SR: Simulation Vs Reality (11 papers)

EVALUATION OF CALIBRATION EFFICACY UNDER DIFFERENT LEVELS OF UNCERTAINTY

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Comments from Building Simulation 2013
Diego Ibarra
Harvard University

Chambery (France), 25-28 August 2013
13th International Conference of the International Building Performance Simulation Association

Building Simulation 2013 papers show that **barriers for using models for FDD, predictive controls and Retrofit analysis are disappearing.**

Issues in Practice about calibration and reuse of building models for retro-fits and operations (personal opinion)

- **Amount of uncertainty (risk)** that exists during design and audit process regarding 4-big-uglies (i.e. weather, occupancy, process loads, infiltration) and other simulation parameters (air flow).

- **Amount of work required (profitability)** to calibrate a building (i.e. audit and measured data) and still have large uncertainty.

Paper evaluates efficacy of **New Calibration approach** as an **alternative to "expert-intensive tweaking single values" approach for enhancing the reliability of a baseline,** while dealing with uncertainty of parameters energy model under different levels of energy audit.

Typical calibration: deterministically search for a single solution that minimizes discrepancy between predicted and measured while ignoring many feasible solutions that may have higher likelihoods.

New Bayesian inference calibration approach to calibrate uncertain parameters while accounting for uncertainty in calibration process.

Heo, Y., Choudhary, R., Augenbroe, G. 2012b. Calibration of building energy models for retrofit analysis under uncertainty, Energy and Buildings, 47:550–560.

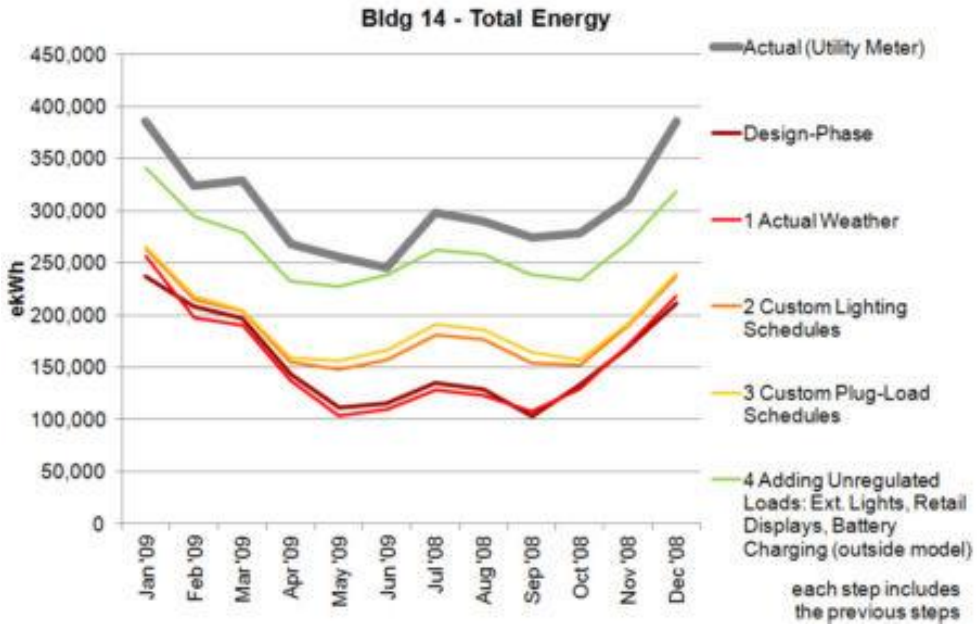
New Bayesian inference calibration approach to calibrate uncertain parameters while accounting for uncertainty in calibration process. Deployed in a formal process designed to minimize the role of expert judgment in the calibration process.

1- Pre-uncertainty quantification (sources)

2- Parameter screening (sensitivity by Morris method)

3- Dominant parameters calibrated by bayesian calibration (prior density functions, set model inputs and outputs form space, measured data)

Instead of…



Holly Samuelson (2012)

New Bayesian inference calibration approach to calibrate uncertain parameters while accounting for uncertainty in calibration process. Deployed in a formal process designed to minimize the role of expert judgment in the calibration process.

1- Pre-uncertainty quantification (sources)

