of energy efficiency, IMT has technical and policy resources that can help you drive deeper investment in higher performance and greater savings in buildings. Browse [their] reports, guides, case studies, infographics, and more below or create a custom search to find the resources that best meet your needs."
IOU Energy Education Centers	Learning Center	SCE, PG&E, SDG&E, SoCalGas	Offer a variety of training, on-demand courses, tools, and more, both in-person and online. The IOU Energy Education Centers offer courses in BEM topics, spanning energy codes and standards, building energy simulation, building performance, software, and more. Course offerings vary based on the center. SCE Online Classes Locations: Irwindale, Tulare PG&E Education Programs Locations: Stockton, San Ramon SDG&E Classes Location: San Diego SoCalGas Classes Location: Downey

National Renewable Energy Laboratory	Research Center	NREL	The website provides access to NREL publications and other tools for BEM professionals.
New Buildings Institute (NBI)	Organization	NBI	"NBI has worked collaboratively for more than 20 years with industry market players that include governments, utilities, energy efficiency advocates and building professionals to promote advanced design practices, innovative technologies, public policies and programs that move buildings to zero energy and zero emissions. Our work falls into three major program areas (Getting to Zero Leadership, Building Innovation, and Advanced Codes & Policies) and includes three key markets where our efforts can make the largest impact. NBI staff members can help your organization achieve zero energy and zero carbon emissions." They also offer tools and guides and case studies for this purpose.
Northwest Energy Efficiency Alliance	Professional Development Training Courses for BEM	Northwest Energy Efficiency Alliance	"The Northwest Energy Efficiency Alliance (NEEA) is an alliance of utilities and energy efficiency organizations that pools resources and shares risks to transform the market for energy efficiency to the benefit of consumers in the Northwest." They provide residential and commercial and industrial training resources.
OneBuilding	Support Group	Gard Analytics	This is a series of mailing lists and forums for support on different BEM Software and applications.
OpenEI	Resource Tool/Sharing	NREL	"The building energy technologies page is a source of freely accessible information on energy usage in the building industry as well as tools to improve efficiencies."
Pacific Northwest National Laboratory	Research Center	PNNL	The website provides links to PNNL publications on BEM and other tools for BEM professionals.
Project StaSIO	Resource Tool/Sharing	IBPSA	"Project STASIO aims to provide supporting content on inputs, outputs, and case studies around the first three 'modeling cycles' defined by the ASHRAE 209 standard."
Software-Specific Training	Professional Development Training Courses for BEM	Software companies	BEM software companies offer training courses and customer support to train users on their software. These courses may be offered to individuals or organizations and may be live or on-demand.
	Learning Center	Energy-Models.com	"Energy-Models.com is a site for energy modelers, building simulators, architects, and engineers who want to learn the basics, to advanced concepts of energy modeling. Includes online training courses and tutorials for eQUEST, Trane TRACE 700, OpenStudio, and LEED for energy modeling." All energy modeling courses are video based.
U.S. Department of Energy Emerging Technologies Website	Organization	U.S. Department of Energy	Landing page for the DOE's involvement with BEM, including presentations, resources, software, and projects.

UCLA - Energy Atlas	Tool	UCLA	"The Energy Atlas is a database of building energy consumption that links utility account information to building characteristics, sociodemographic data, and other significant attributes that can be expressed spatially. The public portion of the Energy Atlas is a front-end website which displays spatially aggregated energy consumption statistics at an annual temporal resolution for most neighborhoods, cities, and counties in Southern California."
UnMetHours	Resource Tool/Sharing	Big Ladder Software	This is a Q&A website for Building Energy Modelers. They also have some training workshops listed.
US Green Building Council	Organization	USGBC	The US Green Building Council hosts and provides educational courses in BEM, including BEM for LEED.

