



Notes

California Technical Forum (Cal TF)

Modeling Charrette

May 30, 2019

9:30 a.m. – 4:30 p.m.

Pacific Energy Center
851 Howard Street, San Francisco

Time	Agenda Item	Discussion Leader(s)
9:30 – 10:00	Opening, Agenda and Introductions <ul style="list-style-type: none">• Icebreaker	Annette Beitel, Cal TF Facilitator
10:00 – 10:30	Goals and Desired “Future State” <ul style="list-style-type: none">• Review input to date• Review Future State “Starting Point” slide ACT: Participant Input on goals for the day that could lead to improvements in the California modeling ecosystem and desired “ Future State ”; Identify Future Opportunities for modeling tools.	Annette Beitel Martha Brook, CEC Manisha Lakhanpal, CPUC Steve Kromer, SKEE
10:30 – 11:30	Brief History and Current State <ul style="list-style-type: none">• Brief History of Modeling• Prior attempts at modeling “reform”• Current State: Use Cases, Models, Interfaces, Building Prototypes/Rulesets• Review Handouts 1 and 2• Proposed metrics for reviewing models/interfaces/future states ACT: Participant Feedback on whether “current state” descriptions (Handouts 1 & 2) complete and correct; Start identifying broad areas of agreement.	Steve Kromer Doug Mahone, Cal TF Member Roger Baker, Cal TF Staff

11:30 – 12:00	Current Challenges in CA Building Simulation Modeling <ul style="list-style-type: none"> • Example 1: Many models, one building • Example 2: Documentation and reproducibility <p>ACT: Participant Feedback on challenges they have experienced with building simulation in CA.</p>	Steve Kromer Ayad Al-Shaikh, Cal TF Staff
12:00 – 12:30	LUNCH	
12:30 – 1:15	“Future State” Case Study: LADWP Use of Modeling Tools <p>ACT: Inform participants about advanced modeling capabilities and potential real-world applications.</p> <p>Participant Questions; Participant Input on other “Future State” Uses.</p>	Armen Saiyan, LADWP Andrew Parker, NREL Chan Paek, SCG
1:15 – 2:15	Exercise #1: Harmonizing/Standardizing Modeling Approaches (Inputs and Modeling Tools/Software) Across IDSM Programs/Use Cases <ul style="list-style-type: none"> • Identify commonalities between Use Cases • Can use cases that are similar be more aligned (engines, interfaces, rulesets, prototypes)? • How can they be more aligned? <p>ACT: Participant Input on opportunities to harmonize use cases.</p>	Roger Baker Doug Mahone Steve Kromer Armen Saiyan Ayad Al-Shaikh
2:15 – 2:45	Exercise #1 Report-out	Team Leads
2:45 – 3:00	Break	
3:00 – 4:15	Exercise #2: Additional Participant Feedback on Key Issues for TPP <ul style="list-style-type: none"> • Identify the path forward (near- and long-term) in the following areas: <ol style="list-style-type: none"> 1. Goal/Metrics 2. Desired Future State for CA Modeling Ecosystem 3. Future Uses of Modeling & Emerging Needs 	Roger Baker Doug Mahone Steve Kromer Armen Saiyan Ayad Al-Shaikh

	ACT: Participants to visit 1-2 stations/topics of interest and identify considerations for path forward. Facilitated discussions to identify recommendations for path forward.	
4:15 – 4:30	Next Steps and Close <ul style="list-style-type: none"> • Cal TF Staff will clarify and follow-up on issues, as needed • Cal TF Staff prepares Draft TPP • Circulate to participants for comment; Identify industry peer reviewers • Teleconference, possible follow-up meeting in fall. ACT: Discuss next steps and timing.	Annette Beitel

List of Attendees – In Person

Last Name	First Name	Company
Al-Shaikh	Ayad	Cal TF staff
Athalye	Rahul	NORESCO
Baker	Roger	Cal TF staff
Barnes	Jennifer	Cal TF staff
Beeler	George	AIM, Cal TF member
Beitel	Annette	Cal TF staff
Boyce	Bryan	Energy Solutions
Brook	Martha	California Energy Commission
Buckley	Liam	IES Ltd.
Bulger	Neil	Red Car Analytics
Chhabra	Mohit	NRDC
Contoyannis	Dimitri	Model Efficiency
Costa	Marc	The Energy Coalition
Coulter	Dallen	Southern California Edison
Criswell	Scott	SAC Software Solutions, LLC
Dela Cruz	Imma	SF Environment
Ehrlich	Charles	PG&E CIT
Endurthy	Akhilesh Reddy	Solaris-Technical, LLC.
Fergadiotti	Andres	Southern California Edison
Fette	Nicholas	Solaris Technical
Froess	Larry	Sacramento - California Energy Commission
Haselhorst	Susan	Energy & Resource Solutions, Inc. (ERS)
Jenkins	Rebecca	SCG
Kromer	Steve	SKEE

Last Name	First Name	Company
Kruis	Neal	Big Ladder
Lakhanpal	Manisha	CPUC, Energy Division
Liu	Henry	PG&E
Long	Steven	Lockheed Martin
Mahone	Douglas	TRC (retired), Cal TF member
Maxwell	Jonathan	Energy & Resource Solutions, Inc. (ERS)
Melloch	Tim	Cal TF staff
Mendon	Vrushali	Resource Refocus LLC
Modera	Mark	UC Davis
Neumann	Ingrid	California Energy Commission
Pande	Abhijeet	TRC
Parker	Andrew	NREL
Punjabi	Sonia	PG&E
Ramirez	Bob	DNV GL
Reynoso	Ed	SDG&E, Cal TF member
Richard	Kerri-Ann	Energy & Resource Solutions, Inc. (ERS)
Ridgley	Robert	California Energy Commission
Rogers	Christopher	CLEAResult, Cal TF member
Roth	Amir	US Department of Energy
Saiyan	Armen	LADWP, Cal TF member
Saxena	Mudit	Vistar Energy Consulting
Seto	Jeffrey	Alternative Energy Systems Consulting, Inc. (AESC)
Shahinfard	Sepideh	Cadmus, Cal TF member
Singh	Alok	Southern California Edison
Torres-Garcia	Tomas	Cal TF staff
Tsan	Bach	Southern California Edison
Vu	Martin	RMS Energy Consulting, LLC, Cal TF member
Wilcox	Bruce	
Wilson	IBPSA-USA	IBPSA-USA

List of Attendees – Via Webinar

Last Name	First Name	Company
Burrows	Tim	Sustainable Returns
Collins	Greg	
Cooper	Benjamin	
Escala	Aida	California Energy Commission
Fisher	Anne	California Energy Commission
Glazer	Jason	GARD Analytics, Inc.
Hanna	James	Energy Solutions
Janusch	Nicholas	California Energy Commission
Kotewa	Lawrence	Elevate Energy
Kwong	Melanie	LADWP

Last Name	First Name	Company
Lor	Thomas	Southern California Edison
Maddox	Doug	Maddox Energy Consulting
Mateo	Tiffany	California Energy Commission
Mendon	Vrushali	Resource Refocus LLC
Paek	Chan	SCG
Shallenberger	David	Synergy Companies
Sun	Luke	LADWP
Tso	Bing	SBW Consulting
Valenzuela	Keith	
VanSise	Randy	Onsite Energy Corp
Vicent	Will	Southern California Edison
Wall	Elise	2050 Partners, Inc.

Icebreaker

Attendees were asked to anonymously respond to two questions in writing:

1. I have the following objectives for today's meeting/If I could change on thing, it would be...
2. I have the following concerns about the meeting

The responses to question #1 demonstrate that participants had a broad range of expectations from the charrette, including:

- Many viewed the charrette as an educational opportunity on a range of topics;
- Others wished to gain insight into the broader modeling industry and issues facing practitioners;
and
- Many were interested in the future of modeling in California.

The responses to question #2 gravitated around a general concern or belief that few or intangible results would come out of the charrette and related efforts:

- Some were concerned that there would not be actionable objectives;
- Some were also concerned that the effort would devolve into entities protecting their interests;
and
- Many were concerned that there would not be effective decision-making or willpower to enact necessary policy changes in California.

All responses were collected and are provided as Appendix 1.

Goals and Desired “Future State”



Cal TF Business Plan Goal



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Develop High-Level Proposed Approach for Achieving Statewide Consistent Approach To Building Simulation Modeling in California.


"Consistent" is not intended to mean "the same" or "identical" modeling

Identify common goals and propose approaches to harmonize modeling to:


- **Reduce inefficiencies** – leverage taxpayer/ratepayer investments, encourage collaboration
- Maintain or improve **modeling rigor**
- Identify what constitutes **sufficient evidence** such that results of a new model are **reliable for savings calculations**
- Achieve **consistent documentation** so results are **transparent** and can be **reproduced** and **peer reviewed**

5/30/2019

Annette Beitel described the objective of the charrette. CalTF sees opportunities to harmonize modeling efforts, and also sees issues with documentation and transparency of the current processes.



CPUC Staff Comments



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DEER 2021 Draft Scoping Memo explores use of other building simulation tools beyond DOE2:

"This is another issue that has been raised in many venues, especially with the increased use of the EnergyPlus™ building simulation tool for other state-sponsored work (e.g. California Energy Commission Title 24 compliance tools) and custom projects."

Staff is seeking stakeholder input:

- Why do we (CPUC) need to change from status quo?
- How do we get to the desired outcome?
- How to fund transition effectively, particularly do we create new prototypes or convert existing DEER prototypes?
- How can staff gain confidence with use of other building simulation tools?


Assessment should lay out **questions, issues, needs, concerns** and establish a **systematic plan** for deciding **whether new tools and prototypes should be developed** and **establish a timeline for the development and execution**.


Also . . . "What is necessary for us (CPUC) to feel comfortable that alternate modeling engines are producing accurate results and not over-inflating savings?"


5/30/2019

Manisha Lakhanpal (Supervisor – Energy Efficiency - Industrial/Agricultural Programs and Portfolio Forecasting) described the role of CPUC Staff. Noting audience familiarity with DEER, Staff’s role is to facilitate and add value to the effort. For today, following guidance from Steve Kromer that “before you make decisions you need to know what is out there.” Staff’s consultants provide input into the process and, given where they are in the process (beginning the scoping for DEER2021), is this the right time to consider changes in modeling approaches and tools? While the adage “if it’s not broke, don’t fix it” could apply to the current state, there is also recognition that newer tools that can do as good or better at modeling beg the question “why not change now?” She acknowledges that no matter how fast industry moves in this sphere, the regulatory machine is generally slower and may not be able to keep up. To this end, changes to modeling approaches may not happen until 2022 or 2023. Staff needs to be able to articulate a rationale for making those changes, and there are budgetary considerations that can impact timing. Fortunately, Staff, working with Sue’s team, Bob’s team, and Steve Kromer, should be well positioned to advance this effort going forward.

