中國建築科學研究院
China Academy of Building Research
建筑环境与节能研究院
Institute of Building Environment and Energy Efficiency

CABR近零能耗示范楼
Introduction of CABR Nearly Zero Energy Building

中国建筑科学研究院-建筑环境与节能研究院
Institute of Building Environment and Energy（IBEE）
China Academy of Building Research （CABR）
2014.08.26

BR近零能耗示范楼
BR-NZEB

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1. 近零能耗示范楼背景
Background

2. 示范意义与示范目标
Project analysis and objectives

3. 设计、建造、调试、实验、运营
Implementation

4. 近零能耗示范楼技术体系
Overview of technological design

5. 近零能耗建筑课题及中美合作
NZEB Research & China-US Cooperation

6. 总结
Conclusion

建设目标
Objective

示范项目将面向中国建筑节能技术发展的核心问题：

1. 秉承**“被动优先，主动优化，经济实用”**的原则
2. 以先进建筑**能源技术**为主线，以**实际数据**为评价
3. 集成展示世界前沿的建筑节能和绿色建筑技术
4. 为中国超低能耗建筑工作的开展进行探索、研究和示范。力争打造为中国建筑节能科技未来发展的标志性项目
5. 并为制订中国**近零能耗建筑技术标准**提供依据。

示范项目将以近零能耗为目标，达到建筑能效评价标识最高等级标准，并以中国绿色建筑评价标准三星级，LEED绿色建筑评价标准金级为目标进行设计和建造。

目录
Outline

示范意义分析
Project Analysis

1. 北方建筑：针对寒冷地区城市典型问题因地制宜进行示范：夏季炎热多雨、冬季寒冷干燥、空气品质差、交通拥堵

Typical North China Building: demonstrate technologies that are suitable for cold and dry winter, hot summer, bad outdoor air quality, traffic jams and other issues related to public buildings in big cities in North China.

2.被动建筑：被动房示范：墙、窗、外遮阳、屋面；热阻、气密性；施工工法

Passive Building: insist high quality of building envelope such as wall insulation, window system, air tightness and avoid of thermal bridge.

3. 健康建筑：强调室内空气品质管理：PM2.5, VOC，CO2，T，H

Healthy Building: comprehensive indoor environment control for PM2.5, CO2, VOC, temperature, humidity and noise.

示范意义分析（续）
Project Analysis(cont’d)

4. 智能建筑： 重视ICT技术与用户体验：大量应用RFID，无线传感，人脸识别，智能手机，WEB技术，增强用户体验，展示节能技术

Intelligent Building: application of newest ICT technology: WSN, RFID, Computer Vision, Machine Learning, Wireless Communication, Building Automation

5. 示范建筑： 中美清洁能源合作一期科研成果的示范，二期科研工作的载体。

Demonstrative Building: to show and demonstrate the cutting edge technology, research output from CERC Phase I, and promote NZEB.

6. 实验建筑： 多种冷热源形式，多种设备系统组合，完善的数据收集，灵活的系统形式是极佳的科研载体。

Experimental Building: Various combination of equipment and system, complete monitoring and data collection, control and flexible system design, meet different research and experiment requirements.

示范指标体系 Key indicators of CABR NZEB

指标类型 Type of Indicators	指标 Indicator	目标值 Target	说明 Description
一般指标 General indicator	面积 floor area	4025m^2	容纳180人
	增量成本 incremental cost	Base 800RMB/m^2	Experimental 1200RMB/m^2
	层数 floor	4 层 4F	局部2层 partial 2F
	认证等级 certification	GBL 3 star、LEED platinum、EnergyStar 95+	
能源指标 Energy indicator	**能耗水平 energy consumption**	**25 kWh/m^{2}year**	含采暖、空调、照明 including heating, AC, lightiing
	单位面积碳排放 CO_2		
	节能率 Energy saving	>80%	
	最大空调功率 cooling load	30～40W/m^2	
	最大供热功率 heating load	<15W/m^2	
Reso	recyclable material		
	本地植物指数 local plant	100%	
舒适度指标 Comfort indicator	温度Temperature	20~26^{o}C	
	PM2.5	35	
	温湿度 RH	40%～60%	非自然通风、工作时间
	CO_2	1000ppm	非自然通风、工作时间
	VOC	harmless	
其他指标 Others	BA points 检测点数量	1500点	
	wifi覆盖	100%	

能耗指标 Energy Consumption Target: 25 kWh/(m^2.a)

冬季：采暖不依靠化石能源

Winter: zero use of fossil fuel for heating

夏季：空调能耗降低50%

Summer: cooling energy consumption reduced by 50%

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时间计划
Project Timeline

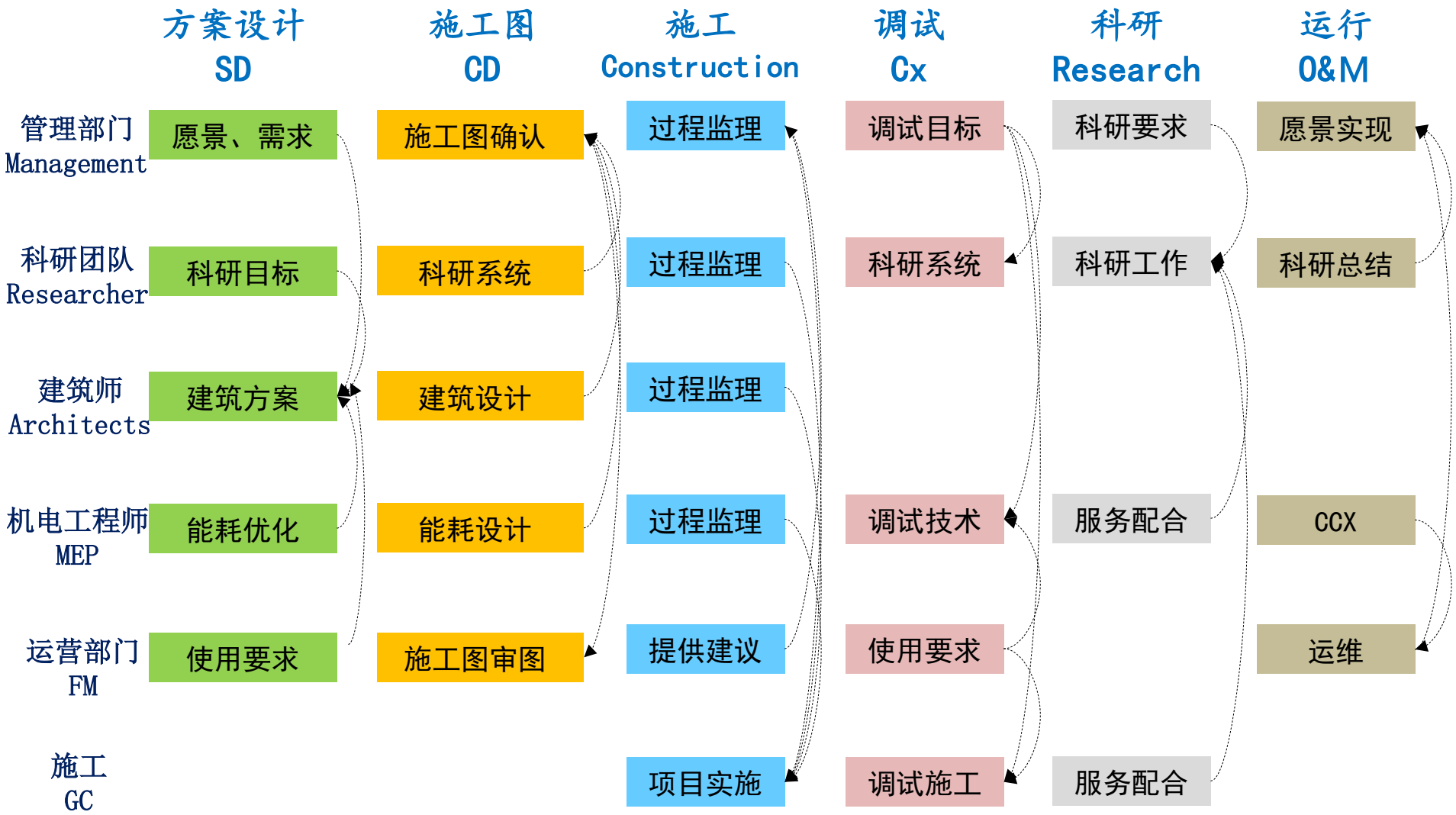
2013年
- 项目启动 kick-off
- 设计、优化 design/optimization
- 施工启动 construction start

