COLLABORATE AND CAPITALIZE:
Post-Report from the BEM Innovation Summit

in partnership with

AUTHORED BY
Rocky Mountain Institute

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Official Summit Partners

- ASHRAE: American Society of Heating, Refrigeration, and Air-Conditioning Engineers
- IBPSA-USA: United States Regional Affiliate of the International Building Performance Simulation Association
- IMT: Institute for Market Transformation
- USGBC: U.S. Green Building Council

While these entities were official summit partners, their partnership does not imply an endorsement of all statements, problem prioritization and solutions proposed in this Summit Post-Report.

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1 INTRODUCTION

IN MARCH OF 2011, Rocky Mountain Institute (RMI) convened an invited group of key stakeholders within the building energy modeling community to increase collaboration and develop implementation plans to address key barriers. This report:

- Briefly describes the motivation for convening the Building Energy Modeling (BEM) Innovation Summit
- Provides a recap of the group events and discussions from the Summit
- Provides a detailed summary from each breakout group
- Presents "implementation plans" for some key action items and projects that came out of each breakout group's work over the 2-day Summit

The intent of this summary report is to document what occurred at the Summit but also, more importantly, to motivate others within the energy modeling community to join this collective effort to capitalize on the numerous opportunities to improve the use of and processes for energy modeling.

For more information on the history and current state of the energy modeling industry within the United States, refer to the Pre-Read report, located on the BEM Summit website. The Pre-read also begins to identify tasks to advance the future of energy modeling and identify gaps and barriers between the current and desired state.

Additionally, RMI wrote nine "Pre-Proposals" after the Summit, as an attempt to further flesh out the implementation items identified by the breakout groups. Please go to the BEM Summit website to download these Pre-Proposals. The Pre-Proposals were developed solely by RMI and do not represent the consensus of all Summit attendees. RMI intends for these Pre-Proposals to be a starting point for anyone pursuing funding for these efforts and anticipates that the group that is championing each effort will edit these as needed. As you read this report, think about how you and your organization would like to be involved. Please visit this online form to indicate your interest in either funding or contributing to these efforts.

2 BEM INNOVATION SUMMIT: BACKGROUND

THIS SECTION OUTLINES why the building energy modeling community needed the Summit, proposes what we could achieve if the Post-Summit work accomplished its goals, and provides more details on the actual event. Please refer to the Summit website for more information on the event, including links to blogs and live videos.

2.1 Problem Statement

Reliable and consistent whole-building energy and financial analysis is necessary to achieve increasingly aggressive performance targets in the buildings sector, and to motivate building owners to invest in energy efficiency. To meet today's market needs, the number of energy modeling practitioners has increased dramatically in a short period of time. These practitioners must follow complex modeling and reporting procedures, and very few have received formal training. Aggressive building design schedules also place additional pressure on the modeling process.

During the rapid growth of this industry, professional organizations, national labs, and even private consulting firms, have all made great contributions to the field of energy modeling. Despite these intentional (and often self-funded) efforts, there is a need for more collaboration among these various stakeholders, and many opportunities still exist to increase the effectiveness of modeling to support low energy building design and operations. In order to realize these opportunities, we need to address several issues within the industry, as shown in Figure 1.

Figure 1: Issues within the Building Energy Modeling Industry

1	Lack of CREDIBILITY: Customers (of energy modeling services) and other stakeholders do not have confidence in energy modeling results, for the following reasons: • *Lack of Quality*: Energy modeling results may not reflect realistic building energy consumption and costs. • *Lack of Reproducibility*: Different practitioners do not produce the same energy modeling results, even when using the same tools and building characterization data. • *Misguided Expectations*: Customers do not have a clear understanding of what modeling can and should provide. • *Difficulty in Assessing Skills*: It is difficult for customers to assess the skill level of a practitioner.
2	Limited Time for CRITICAL THINKING: Currently, practitioners do not spend the majority of their time on critical thinking and informing design.
3	Need for More EXPERIENCED AND SKILLED Practitioners: A limited number of energy modelers possess sufficient skills and experience.
4	Low MARKET DEMAND: The demand for and value of energy modeling services could be much higher.

2.2 Why a Summit? Why Now?

The need to identify best practices and deliver quality tools for performing in-depth performance analysis has never been greater. RMI believes that the challenges outlined in Figure 1 could benefit greatly from simply convening stakeholders within the energy modeling sector and starting a collaborative dialogue. Industry organizations such as ASHRAE, IBPSA-USA, USGBC, and IMT are playing a large role in influencing the energy modeling industry, and recognize the importance of collaborating with other efforts taking place. By coordinating and building upon these efforts, we can truly capitalize on the opportunities that exist for continued growth and success.

2.3 Objective

The objective of this event, and any follow-up efforts that occur, is to collaborate and capitalize on the biggest opportunities for building energy modeling to support widespread solutions for low-energy buildings with reduced electric demand.

2.4 Attendees

In addition to RMI personnel, approximately 55 invited guests attended from the following stakeholder groups:

- Software developers of building energy use simulation tools and Building Information Modeling (BIM) tools
- Expert building energy modeling practitioners and educators
- Key representatives from the Department of Energy (DOE) and national labs
- Decision makers from professional and industry standards organizations

Please refer to Appendix A for biographical summaries for each attendee, and visit the BEM Summit website to read vision statements from the attendees.

2.5 Industry Partners

The BEM Innovation Summit was a Rocky Mountain Institute event, developed in partnership with the following organizations:

- ASHRAE: American Society of Heating, Refrigeration, and Air-Conditioning Engineers
- IBPSA-USA: United States Regional Affiliate of the International Building Performance Simulation Association
- IMT: Institute for Market Transformation
- USGBC: U.S. Green Building Council

Together these organizations worked with RMI in a spirit of collaboration and partnership to mutually promote an effective, coordinated improvement of the building energy modeling industry through the BEM Innovation Summit.

3 BEM INNOVATION SUMMIT: RECAP

THE BEM INNOVATION SUMMIT was a two-day event that combined targeted discussions and activities among the larger group with smaller breakout group working sessions that addressed more discrete parts of the problems. After some opening talks to kick-off the event, the first day featured two panel discussions focused on:

1. The needs of practitioners and customers
2. The perspective of the software developers

These facilitated question and answer sessions helped prepare each breakout group for the work they would do within their focus area. Summit attendees also participated in live debates and rapid-fire "Ignite" sessions, where they expressed their thoughts on the future of energy modeling within a 60 second sound bite. Please visit the RMI Blog for additional write-ups and video footage of the event, and visit RMI's Facebook page to see event photos.

> *This is a collection of the best and brightest, and I think this [Summit] is going to set the stage for where we're going in the next decade.*
>
> LYNN G. BELLENGER

3.1 Opening Talks

Current ASHRAE President Lynn G. Bellenger, P.E., opened the BEM Innovation Summit by outlining her vision of building energy modeling in the year 2025. Lynn envisions design teams taking advantage of energy modeling from early concept design through to operation. BEM training will consist of less experienced analysts paired with skilled experts, and all modelers will have a sufficient understanding of building physics. Simulation tools will be robust enough to not only assess energy use but also acoustics, thermal comfort, and air quality. In 2025, BIM models will seamlessly interface with energy models as well as freely available weather information in a standardized format.

In this future, equipment manufacturers will provide necessary performance data in accordance with ASHRAE Standard 205, and all simulation programs will follow these protocols. Companies that develop new systems will contract with the national labs to model these systems and make the algorithms available in the public domain. Lynn's vision highlighted enormous potential for building energy modeling – a potential that this community can realize only with greater coordination and partnership.

> *I think we're all on a very similar page. If we were able to assess our values and our motivations for how and why we came to the field of practice that we're in, I think we'd find that there are a lot of similarities.*
>
> JAMES BREW

Next, James Brew, AIA, a principal at RMI, urged conference attendees to think outside of the box and collaborate. Arguing that stories are more powerful than facts or statistics, he stressed that compelling stories can help us avoid the "curse of knowledge" that often prevents the conception of new ideas. James encouraged attendees to recognize the power of collective action. He noted the amount of "cognitive abundance" convened at the Summit, and challenged everyone to envision what the industry would look like if it were a collective in which people continually improved the tools.

3.2 Practitioner and Customer Needs Panel

The Practitioner and Customer Needs Panel brought together eight customers and practitioners of energy modeling to discuss what they need from the building energy modeling industry going forward.

THE EIGHT PARTICIPANTS WERE:

ELLEN FRANCONI
Rocky Mountain Institute

DJ HUBLER
Johnson Controls

PEGGY YEE
U.S. General Services Administration

BILL WORTHEN
American Institute of Architects

GAIL HAMPSMIRE
Green Building Certification Institute

TOM WHITE
Green Building Services

LINDA MORRISON
Ambient Energy

ERIK KOLDERUP
Kolderup Consulting


The discussion started with an introductory statement from each panelist, and nearly every panelist highlighted a different problem within the industry. DJ Hubler noted that most people consider energy modeling to be a black box exercise, and expressed the difficulty in getting people to buy into huge energy savings if they don't understand how the savings were calculated. Bill Worthen observed that architects don't speak the same language as energy modelers, quipping, "What you call geometry is what we call design."

Tom White added that when he hires new graduates, they are great at using the software tools, but lack a basic understanding of how building systems are actually applied and interact in real life.

With introductions out of the way, moderator Mike Brandemuehl (ASHRAE/CU Boulder) moved onto the first question, *"What would you like to see as improvements from the tools?"* Several panelists agreed that there were a lot of time-saving opportunities for software tools by automating certain tasks, such as baselines and calibration. Erik Kolderup added that giving smart guidance to energy modelers within software tools would be a short-term, high-value item.

The next question addressed professional certification: *"How do you communicate that you have the level of judgment that is required? What role could certification play?"*

MOST PANELISTS AGREED *that a widely recognized and credible certification was critical to the advancement of the industry. Peggy Yee noted that past performance should be a component of certification. As the industry moves toward performance-based contracting, building owners and stakeholders must be able to hold designers and energy analysts accountable for their work.*

Dr. Brandemuehl continued, *"What support do current practitioners need? What resources are available? What are the biggest gaps – data on loads, how to model?"*

Tom White thought that the current list-serves were the most comprehensive resource available, but that they are not comprehensive enough in isolation. Ellen Franconi added that the energy modeling community would benefit from an organization taking the initiative to put together all the fragments of knowledge into a central location. Bill Worthen noted that consistency was more important than accuracy, stressing that it's hard to build trust if everyone's results are wildly different.

This led to the next question: *"Is accuracy a problem?"* Gail Hampsmire asserted that we must always be driving toward accuracy, but that the current requirements of practitioners often get in the way. Baselines and compliance models dominate the modeler's time and as a result, there are usually little resources left over for actual design assistance. Also, the lack of available operational data is a problem. Practitioners could use this data to calibrate and better understand the energy model. Peggy Yee added that accuracy is critical if we want to move toward performance-based codes, which segued nicely into the final question. *"Do regulations or contracting need to change?"*

ERIK KOLDERUP ECHOED THE EARLIER STATEMENTS *saying, "What we're really trying to do is get energy modeling used early." He continued, "Performance requirements, asset rating requirements, absolute energy standards…will start getting people thinking about this earlier." The panel agreed that a primary goal of energy modeling is to inform design and support low energy building design and operations.*

3.3 Software Developer Panel

The Software Developer Panel provided an opportunity for modeling-tool developers to share their industry perspectives with the other BEM Summit participants. Mike Brandemuehl again facilitated this audience–driven question and answer (Q&A) activity, which gave participants a unique opportunity to ask questions of some of the most prominent energy modeling software developers in the industry. The panel was comprised of six professionals from different firms that develop whole-building simulation modeling tools.

In expressing how they prioritize tool development efforts, the panelists agreed that the most important information resource was the customer. Most tool development firms currently incorporate customer feedback as part of the development process, maintaining close customer connections and aiming for continuous input. Jeff Hirsch pointed out that upgrading a simulation program to better meet customer needs requires committing significant staffing resources and financial investment to the effort. Thus, it is important to take a long-term view in charting a path forward. In addition, customers' needs may change over time. Upgrades should be highly relevant and impact a large percentage of customers.

The solution techniques and level of detail used in whole-building simulation tools, especially in the way that the HVAC system and plant are modeled, have a large impact on ease-of-use and performance. For example, eQUEST/DOE-2 models the HVAC in fixed configurations, which reduces user inputs as well as runtimes. Programs like TRNSYS and EnergyPlus provide more flexibility in modeling HVAC configurations, which requires more user effort in defining the HVAC system. Tim McDowell acknowledged that, currently, the more structured programs tend to be easier to use, while the more modular/flexible programs require additional modeling time. Matt Biesterveld added that selecting or sequencing the use of the different types of tools should be a complimentary and standard practice for modelers. However, selecting the right tool for the task requires professional judgment.

Michael Wetter (IBPSA-USA/LBNL) described a different approach, followed by IDA/ICE and Modelica, to make a single tool that is usable for different types of applications and users (e.g. architects and. engineers). The developers of IDA/ICE and Modelica handle this through the graphical interface and use of default values. But software developers could also design modeling programs such that the algorithms used in the analysis vary along with the interface to better support a range of applications and types of users.

THE SIX PARTICIPANTS WERE:

DRU CRAWLEY
Bentley Systems
AECOsim Energy Simulator

TIM MCDOWELL
Thermal Energy System Specialists
TRNSYS

MATT BIESTERVELD
Trane Commercial Systems
TRACE

DON MCLEAN
IES Virtual Environment
IES VE

BRENT GRIFFITH
National Renewable Energy Laboratory
EnergyPlus

JEFF HIRSCH
Jeff Hirsch Associates
eQUEST

When questioned about typical areas of concern for tool refinement, Jeff Hirsch highlighted the following:

1. Accuracy of algorithms
2. Availability of usage data for confirming algorithms
3. Program interface and documentation

Dru Crawley mentioned other development considerations such as meeting customer application needs for voluntary green building programs (i.e. LEED) and code compliance (ASHRAE 90.1, IECC, etc). The panelists further identified two high priority items for simulation tool evolution – interoperability and communicating to the industry the types of projects to which simulation models should be applied to, for the purpose of supporting design and operational decisions.

Peter Alspach (Arup) noted that as developers increase tool capabilities to better capture passive systems and built environment (e.g. air quality) modeling, there will be a need for more sophisticated validation. This presents a challenge to the industry. Brent Griffith responded by stating that assigning the responsibility of integrated-design model validation to the developers would over burden them. In addition, it would necessitate developers validating multiple simulation engines. However, developing tools using interoperable modules would lead to shared validation efforts.

The panel further clarified that monitored performance data are required to complete validations of passive and environmental modeling. Current methods relying on utility-level metered data and shoebox models are not sufficient. Don McLean anticipates that improved data for completing validations and sensitivity testing will become more available as modeling applications start to embrace hybrid models, which use calibrated design models to inform building operating strategies.

As the lively Q&A continued from the audience, the panelists began to debate the pros and cons of the public funding of modeling tools. Some panelists felt public funding (e.g. from the U.S. Department of Energy – DOE) encroached upon the competitive market and constrained innovation. Others expressed concern that public funding was devaluing the real costs associated with private-sector tool development, since one cannot compete against a free tool. The panelists then conveyed a common desire to see DOE invest in efforts that are more generic and can be applied across products. In light of the fact that there is an incredible amount of necessary work to do within algorithm development, interoperability, field work, etc., Jeff Hirsch suggested that DOE fund things that smaller, private companies cannot accomplish. This would include massive data gathering efforts that require lab and field work, as well as other longer term commitments.

Lynn G. Bellenger (ASHRAE/Pathfinder Engineers & Architects) reminded the group that ASHRAE research projects have filled such needs in the past (e.g. algorithm development completed as part of the ASHRAE Modeling Toolkits). Dru Crawley responded, "One of the frustrations I've had is that the toolkits [ASHRAE] develops have copyrights which don't allow re-use of the models. It would be nice to have them freely available for re-use." Lynn, as the cuurent ASHRAE president, committed to follow up on this issue, to ensure that the industry can benefit from ASHRAE's work.

AMIR ROTH, *program manager for building performance simulation tools at DOE presented the public side of the tool-funding debate. While DOE recognizes potential conflicts between its own tool development and commercial efforts, Roth believes that they can minimize this interference. DOE is looking to alleviate some of these concerns and tensions by being more transparent about the goals of their tools efforts and roadmaps, by explicitly working with companies to develop capabilities that will benefit the entire industry, and by (hopefully) opening up their licensing. DOE is committed to advancing the future of BEM and continuing to provide, enhance, maintain, and support a state-of-the-art BEM engine. DOE believes that it is uniquely positioned, and even obligated, to lead this effort by pulling together the capabilities and expertise of the national labs, universities, and private companies.*

3.4 Talking Heads: Live Debates

The intent of the Talking Heads debates was to address two big questions posed again and again by participants throughout the planning of the Summit:

1. How much building physics expertise should be required of an energy modeler?
2. To what extent should the modeling process be automated?

Attendees addressed these questions at the Summit in two separate debates moderated by Mike Opitz, representing USGBC. The intent was not to "win" or "lose" the debate, but to offer the plenary session a full range of important considerations when thinking through these questions, the answers to which will play a big role in shaping how industry leaders approach the long-term outlook and development of energy modeling.

Debaters: Dan Nall, WSP Flack and Kurtz, and John Bacus, Google SketchUp brought the following perspectives to the first debate question.

