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Institute of Building Environment and Energy Efficiency

Development and case study of passive buildings in China

CHEN Xi & ZOU Yu

Institute of Building Environment and Energy

China Academy of Building Research

China Passive Building Alliance

中国被动式超低能耗建筑联盟
China Passive Building Alliance

OUTLINE

- Status in quo of passive building in China
- Best Practices and Case Study
- Conclusion and future work

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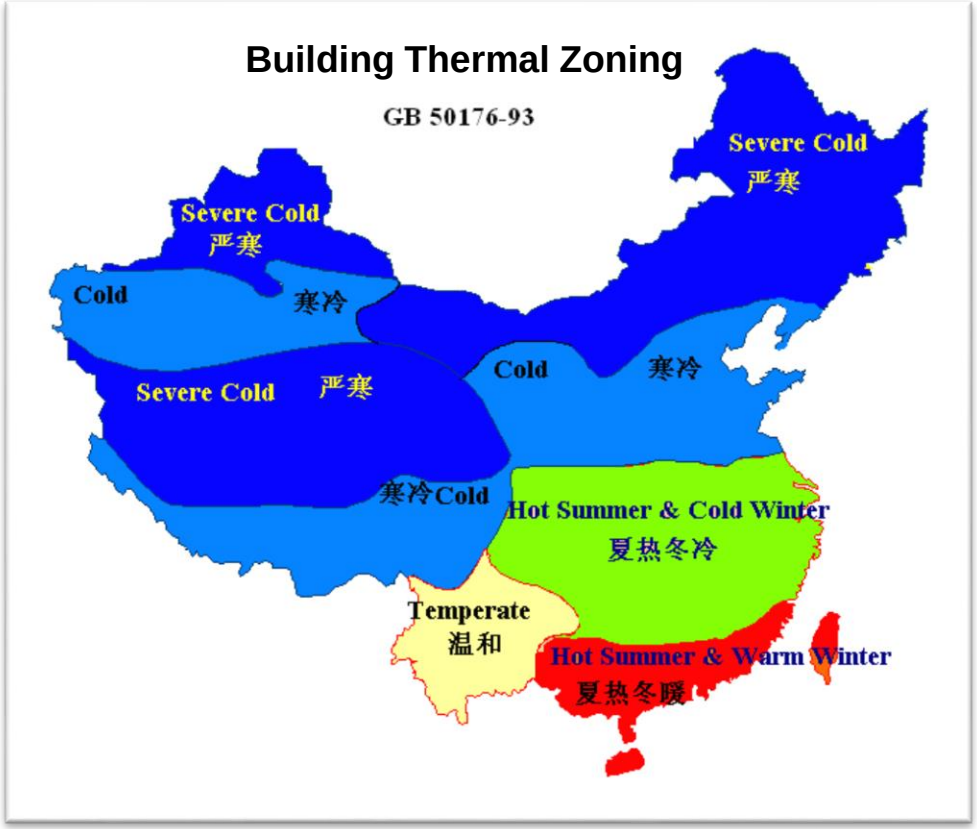
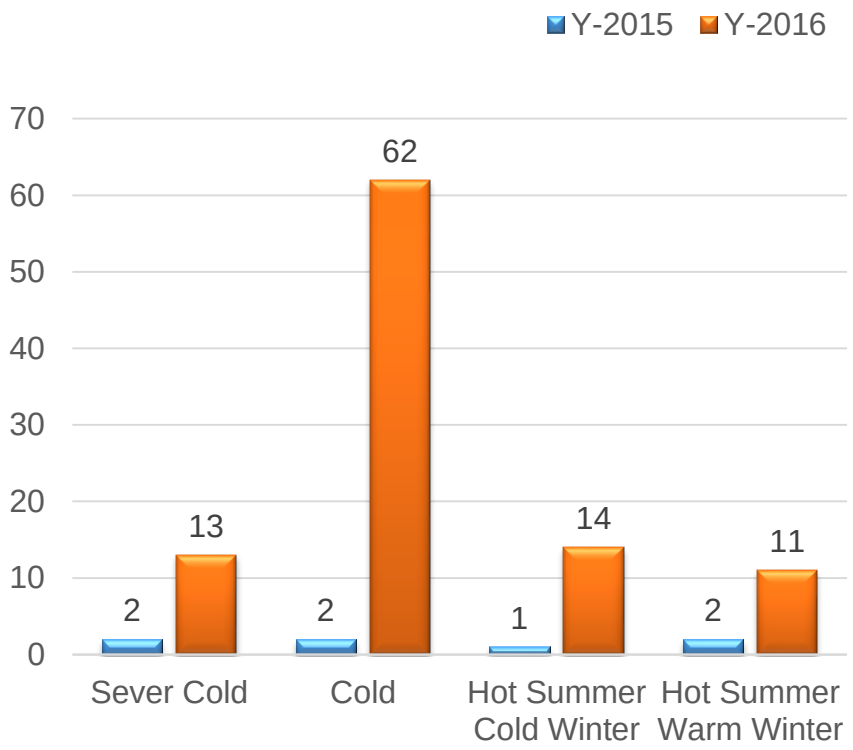
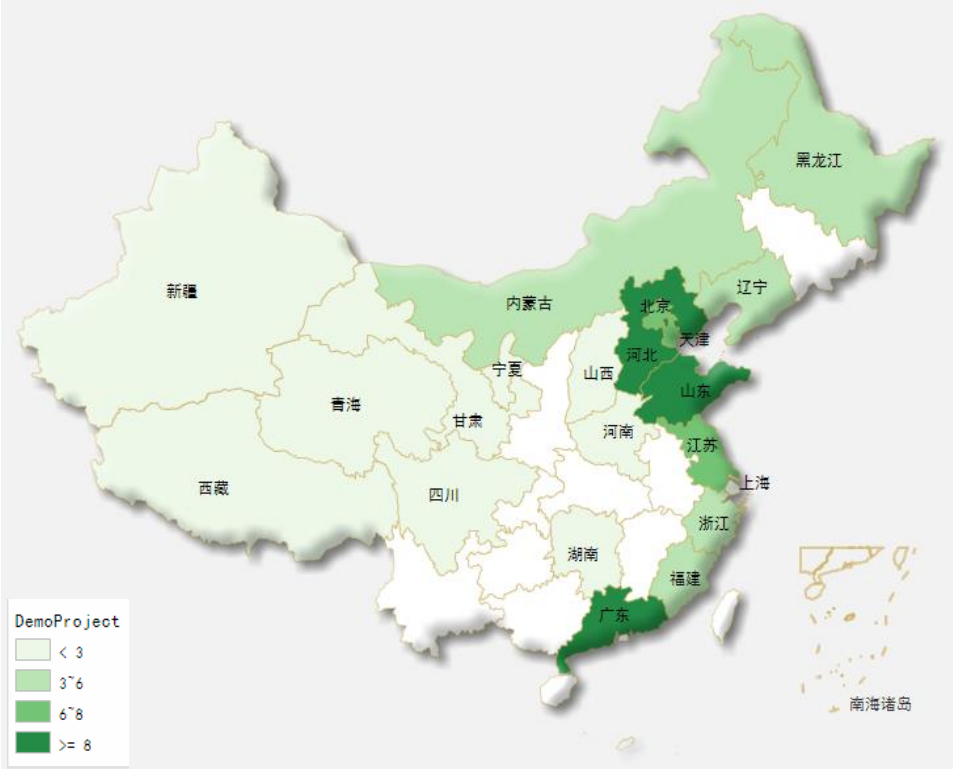
Status in quo of passive building in China





