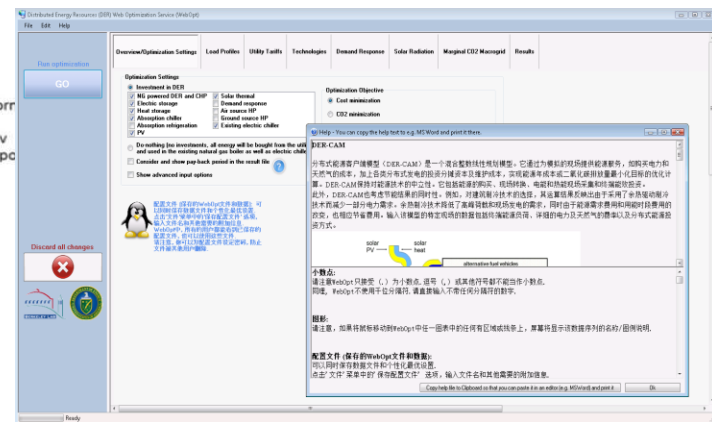
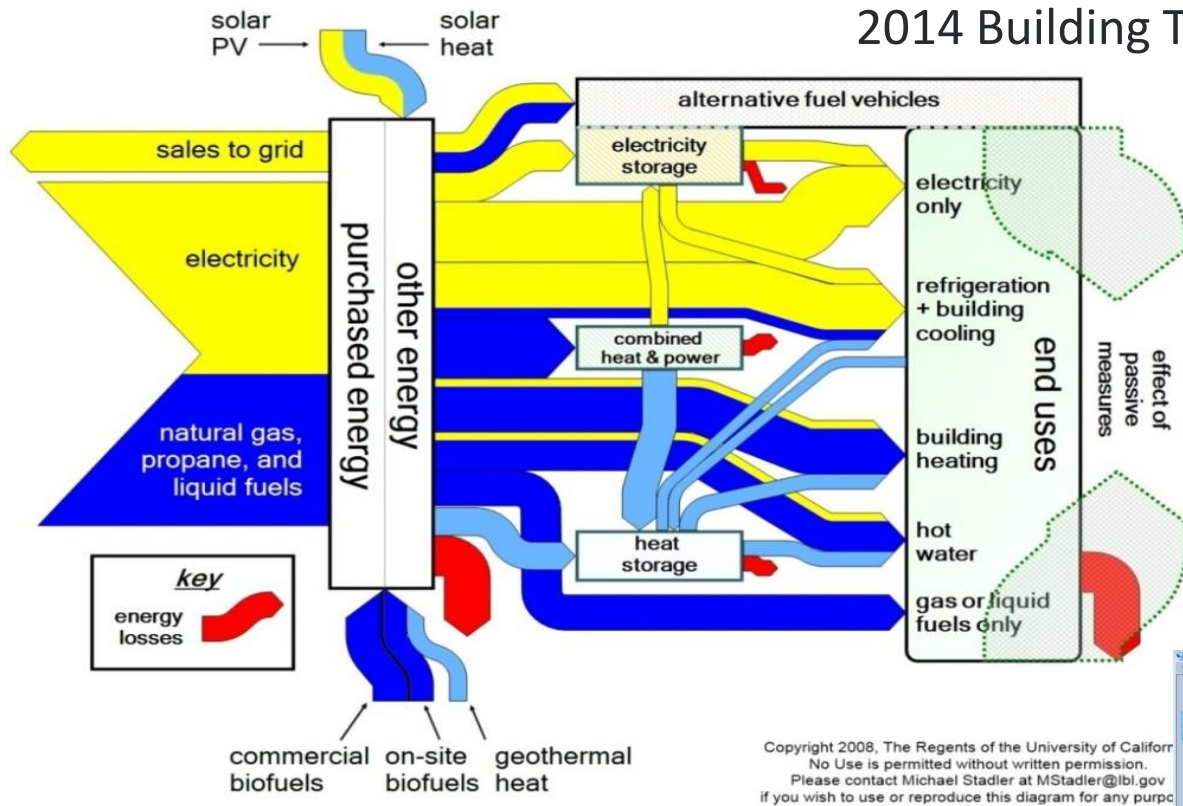


# Microgrid Equipment Selection and Control in Buildings

2014 Building Technologies Office Peer Review



CERC-BEE is a five year, \$50M program created by the U.S. Department of Energy and Chinese Ministry of Science and Technology. This work is being done under the buildings part of the program, <http://cerbee.lbl.gov/>  
 In this project LBNL is working with Tianjin University, and C3 Energy on the U.S. side, and XingYe Solar in China.