1. How much building physics expertise should be required of an energy modeler?

A LOT OF EXPERTISE SHOULD BE REQUIRED

- Users need to have a qualitative understanding of what is going on inside the tool and be able to compare the outputs to their expectations (which means they should have enough expertise to have reasonable expectations). Otherwise, they won't be able to understand why the deviation occurred, or to use the results to guide the design process.
- Users should be limited to doing studies where they understand the meaning of the inputs, and the implications of the outputs. The point is to be able to use modeling to reinforce qualitative causal models.
- Basic understanding of the causal mechanisms that led to the model outputs are much more useful for guiding smart design than 1,000 uninformed energy modeling iterations.
- Even when energy modeling is done early on (i.e. Schematic Phase) and is relatively simple, results can be used incorrectly – or not at all – if the practitioner does not have enough know-how to analyze the outputs.
- In the absence of appropriate training or knowledge, people can't draw the right conclusions from data that is staring them in the face.
- There is a place for early design analysis, such as massing studies, that can and should be done any design team member, but this is NOT full blown energy simulation.

THIS SHOULD NOT BE A REQUIREMENT

- Anyone involved in the design or retrofit of a building, with an interest in building performance should be able to do an energy analysis. Users need to have minimum competencies (i.e. completed architectural training) but not explicit building science training.
- Everyone designing buildings should be able to do analysis early and often while striving toward an excellent solution. While a building physics expert is still immensely useful on a design team, there are multiple and continuous opportunities for non-technical people to improve the design.
- There are a million models made every week in Sketchup. Surely, we can do something with that value! The more solutions you have on the table, the greater proportion of good decisions you'll have to bad.
- "What is the value of a sketch using a pen and a piece of trace paper? I think it has considerable value…Does it automatically perform complex analysis? Well, obviously no. Can it lead you in the correct direction? Probably, yes. Sketchup is your pen and paper."
- When you make tools available early in the design, and available to many types of users, there is more of a burden on the tool to prevent misuse and automate more functionality. These types of tools need to clearly convey to the users what the tool can and cannot do, and how it should be used.

2. To what extent should the building modeling process be automated?

Debaters: Godfried Augenbroe, Georgia Institute of Technology (far left), Vladimir Bazjanac, LBNL (center left), Chip Barnaby, ASHRAE/Wrightsoft (center right), John Kennedy, Autodesk (far right).

Mike Opitz kicked off the second debate with the question, *"What level of automation do you support?"* This question solicited a wide range of fiery responses, but even the most pro-automation participant, John Kennedy, agreed that 100% automation was not a possibility or a goal. As Kennedy voiced, "I don't think we can get fully automated. There are lots of risk and liability in the performance of a building, and there is no way anyone is going to rely on a single-button click."

Two major points emerged to explain why a "single-button click" was not possible. On the one hand, the design community still does not completely understand the energy modeling process. As Godfried Augenbroe stated, "Automation is about process, not software. You can't automate what you don't understand. We have so little understanding about the tools and the types of tools that can give us confidence in certain points in the process – automation is futile!" Vladimir Bazjanac continued, "What you can automate are things – data, specifically – that have been created by somebody else who is contractually responsible for the delivery of that data… but you cannot automate people's decision making… so when I talk about automation, I always talk about 'semi'-automation."

Chip Barnaby was in favor of automating those aspects of the process that didn't require building physics judgment or decision-making. For example, many aspects of the energy modeling process have evolved to address regulatory requirements, i.e. generating a baseline or submitting forms to comply with various regulatory entities. He proposed that stakeholders in the room convene committees or entities to clearly set out these processes and "run them to the ground." When fully detailed and straightforward, developers could implement these processes within the software tools, leaving practitioners with more time for critical thinking. Vladimir Bazjanac countered, "Data transformation is more complicated. You have to transform [data] into a format that is acceptable for simulation. The problem today is human intervention in the data transformation, which is totally arbitrary. The whole point is data integrity."

IN SUMMARY, *Godfried Augenbroe proposed, "Automation is much more than some interface that transports data from here to there between data items. [It should be] processes we do as humans, uploaded into a computer in a way where they provide new value to the process." He added, "This value is fairly limited and not well-supported," which was for this group, of course, highly debatable.*

3.5 Breakout Group Sessions

RMI dedicated a significant portion of time at the Summit to working sessions in smaller breakout groups (10-15 people). These groups worked together to identify critical needs that require immediate action, prioritize efforts, and brainstorm solutions within the following broad categories related to energy modeling. Although there was significant overlap across these groups, we have summarized the scope of each breakout group in the figure below:

Table 1: Scope of Breakout Groups

METHODS AND PROCESSES	SIMULATION ENGINES AND PLATFORMS	EDUCATION, TRAINING, AND CERTIFICATION	MARKET DRIVERS AND CUSTOMER DEMAND	SUPPORT AND RESOURCES
➢ How might we modify methods and processes to maximize modeler effectiveness? ➢ What aspects of the modeling process should we standardize and/or automate? ➢ Does this vary according to the end use of the model?	➢ How might simulation tools better serve the industry? ➢ What do software developers need in order to improve their development efforts? ➢ Identify critical gaps and immediate needs for tools to streamline the modeling process.	➢ What is the best way to develop a skilled and experienced workforce? ➢ Who should we be educating and how should they be educated? ➢ This includes professional development as well as University curricula. ➢ What should be the role of professional certification programs for practitioners? ➢ How can we improve the current certification programs?	➢ What market demand shift is required to support the best uses of building energy modeling? ➢ What are the most impactful uses of BEM? ➢ What is the value proposition for each of these uses? ➢ What is the overall market potential and what are the untapped markets?	➢ What are the gaps in supporting resources that currently exist when a practitioner has a question or needs data, during the energy modeling process?

The following sections provide a summary of each breakout group session and the implementation plans that each group developed. RMI took all of the ideas and documentation generated by the groups, including diagrams, detailed notes, and slides that each group shared in the report out sessions, and synthesized the information into these summaries.

4 BREAKOUT GROUP SUMMARY: METHODS AND PROCESSES

GROUP MEMBERS

David Reddy
360 Analytics

Ron Nelson
Institute for Market Transformation

Linda Morrison
Ambient Energy

Lane Burt
USGBC

Gail Hampsmire
Green Building Certification Institute

Tom White
Green Building Services

Mark Frankel
New Buildings Institute

Phil Haves
Lawrence Berkeley National Laboratory

Steve Kromer
Energy Valuation Organization

Satish Narayanan
United Technologies

FACILITATOR

Ellen Franconi
RMI

NOTE TAKER

Mike Bendewald
RMI

* Dru Crawley and Joe Huang also made contributions to the group discussion

While the content presented in this Breakout Group section was developed in a collaborative process, it does not imply an endorsement of all statements and proposed solutions by each group member.

4.1 Executive Summary

The overall objective identified by the Methods and Processes group was to define a set of procedures that we could apply across common modeling applications and also communicate to the industry. Such an effort would support modeling consistency, reproducibility, accuracy and credibility in developing the business case for energy efficiency. Ideally, we would define procedures to address: the use of baselines, quality assurance, informative data sources, operating assumptions, the appropriate level of detail for benchmarking, calibration, uncertainty analysis, communicating results, and documentation.

Before we could delve into identifying procedures for any of these areas of need, we needed to consider a way to structure and identify the shared methods. As a start, we examined modeling elements across a dozen common applications. Our investigation considered: the application timing (occurring during design, construction/commissioning, operation, or retrofit), the basis of model input assumptions (standardized, projected, actual, or adjusted actual), and outcome format (yes/no, single performance value, or range of performance values). Our vision is to build from this initial investigation and develop a framework that identifies common methods across modeling applications. We would characterize the methods as being appropriate for either: 1) outlined procedures, 2) standardized methods, or 3) automated and incorporated directly into modeling tools. The framework and methods we plan to develop will lead to the creation of modeling guidelines. Specifically, we see our efforts culminating with the development of detailed work plans that funding agents will release through a request-for-proposal process.

4.2 Long Term Desired Outcomes

Our group desires that modeling methods be better defined so they can capably support current and upcoming energy-efficiency market drivers, such as: codes, disclosure requirements (e.g. asset ratings), and risk evaluation and mitigation. We also recognize that there is a need to define a continuum of modeling processes that we can apply over the building life cycle.

As energy modeling practitioners, we've experienced frequent misalignment between owner's expectations for modeling services and the modeler's actual scope of work. This contributes to the lack of credibility for modeling results and recommendations. We believe that we can accomplish better alignment between expected and delivered services by:

- Clarifying modeling terminology
- Differentiating modeling scopes of work that address performance comparisons (integrated design assistance), predictions (hybrid models), and validations (e.g. compliance)
- Communicating the responsibility of building services professionals (designers, commissioning agents, verification agents, operators) and tenants to achieve performance targets

Another factor that contributes to the lack of modeling credibility is the practice of reporting performance results as a single value instead of as a range of probable values. We can address this issue by adding uncertainty analysis into building simulation tools. Ideally, we would like to see plausible ranges of values identified (which are supported by field data) within simulation tools and used to generate a range of predicted performance values. Similarly, we believe modelers and customers would benefit from simulation tools incorporating sensitivity analysis capabilities. This would allow a modeler to show the customer the impact that a set of assumptions has on the results. Such an analysis helps the modeler identify and communicate the most important parameters that need specification.

Our group agreed that measurement and verification (M&V) provides the much-needed feedback loop for linking achieved performance with design predictions. However, practitioners apply M&V infrequently or cursorily due to its costs and value to the owner. The clarifications of modeling methods will help streamline some M&V processes (e.g. model calibration). Developing a continuum of modeling procedures throughout the building life cycle will also help. As we move towards meeting outcome-based performance requirements, M&V will support allocating achieved-performance responsibilities between building service professionals and tenants.

4.3 Current Business as Usual (BAU)

Due to a lack of defined methods, practitioners follow a variety of processes in delivering energy modeling services. In the modeling scopes-of-work, design professionals rarely differentiate between different types of applications (e.g. comparison, prediction, or validation). Potential customers do not see modeling as a service that they can use continuously throughout the building life. There is a lack of feedback linking achieved performance to design for improving future efforts.

Top Challenges

Consistent with the BAU, the group identified the top challenges for modeling methods and processes to be:

- Issues with consistency, reproducibility, and credibility, which stem from the lack of consistency in modeling methods
- Lack of modeling credibility is fueled by the mismatch between expectations of customers and the scope of services being requested
- Lack of feedback provided to designers and modelers due to limited M&V efforts and the discontinuity of modeling services being conducted over the building life cycle

Our group discussion revealed additional challenges, such as:

- Practitioners seldom practice sensitivity and uncertainty analysis due to the lack of standardized methods and the time required to perform it within existing software tools. This results in practitioners reporting a single predicted performance value instead of a probable range of performance values. This contributes to customers' expectations for models to closely predict actual performance.
- Lack of available data to support the definition of a range of input values
- Tools are currently incapable of effectively performing uncertainty/sensitivity analyses
- Methods need to be defined for assigning responsibilities between building service professionals and tenants for actual achieved performance through modeling and M&V

Current Players and Redundant Efforts

Several organizations are attempting to address these challenges. The Commercial Buildings Net Work (COMNET) represents a first attempt to standardize and automate part of the modeling process - the baseline building model development[1]. The Institute for Market Transformation (IMT) in conjunction with Architectural Energy Corporation (AEC) is developing COMNET and bringing it forth to the industry. Objectives for improving modeling methods and quality are motivating the development of COMNET. The issues identified by the Methods and Processes group are much broader than IMT/AEC's current focus on developing a rule set to translate building codes to simulation program input. However IMT could provide an umbrella role for improving modeling methods through standardization efforts.

ASHRAE technical committees, specifically TC 4.7, also address modeling quality issues and their efforts could support standardization of some modeling procedures. Joe Huang, chair of TC 4.7 Applications Subcommittee has offered to bring the Methods and Processes work plan to the subcommittee for consideration for inclusion in their work.

The International Building Performance Simulation Association (IBPSA-USA) is starting to address modeling procedures in its Building Energy Modeling (BEM) Workshops and Building Energy Modeling Book of Knowledge (BEM Book) wiki. IBPSA- USA is planning to facilitate the review of COMNET by the industry (including simulation software developers) to make it successful as an open-source application that is steered by broad industry input.

Through the Efficiency Valuation Organization (EVO), the International Performance Measurement and Verification Protocol (IPMVP) provides documentation on M&V procedures. EVO has plans to expand its document library to make their protocols more accessible to a wider audience and provide greater context for new M&V applications. This effort will provide an opportunity for the new M&V documents to align with the modeling Methods and Processes framework. They can also include specific guidance on allocating risk between designers and tenants for meeting outcome-based performance requirements.

These efforts all have merit but none of the players address the broad scope that our group identified for improving modeling methods. Because of the fundamental nature of the work and its over-arching implications on the building industry's ability to meet performance targets, we hope that the Department of Energy (DOE) will also get involved.

[1] The COMNET Modeling Guidelines and Procedures (MGP) establish two baselines (ASHRAE 90.1-2001 and 2007) with specific applications in mind -179D tax deductions and green building ratings. The 90.1-2010 is the next baseline to be implemented. Its methodology can be extended to support other applications as needed. Baseline buildings are constructed automatically with COMNET compliant software (yet to be implemented by vendors). As a complementary effort, COMNET seeks to define a quality assurance (QA) program that complements the ASHRAE BEMP certification. COMNET modelers would use procedures defined by its modeling guideline protocol for manual or automated modeling and would abide by other methods and procedures defined by the COMNET QA Committee.

4.4 Solutions

To address immediate needs in a timely manner, we will create a customer brochure to outline the differences in a modeler's scope of work for applications focused on 1) making performance comparisons to inform design, 2) making performance comparisons to demonstrate compliance, or 3) providing performance predictions.

Table 2 presents a list of modeling applications and the category that each falls into. Our effort to educate customers about the possible range of modeling levels-of-effort to better match service expectations with services delivered overlaps with similar efforts identified during the Summit by the Market Drivers and Customer Demand group. Thus, the two groups plan to coordinate their work in this area.

Table 2: Example List of Modeling Applications

APPLICATION NAME	DESCRIPTION	MODELING FOCUS		
		COMPARISON	COMPLIANCE	PREDICTION
Design ECM Evaluation	Evaluate energy efficient design alternatives	X		
Code Compliance	Evaluate design performance relative to a code baseline		X	
LEED Compliance	Evaluate design performance relative to a certification baseline		X	
Asset Rating	Assess performance based on components specified in design	X		
Efficiency Investment	Verify contractual requirements met per financing agreement		X	
Integrated Project Delivery	Assess performance improvements attributable to design team, operators, tenants	X		X
Measurement & Verification	Verify energy efficiency savings relative to a normative baseline			X
Performance Rating	Assess performance based on the post-occupancy energy use			X
Integrative Design Assistance	Evaluate integrated strategies for improved performance	X		
Operations	Evaluate impact of control and operational changes			X
Commissioning	Support diagnostics of components and systems			X
Outcome-based Code	Assess performance relative to an outcome-based target			X

Our group spent most of its time addressing broad considerations for developing modeling method improvements. We identified an initial set of key parameters we believed to be important to create a methods framework. These parameters, as indicated in Table 3, include: analysis timing during the building lifecycle, basis for modeling input, and results format requirements. The framework will support the grouping of methods across applications and serve as the backbone for the development of modeling procedures.

Table 3: Initial Categorization of Modeling Applications

APPLICATION	APPLICABLE LIFECYCLE PHASE	BASIS FOR BUILDING MODEL INPUT ASSUMPTIONS				OUTPUT TYPE
		STANDARDIZED	PROJECTED	ACTUAL	AJDUSTED ACTUAL	
Design ECM Evaluation	SD, CD, O, R	X				# <>
Code Compliance	SD, CD, O, R		X		X	Y/N
LEED Compliance	CD, C, O, R		X		X	Y/N (design); # (operation)
Asset Rating	SD, CD	X				#
Efficiency Investment	O, R		X	X	X	<>
Integrated Project Delivery						<>
Measurement & Verification	C, O, R			X	X	#, <>
Performance Rating	O, R	X				#
Integrative Design Assistance	SD, CD, O, R	X				<> (prediction); # (comparison)
Operations	O			X		#
Commissioning	C, O		X	X		#
Outcome-based Code	O				X	Y/N

TABLE KEY

Standardized – scheduling, plug and other operational input values based on standardized assumptions
Projected – scheduling, plug and other operational input values based on anticipated values
Actual – scheduling, plug and other operational input values based on observed/measured values
Adjusted Actual – scheduling, plug and other operational input values based on normative, pre-defined or agreed upon values

SD: Schematic design
CD: Design and construction documents
O: Operation
C: Construction
R: Retrofit
#: Single number
Y/N: Yes/No answer
<>: Number range

We envision that this set of procedures, or Methods & Processes Guidelines, would cover energy modeling for New Building Design, Retrofit, Operations, as well as the over arching process for Modeling throughout the Building Lifecycle. The Guidelines would be relevant to common modeling applications, as outlined below. The guidelines would address specific procedures for:

- Using baselines
- Performing quality assurance
- Using data sources for calculating input values
- Making operating assumptions
- Benchmarking
- Completing model calibration
- Performing uncertainty analysis
- Defining the appropriate level of detail
- Communicating results
- Documenting results

Before the Guidelines could be developed, initial work needs to be completed to:

- Identify an effective way to categorize modeling elements so that common methods could be identified across applications
- Develop a framework for organizing the "a la carte" approach to modeling methods
- Define key modeling terminology
- Determine methods that are best defined as either: a set procedures, a standardized process, or fully automated within simulation tools

We felt it was important to identify all elements that should be standardized and/or automated. However, the Guidelines would specify using a defined set of procedures for items that are not suited for standardization or automation, or have yet to be standardized/automated in the interim.

