4th U.S.-China Energy Efficiency Forum
September 25, 2013

Compiled Presentations from Track 1, Breakout Session 2/Afternoon

High Performance Buildings

Collaboration on Building Code and Labeling System

Wei Feng
China Energy Group
Lawrence Berkeley National Laboratory

September 25, 2013

Building Energy Efficiency Code and s

Concept

- Assist China develop commercial and residential building codes
- Disseminate building simulation tools (e.g. DOE-2) to China for building code development
- Help China to develop a window rating and labeling program

Opportunity

- Evaluate energy savings of China's new commercial building code (GB50189-2013, 65% savings based on the 1980's baseline)
- Bring tools developed in the U.S. to China's building code development

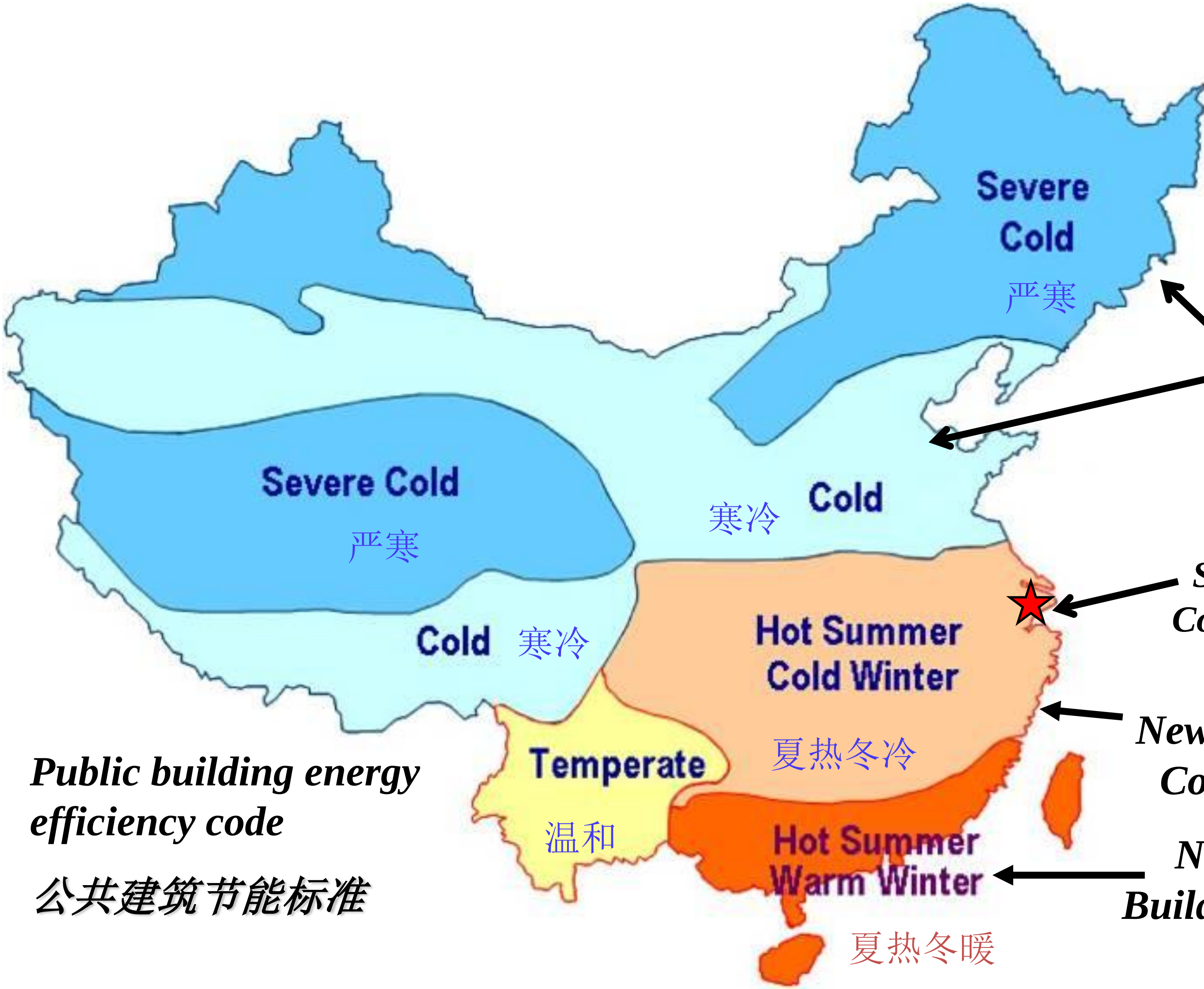
Successes

- Assisted drafting the first national building energy standard (GB50189-2005) development
- Participated in the development of residential energy standards for the Hot Summer Cold Winter region (JGJ134-2001)
- Help China setup a pilot window rating and labeling program, drawn from U.S NFRC. Pilot location was in Guangzhou province.
- Provided training of DOE-2 and other building simulation software

Collaborators:

- China Academy of Building Research (CABR), Guangdong Institute of Building Research

Buildings: Training in Developing New Building Codes
建筑行业：新建筑标准开发培训



Improved New Heating Zone Residential Building Code 改进的新供热区民用建筑标准

Shanghai Commercial Code 上海商业建筑标准

New Residential Building Code 新民用建筑标准

New Residential Building Code 新民用建筑标准

Public building energy efficiency code

公共建筑节能标准

Building Energy Efficiency Collaboration with China

- US-China Agenda 21 energy efficient demonstration office building in Beijing; 中美21世纪节能示范办公楼 (美国能源部中国科技部合作项目,1998年始,2003年底完成)
- Establishment of energy efficiency design standard for residential buildings in the HotSummer Cold-Winter Region in Central China (promulgated Oct. 2001); 协助制定夏热冬冷地区住宅节能设计标准 (2001年10月颁布)
- Establishment of energy efficiency design standard for residential buildings in the HotSummer Warm-Winter Region in South China (promulgated Oct. 2003); 协助制定夏热冬暖地区住宅节能设计标准(2003年10月颁布)
- Development of national energy efficiency design standard for public buildings (expected completion end 2004); 协助制定国家公共建筑节能设计标准(2004年底完成)
- Pilot project on labeling and rating system for energy efficient windows (2002-2005), with demonstration project in Guangdong Province (2004-5). 节能门窗标签分级试验性计划 (2004-2005), 广东省试点项目(2004-2005)
- US-China Joint Working Group on Green Building Rating System in support of a Green 2008 Beijing Olympics (start 2002). 中美绿色奥运合作联合工作组绿色奥运建筑评估体系(2002年始)

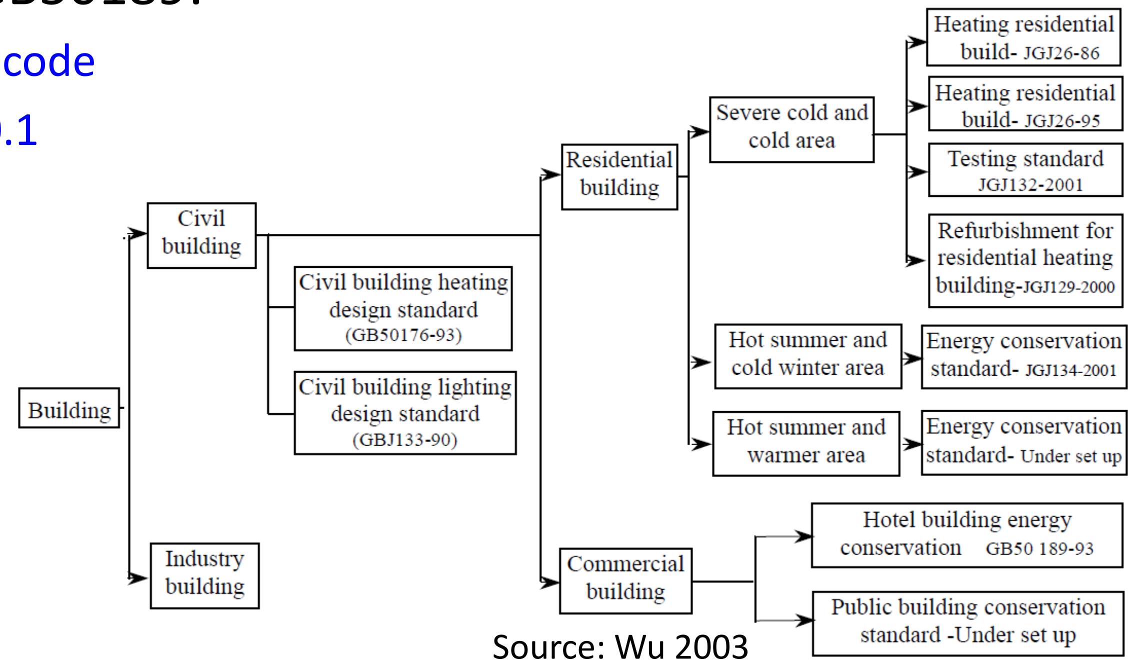
Building Code Structure

Building codes in China:

- National level: one commercial building code (GB50189), and three residential building code (JGJ 26, 134, 75) – defined on climate zone basis
- Local level: provinces can have their own building code, some provincial level codes are stringent than national level code (e.g. Tianjin, Shanghai, Jiangsu..)

Commercial building code -- GB50189:

- China's commercial building code
  – equivalent to ASHRAE 90.1
- First released in 1993
  with initial focus on hotel
- Last update in 2005
- New code will be release
  at the end of 2013



Source: Wu 2003

Commercial building code

Commercial building code -- GB50189:

- Use 1980's commercial building characteristics as baseline (100%)
- Last update in 2005 achieved 50% energy savings from 1980's baseline
- New update in 2013 aims to achieve 65% energy savings → To be validated!

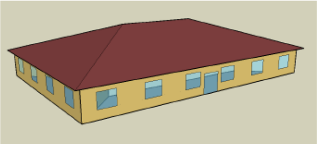
Importance of commercial building code

- Commercial building floor space increases from 2.8 billion m^2 (1996) to 7.1 billion m^2 (2008). Approximately, 0.5 billion m^2 new construction was built per year.
- Per capital, increases from 7.4 m^2/person (1996) to 11.5 m^2/person (2008)
- Will continue to increase in next 20~30 years because of fast urbanization

Reference Buildings – Models to Support Building Codes

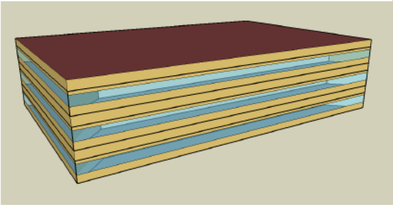
BERKELEY LAB

Office Buildings

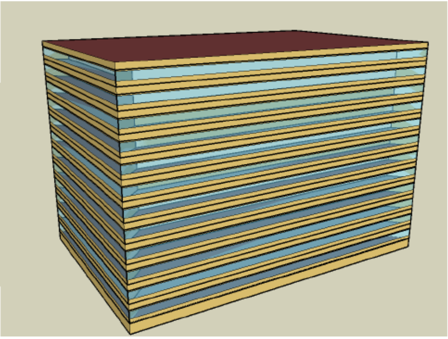


Small Office
1 floor, 5,500 ft²

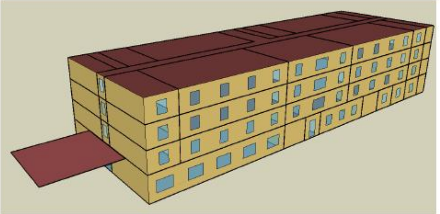
Medium Office
3 floor, 53,630 ft²



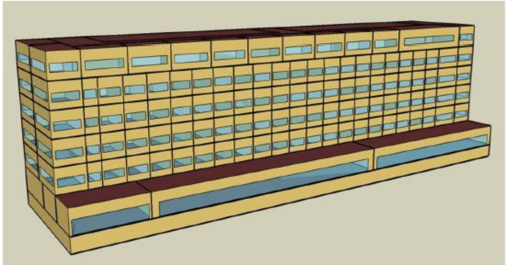
Large Office
12 floors, 498,588 ft²



Lodging

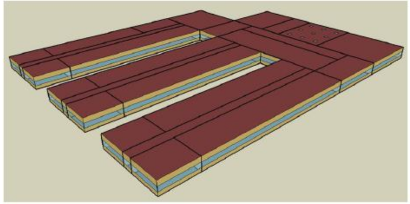


Small hotel
4 floors, 43,200 ft²



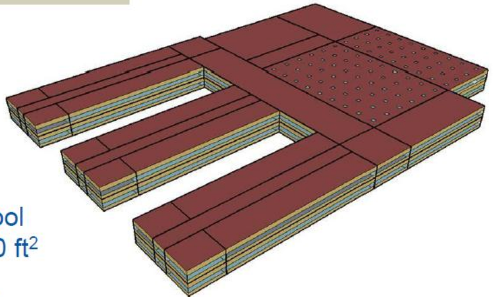
Large hotel
6 floors, 122,120 ft²

Schools



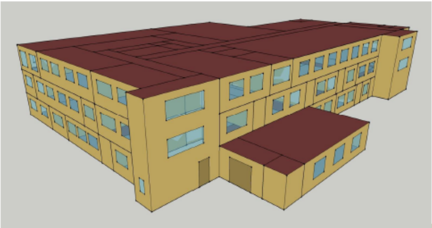
Primary School
1 floor, 73,960 ft²

16 X 16 X 3 = 768 models!

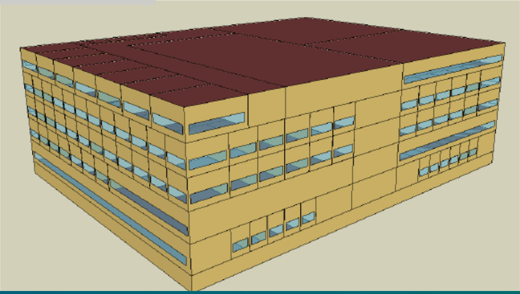


Secondary School
2 floors, 210,890 ft²

Healthcare



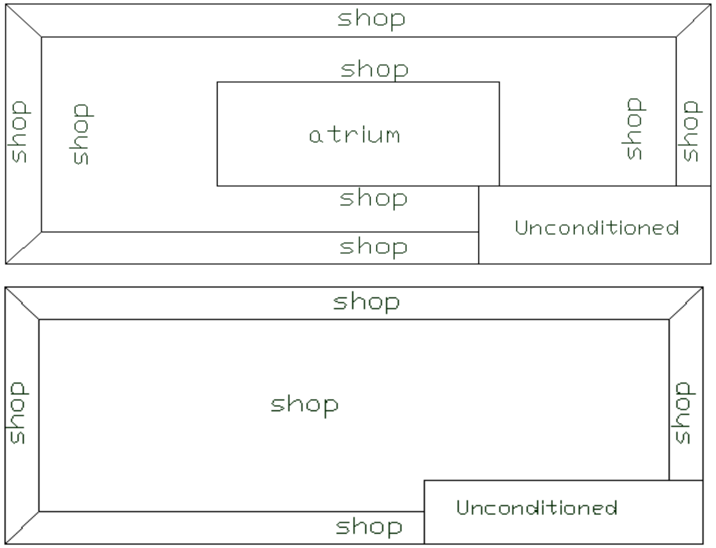
Outpatient Healthcare
3 floors, 40,946 ft²

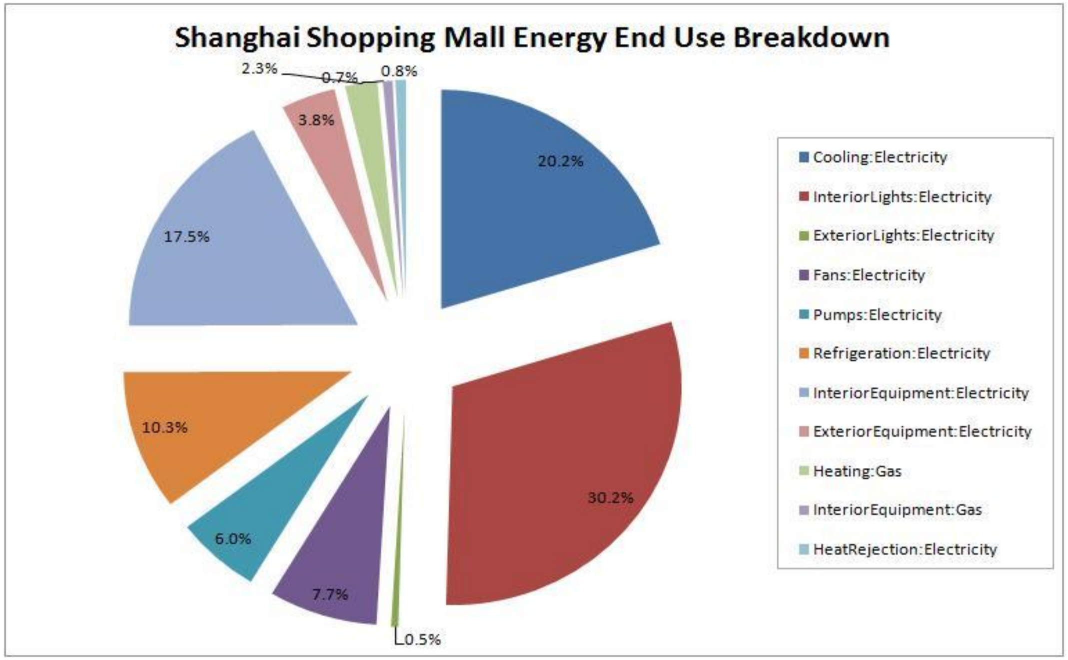


Hospital
5 floors, 241,351 ft²

Reference Buildings – Models to Support Building Codes

- A Chinese shopping mall reference prototype developed by LBNL and its Chinese partners
- LBNL is working with CABR to identify key parameters to conduct reference building survey and modeling.





Thank You!