Energy Efficiency & Renewable Energy

Wei Feng, weifeng@lbl.gov  
 Lawrence Berkeley National Laboratory

# Project Summary



## Timeline:

Start date: June 2011

Planned end date: Dec 2015

## Key Milestones

1. UNM Mech Eng Bldg.; summer 2012
2. Chinese WebOpt; Dec 2012
3. U.S.-China regional comparison study on DER technology potential in buildings; mid 2013  
Reference Buildings Analysis Set; Fall 2013
4. XingYe HQ Building, Zhuhai, devel.: 2014

## Budget:

Total DOE \$ to Dec 14: \$700K  
(\$340K in hand)

Total DOE \$ to Dec 15 : \$300K

## Target Market/Audience:

Developers of complex commercial buildings and microgrids involving integration of on-site generation, storage, load control, grid services, etc. in the U.S. and China.

## Key Partners:

U of New Mexico	Tianjin University
C3 Energy	Tongji University
PNM (electricity utility)	XingYe Solar
Santa Fe Com. Col.	Beijing U. of Const. & Architecture

## Project Goal:

Using a Software as a Service model provide optimal equipment choice and operating guidance for low energy buildings employing multiple supply and demand-side technologies .



# Purpose and Objectives

**Problem Statement:** Ultra efficient buildings and microgrids offering low carbon resilient energy services require complex optimization for equipment choice, operations.

## **Target Market and Audience:**

1. Investment & Planning: building designers & owners, visualization developers
2. Operations: DER equipment & control system vendors, microgrid operators
3. Analysis: policymakers, vendors

**Impact of Project:** Provide methods and software to operate building microgrids.

1. Output: software tools to optimize DER technology selection and operation.
2. CA 2050 study shows commercial buildings have large DER technology potential. Our regional study shows DER technologies may reduce CO2 intensity in Chinese commercial buildings by 40%.
  - a. near-term: 4 NM buildings and XingYe building demonstrations
  - b. intermediate-term: extend NM buildings and add controls capabilities
  - c. long term: demonstrate DER technologies optimal operation and controls add power quality and grid interaction



# Approach

**Approach:** Deploy software tools base on the Distributed Energy Resources Customer Adoption Model (DER-CAM) developed over a decade at LBNL.

The first, a web-based DER-CAM version, WebOpt, finds optimal on-site generation, storage, control, etc., equipment combinations that minimize cost, carbon footprint, or a combination, using either English or Chinese.

The second is a 1-7-day-head optimal control strategy generator, Operations DER-CAM. This is being used at UNM Mech Eng. Bldg. & U. of Tianjin Bldg. 26, with others in process.

The third is an automated WebOpt analysis of multiple buildings to build bottom up estimates of market trends.

**Key Issues:** Need to extend WebOpt to other technologies, developing interfaces to various control systems difficult, need to develop standard protocols for use of operating schedules, e.g. BACnet, licensing slow

**Distinctive Characteristics:** DER-CAM is an analytic model that delivers ultra-fast guaranteed optimal solutions to complex building investment and operations problems.

# Progress and Accomplishments



**Lessons Learned:** Interest in microgrids is exploding but changing objectives, challenge of implementing schedules in building control systems is significant (simplified approach needed),