We will document the initial proposed framework and standardization priorities in a white paper on Modeling Methods and Processes. The Methods and Processes group has committed to carry out this work on a voluntary basis. The white paper would lay the foundation for developing work plans for creating the Guidelines.

The Methods and Processes group hopes to work with supporting organizations (ASHRAE TC 4.7 Applications Subcommittee, IMT, LBNL, etc.) to identify funders for the work and write the work plans. Collaboratively, we would work with the funding agencies to apply the white paper concepts in the work plans, which we would then tailor to meet industry and agency objectives.

In our implementation plan, we also included a line item for field-testing the Guidelines. The findings would inform their refinement and continued maintenance.

Overall Implementation Plan

This breakout group is committed to continuing its work following the Summit, until a larger organization (such as ASHRAE TC 4.7) takes over these efforts. Ideally, the energy modeling community can use the white paper to help secure funding sources and lay the foundation for the work plans, which will ultimately result in the development of the Guidelines. Whoever takes on this work will need funding to develop and implement the work plans.

Table 4: Methods and Processes Implementation Plan

ACTION ITEMS	CHAMPION (PARTNERS)	TIMING	FUNDING
Customer Guide[2]	Tom White, Dru Crawley, Linda Morrison (Customers, M&P Group)	April 2011	TBD
White Paper laying groundwork for Methods and Processes Guidelines	Tom White (M&P Group)	May 2011/ June 2011, ASHRAE Conferences	N/A
Identify funding for the M&P Guidelines	TBD	March 2012	DOE, ASHRAE, USGBC, AIA, CEC, Energy Foundation, EDR
Work Plan/Outline	Contractor	March 2012	RMI, IMT, LBNL
Methods and Processes Guidelines	ASHRAE TC 4.7 (M&P group)	Within 2 yrs	DOE, ASHRAE, CEC
Field testing Methods and Processes Guidelines	Funder, GSA?, DOE?	TBD	TBD

Please visit the BEM Summit website to download RMI's Pre-Proposal summaries for the efforts listed here. These "Pre-Proposals" were developed solely by RMI and do not represent the consensus of all Summit attendees. RMI intends for these Pre-Proposals to be a starting point for anyone pursuing funding for these efforts and anticipates that the group that is championing each effort will edit these as needed.

Key Issues To Consider

The solution identified by our group is broad, ambitious and critical for moving modeling methods forward. While much needed, the plan will require dedicated champions to see it through. A partnership between IMT and ASHRAE TC 4.7 could accomplish this.

Completing the white paper is a key element of the implementation plan but it relies on volunteer efforts. If the momentum gained by the Summit is lost and volunteer efforts prove insufficient to develop the paper, additional funding will be required to complete this.

[2] Linda may be able to tie this into a brochure already being prepared for the Colorado Governor's Energy Office.

5 BREAKOUT GROUP SUMMARY: SIMULATION ENGINES AND PLATFORMS

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While the content presented in this Breakout Group section was developed in a collaborative process, it does not imply an endorsement of all statements and proposed solutions by each group member.

5.1 Executive Summary

The Simulation Engines and Platforms group kicked things off with a discussion about who uses energy modeling tools and why they use them. We came to the conclusion that practitioners use the tool(s) that they are most familiar with because there is a lack of transparency in the current tools. Practitioners have a hard time determining which tool is best for their purposes, and there is a steep learning curve to using most tools effectively. We then moved to a discussion on interoperability, but we decided that this topic was too large to cover at the summit.

During the second day of the Summit, our group brought more focus on the critical mission: how to help users design and operate better buildings. We identified the lack of collaboration between developers and practicing energy modelers as a significant problem. If developers were more involved in writing standards and communicating the capabilities of current tools to the energy modeling community, then it would much easier to automate the standards and provide practitioners with the information necessary to help them design better buildings. We had only a short discussion as to what is required for energy modeling tools to better support the operational phase of buildings.

5.2 Business as Usual (BAU)

Currently, practitioners pick and choose which tools to use, mostly based on which ones they are most familiar with, but also on several other variables, including ease of use, ability to model specific systems, and cost (of time and the tool). Most of the current tools cannot adequately simulate all of the features desired by practitioners, often requiring redundant models, intermediate tools and use of simulators outside their range of applicability. Practitioners use different tools for early design, detailed design, energy analysis and system sizing, and rarely use energy modeling during building operation.

Current Strengths

- The pace of tool development has increased rapidly in the recent past
- Simulation run times have drastically decreased from the early days
- Graphical interfaces and other advancements have significantly reduced the time requirements and user errors that are often associated with constructing models
- Many different tools are available, making building simulation accessible to many different types of users, and providing practitioners with more choices

Current Challenges

- There are many competing platforms, and none is using a standard for data exchange, model exchange and simulator exchange, which makes collaboration difficult.
- There is no lobby for developers.
- There is not enough support or guidance for how the architectural community should interact with energy modeling tools.
- A significant amount of translating and pre-processing is required to bridge the gap between design/project specifications and energy model inputs.
- Commonly used energy modeling tools are not capable of analyzing the energy and cost implications of many energy saving technologies.
- There is no standard to exchange and share the investment in models across different tools.
- Multiple tools and models are often required for a single building, with no easy way to convert and share data between tools.
- Compared to other industries, the resources to develop computational tools for buildings are very small, there is little collaboration between the developers, and the customers expect tools to be free or low cost.
- Software developers create tools in rather homogenous teams that often consist of mechanical or civil engineers, and the teams typically do not include experts from domains such as controls, language design, numerical methods, and computer science and software architecture.

5.3 Long Term Desired Outcomes

We determined that simulation engines and platforms should have one over-arching mission: *Help users design and operate better buildings.* In addition to this mission, there are several supporting goals:

- Transparency
- Ability to model complex systems
- Increased credibility through validation
- Multiple levels of models:
  - Schematic Design, Design Development, Operations, etc.
- Scalability to large systems/buildings
- Flexible and extensible:
  - To model new technologies (i.e. easy to model any building using current technology, but also has capability to add new features in the future)
  - To adapt tools to new use cases, such as use in operation, which need other features that only time-domain simulation of a whole building system

5.4 Solutions and Future Work

The following table outlines what the developers see as the critical issues in the industry and the most influential partners with which to work on these issues.

Table 5: Critical Issues within BEM (Developer Perspective)

CRITICAL ISSUES	PARTNERS
Define what can be standardized within tools	ASHRAE, IBPSA-USA, COMNET
Coordinate/ influence automation efforts	ASHRAE (TC 4.7 sub-committee), COMNET, USGBC, ICC
Broaden the user base	USGBC, AIA, BOMA, DOE, SketchUp, The Weidt Group, IBPSA and its regional affiliates
Increase credibility through validation	ASHRAE (Std 140 committee), DOE GPIC[3]
Define user needs for BEM in design	AIA, ASHRAE
Define user needs for BEM in operation	ASHRAE, Controls Community

Our group agreed that it is unrealistic to expect so many competing entities to work together to form a single tool or a set of non-overlapping tools. Instead, it would be better to form a venue for developers that would coordinate efforts for working toward solutions in various areas. IBPSA-USA will organize this venue and will create a Developer Group. One task of the Developer Group will be to organize themselves and ensure that software developers are involved in some of the other working group efforts, namely Methods and Processes, as well as key industry efforts such as the development of ASHRAE Standards, and other work through ASHRAE TC 4.7.

Table 6: Simulation Engines & Platform Group – Action Items

ACTION ITEMS	DRIVER	DEADLINE
Launch IBPSA-USA Developer Group	Michael Wetter	June 1, 2011

[3] Greater Philadelphia Innovation Cluster

6 BREAKOUT GROUP SUMMARY: EDUCATION, TRAINING, AND CERTIFICATION

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While the content presented in this Breakout Group section was developed in a collaborative process, it does not imply an endorsement of all statements and proposed solutions by each group member.

6.1 Executive Summary

In order to maximize the time for our breakout sessions, we focused on professional certification programs, as the larger group identified this as an area of concern and importance. In terms of education, we agreed that IBPSA-USA was taking the lead in defining the body of knowledge required for energy modeling, and that university-level curriculum was too large of a topic to tackle at the Summit.

After covering some quick short term needs, such as requiring professional recommendations for exams and developing more preparatory materials, we determined that a single certification exam with buy-in from multiple organizations would ensure that the impact of certification is strong and truly gains traction in the industry. The Department of Energy (DOE) is uniquely positioned to serve as a facilitator, citing current industry efforts around creating "national guidelines" which will define a common body of knowledge that any training organization will be able to draw from when developing curriculum. We then debated whether a two-level certification accrediting individuals at different stages of professional development could prove to be more robust than a single level. It was not certain if a lower level certification would carry any value in the industry.

6.2 Long Term Desired Outcomes

First, we brainstormed desired outcomes for the futures of education, training and professional certification for building energy modeling. The group voted on outcomes that were top priorities – those items are bolded in the list below.

- **Practitioners have the knowledge and experience to effectively use BEM within an integrated design process to lower building energy use.**
- **Universities provide a clear discipline and/or degree program that teaches this knowledge and provides a clear skill set. The scope and boundaries of such a program has consistency across various universities.**
- **Energy analysts have a clear and rewarding career path, with many continuing education opportunities.**
- With an educated, trained and certified workforce, customers and other stakeholders have confidence in energy modeling results, which are now more reproducible and defensible. The demand for, and valuation of, energy modeling services has increased.
- Building design is a more collaborative process - there is a role for modeling in every phase, and everyone understands the role of modelers. Design teams are educated about successful integrated design in general.
- Mechanical design engineers are also competent energy analysts.

6.3 Current Business as Usual (BAU)

In North America, some practitioners have engineering degrees, which provide a foundation for learning building science and modeling. However, most modelers learn from doing, and follow ad hoc methods along the way. Companies often assign energy modeling to men and women just entering the industry, and these practitioners are self-taught.

There are almost 25 universities with some type of course offering in the energy modeling field. A variety of organizations currently offer professional training courses, typically focusing on a specific tool. ASHRAE and AEE have recently instituted two certification programs that aim to gauge whether or not an energy modeler has a certain level of knowledge and experience. There is not a clear understanding of the difference between using simulation tools and performing building energy analysis.

Current Strengths

- The need for energy modeling services is growing. As a result, professionals are actively seeking opportunities to hone their skills to meet and serve this need.
- In the last year, ASHRAE and AEE initiated two modeling certification programs, allowing modelers to distinguish themselves and demonstrate their capabilities to clients.
- In the past decade, the number of universities offering courses in energy modeling has significantly increased.
- Most practitioners currently "learn by doing" which can be an effective way to learn, but also can be very time consuming.
- Because there is no specific required skill set or knowledge base for energy modeling, a number of different types of professionals have become energy modeling practitioners. This brings a number of unique perspectives to the field.

Current Challenges

- Not all energy modelers have a solid understanding of building science/system design or know how to correctly translate building info into simulation inputs.
- There are multiple certification programs available, but none have gained real traction in the industry, nor are they able to distinguish between skill levels.
- There is a gap in expertise between the architect and design team and the energy analysts.
- The industry does not have clear agreement on what knowledge and skills should be covered within training and education programs.
- Key tasks like quality control and calibration are not widely understood among practitioners.
- There is often no clear career path progression for practitioners.
- There are limited comprehensive and formalized training opportunities for industry professionals, especially building operators and commissioning agents.
- There are few Universities that offer a strong curriculum that raise the skill-set of architects and energy modelers. Different universities provide education that is inconsistent across programs and doesn't tie into certification programs.
- Some practitioners do not have the skills or experience to know when a whole building model is appropriate, nor have the experience to identify the proper tool for a given application.
- Practitioners struggle with correctly interpreting the existing vast array of energy codes, performance baselines, and green building standards.
- There is confusion regarding the distinction between tool use vs. energy analysis.
- There is no liability in certification programs.
- There is a lack of available curricula for building energy modeling and building science (due to intellectual property restrictions).
- The cost of training and education can be prohibitive.

Current Players and Redundant Efforts (Professional Certification)

Currently, both ASHRAE and the Association for Energy Engineers (AEE) have certification programs for energy modelers. ASHRAE's Building Energy Modeling Professional (BEMP) certification and AEE's Building Energy Simulation Analysts (BESA) certification have significant commonalities. Eligibility requirements are similar between the two certifications, the difference in content is unclear, neither differentiates between varying skill levels, and both certifications are pass/fail.

A significant difference is that the BESA exam requires the completion of pre-exam seminar before sitting for the exam. It also means the program would not meet requirements for ANSI approval. This requirement translates into significantly higher costs for the certification process, as compared the BEMP program. As of April 2011, there are 31 BESA certified professionals and 127 BEMP certified professionals.

Additionally, the DOE is currently sponsoring a project to develop (1) job task analyses (JTAs), which identify and catalog all of the activities a worker performs in a given job; and (2) the knowledge, skills, and abilities (KSAs), which define the minimum requirements necessary to adequately perform those tasks, for six building job categories, including "energy modeler". The project goal is to create "national guidelines" which will define a common body of knowledge that any training organization will be able to draw from when developing curriculum, helping to ensure consistent core competencies among training programs.

6.4 Solutions

The certification work will be championed by ASHRAE (contact: Amy Musser) while IBPSA-USA will champion the effort to build the body of educational knowledge (contact: Joe Deringer). RMI will play a contributing role, and follow up with the appropriate contacts and committees with ASHRAE and IBPSA-USA to ensure that things are moving along, and that work is aligned with other key organization such as DOE, AIA, IES, IALD, USGBC, and AEE.

The following table outlines the overall implementation plan for this topic area. Please visit the BEM Summit website to download RMI's Pre-Proposal summaries of the following efforts:

- Pre-Proposal: Energy Modeling Certification Improvements
- Pre-Proposal: Energy Modeling University Improvements
- Pre-Proposal: Energy Modeling Online Training Courses

These "Pre-Proposals" were developed solely by RMI and do not represent the consensus of all Summit attendees. RMI intends for these Pre-Proposals to be a starting point for anyone pursuing funding for these efforts and anticipates that the group that is championing each effort will edit these as needed.

Table 7: Implementation Plan for Education, Training and Certification

ACTION ITEMS	CHAMPION (PARTNERS)	CONTACT	TIMING	KEY ISSUES/NOTES
Require more stringent and comprehensive professional recommendations for certification as a prerequisite	ASHRAE[4] AEE	Amy Musser	ASAP	Key to ensure actual modeling proficiency
Create demand to take BEMP exam	ASHRAE (RMI)	Amy Musser	6 months	Marketing campaign, all Summit attendees take exam
Refine 'Black Belt' concept (levels of career progression for BEM) to 2-3 levels	RMI (ASHRAE)	Kendra Tupper	6 months	
Turn the content from the BEM Workshops into online webinars/ courses	IBPSA-USA, (RMI, ASHRAE)	Joe Deringer	1 year	IBPSA-USA board members are quite active in this area. Major funding is from DOE & CEC.
Develop desk reference for BEMP (with more practice problems and 'Black Belt' concept)	ASHRAE (IBPSA-USA)	Amy Musser	1 year	
Form committee to examine opportunities to improve higher education for BEM	Mike Brandemuehl? (Godfried Augenbroe?)	?	Jan 2012	See eLAD.lbl.gov wiki for an extensive example developed to improve education for lighting & daylighting.
Incorporate building energy analysis into M&V certification and training	EVO (IBPSA-USA, ASHRAE)	Steve Kromer	1-2 years	
Form single certification exam with buy-in from multiple organizations	ASHRAE (AEE, AIA, IES, USGBC, IBPSA-USA)	Amy Musser	1-2 years	DOE funding could support this
Develop actual hands-on problems for ASHRAE BEMP exam[5]	ASHRAE (IBPSA-USA, RMI, IES, AIA)	Amy Musser	2-3 years	Graphical/animation interface, partial credit options
Review & revise Body of Knowledge for BEM, add content to BEMBook wiki	Covered in Knowledgebase plan (Section 8.4) from Support & Resources	Joe Deringer	2-3 years	- Need to vet knowledge - Align w/ DOE guidelines
Consider expanding BEMP to a two-level certification (similar to EIT and PE)	ASHRAE	Amy Musser	3+ years	Market demand needed prior to development

[4] Lynn G. Bellenger, current ASHRAE president will work with the ASHRAE BEMP certification committee to get this addressed.
[5] Both the BEMP and BESA exams currently are 100% multiple choice questions

Key next steps to get the larger implementation plans off the ground include:

Table 8: Key Next Steps for Education, Training and Certification

ACTION ITEMS	DRIVER (PARTICIPANTS)	DEADLINE
Get ASHRAE and AEE talking about how to merge certification programs	Lynn Bellenger (Sonal Kemkar, AEE Representative)	July 1, 2011
Respond to Doe's RFP to develop "national guidelines" for energy modeling education	Kendra (Lynn, Mike Brandemuehl, Dan Nall)	April 17, 2011
Identify individuals willing contribute to the BEMBook wiki (from Summit surveys)	Kendra Tupper (provide info to Joe Deringer)	May 1, 2011
Identify opportunities for improvement in higher education	Godfried Augenbroe?	?
Summit attendees take BEMP exam	Kendra Tupper	Jan 2012

Key Issues To Consider

Two significant issues remain unresolved and merit further consideration.