Martha Brook (CEC) Comments








- Need to establish sustainable, effective roles for state government
 - Better to reference industry standards than for governments to establish, maintain and update all standards, including model tool sets
 - Govs should only fund the application layers needed for policy development & implementation
 - Govs could help launch but then collaborate with others to support model test stds, MAP database (see below)
- Leverage past investments in CA and US
 - We have already paid multiple times to model every building in CA, for example
 - MAP == Model Amnesty Program → statewide model database: inputs & outputs
- Use all approved model results: distributions are better than singular estimates for decision making

5/30/2019

Martha Brook (Technical Advisor to Commissioner McAllister) has history – moved code compliance software to the current open source platform used now. She is considering how to expand the use of the software beyond code compliance, and public-private partnership needs to expand in order to advance these efforts. We need to be able to rely on high-quality software, but also must manage within budget and resource constraints. Believes CPUC and CEC can collaborate much more than they have. They work together through DAWG – why not a modeling working group?

Proposes a “Model Amnesty Program” (MAP), noting that a large number of building models have been constructed using taxpayer or ratepayer dollars, and “we want them back.” Advocates for collecting those models and building a database or repository for them so we don’t have to rebuild them again.

Furthermore, regulators should look at building consumption as ranges or distributions rather than point estimates. Ranges make more sense for large-scale decision making.



Statutory and Regulatory Requirements

re: Modeling

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10.3. (Rule 10.3 of Commission's Rules of Practice and Procedure) - Computer Model Documentation.


(a) Any party who sponsors testimony or exhibits which are based in whole, or in part, on a computer model shall provide to any party upon request, the following information:

- (1) A description of the **source of all input data**;
- (2) The complete **set of input data** (input file) as used in the sponsoring party's computer run(s);
- (3) **Documentation** sufficient for an experienced professional to understand the basic logical processes **linking the input data to the output**, including but not limited to **a manual** which includes:
 - (A) A complete list of variables (input record types), input record formats, and a description of how input files are created and data entered as used in the sponsoring party's computer model(s).
 - (B) A complete description of how the model operates and its logic. This description may make use of equations, algorithms, flow charts, or other descriptive techniques.
 - (C) A description of a diagnostics and output report formats as necessary to understand the model's operation.
 - (4) A complete set of output files relied on to prepare or support the testimony or exhibits; and
 - (5) A description of post-processing requirements of the model output.

See also Public Utilities Code section on computer modeling (Secs. 1821 and 1822.)

5/30/2019

Annette Beitel – discussed Commission rules regarding documentation, transparency, and visibility into the modeling process, which were key drivers for the charrette and software discussion.



Other Stakeholder Goals

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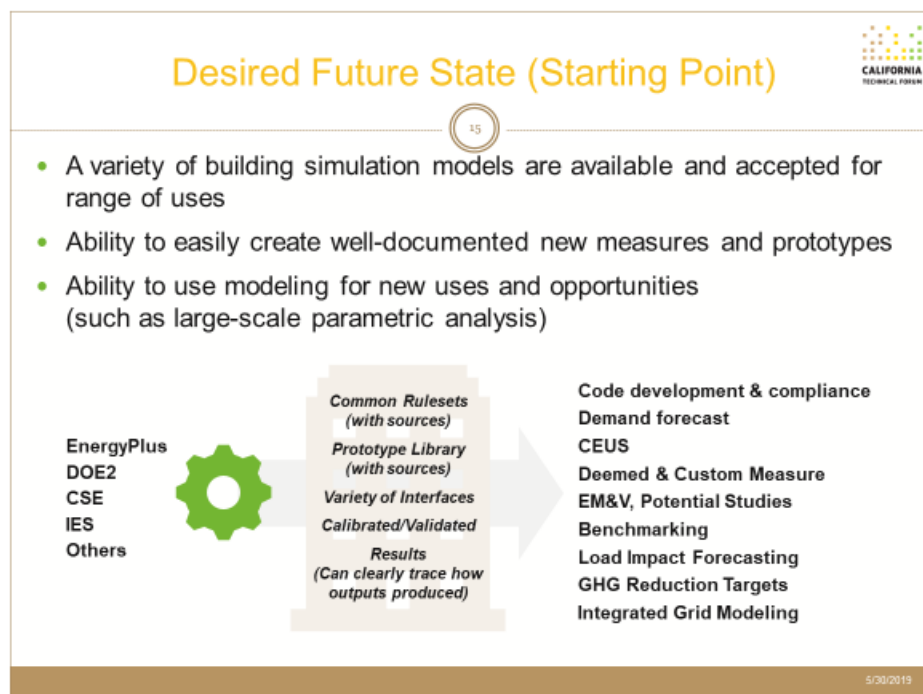
- **Level Set:** Build common understanding of “current state”
 - Current use cases
 - Current building simulation models, rulesets
 - Identify broad areas of agreement
- **Improve Tracking and Coordination:** How can CA better track and coordinate existing efforts to improve modeling (transparency, usability, etc.) while reducing costs?
- **Anticipate and Plan for Future Needs and Opportunities:** How can modeling be used to meet future needs (such as analysis for grid, electrification, GHG reduction)?
 - Advanced modeling capabilities
 - New opportunities for modeling
- **Emerging Trends:** Identify emerging technical and policy trends that can benefit from modeling
- **Other (Participant Input)?**

5/30/2019

Steve Kromer – worked at LBNL and on DOE2, noted that IPMVP Option D is not used as much as it should. Looking at commercial programs across the country as well as California, and whether they are using modeling and, if so, how. He noted that a lot of programs are used in California but they are not well-coordinated. Notes that a modeling task force would be a good way to help all parties know what else is going on with modeling. Improving coordination and tracking so we all know where to look and what to use would be helpful.

We also need to look at emerging needs (grid, storage, solar, etc.) as they pertain to larger issues like climate change.

Any other goals to consider? **Attendees were invited to provide input.**



Annette Beitel – described the proposed future state for modeling:

- Multiple approved modeling tools available for practitioners to use.
- Measures and building prototypes are well-documented and transparent (practitioners can review and understand how measures/prototypes were developed, and the sources used to develop measures/prototypes are clearly and publicly available).
- Building simulation tools can be used to model newer technologies and clean energy solutions (such as grid modernization and building electrification) that California is moving toward.

Getting to the future state would require developing common rulesets, sharable prototype libraries, models that can be calibrated and validated for use for multiple use cases, and results that can be replicated and traced. The last item is critical, as Commission decisions have requested more transparency and the current modeling scheme does not provide the requisite transparency.


We want to encourage private sector development to support this work.

There are a number of uses for modeling in California:

- Code development
- Code compliance
- Demand forecasting
- CEUS
- Deemed and Custom Measures
- EM&V, Potential Studies
- Benchmarking
- Load Impact Forecasting
- GHG Reduction targets
- Integrated Grid Modeling

Brief History and Current State

Overview




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- History of model development
- History of modeling in California
- Prior CA collaboratives seeking reform/improvements to CA modeling ecosystem
 - How this charette is different from prior efforts
 - How could this charette produce actionable outcomes that prior efforts have been unable to achieve ... that will lead to improvements in the CA modeling ecosystem

5/30/2019

Steve Kromer – There is a long history of modeling in CA and nationally (see slide in presentation appendix). We won't rehash details on history, that can be found in reports. In CA, we have DEER, which started at CEC.

Simulation Engines Used Across the State




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- The California Energy Commission and the California Public Utility Commission (and LADWP) have built or supported development of simulation engines for a range of energy analysis needs
- The CEC currently utilizes **EnergyPlus**, **CSE**, **IES** and other simulation engines to assist in Title 24 code compliance (CBECC)
- The CPUC uses **DOE2/eQUEST** in the **MASControl** tool used to develop DEER database values
- Innovative programs – BRICR (EnergyPlus) and The Energy Coalition (**Open Studio**)
- LADWP – we'll hear from them later today...

5/30/2019

CEC has been involved in code development. CEC also oversaw DEER development until 2005 when CPUC took it over. CPUC uses MASControl as a layer on DOE2 and runs models to create DEER savings values. Going forward, there are things going on in San Francisco, like the SFE (San Francisco Environment) program using OpenStudio as part of Open Efficiency platform, where multiple models can be stored and run through multiple scenarios to help with decision-making. There is also the BRICR project, which is the BayRen Integrated Commercial Retrofit, as well as the southern California project using Open Studio being run by the Energy Coalition. So, we know if we run MASControl we can get outputs from a large number of models, but other platforms will also produce large numbers of outputs that can be used for a variety of purposes. The LADWP project may show what can be done in a less-regulated environment.

Prior Collaborative Efforts to Understand / Improve Modeling





- **Rocky Mountain Institute (2011)**
 - Not CA-specific.
 - Voluminous materials produced; information on specific models out-of-date but good section on history of modeling.
- **CPUC Energy Modeling Tools Workshop (2015)**
 - To exchange information on the predominant whole building energy modeling simulation tools in the market to understand what's out there, how it's used, and how we understand the strengths and weaknesses of each tool.
 - Did not produce specific action items or "next steps."
- **Cal TF Technical Position Paper (January 2016 Cal TF affirmed)**
 - Compared DOE 2.2/EQuest and EnergyPlus/Open Studio for developing deemed measures for eTRM.
- **SCE Software Symposium (2017, 2018)**
 - Focus on improving code compliance software tools.
- **Participant Input:** Any Others?

5/30/2019

There were a number of prior efforts to address modeling:



- 2011 RMI workshop, produced a list of to-dos that no one followed up on
- 2015 CPUC workshop, was largely informational but did not produce action items
- 2016 Cal TF TPP, which is expected to be updated as a result of this charrette
- 2017-8 SCE symposia (3), focused on code compliance issues, also resulted in "roadmap" documents.

Are there any others? **Attendees are invited to provide input.**

There are three documents worth reading to get up to speed on modeling in California: the SCE roadmap, the Cal TF TPP #3, and the report for OpenEfficiency. Steve authored a paper on modeling and data resources in CA EE programs as part of a DOE funded project called Open Efficiency. The platform started as an M&V platform and has since morphed into something larger.