2014年
- 主体竣工 Complete construction
- 机电、测量系统调试 commissioning
- 制冷工况实验 experiment in Summer

2015年
- 制热工况实验 experiment in Winter
- 项目运行优化 ongoing commissioning
- 数据监测 data collection

2016年
- 研究工作汇总 research summary
- 项目后评估 evaluation
- 后续研究工作 Other research work

设计建造过程
Process flow



建筑形式
CABR NZEB

建筑形式
CABR NZEB

建筑形式
CABR NZEB

建筑形式：首层
1st floor

会议 Meeting Room

办公 Office

机房 Equipment room

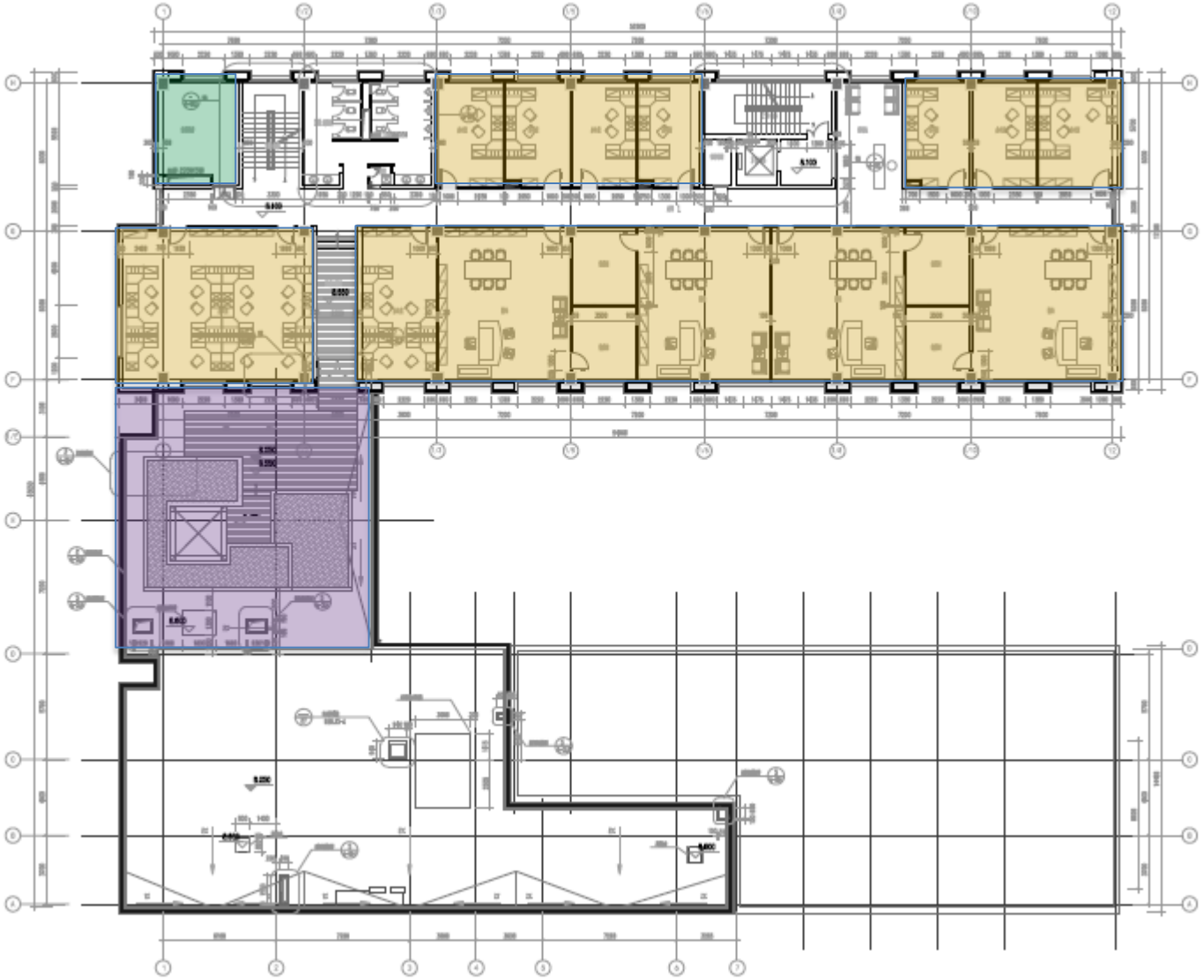
建筑形式：二层
2nd Floor

会议 Meeting Room

办公 Office

机房 Equipment room

建筑形式：三层
3rd Floor



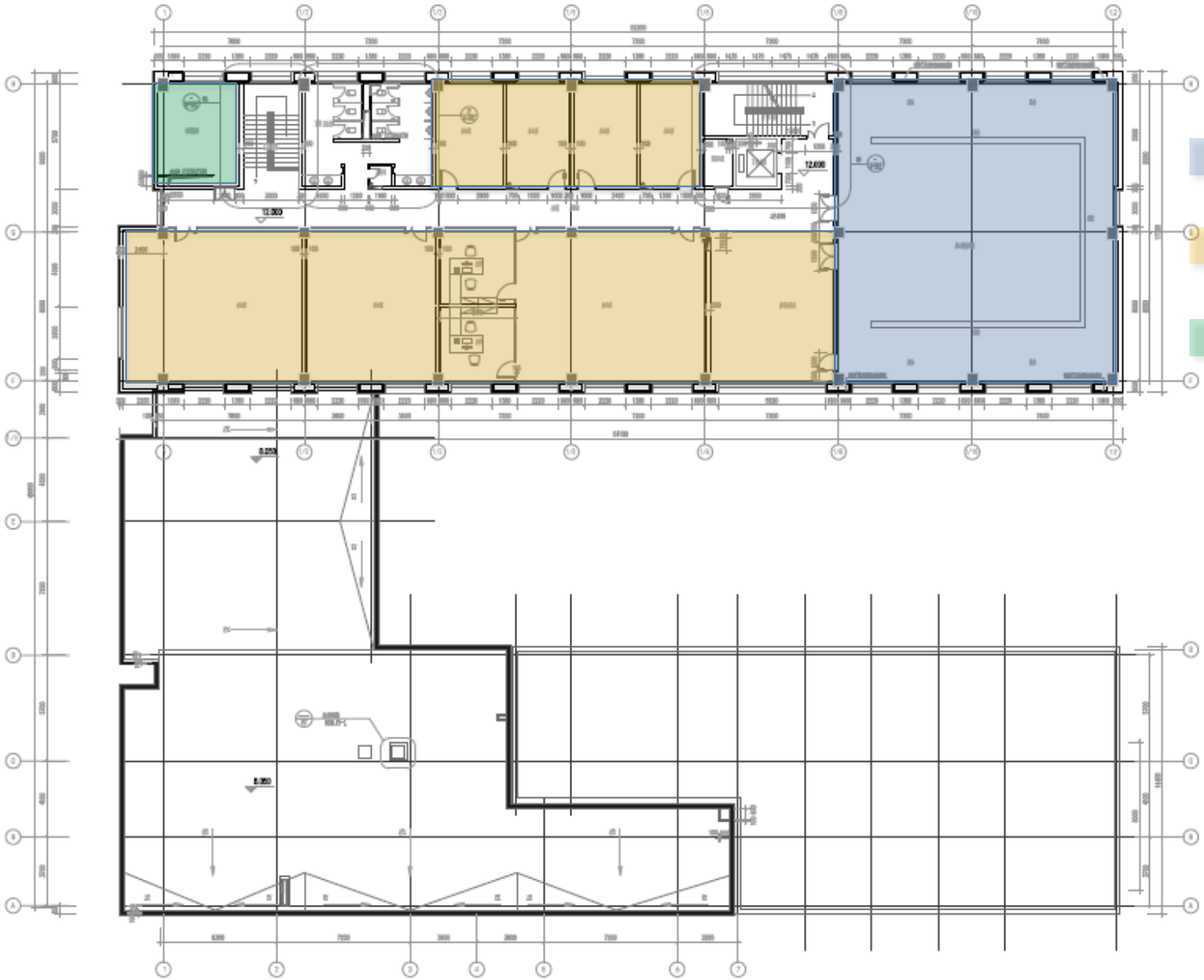
会议 Meeting Room

办公 Office

机房 Equipment room

屋顶花园 Garden

建筑形式：四层
4th Floor



会议 Meeting Room

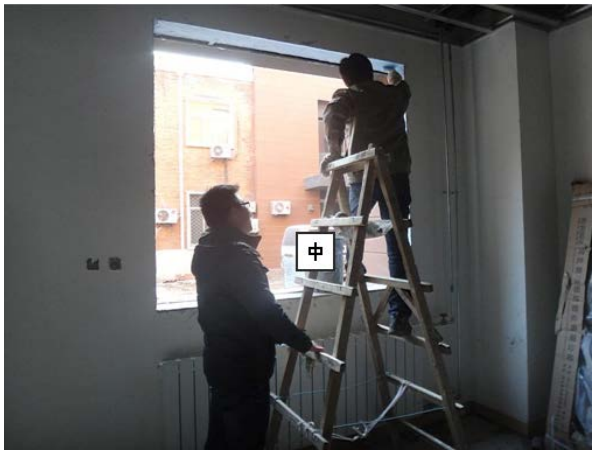
办公 Office

机房 Equipment room

中美交流
US-China Interaction

建造工程
Construction

建造工程
Construction



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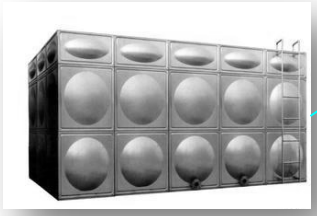
技术体系 – 可再生能源应用
Technology – Renewable Energy

南立面薄膜光伏
建筑一体化设计
Film solar cells

太阳能中温集热槽（供热、制冷、热水）
Median-temperature solar collector

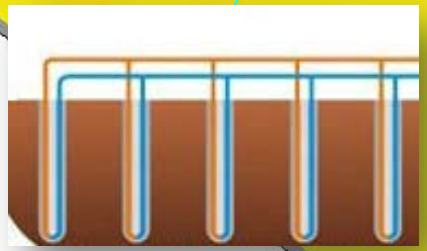
蓄冷水箱（西侧2层部分,30t)
Thermal storage for cooling

高温槽式集热器
High-temperature solar collectors



蓄热水箱（30t)
Thermal storage for heating

地源热泵打井（70口）
70 soil heat exchange wells



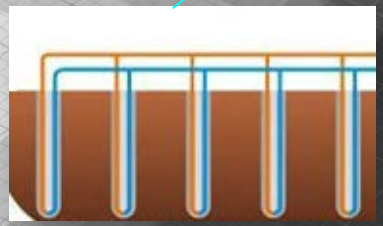
吸收式冷机
Solar driven absorption chiller

技术体系 – 机电系统
Technology – Mechanical System

毛细管辐射吊顶供冷供热（小负荷办公室）
Ceiling radiation cooling and heating

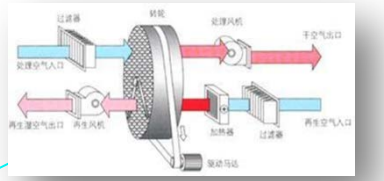
水冷风机盘管供冷供热（会议室）
Fancoils

地板采暖（高温水供冷) Floor radiation cooling and heating



地源井直接供冷

太阳能板预热新风
Integrated Solar thermal system



新风热回收
Ventilation w/ heat recovery

可调节中置遮阳
Controllable shading

Free cooling供冷

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技术体系 – 智能建筑
Technology – Intelligent Building

