Handout #2: "Current State" Tables

The information in the following tables should be considered preliminary; we welcome feedback at the Charrette.

Table 1: Comparison of Predominant Building Simulation Engines DOE-2.2, EnergyPlus, CSE for Code Compliance, Deemed Measure Development, Custom Measure Development, Other Uses in California

Criteria	DOE-2.2/2.3	EnergyPlus	CSE (CEC Residential model)
	Deemed measures	Custom Code Compliance for Commercial	Code compliance for residential
CA Regulatory & Policy Directives			
Transparency and Documentation[1]	Source code can be obtained for inspection in a form that cannot subsequently be compiled to an executable. DOE-2.1 algorithms are described in the Engineering Manual, DOE-2.2 Topics Manual provides high-level engineering discussion.	Calculations, inputs, assumptions, and default values can be reviewed by anyone. EnergyPlus uses few default values. Algorithms and assumptions are fully documented.[2] Engineering as well as input/output reference updated continuously and available both in HTML and PDF.	Source code is publicly available via github: https://github.com/cse-sim/cse Documentation for CSE is also available at github
Inter-Agency Coordination – statewide consistent energy savings values	Not used by CEC, requires consultants to create separate models for code-compliance and ex ante incentives.	Adopted by CEC Title 24 compliance (non-residential), allows consultants to use a single model for code-compliance and custom ex ante incentives.	Developed for CEC and adopted by Title 24 compliance (residential).
Use of Public Funds	Ratepayer dollars used to develop proprietary software.	Taxpayer dollars used to develop open-source software.	

[1] Rule 10.3(3)(B) of the Commission's Rules of Practice and Procedure.
[2] https://energyplus.net/sites/default/files/pdfs_v8.3.0/EngineeringReference.pdf.

Criteria	DOE-2.2/2.3	EnergyPlus	CSE (CEC Residential model)
Operational			
Ownership	J.J. Hirsch	Regents of University of CA and Regents of University of IL	CSE Authors (Rob Barnaby, Charles Barnaby, Big Ladder Software, Wrightsoft Corp) under contract to CEC
Licensing	Proprietary, source code not readily and freely available. Derivatives works are not permitted.	Commercialization-friendly open-source license that permits the development of proprietary derivative works and a variety of business models.	Open Source, may be redistributed with or without modification.
Funding	CA Ratepayers ($?)	DOE ($3.5 million/year); in-kind contributions from industry. Funding level has been stable since 2010.	
Updates, Bug Fixes, and New Features	Few updates since 2009.	Smaller update released every other week, with major releases twice a year.	Updates as needed to address bug fixes and add features. All releases, new features and bug fixes documented on github
Opportunities to Collaborate and Cost-Share	Controlled by vendor.	Large communities of developers, and funding sources – work is readily peer reviewed and auditable for accuracy. CEC and DOE have a history of cost-sharing and collaboration.	Code is available for review and modification; however, only persons who sign Contributor License Agreement may contribute code to original CSE library.
Technical			
Programming Language	FORTRAN, legacy platform used by a small number of developers, with slowly advancing compiler support and few libraries.	C++, modern platform used by a large number of developers, with quickly advancing compiler support and a large number of libraries[3].	C++
Development Team	JJ. Hirsch and associates.	Large and evolving pool of developers (approximately 30 at any given time) that includes individuals from national labs,	Rob Barnaby Charles Barnaby

[3] A “library” in this context refers to a computer program module that automates a function so that the function does not need to be coded from scratch.