Are there any other documents to consider? Attendees are invited to provide input.

Handout #1: Use Cases



Use Cases: CA uses for building simulation modeling.

- Engines used
- "Rulesets" used
- Caveats/Limitations
- Calibration/Documentation

5/30/2019

Doug Mahone –Doug began his career with DOE1 back in 1975 and has since been involved in Title 24 development, worked with utilities to develop Savings by Design, and got involved in evaluation and supervised modeling supervision. Doug categorized modeling in California and identified use cases, which define the purposes of the modeling. Much of the use case definition can be categorized into rulesets.

[Handout #1]

Use Case: Code Compliance has evolved over the past 30 years in California. It is a very specific category of whole-building modeling, in that it assesses whether a new building meets a pre-defined energy efficiency standard. The tools used for this are highly evolved, and they must be certified by CEC to ensure they will properly assess building compliance with California Title 24. In each case, the software models must establish a “base case” and a “code case,” where the base case is the minimally-compliant model of the building under consideration, including such things as window/wall ratios, lighting efficacies, HVAC efficiencies, etc.; this would yield what we call an “energy budget.” The code case model reflects the actual building under consideration which may include certain tradeoffs between systems as long as the total energy used still complies with the energy budget.

In addition to the building assumptions, there are other standardized assumptions that must be used for code compliance. One assumption is the weather data used; standard weather data files are provided for this purpose. Also, operating conditions are standardized, including occupancies, schedules, etc. So these models don’t necessarily reflect the expected operation of the building; rather, since occupancy may change over years and buildings are long-lived assets, the assumptions are intended to reflect how

the building may be used over its lifetime. The models reflect those things that are recognized by code, although more advanced technologies may not be incorporated into the models yet. Importantly, since there are standardized assumptions used, the code compliance models do not even pretend to predict the energy consumption that would be incurred by the eventual occupants with their unique characteristics, let alone actual weather which usually varies from the average.

Bruce Wilcox – prime contractor to CEC for residential software. CBECC-RES has just been published, and it incorporates all the new items including PV, battery storage, and demand response. There is a bit of a cart-and-horse issue here as in California the building codes can actually drive improvements in software and models. Also, Doug should remember that he invented time dependent valuation (TDV), which is a critical component of building code evaluation. For 2022, the codes people are expanding the TDV process to include the energy production system for the entire Western US (not just California).

Use Case: Building Design - The T24 tools can be used for this, but results will be cast in terms of a T24 building. Designers usually want to explore all kinds of options, which may require a more expansive tool that can support the designer and building owner. The choice of model is up to the designer, based on what they know and what they want to model. The base case is also up to the designers, often based on a minimum code building that they can then model alternatives. Weather data can also be selected by the designer; perhaps they want to model the building with extreme-year weather data to see how the building will respond under atypical years. They may have weather data that is more local than the T24 weather stations. They can also set schedules and occupancies based on client's expected use rather than T24 standard schedules. So this is a more free-form use of modeling which serves the designer well while not serving code compliance, program participation or cost-effectiveness modeling.

Use Case: Utility New Construction Programs (e.g., Savings by Design) – These programs incent customers to build beyond code. This program may have constraints such as modeling programs that may be used, base case models, or design conditions. Typically, these programs are less interested in standardized schedules, preferring expected conditions by the customer (occupancy, schedules, etc.). They will still use standardized weather data. Fuel-switching is not typically an option, although that may change. These programs usually have different constraints than code models, and the model used for the program may not be the same model that would be used for code compliance, LEED certification or others, so you may have multiple models as Annette alluded to earlier this morning.

Use Case: Program Evaluation – There was a time when evaluation meant verifying that the program rules were adhered to and no one was “gaming” the system with creative adjustments to software models. The PUC became more interested in the “actual” energy use of buildings, so evaluators would come in and look more closely to how the building was actually used and operating. This meant extensive metering to assess hours of operation and occupancy. Basically, verifying that the assumptions used going in matched what was actually occurring post-occupancy. They'd also model a sample of the buildings to try and ground-truth the model.

Sue Haselhorst – Have we missed a use case – CEC code [development]? Also, creating models that describe the “typical” baseline building versus the specific building. There must be an understanding of what a baseline building is [when codes are developed].

Doug Mahone– The baseline building for code compliance is “your design”, but it reflects your building as if it was a minimally compliant T24 building.

Annette Beitel – Sue has done work outside California, so she may see gaps that we don’t otherwise see. Can you expand on your issue?

Sue Haselhorst– I suspect when you look at codes and what the impacts [of new codes] are going to be, there must be some underlying assumptions that support those impacts. This may also have bearing on deemed measures as well.

Martha Brook – We (CEC) do an impact analysis report for every code update, and we use prototypical models to assess the impacts of the updates and then apply that to the expected population using forecasted stock. Larry’s team funds our contractors to do that analysis.

Sue Haselhorst– So that may be an additional use case to consider.

Annette Beitel – Sounds like we need to add that as another row in the matrix.

Bruce Wilcox – The CASE process is another use case – we are developing prototypical models for the CASE teams to use as part of the 2022 update and analysis.

Use Case: Evaluation via Pre/Post Metering – The savings are determined from before and after metering. You have utility metering, plus possibly end-use metering, then you do energy efficiency improvements and re-meter afterwards. The base case is the building before treatment, and the post case is the building after treatment so theoretically the difference between the two is the savings. Challenge is that weather changes, occupancy can change, schedules can change, so the data must be normalized, and as far as I understand it, this process is still in flux. One thing you need to account for is the difference in weather pre- versus post-treatment. For example, if you are in the central valley, and the year before the treatment the weather was mild, but the year afterward was a real scorcher, the weather affects could reduce apparent energy savings. Normalization can usually address this issue, but the non-weather differences can also affect the veracity of savings. If the building was not fully occupied during the pre-metering period but was fully occupied during post-metering, that could also negatively impact savings. Essentially anything that changes between pre and post must be accounted for; this is where modeling comes in, because that’s how you can control for those other influencers. If you calibrate the model as part of pre-treatment, then apply the efficiency measures, then recalibrate the model during post-treatment, you can use these to isolate the measures from non-measure impacts.

Martha Brook– I don’t think it’s going that way – NMEC appears to be going the way of using statistical or econometric models of the meter data versus engineering models. But now what you describe would be new use cases. There is some great work that David Jump at CPUC has done in terms of NMEC

protocols, and open-source, open energy efficiency meter work that has been put into the Linux Energy Project at the portfolio level.

Use Case: Estimation of Deemed Savings – Uses whole-building energy modeling to estimate energy savings (including interactive effects) across different building types, vintages, climate zones. All use standardized weather data and prototypes and are designed to accurately model measures. Generally, with deemed measures you model one measure at a time, but there are a large number of simulations that go into this work (for DEER), and the workpaper developers are the ones who need to be up to speed on all the requirements.

When you get to custom measures, it's a little more freeform, as you are analyzing savings as they pertain to a specific project. Often times you might model custom measures using simplified tools, where other times you need to use full-blown building simulation models. There are also project-specific issues addressing baseline – do you use code baseline, or industry standard practice, or existing equipment. So, there are a bunch of constraints that affect custom measure models. As I understand it, the custom measure process is still under development.

Use Case Examples			
CEC	CPUC	Other	Future
Code development Code compliance Demand forecast CEUS Policy analysis & Implementation (e.g. SB 350, SB 1477)	Deemed measures Custom measures/projects Project analysis (SBD) EM&V (i.e., potential studies?)	Forecast load impacts Benchmarking Local ordinances GHG targets	LA Project Large-scale regional models to identify where interventions will be most cost-effective

All of this has been a brief overview of the various use cases that are commonly found in California. There are also other use cases that the CEC uses, including forecasting, policy analysis, GHG targets, plus the L.A. project that uses large-scale regional modeling. The use cases I described address single-building model applications. When you get to larger scale regional modeling, the modeling can become more useful although at the same time the process becomes more complex.

Neal Kruis – It seems there is one use case not touched on, and that is the certification and labeling and rating programs that are not governed by the state (e.g., LEED, ENERGY STAR, asset scoring). Very similar to the compliance use case.


Marc Costa – Are there use cases beyond EE, like renewables that can benefit from these use cases (e.g., on-site solar, storage)?

Doug Mahone– As Bruce mentioned, the T24 compliance software is incorporating aspects of that into its software, so those could become part of the use cases. One of the overall themes today is that while there are numerous use cases with different constraints and rulesets. Is there a way to harmonize them or are there tools that can operate in all the different use case situations to reduce the number of models or rulesets?

Mudit Saxena – The cases that look beyond EE include HVAC sizing for which software like IES are attractive because you can reuse components in building models, and the same model that would be used for compliance can also be used for HVAC sizing. That gives an attractive environment for the designer’s perspective. Of course, from an open-source perspective that doesn’t necessarily work. The idea of harmonizing – I think that can be achieved, but we need to consider what the desires are from the building owner’s perspective because that may determine whether that process would work.

Rahul Athalye – Some of the harmonization we are discussing is being addressed from the PRM approach (ASHRAE 90.1 Appendix B). There has been some action towards moving CA to that baseline, which could make the job a little easier.

Handout #2: Current State



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Review


- **Engines**
 - Have we identified key CA engines?
 - What metrics should be used to evaluate?
- **Interfaces**
 - Have we identified key CA interfaces?
 - What metrics should be used to evaluate?
- **Rulesets and Building Prototypes**
 - Have we captured key rulesets and prototypes?
 - Should a repository be created of building prototypes?
 - Should systematic effort be undertaken to document inputs and calibration for rulesets and prototypes?

5/30/2019

Roger Baker – Handout #2 provides a brief comparative analysis of the three predominant software engines, as well as interfaces, rulesets, and prototypes. In the interest of time, **participants were asked to provide feedback on this handout.**

Metrics





What metrics should be used to evaluate models, wrappers, rulesets?