展示中心
Demonstrative center

多种通讯协议与总线
Integration of multi-bus system

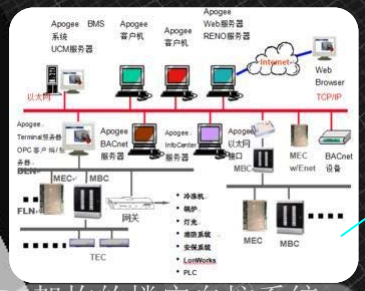
支持多种手持智能设备
Mobil device support

智能视频
Computer vision

RFID

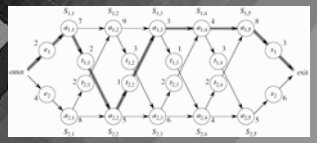
恒照度控制
Intelligent Lighting Control

云计算远程服务器
Cloud computing

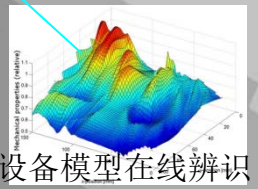


BS架构的楼宇自控系统
BA with BS Structure

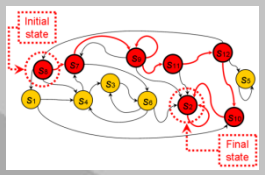
能源管理平台
Energy management system



预测控制与系统优化
MPC

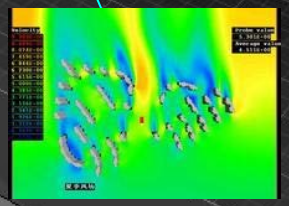


设备模型在线辨识与故障诊断
Building model identification



行为辨识
Behavior identification

技术体系 – 健康建筑
Technology – Healthy Building

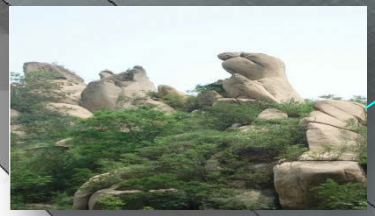


PMV

技术体系 – 节水
Technology – Water Use Reduction

雨水渗透管
Water

植被浅沟、雨水花园
Rain garden



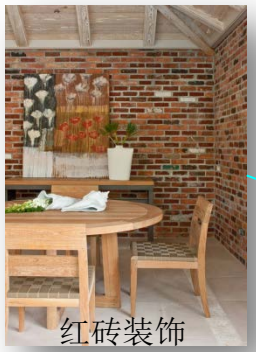
本地免浇灌景观
Local plant need no irrigation

节水感应龙头
Water saving faucet

空调凝水回收
Condensing water recycle

节水感应洁具
Water saving toilet

技术体系 – 材料回用
Technology – Recyclable Resources



红砖装饰
Decoration with construction waste

无障碍设施
Accessibility design

可再利用材料
Recyclable material

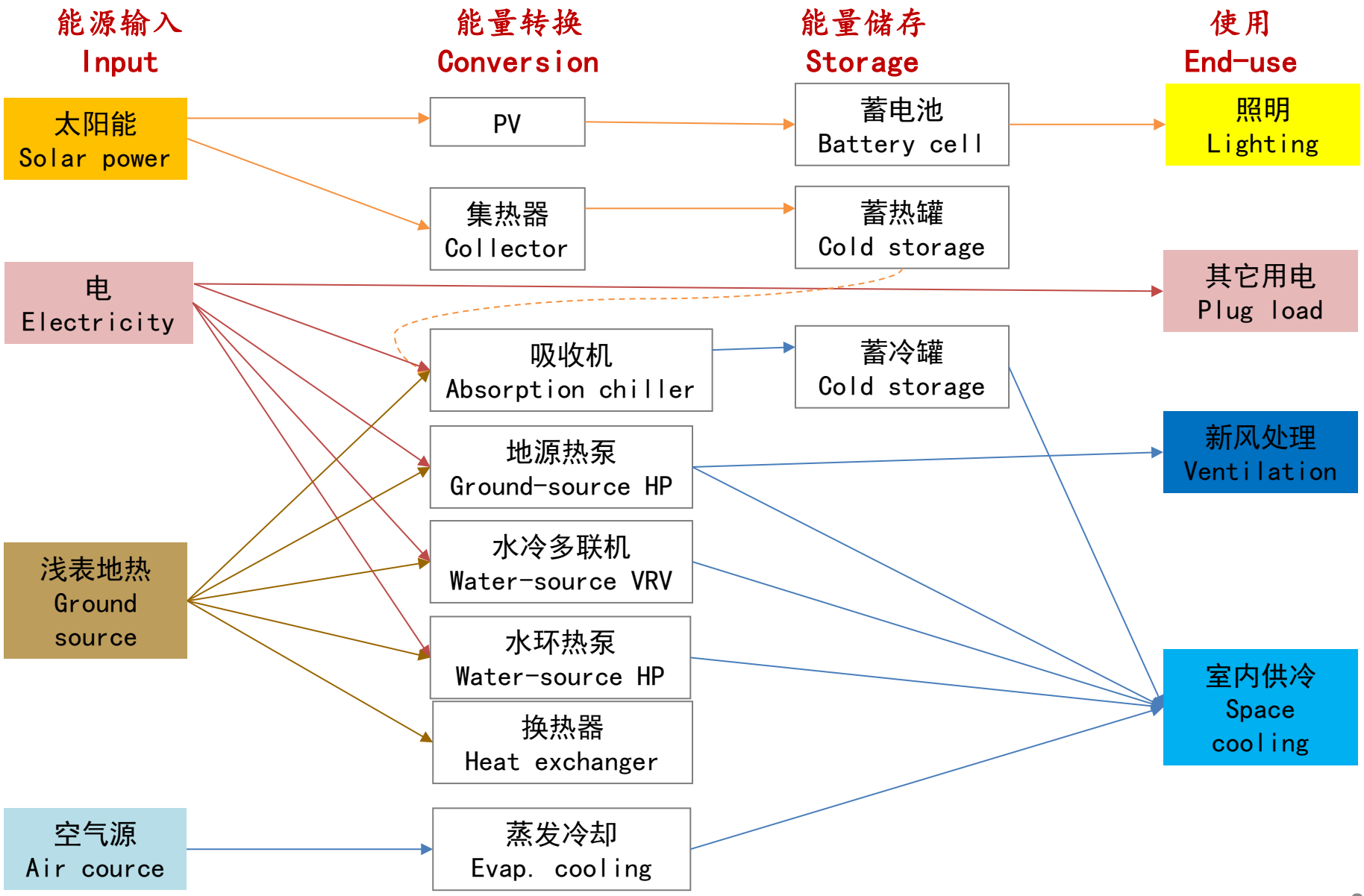