Questions?

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Building Energy Codes Development and Enforcement: Progress and Comparative Lessons

Sha Yu and Meredydd Evans

Pacific Northwest National Laboratory

Fourth U.S.-China Energy Efficiency Forum
September 25, 2013

Overview

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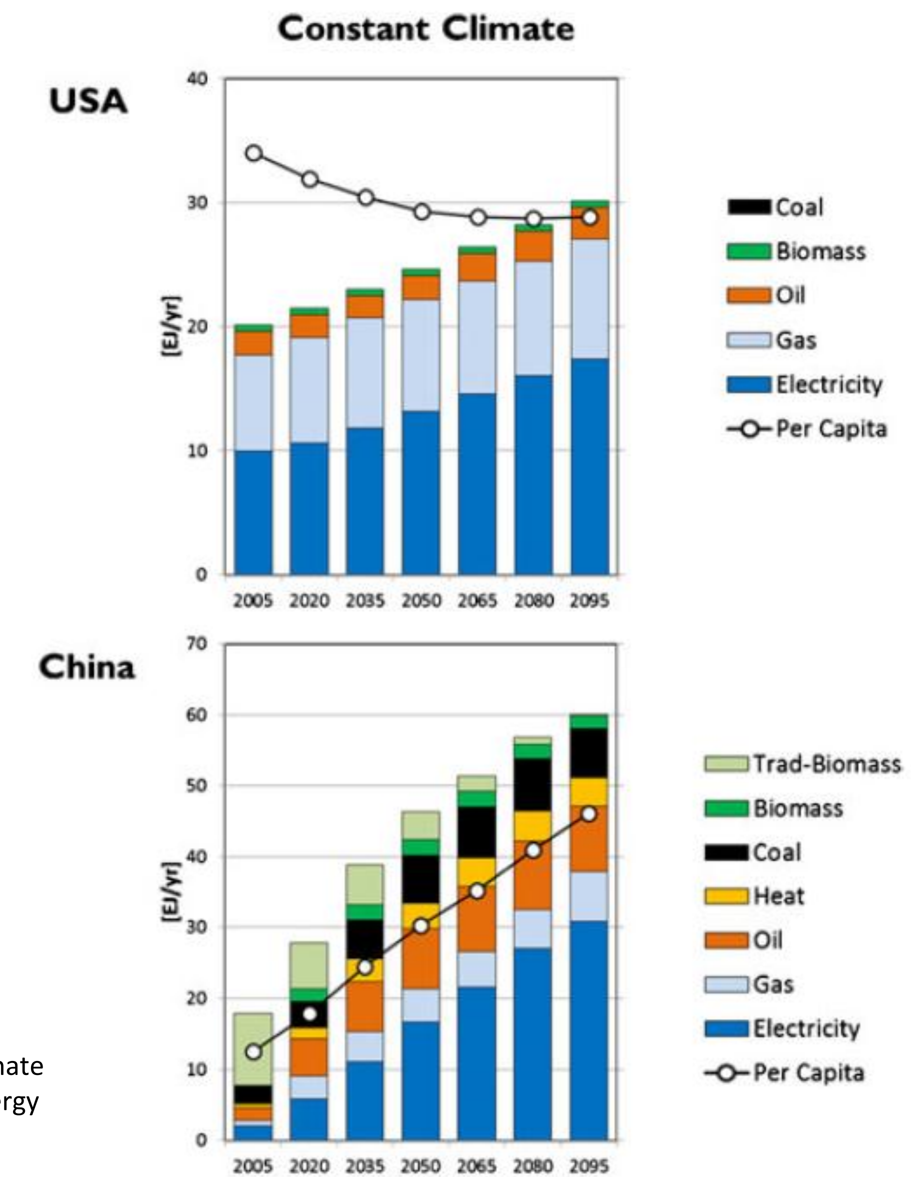
- Building energy use and codes impacts
- Building codes development and enforcement
  - Rural energy code in China
  - Enforcement system in China and the U.S.
- Lessons learned
- Market opportunities

Building Energy Demand in the U.S. and China

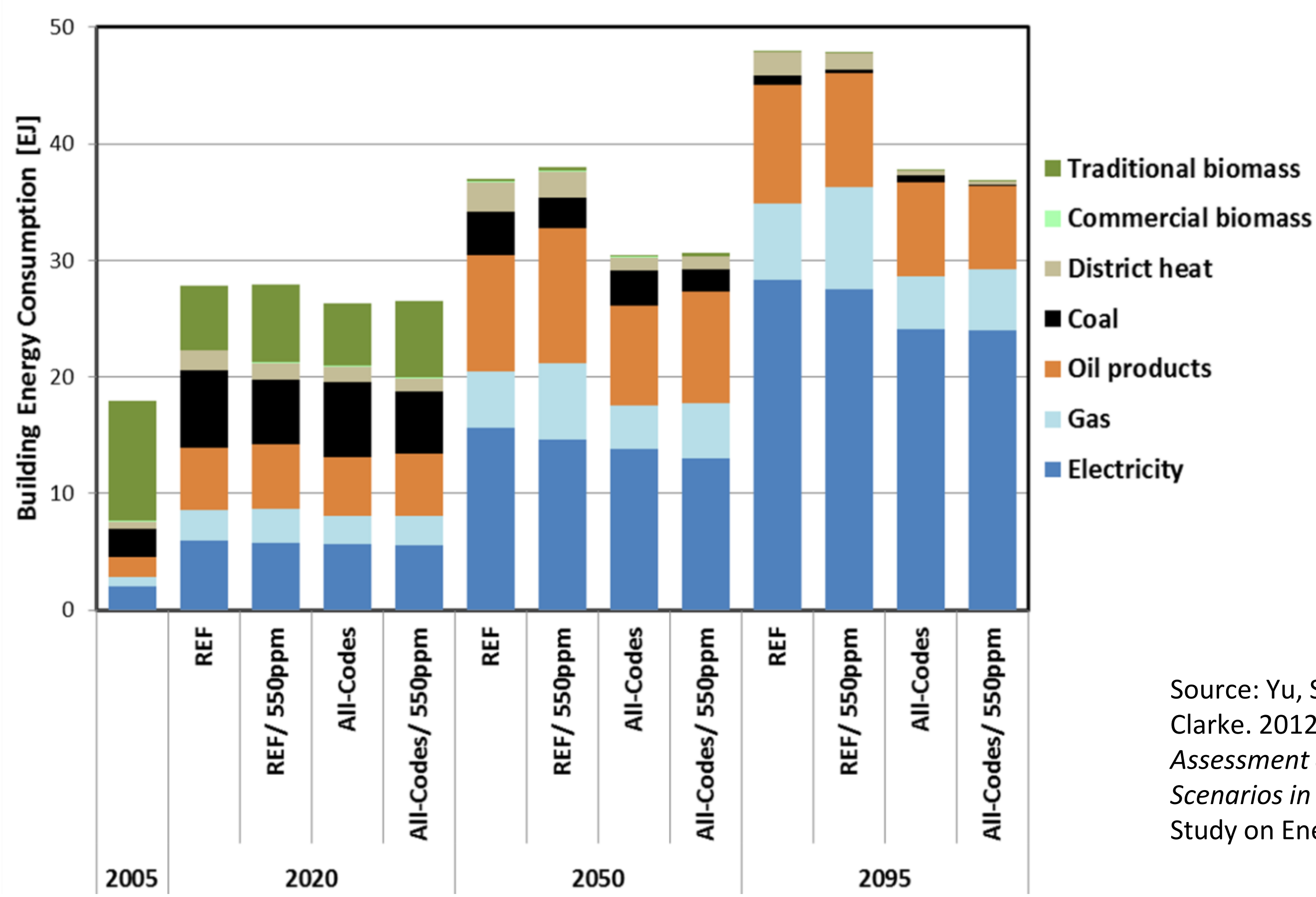
- Buildings in the U.S. and in China will experience increasing share of electricity during the 21st century.
- Per capita energy demand continuing to increase in China over the century, while per capita energy demand in the U.S. steadily decreasing.
- Overall development of fuel mix in the buildings sectors between the two countries will continue to be very different.



Source: Zhou, Y., Eom, J., and Clarke, L. (2013). The effect of global climate change, population distribution, and climate mitigation on building energy use in the U.S. and China. *Climatic Change*, 1-14.

Impacts of building codes and climate policy in China

- Energy codes could significantly reduce building energy use.
- Economy-wide carbon policy has a limited effect on building energy demand and direct CO_2 emissions.
- High compliance is essential for any noticeable impact.

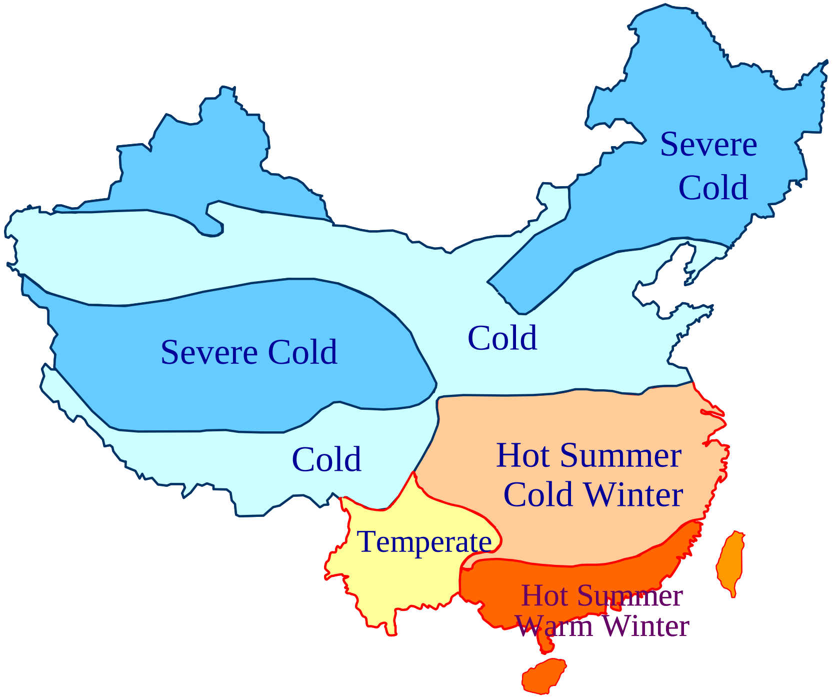


Source: Yu, S., J Eom, Y Zhou, M Evans, and L Clarke. 2012. *A Long-term, Integrated Impact Assessment of Alternative Building Energy Code Scenarios in China*. The 2012 ACEEE Summer Study on Energy Efficiency in Buildings.

Building Energy Codes in China

- China began to adopt building energy codes in the 1980s.
- Now there is one code for commercial buildings.
- Three other codes cover large residential buildings in different climate zones: severe cold/cold, hot summer-cold winter and hot summer-warm winter.
- Energy code for rural buildings went into effective in May 2013.

Map of China’s Climate Zones



Energy Code for Rural Buildings

- Despite fast urbanization, rural buildings still account for a big share of total building stock in the near term (40% today and around 25% at 2030).
- Rural buildings demand more energy than urban buildings at least in the near term.
- Designs and energy uses in urban and rural buildings are different.

Contents of the Rural Energy Code

- Architectural layout and energy efficiency design
- Building envelope insulation
- Heating and ventilation system
- Lighting
- Renewable energy use
  - Solar, biomass, geothermal, etc.

Rural Building Energy Codes: Key Considerations

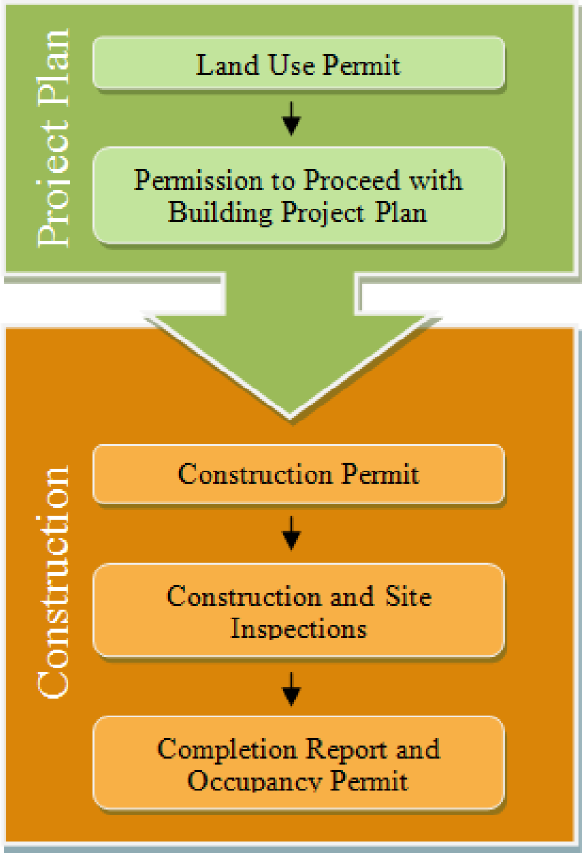
- Understanding building trends, stakeholders

- Making enforceable codes
  - Who will enforce?
  - How will buildings learn of and interpret requirements?
  - How can we build capacity and make this easy?

- Challenges of small buildings
  - Variety of buildings
  - Limited capacity
  - Wide variety of construction materials

Enforcement System

- Key code enforcement steps in Chinese building construction



Construction site inspection roles

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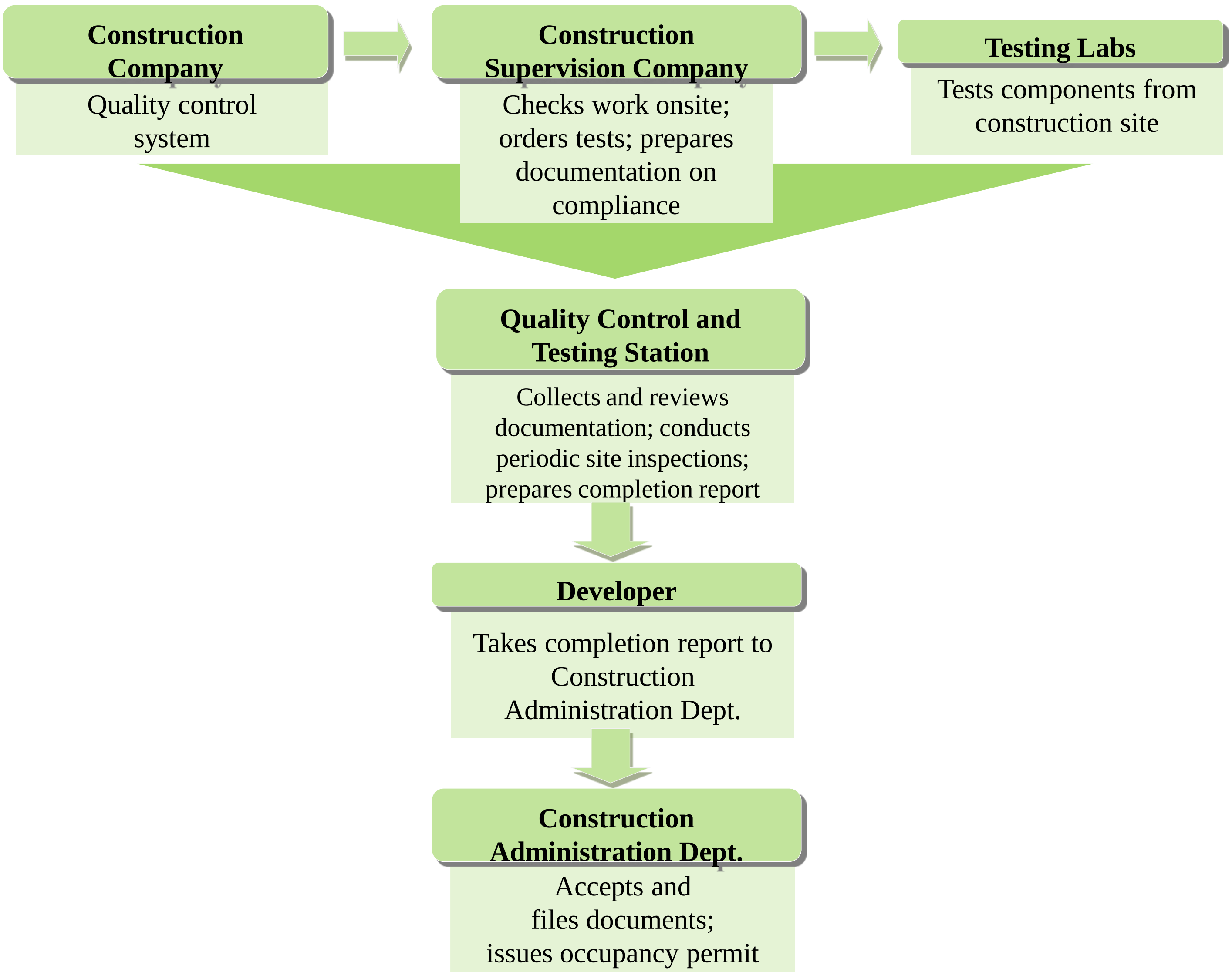

Lessons Learned

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For China

- Enforcement in smaller towns and rural areas.
- Testing and ratings.
- Easier access to training and more user-friendly information.
- Increasingly rigorous codes.

For the U.S.

- The extensive use of third parties in code compliance.
- The "industrialization" of the construction and code compliance processes.
- An example of integrating design and code compliance software.

Market Opportunities

- Codes help build demand for a range of building energy efficiency products like insulation, efficient windows and lighting.
- New post-occupancy and ‘stretch’ code requirements are also building the market for services like building commissioning, energy audits, and performance contracting.
- Because of their large impact on market deployment, codes can also make it easier for companies to obtain value from innovation and R&D.