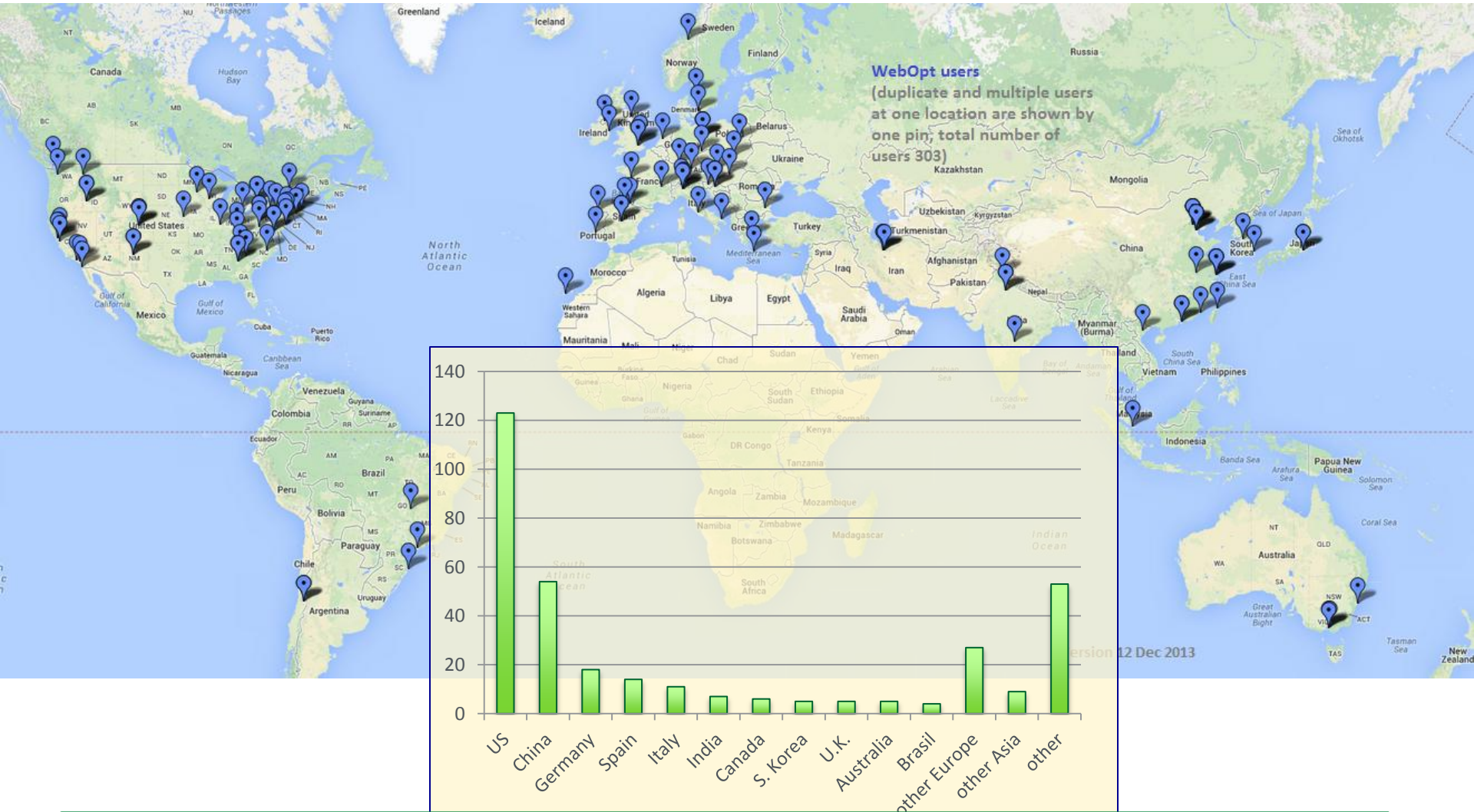
**Accomplishments:** Chinese language interface for WebOpt developed and extensive training conducted in China, ~125 WebOpt users in U.S., ~60 in China, and ~350 worldwide, DER potential study completed and published, Reference Building capability developed (all these suggest rapid deployment possible), energy use of UNM Mech. Eng. Bldg. lowered by 30% in 2012 (gains are most significant for complex energy systems)

**Market Impact:** software subscription in both U.S. and China.

1. Conducted trainings in the U.S. and China to use DER-CAM
2. Beijing Workshop of DER technologies to engage U.S. manufacturers and Chinese stakeholders in using this tool
3. Currently, a few buildings use Webopt for DER technologies selection in the U.S. and China. Implemented UNM ME building real-time control.
4. Shenzhen IBR, district level work

**Awards/Recognition:** Additional funding from PNM.

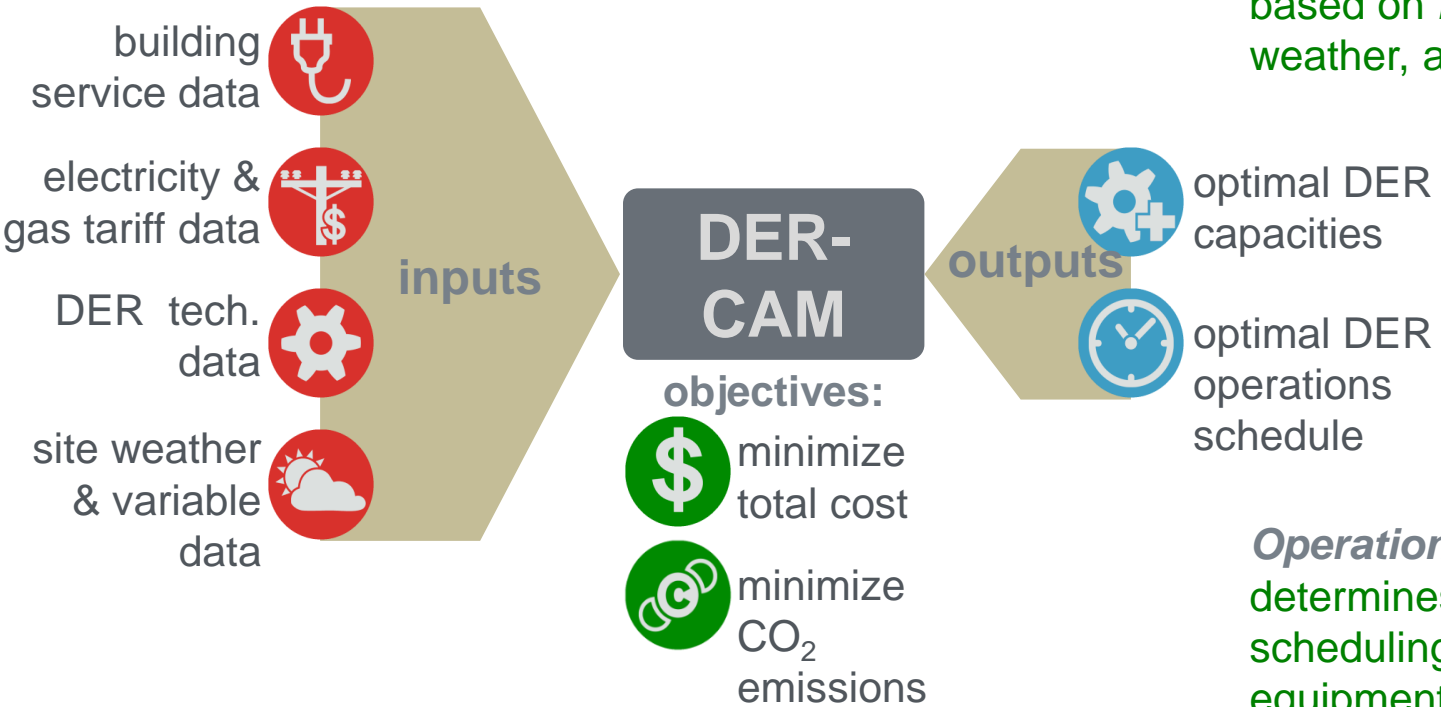
# 1. Invest. & Plan.: WebOpt User Statistics



