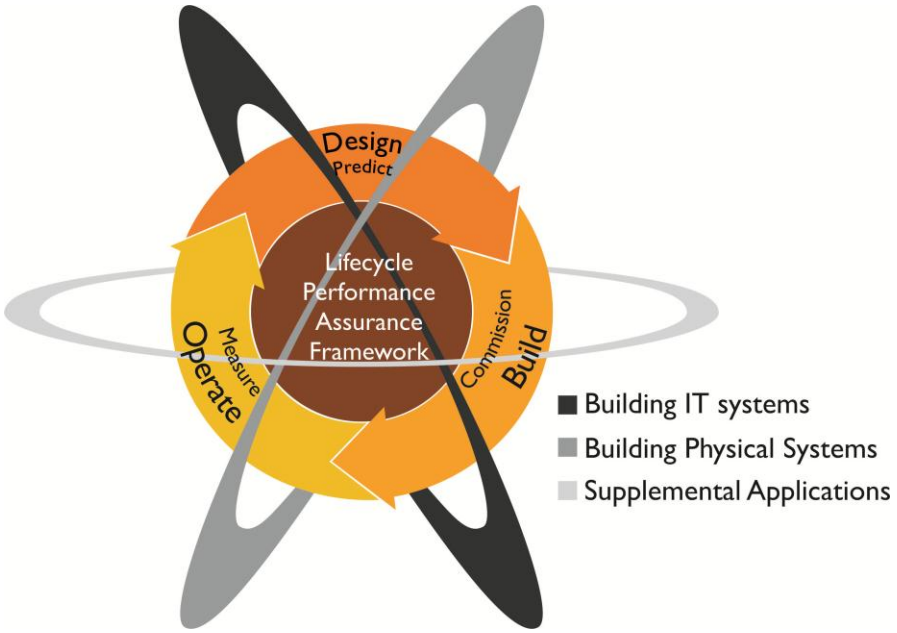
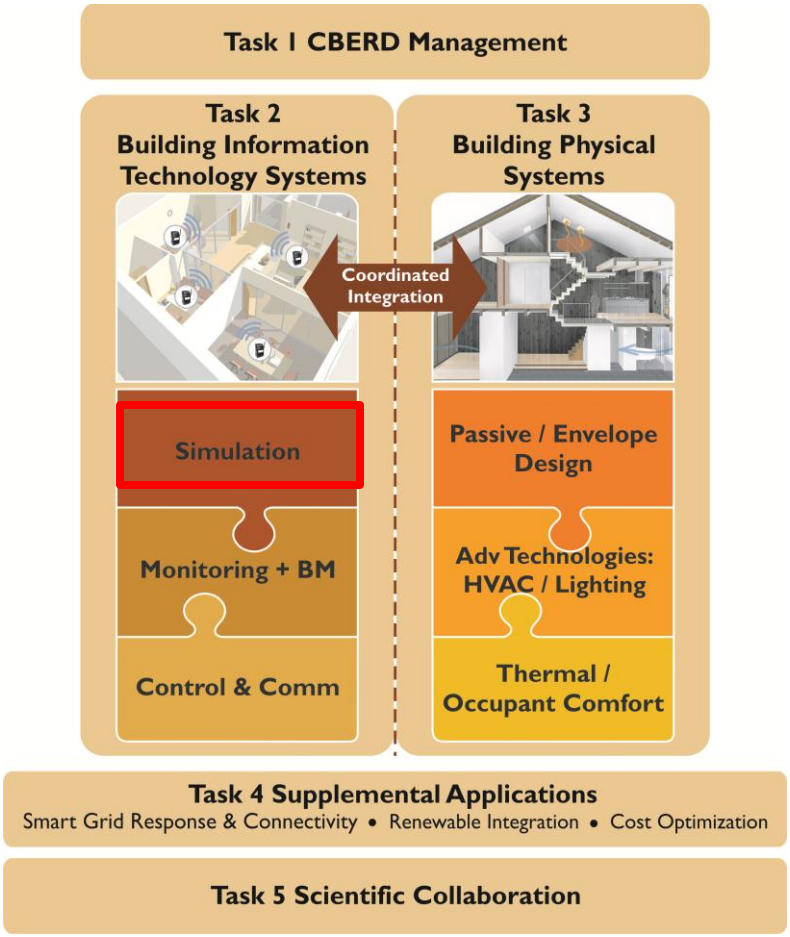
U.S.–India Joint Center for Buildings Energy Research and Development (CBERD):
Simulation & Modeling

2014 Building Technologies Office Peer Review

CBERD promotes innovation in energy efficiency through collaborative research, contributing to significant reduction in energy use in both nations.