Can the metrics be “general” across all use cases, or

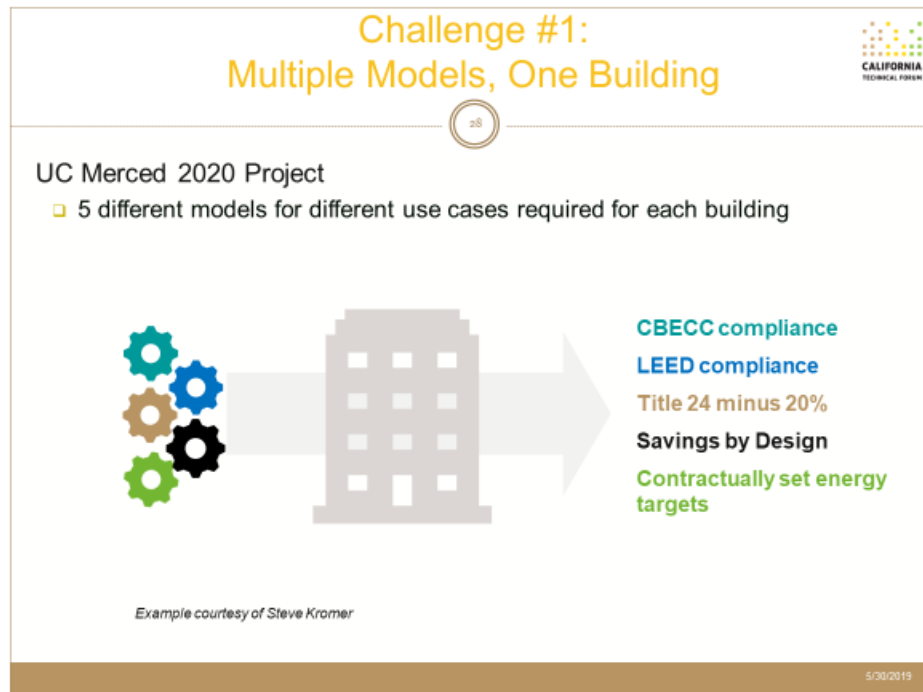
Should they be tailored to the use case?

Should there be a “test” that models must pass before they can be used (the “CEC approach”)

5/30/2019

One of the desired outcomes of this charrette is to determine how to move forward and harmonize use cases and rulesets. One of the key issues is how to measure success. What metrics should be used to define success? (Exercise #2 this afternoon expanded on this issue).

Current Challenges in CA Building Simulation Modeling





Steve Kromer— Parallel to doing the OpenEfficiency platform, Steve was involved with a big project at UC-Merced. The project involves building 13 new buildings as a public/private partnership, so it's being built with outside financing and there are performance metrics associated with the buildings. This means if you are a California taxpayer, your funds are not being used to build this. So, it's like performance contracting on a huge scale. The first 3 or 4 are coming online now; This work had very thick contracts associated with it, and in an effort to incorporate all of California's environmental and efficiency elements, all this was incorporated into the contract packages. So of course, you have to comply with T24, plus you want to comply with LEED. You also want T24-20% and Savings by Design as well. Finally, since they are being constructed pursuant to performance contracts, there are performance verifications that are needed. So, each building needed five models built to accommodate these five goals. Is this really an efficient way to do this in California? Are we all talking to each other? No, there are many silos in the State. Some of these models (T24, T24-20%, Savings by Design) should be relatively similar, but even there we find inconsistencies like airflow – what is the real cfm going to be in the building versus what T24 allows?

In looking at all these models, some of the inputs should be absolutely consistent across all of them. Square footage is one, building geometry (form and fabric) is another. If there were a single platform that contained all those items that form the bases for the different models, that may help; one could pull the common data for each model from this platform if it existed. Perhaps one topic for a future modeling task force would be to decide where such a repository could exist. Such a system, applied to the UC-Merced project, would've made the analysis much easier – pull the data from a repository, put it


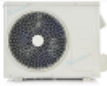

into the models along with whatever specific ruleset each model needs, run the models and then return the data back to the repository for future use.

Another example not on the slides is an EPIC funded project that looked at disadvantaged communities. We were using prototype models for that project, but so was Dmitri. We also looked at the Sonoma project and others. There are many models built and laying around California in huge piles, and they are great but no one has access to them because there is no common library to hold them. One outcome I am hoping for is at least a library or inventory that describes where all the models are at, perhaps for Martha's amnesty program. This is another example of a situation that would benefit from a common, public repository of building models.

Challenge #2: Documentation and Reproducibility



- **MASControl Documentation**
 - Documentation holes
 - Hard to address errors when they occurred
- **Measure Definition**
 - Some measures no longer exist, so need to be developed or retired
 - For measures that do still exist, hard to know how the measure case is defined (i.e., what are keyword changes from base case to measure case)
- **Building Prototype Definition**
 - No documentation on the source of the values in in building prototypes
 - No documentation on the procedure used for calibration of models
 - Unclear what the process is for defining the customer average ("CAv") and measure average ("MAv") values
- **Thermostat Options Definition**
 - No documentation on the source of the value for thermostat options
- **Weighting Data**
 - Data source is not clear
 - × Building stock data seems to come from 2014
 - × HVAC type seems to come from 2013



5/30/2019

Ayad Al-Shaikh— Presented an example from the Cal TF efforts to consolidate deemed measures across the State. As part of this large effort, Cal TF is bringing all measures into alignment, and improving documentation and transparency. Last summer we started work on the 53 HVAC deemed measures, which accounted for 112 million kWh/year and 3 million therms/year of savings in 2018. Around half of the measures are commercial, half are residential; only 6 of the 53 are not modeled. Only one of the modeled measures was not modeled with DOE2. Of the remaining modeled measures, 8 preceded the current MASControl. For those measures, it is difficult to “look under the hood”; Some of them will be retired, but two are still relevant to portfolios today and those are being remodeled.

The next issue is building prototypes. There is little documentation on the prototypes themselves, including how they were developed and calibrated. Next, there are questions around the (residential) thermostat options. There is limited information regarding how those were developed. I learned that

the five setting schedules are built from RASS data, presumably RASS 2003. This may be a good time to revisit the approach as well as the underlying data.

The last issue is the weighting data, which translates the modeling results to appropriately weighted average savings values for each measure. A new set of this data came out for 2020, but it is not entirely clear where the underlying data came from.

Q: How have you been tracking your findings?

Ayad Al-Shaikh – There are some formal data requests that I can provide that address some of those issues. Much of the data we find ends up in the workpapers.

Mudit Saxena – Has the work you’ve been doing been documented in a report that parties can read? Also, from my experience with DEER, much of the prototype data has self-selection bias, because the data relies primarily on program data from prior years rather than eligible population.

Ayad Al-Shaikh – There is no one report – findings are being rolled into measures and will be in the eTRM when published. As for the prototypes, I can’t comment too much on them except to note that they seem to be coming from RASS and CLASS studies rather than program participant data.

Martha Brook – My understanding is that part of the DEER update process involves using EM&V results, which goes to Mudit’s point. To the extent that evaluation results are fed back into DEER to recalibrate models, that could indicate a bias.

Q: Based on what Martha was saying before, it sounds like CEC also has building prototypes. Do they have good documentation for those prototypes? Second, can those prototypes replace the DEER prototypes?

Sue Haselhorst – The prototypes at CEC are focused on new buildings, rather than existing stock as is the case with DEER. Your question does raise an opportunity to work together on prototypes and alignment.

Martha Brook – Good question regarding documentation and why we aren’t collecting and sharing all prototypes that have been created.

Q: The CEC prototypes are new buildings, but they’ve been developed over numerous code cycles so some of the vintage “new” building prototypes may still be applicable for existing stock.

Steve Kromer – These are good questions, and it does raise the question of what the definition of “prototype” is since it may mean different things under different use cases. In the case of DEER, you have to consider that it developed over many years and has evolved over time to suit certain regulatory needs. As such, you may look at the prototypes and say they do not perfectly reflect whole building stock, but they are good enough for what DEER does (measure analysis). When you build tools around something like DEER, like eQuest, which is a really good modeling interface, and MASControl, pretty soon you have a whole toolkit that is pretty hard to break up or replace. How much we want to change all this depends on Sue and Bob and what they determine is best to proceed forward.

Manisha Lakhanpal – One of the biggest challenges is sharing information. With all the work done since the 1970's there is a lot of information out there. As the next EE action plan is developed, one of the goals should be to make this type of information available, perhaps with a 3-5 year timeline to accomplish this.

Steve Kromer – We've heard a number of challenges, so I have been asked to facilitate this next discussion. I spent a year working with MASControl, playing with it and understanding it, and during that time I wasn't thinking about code compliance or looking at Bruce Wilcox's work. The issue and challenge is getting that engine into the tool and getting it to work for everyone. So, with that in mind, what challenges or issues do you have that you would like to share?

Tim Melloch – Comment online from Kevin Madison: Mudit, previous commenter is correct on some points. For example, commercial lighting hours of use are based on evaluation results using sample of participants from previous evaluated program cycle. However, residential hours are based on a much broader study, albeit several years old, of a sampling of the entire population of dwelling units. The idea that program participants introduce a selection bias is a fair point, and depends on whether the characteristics of participants differs from the population as a whole. The DEER team uses the best available data, which happens to be based on EM&V of program participants for commercial buildings.

Mudit Saxena – Commercial lighting is exactly my experience as well, and the problems that we had with commercial lighting use cases came out of DEER; making sense of them is where we saw a bias. It may be that the residential side represents a more diverse sample. I wanted to bring up another point, to Steve's comment – how can one prototype represent all buildings? There is also another approach, which was used by CEUS. That approach was to take hundreds of buildings rather than one building for a given type, make models for all of them, then query hundreds or thousands of buildings, which I like as an approach. This is also the approach taken by NREL for LADWP, and it means we don't have to rely on a single model. It can also reduce the friction associated with creating energy models quickly. I think we need to think about a future where we don't rely on a single model, for example a single office building prototype where if a measure doesn't work out in that prototype, you don't have savings. That doesn't make sense. By having thousands of building models and querying them you can arrive at savings values where appropriate and with less friction.

Steve Kromer – That's a good idea, and if we can capture it concisely and document it and present it to regulators to consider as part of a three-year plan, may be helpful.

Liam Buckley – One challenge we went through was gaining approval (the process) for our software in the Savings By Design program. There were a number of questions we had to answer like are we certified for Title 24, can we take a compliance model and turn it into a non-compliance model, etc., and this all happened through email. There was no clear, transparent process for approving the software tools.

Q: Not addressing Liam's issue, but one of the issues with deemed measures is that they start off as custom measures which are modeled on custom basis; then when they become deemed measures you

cannot model them within a custom project because you don't know if your inputs match what is used in MASControl, so you have to zero out the impact of that measure in your model. What a mess...