<http://building-microgrid.lbl.gov/projects/distributed-energy-resources-web>



# DER-CAM Inputs & Outputs



**Investment & Planning:**  
determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs

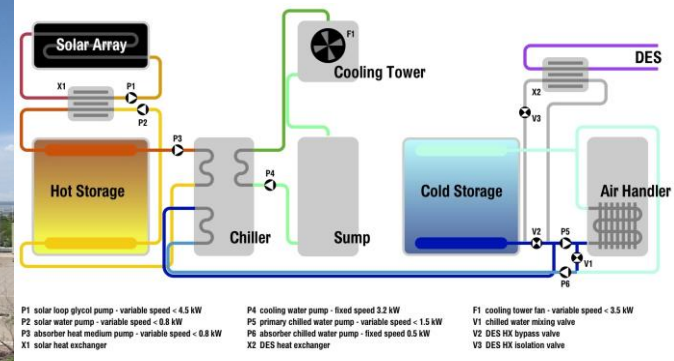
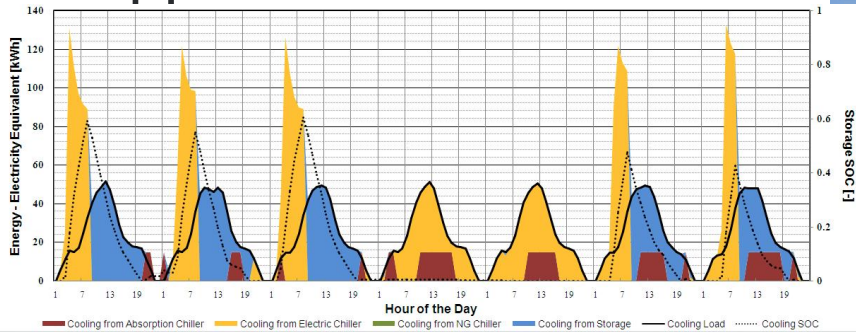
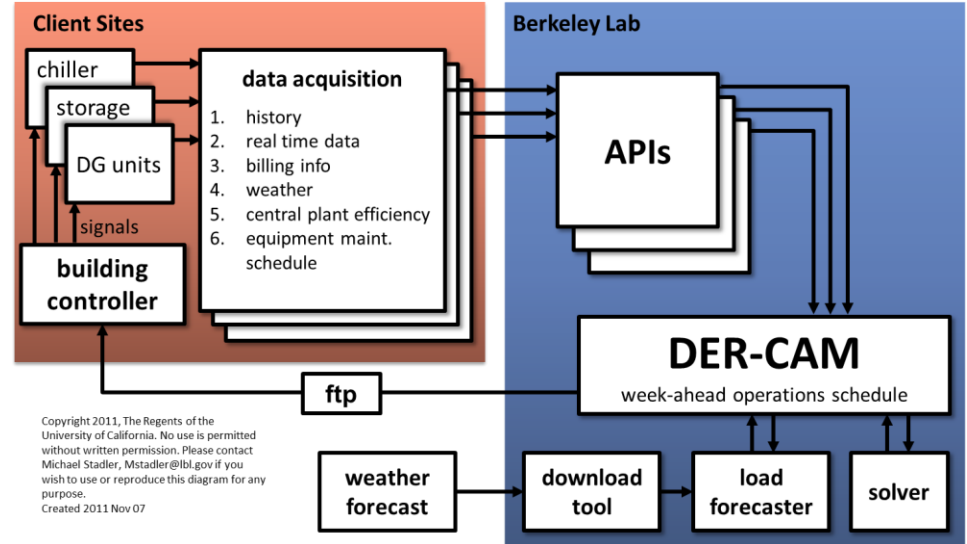
**Operations:**  
determines optimal week-ahead scheduling for installed equipment and *forecasted* loads, weather and tariffs