DEMAND RESPONSE: U.S. EXPERIENCE AND OPPORTUNITY FOR COLLABORATION

Bo Shen
Lawrence Berkeley National Laboratory

The 4th US-China Energy Efficiency Forum
Arlington, Virginia | September 25, 2013

Demand Response (DR)

DR is a reduction in customers' electricity consumption over a given time interval relative to what would otherwise occur in response to a price signal, other financial incentives, or a reliability signal (California Energy Commission)

According to FERC, the DR resource contribution from all U.S. programs was 72,000 megawatts in 2011, about 9.2% of the U.S. total peak demand. This was an increase of 13,000 megawatts from the 2010 survey results

Benefits Brought by DR

- Avoided new capacity, minimizing the lock-in effect of power plant operations
- Reduced capacity use leading to reduced fuel use and associated emissions, resulting in significant cost savings especially during the peak
- Reduction in line losses, more significant when lines are heavily loaded during the peak
- Flatter load curves improve overall power generation efficiency
- Makes economic sense: In many systems, 10% of costs incurred to meet demands which occur less than 1% of the time
- Creates a cost-effective dispatchable resource, allowing greater integration of renewables

Policies Enables DR Expansion

- EPACT 2005 mandates the elimination of barriers to DR participating in the wholesale market
- FERC Order 719 (2008) permits load aggregators to bid DR directly into organized markets
- FERC Order 745 (2011) requires that DR resources are paid the wholesale market price for energy, placing demand side resources on equal footing with generation
- Cost recovery
- Loading orders
- Peak demand mandates (e.g., 4.5% peak demand reduction target by 2015 in PA)

Market Expansions Allow DR to Play a Role

Wholesale market changed from an energy-only market to include some new types of markets

- *Capacity Market to ensure adequate resource availability*: customer load curtailments offered as system capacity to compete with conventional resources. Customers typically receive day-of notice of events and face penalties for failure to curtail when called upon.
- *Ancillary Services Market to support reliable grid operations*: customers bid dispatchable load curtailments as operating reserves or regulation services. If their bids are accepted, they paid the market price for committing to be on standby. Participants must be prepared to respond to a dispatch more frequently and accurately, requiring the employment of different load control strategies from capacity programs designed to shed load during infrequent, peak periods

Smart Grid Technologies Facilitate DR Applications

Open ADR

- An open standard-based protocol to widely and openly communicate price and reliability signals across networks

Auto DR

- A platform that provides fully automated signaling from a utility or ISO/RTO to provide automated connectivity to customer control systems preconfigured with load reduction strategies

Automated DR

- A program/system that initiates the preconfigured curtailment strategy without the need for human intervention at the end-user's site.

China's National DSM City Pilot

- NDRC and MOF jointly initiated a national program of Comprehensive DSM City Pilot in 2012
- Four cities (Beijing, Suzhou, Foshan, Tangshan) selected to conduct the pilot which will last three years
- Incentives provided by Ministry of Finance and matched by local government to support real-time electricity usage information platform, efficiency measures, DR, M&V, and capacity building
- MOF funding level: for permanent load reduction: ￥440/kW (east) and ￥ 550/kW (west/midland); for temporary load shifting: ￥100/kW
- Incentive is result-oriented and penalty imposed for missing the target

Objectives of National DSM City Pilot

- Effectively reduce peak load and energy use
- Develop DSM application demonstration park
- Create online electricity monitoring platform
- Develop electricity management standard
- Cultivate power quality service/curtailment service sector

Electric Use Monitoring and Service Platform

- Devices installed at key process/equipment for real time acquisition of information on electric loads, electricity consumption, power quality, and temperature
- Data transmission platform to transmit the collected data to the centralized monitoring platform through a web-based application
- Web-based interface for real time visualization of load, electricity consumption, power quality, and power factors, etc
- Detailed usage Data assessed by the third party to identify energy saving and peak load reduction opportunities and detect fault. Service provided to the customers recommending improvement
- General information accessed and analyzed by the government for planning and decision-making

Collaboration in DR Development

Activities so far:

- Information sharing of the international best practices in DR applications
- Technical discussion on developing a system modeled after Open ADR
- Performance-based power rationing tool to improve China's direct load curtailment
- Introduction of DR performance measurement & verification methods

Next steps

- Technical and policy research support to pilot cities in designing their DR program
- Promote a wider adoption of DR technologies and strategies
- Improve existing pricing structure to induce DR
- Create incentive program to attract DR participation
- Maximize the opportunity of real-time usage info platform
- Identify opportunities for fast DR

Thank you!

Contact:
BoShen@lbl.gov

Advanced Building Decision Tools Collaboration

Wei Feng
劳伦斯伯克利国家实验室

2013年9月

Advanced Building Decision Tools Collaboration

- **COMBAT: Commercial Building Analysis Tool for Energy Efficiency Retrofit**
- **VisualEPlus: A bilingual building simulation tool using** *EnergyPlus*
- **DER-CAM: Distributed Energy Resource Customer Adoption Model**

Commercial Building Analysis Tool for Energy-Efficient Retrofits (COMBAT)

Purpose: *Analyze commercial building retrofit energy savings and investment cost-effectiveness*

Related Tools: *EnergyPlus*

Audience: *Retrofit practitioners, policy makers, facility managers, and engineers (w/o building energy modeling knowledge)*

Developer(s): *China Energy Group at LBNL*

Availability: *http://china.lbl.gov/COMBAT_Tool ,English and Chinese, SI unit. Funded by Energy Foundation, Schneider-Electric, U.S. DOE.*

Limitations: *Only applies to China's hot summer cold winter climate zone with hotel and shopping mall building types*

Impacts summary: *Trained 50+ people in Shanghai in 2012 including key policy makers. Retrofit of shopping mall or hotel can yield 20%~30% energy savings in Shanghai.*

Potential: *More building types and climate zones could be added to the tool. Work with universities (such as Tongji University) to develop and disseminate it.*

Commercial Buildings Retrofit and COMBAT

Background:

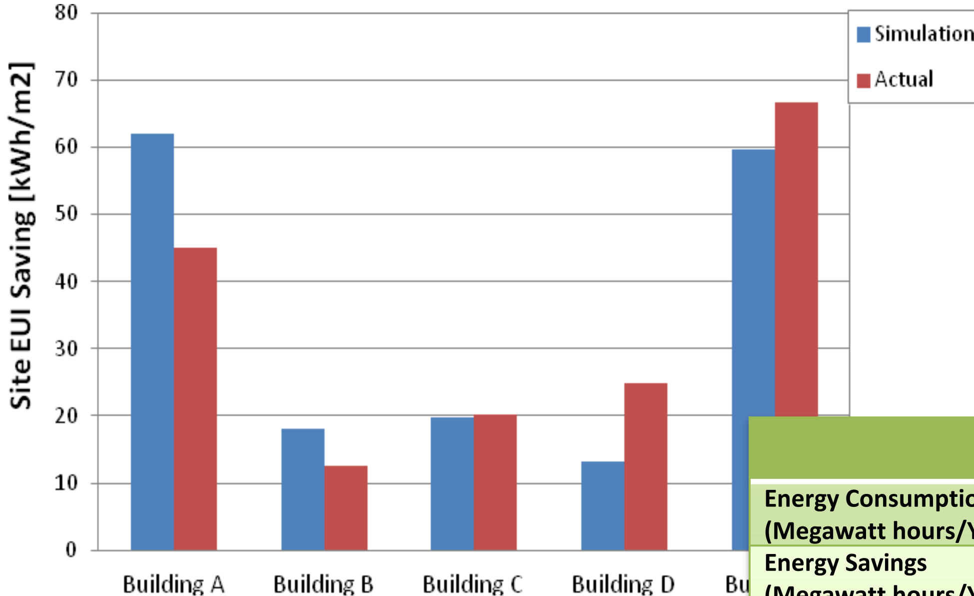
- Commercial (public) buildings retrofit is targeted to save 14 Mtce in China's 12th FYP.
- Central and local governments create large incentive programs for commercial building retrofit
- In Shanghai's Changning district, over 100 buildings need retrofit in the 12th FYP
- No tool existed for quick assessment of energy savings and investment cost-effective as the results of retrofit.

Current impacts:

- COMBAT is developed with collaboration from Tongji University and NRDC Beijing office. The tool has been used for analysis in a few retrofit projects in Shanghai. A training workshop was held in Shanghai in 2012 to train Chinese local government officials, U.S. companies, and Chinese ESCOs on the use of the tool for their retrofit analysis.
- Provide training and work with ECP-China, U.S. companies (e.g. Trane, Autodesk, Schneider Electric) and Chinese ESCOs
- **Selected collaborators:** Tongji University, NRDC Beijing office, Shanghai Energy Conservation and Supervision Center
- **Selected project using COMBAT:** 4 shopping malls and 2 hotels have used COMBAT and compared its calculation results with measured results. More buildings are using the tool in Shanghai's Changning district.

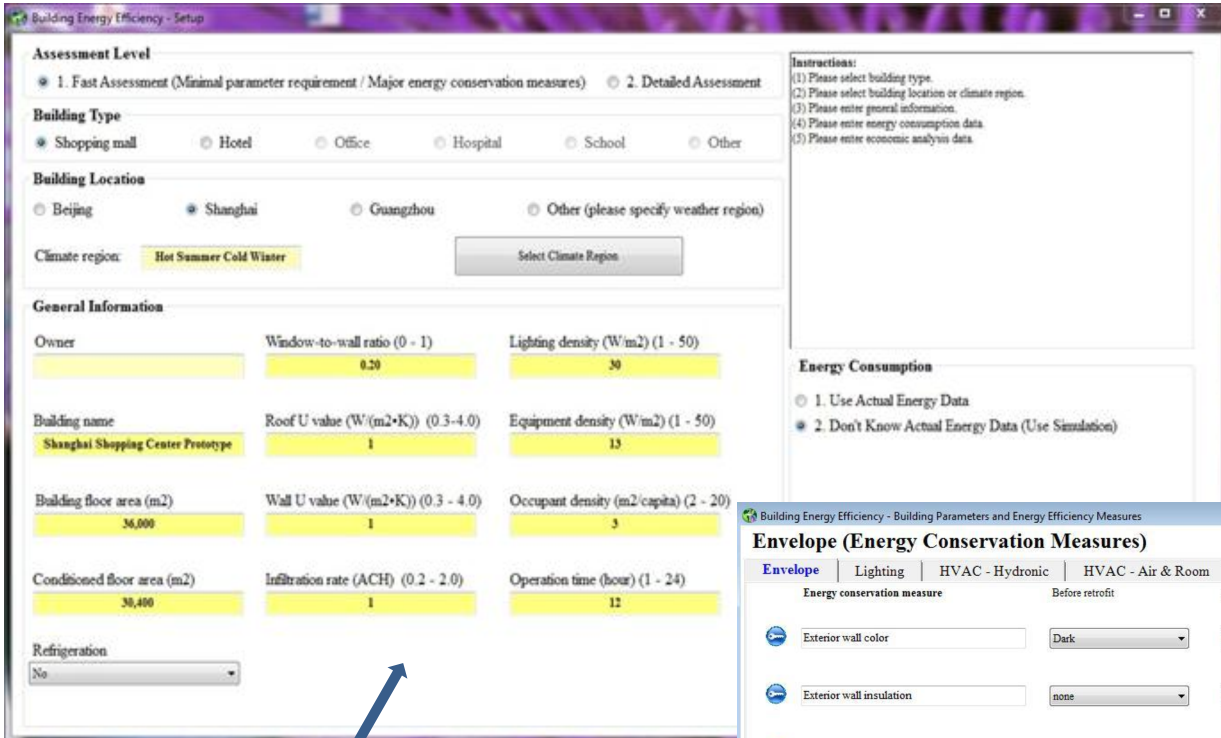
COMBAT: Verifications of Chinese Buildings

- 4 shopping malls and 1 hotel
- Calculated savings in line with measured data



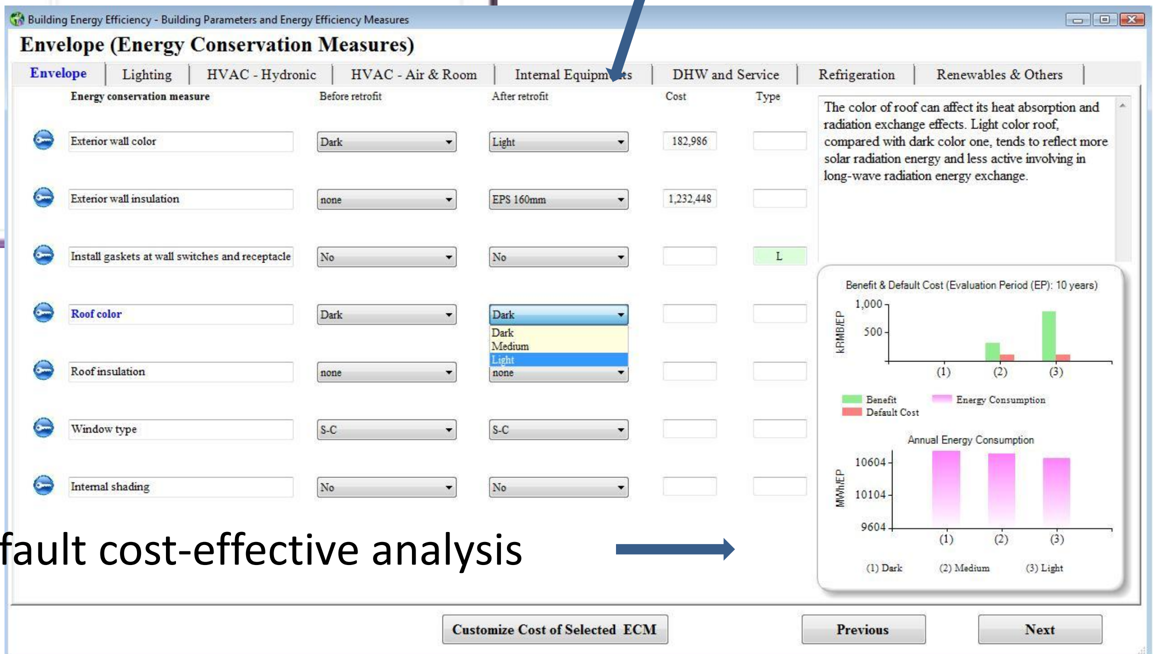
	Building A	Building B	Building C	Building D	Building E
Energy Consumption Before Retrofit (Megawatt hours/Year)	38,847	33,512	73,044	8,287	14,229
Energy Savings (Megawatt hours/Year)					
Calculated	7,902	1,950	4,952	419	3,337
Actual	5,737	1,364	5,033	795	3,723
Relative Error	-37.7%	-43.0%	1.6%	47.3%	10.4%
Energy Saving Rates					
Calculated	20.3%	5.8%	6.8%	5.1%	23.5%
Actual	14.8%	4.1%	6.9%	9.6%	26.2%
Absolute Error	-5.6%	-1.7%	0.1%	4.5%	2.7%
Economic Benefits (RMB/Year)					
Calculated	6,299,256	1,506,165	3,825,256	323,361.4	3,461,041
Actual	5,378,438	1,278,750	4,718,438	745,312.5	3,350,700
Relative Error	-17.1%	-17.8%	18.9%	56.6%	-3.3%