Martin Vu— Steve, I've taken your course on CMVP and I think there are courses out there that are similar for modeling. The issue is that the goals for regulators differ, such that the CEC has different goals and objectives than what CPUC has. That being said, I think this is a good first step. At the same time, what is good for code and code compliance isn't always good for the ex ante review process, and the challenge is to pull out the key parameters that fit both models.

Andrew Parker – To Liam's point, when you want private sector vendors to leverage software to serve your needs, you need to be up-front and transparent about expectations. For example, Title24 compliance software has protocols and requirements published up front so all vendors know what they need to be able to do. If I want to, as a software vendor, invest thousands of dollars or more to "check the boxes" to satisfy the use case, I don't want to have additional requirements trickle in 3 or 4 at a time, causing me to incur additional unexpected costs. I was speaking to another vendor who had the same issue, noting that with CEC, they knew exactly what they were getting into, whereas in the Saving by Design/CPUC side, it was more of a mystery.

Abhijeet Pande – The area I want to highlight is that we are trying to move in lockstep in terms of programs being able to keep up with code updates; there may be requirements in the next code update that the software cannot even model. We may be modeling a custom measure that the software is not able to even model. Sometimes the only software that can model a certain measure is the compliance software, which means I cannot use that software to support other use cases or programs. As a program implementer, I am asked to model more and more innovative things at less and less cost, and the only way to do that is to get away from the "tried and true" and try something innovative. There is really a gap in the ability for modeling software to do those things; I can use IES for some of those things, but if it's not approved then I can't really use it.

Sonia Punjabi – I am a Senior PM for Savings by Design at PG&E, and responding to the comment made by Liam earlier; given what has gone on with Savings by Design over the past year and a half, and the tools that are used, I think it is important that we have a clear process which makes it clear what stakeholders need to play in it, because it is a statewide program. We need clear engagement from CEC and CPUC as well as the vendor community. Some of the issues started off because of concerns with one of the tools. Making the process more of a partnership between IOUs, CPUC, CEC and vendors should make it more streamlined.

Manisha Lakhanpal – I've been in the EE branch for over a year now, and what I hear is that the CPUC process is a black box, and SBD is an example of this. I'd like to follow up with the stakeholder expressing concern to understand the gaps; whether this is a breakdown in communication from program administrators, or is something not clear with respect to tools. So being specific with regard to gaps in the tools helps the regulators clarify what is needed. The other part is how do we know which model is approved? This is part of a discussion that Steve and I had, trying to understand what models are approved and for what purpose(s). I went back and could not find anything in prior decisions that limit

what models we can use, so I'd like to engage with program administrators to understand what is prohibiting them from bringing other modeling approaches or other models forward. This is a dialog we need to have to understand why they believe the CPUC will not approve a model. Where is that understanding coming from?

Sonia Punjabi – This is partly stemming (at least from an SBD perspective) from a program requirement that any tools must be approved by CPUC, so there is a list of tools like EnergyPro, IES-VE, to some extent CBECC-Com, that are approved. I believe they were initially CEC-approved tools, then it became CPUC-approved tools.

Q: Agree with these points. Also, California is a very big state, and there's a lot of things going on besides pursuing incentives. For example, CEC has a benchmarking program that's covered over 4 billion square feet. Add to that all the local governments that are building out their own benchmarking and other ordinances. So, if there's a lot of activity happening outside incentives, like the decarbonization, solar and other initiatives that may also use the same models that EE uses, how does the similar modeling tie into CPUC efforts? If an audit is being done in AssetScore, none of those models can be used in incentive programs, so an opportunity is being lost to increase penetration rates of programs.

Annette Beitel – Closing comments to the morning sessions: Manisha mentioned CPUC limits on tools, noting there are no Commission limits on use of tools. Cal TF has also done such research and found no official prohibitions on tools. However, we had an experience in earlier days with a measure that was brought to us for review; the measure was for Variable Refrigerant Flow (VRF), and the savings for that measure was based on an EnergyPlus model that was developed by NREL. The model was developed by a highly respected PhD engineer within this national lab that has no bias one way or the other regarding the technology or savings. The measure was brought before the Cal TF, which had various questions about the measure. Some modifications were made in response to Cal TF feedback and input, then the measure was submitted by one of the utilities for approval by the EAR team. The EAR team rejected the measure because it was developed in EnergyPlus. Cal TF followed up in an attempt to determine what would be needed to satisfy the EAR consultant that using EnergyPlus to model the measure was acceptable. Tim Melloch and I had several long conversations with Jeff Hirsch in this regard, and we meticulously documented what additional information he wanted. This was done three times, and we sought out and provided the additional information each time. Finally, after being unable to gain the EAR team's approval for the measure despite providing what appeared to be more than sufficient information and data to support its viability, we asked directly "what is the standard, what is required to satisfy the EAR team for a measure modeled in EnergyPlus?" That was the end of the conversation, as we never did receive a response to that question.

This may be unpopular to say, but this is a new day, and we may now be in a position to look at new tools. The CPUC does not want a tool that overestimates or underestimates savings for measures; as such, one of the questions we need to address is: what tests would be needed to satisfy the regulators that the tool(s) do not introduce bias into the results? The practitioners in this room must have the knowledge to come up with those tests.

Sue Haselhorst – A lot of issues wrapped up in what you stated. There's a distinction between these cases that we identified – the use cases. And what you can use for custom measures or what you may use for SBD, that is one set of things. When we are looking at deemed measures where we are looking for one value that can be used across a population, that begs the question what is the population and what does it represent. There's standardization that has to happen with that. We can't do one building with one tool and another set of buildings with another tool – we need to bring this all together. There is some element of selection when we go in to the deemed world, or maybe you folks have something that's different; that's what I'm listening for. It's not acceptable to just say "I don't accept that number", we are looking for the right value for the population, hopefully we use the right prototypes, the right weighting and we have the right tools to get there.

Annette Beitel –That's good – those are very good principles; it helps to articulate a clear and logical rationale, which is wonderful. I think that's a great springboard to start from as we move forward.

“Future State” Case Study: LADWP Use of Modeling Tools

Armen Saiyan— Work at LADWP has been part of an effort to look at a new way to approach goals and potential. More and more, energy efficiency is becoming an increasingly important component to load planning. If enough EE is done, it can begin to affect renewable targets and renewable energy needs.

Intention/Motivation

- EE potentials and goals
 - satisfy AB2021 requirements
 - Internal Integrated Resource Planning
- Comprehensive DSM planning
 - Available potential modeling tools fall short
 - Want to provide accurate: hourly load, GHG, & geographical impacts
- NREL to develop a tool
 - Determine DSM potentials primarily for DSM program planning
 - also has capabilities to expand to other applications



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Typically, when we would approach our load forecasting and DSM, we’d hire some consultants to do a “traditional” potential study and roll that into the forecast process. The modeling tools that we used would often fall short. Loads are becoming fluid in terms of when and where they are, and we needed to be able to look at potential at the feeder and circuit level, not just the system level. We contracted with NREL, in partnership with SCG, to look at new modeling tools that would comprise a comprehensive DSM platform.

Current State of Potential Modeling

- Difficult and tedious to follow
- Applied simplistically with territory building stock based on past surveys
- No consideration for interactive effects
- Use of outdated and incomplete hourly load shapes
- No visibility on distribution of savings impacts across geographies, building types, vintages, grid infrastructure etc...



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The existing tools are generally difficult and tedious to use; either the data is in some big spreadsheet, or in a packaged model that is difficult to follow and work with. They are often based on deemed savings that are applied simplistically across building stock. Interactive effects (stacking effects) of measures are often ignored in these studies. Load shapes are also generally dated and not useful (not granular enough). The output didn't provide visibility into geographic distributions of loads and savings at the substation, feeder and circuit level, which is what we need for effective planning. What we wanted was something that could be given to our distribution planning engineers to incorporate into their work. Also, the existing studies are designed to support IOU goal setting, and as a POU we are kind of the stepchild of the process. So our study was intended to generate transparent, usable information that would be helpful to not only energy efficiency planning but also to help us more effectively manage our grid constraints.

Project Summary

1. Energy models of the commercial & residential building stock in LADWP service territory
2. Calibrate building energy models to real electricity & gas data
3. Apply Energy Conservation Measures to models. Calculate technical savings potential by building type, age, etc.
4. Put savings + costs into economics-driven technology adoption model
5. Calculate realistic EE savings potential (gas & electric) based on measure cost, incentive assumptions, etc.

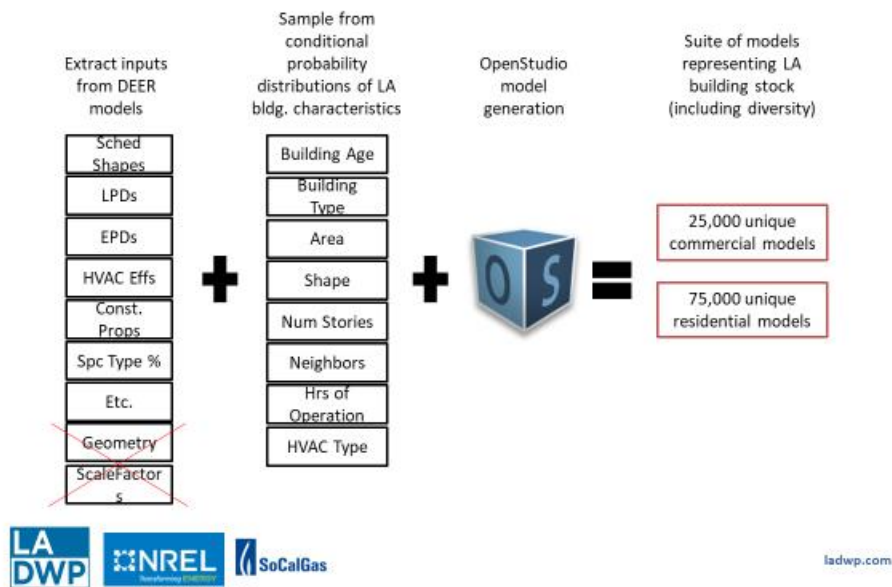
*Today's focus



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NREL is coming up with energy models for the building stock in the LADWP service territory. That building stock data and the models themselves will be calibrated to actual energy data; this includes the customer meter data as well as the system meters that can provide data at the feeder level. The idea is to come up with calibrated models for all the buildings in our service territory, and use that data to develop technical savings potential. That is the focus of our work today. Future work will entail taking that data and building out a consumer adoption model, and come up with realistic potential that we can go after.