# 2. Operations: UNM Mech. Eng. Bldg.

objectives:

- generate optimized scheduling of cooling equipment with *Operations DER-CAM*
  - solar thermal collection
  - hot water storage
  - chilled water storage
  - absorption chiller
- deliver daily automated control instructions
- establish SaaS approach applicable to LEB



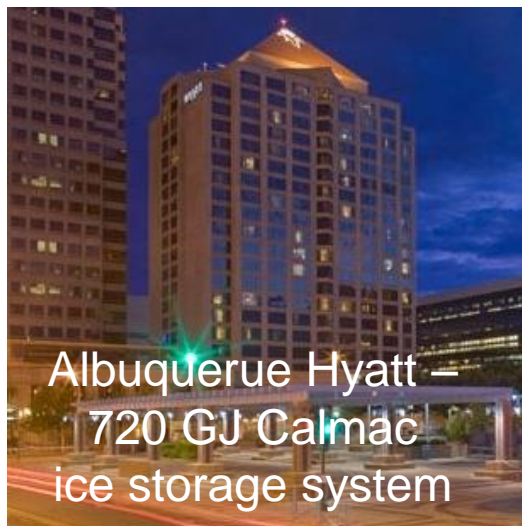




- V. efficient building (40% below typical) saving  $\approx 30\%$  energy costs summer 2012
- Big gains: storage charge-discharge, reduced auxiliary loads & losses
- Tariffs matter! Gains from load shifting harder to capture
- Complex systems benefit more from optimization
- Weather forecasts mediocre in 2012, better now
- Setting up the interaction is non-trivial, need for standard
- Paybacks still long because of low energy bills
- Trials sponsored by Public Service New Mexico starting up



# PNM Project: Customer Sites



- application of DER-CAM four diverse NM buildings
- demonstrate benefits
- demonstrate advantages of Software-as-a-Service model
- com. with diverse EMCSs
- train students in a fast-growing engineering area
- develop business model of a third-party optimizer



# Demonstrations at Tianjin U. Building 26 & XingYe HQ

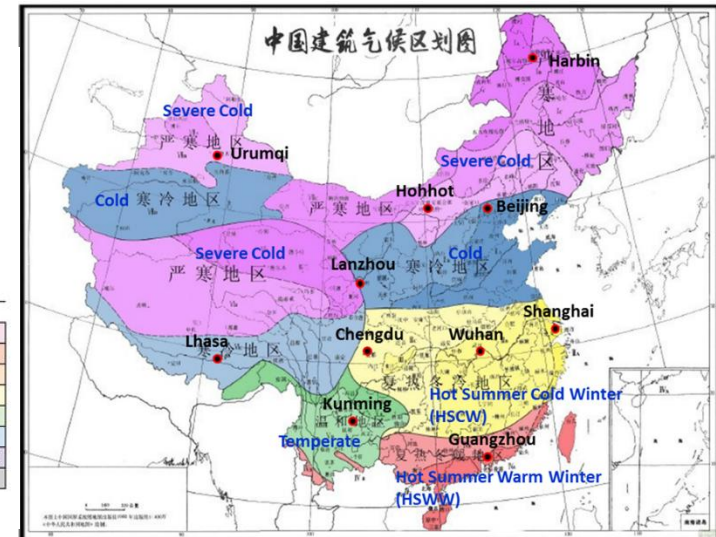
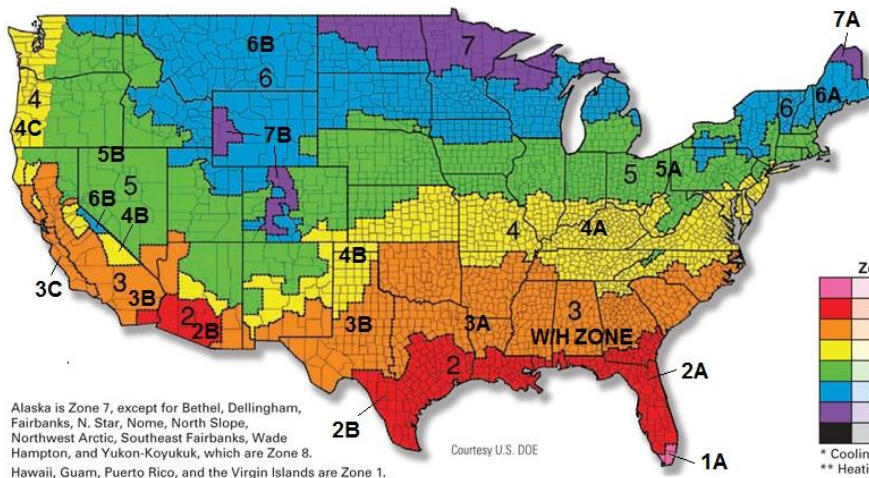
- Background:
  - Bldg. 26 interesting because of the microgrid lab.
  - Possibility of direct control using wireless system under development
  - Prototype direct control demonstration
- Modeling Issues:
  - Heating is not sub-metered → an E Wing E+ model has been developed
  - Coal-fired district heating is a main CO<sub>2</sub> emission source
  - Wireless only control
- XinYe HQ
  - True SaaS control, hopefully with a U.S. controls vendor
  - Building has many exotic technologies, electro-chromatic window experiment