COMBAT Demonstration: Inputs



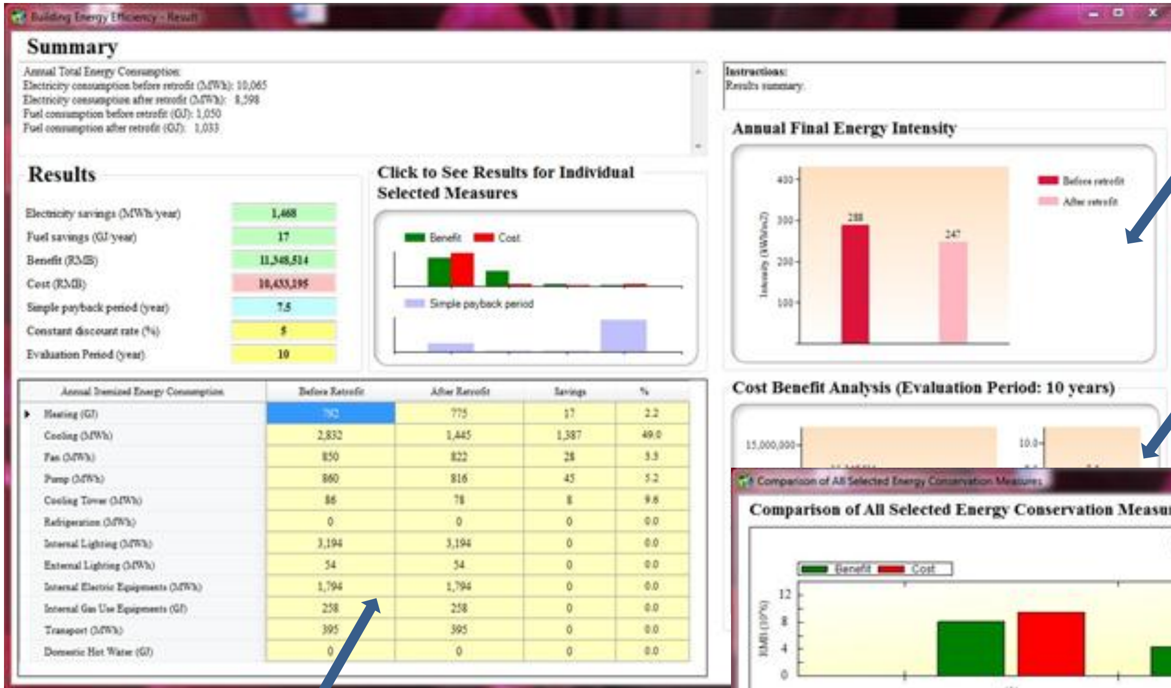
Building characteristics inputs

Retrofit measure inputs



Default cost-effective analysis

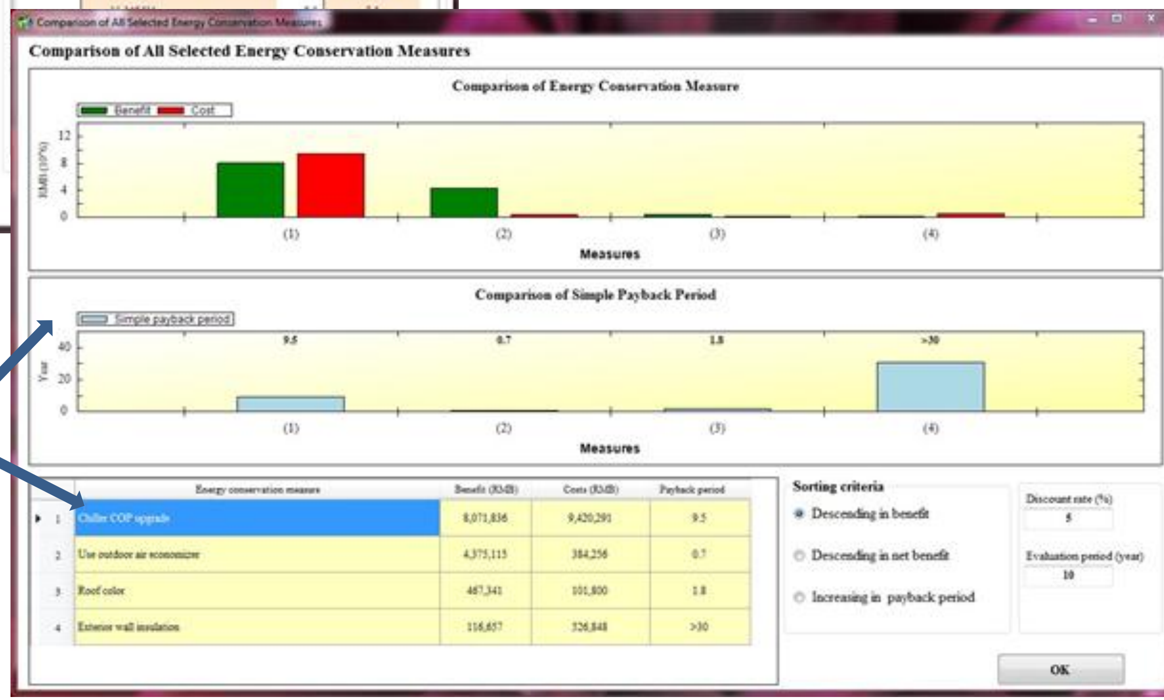
COMBAT Demonstration: Outputs



Energy savings analysis

Payback analysis

Energy savings analysis



Individual measure's cost-effective analysis

Distributed Energy Resources Customer Adoption Model (DER-CAM)

Purpose: *produces optimal investment decisions and dispatch for technologies as fuel cells, PV, solar thermal, electric / heat storage, heat pumps, EVs, etc.; it minimizes annual energy costs, CO_2 emissions, or multiple objectives of providing services to buildings (~100-2000 kW peak)*

Related Tools: *none*

Users: *more than 350 DER-CAM web-clients to date for the simple investment version (multiple versions with different copyrights are available at http://der.lbl.gov/der-cam/how-access-der-cam, stochastic versions for EVS and other technologies as PV exist or are currently under design)*

Developer(s): *developed for 12 years by LBNL, collaboration with China and other countries*

Availability: *simplified investment web version via https://microgrids2.lbl.gov/ (WebOpt); English and Chinese, SI units. Funded by US DOE, CEC*

Limitations: *not all features are provided in the simplified web version, in general more work is needed on passive measures*

Impacts summary: *40 online accounts from China, 73 online accounts from U.S.; University and teaching, building managers and operators, cost reductions up to 30% and CO_2 reductions up to 100% (in ZNEB mode) due to well guided decisions (see next page)*

Potential: *Expand functionality to be able to develop a district energy system optimization toolkit for China's low carbon district/city energy system analysis; cheap and simple real time building management service over the web (multiple requests from national and international companies)*

Distributed Energy Research and Impacts

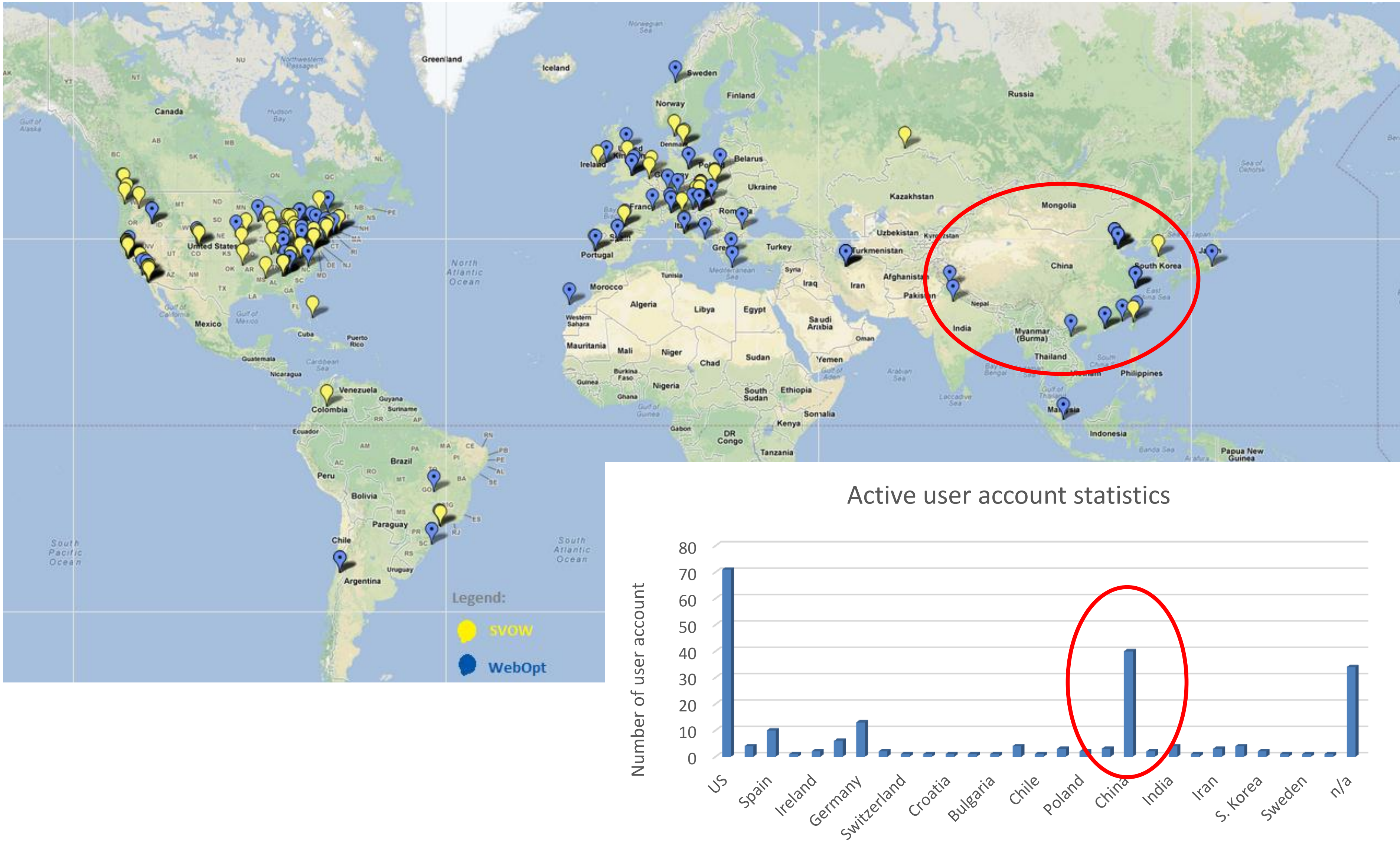
Background:

- China's 12th FYP highlights CHP and other distributed energy as one of its important energy goals
- 1000 distributed natural gas generation in the 12th FYP (each less than 5MW)
- NEA's 12th FYP states that 30 national-level microgrid demonstration projects will be built by the end of 2015
- China State Grid's new policy on distributed energy grid connection (less than 6MW)

Current impacts:

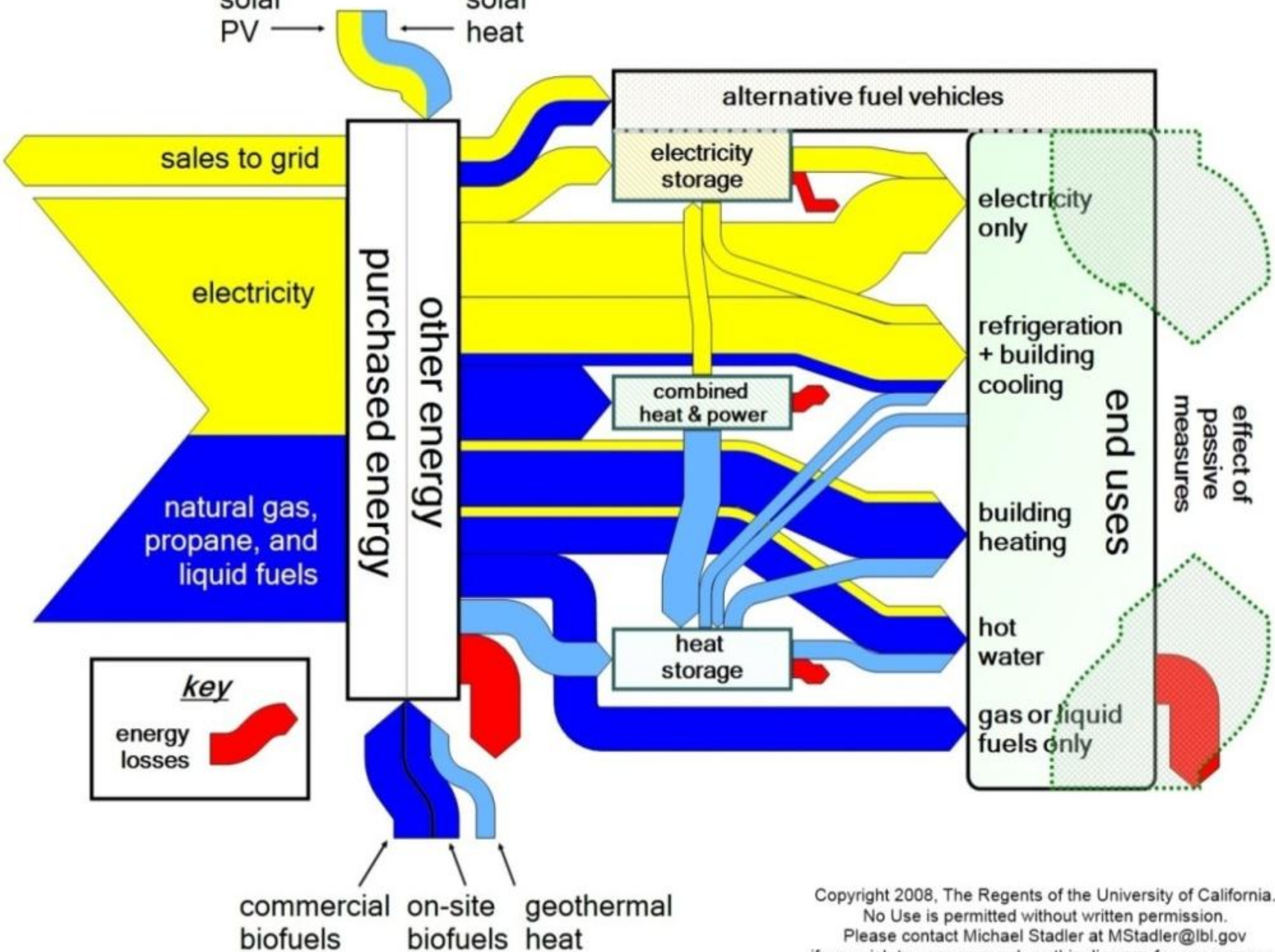
- LBNL is working with the Chinese Academy of Science (CAS) – Institute of Electrical Engineering (IEE), and NEA on the development criteria and evaluation methods for 12th FYP's 30 national-level microgrid demonstration projects by using the DER-CAM tool developed by LBNL.
- Work with ECP-China and U.S. DER companies (e.g. DOW, ICF, Capstone, Honeywell) on China projects.
- **Selected collaborators:** Tianjin University, Tongji University, Shanghai Energy Conservation and Supervision Center, Shenzhen Microgrid Lab, Shenzhen Institute of Building Research, CAS-IEE, Xiamen University, Hefei University
- **Selected DER and microgrid projects LBNL is working on using DER-CAM:** Shanghai Changning Central hospital, DongAo Island (Zhuhai, Guangdong), Tianjin University Microgrid Lab (MOST's 973 project), Shenzhen Microgrid Lab, Shanghai Chongming Island microgrid project

DER-CAM : Active User Accounts Around the World

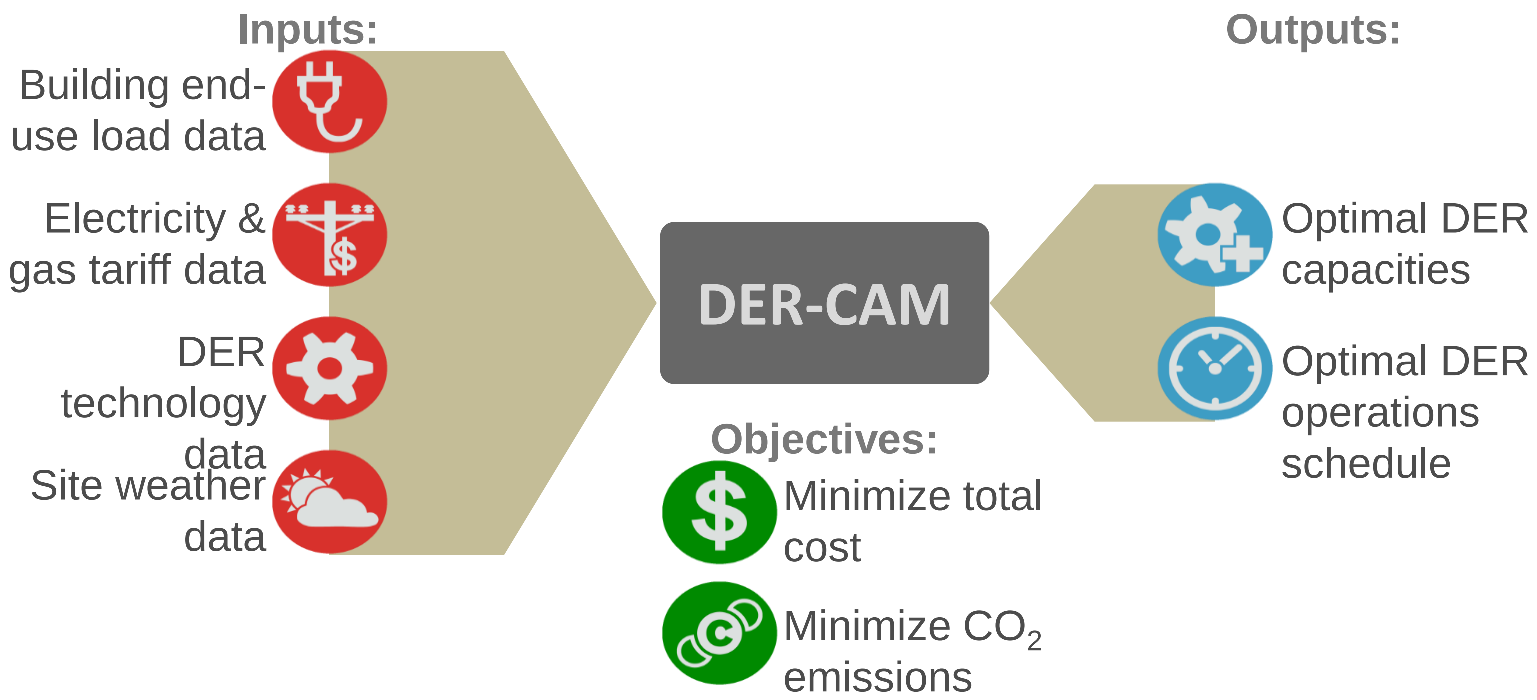


DER-CAM Fundamentals -- Sankey Diagram

Sankey diagram shows how distributed energy is transport, converted and balanced



DER-CAM Demonstration: Inputs



- **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

DER-CAM Demonstration: Outputs

VisualEPlus 2.0 Introduction

Purpose: *a GUI in Chinese and English for the* ***EnergyPlus*** *program, focusing on graphical modeling of HVAC system, and analysis of output results.*

Related Tools: *no other similar GUI in Chinese; intended to be used in conjunction with* ***Open Studio*** *for building modeling.*

Users: *building energy practitioners, academia, and students interested in building energy simulation with* ***EnergyPlus****, particularly in China.*

Developer(s): *Tongji University (lead) and Shandong University in collaboration with White Box Technologies, Inc. and ORNL.*