Appendix 4: BEM Certifications

Name of Certification	Organization / Institution	Short Description
Certified Energy Analyst (CEA)	CABEC	This is a comprehensive examination for California Energy Analysts that incorporates California energy code standards.
Associate Energy Analyst (AEA)	CABEC	This is meant as a stepping stone towards CEA for those who are still working on getting experience with the Standards and energy modeling.
Building Energy Modeling Professional (BEMP)	ASHRAE	"An ANSI-Accredited Personnel Certification Program under ISO/IEC 17024 (#1139), validates competency to model new and existing buildings and systems with the full range of physics; and evaluate, select, use, calibrate and interpret the results of energy modeling software where applied to building and systems energy performance and economics" (source).
Building Energy Simulation Analyst (BESA)	AEE (Association of Energy Engineers)	They are no longer accepting new applications – only renewals. "AEE's Building Energy Simulation Analyst (BESA™) professional certification is designed to recognize individuals with special expertise and experience in the area of utilizing building energy simulation software to assess a facility's energy performance" (source).
Certified Energy Manager (CEM)	AEE	"The Certified Energy Manager is an individual who optimizes the energy performance of a facility, building or industrial plant. The CEM® is a systems integrator for electrical, mechanical, process and building infrastructure, analyzing the optimum solutions to reduce energy consumption in a cost effective approach" (source).
Building Energy Modeling Graduate Certificate	BCIT - British Columbia Institute of Technology	The certification is a series of courses that assess Building Science, Building Energy, and Management & Communication skills.
Home Energy Rating System (HERS) Rater	RESNET - Residential Energy Services Network	"A Certified Home Energy Rater or Rater is a person trained and certified by an accredited Home Energy Rating Provider to inspect and evaluate a home's energy features, prepare a home energy rating and make recommendations for improvements that will save the homeowner energy and money" (source).

Appendix 5: Teacher Training and Curriculum

Name of Resource	Type of Resource	Target Audience	Short Description
Society of Building Science Educators	Organization	University Building Science Educators	The Society of Building Science Educators offers teaching resources, a listserv, and even full courses, accessible with a membership. Some resources include BEM.
Advanced Transportation and Logistics Building Energy Analysis and Audits	Curriculum	Community Colleges	This is a 4-semester community college curriculum for commercial building energy analysis and audits. It includes syllabi and slides.
IBSPA-USA Education Committee	Organization	IBPSA-USA members	They support professional development and education for IBPSA-USA members. One interviewee highlighted an event that allowed faculty to share syllabi and get feedback.

Appendix 6: Building Energy Modeler Roles and Use Glossary[45]

Architectural design: Architects, engineers and consultants use BEM during the design phase to inform cost and energy savings decisions and for daylight and facade modeling.[46]

Contractors: As consumers of energy models, contractors have an important role in creating budgets and timetables and hiring energy modelers for demonstrating code compliance, so it is essential that they have an understanding of the scope of BEM and its potential uses for energy efficiency and cost-saving measures.

***Title 24 Compliance Energy Consultant*:** According to CABEC, an energy consultant will:

- "Choose the compliance method which meets the client's goals, whether that be least cost construction or the most energy efficient structure...
- Use the method of choice with an approved computer program and provide an energy compliance package for building department approval.
- Know any local jurisdiction idiosyncrasies to assure that their Title 24 report will proceed smoothly through the plan check process.
- Advise the client on a variety of matters such as upcoming changes in the Energy Standards; new energy saving equipment, appliances and devices; the latest information on new types of insulation, glazing and other building components."[47]

HERS rater: RESNET describes a HERS rater as, "an individual who is certified by an accredited Rating Provider to inspect and test a home in order to evaluate each of the minimum rated features and complete a Home Energy Rating according to the RESNET Standards."[48]

HVAC design and testing: The U.S. Department of Energy notes that "BEM can help engineers design and size [HVAC] systems that are both cheaper and more energy efficient."[49]

New building development: BEM practitioners focusing on new building development will often incorporate BEM for comparing design alternatives, code compliance, and third-party green building certification.

Measurement and Verification: The Rocky Mountain Institute describes a process of developing "a calibrated model representing the existing building to establish baseline conditions to support a Measurement & Verification approach."[50]

---

[45] This appendix was prepared with assistance from Erik Kolderup.
[46] "Building Energy Modeling 101: Architectural Design Use Case," 2017, US Department of Energy.
[47] "Hiring an Energy Consultant," CABEC.
[48] "HERS Raters," RESNET.
[49] "Building Energy Modeling 101: HVAC Design and Operation Use Case," 2017, US Department of Energy.
[50] "Building Energy Modeling for Owners and Managers: A Guide to Specifying Services," 2013, Ellen Franconi, Kendra Typper, Blake Herrschaft, Craig Schiller, and Robert Hutchinson, Rocky Mountain Institute.