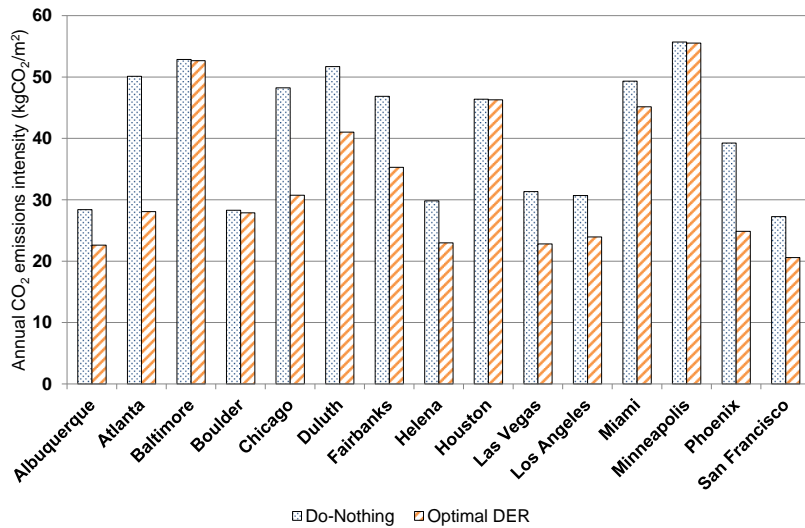
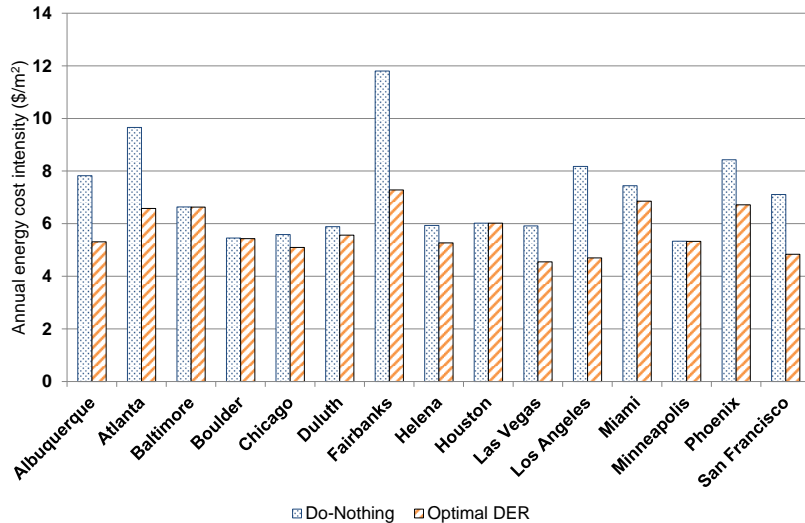