透水地面Water permeable ground

光导管
Solar tube

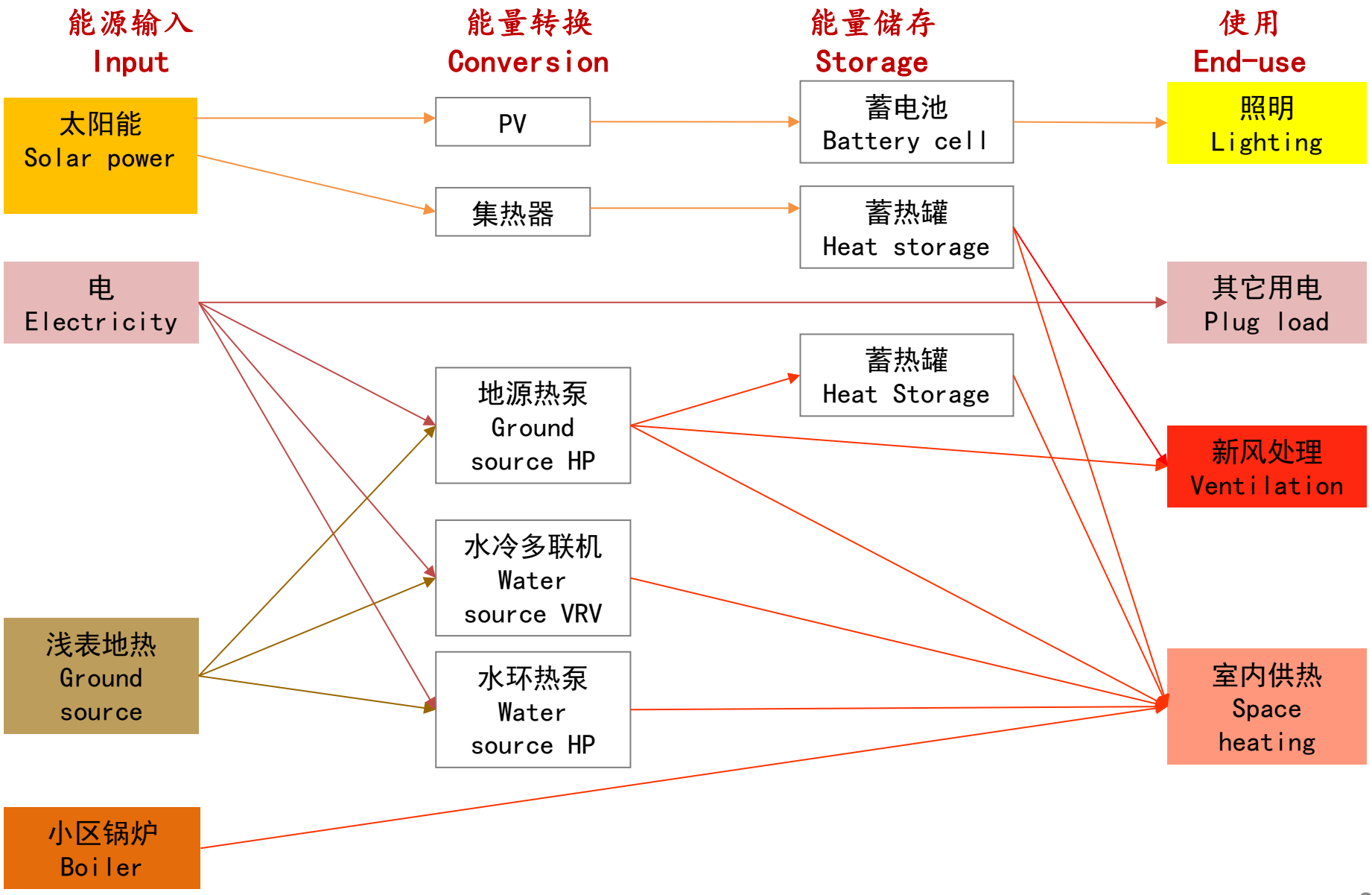
建筑垃圾再利用
Building material reuse

电动自行车棚、充电桩
Electrical bicycle charger

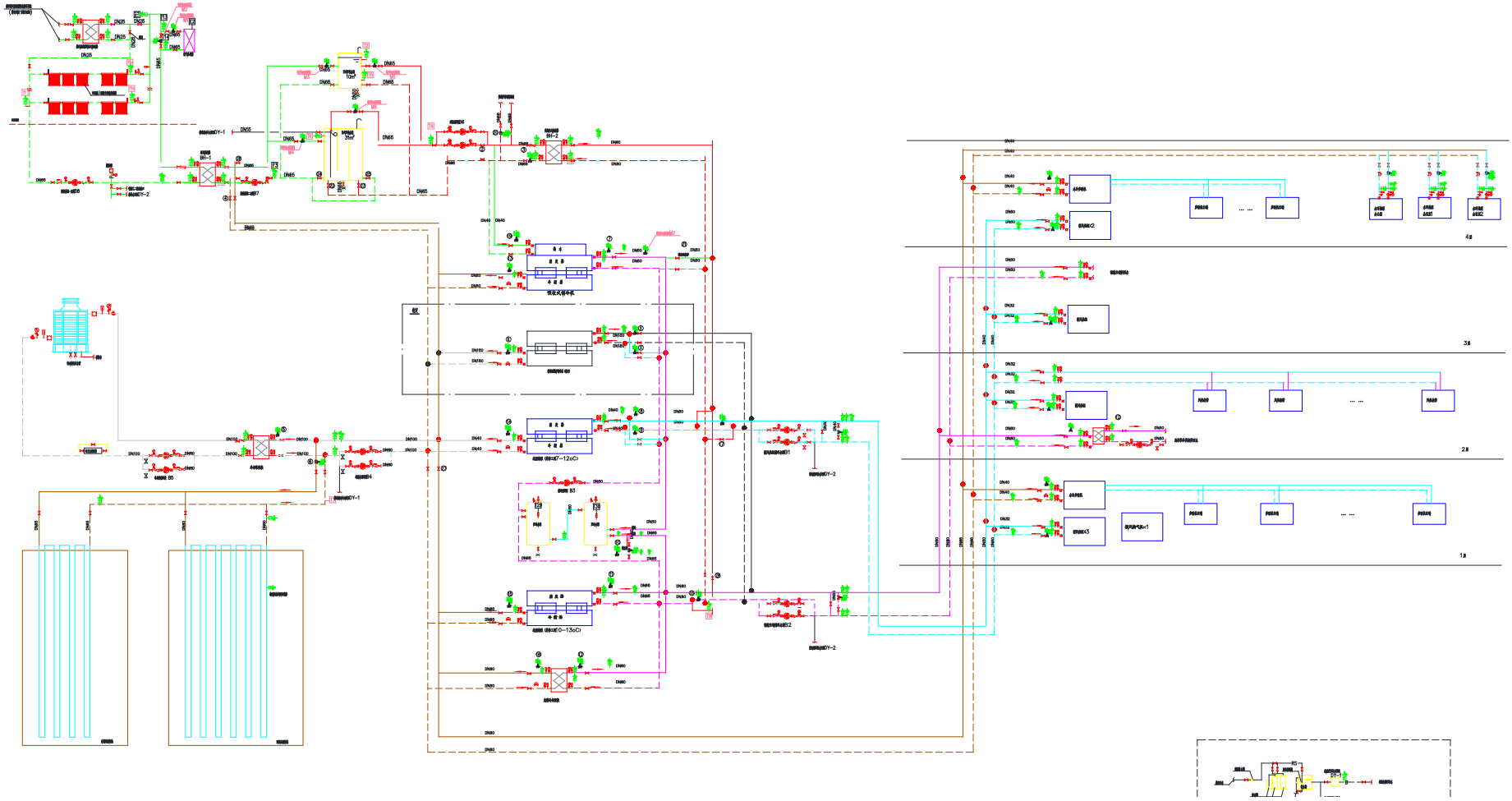
夏季能源流向
Energy Flow – Summer



冬季能源流向
Energy Flow – Winter



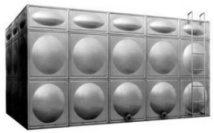
建筑能源系统设计
Energy System Design



建筑能源系统设计
Energy System Design

槽式集热器
HT solar collector

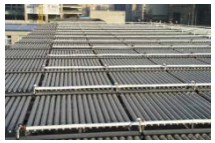
板换
HX



蓄热水箱
Heat
storage

板换
HX

供热
Heating



真空管集热器
MT solar collector

低温吸收式制冷机
Absorption chiller

蓄冷罐
Cold
storage

冷却塔
Cooling Tower

板换
HX

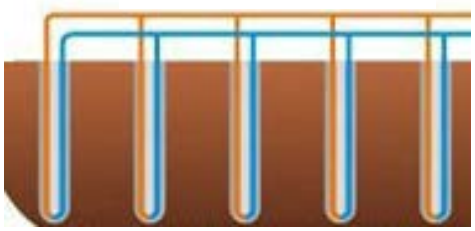
地源热泵 GSHP

供冷
Cooling

地源热泵 GSHP

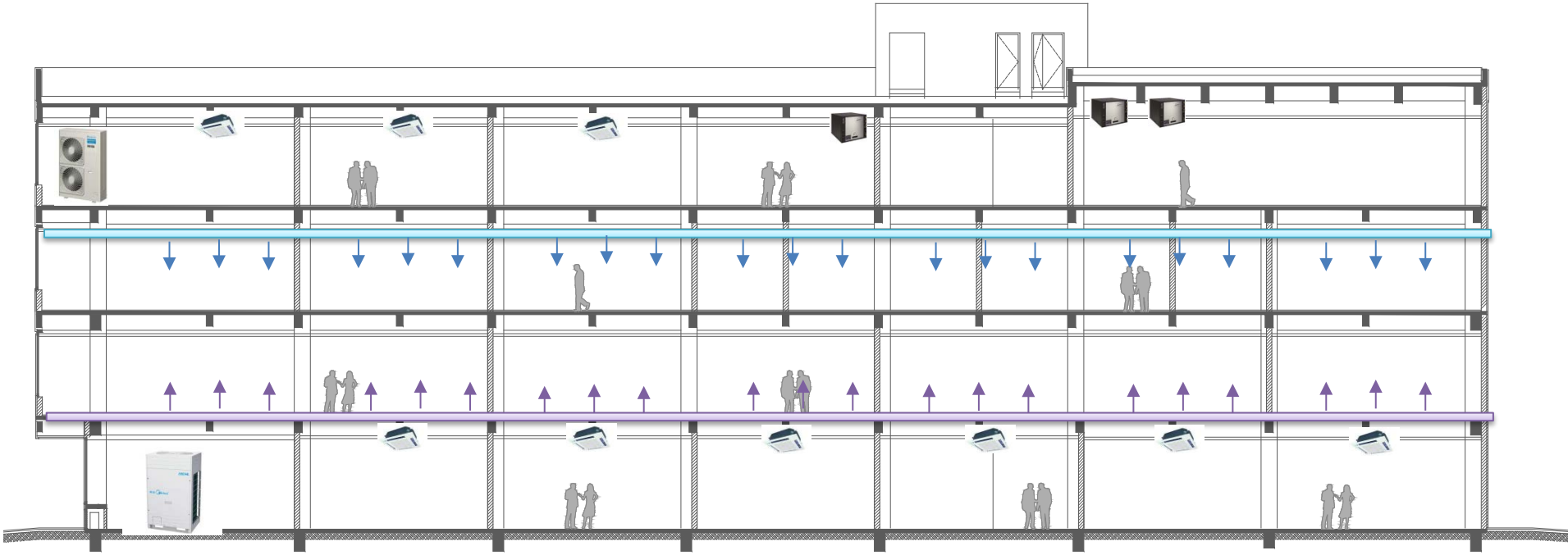
供冷
Cooling

地源换热管
Ground HX wells

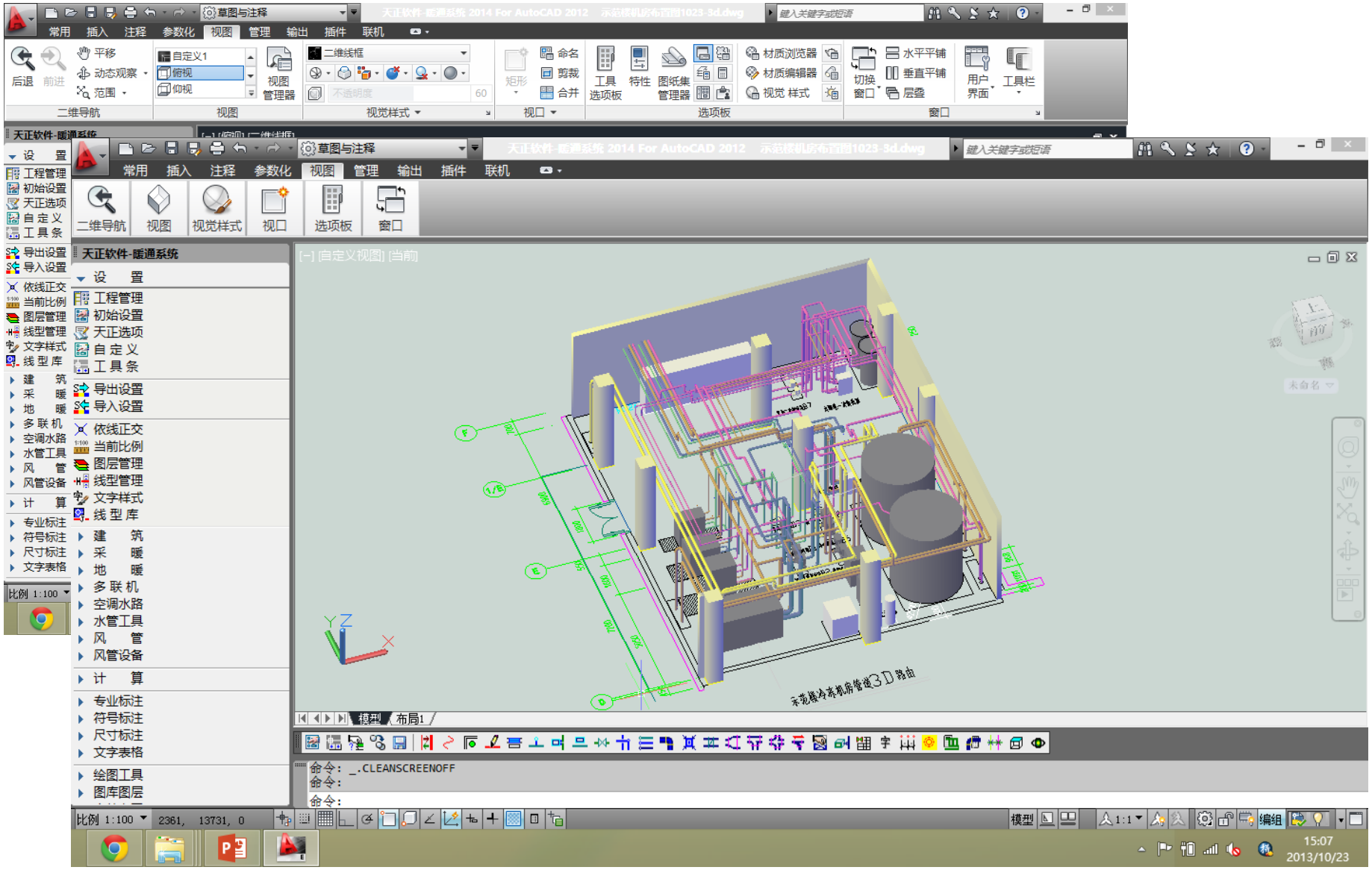


磁悬浮冷机
Magnetic Suspension
Chiller

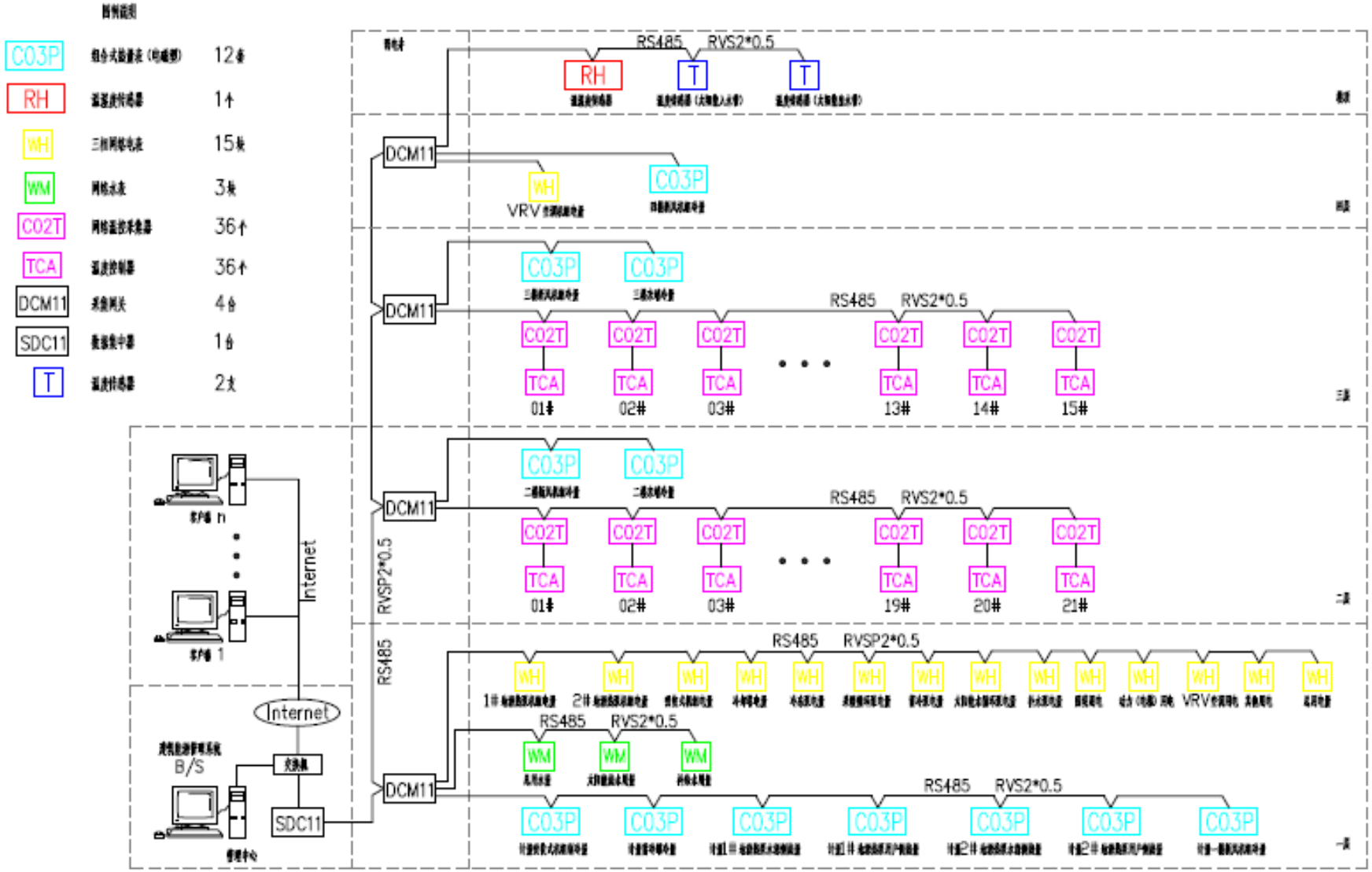
室内末端设计
HVAC Terminals



冷热源站设计
3D design of Heating and Cooling Plant



计量系统图
EMS system diagram

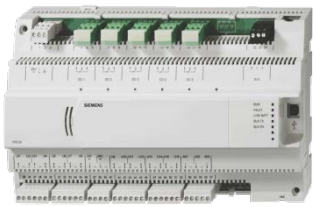


建筑能源管理系统

控制器节能技术
Advanced intelligent controller

Apogee 楼控系统架构　Apogee BMS Framework