1. Multi level certification
2. University programs

We discussed at length the issue of a two-level certification, but we were undecided over whether the lower tier of a two-level certification would have any value.

Several people made the argument that the first level of a certification would be similar to an EIT (Engineer in Training), and would be a test to verify a base level of proficiency out of school and would be potentially valuable for employers. Others argued that such a certification would unnecessary, as potential employers and clients would only be interested in the higher level certification.

We also briefly discussed issues regarding university programs. Intellectual property rights, lack of collaboration between universities and professional organizations, and a dearth of higher education programs focusing on building systems were the three major issues identified. As this is a large topic requiring collaboration among key university programs, we recommend that a separate committee be formed to address this and RMI drafted a pre-proposal (available on the BEM Summit website) that further expands on this concept.

7 BREAKOUT GROUP SUMMARY: MARKET DRIVERS AND CUSTOMER DEMAND

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7.1 Executive Summary

Building energy modeling has enjoyed a steep adoption and market uptake curve in the last decade. However, the two biggest drivers of today's modeling demand – the building owner's need to comply with regulations and codes, and the owner's desire to comply with voluntary programs like LEED, tax incentives and utility incentives – do not necessarily best support our objective of widespread low-energy building design and operation. Most models are seeking to answer, "How many LEED points can I achieve? Do I qualify for this specific incentive?" These uses, which are dominating the majority of today's models, are degrading the perception of modeling's potential value.

Our breakout group began with the premise that the energy modeling community could gain great benefit by aligning energy modeling market drivers with the "end" goals of reducing energy use and demand. The reasons and extent to which energy modeling is used in the next ten years isn't just a matter of what will spontaneously or inevitably happen: this industry can take deliberate action to generate more demand in areas we think are beneficial.

Our core discussions centered on:

- Developing a consensus on the current major market drivers (business-as-usual)
- Proposing best-case future uses for energy modeling within a 10-year horizon (some overlap with current uses)
  - Deep dives on two potential uses to define a value proposition for end-users and identify important success factors.
- Identifying next steps for carrying this thought process forward into concrete action items.

We believe energy modeling can play a major role in supporting our end goals of energy efficiency in the built environment, if we get a few things right. Specifically, we need to:

- Clearly communicate the value proposition of modeling to potential customers,
- Work with key stakeholders to ensure incentives are aligned to support the best-case uses for energy modeling,
- Understand how to leverage modeling (and the costs of modeling) to best inform the nation's large building stock, and
- Improve modeling quality, and the public perception of modeling quality, through compelling case studies.

7.2 Current Business as Usual (BAU)

The good news in the current BAU is that there has been a steep growth curve for building energy modeling over the last decade. The bad news is that we are leaving an immense amount of value on the table. There is a wide range of efficiency-related decisions (from the appliance level, to the building level, to the regional and national level) that we could inform with quality energy modeling, but we are not capitalizing on that opportunity.

Current and potential customers do not have a clear understanding of the value proposition for energy modeling services and often misjudge the best uses of energy modeling. Two major drivers currently dominate market demand, which do not necessarily best support our objective for widespread adoption of low energy design building:

1. The need to comply with mandatory requirements for codes, standards, disclosure and labeling requirements (both federal and local)
2. Desire to meet requirements for certification or financial incentives (i.e. tax incentives and LEED, utility incentive programs)

To a much lesser degree, there is a "second" tier of modeling demand from leading portfolio owners and visionary architecture and engineering (A/E) firms who use modeling to inform and improve design decisions and energy performance.

Barring no intervention or course correction, the perception of modeling value appears to be trending towards a continued degradation. Even though the number of models that the market is demanding has risen steeply, it's not clear this can be sustainable in the long term if:

- Models continue to be of dubious quality (either perceived or actual quality).
- Codes and program compliance continue to drive demand for modeling, and this doesn't showcase the potential value of modeling in broader decision-making.
- There are no success stories to demonstrate the tangible contribution modeling can make to real-life building design and operation.

Current Challenges

- Potential customers perceive the costs for energy modeling services to be prohibitive.
- The value proposition for energy modeling services isn't clear to current and potential consumers.
- Energy modeling credibility has a bad public reputation. Customers are also often misinformed, or have unrealistic expectations, about what energy models will provide to their process. There are far too few documented case studies demonstrating the tangible contribution modeling can make to real-life building design and operation.
- The larger building's community perceives energy modeling to be a niche industry: exclusive, inaccessible, ancillary, and not integrated into the rest of the building design industry.
- There can be unintended consequences. The interaction between market drivers is very important and we can't downplay some without impacting others.
- Uncertainty in models has not been well addressed or explained to end-users.
- There is still a gap between our highest quality energy model and our desired energy-saving decisions. Even when energy models point users to the best design decisions, the broader context of competing trends and forces ("glass facades are cool," low energy prices, leasing structures, low bids) can work against us.

7.3 Proposed Vision

What should be driving people to use models in the future? What role can we (the organizations and stakeholders represented at the Summit) play in shifting demand?

Long-term Vision

The long term vision agreed upon by this breakout group included the following:

- The industry continues to see tremendous growth, spurred on by market drivers that are aligned with broader energy efficiency goals.
- Stakeholders use building energy modeling to inform a broader array of decisions related to energy efficiency– from helping to set national and local building performance goals, to playing a role in valuing real estate assets and assessing investment risk, to helping evaluate the potential impact of specific technologies on the larger electrical grid.
- The BEM community develops a clear value proposition and communicates this for each of the different uses of modeling. Potential end-users understand the tangible value that will result from bringing modeling into their process.
- The industry has a reputable track record, with real buildings that "prove the models," and in turn continue to support market demand.

Potential Future Market Drivers

As a first step toward aligning modeling demand with underlying energy efficiency goals, and toward strengthening market demand for modeling, our group proposed potential future uses for modeling over the next ten years. Stakeholders can use modeling to inform an array of efficiency-related decisions and we questioned, "In the ideal world over the next ten years, what uses could these be? What kinds of decisions could high-quality models inform? Who would be the end-users?"

The following table lists the end-user audiences and possible uses for modeling that we brainstormed for the ten-year horizon. We put this list together with the understanding that some of these proposed uses are already in play in the current BAU, while others are trends that we see on the horizon, and still others represent largely untapped markets.

Table 9: Potential Future Market Drivers in the Ten-Year Horizon.

POTENTIAL END-USER	REASON(S) FOR DEMANDING ENERGY MODELS
Architect and A/E team	➢ To improve the design and performance of buildings (including currently underserved building types) ➢ To qualify for a building permit and to meet building codes (linked to increasingly strict energy efficiency criteria in the future), i.e. 2012 IgCC. ➢ To meet increasingly stringent Federal and municipal/local regulations and legislation
Building Purchaser (residential & commercial)	➢ As part of due-diligence for assessing real estate value ➢ To help choose between consumer products
Homeowner	➢ For direction on how to use the home's systems and appliances (and save on utility bills or participate in demand side utility program)
Commercial Building Owner, both portfolio and individual	➢ To optimize operations and for fault detection ➢ To map a strategy for getting to net-zero ➢ To meet criteria for a carbon market ➢ To strategize effective retrofits (i.e. by leveraging results from a few models to inform a large number of buildings across a portfolio) ➢ To achieve voluntary green building certifications
Federal Government	➢ To help set goals for energy efficiency ➢ To help assess grant/loan risk or qualification for federal efficiency programs (i.e. for the Better Buildings Initiative)
Bank/Investor Entity	➢ To assess real estate value for new construction and retrofits via operational asset rating models
Utility/PUC consumer	➢ To assess potential impact of specific technologies on electrical system ➢ To profile different building responses to potential dispatches ➢ To design efficiency programs
Policy Makers/Code Officials/National Labs	➢ To determine impact of potential changes and technologies ➢ To assess quality of different technologies and products (and determine whether they meet standards)
Software Developers	➢ To assess other modeling tools
Lawyer	➢ To make a case for money contracted or owed
City Planner/Developer	➢ To plan operations at the community or district level

In this proposed future, the group imagined that:

- Key end-users (i.e. policy makers, investors, etc.) are required to understand models to demonstrate competence at their job.
- Models become living documents, often tied to building properties as they changed ownership or occupation.
- Utilities integrate smart grid practices into the electrical system, and modeling plays an important role in this process.
- Codes, design guidelines, and federal mandates continue to be increasingly stringent.
- The BEM community accumulates a growing base of actual data from building operations and incorporates this into building energy models.

We decided to take a closer look at two of the potential future uses listed in the table above, and we expand on these in the following "Deep Dive" discussions. We discussed the value proposition for including modeling in the decision-making process for each of the two uses, and considered how to leverage modeling to support efficient choices, how to engage different stakeholders to ensure success, and how to structure rewards or penalties to encourage ideal outcomes. The following two sections document the salient points from each Deep Dive discussion.

7.4 Deep Dive #1: Requiring BEM for code compliance and building permits

In this scenario, architects would require building energy models to demonstrate compliance with codes and get building permits. In this scenario, the following questions are key considerations.

What is our proposed value proposition for including modeling in the process of getting a building permit? What success factors should we consider?

Table 10 summarizes the answers to these questions, according to the stakeholder that is benefitting.

Table 10: Potential Future Value Proposition for Including BEM in Building Permitting Process, by Stakeholder

KEY STAKEHOLDER WHO BENEFITS	VALUE PROPOSITION OF INCLUDING MODELING IN THE PROCESS	SUCCESS FACTORS (COULD BE INCORPORATED INTO GUIDELINES OR STANDARDS)
Architect	RISK MANAGEMENT: In an emerging paradigm where architects are responsible for using energy models to meet building code, energy models can help mitigate architect risk and provide a defensible case for permit qualification.	➢ Perform models early and often ➢ Include a BEM expert on the A/E design team
Politician	BRAGGING RIGHTS: In an emerging paradigm where municipalities compete with each other to be "more green" and community leaders come under more pressure to demonstrate achievement in energy efficiency, energy modeling can help building departments ensure that constituents have demonstrated compliance with increasingly stringent performance goals.	➢ Structure code to reward the most economic way to achieve best performance. Consider a return on investment (ROI) target as opposed to setting the floor for the "worst performance" that can pass code. ➢ Require BEM understanding in job description of compliance officer. ➢ Provide "cheat sheets" for code officials to help them evaluate models. ➢ Consider automated code compliance tools (like those used for California)
Tool Developers and Service Providers	SERVICE OPPORTUNITY: More stringent code requirements represent opportunities for businesses to develop services and tools	➢ Incorporate QA/QC for simple errors. ➢ Address metrics that are becoming increasingly important: life cycle costs, net present values, returns on investment

7.5 Deep Dive #2: BEM required to determine operational asset rating

In this scenario, building owners/purchasers and financial institutions require building energy modeling to determine operational asset rating for real estate properties. In this scenario, the following questions are key considerations.

In an ideal future, how could operational asset rating stimulate maximum demand for low energy buildings?

Asset ratings that indicate energy consumption and recurring operational costs and needs of a building could:

- Provide guidance on how facility managers should conduct operations and maintenance.
- Trigger periodic inquiry on the part of the building owner/purchaser when there is a gap between actual and projected energy and operational costs. This can ensure scrutiny and optimization of the building design, retrofit, and operation to achieve projected performance.
- Provide public disclosure (and policing) of the actual performance of buildings.

In order to be effective, we should tie operational energy and cost assessments to a simplified asset rating system that is easily understood by building owners/purchasers, and boiled down to a predicted cost range.

How is energy modeling managed/employed to help support this?

This represents a currently untapped market for building energy modeling. To demonstrate tangible value, building modeling should:

- Be individually customized to meet the building type and operational program (detailed internal loads, usage profiles and scheduling)
- Be simple and easy to update
- Be "part of the property" and live with the building even as the asset is transferred
- Provide more fidelity and accuracy than EnergyStar does
- Be tuned to the "best metrics" for that building's uses. Models would be continuously calibrated to the operational characteristics of that building, measure performance in terms that are meaningful to the owner (i.e. EUI/unit of product manufactured or sold for retail), and provide detection of false diagnostics.

Who are the critical stakeholders? What role do they play to ensure that operational asset rating becomes a strong market driver?

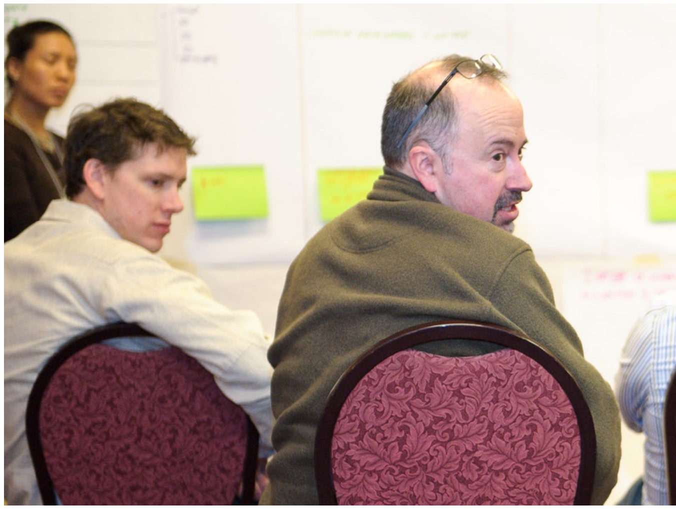
In an ideal world, **financial institutions** (and markets) would require operational asset rating in real estate asset valuing. Building energy models would become part of due diligence for qualifying a mortgage-backed security. **Policy makers** would require public disclosure of building operational asset ratings.

7.6 Format of Future Work and Key Partnerships

Because no current organization is dedicated to understanding market demand for building energy modeling, the group proposed to form a Steering Committee to continue addressing the discussion topics addressed by this breakout group at the Summit. The Steering Committee would be an industry consortium dedicated to understand market demand for energy modeling.

The Committee would identify and spearhead action items to:

- Align energy modeling market drivers with energy efficiency end goals
- Leverage collective market influence to help shift demand in support of the "best uses" of modeling
- Address damaged public perception to the accuracy, quality, and usefulness of energy models



Overall Implementation Plan

OVERALL INTENT

Identify and spearhead action items to:

- *Align energy modeling market drivers with energy efficiency end goals*
- *Leverage collective market influence to help shift demand in support of the "best uses" of modeling*
- *Address damaged PR to the accuracy, quality, and usefulness of energy models*

OVERALL CHAMPION

Steering Committee

KEY PARTNERS

DOE, IBPSA, ASHRAE, BOMA, AIA, NAESCO, RMI, IMT, Commercial Building Energy Alliances (CBEA), Building America (under U.S. DOE)

OVERALL TIMELINE

1 year

CHAMPION

TBD

Table 11: Implementation Plan for Market Drivers and Customer Demand

	INTENT	CHAMPION	PARTNERS	TIMELINE
ACTION #1 Form a Steering Committee	To carry out mission to the left.	TBD Champion	Members of the breakout group, IMT	< 6 months
ACTION #2 Size and prioritize future market opportunity	Complete the list of potential future uses in Table 9. Define the value proposition for modeling in each of the uses. Size the potential market for each opportunity and prioritize proposals for: ➢ Ease ➢ Impact ➢ Timeline ➢ Resource Requirements	Steering Committee	Committee members	< 1 year
ACTION #3 Market research/ branding	For a short list of market opportunities, conduct market research and determine branding strategy for target audiences.	Steering Committee	Committee members	TBD
ACTION #4 Case studies demonstrating value of modeling	Assemble a collection of successful energy modeling case studies. (perhaps through a contest or award)	Steering Committee	Committee members	TBD

Please visit the BEM Summit website to download RMI's Pre-Proposal summaries for the efforts listed here. These "Pre-Proposals" were developed solely by RMI and do not represent the consensus of all Summit attendees. RMI intends for these Pre-Proposals to be a starting point for anyone pursuing funding for these efforts and anticipates that the group that is championing each effort will edit these as needed.

8 BREAKOUT GROUP SUMMARY: SUPPORT AND RESOURCES

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While the content presented in this Breakout Group section was developed in a collaborative process, it does not imply an endorsement of all statements and proposed solutions by each group member.

8.1 Executive Summary

Today's support and resources for energy modeling are hard to access, inconsistent in quality, and uncoordinated. As a result, few (if any) models are genuinely reproducible, thus leading to questions about the accuracy and usefulness of building energy modeling. However, a different future is possible. As discussed in the Support and Resources breakout group, there are many opportunities to improve modeling through improving the supporting resources that are available to energy modelers. These resources range from creating quick-fix resources for practitioners to rethinking how data is manipulated from inception to model.

Our group proposed the development of two new resources that improve access to energy modeling information, one that is primarily knowledge-driven, the "Knowledgebase," and one that is primarily data-driven, the "Database." We also discussed a potential Quality Control Framework, which could greatly enhance model transparency and reporting functionalities. Through the development of these three resources, practitioners would be armed with better information to use, along with their training and experience, to create higher quality models. Developing these needed resources, making them accessible, and making them "official," will require funding and leadership by a few critical organizations and support from many others.