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

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Project Summary

Timeline:

Start date: 10/1/2012

Planned end date: 9/30/2017

Key Milestones

1. Beta version of code compliance tool; 12/31/14
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: $234k

Total future DOE $: $641k

Target Market/Audience:

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

Key Partners:

IIIT Hyderabad	HOK Architects
CEPT	Autodesk
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 throughout the building life-cycle, 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 design analysis tools and data, control strategies and 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: Particular gaps in:

- early stage design analysis
- code compliance tools
- control of passive thermal storage to exploit diurnal swing and shift load

Distinctive Characteristics:

- adoption of rule-based representation of building energy codes and exploitation of similarities between ASHRAE 90.1 and ECBC
- collaboration with leading architectural practice to identify requirements for early stage design analysis

Progress and Accomplishments

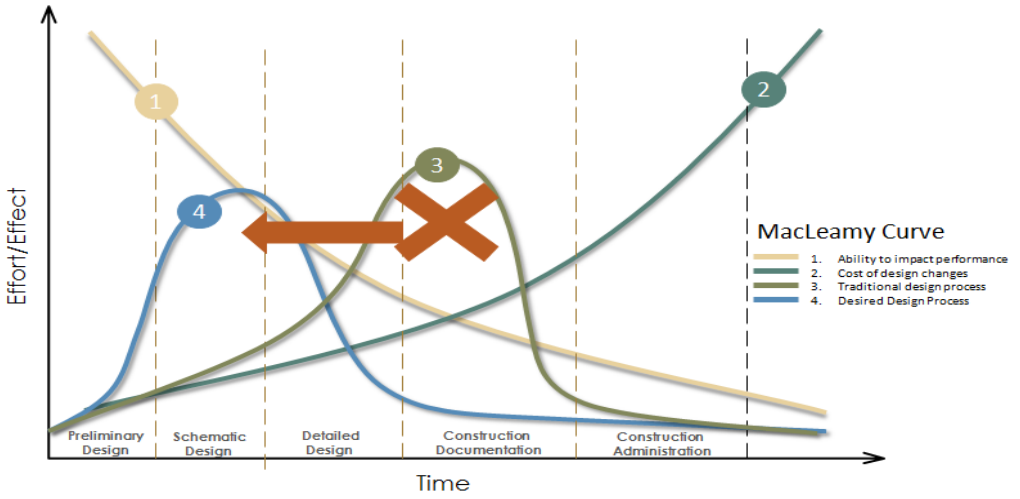
Lessons Learned: Clients are requiring progressively more early stage design analysis

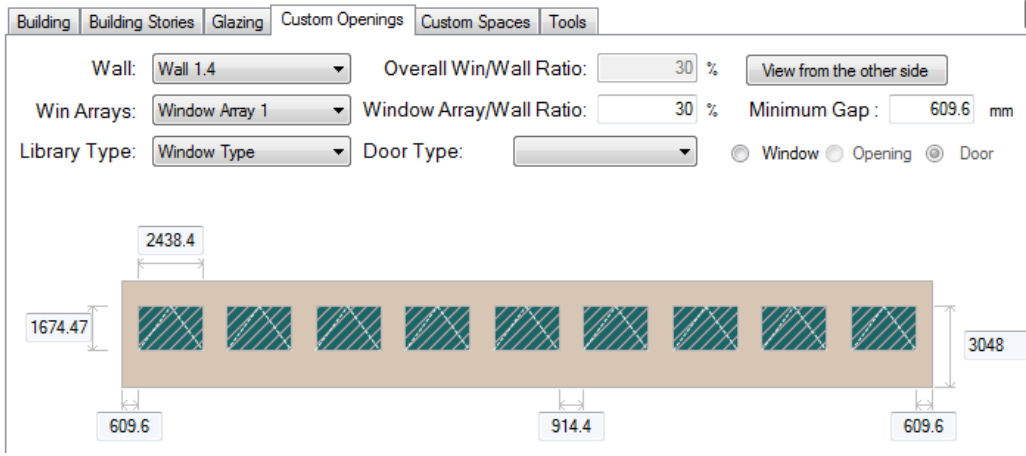
Accomplishments:

- GUI requirements for early stage design analysis
- Simergy support for hybrid (mixed mode) ventilation
- Good progress on model predictive control – radiant slabs, models ← EnergyPlus (next slide)

Market Impact:
(Too early for measurable impacts)

Awards/Recognition:
(None as yet)