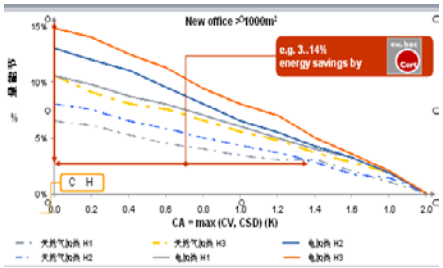
智能控制器 Controller

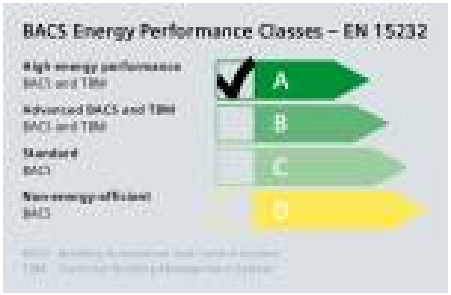


节能功能 Features

- 峰值能源管理
- (Peak demand limiting)
- 最优化启停控制
- (Start-Stop time optimization)
- 设备循环启停控制
- (Equipment scheduling, optimization and sequencing)
- 日夜模式控制
- (Night setback control)
- 自适应控制
- (Adaptive control)
- PID 闭环控制
- PID 参数自整定功能

节能量





自适应控制技术 adaptive control

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签约产业伙伴-国内
Industry Partners-Domestic

奥润顺达 ORIENT SUNDAR

VICOT 奇威特

HOLTOP 环都拓普

海尔中央空调

美的 Midea

TICA 天加中央空调

KONDON 金盾建设

瑞迪北方 RUIDIBEIFANG

建研晖润 JIAN YAN HUI RUN

风神集团 FENGSHEN GROUP

GEAREA 格瑞空调

建研科技股份有限公司 CABR TECHNOLOGY CO.,LTD.

建研爱康 JIANYAN AIKANG

力诺瑞特 LINUO PARADIGMA SOLAR ENERGY

AKE 艾科电子 AKE ELECTRONIC

签约产业伙伴-国际
Industry Partners-International

PHILIPS
SIEMENS
LUTRON
克莱门特 CLIMAVENETA
YAZAKI
GREENERGY
rbm
DAIKIN
aldes 爱迪士
Apollo Solar
TS
CLIMATEMASTER
CPHEX Plate Heat Exchanger
Honeywell
GRUNDFOS
Armstrong Pump Products
SAGE SAINT-GOBAIN
中国节能
SOLATUBE Daylight Technology,Co.,Ltd.

示范楼承载课题 Research Plan

设计方法与标准体系 Design & Bldg. Code