Ultra-low Energy Building Projects distribution by Climate Zones

Status in quo of passive building in China



Ultra-low Energy Building Projects distribution by Provinces

Central Government- Policy and Standards

China State Council

- *Opinions on Further Strengthening the Administration of Urban Planning and Construction (2016)*
- "develop green, energy-effective buildings, **such as passive houses**"

NDRC & MoHURD

- *Action Plan for Urban Adaptation to Climate Change (2016)*
- "promote **passive ultra-low energy green buildings** by using high-performance components of the thermal envelope to improve building tightness and indoor environment"

MoHURD

- *13th Five-Year Plan of Building Energy and Green Building Development*
- "develop ultra-low energy neighbourhoods; nearly zero-energy building pilot projects; and **by 2020**, construct **ultra-low energy and nearly zero energy buildings totalling more than 10 million square meters**."
- National Guideline for residential buildings - published in 2015
- National Standard – on going, planed to be finished in 2018

OUTLINE

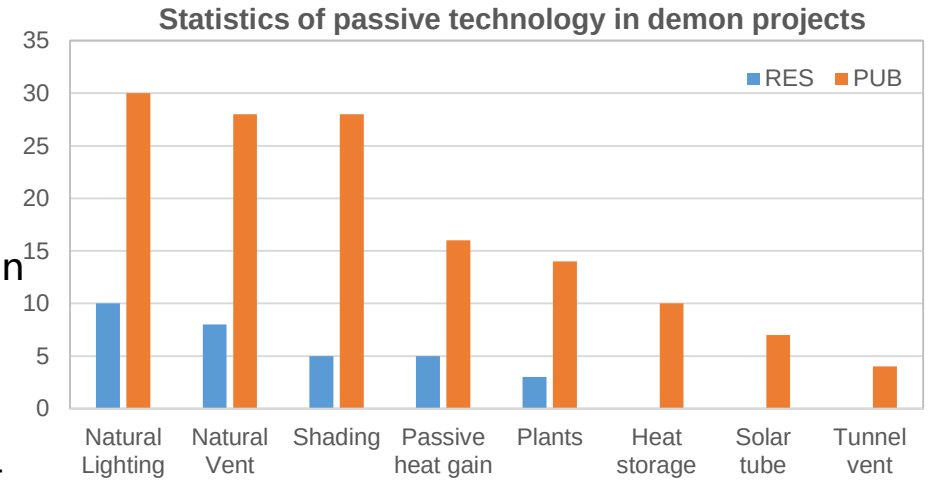
- Status in quo of passive building in China
- **Best Practices and Case Study**
- Conclusion and future work

Best Practices

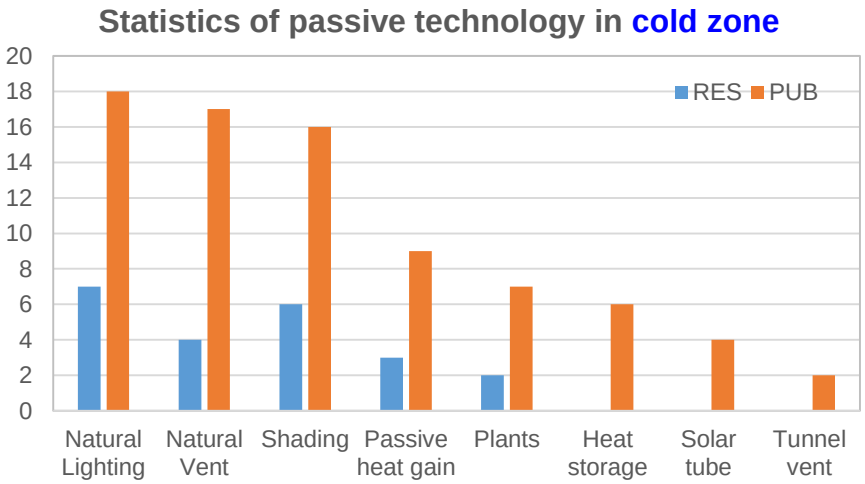
- Cases information including building type, energy performance coefficient, passive and active technical measurement is collected.
- 49 effective reply, where 4 from the server cold zone, 31 from the cold zone, 9 from the hot summer cold winter zone, 5 from the hot summer warm winter zone
- 37 public buildings, 12 residential buildings
- Statistic the passive technical, active technical and the renewable energy application.

• Passive technology application

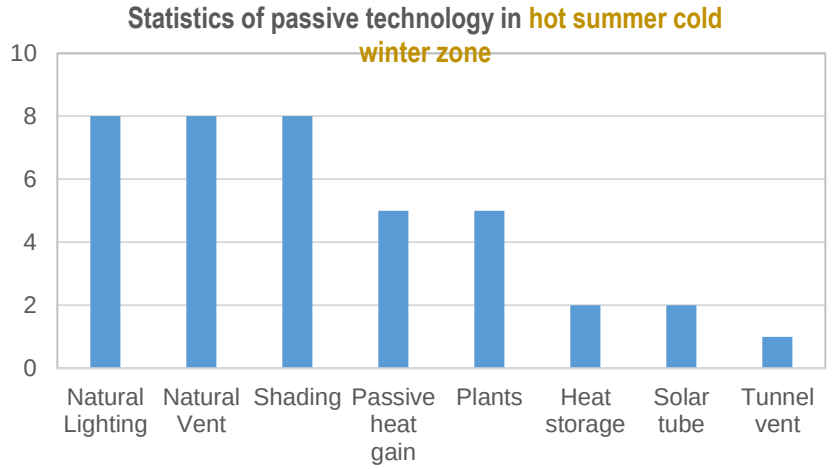
- Generally, the most applied are natural ventilation, natural lighting and shading; shading is used in residential buildings less than in the public buildings, as it is difficult to manage in residential buildings.
- Generally, the least applied are solar tube, heat storage and tunnel ventilation, only few applied in public buildings