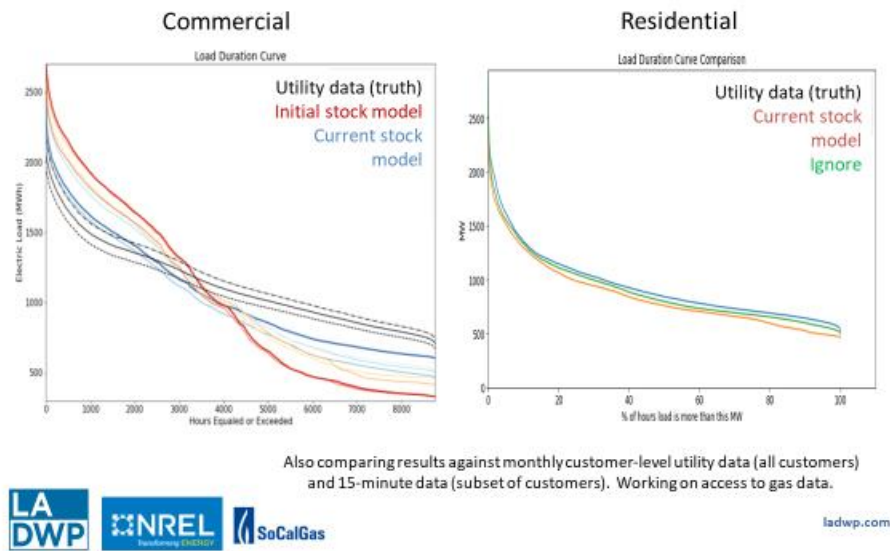
Building Stock Models



Andrew Parker— First, we extract inputs from the DEER models. We are not taking building geometries from DEER, but we are taking HVAC, schedules, and power densities. Next, we collected data about building stock in LA, including building age, type, how close neighboring buildings are, plus some other items from data sources we can find that are either specific to LA or California. We include building stock data as probability distributions rather than point estimates. So, for example, we don't say that all office buildings have a certain VAV air system; we use a distribution that accounts for a variety of systems that are in use. When we combine these probability distributions with the DEER inputs, we come up with 25,000 commercial and 50,000 residential unique models (the presentation erroneously says 75,000). By doing so, we have developed a proportionate population of all different building types that we can simply scale up to reflect the population in the service territory. This means we don't have to do the building weighting process that is used in DEER. So, in LA, I believe there are 50,000 commercial buildings; we can take our 25,000 commercial models and multiply by 2 to generate a representation of the LA commercial building stock.

This gets around the issue people have brought up regarding prototypes, where a very small number of prototypes is intended to represent all the buildings in the service territory, and a given measure in one building type can live or die based on how that prototype is constructed. The building inventory is based on NREL tools called ResStock and ComStock.

Calibration (in progress)



Once we build these models, we need to calibrate them using utility data. The left graph shows how the initial stock model (in red) does not reflect the actual utility data (in black). By going through and calibrating the models we are able to bring the models much closer to actual data, although they still do not match exactly. The residential model came out much closer after calibration. All this is for electric, we still have to do the gas side.

Calibration Changes (partial list)

Commercial

- Removed night setbacks
- Lowered office & retail EPDs
- Plug loads higher @ night
- Lighting schedules less blocky
- Lower LPDs across stock
- Change multifamily schedules
- Added blinds
- Diversity in schedules
- Neighboring building shading

Residential

- Use RASS for many appliance saturation levels
- Add diversity to clothes dryers
- Add diversity to refrigerators
- Add diversity to # bedrooms
- Adjust plug load schedules
- Add holiday lighting

Motto: no changes without supporting data justification!

The calibration process requires adjustments to a variety of things like removing night setbacks, adjusting power densities and plug loads. All these adjustments are based on data that would support these changes. An example of data justification – plug loads being higher at night; we looked at our models, which generally indicated plug loads are 90% daytime and 10% at night. We found a PIER study that looked at office and retail plug load profiles, which showed more plug load draw at night. When we adjusted the plug-load schedules in the models, the output moved closer to the actual data line.

A similar issue with diversity and schedules; DEER assumes everyone comes into the office at 8 a.m. and leaves at 6 p.m., and the lighting power dips at lunch time as folks go out to eat. In reality, there is no mid-day power dip, and not everyone shows up at 8 and leaves at 6. We looked at AMI data and extracted start/end times from that.

Mark Modera – One thing I think this is critical is that people have been “turning knobs” on models for years. Over time we will get more and more data on buildings, and the models will need to be calibrated with actual building data. It will become more critical over time to ensure transparency and reproducibility – using open-source, documented processes that people can see will be important.

Andrew Parker – I agree and all the work NREL is doing will be publicly available (save for customer-specific information).

Rahul Athalye – Where did all the building information come from?

Andrew Parker – They come from many sources. There is a commercial building database we use, testers data, LIDAR data, hours of operation from AMI data, commercial saturation data, and others.

Mudit Saxena – I am involved with the “zero home” tool, which shared much of the same DNA as this tool. Going to the slide on calibration, the graphs do not show the time that the loads occurred; my team found that there is often a load shift that occurs during the calibration. While the kWh is correct, the kW may be off as a result.

Andrew Parker – This is one graph of approximately 300 that we generate when we go through this calibration process, so we look at peak days, look at load duration, almost any graph you can think of because we have 10 engineers looking at all this data.

Mudit Saxena – For the calibration changes, if the base building schedules come out of DEER, do you have a “loading order” for which items you change in what order that perhaps reflects confidence in each data point?

Andrew Parker – Yes, we look at which inputs we have confidence in, as well as which ones we have less confidence in; for the latter, we try to look at acquiring additional data to boost our confidence in those.

Mudit Saxena – This approach toward large scale simulation is very powerful, and this is a direction we should go in.

Martha Brook – I am wondering how the PUC and CEC can leverage what LADWP has done?

Andrew Parker – The platform itself is open-source, the raw data is private, but the code is there.

Martha Brook – How do I get ResStock and ComStock?

Andrew Parker – ResStock is available on a website with contact info, and the code is on github so anyone can download it. ComStock is still under development, but it will be posted when it is done.

Mohit Chhabra – When you compare consumption estimates from model to measure, you said you compare distributions. You could either compare distributions, or for the same building you could come up with a method to minimize error.

Andrew Parker – We do not have models of specific buildings. We have models that represent populations of buildings. If you look at the zip code this building is in, you should find buildings that have these characteristics.

Mohit Chhabra – With residential, one of the factors that drives overestimation of savings is how behavior changes once you improve the efficiency of the house. You may need calibration factors to reflect this, and I can show a couple of ways to do this.

Andrew Parker – Good point, and I'll follow up with you on this.

Armen Saiyan – This effort is a starting point, and we do plan on refining this over time.

Mohit Chhabra – There are imponderables when it comes to modeling residential. A lot of people use thermostats more like on/off switches, and commercial buildings have vacancy rates that affect energy use. Does your modeling incorporate that?

Andrew Parker – Yes, our calibration takes that into account when we adjust various factors. For instance, when we see higher nighttime usage than the models reflect, we can crank up the plug load to compensate. However, this could be due to a variety of factors – vacancy rates, grow houses, so trying to figure out what it could be is one of the challenges (e.g., how many grow houses are in L.A., and how much of the “missing” energy could be accounted for here).

Mohit Chhabra – I think this is great, and on a separate project, we want to look at NREL on a separate use case. We are looking a county that wants to go out to buildings to do energy efficiency and they want to use this type of scaled model to enumerate savings. Challenge is that, at the end of the day if we do a project at “815 123 Street” (hypothetical location), we need to calibrate the models to reflect the savings at that building. All we have, though is anonymized total data for perhaps 500 buildings. At the individual building level the savings would be off.

Mark Modera - If you publish the source code so Martha can download it, how much effort is needed to “work the magic”, meaning getting the data, inputting the data, calibrating the models, etc.?

Andrew Parker – A lot of effort is needed. Also, this whole thing is new and not very refined yet, so there is a learning curve.

Mark Modera – Scalability is also critical, so understanding how to use it.

Andrew Parker – This gets into the big data element. You need IT people who can work with big data to feed into the system. The great thing is, the companies that have the large buildings here also have the software that would do this work. Each run of this platform generates 100 GB of data, but you throw it into a data analytics package and it can take care of the big data manipulations. Also, once the building stock models are calibrated, the refinements become easier and if you maintain them as you go, there is less effort than if you restart this thing all year.

Sue Haselhorst – Do you start with a single model and diversify it to the 50,000 residential models?

Andrew Parker – No, we create 50,000 unique models

Sue Haselhorst – So you are creating parametric models.

Andrew Parker – Yes, and we are building the models from scratch. We don't have 25,000 idf files to work with, we generate each one as we go.

Mohit Chhabra – You said there is a lot of effort to calibrate, and I'd agree that this is desired for this use case. In another case, where you are recommending EE measures for homeowners or for ZNE homes, the margin of error becomes slightly more manageable, so while you do want to calibrate, it may not be as important. The goal for ZNE homes, the question on calibration becomes how good is good enough? If all you are doing is recommending measures for a homeowner, the answer comes earlier than what LADWP is doing.