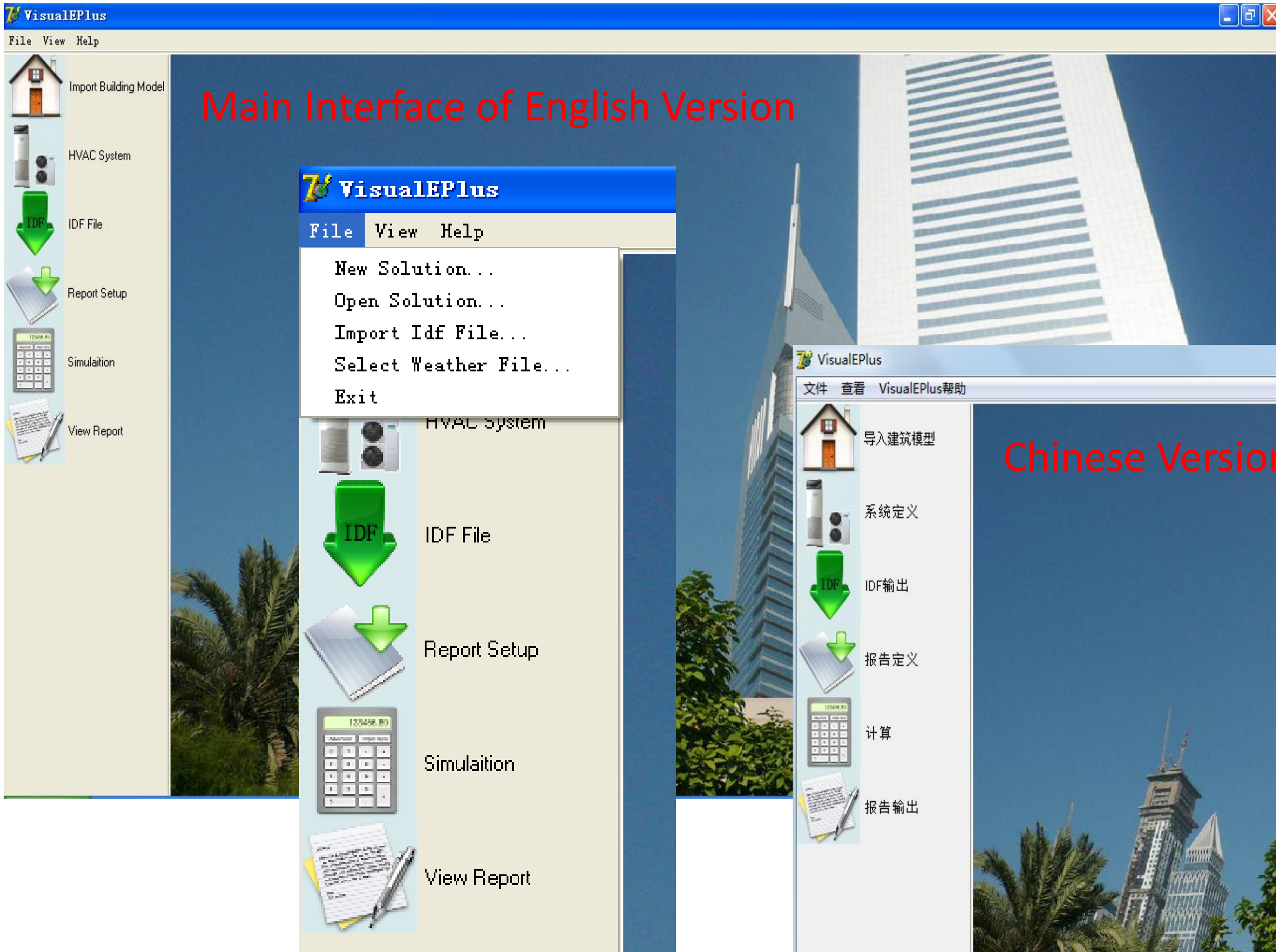
Availability: *Chinese version launched November 2012 http://bsim.tongji.edu.cn/custom.asp?mk=1&id=244; English version planned launch June 2013 to be available at www.whiteboxtechnologies.com and ORNL for users outside of China.*

Limitations: *Simulation GUIs are very complicated software***;** *to limit effort and meet greatest need,* ***VisualEPlus 2.0*** *concentrates on two areas only – HVAC modeling and report analysis; program is still "buggy" with many areas for improvement.*

Impacts: ***VisualEPlus*** *has been introduced at conferences in China, US and Canada starting since 2009 (****HVAC Simulation Seminar*** *Beijing Nov 2009,* ***SimBuild 2010*** *New York Aug 2010,* ***IMECE 2010*** *Vancouver Nov 2010,* ***ASim2012*** *Shanghai Nov 2012).*

Potential: ***VisualEPlus*** *makes* ***EnergyPlus*** *acceptable to the Chinese building energy modeling community, which can then play an important role in building energy efficiency design, standards development, and R&D in China, just as* ***EnergyPlus*** *does in the US.*

VisualEPlus2.0 Demonstration: Inputs

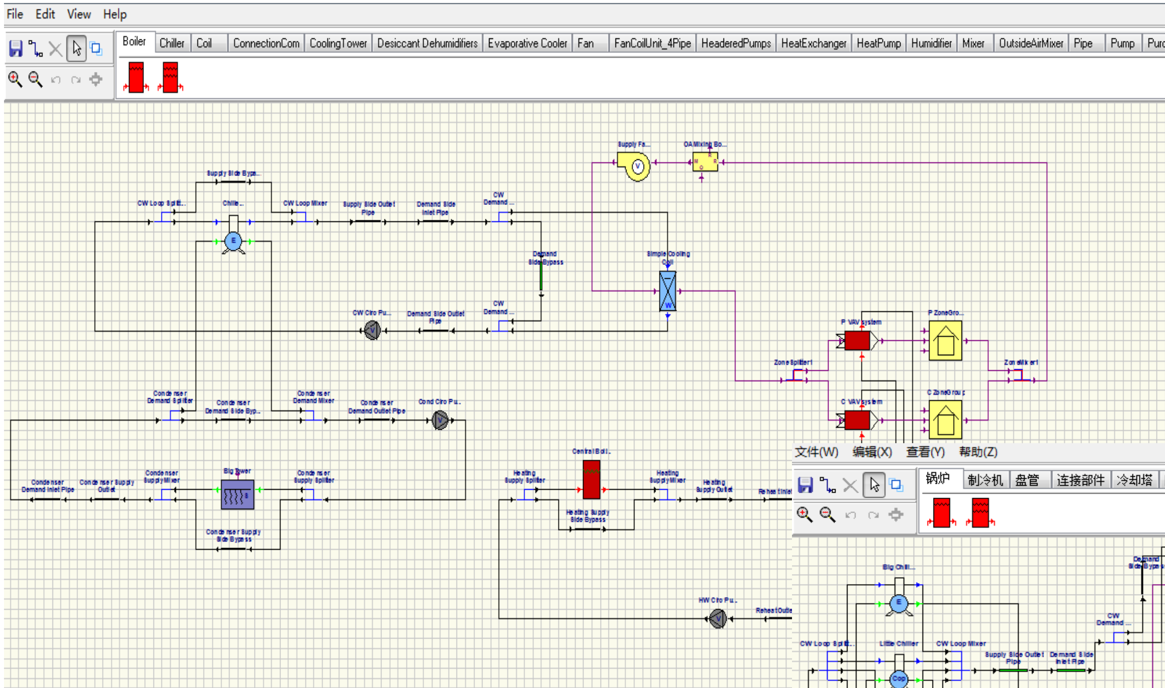


Drop-down Menu for Operation Procedures

Building model needs to be generated by other programs (i.e., Open Studio) & loaded into VisualEPlus 2.0

VisualEPlus2.0 Demonstration: HVAC Modeling GUI

BERKELEY LAB

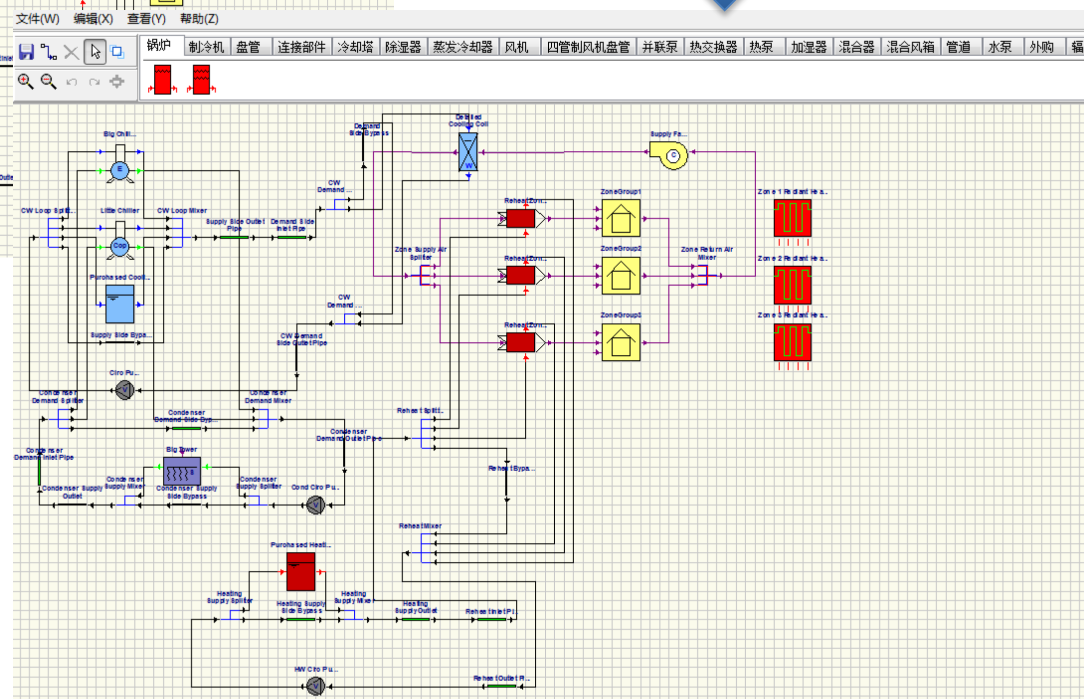


VisualEPlus 用户手册

User Menu

版本：2.0

Chinese Interface

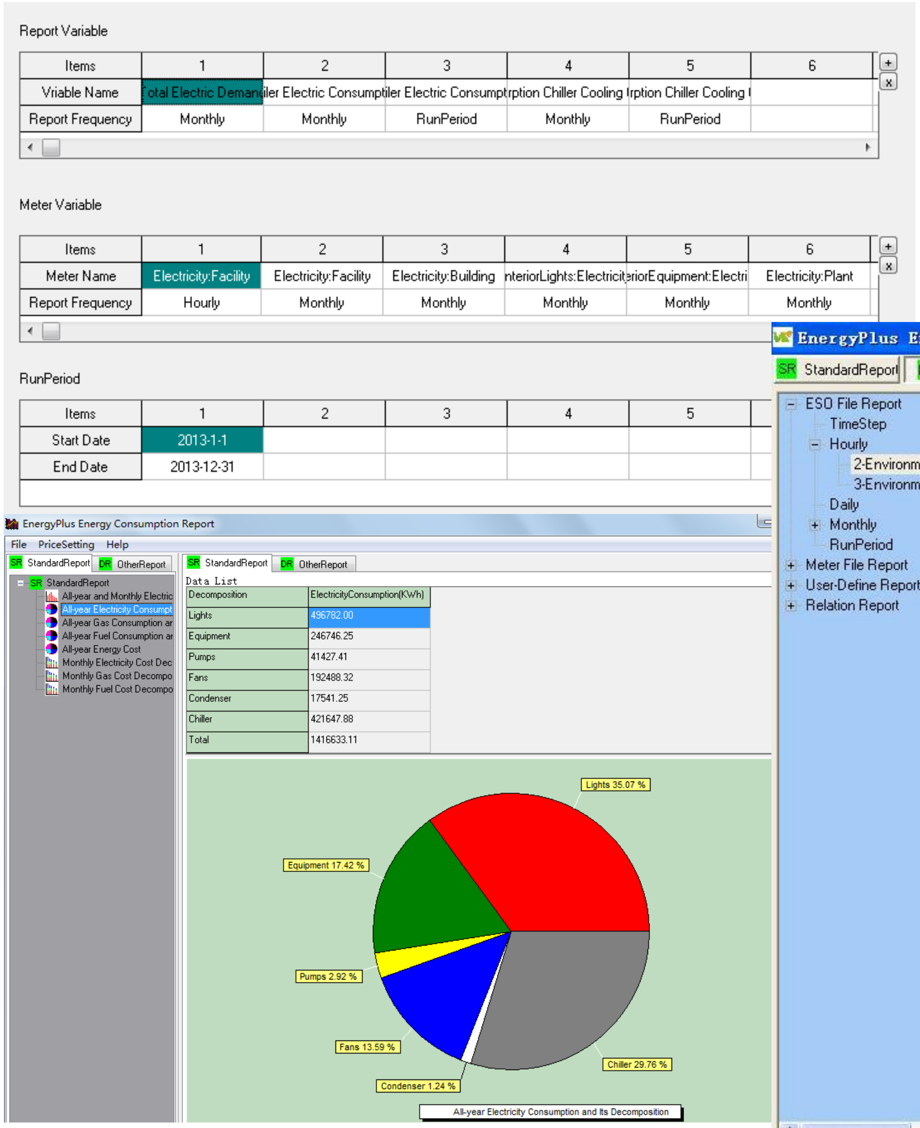


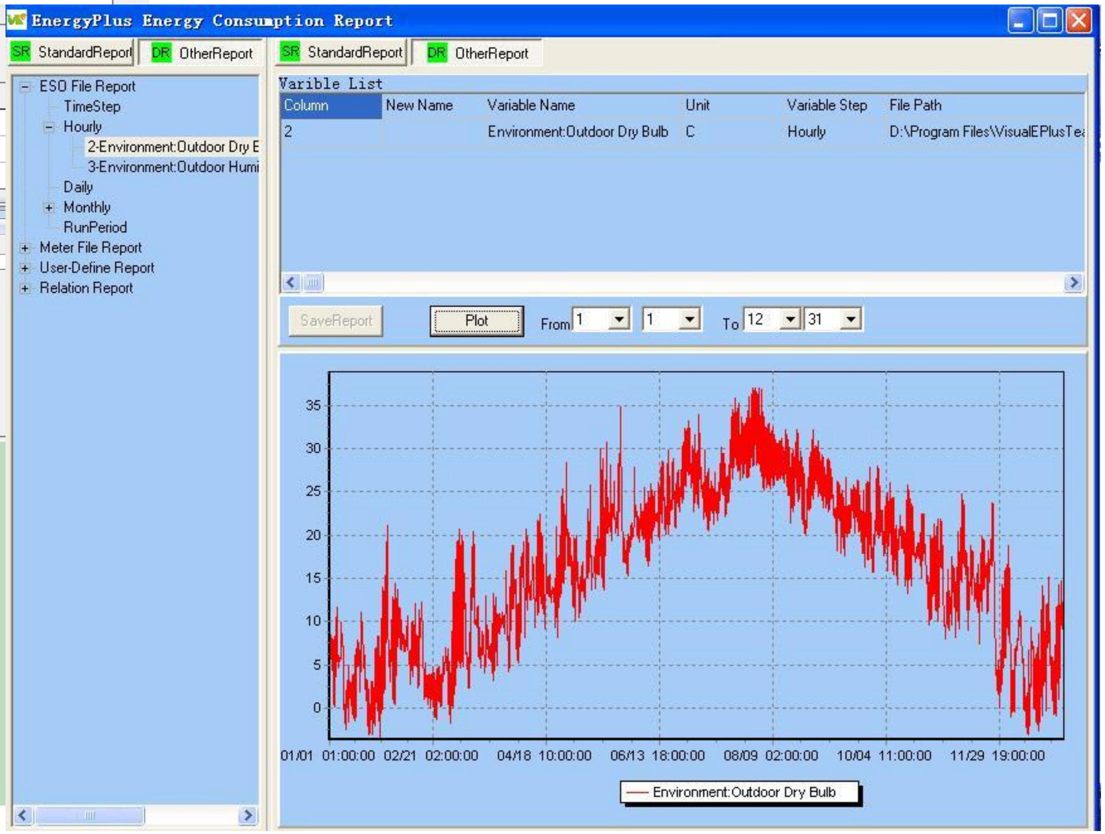
English Menu

- “Drag-and-drop” style graphical modeling for HVAC systems
- 109 HVAC components in 28 categories
- 11 HVAC templates

VisualEPlus2.0 Demonstration: Output

Visualize simulation result in both standard and customized reports for user selected variables, during user selected time periods, and at various time intervals





Thank You!

Questions?

CERC-BEE Cooperative Research Applications and Exploitations of Advanced Decision Tools

Shilei Lu Associate Prof.

TIANJIN UNIVERSITY

2013.9.25 WASHINGTON D.C.

Main research topics

1. Collaborative research in verification of DER-CAM and energy operation optimization（LBNL）
2. Collaborative research in evaluation of the GSHP project with eQUEST（ORNL）
3. Building heat transfer model development of PCM by TRNSYS（ Independent research ）

1. Collaborative research in verification of DER-CAM and energy operation optimization(LBNL)

DAR-CAM is a kind of integrated software designed to select optimal building energy-saving technology ,select optimal energy system 、direct energy saving operation and evaluate the effect of different operating periods

Background：

- There are some application cases of DER-CAM in the United States, whereas there is little application case in China.
- DER-CAM lacks energy systems model ,passive building energy-saving technical modules , meteorological data and price system of energy of China , etc.