Performance rating: According to the U.S. Department of Energy, "inherent performance rating is the basis of procedures such as compliance-demonstration for codes…, green certification via programs like USGBC's LEED, the calculation of asset ratings such as DOE's Energy Asset Score, and performance documentation for tax credits and utility incentives."[51]

Policy: BEM practitioners in the policy space focus on energy policy and code/standards development. While municipal and state governments and utilities drive this type of energy modeling, they may employ the expertise of consulting firms and research institutions to help develop energy policy and codes/standards.

Retrofits: BEM practitioners focusing on retrofits will often use BEM and energy audits to evaluate potential savings for improvements.

Research: BEM researchers may conduct research for policy development, software development, or in an academic context.

Software: BEM practitioners in software roles may have job tasks such as debugging software, researching code, making software improvements, investigating software features, providing training or resources on the energy modeling software, and supporting clients with their questions.

Stock analysis: This large-scale analysis can be used both to inform policy and for a single project.[52]

Uses for building energy modeling:

- California energy code compliance
- Other energy code compliance
- Green building certification (e.g., LEED)
- HERS rating
- California utility incentives (e.g., Savings By Design)
- Other utility incentives
- New building design support – comparative analysis
- New building design support – predictive analysis
- Existing building energy performance verification
- Existing building retrofit alternative analysis
- Value engineering support
- Research
- Policy development
- Product development

[51] "Building Energy Modeling 101: Inherent Performance Modeling Use Case," 2017, US Department of Energy.
[52] "Building Energy Modeling 101: Stock-Level Use Case," 2017, US Department of Energy.

Energy modeler roles and titles

- California energy code compliance consultants
- Energy efficient design consultants
- HERS raters
- MEP design firm staff
- Architecture firm staff
- Policy development consultants
- Researchers
- Energy performance contracting firm staff
- Existing building consulting energy firm staff
- BEM software developers

Consumers of BEM results

- Building departments
- Building owners/developers
- Design architects
- MEP design engineers
- Utility staff
- Green building certification reviewers
- Contractors
- Policy developers
- Manufacturers

Uses for BEM	Energy Modelers	Users of BEM Results
California energy code compliance	• California energy code compliance consultants • Energy efficient design consultants • MEP design firm staff	• Building departments • Design architects • MEP design engineers • Contractors
Other energy code compliance	• Energy efficient design consultants • MEP design firm staff	• Building departments • Design architects • MEP design engineers • Contractors
Green building certification (e.g., LEED)	• Energy efficient design consultants • MEP design firm staff	• Green building certification reviewers
HERS rating	• HERS raters	• Building departments • Building owners/developers
California utility incentives (e.g., Savings By Design)	• California energy code compliance consultants • Energy efficient design consultants • MEP design firm staff	• Utility staff

Other utility incentives	• Energy efficient design consultants • MEP design firm staff	• Utility staff
New building design support – comparative analysis	• California energy code compliance consultants • Energy efficient design consultants • HERS raters • MEP design firm staff • Architecture firm staff	• Design architects • MEP design engineers • Building owners/developers
New building design support – predictive analysis	• Energy efficient design consultants • MEP design firm staff	• Design architects • MEP design engineers • Building owners/developers
Existing building energy performance verification	• Energy efficient design consultants • MEP design firm staff • Energy performance contracting firm staff • Existing building energy consulting firm staff	• Building owners/developers • Utility staff • Contractors
Existing building retrofit alternative analysis	• Energy efficient design consultants • MEP design firm staff • Energy performance contracting firm staff • Existing building energy consulting firm staff	• Building owners/developers • Design architects • MEP design engineers • Utility staff • Contractors
Value engineering support	• California energy code compliance consultants • Energy efficient design consultants • MEP design firm staff	• Contractors • Building owners/developers • Design architects • MEP design engineers
Research	• Researchers	• Researchers
Policy development	• Energy efficient design consultants • Researchers • Energy efficient design consultants	• Policy developers • Utility staff
Product development	• Energy efficient design consultants • Researchers	• Manufacturers