8.2 Long Term Desired Outcomes

In the future, the energy modeling community will vet support and resources, and these will be easily accessible and continuously updated. Our vision specifies that:

- Every energy modeler knows where to find trusted information.
- Existing resources and data are organized, shared, searchable, easy to use, and reported in a standardized format.
- The community continually revises and updates resources to keep pace with emerging technologies and industry needs.
- The level of accuracy and validity of each data source is clear to the user.
- Developers embed more resources within modeling tools, providing context-sensitive help and seamlessly integrating learning into the workflow.
- When practitioners need work-arounds, the industry vets them as short-term solutions and then developers ultimately eliminate them as they incorporate the functionality into tools.
- Standardized, third party verified data transformation rules allow practitioners to import data (i.e. manufacturer's equipment data) from various sources into simulation programs
- Code compliance developers align their efforts with other building ratings and modeling improvements.

8.3 Current Business as Usual (BAU)

When practitioners perform an energy model, there are many sources of information that they must draw from to complete the work, in addition to their individual knowledge, professional judgment, and experience. In many cases, the necessary information is not available or is not easily accessible. Often resources are not searchable or context-specific and it can be difficult to ascertain the accuracy and validity levels of the data. Many existing resources that are reliable, such as software documentation and help files, research studies, newsletters, and white papers, are under-utilized or unused, largely because of their inaccessibility and density. Schedule pressures leave little time for reading and weeding through hundreds, if not thousands of documents. As the demand for energy modeling has grown, there has been an increased reliance on software support centers to answer general modeling questions, in addition to program-specific questions.

Practitioners frequently pass down knowledge from person-to-person, relying on a few experts within an organization, or on connections to experts within an individual's professional network. Past projects and models are another resource that practitioners draw from to build libraries of properties and information. However, these can get outdated when practitioners lack the time that is needed to update them. Modelers use engineering judgment, experience, and standard rules of thumb to fill in the remaining gaps.

Assuming we put little effort into improving modeling support and resources, many of the current practices will continue. Data will not be readily available and quality control processes will continue to be underutilized and time consuming. As a result, model usefulness and overall quality will likely suffer as the growing modeling community struggles to keep up with the increased demand for energy modeling.

Current Strengths

Although they often are not well known or well utilized, we identified many good energy modeling resources already in existence, including:

- **Current Documented Knowledge:** many good resources such as text books, scientific journals, conference proceedings, software documentation, industry articles, training sessions, in-house tools and documentation developed by practitioners
- **Individual "Fountains" of Knowledge:** numerous strong individuals within the industry (many of whom attended the summit) who could contribute their expertise to vet and add to existing resources
- **List Serves:** users can ask questions and developers can identify bugs in their software and inform users about product features that are not well known or well documented
- **User Groups:** building simulation user groups are helping to share knowledge through monthly meetings and forums
- **IBPSA-USA BEMBook wiki:** an effort to define and share a body of knowledge for building energy modeling

Current Challenges

There are many challenges that span the entire energy modeling process, including:

- **Time Constraints:** modelers focus only on delivering work, rather than reading, writing, keeping up with industry changes, or searching for better solutions
- **Lack of Funding:** the value of improving supporting resources is not typically recognized, thus funding is not directed toward aggregating and improving modeling information
- **Constantly "Reinventing the Wheel":** modelers each develop their "own" way of transforming data inputs and modeling certain systems using in-house spreadsheets and workarounds
- **Limited Manpower:** the best engineers and software developers aren't choosing energy modeling careers, which leads to a lack of talent across the field from practitioners to academic faculty. Also, the most junior staff members are often the ones doing the actual modeling
- **Poor Expectation Management:** the industry is not clearly setting expectations for clients about what energy modeling should be used for and the value it can provide

Additionally, our group identified many challenges that relate to different phases of the energy modeling process. We have detailed these challenges to creating effective support & resources, as well as some potential solutions, in the table below.

Table 12: Challenges to Creating Better Support & Resources and Potential Solutions (Organized by Modeling Phase)

PHASE	CHALLENGES	POTENTIAL SOLUTIONS
1 Collect Building Data	• It is hard to scale peer-to-peer advice and knowledge sharing. • Often the energy modeler is not involved in early design meetings. • The modeler often has to fabricate data, and assumptions are not apparent to anyone but them. • It is difficult to get complete, accurate, site-specific weather data, particularly historical data for retrofits.	• Develop processes to institutionalize information and expertise. • The modeler becomes a valued member of the team, or the MEP engineer should always be the modeler. • Establish low-energy, industry-vetted targets for process loads, lighting, etc. that practitioners can use for model inputs. • Develop better weather tools and set standards for instrumentation needed to create future weather file (ASHRAE TC 4.2).
2 Convert to Simulation Input	• List serves are cumbersome and may not be reliable, since experts often don't have time to contribute. • It is hard for practitioners to obtain building audit data for use in simulation. • Baselines are re-created over and over again. • Practitioners must manipulate data from various sources to fit the input requirements of modeling programs. • The process for data acquisition is complex and time consuming.	• Catalogue and rate list serve information and advice so that it is easier to access and indicates the level of quality. • Develop building audit procedures that specify the inputs necessary for modeling. • Automate the generation of baselines (COMNET / ACM). • Develop data transformation rules to maintain data integrity (ASHRAE Standard 205). • Semi-automate data acquisition. • Develop standardized model input format that is simple and easy to understand.
3 Computer Simulation	• Limited ability to accurately model innovative HVAC systems. • Practitioners need Work-arounds to model some kinds of systems. • Software architectures need to represent buildings more accurately. • Users expect tools to do it all. • Libraries of building equipment/entities are outdated.	• Establish process for vetting work-arounds, as a short-term solution. • Make help files searchable.
4 Quality Control (QC)	• One person does both the model and QC. • Software limits the ability to ask questions about inputs and outputs (i.e. "What % of façade is glass?"). • It is time-consuming to diagnose bizarre results. • There is not a consistent QC process that all practitioners follow. • Most software is a "black box" that is not transparent. • There is a lack of good end-use benchmark data from real buildings to inform inputs and results.	• Have third party reviewers, possibly as a fee-based system. • Develop ad-hoc input and output reporting, including a visual analysis. • Tools have trace/debug function and energy balance reports. • Develop a standard set of QC questions and complete input documentation. • Allow the user to view the source code that is running. • Compile more case studies with measured and verified data for multiple building types.
5 Support Decision Making	• People who look at results can't transparently see assumptions or judge the quality of a model. • There is limited ability to provide high-level feedback early in the design process. • Clients don't understand the uncertainty level of what they are given. • Customers demand performance numbers and predictions early on in the process, when results are not reliable. • Many different metrics are used, such as NPV, LEED points, site energy, source energy, peak power, etc. and programs don't provide them all (or ways to easily relate them).	• Make assumptions (and their accuracy) visible within results and output reports. • Provide graphical gauge of energy performance in GUIs as you model. • Practitioners must clarify to clients what they providing at each stage of the model, and potentially only use ranges. • Establish standardized energy goal setting process and best practices, potentially incorporating them into Integrated Process Design documents. • Tools should provide the ability to "slice and dice" results in different ways to look at different metrics.
6 Model Calibration	• It is challenging to identify the few key variables that affect quality calibration. • It is hard to get good data on key inputs, such as occupancy schedules. • Benchmark data does not include granular enough information on end-use breakdowns. • There are no standardized procedures for calibration. • Tools lack functionality for auto-calibration.	• Provide built-in sensitivity analysis in simulation tools that can indicate what the most important variables are. • Practitioners need better "real" building data for various buildings types to inform future models.

8.4 Solutions

After discussing the challenges, our group identified eight potential areas to focus on:

1. Quality control
2. End-use benchmark data
3. Data transformation rules
4. How-to guides for modeling simple and complex systems
5. Standardized model inputs and output reports
6. Scaling list serves and peer-to-peer counsel
7. Translation of common metrics
8. How to communicate results and what they mean to non-modelers

Based on group voting and discussion, as well as input from the entire Summit forum, we focused on the topics of how to consolidate existing knowledge, how to improve access to real building data to inform model inputs, and how to improve approaches to quality control. From here, we developed plans for a "Knowledgebase," a "Database," and a Quality Control (QC) Framework.

Building Energy Modeling "Knowledgebase"

To remedy the problem of poor accessibility to information, the Support and Resources group proposed the creation of an industry "Knowledgebase" — a new coordinating framework of building science and simulation information that includes expertise-based ratings of the information. Through a collaborative effort of multiple organizations, the Knowledgebase would be continually updated to incorporate new building science and simulation resources.

We do not intend for this Knowledgebase to be a substitute for building science curriculum or modeling training, but rather we propose this as a convenient, organized, and searchable access point or structural index to the thousands of already existing resources about building simulation. Given the current needs and the expected growth of the building simulation industry, it is important to create a proper foundation for identifying, cataloging and rating the quality of existing resources, as well as new information that is sure to accumulate in greater quantities in the coming years.

As a first step, the structure and format of the knowledgebase must be determined. A solid foundation for the structural framework of a knowledgebase has recently been developed by IBPSA-USA, with input from ASHRAE and

RMI, in its development of the BemBook wiki (see bembook.ibpsa.us). This current framework can be refined and extended to identify which content the Knowledgebase will house. The Knowledgebase structure should include mechanisms for linking to other resources, as well as interactive components that allow users to rate the information and add comments. Once the knowledgebase structure is developed, the proposed approach is three-fold:

1. First, the Knowledgebase creators must identify existing information, catalogue and rate this information, and then either provide links to it from the Knowledgebase framework or incorporate it into the Knowledgebase.
2. Second, they must identify and prioritize key gaps in the resources currently available to add to or link to the Knowledgebase.
3. Third, they should establish a collaborative group of interested professional and public-interest organizations, R&D laboratories, educational institutions, and other parties who can together begin to fill the gaps by:
   - Improving access to existing written information,
   - Documenting known, but not yet written-down information from experts in the field, and
   - Linking new research, student theses, and white papers to the knowledgebase.

Software developers can then begin to integrate this information and/or provide links to the Knowledgebase from their software (e.g. context-specific help that can point users to specific resources in the Knowledgebase for more information).

The Knowledgebase framework, with its evolving structure, content and links is expected to primarily serve as a resource to practitioners who are constantly in need of supporting information to validate their modeling approaches. But, it could also evolve to include resources for students, researchers, policymakers, building owners, facility mangers, and entrepreneurs hoping to better understand building simulation, its uses, and its evolution.

Building Energy Modeling "Database"

Our group also identified the need for a public, centralized resource that hosts granular building data, far beyond what the U.S. Energy Information Administration's Commercial Building Energy Consumption Survey (CBECS) database or the U.S. Green Building Council (USGBC) offers. The vision is that data from existing commercial buildings helps to inform inputs for the modeling of new buildings, as well as retrofits.

This "Database" will be largely composed of measured field data from individual buildings that practitioners can use to inform modeling inputs such as operating schedules, air infiltration rates, plug load data, and process load data. It should also include vetted and ready-to-use pieces of data that can be used in models, such as material properties, wall constructions, and representations of appliances. Initially, practitioners will use the Database as a reference to generate better inputs, which will likely lead to increased productivity and accuracy. In the future, the energy modeling community can use more sophisticated and rigorous statistical methods and data transformation rules to auto-generate inputs based on information in the Database (as opposed to simply using the data to inform non-reproducible solutions).

To get this effort started, a thorough analysis of data needs and issues related to liability, privacy, accessibility, and proprietary information should be conducted. Then the champion for this resource should set up the structure of the Database and identify methods for collecting and authenticating data (perhaps through policy). Over time, statistical analysis could help to auto-generate inputs for modelers based on information in the Database. In the long-term, data could get automatically added to the Database by linking directly to building management systems. Software developers could also use the Database to inform better ranges of acceptable inputs.

Quality Control (QC) Framework

A lack of transparency regarding inputs (and which ones are assumptions) and outputs makes reviewing energy models challenging and time-consuming. To address these challenges, we proposed the development of a standardized Quality Control (QC) Framework. The framework focuses on improving access to data that can be used during the QC process, and not necessarily the QC process itself. When discussing QC, we proceeded under the assumption that the "black box" of simulation engines works correctly, and thus, improving inputs will also result in improved outputs.

Our group developed the QC Framework by talking about energy modeling inputs and outputs, and the types of information that could be provided, as shown in Table 13. A simple recommendation was that modeling inputs could be checked by having a smart "echo" report that simply shows all the inputs that you have entered. Another idea was that a more sophisticated version of this echo report could even be used to auto-generate a design intent document, allowing for a bottom-up check of the assumptions against the top-down owner's requirements.

Our group also identified the need to develop a standardized report format across all simulation software platforms. Having standard formats for input and output reports would help users and customers become more familiar with energy modeling results and would allow for easier comparison checking between models.

Another idea was that simulation programs could let the user know when an input value is outside of the typical range, as long as this error-checking functionality could be turned off when users want to test out un-realistic values.

We also identified potential solutions for exposing assumptions within models. One idea was that meta-data output reports could show comparisons to norms, including how far off a particular value is from the standard deviation and how many of the inputs have been changed from the default values. Once the reports are developed (possibly by an ASHRAE Technical Committee), the reporting functionality will need to be embedded into simulation platforms and tools. For outputs, software programs should carry variability and uncertainty ranges associated with inputs through the calculations so that the output can also carry an overall uncertainty range.

Table 13: QC Reporting Framework

	INPUT	OUTPUT
Detailed Data	Smart "Echo" Reports	Standardized Output Reports Design Intent Documents
Meta-Data	• Expose Assumptions • Comparisons to Norms: • Standard Deviations • Uncertainty • Amount of Default vs. Customized Values	Output Variability and Uncertainty

Overall Implementation Plan

Our group identified big picture action items along with potential champions, approximate timing, partners, and potential funding sources for each of the three focus areas.

Table 14: Big Picture Support & Resources Implementation Plan

FOCUS AREA	ACTION ITEMS	CHAMPION	TIMING	PARTNERS	FUNDING
Knowledge-base	Develop framework and collect existing resources	IBPSA-USA (key contact: Joe Deringer)	2 yrs	SBSE IFMA BOMA BPI CBE DOE GSA NBI AIA RMI NIBS NSF	Google Foundation JCI IBE Energy Foundation Penn Buildings Hub DOE
	Identify gaps in current information	Consulting firm, Non-Profit group, University program, etc.	6 mo		
	Continuous update of Knowledgebase	Long-term "owner" of Knowledgebase	On-going		
Database	Create building energy modeling database	NREL (key contact: Nick Long)	2 yrs		
QC Framework	Create standard approach to QC	ASHRAE TC 4.7 (key contact: Joe Huang)	1 yr		

Immediate Next Steps and Key Concerns

Although specific organizations have agreed to champion the group's focus areas, it will be important to continue collaborating as these efforts move forward. IBPSA-USA will continue to champion the development of the BEMBook Wiki, which will serve as the beginning of an official body of knowledge for the energy modeling community, and will also champion the development of the Knowledgebase. The Knowledgebase and Database efforts will likely have some overlaps relating to strategies, resources, and technologies. Rather than having redundant efforts, we should work to capitalize on these potential synergies. Development of the QC Framework should proceed in coordination with the development of comprehensive energy modeling guidelines (see Section 4.4), hopefully occurring under ASHRAE TC 4.7.

To get these three plans off the ground, the group identified the need for the creation of brief "pre-proposals" that summarize the ideas that were generated by the group. Please visit the BEM Summit website to download RMI's Pre-Proposal summaries for the efforts listed here. These "Pre-Proposals" were developed solely by RMI and do not represent the consensus of all Summit attendees. RMI intends for these Pre-Proposals to be a starting point for anyone pursuing funding for these efforts and anticipates that the group that is championing each effort will edit these as needed.

9 SYNTHESIS AND ROADMAP FOR THE FUTURE

TO WRAP UP THE SUMMIT, Victor Olgyay (Rocky Mountain Institute) led a group discussion focused on synthesizing the work that we had done, and charting a course forward. He posed the question, *What are the most important things that have come up in these 2 days, and what aspect of this Summit has had the most value for you?*

This brought the discussion back to a point made by Mike Optiz during the Ignite session: every thriving industry has a healthy balance of competition and cooperation, or 'coopetition'. Attendees felt that we had moved towards greater collaboration and changed course of the battleship, in a good way.

Participants appreciated that everyone was a contributor at the Summit. At technical conferences you listen and learn, but here, everyone did his or her part.

RMI also received overwhelming feedback that one of the most valuable aspects of the Summit was simply convening this diverse group of software developers, architects, energy modeling practitioners, policymakers, etc. To further illustrate this point, Amir Roth noted that he gained valuable insights into this industry from both the software vendor point of view and the engineer/consultant view, which have helped to shape his thoughts about DOE's role going forward.

9.1 Key Themes

The following key themes were continually discussed throughout the Summit (this does not imply endorsement of all statements by every attendee).

1	This community needs more effort around *marketing and customer education*; we must improve the credibility of the industry and potential customers need to understand the value proposition.
2	Energy modeling is not currently being used they way it should be. How can we leverage this service to *best support reducing energy use in buildings*?
3	Most of the service providers need *more education and training* (especially around building physics).
4	In the future, we should be able to effectively utilize energy modeling *throughout the building life cycle*. We are currently missing opportunities to use building energy modeling to inform and improve building operations.
5	We need to determine what can (or should) be *standardized and/or automated*.
6	We could improve the quality of analysis by providing practitioners with access to *better knowledge and data resources*.
7	Modeling many standard and innovative building technologies requires work-around that questions whether the *scope of current tools* capture the relevant phenomena.
8	*Current software validation tests* do not address many low energy technologies and interactions between HVAC and control systems.
9	Increased *coordination and information exchange* is essential.