Potential Applications

- Refined Territory specific prototype models
- Robust reference for potential deemed savings of applicable measures
- Determining Technical Potentials for measures by geographic region, building type, sector etc ...
- Can be expanded for other DER measures
- DSM, DER Program planning tool



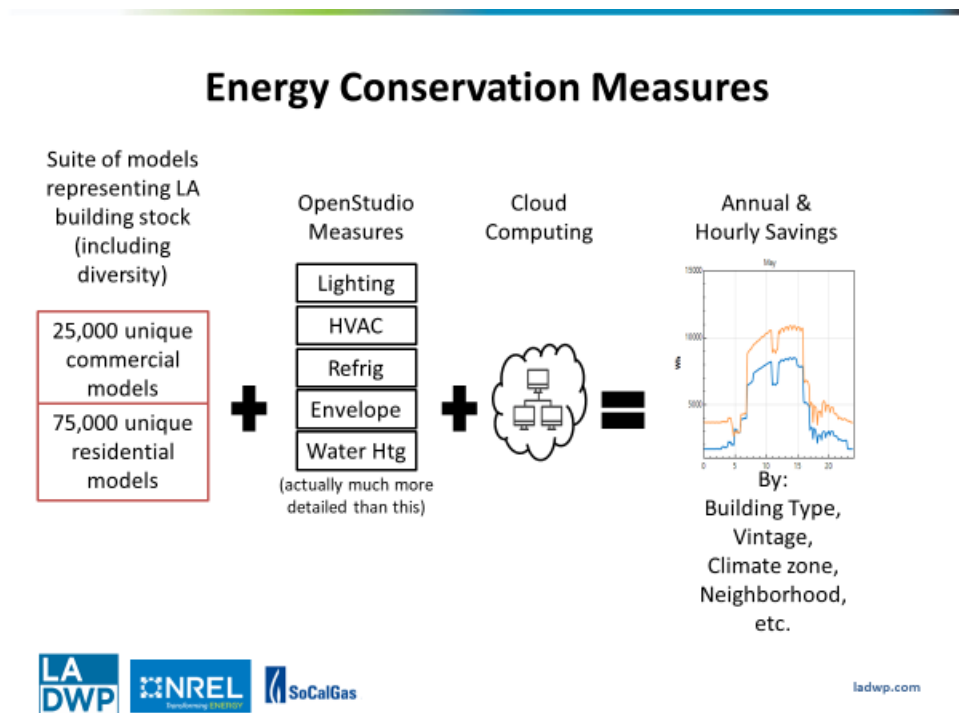
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Armen Saiyan – One clarification; we do not plan to use this project to claim savings. The value of this approach is for forecasting, geo-targeting, and bundling strategies.

Vrushali Mendon – Where is the commercial building data you used?

Andrew Parker – ComStock is not public yet; ResStock is available and there is documentation available.

Vrushali Mendon – When you are going from a population-based profile to figure out bundling of measures, can you elaborate how that would work?



Andrew Parker – Once we have all the models, we then run a bundle of measures to each model, one at a time, to each model, to determine savings and then aggregate for each building. The output will tell us what fraction of buildings would have higher savings potential versus others. With this approach, you can't do full combinatorial analysis; you need to narrow the list of measures you want to start with (the whole universe would be too cumbersome). Another piece of this is that we're building a data viewer website that will allow people to slice and dice results to see which measures make the most sense and the least sense.

Martha Brook – To Mark's point about sophistication and scaling of this, I want to put in context is what we have now; Armen's point about using this process to address goals and potential (for LADWP) – what we have now (for CA) is not adequate. I tried to use the goals and potential tool, and it is very difficult and not transparent for the user. The ratepayers of CA pay a lot of money for this, and we should think not just about how much work it would be but how beneficial it would be, particularly compared to what we do now.

Armen Saiyan – The biggest thing we are seeing is that this may be the best way to bridge the gap between the different “houses” of the utility. One thing is the granularity of the data; since it is mapped geographically, we can coordinate DER, EE and DS groups (which are traditionally siloed).

Mark Modera – At some point you hand over the keys to the data scientists. How much transparency will you lose when to do this? From personal experience, data scientists from Davis come up with conclusions from models that intuitively look wrong, but you have to sift through their processes to figure it out. How do we manage the process of “going into the dark”, which is what data science often appears to be.

Mark Costa – How do you see the analysis handle residual assets, permitting, rebates, compliance with L.A. ordinances? How do you see this interact with those other use cases?

Armen Saiyan – We had discussed with the DER planning team and they see benefits of the model. The other things that this may address is establishing a robust reference for deemed savings. Having these refined, territory-specific models may also support other use cases, but not every case.

Mark Costa – You calibrated the models for measures as well as EE packages? Can the measures be institutionalized and put into a “solutions directory” and provided for programs?

Andrew Parker – Yes, you can use the same measure on the stock and also put it in the repository for custom projects so you know practitioners are using the same measure from a programmatic standpoint.

Mark Modera – The reality is we have laws that say you can’t have a model that says what a building at some address uses, so you have to aggregate them to protect privacy.

Armen Saiyan – Yes, and these models are aggregated to a point within the platform, so there’s no customer data in the platform – it’s used for calibration but it’s not built into the models.

Steve Kromer – Your thought about applying this to deemed measures is interesting, and I am bringing up the prior comment about bias in the data sources. Have you thought about how you might use this in the context of other data. For example, for the program, you will not get everyone that you modeled, so there may be differences in the outcome.

Armen Saiyan – The idea is to update models as the program data comes in. Alternatively, you could do a subsegment of participating customers with their own characteristics.

Andrew Parker – Once you have this sort of scale approach, these kinds of questions will inevitably come up, so I’d be thrilled if others could use this and identify issues.

Mudit Saxena – What’s the process to “bless” this platform or tool?

Andrew Parker – We send the documentation to Armen and he says “good.” At least for L.A. If you wanted to expand this approach to all of California, you would have to go through an entire process

including documentation and regulatory approval. At least, with the L.A. model, we have a starting point that you can show to regulators and pique their interests.

End of Topic Sessions

Appendix 1: Ice Breaker



Cal TF Modeling Charrette

Ice Breaker Responses & Summary

Overview

At the start of the Cal TF Modeling Charrette, participants were asked to anonymously respond to the following questions (in writing):

- I have the following objectives for today's meeting/If I could change one thing, it would be...
- I have the following concerns about the meeting

All responses were collected. Respondents then broke into small groups where they took turns randomly selecting a completed form and reading it to their group. The groups briefly discussed each response in turn.

The responses are summarized in the sections below (verbatim responses are in *italics*). **Table 1** provides all of the anonymous responses.

Participant Objectives

Participants' comments indicate that participants had a wide range of expectations from the charrette.

General Education about Modeling in CA

Many participants viewed the charrette as an educational opportunity on topics ranging from modeling-specific to a broader industry view. Participants were interested in learning about specific details or techniques for conducting modeling, including the calculation methods for GHGs, custom calculations, and metering data. Others expressed more general needs around modeling software and approved tools.

Assumptions & basic framework of various building EE simulation software.

I would like a clear understanding on which energy modeling tools should be used in which applications so that it avoids confusion in the marketplace on which tools are "approved" for energy savings estimates

Better Understanding of Issues Facing Practitioners

Other participants attended to gain insight into the broader modeling industry and the issues facing practitioners.

Understand the full breadth and depth of the modeling issues

To learn the landscape of current coordination efforts around integrating whole-building modeling for small-medium commercial energy assistance programs implemented by local govt.

Gain Understanding of Future of Modeling in CA – Opportunities and Possibilities

Many participants were specifically interested in the future of modeling in California.

To learn the future direction of modeling

Understanding if there's any chance that CA will make any decisions/changes that result in meaningful improvements in the modeling process

Understanding Role of Cal TF

Some participants expressed a desire to learn about the Cal TF. Specifically, they wanted to understand the Cal TF mission, vision, and goals, and understand their relationship and role in advising the CPUC.

I am interested in learning more about Cal TF's role in advising the CPUC and what their current vision is for using energy modeling to support utility programs

Make Modeling in CA More Standardized, Transparent and Well-Documented

Many participants expressed a desire for building energy modeling in California to be more standardized and transparent.

Want to see CA transition to using open-source software for shared calculations (eg. deemed savings, code updates) and a certification system for project level software

Standardize rulesets for modeling and have an easy/traceable documents to follow through. Open to all platforms

Ensure that CA is moving towards transparent, rigorous, and accurate modeling practices for savings estimation

It would be ideal to have standardized modeling tools, processes, and deliverables for the different uses of modeling tools

Better documentation in tools replacing DEER, a bit more academic (publish studies with dates)

Need More Education/Coordination of Modeling Community

The need for education to support and inform the modeling community in California was identified by one participant. Another expressed a need for a process to create and adopt energy efficiency measures more expeditiously.

Maybe need an online journal, blog, or forum to help track developments for the sake of new entrants to the community (like myself)

I would like to know about the GHG calculations for each of these tools? What are the load shape sources? Which one of these tools can be modified to do custom calculations and metering data.

Learn more about existing data repositories or collections of existing simulation results

Library, training videos and/or website repository

How can we work together to standardize inputs/outputs

Participant Concerns

The concerns participants expressed about the charrette were more focused around outcomes and stakeholders.

Charettes Will Not Produce Change/Action

A consistently expressed concern was that no change would occur/result from this effort.

Same old thing...lots of talk very little action

These meeting often result in rehashing the same issues, and arguing about simulation engines

Too difficult to arrive at consensus for where to go from here

Some participants expressed concerns about the outcome of the charrette.

Leaving without concrete, actionable objectives

It will only be a battle of protecting organizational interests

Concerned that some are interested in the status quo to the extent that they will torpedo progress. Concerned that some will torpedo progress if they are not allowed to define the new state to their liking

The Commission and other stakeholders will not be able [to] relax their own requirements so that BEMs can be useful for all the necessary rulesets (2) No BEM developers will step up and deal with the various ruleset requirements

Many participants were concerned that there would not be effective decision-making during the charrette or to enact the recommended changes within the policy environment in California.

Decisions made too slowly end up being less effective and regulatory needs may be moving faster. With time will come different challenges unforeseen today

Too difficult to arrive at consensus for where to go from here

Who will be the final arbitrator of which energy modeling tool will be the tool of choice when competing tools produce different results with different assumptions and functionalities?

Even though the group reaches consensus here, how will it be translated into state policy changes?

Need to Include All Key Stakeholders In Charette Planning/Participation

There were concerns about the way the event was organized, the parties represented and the Cal TF role as organizer.

There should be more collaboration in preparation for these events. How can we properly assign responsibility in the respective areas, accuracy, education, simplify

Cal TF does not represent BEM users or organizations -> IBPSA-USA

Biased whitepaper

Appearance of conflicts of interest

That this forum is too insular. Modeling is used by LEED, design community, etc. I think we need feedback from these communities to better solve the issues

Topics & coverage too broad to result in meaningful change (though likely will increase overall understanding by many participants)

It does not represent enough practicing modelers

Technical Concerns About State of CA Modeling (Transparency, Complexity, Need to Be Software Agnostic, etc.)

Some participants expressed concerns specific to modeling rather than the charrette.

Transparency in the inputs in the modeling tools

Mandating EnergyPlus Only

Remain software agnostic & focus on the needs, applications & requirements

Models are too complex to compare efficiently and rigorously

Moving the current building prototypes to the new software and maintenance

How will energy models be prioritized in comparison to other energy savings estimation methods such as engineering formulas and calculations and data logging info?