### 3. Analysis: U.S and China building DER regional study

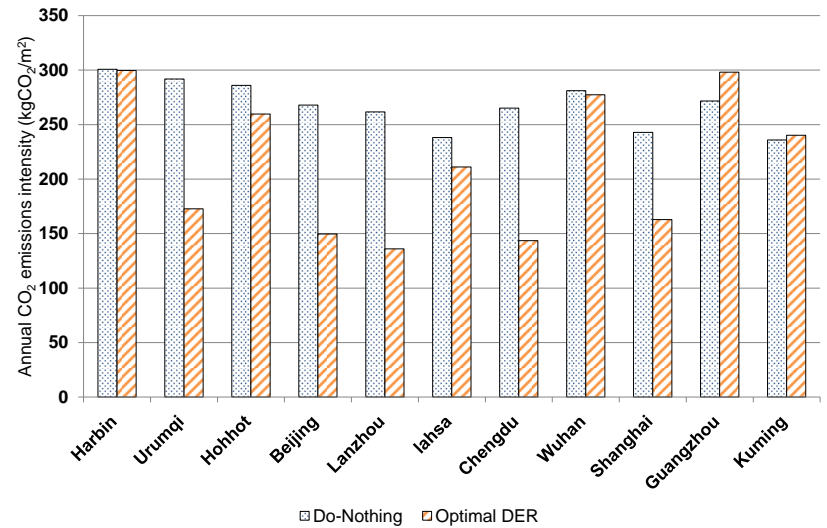
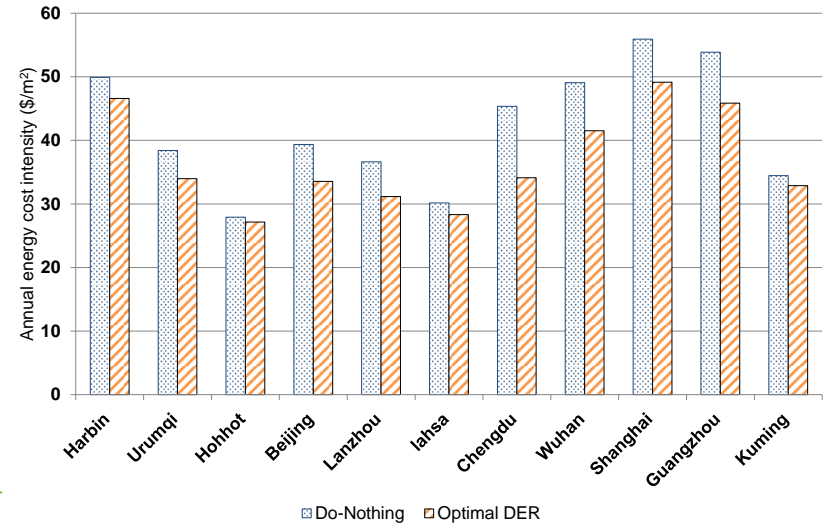
- Purpose: A regional comparison of U.S. and Chinese buildings' potential for adopting distributed energy resources
- One commercial building in China (mall) and the U.S. (office)
- 11 cities in China and 16 cities in the U.S.
- Upcoming in Energy and Buildings: Gonçalo Mendes, et al <http://authors.elsevier.com/sd/article/S0378778814002679>
- Analysis is much easier with Reference Building capability



# Results – commercial buildings, cost optimization



- 1, U.S. office energy cost savings by floor space
- 3, U.S. office CO2 emission reduction by floor space



- 2, Chinese mall energy cost savings by floor space
- 4, Chinese mall CO2 emission reduction by floor space



# Project Integration and Collaboration

**Project Integration:** Reference Building capability developed for C3 Energy, and collaboration with XingYe on development of its demonstration building in Zhuhai.

## **Partners, Subcontractors, and Collaborators:**

University of New Mexico, working together under PNM project  
Tianjin University, Blg. 26 demonstration, Wuhan development, and possible collaboration on its new campus buildings, notably the library

**Communications:** CERC reviews, Energy & Buildings article, ACEEE conference paper, graduate student thesis, Shenzhen IBR

# Next Steps and Future Plans



## Next Steps and Future Plans:

1. The UNM Mech. Eng. Bldg. Demonstration will be extended to 4 additional buildings, the first two should be functional this summer.
2. The XingYe HQ building will be partially designed with the assistance of WebOpt, and it will be controlled by Operations DER-CAM. Seeking a U.S. controls vendor partner.
3. Working with UNM to standardize data exchange.
4. Active shading demonstration will be a first experimental use of DER-CAM controlling the window shading Berkeley Lab's 71T Windows Lab.



# Team members

- U.S.: Chris Marnay, Nan Zhou, Michael Stadler, Wei Feng, Gonzalo Mendes, Gonzalo Cardoso, Nicholas DeForest, Shi Wang, He Gang?
- China: Neng Zhu (Tianjin), Hongwei Tan (Tongji), Duo Luo (Xingye), Jia Wang (BACU)

## Websites:

[china.lbl.gov](http://china.lbl.gov)

[building-microgrid.lbl.gov](http://building-microgrid.lbl.gov)

## Contacts:

Project Management: [NZhou@lbl.gov](mailto:NZhou@lbl.gov)

Microgrids in China: [ChrisMarnay@lbl.gov](mailto:ChrisMarnay@lbl.gov) and [WeiFeng@lbl.gov](mailto:WeiFeng@lbl.gov)

DER-CAM and Microgrids in the U.S.: [Mstadler@lbl.gov](mailto:Mstadler@lbl.gov)





# REFERENCE SLIDES

# Project Budget



**Project Budget:** Overall full project cycle budget should be 1 M\$.

**Variations:** Early budget erratic, but consistent now.

**Cost to Date:** \$360K of \$700K granted.

**Additional Funding:** \$85K from PSN, in-kind from industrial partner, funded visitors from China & Europe, shared travel with other China projects.