Assignment：

- To improve relative modules of DER-CAM
- Select demonstrating building to validated the feasibility of DER-CAM
- Select existing buildings to optimize DER-CAM operation
- Select new buildings to find an optimization design method of energy system by using DER-CAM

1. Collaborative research in verification of DER-CAM and energy operation optimization(LBNL)

1. Saidi office building in Chongqing
2. TJU 26# building in Tianjin
3. Wanke office building in Shenzhen
4. SYJZU office building in Shenyang
5. TJU new library in Tianjin

Proof scheme

- Designbuilder was used for model establishment and basic settings

  (1)Activities Settings

  (2)Lighting Settings

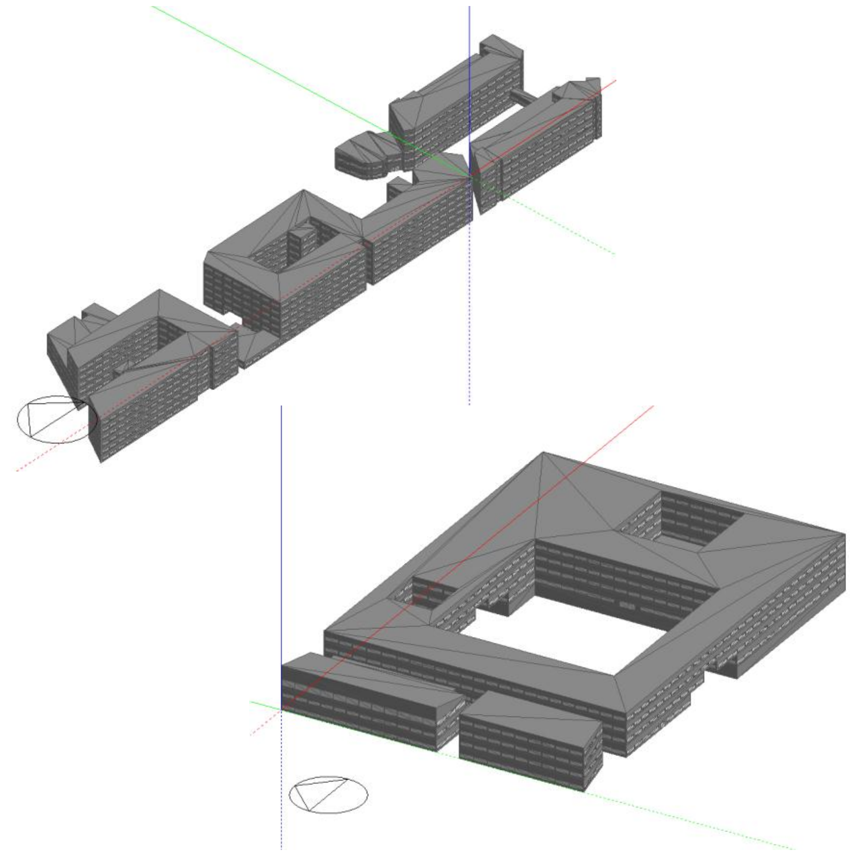
  (3)Plug load

  (4)HVAC

  (5)Structure Settings

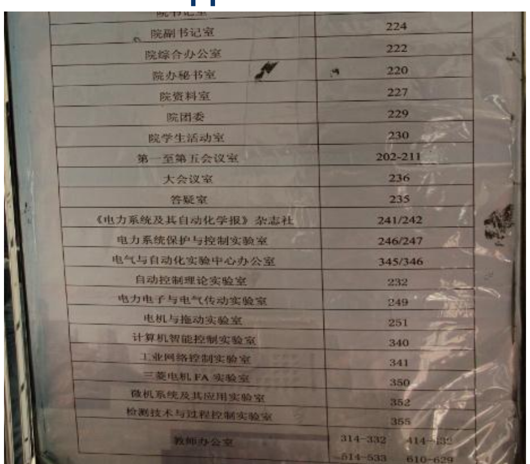
- DER-CAM was used for the design of energy system

Cooling ,Space Heating and Water Heating
(Week ,weekend and peak）



TJU 26# Building

Appearance



Room function and No.

Equipment list

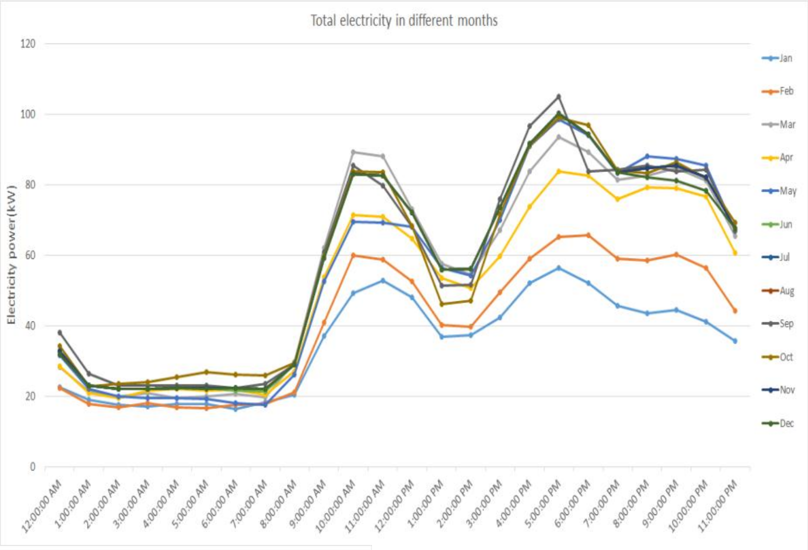
	Equipment No.	Equipment Name	Equipment Power (W)	Equipment Quantity	Total Power (W)
Office	1	Fluorescent Lamp	18	1000	18000
	2	Computer	300	210	6300
	3	Printer	638	20	12760
	4	Split AC	750	48	36000
Laboratory	5	Fluorescent Lamp	18	700	12600
	6	Experimental Equipment	-	-	4200
Equipment Room	7	Water Pump	45000	3	135000
	8	Fluorescent Lamp	18	20	390
Supplementary Area	9	Water Heater	10000	1	10000
	10	Air Curtain	12000	3	36000
	11	Elevator	15000	2	30000
	12	Corridor Lamp	11	245	2695
	13	Staircase Lamp	14	42	588
	14	Exhaust Fan	150	12	1800

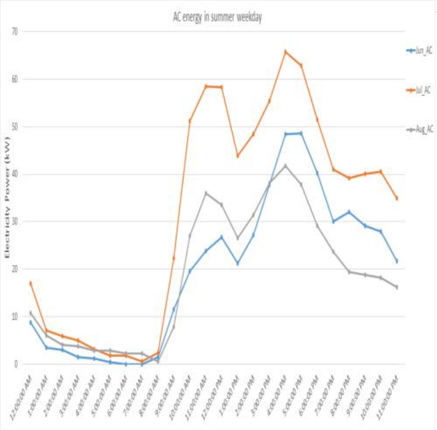
Building energy-subentry measure

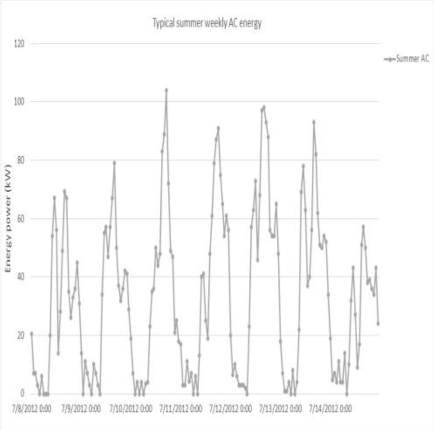
Power distribution No.	Circuit No.	Varying Ratio	Circuit Purpose	Electricity meter No.	Type
AA1-1		1000/5	Main Power	D1	Multifunctional Harmonic
AA1-3	1-WL2	200/5	Lighting/Equipment	D2	3 Phase 4 Wire
	1-WL3	200/5	Lighting/Equipment	D3	3 Phase 4 Wire
AA1-6	1-WL4	200/5	Lighting/Equipment	D4	3 Phase 4 Wire
	1-WL5	200/5	Lighting/Equipment	D5	3 Phase 4 Wire
	1-WL6	200/5	Lighting/Equipment	D6	3 Phase 4 Wire
AA1-5	1-WPE3	20/5	Lighting/Equipment	D7	3 Phase 4 Wire
	1-WPE3	50/5	Dynamic	D8	3 Phase 4 Wire
	1-WPE3	50/5	Dynamic	D9	3 Phase 4 Wire
AA2-1		2000/5	Main Power	D10	Multifunctional Harmonic

Test data and Simulated data

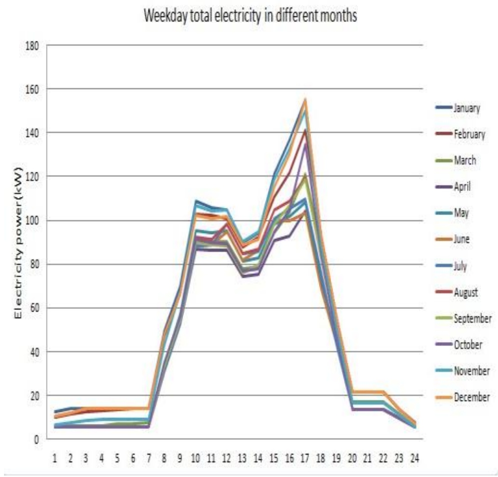
inspection data—separate metering

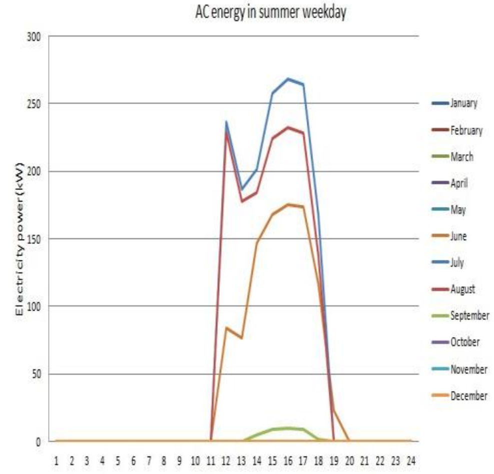


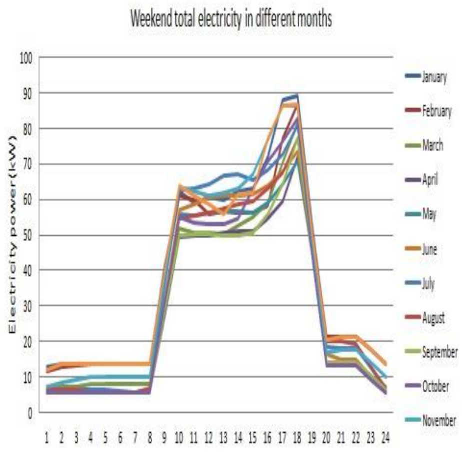




Simulation data analysis（including total energy consumption and subentry energy consumption）







AC energy in summer weekday

Typical summer weekly AC energy

DER-CAM data analysis

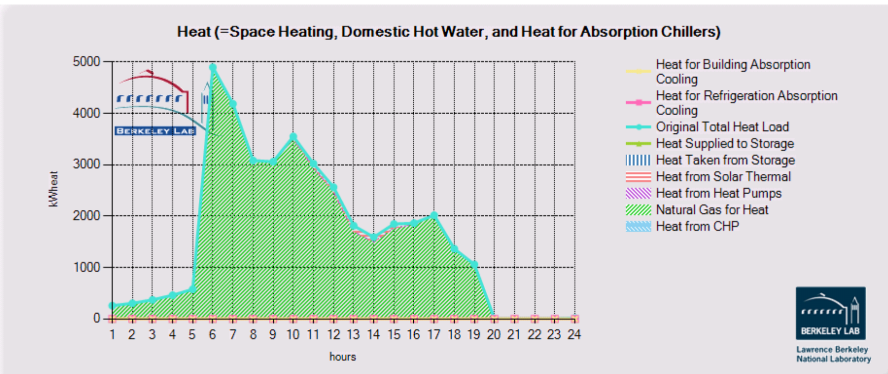
Results	Utility Electricity Consumption(kWh/a)
Designbuilder SImulation (Do-nothing in DER-CAM)	1,260,365.1
Energy Monitor System (Do-nothing in DER-CAM)	1,280,562.3
Difference percentage(%)	1.6%

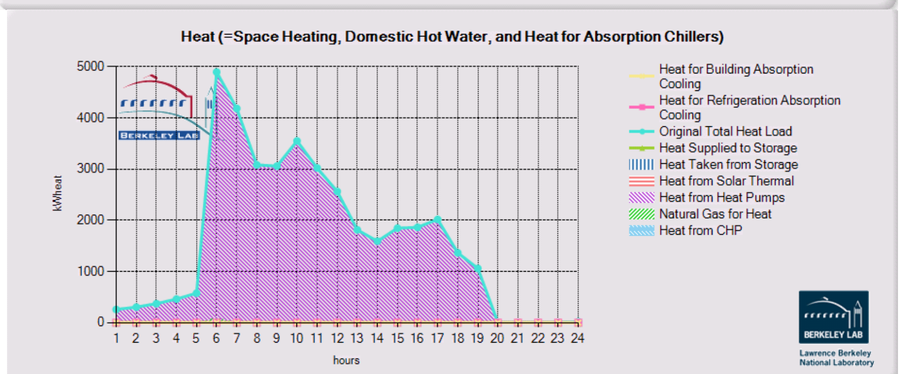
The simulation results are similar to the DER-CAM analysis results.

DER-CAM for optimizing operation

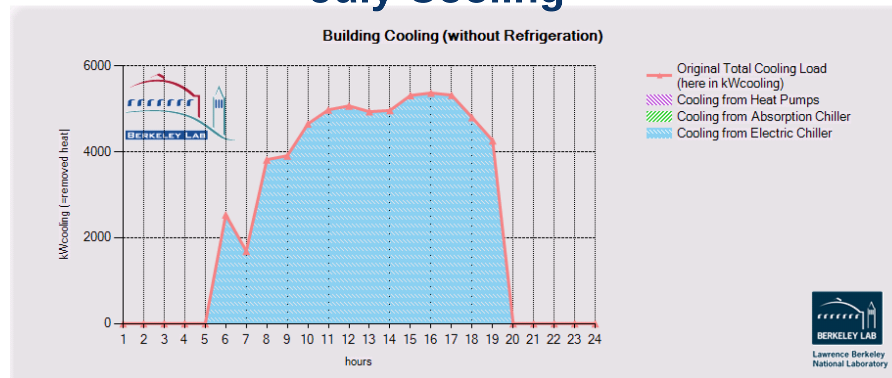
Four kinds of technologies(PV, Solar Thermal, GSHP and Existing Chiller)were used in optimization of simulation results

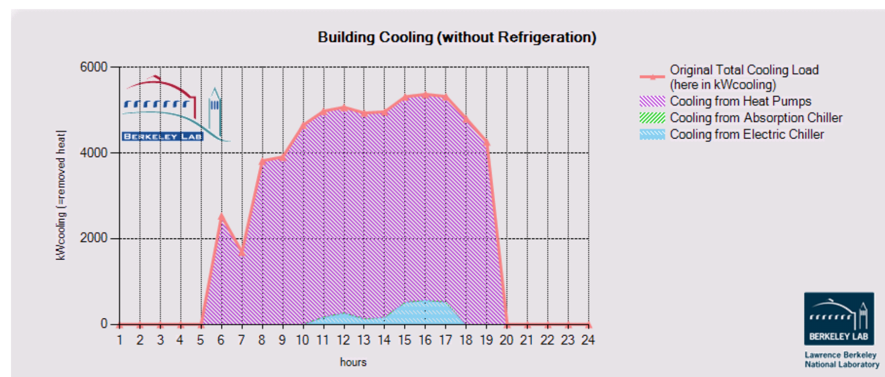
January Heating





July Cooling



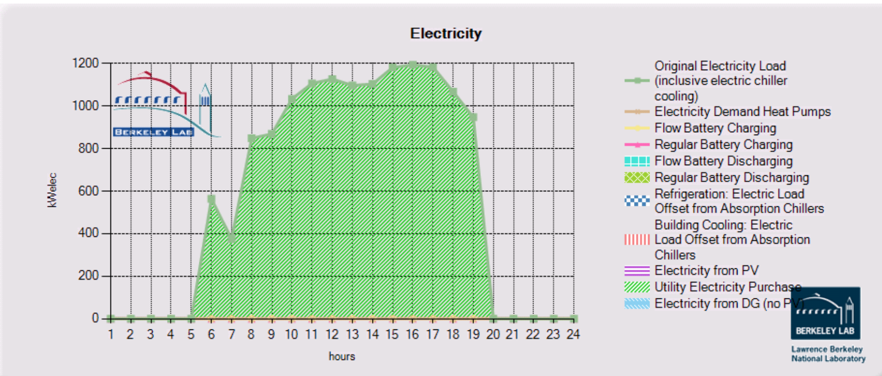


Natural Gas for Heat in case least cost in JAN；Heat from Heat Pumps in case the largest emissions reductions in JAN

Cooling from Electric Chiller in case least cost in JUL；Cooling from Heat Pumps combines with Electric Chiller in case the largest emissions reductions in JUL

DER-CAM for optimizing operation

July Electricity



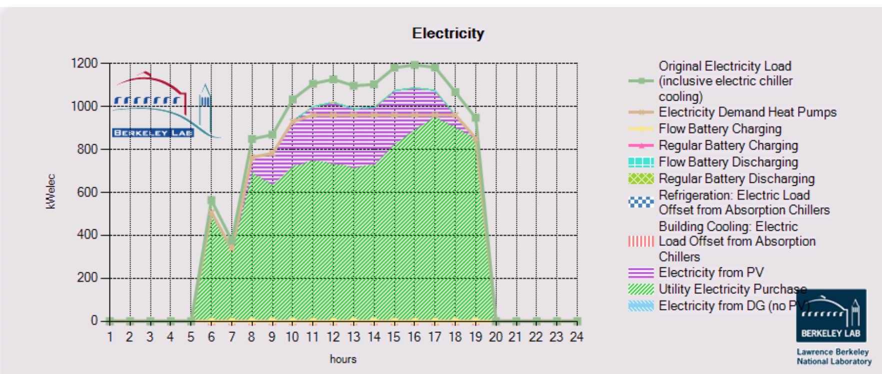
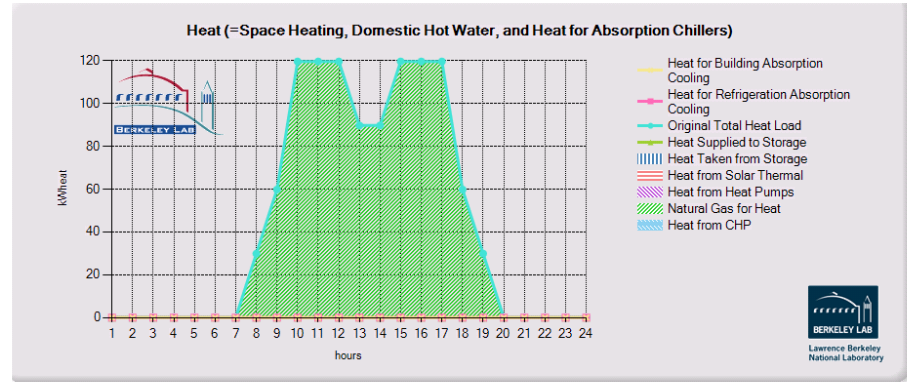