37 public buildings and 12 residential buildings in all



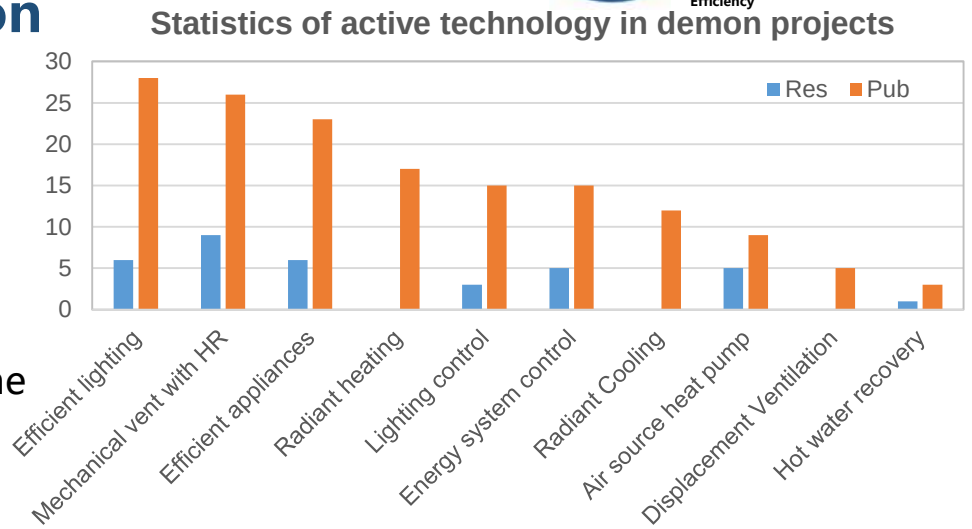
23 public buildings and 8 residential buildings in Cold Zone



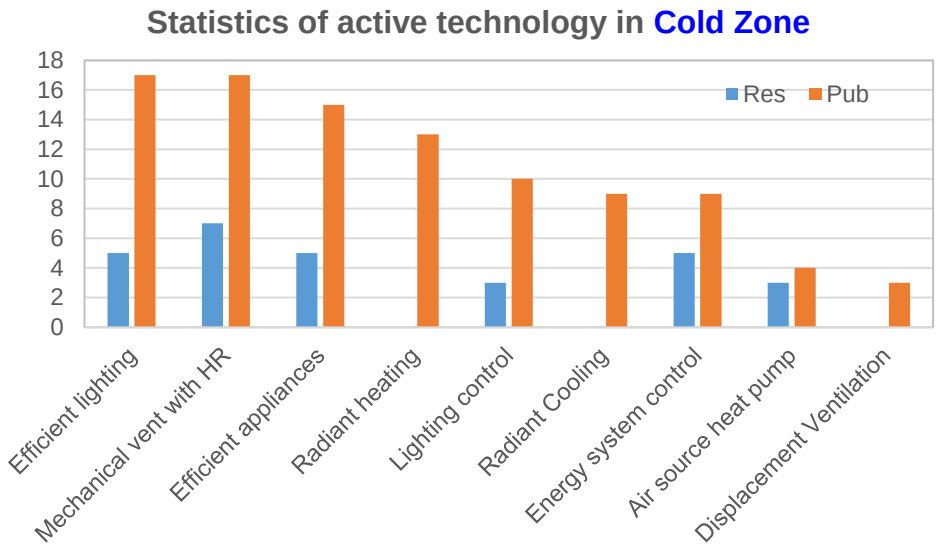
9 public buildings in hot summer cold winter zone