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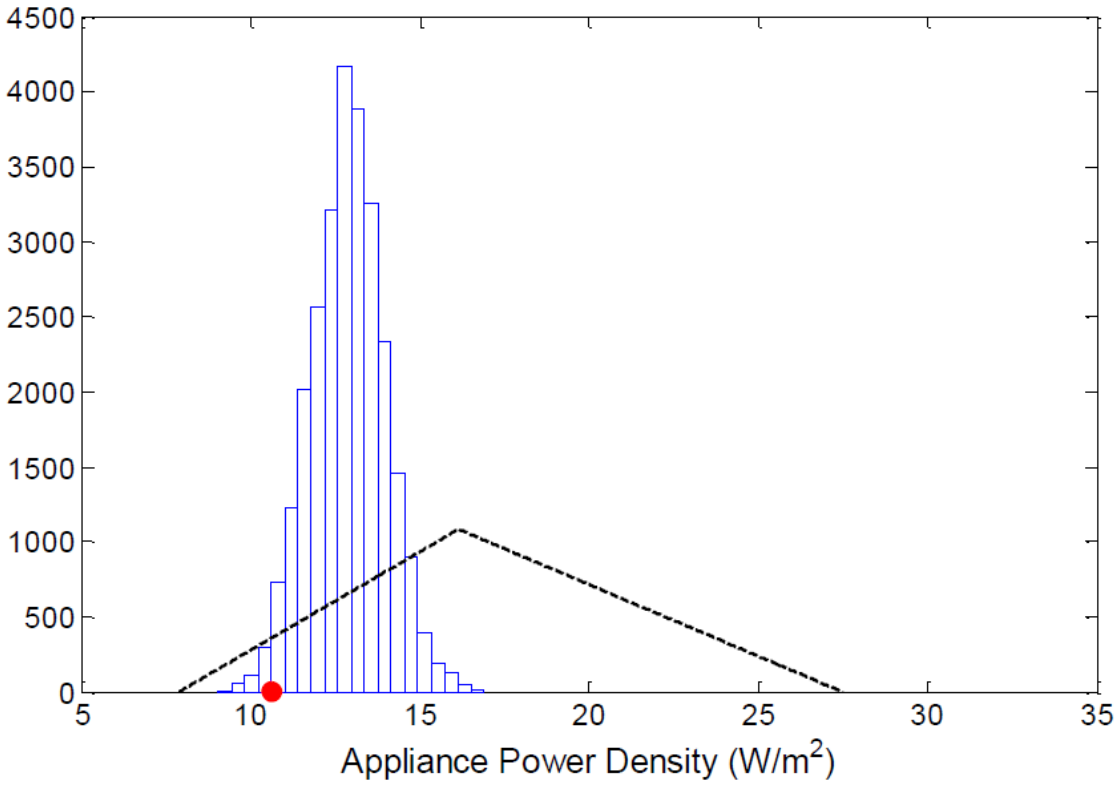
Do…



Calibration of 3 Office Buildings using DOE Benchmark EnergyPlus models: Small office, Medium office and Large office.

Table 1 Levels of data available for three audit levels

DATA	LEVEL 1	LEVEL 2	LEVEL 3
Utility bills (1 yr)	X	X	X
As-built drawings	X	X	X
Walk-through site visits		X	X
Detailed audit			X
Monitored end-use data			X

LEVEL 2 Results

Table 4 Evaluation of calibration parameter values against true parameter values at Level 2

	CVRMSE IN PARAMS		DIFF.
	Uncalibrated	Calibrated	
Small Building			
Infiltration	1.05	0.32	0.73
Outside air flow	4.28	1.29	3.00
Heating sys. eff.	0.19	0.21	-0.01
Fan pressure rise	0.43	0.27	0.16
Medium Building			
Outside air flow	4.22	0.38	3.84
Appliance power	0.73	0.24	0.49
Infiltration	6.35	1.93	4.42
Heating sys. eff.	0.08	0.07	0.01
Large Building			
Outside air flow	4.20	0.43	3.77
Appliance power	0.71	0.10	0.61
Infiltration	0.65	0.37	0.28
Heating sys. eff.	0.08	0.06	0.01

Table 5 Evaluation of model predictions (Level 2) against utility bills

	CVRMSE (ELECTRICITY)		CVRMSE (GAS)	
	Uncal.	Cal.	Uncal.	Cal.
Small building	0.18	0.12	1.79	0.25
Medium building	0.29	0.08	10.14	1.39
Large building	0.61	0.16	1.42	0.18

LEVEL 1 Results

Table 7 Evaluation of model predictions (Level 1) against utility bills

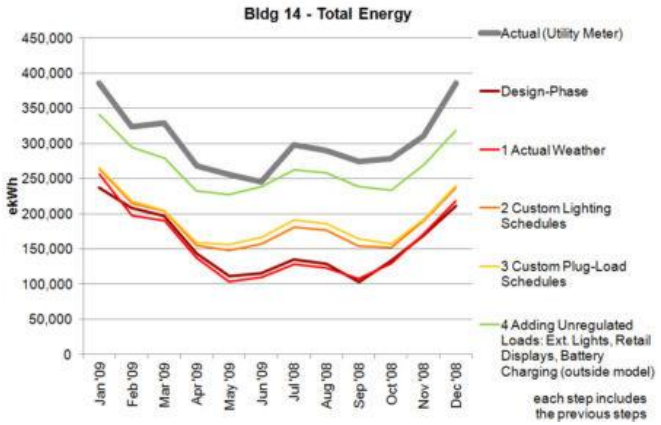
	CVRMSE (ELECTRICITY)		CVRMSE (GAS)	
	Uncal.	Cal.	Uncal.	Cal.
Small building	1.17	0.75	5.64	0.86
Medium building	1.56	0.57	31.47	8.63
Large building	3.65	0.74	4.94	1.05