Highlighting the importance of marketing and customer education, attendees agreed that one of the most important things is to craft the simple message that the advancement of building energy modeling is critical. It is perhaps the least understood aspect of the green building movement and there are a lot of people in positions of influence that don't fully understand this field.

We also discussed at length the need for metrics and how to set up metrics with which we can measure the industry. Of course, using metrics implies the need to collect data, which is potentially quite costly and time consuming. If we could establish metrics, then we could report them in an annual Status of the Industry report.

9.2 What will YOU do?

During the wrap up activity for the Summit, Victor posed the question, *"How will you change what you do based on what you've heard in the past 2 days?"* Many people mentioned that they would like to be involved in continuing work efforts, and some noted that these discussions will impact how they focus the strategic direction of their organizations' role within the energy modeling community.

Peggy Yee (GSA) stated that it was helpful to understand the challenges that energy modelers are facing. Peggy felt that customers need to reframe the questions they are asking of modelers and promised to bring that message back to the GSA to influence the way the organization interfaces with energy modelers.

Finally, a portion of the wrap up activities for the Summit centered around a series of real time voting questions, which polled the attendees on what they would commit to following the Summit.

Table 15: Voting Poll Results – What will you commit to following the Summit?

Will you read the post summit report?	YES: 90% NO: 10%
Will you share these outcomes with your organization?	YES: 96% NO: 4%
Will you share these outcomes with external groups?	YES: 84% NO: 16%
Will you share updates from your organization to increase industry cooperation?	YES: 91% NO: 9%
Will you participate in working groups following the Summit?	YES: 91% NO: 9%
Will you pursue funding for working groups?	YES: 35% NO: 65%
Based on what was discussed at the Summit, will you do your own job differently?	YES: 54% NO: 46%
Based on what was discussed at the Summit, will you refocus the strategic direction of your organization?	YES: 60% NO: 37%

9.3 Role of Major Organizations

Moving forward, it is helpful to understand the roles of each major organization within the energy modeling community. Based on discussions at the Summit, there was a general consensus that the focus areas should align as follows.

Table 16: Role of Major Organizations

ORGANIZATION	FOCUS AND ROLE IN ENERGY MODELING COMMUNITY
Department of Energy	➢ Tackle big topics that no one else can - fill large data gaps - field testing - determine metrics to measure success of energy modeling industry ➢ Fund and prioritize other efforts ➢ Ensure that these efforts are meeting the larger goal of reducing energy use
ASHRAE	➢ Professional certification ➢ Standards & guidelines for energy modeling ➢ TC 4.7 participates in the development of the modeling guidelines (see Section 4.4) ➢ Continued development of validation suites for simulation models
IBPSA-USA	➢ Education and training - Develop body of knowledge ➢ Organize software developers to contribute to other efforts ➢ Help increase coordination and communication within the community - Newsletter with updates from key organizations, hosted on BEMBook Wiki (key contact: Joe Deringer)
AIA	➢ Education and training for architects ➢ Partner with RMI on future work in Market Drivers and Customer Demand
USGBC	➢ Should be involved in the Methods and Process group ➢ Should be involved in the Market Drivers and Customer Demand group ➢ Potential funding source?

Moving forward, RMI will continue to support and collaborate with the major organizations listed above, and champion more industry-wide coordination whenever possible.

9.4 How can we further increase cooperation and information flow?

A key theme that emerged at the Summit was the need to increase cooperation and information flow within the building energy modeling community. We discussed that creating a whole other group is not valuable, but we should instead continue to build on efforts of existing organizations such as IBPSA-USA, AIA, and ASHRAE. The following ideas were proposed:

- RMI updates the pre-read annually (which would require some financial support from the modeling community)
- RMI releases Post-Summit Report in May 2011
- RMI develops short "pre-proposals" for key items in the implementation plans. Working groups will use these documents to secure funding for these efforts.
- RMI releases a slide deck summarizing the BEM Innovation Summit
- RMI hosts a webinar to present the Post-Summit Report
- IBPSA-USA hosts a newsletter with updates from key organizations on the BEMBook wiki
- Summit attendees and working group members share these ideas at ASHRAE, AIA, and IBPSA-USA conferences
- RMI is scheduled to speak about the Summit at the keynote of the IBPSA World conference in November 2011
- Use ASHRAE and IBPSA-USA conferences to reconvene Summit participants
  - ASHRAE Summer 2011 Conference (Montreal): A portion of the IBPSA-USA Sat meeting will be dedicated to the Summit
  - Simbuild 2012 Conference (Madison): Potential meeting at conference (either the Tuesday before or the Saturday after)
- Use a Google Site to share information
- Use IBPSA Linked In discussion group to keep the conversation going
- Marketing/press around this group
  - RMI's communications team is marketing this effort. If your organization would like to help in this effort, or you have marketing opportunities you know of, please contact Kelly Vaughn at kvaughn@rmi.org.
- Get a few questions on State of Green Building on energy modeling (Pike Research).

9.5 Future Work and Key Next Steps

An overwhelming majority of the Summit attendees (91%) responded that they would continue to volunteer their efforts by helping with future work coming out of the Summit. We hope that others within the energy modeling community will join this collective effort to capitalize on the numerous opportunities to improve the use of and processes for energy modeling.

Please visit this online form to indicate your interest in either funding or contributing to one of the following efforts:

1	Reviewing the White Paper on modeling guidelines, produced by the Methods and Processes group	See Section 4.4
2	Helping with improvements to existing professional certification programs	See Section 6.4
3	Serving on a committee to examine opportunities to improve higher education for building energy analysis	See Section 6.4
4	Creating webinars and training courses around building energy modeling and building physics for a wide array of professionals such as architects, building operators, commissioning agents, etc.	See Section 6.4
5	Serving on a Steering Committee to address issues related to market drivers and customer demand for building energy modeling	See Sections 7.6
6	Helping to launch an awareness campaign targeted at potential customers to: ➢ Clearly communicate the value proposition for including building energy modeling in a variety of applications, ➢ Arm potential customers with case studies that demonstrate the tangible benefit modeling has brought to different "real-world" projects, and ➢ Teach potential customers when and how to incorporate modeling into their decision-making processes.	See Section 7.6
7	Working to create and maintain the "Knowledgebase" - a new hub of expert-rated building simulation information that is maintained and continuously populated with new building science and simulation resources	See Section 8.4
8	Contributing to the IBPSA-USA BEMbook wiki - an online compendium of the domain of building energy modeling (BEM). The intention is to delineate a cohesive body of knowledge for building energy modeling.	
9	Working to create and maintain the "Database" - a public, centralized resource that hosts granular operational building data, beyond just energy use	See Section 8.4
10	Helping to develop a standardized quality control framework for energy modeling	See Section 8.4
11	Serving on the Software Developer Forum under IBPSA-USA	See Section 5.4

10 APPENDIX A: SUMMIT ATTENDEES

MARLIN ADDISON
M.S. Addison & Associates

Marlin S. Addison is Principal of M.S. Addison and Associates in Tempe, Arizona and serves as Clinical Assistant Professor and Director of the Building Energy Simulation Lab at Arizona State University. Mr. Addison is recognized nationally as the leading expert in the U.S. in the professional use and instruction of computerized energy and economic analysis. He has more than twenty years of experience designing and evaluating residential, commercial and industrial facilities using detailed energy-use simulation methods and has presented more than two hundred professional seminars on detailed simulation methods and economic analysis. During his career, he has consulted on some of the nation's most notable showcase sustainable building projects, including the National Audubon Society Headquarters in New York City, the headquarters of the American Association for the Advancement of Science in Washington, D.C., and the Natural Resources Defense Council office in Santa Monica, CA.

PETER ALSPACH
Arup

Peter Alspach, PE, is an Associate Principal with Arup based in the Seattle office. Peter is Arup's Americas Regional Mechanical and Environmental & Building Physics skills leader where he leads the ongoing development of training, tool development and selection, knowledge sharing, and regional coordination for Arup's 10 regional offices. Peter has experience in both mechanical systems design and building physics/energy analysis and simulation covering a wide range of project types and sizes. As a leader of building simulation at Arup he has worked to develop new internal software tools as well as served as an industry technical advisor for several other development efforts, including the development of EnergyPlus. Peter lectures regionally and nationally on the subjects of low energy mechanical systems design, facade design, passive systems design and building physics analysis. Peter holds a BSME from Washington University in St. Louis and an MSCE from the University of Colorado, Boulder.

GODFRIED AUGENBROE
Georgia Institute of Technology

Professor Godfried Augenbroe has a 30-year track record of research and teaching in building performance. He heads the PhD program in Building Technology and MS program in High Performance Building at Georgia Tech. He has advised more than 20 finished PhD theses in the field, chaired major international conferences, is associate editor of two scientific journals, and has published two books and over one hundred and fifty refereed papers. He teaches graduate courses and conducts research in the fields of building performance concepts, building simulation, indoor air quality, intelligent building systems, acoustics, system monitoring and diagnostics. Since the early nineties, Augenbroe has coordinated four major EU funded consortia of academic and industrial partners, in the fields of design tool interoperability, energy performance simulation, outsourcing and project planning.

JOHN BACUS
Google, Inc.
SketchUp

John Bacus is Product Manager for the Google SketchUp development team where he is responsible for the ongoing design of the growing SketchUp family of products. Prior to joining Google, John was the Director of Product Design for @Last Software, where he worked on SketchUp from the first Mac OS X release through the product's acquisition by Google in 2006. During this time, SketchUp has won numerous awards, including "3D Product of the Year" and a "5 Mice" rating from Macworld Magazine. Prior to @Last, John was a professional design consultant working on a wide range of architectural and urban design projects in both Europe and the U.S. John holds a MArch. (Thesis Prize) from the Rice University School of Architecture, and a BArch. (Ledlie Award) from The Cooper Union for the Advancement of Science and Art.

CHIP BARNABY
Wrightsoft/ASHRAE

Charles S. "Chip" Barnaby is Vice President of Research at Wrightsoft. He is involved in software development, focusing on implementation of loads, energy simulation, and operating cost aspects of Wrightsoft's products. He also leads Wrightsoft's research efforts, working on EnergyPlus enhancements and ASHRAE-funded projects. He is active in ASHRAE, serving on several technical committees and is chair of SPC-205 (Data Exchange Protocols for Energy Simulation of HVAC&R Equipment Performance). He is Vice-President of the International Building Performance Simulation Association (IBPSA) and Treasurer of its US affiliate (IBPSA-USA). He holds the ASHRAE Building Energy Modeling Professional (BEMP) certification.

VLADMIR BAZJANAC
Lawrence Berkeley National Laboratory

Vladimir Bazjanac, Ph.D., Building Technologies Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, University of California. Leader of buildingSMART International (bSI) Technical Advisory Group. Member of the bSI International Management Committee, the bSI Technical Executive Committee and the bSI Software Implementation Support Group. Consulting Professor, Civil and Environmental Engineering Department, Stanford University. Former long- time faculty member in the Department of Architecture, University of California at Berkeley. Won national architectural design, industry and scientific awards. Published over 130 articles, papers and reports related to the AECOO industry on design theory, simulation, information technology, and software interoperability. Lectured at major universities and professional societies in both Americas, Europe, Australia and Asia.

LYNN G. BELLENGER
Pathfinder Engineers & Architects LLP/ASHRAE

Lynn G. Bellenger, PE, Fellow ASHRAE, LEED AP, is a partner at Pathfinder Engineers & Architects LLP, and is the first female president in ASHRAE's 116 year history. She is ASHRAE certified as a Building Energy Modeling Professional and a High Performance Building Design Professional. She is a nationally recognized leader for energy projects ranging from comprehensive energy audits to multi-discipline design for institutional, industrial and commercial buildings. She pioneered techniques that are widely used today, such as redesigning and rebalancing HVAC systems to meet actual cooling loads. Project experience includes evaluating and designing retrofit options, such as alternative utility rates, cogeneration systems, total lighting retrofit, chiller upgrades and central plant improvements, boiler retrofits, motor replacement, and HVAC system redesign.

MIKE BENDEWALD
Rocky Mountain Institute

Mike Bendewald is with Rocky Mountain Institute and will be helping to moderate the Summit. His recent focus at RMI is providing life-cycle cost analysis for new building and retrofit projects, participating in building energy audits and managing the content development for RMI's RetroFit Depot, which is an online resource for explaining the principles of deep retrofits, detailing the deep retrofit process and providing useful tools. A member of ASHRAE and USGBC, Mike has a Masters of Science in Civil Engineering from the University of Colorado at Boulder, Building Systems Program.

MATT BIESTERVELD
Trane Commercial Systems

Matt Biesterveld is an Engineering Manager at Trane with over twelve years of experience with HVAC building load and energy simulation. As Manager for the Customer Direct Service (C.D.S.) group, he is responsible for overseeing development, support, and customer training for all C.D.S. HVAC applications. During his time with C.D.S. he served various roles as a Project Manager as well as Team Leader for all design applications. He also completed several projects under Trane's Advanced Engineering Support (A.E.S.) program where he was responsible for LEED/90.1, EPACT, and performance contracting building simulation projects. He successfully completed the Trane Graduate Training Program, holds a Bachelor of Science degree in Mechanical Engineering from the University of Wisconsin – Platteville, and was among the first to become an ASHRAE Building Energy Modeling Professional (BEMP).

ROBERT BOLIN
Syska Hennessy

Syska Hennesy Group Senior Vice President, Bolin is a LEED® Accredited Professional with over 20 years of consulting mechanical engineering experience. His specialty is collaborating to develop integrated, high performance buildings utilizing passive low energy systems. During his years at Syska Hennessy he has led teams to work on such projects as the LEED® Platinum Natural Resources Defense Council Headquarters in Santa Monica, CA; the LEED® Gold Santa Monica Library; and the LEED® Gold GSA Environmental Protection Agency, Region 8 Headquarters in Denver, CO. Bolin has an M.S. in Architectural Engineering from Pennsylvania State University, and a B.S. in Architectural Engineering from the University of Colorado. He is a GSA Design Excellence National Peer, a past board member of the U.S. Green Building Council, and an Adjunct Research Professor for the School of Architecture at the Illinois Institute of Technology. In addition, he is a published author of many articles, and a contributor to past ASHRAE Standards.

MIKE BRANDEMUEHL
University of Colorado, Boulder/ASHRAE

Michael Brandemuehl, PhD, PE, FASHRAE, is Professor of Civil, Environmental, and Architectural Engineering at the University of Colorado Boulder. He performs teaching and research related to the design, operation, and analysis of building energy systems, with emphasis on the modeling and simulation of HVAC&R systems and their controls, and application of renewable energy technologies. Prior to joining the Colorado faculty, he worked as a research engineer at United Technologies Carrier. He received his Ph.D. in Mechanical Engineering from the University of Wisconsin - Madison, where he was first introduced to TRNSYS as an undergraduate in 1975. He currently serves on the ASHRAE Board of Directors and participates in the activities of TC 4.7 Energy Calculations and TC 7.5 Smart Building Systems. He is also Past President and Board member of IBPSA-USA.

JAMES BREW
Rocky Mountain Institute

James Scott Brew is a Principal Architect and urban ecologist with Rocky Mountain Institute where he specializes in creating sustainable homes, buildings, campuses, and communities. He has over 3 decades of design and construction experience, and has completed hundreds of projects in historic preservation, healthy/high-performance/low-energy homes, buildings, and creating sustainable campus and community plans. His work extends from the US to Asia and Europe. Before joining RMI, James spent 18 years as a principal owner, vice-president and leader of sustainable design, growing his own Minnesota-based architecture and engineering firm from a small, single-focused team, to over 165 people in 7 client-focused teams. James is a Certified Passivhaus Design Consultant and an ambassador for the Living Building Challenge. He is a frequent speaker at national and international conferences on many aspects of sustainability, energy, integrative design, and the business case for going "beyond green".

MARTHA BROOK
California Energy Commission

Martha Brook, a licensed mechanical engineer in the state of California, has worked at the California Energy Commission for 19 years, where she has gained experience in long-term energy demand forecasting, building energy efficiency standards (Standards), and research and development of energy efficient technologies for residential and commercial buildings. Ms. Brook is currently leading efforts to advance the Standards to deliver the climate change benefits of low carbon footprint buildings.

LANE BURT
U.S. Green Building Council

Lane is Technical Policy Director at the U.S. Green Building Council. Lane has helped draft legislation related to building and appliance energy efficiency, including provisions of the Recovery Act, the American Clean Energy ad Security Act, and the Home Star Act. He has worked on building energy labeling, incentives, codes and standards at the federal level and in China, and has testified as an expert witness in congressional hearings on these topics. Lane is a mechanical engineer. Before turning to policy, Lane worked on the design and modeling of high-performance commercial buildings in Charlotte, N.C., and recently served as a member of the Energy & Atmosphere Technical Advisory Group (TAG) working on developing LEED 2012.

AARON BUYS
Rocky Mountain Institute

Aaron Buys is a Consultant with Rocky Mountain Institute where he is responsible for modeling energy performance and performing life cycle cost analysis for commercial buildings. He also develops software tools that improve and promote these activities. Past experiences include commercial HVAC system design and renewable energy research.