Criteria	DOE-2.2/2.3	EnergyPlus	CSE (CEC Residential model)
		universities, consultants and software vendors. Most developers are active in energy modeling professional, research, and standard-making organizations such as ASHRAE and IBPSA.	Bruce Wilcox Michael O'Keefe Neal Kruis Big Ladder Software Wrightsoft Corp
Development process & QA/QC	Development process is closed. Updates, including inputs, calculations, assumptions and default values not readily available or subject to public peer review process, so errors or incorrect approaches may not be identified.	New features and bug fixes undergo extensive review, testing, and documentation. Source code repositories, issue tracker, automated test dashboard, feature request system, and Q&A forum are publicly available.	Development process, Q&A, and feedback primarily managed through github.
Modeling capabilities[4] [5]	In general, based on simplified equations developed when computation was more expensive ('70s and '80s).	In general, based on more sophisticated computations requiring greater computation power. Can "hook in" Radiance for daylight analysis.	CSE is a batch-based tool, which appears to use simplified equations. There is code addressing commercial buildings and equipment.
• **Time step**	Fixed one-hour time step precludes effectively modeling building controls, equipment cycling, and start/stop effects.	Variable timesteps as small as one minute can effectively model controls, equipment cycling behavior, and start/stop phenomena.	Fixed one-hour time step

[4] Extensive comparison between DOE-2.2 and EnergyPlus performed in Nov. 2010 by H. Rallapalli as Masters Thesis at Arizona State University under supervision of H. Bryan, M. Addison and T. Reddy, http://repository.asu.edu/attachments/56303/content/rallapalli_asu_0010n_10220.pdf

[5] DOE-2.2 modeling capabilities from eQUEST documentation from EDR website (www.doe2.com/download/equest/eQuestv3-Overview.pdf). EnergyPlus modeling capabilities from EnergyPlus documentation and personal communications with DOE and NREL staff.

Criteria	DOE-2.2/2.3	EnergyPlus	CSE (CEC Residential model)
• **Commercial refrigeration**	A separate build of DOE2.2 (DOE2.2R v52h) models commercial refrigeration equipment.	Models commercial refrigeration within the main (only) build.	N/A
• **Economics & utility tariffs**	Hourly time-step limits accuracy for utility tariffs requiring sub-hourly calculations. A single tariff calculation for each energy source requires generation and T&D tariffs to be lumped and may require complex tariff structures to be simplified.	Sub-hourly time-step accurately model utility demand tariffs requiring sub-hourly calculations. Multiple tariff calculations for each energy source to be flexibly defined, allowing generation and T&D tariffs to analyzed individually. Supports complex tariff structures.	None found
• **Residential**	Supports residential modeling.	Supports residential modeling except for leakage and radiant heat losses for ducts in unconditioned spaces, so is not yet approved for Title 24 compliance for residential buildings.	Supports residential modeling
Testing and Validation[6]	Refers to standardized, cross-engine testing and validation, not to product testing performed by the developer or associates.		Unknown
• **ASHRAE 140 – analytical & comparative**	Yes	Yes	

[6] Validation of building energy simulation engines uses a combination of ***analytical tests*** (do simulated results match analytical results for simple configurations?), ***comparative tests*** (do different analytically sound engines produce similar results for more complex configurations?), and ***empirical tests*** (do simulated results match measured field results?).

Table 2: List of Interfaces for Each Building Simulation Engine

Criteria	DOE-2.2	EnergyPlus	CSE
	EQuest MASControl	Open Studio Design Builder CBECC-Com EnergyPro Simergy IES-VE (for code compliance only)	CBECC-Res EnergyPro Right-Energy Title 24

Table 3 List of "Rulesets" for Each "Use Case"

Use Case (Purpose of Model)	Rule Set	Documented and Calibrated?	Comments
Energy code compliance – demonstrate that building meets code under standardized conditions	Built into CEC building simulation tools and wrappers.		Does not produce energy savings for a particular building, rather determines code compliance.
Energy efficient building design tool – explore trade-offs and evaluate cost effectiveness of options	No rule set. Individual to building.		
Utility new construction programs – demonstrate that building meets program requirements	Title 24 as baseline		
Evaluation of utility whole building new construction programs – accurately estimate real-world savings performance of as-built participant buildings	No rule set, tailored to building		
Estimate efficiency measure savings using before/after metering data – use models to normalize metered data, and to control for non-measure variables. Rules for how to do this are still being developed.	Not applicable		
Estimate DEEMED savings for new, weather-dependent measures – same uses as above	"Ruleset" defined via DEER Building Prototypes		
Estimate savings for CUSTOM measures or bundles – Same issues as above for DEEMED measures, but limited to measures not suited to DEEMED approaches	Base on individual buildings (OR DEER assumptions)		