Level 2 with more parameters

Table 9 Evaluation of model predictions (Levels 2 and 1) against utility bills

	CVRMSE (ELECTRICITY)	CVRMSE (GAS)
Model Level 2		
Four params	0.08	1.39
Six params	0.07	1.18
Eight params	0.07	1.25
Model Level 1		
Four params	0.57	8.63
Six params	0.35	1.56
Eight params	0.28	1.56

CONCLUSIONS FOR PRACTICE > LESS EFFORT > LESS UNCERTAINTY



- **OpenStudio**
- **Faster Algorithms**
- **Uncertainty Database for Modeling**

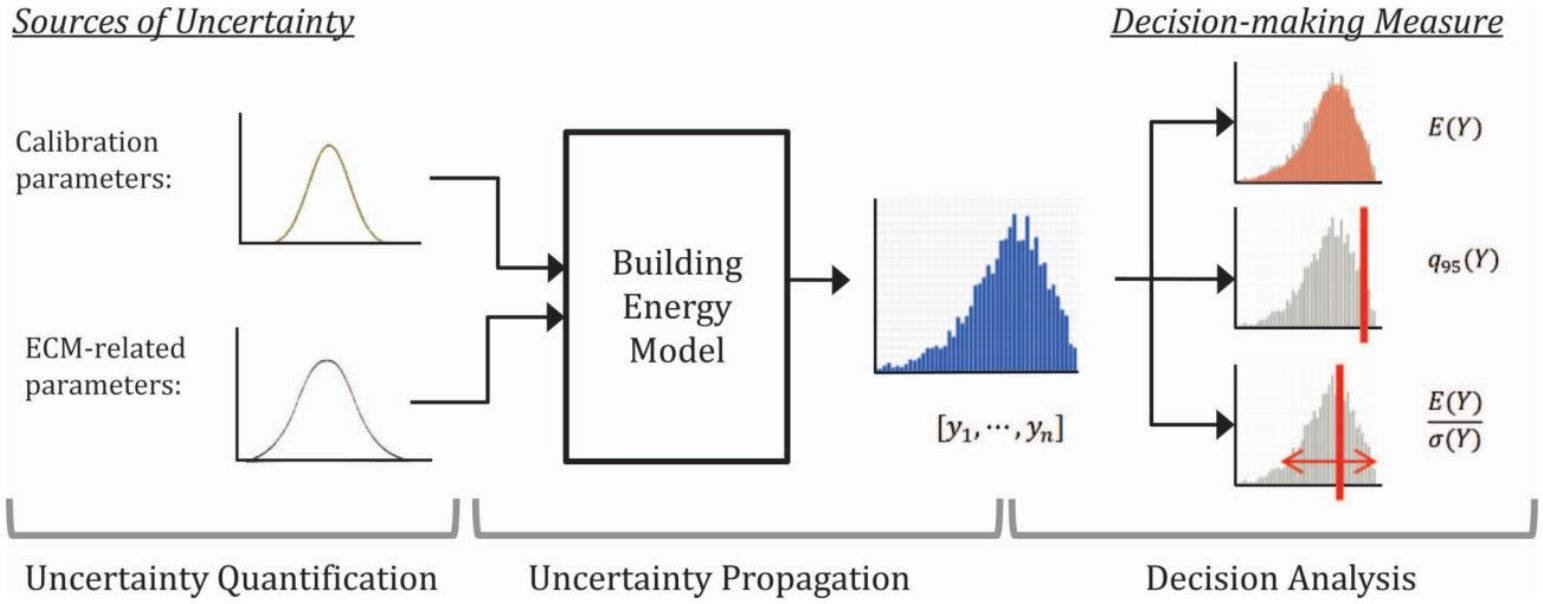


Figure 4. Probabilistic analysis process for risk-conscious decision-making.

Thank you

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LEVEL 1 Results

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Outside air flow	4.22	0.38	3.84
Appliance power	0.73	0.24	0.49
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Heating sys. eff.	0.08	0.07	0.01
Large Building			
Outside air flow	4.20	0.43	3.77
Appliance power	0.71	0.10	0.61
Infiltration	0.65	0.37	0.28
Heating sys. eff.	0.08	0.06	0.01

Table 6 Evaluation of calibration parameter values against true parameter values at Level 1

	CVRMSE IN PARAMS		DIFF.
	Uncalibrated	Calibrated	
Small Building			
Infiltration	1.08	0.39	0.69
Outside air flow	4.18	1.18	3.00
Heating sys. eff.	0.29	0.31	-0.02
Appliance power	0.96	0.86	0.10
Medium Building			
Outside air flow	4.22	0.30	3.92
Appliance power	0.96	0.49	0.47
Lighting power	0.34	0.27	0.07
Heating sys. eff.	0.13	0.16	-0.03
Large Building			
Appliance power	0.95	0.17	0.78
Outside air flow	4.18	0.48	3.70
Lighting power	0.84	0.18	0.65
Infiltration rate	0.65	0.33	0.32