COREINA CHAN
Rocky Mountain Institute

As a consultant with RMI's built environment practice, Coreina Chan manages RetroFit amplification efforts to support the scaling of deep retrofits in the commercial building sector. Coreina has been a major contributor to the goals and outcomes of the BEM Innovation Summit, a critical project within the RetroFit initiative. In her tenure with RMI, Coreina has worked on multiple building projects, facilitating workshops to help design teams establish efficiency and performance goals, and implement integrative design processes.

REBECCA COLE
Rocky Mountain Institute

Rebecca Cole manages the development and execution of the strategic marketing plan for the buildings sector, including messaging and positioning, project management and communications activities. In addition, Rebecca manages RMI's public relations strategy, driving the RMI's external communications efforts and objectives.

DRU CRAWLEY
Bentley Systems, Inc.

Dru Crawley, Ph.D., is Director of Building Performance Products at Bentley Systems, Inc., and leads the team developing a new generation of building energy and sustainability software including AECOsim Energy Simulator, AECOsim Compliance Manager, Hevacomp Simulator, and Hevacomp Mechanical Designer. Prior to joining Bentley in 2010, he managed DOE's building energy software tool development including EnergyPlus, OpenStudio plug-in for Google SketchUp, and DOE-2; and lead DOE's Commercial Building Initiative – working to achieve cost-effective low-energy commercial buildings. He is active in IBPSA (serving on the board of directors since 1998). In ASHRAE, he has been chair of TC 4.7 (Energy Calculations, TC 4.2 (Climatic Data), TC 7.1 (Integrated Building Design), TC 2.8 (Building Environmental Impacts and Sustainability), as well as participating in Standards 90.1, 140, 169, 189.1, 203, and 205.

SCOTT CRISWELL
SAC Software Solutions, Inc.

Scott Criswell is President of SAC Software Solutions, Inc. - focusing on the development of building energy simulation tools. Scott has led the development of a variety of tools that interface with DOE-2, including eQUEST, PowerDOE and COMcheck-Plus. He led the design and development of software modules that tackled many challenging features, including energy code compliance analysis, building model QC reporting, 3-D building visualization, large batch energy simulation analyses and "wizard" defaulting mechanisms and user interfaces that help to streamline building model generation. Scott earned a B.S in Physics from the University of California, San Diego in 1987.

ALLAN DALY
Taylor Engineering, LLC

Allan Daly, P.E., Principal, Taylor Engineering, brings together his broad experience from government, research, teaching, and consulting in the design of innovative and sustainable mechanical systems. Allan has recent project experience with a number of low-energy projects and a few with zero energy goals. Allan also teaches and lectures widely to both professional and academic audiences on the topics of energy efficiency, integrated design, building simulation, and UFAD system design. Allan has been with Taylor Engineering since 2000 and previously worked for Ove Arup and Partners, San Francisco. His current work specializes in institutional projects, commissioning work, energy modeling, and green building projects. These include work at the new University of California at Merced, which will be an entire campus of LEED Silver (or better) rated buildings. Allan is a former member of the USGBC Energy and Environment Technical Advisory Group.

JOE DERINGER
Institute for the Sustainable Performance of Buildings/ IBPSA-USA

Joseph J. Deringer, AIA, LEED AP, is Executive Director, Institute for the Sustainable Performance of Buildings (SuPerB). He has presented seminars and webinars on energy efficiency, sustainability, & commissioning to over 6000+ building industry members, including numerous 90.1 workshops. For IBPSA-USA, he has recently led activities to develop a BEMBook wiki (bembook.ibpsa.us) and to develop a workshop on building energy modeling. Has produced eLearning software tools including www.learnhvac.org and www.ecoadvisor.org, has served on ASHRAE 90.1 energy committee for 15 years, has chaired its envelope subcommittee for 10 years, and has assisted 7 countries to develop first generation energy codes. He has performed energy simulations for many buildings worldwide, and has managed energy projects for a number of Federal agencies, utilities, and international donor organizations.

ERY DJUNAEDY
Integrated Design Lab, University of Idaho

Ery Djunaedy, PhD is a Research Scientist (Building Physics Specialist) at the Integrated Design Lab (IDL) at University of Idaho Boise. He has degrees in the area of Building Physics/Science from the Institut Teknologi Bandung, Indonesia, National University of Singapore, and Technische Universiteit Eindhoven, Netherlands. His main interest is in building performance simulation, especially the building energy and airflow simulation. He has used advanced simulation tools like the energy and computational fluid dynamics simulations to design high performance buildings. He has taught building physics courses to architecture students in the Netherlands, the UAE and now in the US. He has been involved in various building design projects in Boise, Idaho and throughout the Northwest region since 2006 when he first joined the IDL.

PETER ELLIS
Big Ladder Software

Peter Ellis is President of Big Ladder Software, a Denver-based company dedicated to developing open-source software for building energy modeling. He has been involved in developing building energy simulation software for more than ten years. He joined the EnergyPlus development team in graduate school where he authored component models for Trombe walls, tubular daylighting devices, and light shelves. Before founding Big Ladder, he worked at the National Renewable Energy Laboratory where he developed more features for EnergyPlus including solar hot water systems, hot water heaters, and energy management systems. He was also the creator of OpenStudio—an EnergyPlus plug-in for Google SketchUp. In addition to his work as a developer, Peter has been equally invested as a user, applying the software to perform whole-building energy analyses on a number of real-world projects. He has trained scores of new users in the intricacies of EnergyPlus in training workshops at US and international locations. He currently serves as webmaster and board member for IBPSA-USA.

CAROLINE FLUHRER
Rocky Mountain Institute

Caroline Fluhrer, EIT, LEED AP, is a consultant with RMI's built environment practice and has four years of experience providing workshop facilitation, building energy modeling, life cycle cost analysis, and LEED documentation services. Her energy modeling work at RMI has focused on new building energy models as well as developing templates and content for building energy modeling support tools. Prior to joining RMI, Caroline was at Stanford University completing undergraduate and graduate degrees in engineering. Caroline's current focus is RMI's new book—Reinventing Fire—which provides a pathway for getting the U.S. (nearly) off fossil fuels by 2050. Caroline is leading the building sector research, which is mostly focused on needed policies, innovation, and technology advancements (including those related to building energy modeling) that will increase the breadth and depth of energy efficiency adoption.

ELLEN FRANCONI
Rocky Mountain Institute

Ellen Franconi, PhD, LEED AP, BEMP, is a senior consultant within RMI's built environment practice. She has worked in the building energy field and performed simulation analysis for nearly 25 years. Her modeling career has transformed with the industry. She's performed simulation analysis to support research, utility DSM programs, M&V and integrated design assistance. Her work is application focused - giving her first-hand experience of the challenges modelers face in today's market. She has held positions at two DOE research labs, three consulting firms, and one non-profit. She has served a 5-year term on the USGBC Energy & Atmosphere Technical Advisory Group, is the vice-chair of the IPMVP committee and is on the IBPSA board. She is a member of ASHRAE.

MARK FRANKEL
New Buildings Institute

Mark Frankel is the Technical Director for the New Buildings Institute. Currently Mark is involved in national coalitions to improve building performance feedback, is working on the development and implementation of codes and programs focused on building performance outcome and benchmarking. Mark Frankel has been consulting on energy efficiency and sustainable design for over 20 years. His work in this period has encompassed a broad range of technical topics, including lighting and daylighting, passive and high performance mechanical systems, commissioning, energy modeling, and site design, IAQ, stormwater management, water efficiency, and others. This work has included life cycle cost evaluation for a range of public and private development models. Mark has consulted on hundreds of capital projects, ranging in scale from single and multi-family residential projects to large commercial buildings all over the country. Mr. Frankel also has extensive experience with the USGBC's LEED program, both as consultant to projects successfully targeting LEED, and as a technical consultant to the USGBC on the LEED program. Mr. Frankel serves on the Board of Directors of the Cascadia Green Building Council, the USGBC LEED Technical Committee, is a licensed architect in Washington, a member of AIA and ASHRAE, and a LEED AP.

BRENT GRIFFITH
National Renewable Energy Laboratory

Brent Griffith is a Senior Engineer at the National Renewable Energy Laboratory in Golden, Colorado. He is heavily involved with EnergyPlus, the US. Department of Energy's building energy simulation program. As a senior member of the EnergyPlus development team, Brent is involved in planning, development, distribution, maintenance, and user support. As a member of NREL's commercial buildings research group, Brent has developed applications that interface with EnergyPlus and used them to conduct large-scale modeling studies related to the potential for low energy commercial buildings in the US and estimating if commercial properties qualify for incentives under section 179D of the IRS tax code.

GAIL HAMPSMIRE
Low Energy Low Cost/ Green Building Certification Institute

Gail Hampsmire (Stranske), Principal in Charge at Low Energy Low Cost, is a licensed professional engineer with a wealth of experience in the design, implementation, and operation of high performance buildings. Gail's key expertise includes identification, analysis, and computer modeling of energy efficiency opportunities for new and existing facilities. She is competent with various brands of building energy use and cost analysis software and is well-versed in code compliance. Also, she has conducted market research and assisted in developing efficiency standards and strategies for utilities and commercial property owners around the country. With eleven years of consulting experience, Gail has provided expertise for nearly one hundred Green Building projects including new construction of a small LEED Platinum environmental showcase facility, new construction of a multi-billion dollar LEED campus exceeding 15 million square feet, and Existing operations and maintenance of a large multi-tenant state-owned office building. Additionally, Gail has contributed towards the implementation of the LEED Green Building Rating system by writing sections of the LEED NCv2.2 reference guide, developing the Adobe template forms for the NCv2.2 LEED Online rating system, and providing review and comments for the LEED 2009 reference guides. Gail has also provided consulting to the USGBC (and most recently GBCI) to review LEED Online submissions, and to train and evaluate new reviewers in their reviews of the Energy & Atmosphere Credit Energy Efficiency Credit (EAc1).

PHIL HAVES
Lawrence Berkeley National Laboratory/ IBPSA-USA

Philip Haves is the leader of the Simulation Research group in the Building Technologies Department at Lawrence Berkeley National Laboratory. He has a BA in Physics from Oxford University and a PhD in Radio Astronomy from Manchester University. He is a Fellow of the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), the immediate past chair of ASHRAE's Technical Committee 4.7 Energy Calculations and a former president of the US affiliate of the International Building Performance Simulation Association. He has particular interests in the use of simulation through the building life cycle and in the use of simulation to develop and test control strategies for low energy buildings. He has contributed to a number of low energy building design projects and is currently leading a project to develop a comprehensive graphical user interface for the EnergyPlus building energy simulation program.

ROGER HEDRICK
Architectural Energy Corporation

Roger Hedrick is Director of Technical Resources at Architectural Energy Corporation (AEC) in Boulder, CO. He has been doing energy models since the late 70's (yes, with cards), and has been active in building energy conservation work throughout his career. At AEC he has been performing energy models for LEED and utility rebates, using DOE 2.2 and EnergyPlus. Recently he has become involved in AEC's work on COMNET and California's Title 24. Roger is also the chair of ASHRAE SSPC 62.1, which is the committee responsible for Standard 62.1, Ventilation for Acceptable Indoor Air Quality.

JEFF HIRSCH *James J. Hirsch & Associates*	Jeff Hirsch, owner at James J. Hirsch & Associates, is an expert in the field of building energy performance simulation and energy efficiency technology analysis. During the past thirty years he has been a leader in the research and development of computer software used for the analysis of building energy use as well as the prediction of the cost effectiveness of energy efficiency technologies. Current primary building energy use and performance simulation tools developed and offered free to the public by JJH include eQUEST and DOE-2.2. JJH also develops and supports the DEER (Database of Energy Efficiency Resources) with Itron for the California PUC.
STEPHANIE HODGIN *Rocky Mountain Institute*	Stephanie Hodgin, LEED AP, is an Analyst with Rocky Mountain Institute and focuses on sustainable design and construction strategies for a variety of project types, including office buildings, schools, manufacturing facilities and museums. She also has experience planning and facilitating sustainable design charrettes. Stephanie has a Bachelor's degree in Biology and a Master's degree in Construction Management and her main area of expertise is in green building rating systems. While guiding numerous projects through the LEED certification process, Stephanie has seen the challenges of integrating energy modeling into the design process and for documenting energy savings for EA Credit 1 points.
JOE HUANG *White Box Technologies, Inc.*	Joe Huang is President of White Box Technologies, which specializes in building energy design and analysis. A former employee of Lawrence Berkeley National Laboratory for 26 years (1981-2007), Mr. Huang has over 30 years of experience in building energy simulations, beginning with the use and maintenance of the DOE-2 program, and later participated in the development of EnergyPlus. His work includes evaluating building energy efficiency and sustainable design, supporting national, state, and nongovernmental organizations in developing building energy standards and ratings, and providing technical evaluation of policy programs. He was the US representative on IEA's Annex 28 on Low Energy Cooling from 1993 to 1998. Mr. Huang has also done extensive work in developing weather data for use in building energy simulations, including over 3,000 "typical year" weather files for international locations for ASHRAE, and has provided training in simulations and assistance in the development of building energy standards in China, Mexico, Egypt, Vietnam, and Tunisia.
DJ HUBLER *Johnson Controls, Inc.*	DJ Hubler is a project development engineer at Johnson Controls and has been recognized as a subject matter expert in the field of energy modeling for the Northwest Region of Johnson Controls. In the role of subject matter expert, DJ has worked to standardize energy modeling methods at Johnson Controls to increase credibility and savings potential from energy models. Mr. Hubler holds a Bachelor's degree in mechanical engineering from Oregon State University. DJ's experience with energy modeling has been focused on creating calibrated models for existing buildings from building energy audit data. DJ presented on performing energy audits to best collect data to calibrate models at a recent ASHRAE conference.

RON JUDKOFF
National Renewable Energy Laboratory

Ron Judkoff directs the Building Energy R&D Program at the National Renewable Energy Laboratory (NREL). Technology areas include development of Building Energy Simulation software, Ultra-Efficient and Zero Energy Buildings, Building Energy Retrofits, Building Integrated PV, innovative HVAC systems, and Active and Passive Solar Heating and Cooling. Previously, Ron was a Senior Architectural Engineer in the NREL Buildings R&D Program specializing in the "energy design" of highly efficient architecture, energy retrofits, and in simulation and monitoring techniques. He has published over 100 papers in the peer-reviewed and popular literature. For five years he headed, as "Operating Agent", an International Energy Agency multinational task on developing validation methods for building energy simulation software. He chairs ASHRAE SSPC-140, Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs, and he is the author of the section in the 2005 ASHRAE Handbook of fundamentals on "Model Validation and Testing". Ron holds a Masters in Architecture degree from Columbia University, and has been the recipient of several national awards.

SONAL KEMKAR
Department of Energy, Building Technologies Program

Sonal Kemkar manages projects for the Commercial Building Integration and Deployment team at the U.S. Department of Energy. In her current role, Sonal works on a wide array of DOE's commercial building initiatives including leading the DOE effort to standardize and train the commercial building workforce nationally. Before joining the DOE, Sonal was a Project Engineer for the largest builder of green buildings in the nation and the Technical Program Manager at a Washington, D.C.-based nonprofit organization promoting energy efficiency, green building and environmental protection in the United States and abroad. Sonal also has extensive international experience: she was a Sustainability Consultant at the United Nations Environment Program in Bangkok, Thailand where she helped develop national green building policies and design net-zero demonstration projects around the Asia-Pacific region.

JOHN KENNEDY
Autodesk

John F. Kennedy, Senior Manager of AEC Building Performance Analysis at Autodesk, Inc., AIA Allied member, ASHRAE member and a licensed mechanical engineer, has over eighteen years of experience developing and expanding the market for building energy analysis solutions. Mr. Kennedy is the lead creator of the open Green Building XML (gbXML) schema and the Autodesk Green Building Studio web service. Mr. Kennedy was the President and CTO of Green Building Studio, Inc. prior to its acquisition by Autodesk. Mr. Kennedy has degrees in mechanical engineering with an emphasis on resource sustainability and received top honors from San Francisco State University. Mr. Kennedy presented his resource sustainability thesis to the Clinton administration's Interagency Material and Energy Flow Workgroup in 1997.

ERIK KOLDERUP
Kolderup Consulting

Erik Kolderup has provided energy consulting services since 1990, serving as Vice President of Eley Associates and Associate Principal at Architectural Energy Corporation in San Francisco, before starting Kolderup Consulting in 2007. His focus is the use of building energy modeling to improve building design. He has also trained design professionals through organizations such as the Collaborative for High Performance Schools, Pacific Gas & Electric, the State of Hawaii and IBPSA. He is a Lecturer at Stanford University where he teaches a course on energy efficient building systems. He holds degrees in electrical engineering and industrial engineering from Stanford University and is an ASHRAE-certified Building Energy Modeling Professional.

STEVE KROMER
Efficiency Valuation Organization/IPMVP

Steve Kromer is an efficiency consultant, focusing on energy savings verification (Program Evaluation and M&V) and energy efficiency data management systems. Mr. Kromer holds a B.S. in Mechanical Engineering from Virginia Tech. He was a senior engineer at the Lawrence Berkeley National Laboratory (where he is currently a guest researcher) and a director at Enron Energy Services. Mr. Kromer is currently under contract to the California Public Utilities Commission, Energy Division. Mr. Kromer is the Immediate Past Chairman and current treasurer of the Efficiency Valuation Organization (EVO). He is on the International Certification Committee of the Association of Energy Engineers and is a founding member and current Chairman of the Certified M&V Professional (CMVP) committee. He is a founding partner of Open-EMV.com.