Figure 1 shows Base Electricity Load in JUL; Figure 2 shows PV should be used to replace part of Electricity Load in case the largest emissions reductions in JAN

July Heating



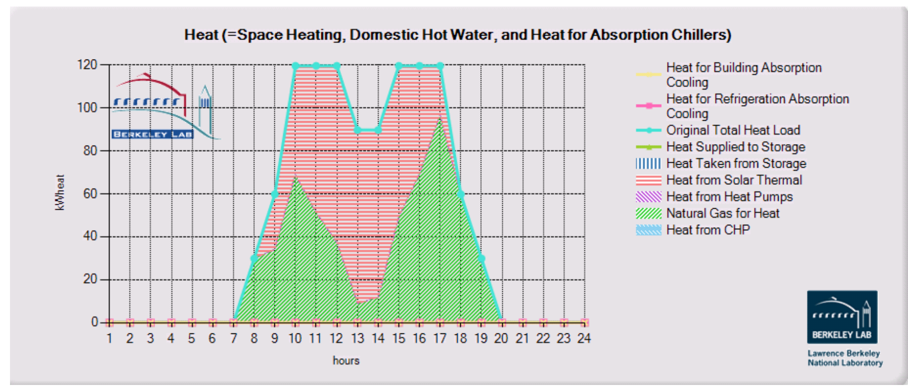


Figure 1 shows Base Hot Water Load in JUL; Figure 2 shows Solar thermal should be used to replace part of Hot Water Load in case the largest emissions reductions in JAN

Next step

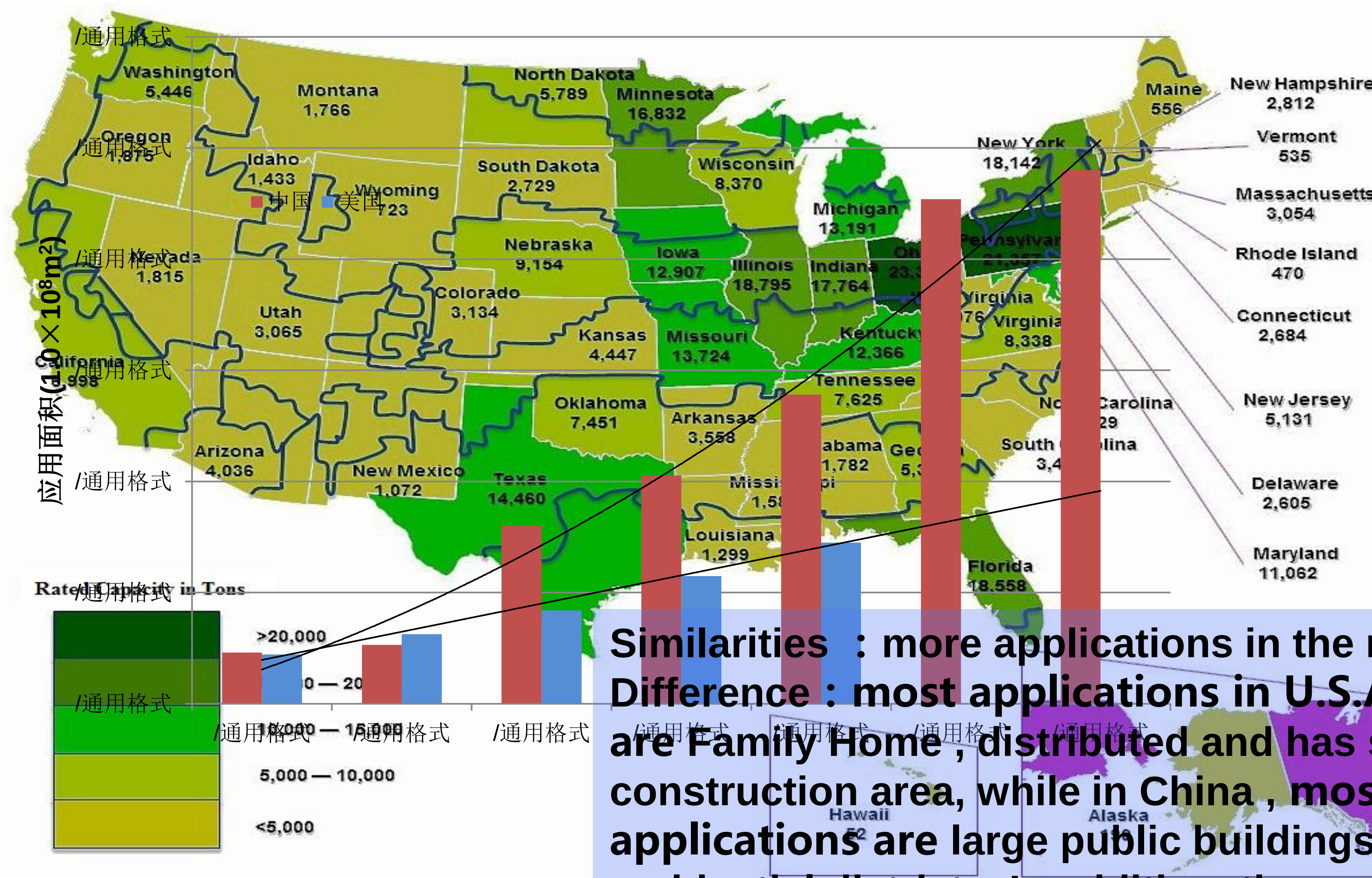
1、 Optimizing operation of *TJU 26# Building by using* DER-CAM

At present， the data of subentry energy consumption was under our belts， we are collecting the data of each room to make the information of operational aspect as detailed as possible

2、 Optimizing operation of *new building by using* DER-CAM

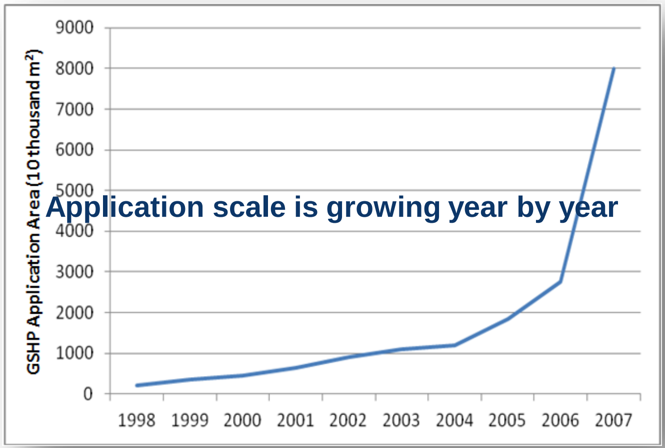
Select TJU new library and combine with local energy resource, climate and energy cost , etc.

2.Collaborative research in evaluation of the GSHP project with eQUEST（ORNL）



Similarities：more applications in the north
Difference：most applications in U.S.A. are Family Home，distributed and has small construction area, while in China，most applications are large public buildings and residential districts. In addition, the development velocity of the U.S.A. slows down，China develop rapidly.

2.Collaborative research in evaluation of the GSHP project with eQUEST（ORNL）



Actual energy efficiency level？

Energy-saving effect？

Economy？

《可再生能源建筑应用示范项目测评导则》

Test time： 2~3 days , not whole year operation

Energy saving ability： appoint conventional energy efficiency of system , efficiency value

Payoff period： static

eQUEST

快速能耗仿真软件工具

simulation time： 8760 hours

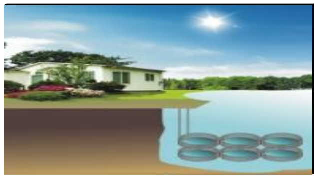
Energy saving ability：gshp system and conventional system are simulated in the same loading condition, dynamically and targeted

Payoff period：set electricity price freely

An Overview of Cases

Sewage -SHP

Beijing	residential building	42,000m^2
Shenyang	school building	35,000m^2
Dalian	commercial building	19,000m^2



Seawater -SHP

Dalian	residential building	255,000m^2

GWHP

Inner Mongolia	school building	102,000m^2
Beijing	residential building	83,600m^2
Shenyang	office building	22,000m^2
Shenyang	hospital building	100,000m^2
Beijing	commercial building	100,000m^2
Beijing	commercial building	40,000m^2
Beijing	commercial building	80,000m^2

Testing Content

Water temperature ：
- ●Evaporator supply and return
- ●Condenser supply and return
- ●User supply and return
- ●Well water supply and return

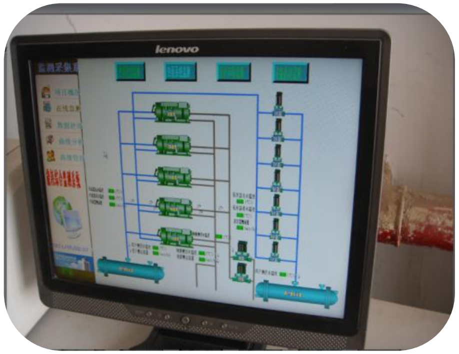
30min/collection

Flow ：
- ●Evaporator cycle
- ●Condenser cycle
- ●User cycle
- ●Well water cycle

30min/collection

Electrical consumption ：
- ●Heat pump units
- ●Circulating water pump
- ●Submersible pump
- ●Others

1 day/collection



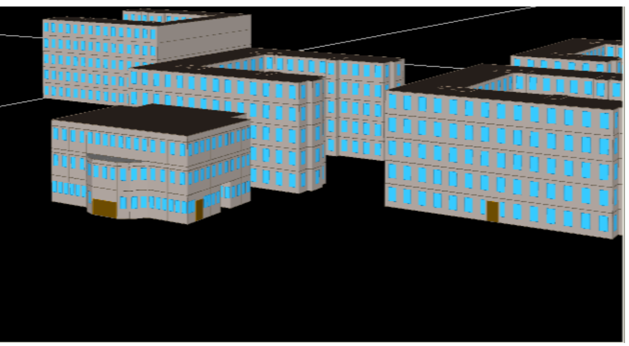
renewable energy demonstration program ：

●Inspection platform get temperature , flow and electrical consumption data directly

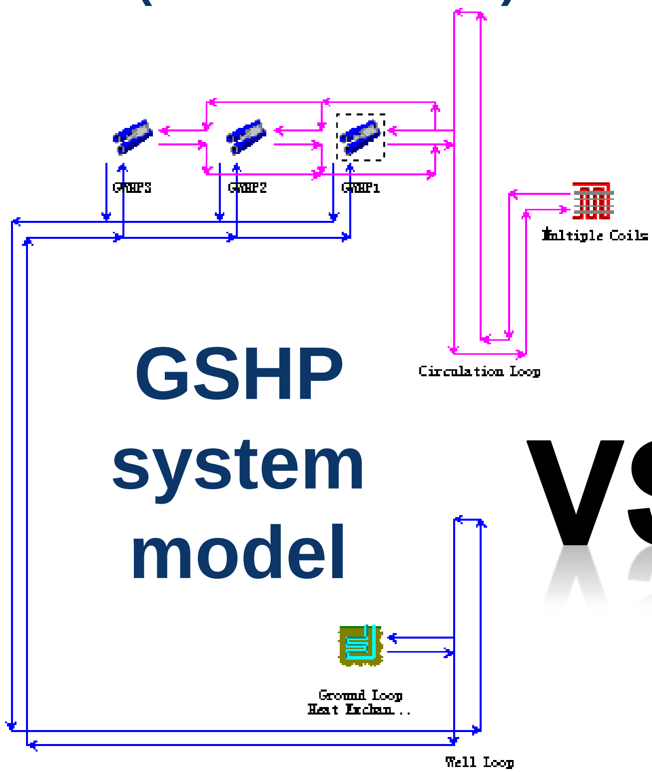
●10min/collection

eQUEST Simulation Example

●Calculate quantity of energy saving of GSHP by operating GSHP system and conventional system (chiller + boiler) in the same building model.

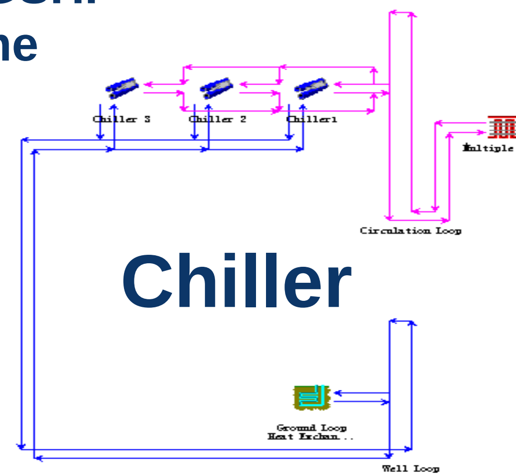


Building model



GSHP system model

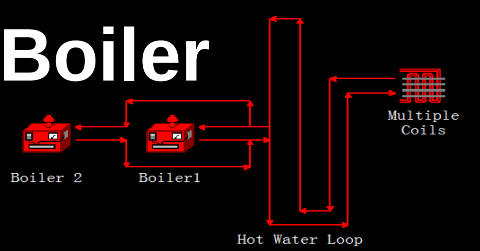
VS



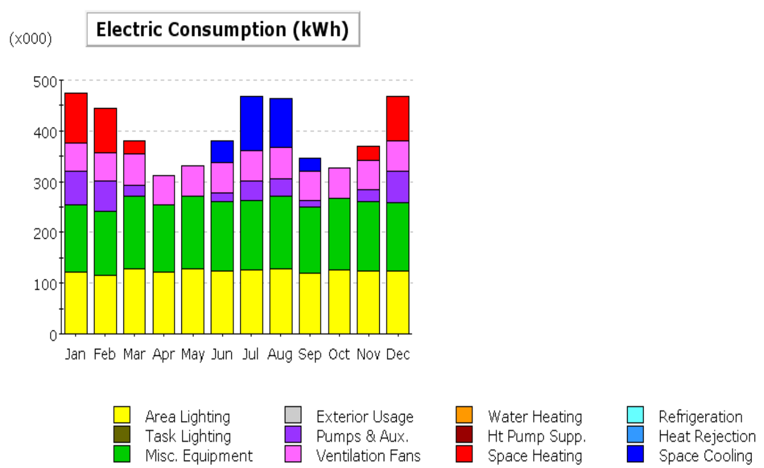
Chiller

+

Boiler

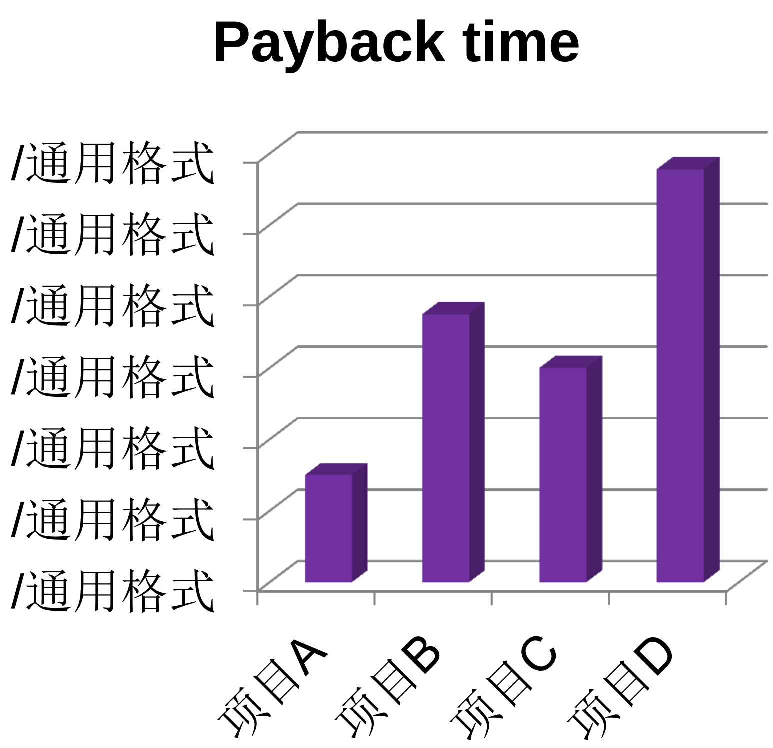


●Quantity of energy saving



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	42.6	106.2	95.5	26.9	-	-	-	271.2
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	96.9	87.5	25.6	-	-	-	-	-	-	-	26.8	88.5	325.4
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	57.1	55.1	61.0	59.0	61.0	59.0	61.0	61.0	57.1	61.0	59.0	59.0	710.3
Pumps & Aux.	65.3	60.0	22.3	-	-	16.9	37.6	35.6	13.7	-	22.1	62.1	335.5
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	133.3	126.7	143.4	130.5	143.4	137.9	136.0	143.4	129.3	139.5	137.9	134.9	1,636.3
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	121.3	114.9	127.4	122.8	127.4	123.2	126.9	127.4	120.2	126.9	123.2	124.3	1,485.7
Total	473.8	444.1	379.7	312.3	331.8	379.6	467.7	463.0	347.2	327.4	369.0	468.9	4,764.4