Time/effort required to modify the existing approaches

Conflate custom & deemed requirements

Table 1. Ice Breaker Responses (Verbatim)

Identifier	I have the following objectives for today's charrette:	I have the following concerns about the charrette:
1	<ul style="list-style-type: none">History of modeling tools in CA in regard to deemed programsForum's perspectives on the future of modelingFuture of DEERIntegration of modeling with various programs such as NMEC	<ul style="list-style-type: none">Transparency in the inputs in the modeling toolsPossibility of one tool for all projectsTime/effort required to modify the existing approaches
2	<ul style="list-style-type: none">Learn, track and listen to how BEM software is used	There should be more collaboration in preparation for these events. How can we

Identifier	I have the following objectives for today's charrette:	I have the following concerns about the charrette:
	<ul style="list-style-type: none"> Ensure alignment with the industry and other statewide efforts 	properly assign responsibility in the respective areas, accuracy, education, simplify
3	To gain a better "big picture" understanding of energy modeling and current issues facing practitioners	None!
4	<ul style="list-style-type: none"> Understand Cal TF Simplify BEM for Savings By Design 	<ul style="list-style-type: none"> Mandating Energy Plus Only Cal TF does not represent BEM users or organizations -> IBPSA-USA Biased whitepaper
5	Learn about and contribute to the understanding of the use of modeling tools in Energy Efficiency	<p>Appearance of conflicts of interest</p> <p>1 immutable thing about CA EE: "The definition of energy efficiency: a product or service that a. is more expensive, b. uses less energy, and c. provides equipment service as the <u>baseline</u>"</p>
6	A greater appreciation of the power of good, well built energy models in predicting energy performance & load shapes. Let's recognize that modeling and statistical analysis using AMI data are both needed to achieve our goals!	Too much inertia w/ existing ways of working with old DOE2 based modeling methods.
7	<ul style="list-style-type: none"> To learn the landscape of current coordination efforts around integrating whole-building modeling for small-medium commercial energy assistance programs implemented by local govt. To answer: What is the feasible scope for local govt implementation to support an energy services market, providing standard data formats efficiently to provide access to small-medium to robust energy mgmt. services 	[left blank]
8	Understand the full breadth and depth of the modeling issues	That this forum is too insular. Modeling is used by LEED, design community, etc. I

Identifier	I have the following objectives for today's charrette:	I have the following concerns about the charrette:
		think we need feedback from these communities to better solve the issues
9	Learn what the CA ecosystem re: BEM <ul style="list-style-type: none"> Who is doing what? How can we work together to standardize inputs/outputs 	Same old thing...lots of talk very little action
10	Things to change: (1) Better documentation in tools replacing DEER, a bit more academic (publish studies with <u>dates</u>) (2) Maybe need an online journal, blog, or forum to help track developments for the sake of new entrants to the community (like myself)	I may not have much to contribute in regard to experience with <u>building</u> modeling. I'm worried that I won't know to whom to send my future questions after today.
11	Answer questions & provide input re: existing/past CBECC & eQuest/DEER tools/rulesets	Topics & coverage too broad to result in meaningful change (though likely will increase overall understanding by many participants)
12	<ul style="list-style-type: none"> Make it easier to use and understand Standardize rulesets for modeling and have an easy/traceable documents to follow through. Open to all platforms 	Too much to cover, too little time.
13	<ol style="list-style-type: none"> Gain insight of full needs Make path to tools usable for all (academics...lay user) Lower barriers to leverage models 	<ol style="list-style-type: none"> Changes will happen Changes will simplify process/improve quality
14	<ul style="list-style-type: none"> I am interested in learning more about Cal TF's role in advising the CPUC and what their current vision is for using energy modeling to support utility programs Ideally, we can select one or more issues to prioritize, and then begin working on a plan to solve them 	<ul style="list-style-type: none"> These meeting often result in rehashing the same issues, and arguing about simulation engines
15	I would like to know about the GHG calculations for each of these tools? What are the load shape sources? Which one of these tools can be modified to do custom calculations and metering data.	[left blank]

Identifier	I have the following objectives for today's charrette:	I have the following concerns about the charrette:
16	Identify what's broken & not working	Remain software agnostic & focus on the needs, applications & requirements
17	Assumptions & basic framework of various building EE simulation software. Learn more about existing data repositories or collections of existing simulation results	[left blank]
18	<ul style="list-style-type: none"> Address the issue of forward vs. inverse modeling (i.e. measured data vs. ground up simulation) Address how to compare model results Address model calibration 	<ul style="list-style-type: none"> Too difficult to arrive at consensus for where to go from here Models are too complex to compare efficiently and rigorously
19	Understanding if there's any chance that CA will make any decisions/changes that result in meaningful improvements in the modeling process	It does not represent enough practicing modelers
20	I would like a clear understanding on which energy modeling tools should be used in which applications so that it avoids confusion in the marketplace on which tools are "approved" for energy savings estimates	<ol style="list-style-type: none"> How will energy models be prioritized in comparison to other energy savings estimation methods such as engineering formulas and calculations and data logging info? Who will be the final arbitrator of which energy modeling tool will be the tool of choice when competing tools produce different results with different assumptions and functionalities?
21	Learn about all of the modeling software possibilities and pros & cons	Moving the current building prototypes to the new software and maintenance
22	Understanding BES requirements/landscape for evaluation of deemed/custom measures moving forward	Transition from current DOE2 tools to ET
23	(change one thing) Continuity between systems/models	[left blank]
24	<ul style="list-style-type: none"> Learn about Cal TF, their mission/mandate, their goals Understanding the California modeling landscape: 	<ul style="list-style-type: none"> Standardization of prototypes

Identifier	I have the following objectives for today's charrette:	I have the following concerns about the charrette:
	<ul style="list-style-type: none"> ○ Roles ○ Players 	
25	<ul style="list-style-type: none"> • Better understanding of energy modeling • Software to help make better decisions on EE 	<ul style="list-style-type: none"> • Focus on problems not solutions
26	<ul style="list-style-type: none"> • Addressing concerns about consistency without limiting software options • Explore ways to harmonized CA and national efforts 	<ul style="list-style-type: none"> • Leaving without concrete, actionable objectives • It will only be a battle of protecting organizational interests
27	<ul style="list-style-type: none"> • (overall/general) Begin the process of building consensus on how best to use energy models and modeling results to support CA's clean energy policy goals • (specific/short-term) CPUC and CEC share resources for energy modeling + results databasing 	<ul style="list-style-type: none"> • (specific) spending too much time on problem I.D. and not enough time on finding solutions
28	<ul style="list-style-type: none"> • Listen, observe & learn what's in store for modeling EE world 	<ul style="list-style-type: none"> • Industry could move too fast for reg. process to keep pace
29	<ul style="list-style-type: none"> • Not for the charrette, but in general: <ul style="list-style-type: none"> ○ Want to see CA transition to using open-source software for shared calculations (eg. deemed savings, code updates) and a certification system for project level software ○ Want to see CA align better with ASHRAE 	<ul style="list-style-type: none"> • Concerned that some are interested in the status quo to the extent that they will torpedo progress. Concerned that some will torpedo progress if they are not allowed to define the new state to their liking
30	<ul style="list-style-type: none"> • Come up with an implementable/actionable plan and follow through on the development of an energy efficiency tool/platform for all of CA 	<ul style="list-style-type: none"> • Dependence on multiple tools that all provide different results • Complex tools that are not user friendly
31	Learn about modeling history – why things are the way they are today.	Even though the group reaches consensus here, how will it be translated into state policy changes?

Identifier	I have the following objectives for today's charrette:	I have the following concerns about the charrette:
		Even though CA is large – what ability does this group have to change national issues?
32	Understand how Cal TF modeling protocols align with those to be used for programs, codes, and designers	If there will be any concrete takeaways that can move longstanding simulation questions towards resolution
33	<ol style="list-style-type: none"> 1. Encourage CEC & CPUC to make BEM used for code compliance useful for A/E best practice design 2. Change from % better than T24 to energy/sq. ft. compared to ZNE 3. Make reduction of GHG goal of EE not \$ saved 4. EE programs should aim for most cost effective way to reduce GHG 5. Calculate GHG of NG from the source including fracking, pipeline leaks, well leaks, etc. over its 20 year life <u>not</u> 100 yrs. 	That the above will not be accomplished
34	Find out what people are thinking about modeling	[left blank]
35	Change one thing about modeling in CA <ul style="list-style-type: none"> ○ (User interface) having one approved modeling standard ○ Library, training videos and/or website repository 	[left blank]
36	<ul style="list-style-type: none"> • Understand the issues facing different participants • Ensure that CA is moving towards transparent, rigorous, and accurate modeling practices for savings estimation 	<ul style="list-style-type: none"> • Too “model-choice” focused. Ignores socioeconomic factors that impact models • May over-complicate the issue. Modeling rigor & best practices are as more important than model choice
37	<ul style="list-style-type: none"> • Scheme for assuring consistent and representative savings values across the state for a typical measure for deemed savings <ul style="list-style-type: none"> ○ How will we determine population characteristics 	<ul style="list-style-type: none"> • Conflate custom & deemed requirements

Identifier	I have the following objectives for today's charrette:	I have the following concerns about the charrette:
	<ul style="list-style-type: none"> Narrow where we need statewide models – why lighting, for example 	
38	Agree that one or more BEMs will have full flexibility to implement all rulesets	(1) The Commission and other stakeholders will not be able [to] relax their own requirements so that BEMs can be useful for all the necessary rulesets (2) No BEM developers will step up and deal with the various ruleset requirements
39	It would be ideal to have standardized modeling tools, processes, and deliverables for the different uses of modeling tools	Modeling in CA is very established and will be very difficult to standardize and change
40	Understand landscape of modeling. Simplified approach	Get caught in minutia of modeling details
41	(or change in CA environment) Create a process for creating, vetting and adopting energy efficiency measures faster	Decisions made too slowly end up being less effective and regulatory needs may be moving faster. With time will come different challenges unforeseen today
42	Meet people. Share ideas. Help others. Connect & learn	It might get too detailed (on mechanics of modeling)
43	Basic: Understand alternative proposals for using one or multiple different models Advanced: Consider ramifications of modeling replacement or expansion of options on evaluation	Decisions on change are already made and I'm still catching up
44	To learn the future direction of modeling	[left blank]