- **子课题1**：寒冷地区超低能耗建筑技术适用性分析
- **子课题2**：基于BIM的超低能耗建筑设计软件工作的开发和应用
- **子课题3**：超低能耗建筑评价与设计标准研究

围护结构 Building Envelope

- **子课题1**：外墙外保温系统测试方法及工程应用研究
- **子课题2**：真空绝热保温体系在寒冷地区超低能耗示范楼的长期监测研究

建筑设备 Energy System

- **子课题1**：适用于超低能耗建筑的地源热泵应用技术研究
- **子课题2**：新型照明控制系统的研究与示范
- **子课题3**：超低能耗建筑联合蓄冷蓄热研究

可再生能源利用 Renewable Energy

- **子课题1**：太阳能空调供暖优化设计及控制技术研究
- **子课题2**：太阳能与地源热泵复合供能技术研究
- **子课题3**：太阳能通风发电系统的研究

调试与运营管理 Cx and O&M

- **子课题1**：既有建筑空调系统调试技术研究
- **子课题2**：超低能耗建筑跨系统在线学习优化系统
- **子课题3**：基于人员行为辨识的建筑能源管理系统
- **子课题4**：基于能耗比对工具的低能耗建筑能耗评价方法的研究

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CLIMATEMASTER

China-US Cooperation water-source heat pump

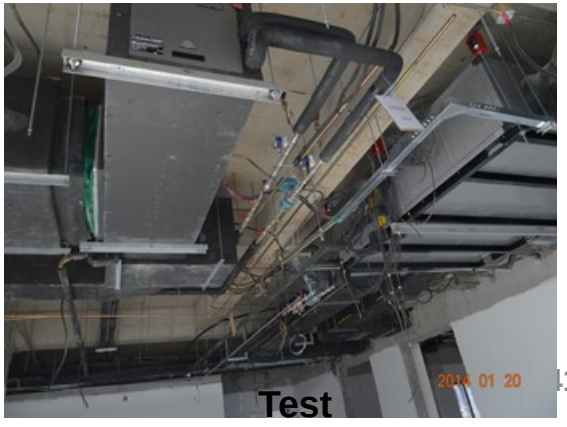

shipment


examination


installation

Three climatemaster water-source heatpumps have been used as the major heating/cooling source of three rooms and the exhinibition/meeting room of the project.
The equipment has arrived and been installed under the aide from the US partner.

Model	Water Loop Heat Pump				Ground Water Heat Pump				Ground Loop Heat Pump			