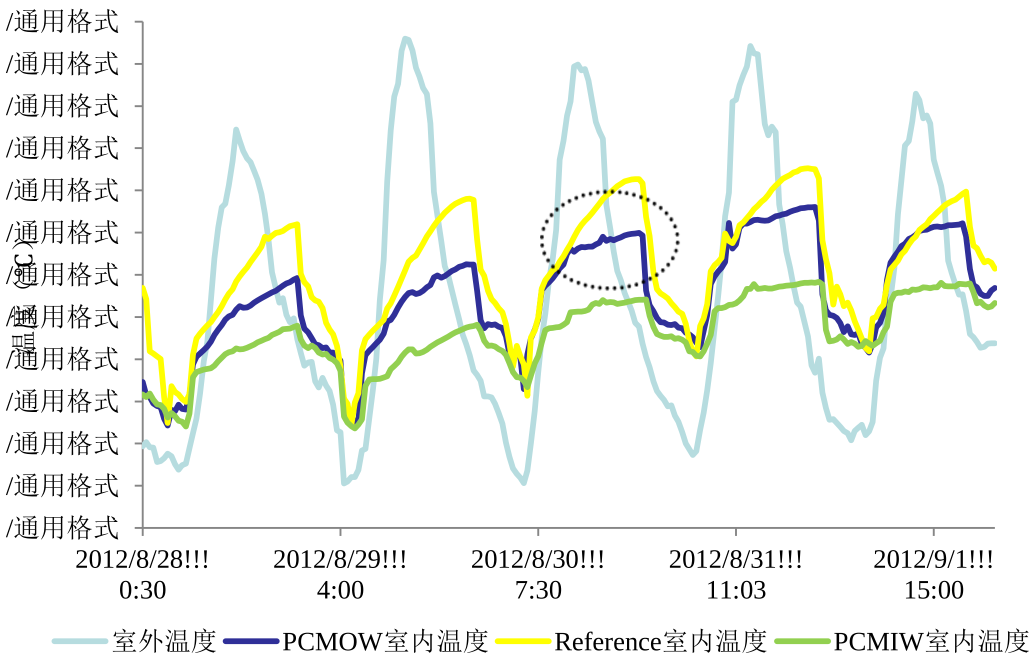
NEXT STEP

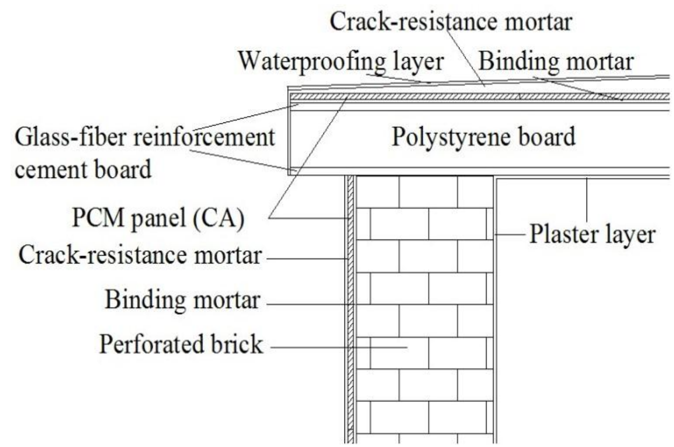
1、Collect operation curves of major GSHP in China and add to eQUEST database.
2、Find the actual optimum operation of each equipment by analyzing operation strategies in eQUEST model.

3.Building heat transfer model development of PCM by using TRNSYS

1、PCM apply in cool storage in summer

Encapsulating PCM with energy storage slab , and integrate in two ways : the PCM set outside the construction（PCMOW）, the PCM set inside the construction（PCMIW）





PCMOW

PCMIW

Questions：

1、The PCM simulation module of Energyplus is based on enthalpy-temperature correspondence method , a fit curve is defined by pointing different temperature correspond to different enthalpy , thus all phase change process are considered as an integration process . Using the finite difference method, established a equation of energy , and made its discrete solutions. While only one enthalpy-temperature curve could be inputted in the PCM simulation module , melting process and solidification process can not be distinguished.

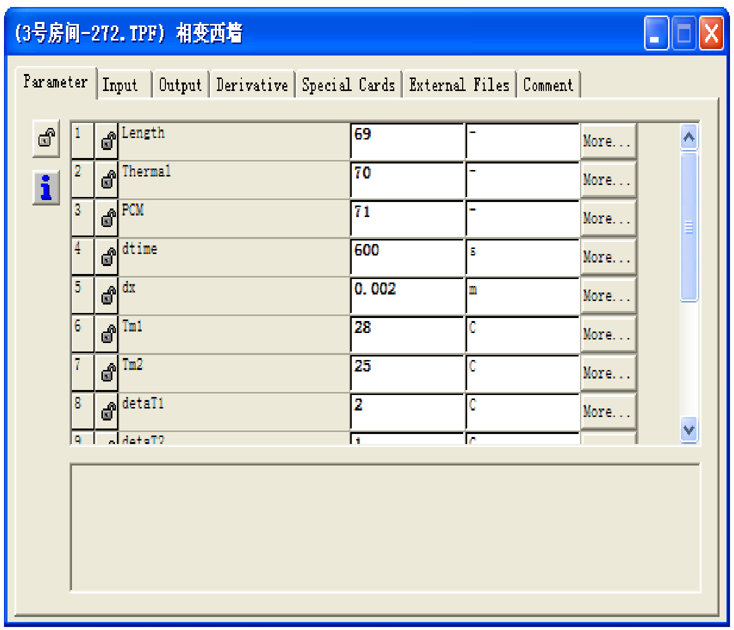
2、 The transformation of PCM may not be a complete process, mostly the process is an incomplete transformation in actual conditions.

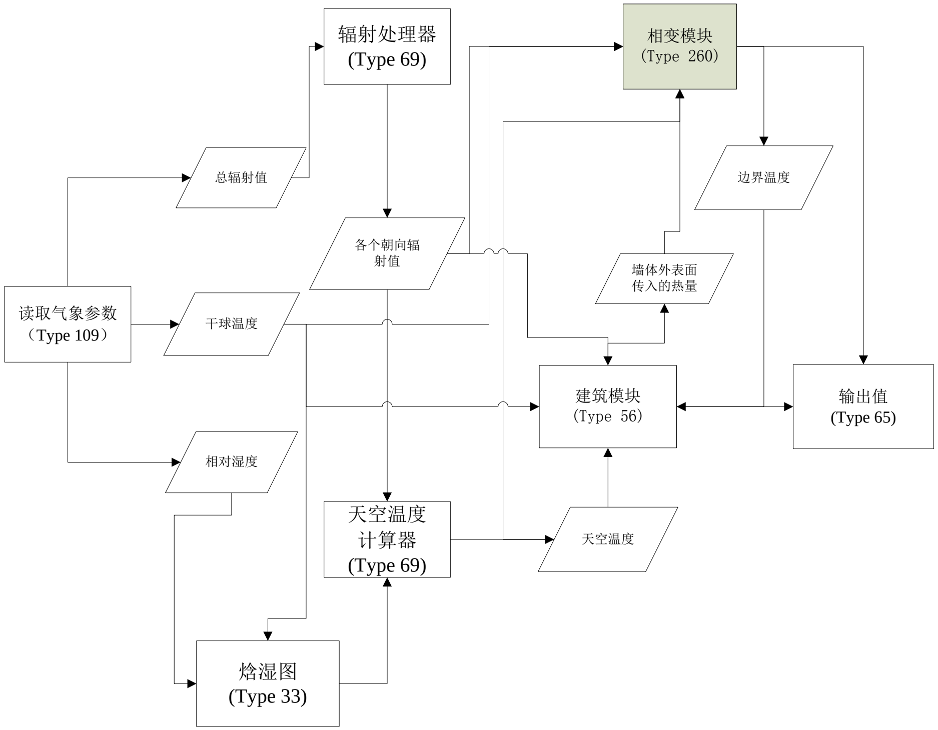
3、 Supercooling of PCM should be considered.

Creating PCM Heat Transfer Calculations Module based on TRNSYS

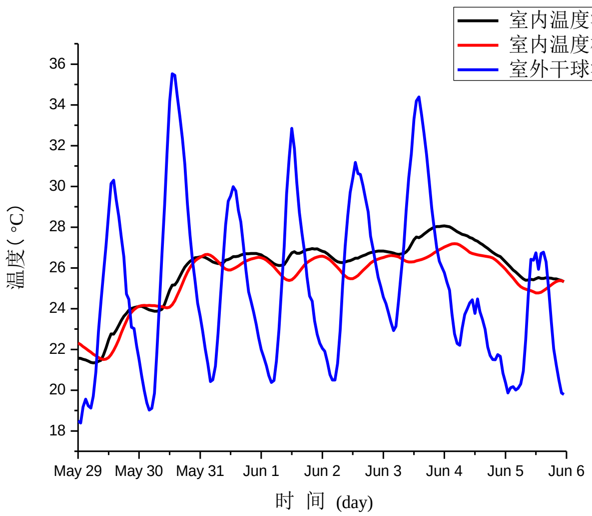
TYPE272

By introducing the coefficient *Latent heat utilization* , optimized the enthalpy-temperature correspondence method, incomplete transformation in actual conditions could be solved very well. This simulation module also take supercooling of PCM into account .

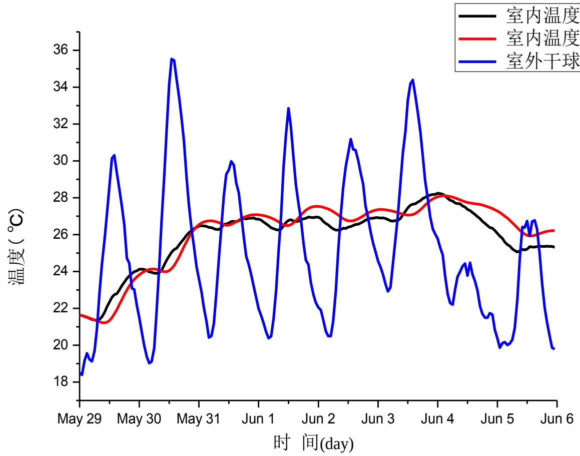




Natural cool storage: Simulation and Experimentation of PCMIW,PCMOW



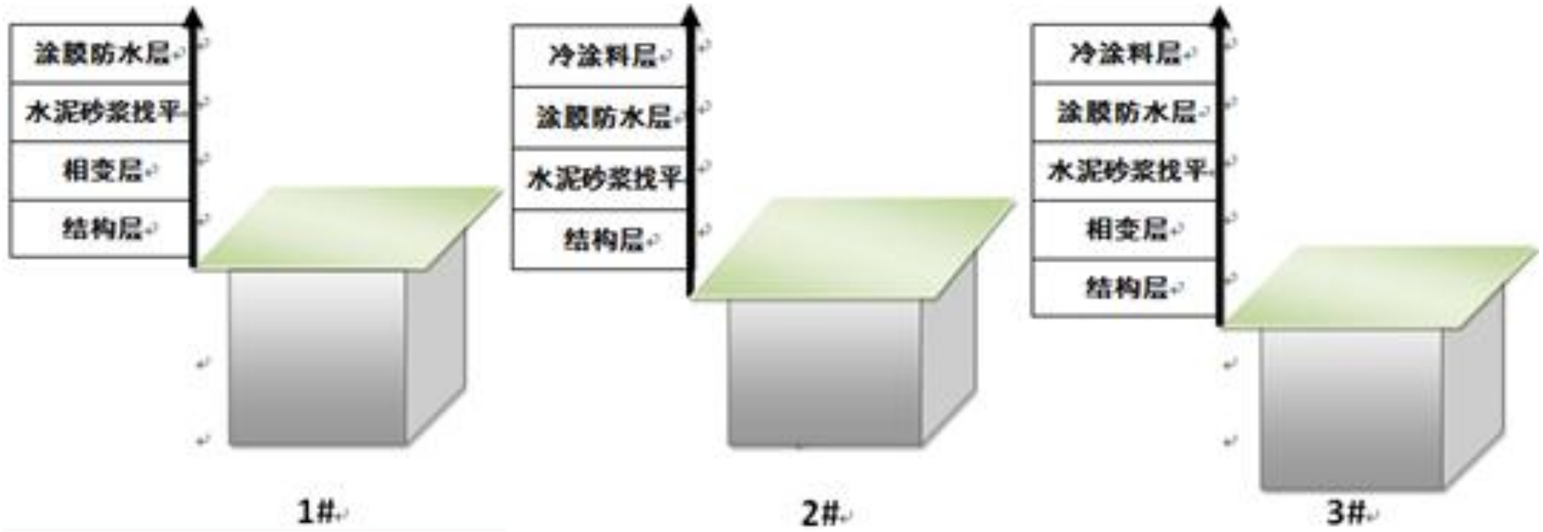
	MRE	$\bar{d}$	S_d	$\bar{d}\pm1.96S_d$	一致性界限外点数的百分比
室内温度	1.91%	0.42	0.42	1.24/-0.40	6.77%
北墙内壁温度	1.25%	-0.17	0.35	0.51/-0.84	6.77%
南墙内壁温度	1.45%	0.26	0.4	1.04/-0.53	9.89%
东墙内壁温度	1.11%	0.03	0.36	0.74/-0.67	9.89%
西墙内壁温度	2.51%	0.61	0.43	1.44/-0.23	6.25%
屋顶内壁温度	2.84%	0.66	0.57	1.78/-0.46	2.08%



	MRE	$\bar{d}$	S_d	$\bar{d}\pm1.96S_d$	一致性界限外点数的百分比
室内温度	1.82%	-0.21	0.54	0.85/-1.27	7.29%
北墙内壁温度	2.77%	-0.71	0.41	0.09/-1.50	5.73%
南墙内壁温度	3.35%	-0.86	0.43	0.02/-1.69	5.21%
东墙内壁温度	4.34%	-1.09	0.4	-0.30/-1.88	5.73%
西墙内壁温度	2.52%	-0.57	0.53	0.48/-1.62	7.29%
屋顶内壁温度	2.39%	-0.54	0.54	0.52/-1.60	4.17%

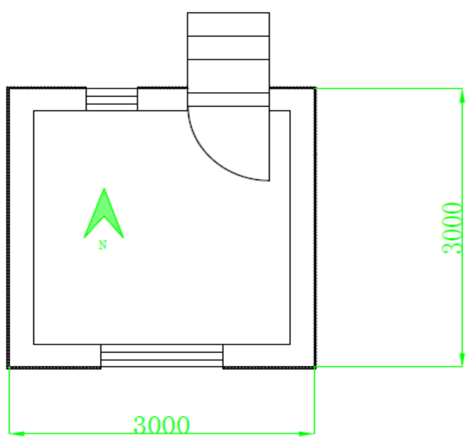
Next： The integrated application of the Cool Roof and PCM

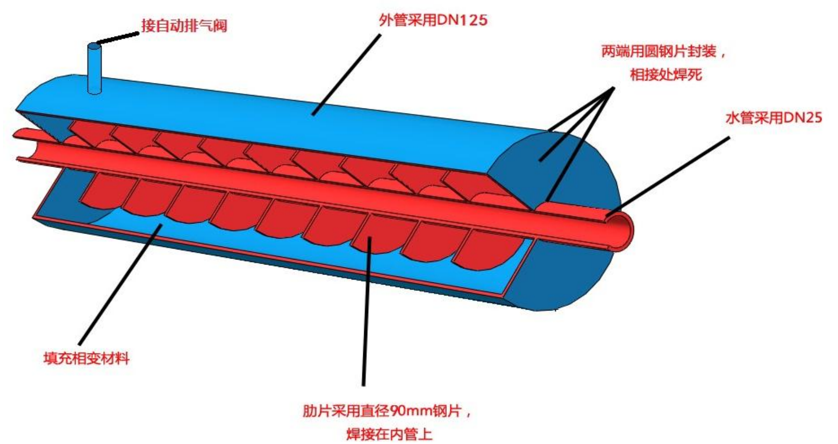
Put forward the optimal combination of PCM and COOL ROOF in different climatic region , which has important implications for power peak shaving and valley filling of power load , reducing building energy consumption and improving the indoor thermal environment.

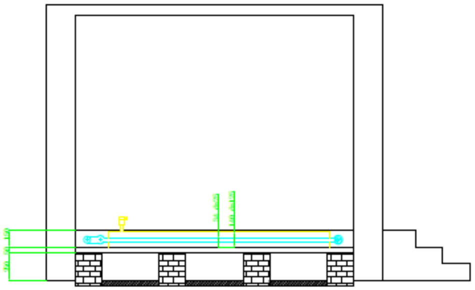


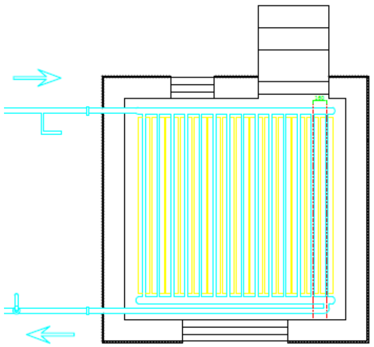
Next：The Research of PCM integrated Solar House

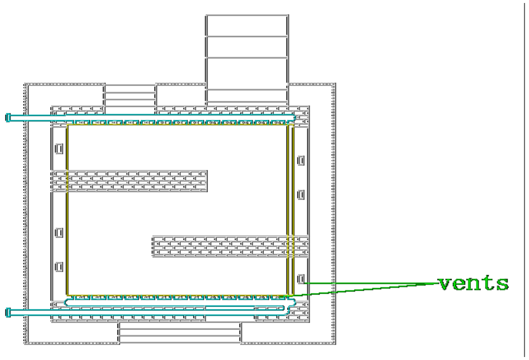
To search a new method of coupling of solar energy and PCM . Using efficient collector to collect solar energy and store in PCM , releasing when needed , to maintain a stable thermal environment .











天津大學

TIANJIN UNIVERSITY

Thank you！

Email:lvshilei@tju.edu.cn