CBERD Task 2.1 Simulation & Modeling

2015 Building Technologies Office Peer Review

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Project Summary

Timeline:

Start date: 1/1/2013

Planned end date: 9/30/2018

Key Milestones

1. Implementation of ECBC ruleset for code compliance; 9/30/15
2. Implementation of real-time MPC strategies in a building or tests-bed equipped with a low energy HVAC system; 9/30/2016

Budget:

Total DOE $ to date: $386k

Total future DOE $: $521k

Target Market/Audience:

- A&E design practitioners
- Code officials
- Control engineers
- Operators
- Researchers

Key Partners:

IIIT Hyderabad	Autodesk
CEPT	HOK Architects
UC Berkeley	Schneider Electric

Project Goals:

- Improve building energy efficiency through the use of smart, integrated simulation tools for design and operation
- Develop new methods for reducing the energy consumption of existing and new buildings – controls, diagnostics

Purpose and Objectives

Problem Statement:
Simulation tools do not fully meet the needs of practitioners from early stage design to operation

Target Market and Audience:
- Architects, mechanical engineers, code officials, control engineers, operators.
- Existing and new commercial buildings in India and the US
- Enabling technologies, contributing to technical potential of 40% of 510 TWh/yr in India and 36% of 3200 TWh/yr in US by 2030

Impact of Project:
1. Products: Improved analysis tools for early design, rulesets for code compliance, control strategies for radiant slab systems, diagnostic tools
2. Impact metrics:
   a. Near-term: Adoption
   b. Intermediate-term: Case studies of benefits
   c. Long-term: Impact on building stock

Approach

Approach: Identify needs/opportunities to improve tools and supporting data. Develop, implement and test new, high priority capabilities for existing tools and control systems. Leverage external R&D

Key Issues - selected for joint research interest and impact potential:

- early stage design analysis - optimization
- code compliance tools - extend ASHRAE 90.1 Appendix G capabilities to ECBC
- control of passive thermal storage to exploit diurnal swing and shift load - model predictive control
- automated diagnostics - test new and existing methods

Distinctive Characteristics:

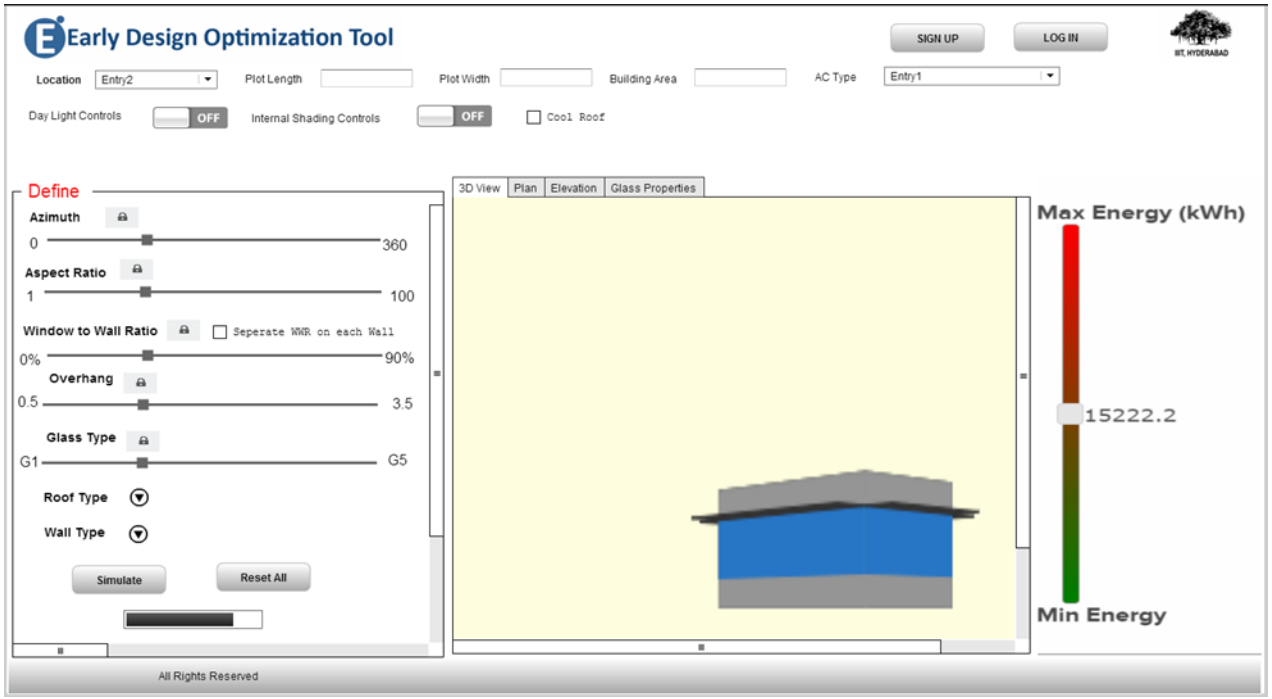
- adoption of rule-based representation of building energy codes and exploitation of similarities between ASHRAE 90.1 and ECBC
- collaboration on test facility design