	Cooling 30°C		Heating 20°C		Cooling 15°C		Heating 10°C		Cooling 25°C		Heating 0°C	
	Capacity kW	EER W/W	Capacity kW	COP	Capacity kW	EER W/W	Capacity kW	COP	Capacity kW	EER W/W	Capacity kW	COP
TSH/V009	2.29	4.5	2.70	4.8	2.73	7.4	2.29	4.3	2.46	5.3	1.73	3.4
TSH/V012	2.88	4.5	3.36	4.5	3.27	7.2	2.87	4.0	3.03	5.3	2.31	3.5
TSH/V/D018	4.58	4.5	5.46	5.2	5.24	7.5	4.46	4.5	4.80	5.6	3.44	3.6
TSH/V/D024	6.18	4.9	7.03	4.9	7.04	7.8	5.94	4.3	6.48	5.8	4.51	3.7
TSH/V/D030	6.94	4.6	8.29	5.0	7.80	6.9	6.98	4.4	7.24	5.3	5.60	3.8
TSH/V/D036	8.12	5.0	9.45	5.5	9.18	7.6	7.81	4.8	8.49	5.8	6.10	3.9
TSH/V/D042	9.21	4.8	11.73	5.4	10.56	7.3	9.52	4.6	9.68	5.9	7.50	3.8
TSH/V/D048	11.57	4.6	14.24	5.0	13.27	7.0	11.63	4.4	12.29	5.3	9. 26	3.7
TSH/V/D060	15.02	4.8	16.71	5.0	16.50	7.0	13.94	4.5	15.58	5.5	11.04	3.7
TSH/V/D070	16.62	4.3	20.37	5.0	18.98	6.5	16.48	4.3	17.43	5.0	12.82	3.6


Test

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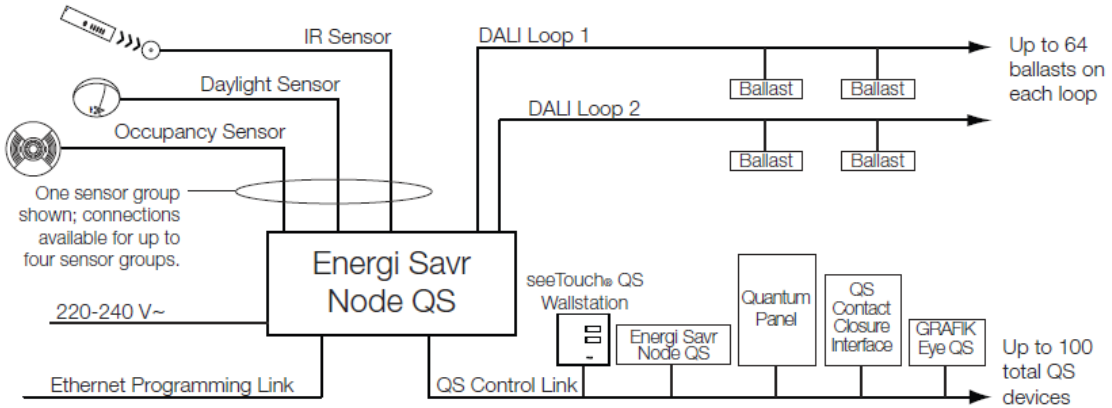
China-US Cooperation
smart lighting control system

LUTRON's smart lighting control system has been used to control the 2nd and 3rd floor of the demo building.