• Active technology application

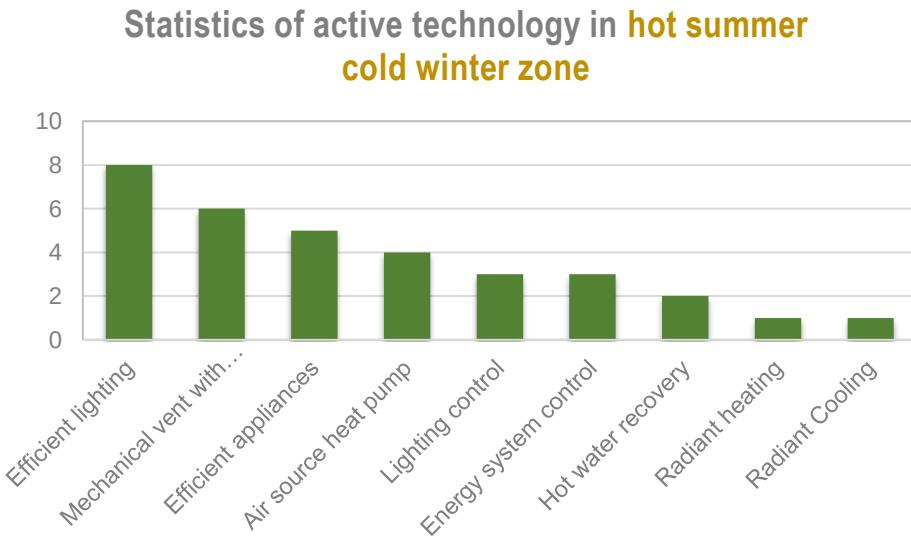
- Generally, the most applied are efficient lighting, mechanical ventilation with heat recovery and efficient appliances
- For residential building, the mechanical ventilation with heat recovery is applied the most