Progress and Accomplishments – Early Design Optimization

Lessons Learned: Clients are requiring progressively more early stage design analysis

Accomplishments: Early Design Optimization Tool (eDOT)

- Based on survey of architects
- On-line tool
- Multi-parameter optimization:
  - 10 envelope parameters
- 4 HVAC system types
- Uses EnergyPlus and GenOpt



Market Impact:
(Too early for measurable impacts

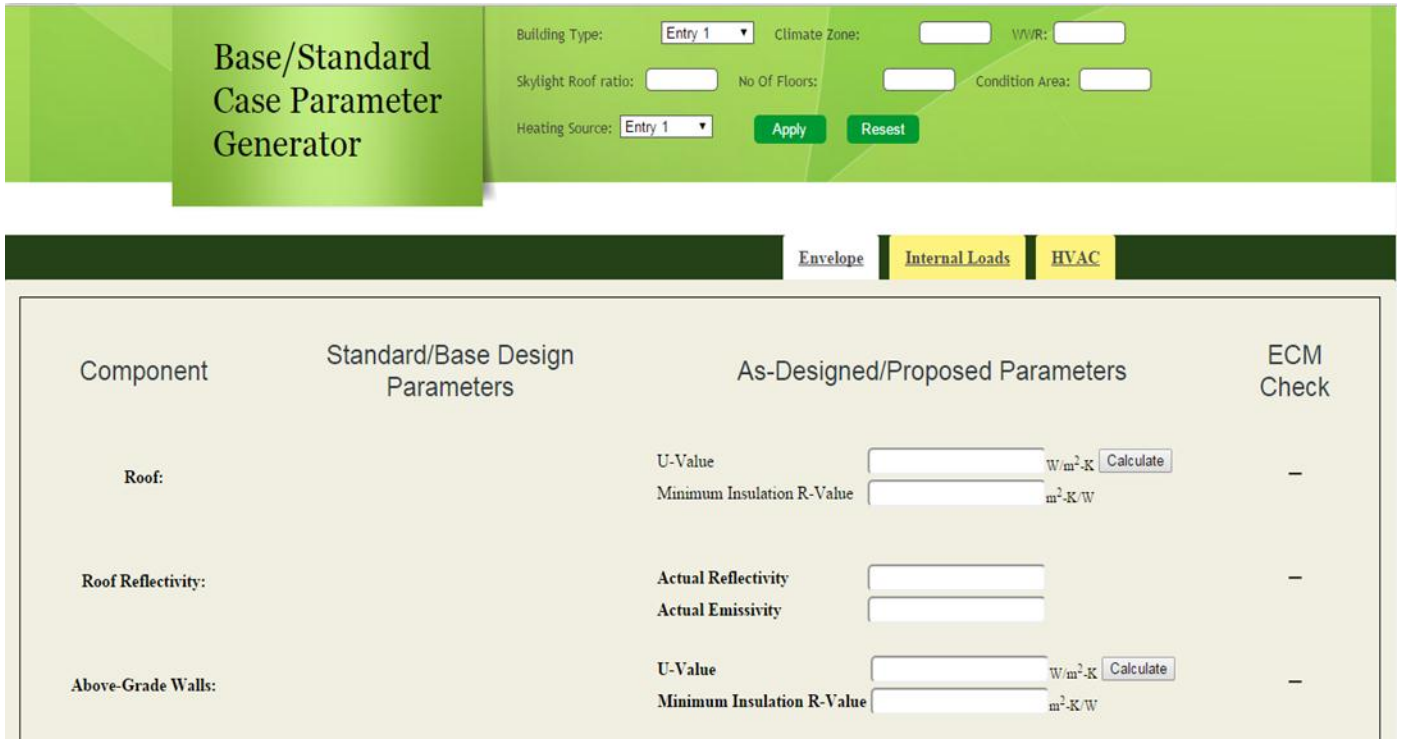
Awards/Recognition: (None as yet)

Progress and Accomplishments - ASHRAE 90.1/ECBC

Lessons Learned: Easier access to performance-based code compliance tools needed

Accomplishments: Tool for ASHRAE 90.1/ECBC base case parameters

- Generate base case parameters from as-designed /proposed case
- Useful stand-alone
- First step in mapping ECBC to Appendix G



Market Impact:
(Too early for measurable impacts

Awards/Recognition: (None as yet)