Wireless sensor networks, Occupancy based control, Daylight sensors and IR sensors has been installed to reduce the lighting power consumption.



Energy consumption data will be collected onsite and compared to the values of the 1st and 4th floor.

The system was designed by the US partner and the product has been installed and under commissioning.

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China-US Cooperation
air barrier system

1. Wrap window with 3M air barrier

Before wrapping air barrier

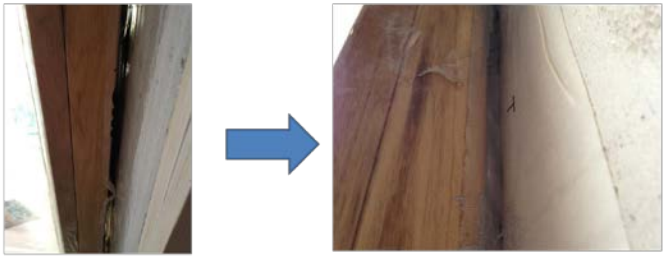
Wrap window with 3M air barrier before installation

2. Wrap rough opening with 3M air barrier

Before wrapping air barrier

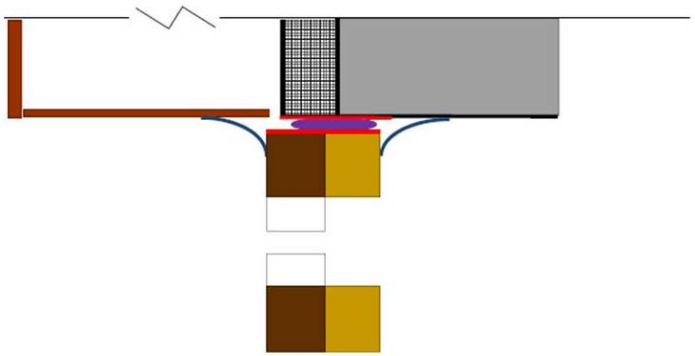
Wrap rough opening with 3M air barrier

3. Sealing the gap with 3M powerline 540



Before sealing

Sealing the gap with 3M powerline 540



3M provide the air barrier system, which include 3M air barrier product and powerline 540 sealing.
The chosen window's thermal property and performance that affect the installed room will be monitored and compared against other windows.

The research will be conducted collaboratively between the Lawrence Berkeley National Laboratory, ORNL, and CABR.

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China-US Cooperation
liquid flashing window sealing system

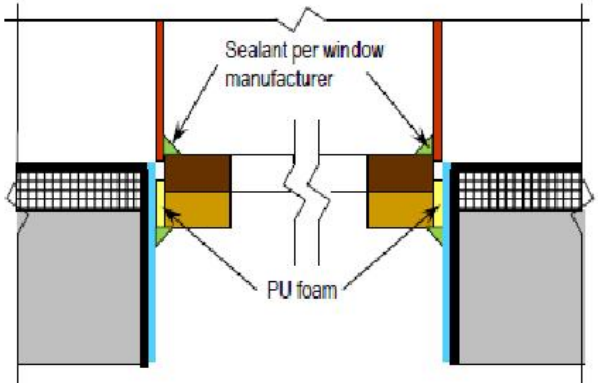
1． Before brushing liquid flashing

2. brushing liquid flashing

3. Installing windows

DOW provide the liquid-flashing material and help CABR develop an approach to handle the air-sealing problem of the windows.

The research will be conducted between the Lawrence Berkeley National Laboratory, ORNL, and CABR.



4. finish

中美合作课题
US-China Tentative Research projects

	Project General Information			Collaboration Area		
	CERC-US Projects	US Research leader	China Research leader	Research	Codes and Standards	Pilot Project
B1	Sun shading systems, low-e window technology, design, and related products	LBNL - Eleanor Lee eslee@lbl.gov	CABR-Song Bo songbo75@sohu.com;songbo163163@163.com;sisi_zh@163.com	Simplified Shading Coefficient Calculation Method Compared with JGJ/T 151-2008<Calculation specification for thermal performace of windows, dorrs and glass curtain walls>	The simplified method could be used in GB 50189 <Design Standard for Energy Efficiency of Public Buildings>.	If LBL would like to donate the latest ultra-low energy window or sun-shading system, CABR would like to use it in Pilot Project. Result testing and simualtion proof could follow up in Y14&15
B2	Liquid Flashing to Air Seal Windows, Doors and Piping Penetrations	ORNL - Diana Hun hunde@ornl.gov	CABR-Yang Yuzhong	Based on US original proposal	N/A	How to cooperate is under discuss by Yuzhen and Diana.
D2	Ground Source Heat Pump (GSHP)	ORNL - Xiaobing Liu, (Patrick Hughes) liux2@ornl.gov	CABR-XU Wei xuwei01@126.com	Based on US original proposal	N/A	CABR had already use CM in pilot building. System will be tested and simulated billateral.
New	Building energy system Commissioning	LBL	CABR-Song Yehui songyh@ncsa.cn	Waiting to be discussion	Building Energy System Commissioning Guideline	LBL and CABR both choose a project to exchange commissioning experience.
New	GB50189 Energy Saving Potential Post Analysis		CABR-Zou Yu zouyu01@126.com	ASHRAE90.1-2013 VS GB50189-2013; GB50189-2005 VS 2013;GB50189 Post Evaluation	GB 50189 <Design Standard for Energy Efficiency of Public Buildings>	N/A

目录
Outline

总结 Summary

目标 Target

示范项目位于中国建筑科学院内，建筑面积约4025平方米，共4层，建成后作为建筑环境与节能研究院的办公会议楼和技术展示中心，依托中国建筑科学研究院，在行业内进行技术辐射和推广，并打造成政府、行业和公众的技术交流、展示平台。

The CABR NEZB is a 4 floor building of area of 4025m^2. CABR NZEB has become the integrated platform for cutting edge NZEB technologies. It also serves as the R&D facility for NZEB related products and solutions.

优势 Advantage

项目北京的中心地带，属于寒冷气候区，承担单位有长期从事建筑节能工作的经验，并且非常重视本示范工程项目，成立院领导小组和工作小组，已开展大量的设计、优化、合作伙伴邀请和课题设计工作。

The project is located at the center of Beijing, which belongs to a cold climate zone. The building has full support from CABR and partners with sufficient funding, strong research and engineering team, excellent public awareness and industry support.

总结 Summary

愿望 Vision

项目建成后，将向公众开发数据，并进行公开后评估，将建成为有真实数据的近零能耗示范楼。

项目将成为CERC二期研究工作的有力载体，成为与众多研究合作伙伴共同开展研究的有效场所，为近零能耗建筑研究工作提供支撑。

The project has deep connection to building industry. The building will boost the strong growth of NZEBs in China. With its openness to public, CABR NZEB hope to become a public education center for NZEBs in China.

中国建筑科学研究院近零能耗示范楼以先进建筑能源技术为主线，以实际数据为评价，运用全新设计理念打造中国建筑节能科技未来发展的标志性项目，以国际化视野推动建筑可持续发展，树立中国零能耗建筑探索新坐标，引领中国建筑节能事业发展新航向！ CABR NZEB applies advanced energy conservation technology, collects real-time operation data for evaluation, uses innovative design concept to create signature project for future development of energy efficiency technology in China, with international perspective to promote sustainable development. It is a new icon for zero-energy building and steering the development of building energy conservation in China.

谢 谢！
Thank You!