NICHOLAS LONG
National Renewable Energy Laboratory

Nicholas Long is a Senior Engineer in the National Renewable Energy Laboratory's Commercial Buildings Group in Golden, CO. Nicholas is the team lead for the development of energy analysis tools including OpenStudio (an EnergyPlus plug-in for Google SketchUp), ModelMaker, and the High Performance Building Database. Nicholas was the lead software developer of the NREL Analysis Platform software called Opt-E-Plus which performs multivariate, multiobjective optimizations using EnergyPlus to help provide feedback during the early design phase of building projects. Nicholas has performed several training programs on energy modeling software programs within the United States and internationally and has contributed to several building projects including early design phase support, detailed modeling, end-use analyses, commissioning, site weather data analyses, and installation of metering systems.

CLIFF MAJERSIK
Institute for Market Transformation

Cliff Majersik, Executive Director, bears primary executive responsibility for the Institute for Market Transformation. He directs IMT's research into green building, COMNET, energy efficiency and property value. Mr. Majersik serves on the COMNET Standing Committee, an initiative of RESNET that aims to develop a standardized BEM methodology for commercial buildings. He leads IMT's education and outreach to the finance, appraisal and real estate sectors. Mr. Majersik provides expert assistance to federal, state and local officials in developing energy and building policy and legislation. He was a leader in crafting Washington's Energy Act of 2008 and Green Building Act of 2006. Before joining IMT in 2002, Mr. Majersik served as Director of the eProcurement Project and eBusiness Director for Conservation International's Center for Environmental Leadership in Business. Previously, he worked as a management consultant at the Corporate Executive Board specializing in E-commerce, sales-channel management, and strategic customer relationships. In 1994, he founded a web-based collaboration software company, eventually growing the firm to 25 employees. He currently serves on the board of directors of GreenHOME and on the Washington DC Green Building Advisory Council. He received his bachelor's degree, cum laude, in Political Economy from Williams College. He is a LEED accredited professional.

TIMOTHY MCDOWELL
Thermal Energy System Specialists/IBPSA-USA

Tim McDowell, BEMP, is the Vice President of Thermal Energy System Specialists (TESS), a consulting company in Madison, Wisconsin. TESS is one of the developers of the TRNSYS software package and also serves as the US distributor. Tim has been with TESS since 1995 and has experience using TRNSYS to model various building energy systems including ground-coupled heat transfer, geothermal energy, dedicated outdoor air systems and LEED modeling. He has developed coupled simulation for combined airflow and thermal modeling and optimization. Tim is currently Vice-Chair of ASHRAE TC4.7 Energy Calculations and Secretary of IBPSA-USA.

DON MCLEAN
Integrated Environmental Solutions

Dr. Don McLean is Founder and Managing Director of Integrated Environmental Solutions (IES). Don has over 25 years experience in the use and development of building simulation software and also spent two years as a Building Services Engineer at Balfour Kilpatrick. His experiences developing and applying building simulation programs combined with his knowledge of Environmental Engineering and his experience with architects gave him a unique understanding of how building performance tools can significantly improve the building design process. In June 1994, Don founded Integrated Environmental Solutions (IES) in order to develop the <Virtual Environment> suite of integrated building design and simulation tools. His objectives were to overcome many of the obstacles to the uptake of building simulation products and ultimately fully integrate them into the building design process.

JOHN MELCHERT
The Weidt Group

John Melchert is Partner and Senior Vice President of Software Development at The Weidt Group, a 33-year old firm providing energy design assistance, measurement & verification, ongoing performance benchmarking services, and specialized software tools for state and local governments, architects, engineers, building owners, and utilities. For nearly 30 years Mr. Melchert has led large innovative software development projects with a deliberate focus on object-oriented behavioral models for expert systems and engineering applications. Over the last 18 years at The Weidt Group, Mr. Melchert has played a visionary and architectural role in the development of several virtual model based systems for manufacturers and designers in the architectural, construction, and engineering industry.

LINDA MORRISON
Ambient Energy

Project Manager and Team Leader for Ambient Energy's Building Performance Engineering Team. Perhaps the newest BEMP in the country – took the exam March 4! Old hat with 17 years energy audits and modeling existing buildings for performance contracting plus building performance simulation (energy, daylight, renewables, bulk airflow, CFD, etc.) for new construction. Mechanical Engineer by education. Trained loads of people in various tools from degree day models to simulation to M&V. All about creative energy solutions matched with actual operating performance. We will be the ones to change the world through our work in our professional lifetimes!

DANIEL NALL
WSP Flack + Kurtz

Daniel H. Nall, PE, FAIA, LEED, BEMP, has been involved with building energy modeling for over 35 years both as a user and as a software developer. He is Director of Sustainability for WSP Flack + Kurtz, a Fellow of AIA, a member of the ASHRAE Building Energy Modeling Certification Committee, the ASHRAE Building Energy Quotient Committee, and Vice Chair of the ASHRAE/IES/USGBC/ANSI Standard 189 Committee. He was a Director of the USGBC NY Chapter, a member the AIA National Committee on the Environment, and Vice Chairman of the USGBC Energy and Atmosphere Technical Advisory Group. He was one of Engineering News Record's "Newsmakers of 2007," and was named "Outstanding Practitioner" by IBPSA-USA in 2004. He has been a faculty member at the Schools of Architecture at the University of Pennsylvania, Princeton University and Columbia University. He is the author of over 30 articles and papers in professional and technical journals and conference proceedings.

SATISH NARAYANAN
United Technologies Research Center

Satish Narayanan is a Project Leader in the Energy Systems Program Office at UTRC. The R&D program portfolio he leads is focused on maturing and demonstrating system solutions to energy efficient buildings spanning the entire building lifecycle, involving high performance building simulations an computational design tools, and advanced whole building control and diagnostic systems. Since joining UTRC in 1998, he has worked in a broad range of problems involving physics-based modeling, experimentation and control of dynamic phenomena in aerospace and building systems. His expertise is in nonlinear dynamical systems methods applied to model reduction and control in unsteady flow and thermal energy systems, having published over 10 archival journal articles, over 30 conference papers and receiving 4 patents.

RON NELSON
Institute for Market Transformation

Ron Nelson, consultant, leads the COMNET effort for the Institute of Market Transformation (IMT). A collaborative project of RESNET, the New Buildings Institute, the Architectural Energy Corporation, and IMT, COMNET aims to establish a standard methodology for building energy modeling of commercial buildings and to ensure high quality in the professional practice of COMNET's building energy modelers. He comes to IMT after completing a MArch at the University of New Mexico in 2009. He was a physicist with the Los Alamos National Laboratory for 31 years, and spent the majority of that time working at the Lujan Neutron Scattering Center. He received a PhD in Physics from Duke University in 1971, an MBA from the University of New Mexico in 1997, and a BS in Physics and Mathematics from Florida State University in 1967.

VICTOR OLGYAY
Rocky Mountain Institute

A principal architect directing RMI's Buildings Practice, Victor Olgyay is leading an initiative to encourage widespread adoption of comprehensive building energy retrofits resulting in energy savings of at least 50%. Victor has a wide range of experiences in architectural design and planning, with specializations in bioclimatic building, renewable energy and daylighting design. Current RMI projects include the National Museum of African American History and Culture, Ford Auto Dealership Retrofits, and the International Monetary Fund HQ1 Retrofit. Victor was an Associate Professor and Director of Research at the UH School of Architecture from 1993 to 2000. He was appointed Chairman of the AIA Honolulu Energy and Environment Committee 1995–2000, and in 1998 he was named a Dana Fellow of the Joslyn Castle Institute for Sustainable Communities. He is currently a member of the National Academy of Environmental Design Research Committee. His current research has focused on ecological restoration and on ecosystem services as criteria for green building assessment. This work was published by Elsevier (Solar Energy 77 (2004) 389 – 398) and has been widely presented, including at the American Solar Energy Association (San Diego, 2008) and the Towards Net-Zero conference (London, 2009). Recently Victor's research has expanded into building tool application, especially for demonstrating the reduction of carbon, water, and ecological footprints.

MIKE OPITZ
United States Green Building Council

Mike Opitz is the Vice President of LEED Implementation at USGBC. During his time with USGBC Mike has overseen the revisions to the LEED for Existing Buildings: Operations and Maintenance rating system, managed the LEED certification team, and directed ongoing operations of the LEED for Existing Buildings program. Prior to joining USGBC Mike's professional career has focused on energy efficiency in buildings, starting with the development of a regional model energy code in Russia in the 1990s that has since been locally adopted by regions constituting 75% of the country. Mike also spent several years at a consulting firm in the DC area where he was responsible for quality assurance and quality control of energy measurement and verification, and also managed an energy performance contract for the U.S. Army covering 700 buildings across five installations. Mike is a licensed Professional Engineer and a LEED Accredited Professional. He holds dual master's degrees in Mechanical Engineering and in Technology and Policy from the Massachusetts Institute of Technology.

ALEKA PAPPAS
Group 14 Engineering

Aleka Pappas, EIT, BEMP, is a building energy engineer for Group14 Engineering in Denver, assisting architects and engineers during the design process to optimize the energy performance of buildings. She has a BA in Architecture from Washington University in St. Louis, an MS in Building Systems Engineering from the University of Colorado at Boulder, and over 10 years experience working in the A&E field, including positions as an intern architect and as an HVAC design engineer. Aleka is an expert in building energy simulation software such as DOE-2 and EnergyPlus, and has extensive experience with computational fluid dynamics (CFD) modeling. She attempts to bring together expertise from architects and engineers on projects to help teams find the best possible energy efficiency solutions.

DAVID REDDY
360 Analytics

David Reddy is a founding partner at 360 Analytics; a young, dynamic energy analysis consulting firm with offices in Seattle and Bellingham, Washington. To help close the loop between design phase predictions and real-world building performance, 360 Analytics focuses on benchmarking energy model results with actual energy use, as well as the integration of monitoring data to improve model predictions. Prior to starting 360 Analytics in 2009, David was a subcontractor/employee of Madison Engineering PS, where in addition to energy modeling, he worked on projects ranging from California Public Utility Commission's 2008 DEER update, to the development of eQUEST's LEED v3.0 compliance analysis tool. David holds a BS in Mechanical Engineering and is currently working towards completion of his thesis for a MS of Mechanical Engineering degree, all at the University of Washington.

MIKE ROSENBERG
Pacific Northwest National Laboratory/ ASHRAE

Michael Rosenberg is a Senior Research Scientist with Pacific Northwest National Laboratory. He has worked for over 18 years improving energy-efficient practices in residential and non-residential facilities. He has been involved in designing high performance buildings, analyzing complex building systems, upgrading building energy codes, and developing and administering beyond-code energy programs. Energy simulation has played a key role in each of these endeavors. Mr. Rosenberg is a member of the ASHRAE Standard 90.1 Energy Cost Budget Subcommittee and the LEED Energy and Atmosphere Technical Advisory Group, and was recognized by the Association of Professional Energy Managers as 2007 Oregon Energy Manager of the Year. He is a Certified Energy Manager and LEED Accredited professional. Prior to joining PNNL Mr. Rosenberg spent 8 years at the Oregon Department of Energy as a Senior Energy Analyst and 7 years at Hatten/Johnson Associates, Mechanical Engineering Consultants.

AMIR ROTH
Department of Energy, Building Technologies Program

Amir Roth, PhD is the acting program manager for building performance simulation tools at the US Department of Energy's Building Technologies Program. He was previously with the University of Pennsylvania as an associate professor in the Computer and Information Science Department and a former chair of the undergraduate computer science program. He has also worked as a software engineer at Microsoft and a research engineer at Intel. He is a member of ASHRAE, IEEE, and ACM.

KEVIN SETTLEMYRE
Sustainable IQ

Kevin is President of Sustainable IQ, a consulting firm that collaborates with national labs, start-up companies, A/E firms and project teams to collaboratively develop and implement innovative sustainable ideas and strategies. Kevin has a diverse professional practice background spanning 15+ years. He has practiced as an architect, façade engineer (Arup) and held technical and executive roles within software companies including Revit Technology, MOCA Systems, and IES, where he served as President, IES North America. In addition he was a co-founder/co-director of innovative programs, such as NEXUS – Boston's Green Building Resource Center, and he has directed consulting groups for numerous years. He also is a LEED faculty member (selected position) for the US Green Building Council for the past five years. Kevin holds two masters degrees from MIT in Building Technology and Civil & Environmental Engineering, as well as a professional degree in architecture form the University of Oregon.

MUTHUSAMY SWAMI
Florida Solar Energy Center

Muthusamy Swami, Ph.D. is Program Director for Simulation Software Development at the Florida Solar Energy Center. He leads the development of software tools involving building energy codes and ratings, including LEED, ASHRAE appendix G and federal energy tax deduction with a key feature being the auto-generation of the reference or baseline buildings. Additionally, his buildings-related research has addressed building energy efficiency, building security, contaminant transport and dispersal, radiant energy transfer, pressure coefficient correlations for natural ventilation, and combined thermal and moisture storage. He is active with the Florida Building Commission and COMNET.

KENDRA TUPPER
Rocky Mountain Institute

Kendra Tupper, PE, is a Senior Consultant with Rocky Mountain Institute and has 9 years of experience in building system engineering and energy simulation. Kendra has a Bachelors Degree in Mechanical Engineering and a Masters Degree in Building Systems Engineering. She has experience as both an energy modeling practitioner and an HVAC designer for large commercial buildings. Kendra's energy modeling work at RMI focuses on creating tools and templates to streamline processes, developing content for education and training programs, and project managing the BEM Innovation Summit. She currently serves on the ASHRAE TC 7.6 Committee (Building Energy Performance) and teaches professional training courses on energy modeling fundamentals and best practices.

NORM WEAVER
Fort Collins Utilities

Norman Weaver, PE, Fort Collins Utilities, is an energy efficiency technology specialist with experience in the evaluation and design of energy efficiency and renewable energy systems. Recent FCU projects include monitoring and analysis of participants in the Photovoltaics Net-Metering program and building modeling for the Integrated Design Assistance program. Prior to joining FCU, Mr. Weaver provided technical and software support for development of Energy-10 and technical support for the 2002 and 2005 US DOE Solar Decathlon as president and principal engineer for InterWeaver Consulting. He maintains affiliations with ASHRAE and IBPSA.

MICHAEL WETTER
Lawrence Berkeley National Laboratory/ IBPSA-USA

Michael Wetter is the Deputy Group Leader of LBNL's Simulation Research Group. He is the President of IBPSA-USA, the Treasurer and a member of the Board of Directors of IBPSA, a member of the Editorial Board of the Journal of Building Performance Simulation, a recipient of the Outstanding Young Contributor Award of IBPSA, and a member of ASHRAE. His research includes the development of next-generation tools for building system modeling, simulation and optimization, the integration of simulation tools into the research process, and their use for design and operation of buildings. He created various software for building energy modeling, simulation and optimization, including the Modelica Buildings library, the Building Controls Virtual Test Bed, and the GenOpt optimization program.

TOM WHITE
Green Building Services

Only two years out of college, Tom participated in the original development and testing of DOE-2.1B back in the very early 1980s when he worked at Altas Corp. in Santa Cruz, CA. He brings more than 30 years experience in the engineering and applications of building energy systems to his current job as Technical Director at Green Building Services in Portland, OR. His more recent jobs include serving on the faculty at the Oregon Institute of Technology, teaching "green building" courses in HVAC, energy management, and energy-efficient building design, and developing the energy services team at Glumac, a mechanical-electrical-plumbing design firm, where Tom led a very capable group of engineers in modeling more than three dozen LEED projects. Tom is a LEED accredited, P.E, and holds both bachelor's and master's degrees in mechanical engineering, as well as bachelor's degree in biological sciences.

CHRIS WILKINS
Hallam-ICS/ASHRAE

Chris Wilkins is a VP and Director of Engineering for Hallam-ICS. Hallam-ICS is deeply involved in traditional and advanced energy modeling as part of their consulting engineering practice. Chris is also very involved in ASHRAE currently serving as Chair of the BIM Steering Committee and Chair of TC 4.1 Load Calculation Data and Procedures. He was recognized by ASHRAE in 2009 with the Service to ASHRAE Research Award. Chris currently serves on the Board of Direction of buildingSMART alliance.

BILL WORTHEN
The American Institute of Architects

Norman Weaver, PE, Fort Collins Utilities, is an energy efficiency technology specialist with experience in the evaluation and design of energy efficiency and renewable energy systems. Recent FCU projects include monitoring and analysis of participants in the Photovoltaics Net-Metering program and building modeling for the Integrated Design Assistance program. Prior to joining FCU, Mr. Weaver provided technical and software support for development of Energy-10 and technical support for the 2002 and 2005 US DOE Solar Decathlon as president and principal engineer for InterWeaver Consulting. He maintains affiliations with ASHRAE And IBPSA.

PEGGY YEE
General Services Administration

Dr. Peggy Yee is a Program Expert at GSA's National 3D-4D-BIM Program. Peggy's professional interests involved the development and implementation of virtual design and construction technologies in the AEC industry worldwide to increase the quality and efficiency throughout the facility lifecycle. Peggy received her PhD from Stanford University's Center for Integrated Facility Engineering (CIFE).