Progress and Accomplishments - Model Predictive Control

Lessons Learned:

Model predictive control can improve energy and comfort but needs integrated tools for practitioners

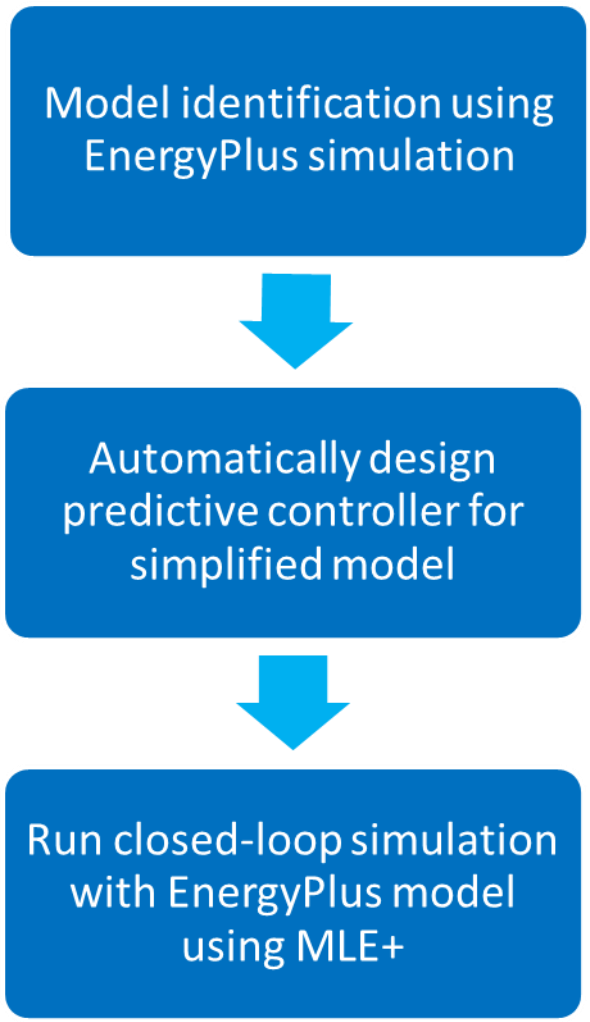
Accomplishments:

Development of tools for model identification and simulation

- Generate base case parameters from as-designed /proposed case
- Useful stand-alone
- First step in mapping ECBC to Appendix G

Market Impact:
(Too early for measurable impacts)

Awards/Recognition: (None as yet)



Project Integration and Collaboration

Project Integration:

- Collaboration with Architectural Energy Corporation, 360 Analytics and Wrightsoft on development of code compliance rulesets
- Collaboration with Infosys and UC Berkeley CBE on measurement of radiant system performance

Partners, Subcontractors, and Collaborators:

- Collaboration with AutoDesk Research on real-time visualization of energy and IEQ performance
- Collaboration with IIIT Hyderabad on ECBC ruleset development
- Collaboration with UC Berkeley on development of model predictive control for radiant slabs
- Collaboration with IIIT Hyderabad on design and commissioning of diagnostics test facility

Communications:

(None as yet – key opportunity: Building Simulation 2015 in Hyderabad)

Next Steps and Future Plans - I

- Rule sets for performance-based code compliance:
  - Uses rule-based approach developed by CBERD partner CEC – rules as data
  - Builds on ASHRAE 90.1 ruleset recently developed by an Architectural Energy Corp team, funded by DOE
  - Development of ECBC ruleset by IIIT-Hyderabad and LBNL, adapted from ASHRAE 90.1 ruleset (ECBC is based on ASHRAE 90.1)

- Continue development of model predictive control for thermal mass storage in low energy systems – radiant slab cooling, natural ventilation:
  - Specification of a graphical user interface for EnergyPlus users to access MPC tools and prototyping in OpenStudio
  - Characterization of effect of uncertainty in input data and model simplifications on actual quality of control

- Testing of eDOT at LBNL and HOK

Next Steps and Future Plans - II

- Collaboration with AutoDesk Research on visualization of energy and IEQ performance: Project Dasher + real-time EnergyPlus
  - Initial implementation in LBNL Building 90 (FLEXLAB)

- Develop model-based fault detection and diagnosis (FDD) tools for whole building, system and component levels:
  - IIIT-Hyderabad fault diagnostics test facility:
    - Matched pair of cells, each with its own air handling unit
    - Comparative testing of new and existing FDD methods
    - Next step: commissioning

REFERENCE SLIDES

Project Budget

Budget History					
1/1/2013 - FY2014 (past)		FY2015 (current)		FY2016 – 12/31/2017 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$360k	~$80k	$180k	~$1M	$367k	~$1M

Variances: No significant variances

Cost to Date: ~50%

Project Plan and Schedule