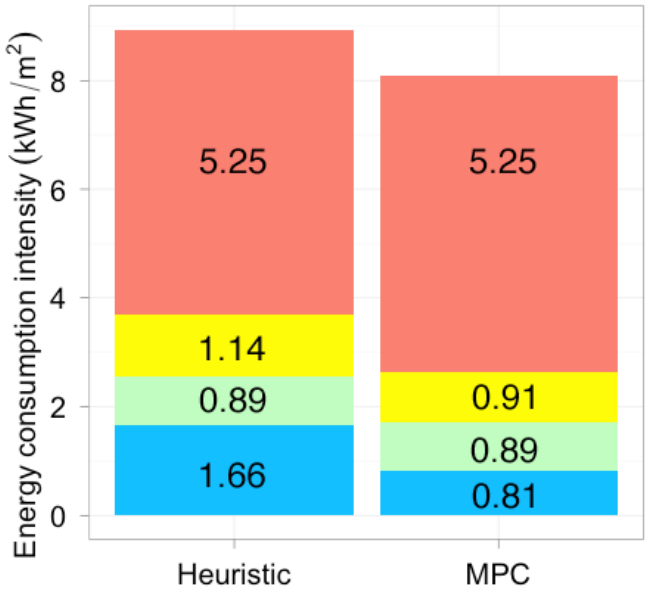


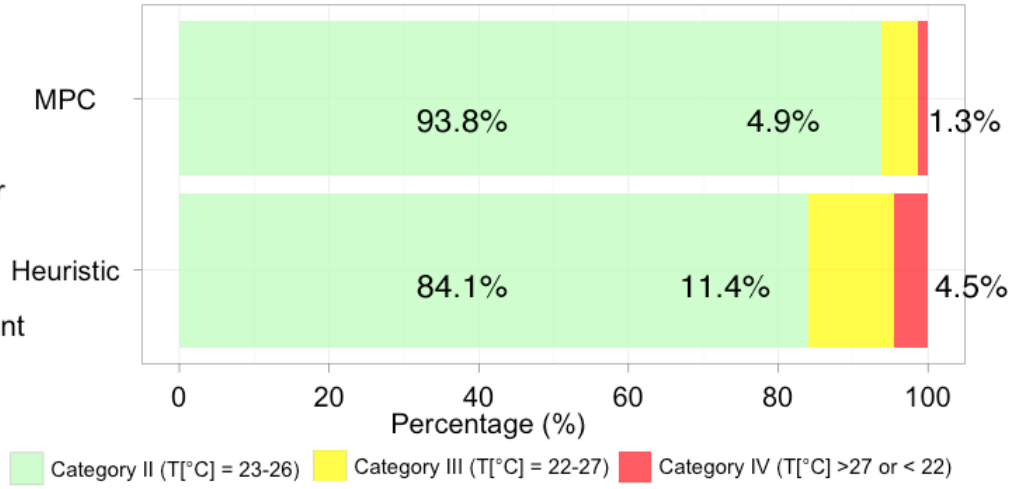


Progress and Accomplishments – Model Predictive Control

Simulation comparison of Standard Control and Model Predictive Control (MPC):

- Calibrate EnergyPlus model of Brower Center building, which has radiant slabs
- Derive simplified model for MPC from EnergyPlus model
- Test MPC on calibrated EnergyPlus model
- Create metrics for energy and comfort and compare MPC to heuristic control.





Energy Comparison of MPC vs Standard Controls (Note cooling energy savings)

Comfort comparison of MPC vs Standard Controls

Project Integration and Collaboration

Project Integration:

- Collaboration with David Brower Center and Infosys on measurement of radiant system performance
- Collaborated with Digital Alchemy on implementation of hybrid ventilation in Simergy
- Collaborating with Architectural Energy Corporation, 360 Analytics and Wrightsoft on development of code compliance rulesets

Partners, Subcontractors, and Collaborators:

- Collaborated with HOK architects on early stage tool requirements
- 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 of diagnostics test facility

Communications:

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

Next Steps and Future Plans - I

1. Simergy support for code compliance: US (ASHRAE 90.1) and India (ECBC), leveraging:
   - Rule-based approach developed by CBERD partner CEC – rules as data
   - CEC software and Title-24 rules will be integrated with Simergy (Digital Alchemy, funded by California utilities)
   - Development of ASHRAE 90.1 ruleset (Architectural Energy Corp team, funded by DOE through PNNL)
   - Development of ECBC ruleset by IIIT-Hyderabad, adapted from ASHRAE 90.1 ruleset (ECBC is based on ASHRAE 90.1)
   - Simergy/ECBC useful in future development of ECBC, including natural ventilation

2. Continue development of model predictive control for thermal mass storage in low energy systems – radiant slab cooling, natural ventilation

Next Steps and Future Plans - II

3. Develop Simergy-based tools for specific applications:
   - Chiller sizing
   - Demand response
   - Cool roofs

4. Develop model-based fault detection and diagnosis tools for whole building, system and component levels:
   - IIIT Hyderabad fault diagnostics test facility
   - Real-time EnergyPlus
   - Display actual performance using AutoDesk's Project Dasher

REFERENCE SLIDES

Project Budget

Budget History					
1/1/2013 - FY2013 (past)		FY2014 (current)		FY2015 – 12/31/2017 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$150k	~$50k	$175k	~$1M	$550k	~$1M

Variances: No significant variances

Cost to Date: ~30%

Project Plan and Schedule