## Budget History

FY11– FY2013 (past)		FY2014 (current)		FY2015 – Dec 2015 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
400	100	237.5	200	362.5	250



# Project Plan and Schedule

- At least 2 of the 4 buildings shown on slide 10 are being modeled, and links to their EMC's will be established
- They will be controlled for the summer of 2015
- A U.S. controls vendor will be recruited for the XingYe HQ project
- Electrochromic window DER-CAM capability will be developed in lab environment
- The XingYe HQ building will be controlled upon its completion

Project Schedule												
Project Start: Q4 FY12	Completed Work											
Projected End: Q1 2016	Active Task (in progress work)											
	◆ Milestone/Deliverable (Originally Planned)											
	◆ Milestone/Deliverable (Actual)											
	FY2013				FY2014				FY2015			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
<b>Past Work</b>												
Q1FY13: complete Chinese language WebOpt	◆											
Q2FY13: complete UNM.M.E. demo. & publish results		◆										
Q2FY13: US-China tech. potential comparison		◆										
Q4FY13: Blg. 26 E+ model built				◆								
Q4FY13: Reference Building analytic set completed				◆								
Q2FY14: sign-up of 4 candidate NM buildings						◆						
<b>Current/Future Work</b>												
Q3FY14: establish EMCS vendor for XingYe Blg.							◆					
Q4FY14: complete modeling of EC window experiment							◆					
Q4FY14: establish DER-CAM & cntrol. interface ≥2 NM blgs.								◆				
Q3FY14: complete EMCS API & install for XingYe Blg.										◆		
Q4FY15: control ≥2 NM blgs.												◆



# A Project of CERC-BEE (US-China Clean Energy Research Center Building Energy Efficiency Consortium)

Pioneering U.S. China Innovation for Widespread Adoption of Very Low Energy Buildings Through Partnerships and Real World Impact

**U.S. Research Leads**

**U.S. Industrial Partners** (Funding +40% Annual Average Growth Rate)

**Research Strategy → Huge Impact:**

- U.S./China construction market ~ 2B m2
- CO2 savings ~ 100Mt/year by 2025

**Technologies, Software**

**Demonstration Buildings, Commercial Impact, Tools and Guidebooks**

**Wide Adoption Very Low Energy Buildings**

**New Patent Applications**

**Market**

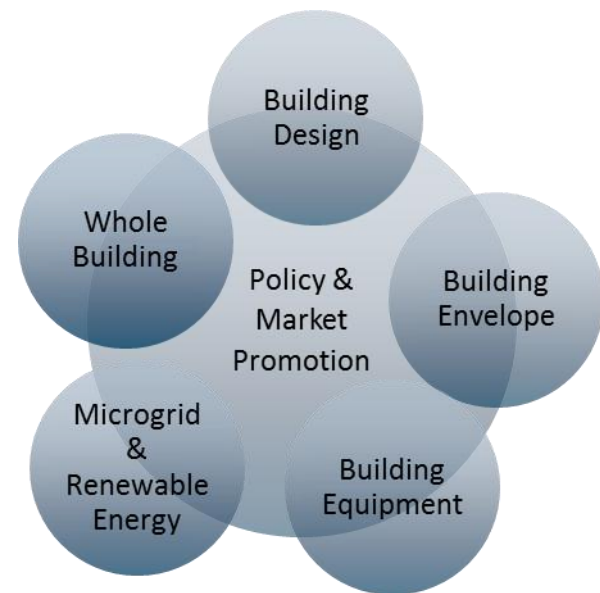
**Policy**

**ABOUT:** CERC-BEE is a five year, \$50M program created by the U.S. Department of Energy and Chinese Ministry of Science and Technology.

**R&D TEAMS:** U.S. national laboratories, and U.S. and Chinese universities, and research institutes team up with industry partners to accelerate innovation and deployment.

**SELECTED RESEARCH OUTCOMES:**

- Launched eight new products and developed two software tools (e.g. Cloud tool for microgrids, 40 new users from China)
- Won R&D Top 100 Award for GSHP by Climate Master
- Exceeded IP goals: ~ 25 patents filed, 4 approved; inventions disclosed and more in process (e.g. sprayable liquid flashing, cool roof materials)
- Developed 20 standards (e.g. LBNL involved in new Chinese commercial building code revision)
- Published 135 Chinese and 54+ US academic research papers



Website: [cercbee.lbl.gov](http://cercbee.lbl.gov)