37 public buildings and 12 residential buildings in all

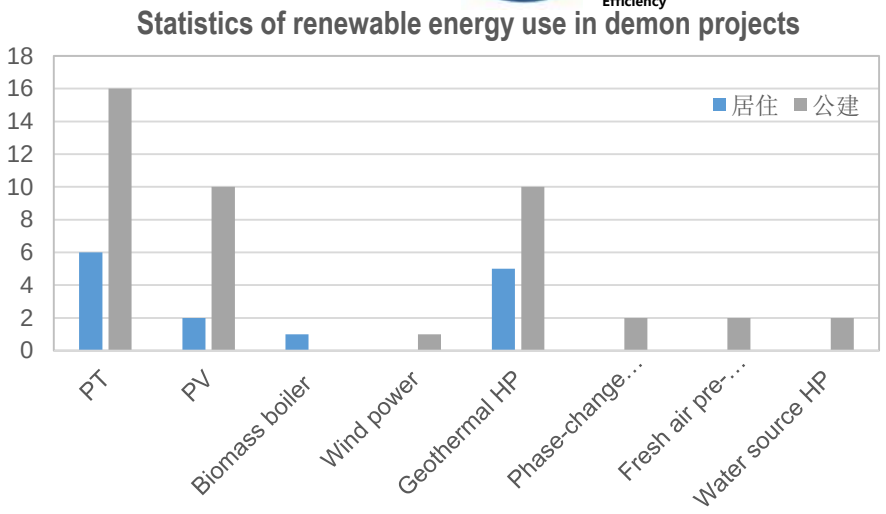


23 public buildings and 8 residential buildings in Cold Zone

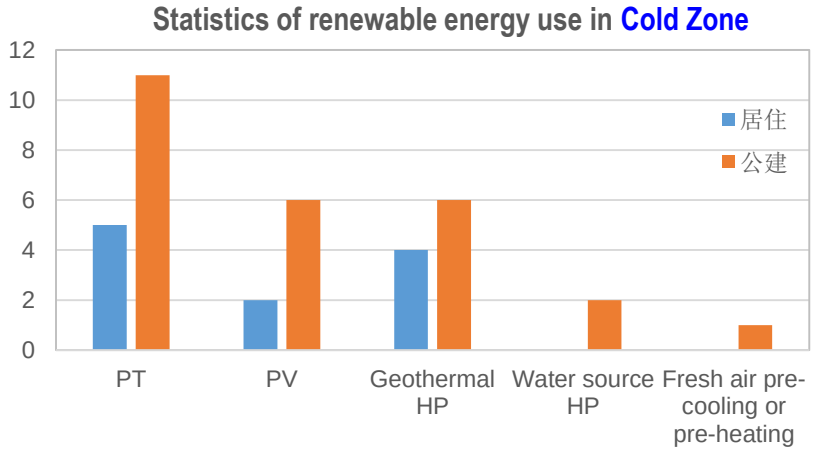


9 public buildings in hot summer cold winter zone

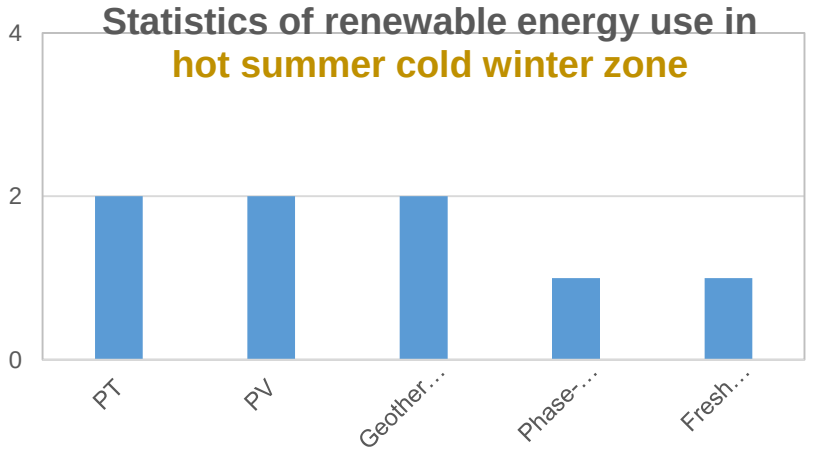
- **Renewable energy application**
- Generally, the most applied are PT, PV and geothermal HP
- PV is applied more in public buildings



37 public buildings and 12 residential buildings in all



23 public buildings and 8 residential buildings in Cold Zone



9 public buildings in hot summer cold winter zone

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Project Background

CABR NZEB is the demonstration building of U.S. China Clean Energy Research program (CERC) on building energy efficiency.

The aim of this demo building is not only to meet a requirement of the CERC project, it is also a summary of CABR's research in the filed of building environment and energy over decades.

The project addresses fundamental issues about the building energy efficiency in China. The principle of the building is "passive building, advanced technology, practical function". CABR demo building can be considered as a innovative Chinese attempt to achieve Nearly Zero Energy Building(NZEB) with affordable cost. The experience acquired from CABR project will be valuable input to the development of future Chinese standard and roadmap toward NZEB.

Overview of CABR Nearly-Zero-Energy building

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The CABR NZEB with floor area of 4025m^2, located at the center of Beijing in cold climate zone, is an office building for CABR. It has become an integrated platform for CERC-BEE cutting edge technologies demonstration and serves as well as the R&D facility for CABR's products and solutions. The building has deep connection with the industry sector and could help raise public awareness from successful demonstration. With real-data-based evaluation and its openness to the public, CABR NZEB has become a signature NZEB project and an education center. It is facilitating strong growth of NZEBs in China and laying foundation for future development of China's NZEB standard.

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

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

冬季 Winter ：采暖不依靠化石能源 zero use of fossil fuel for heating

夏季 Summer：空调能耗降低50% cooling energy reduced by 50%

照明：能耗降低75% reduction of

示范指标体系
Key indicators of CABR NZEB

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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 500RMB/m^2	Experimental 1500RMB/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%

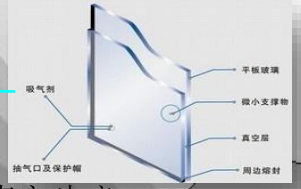
Technology – Building Envelope

无热桥设计
Non-thermal bridge design

气密性保障
Air tightness test

屋顶花园
Roof garden

可调节中置遮阳
Intelligent facade

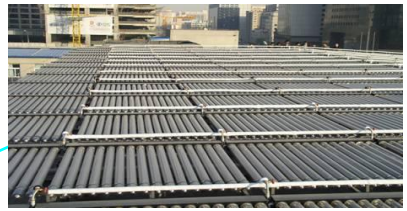


Low-e真空玻璃
Low-e vacuum window K<1.0W/m2K

真空绝热板
STP vacuum plate insulation(0.004W/m^2K)

Technology – Renewable Energy

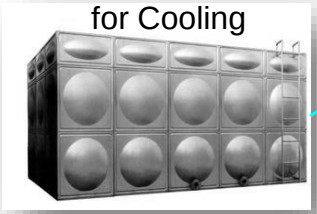
南立面薄膜光伏建筑一体化设计
BIPV



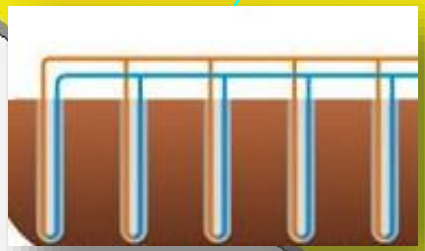
太阳能高温集热槽（供热、制冷、热水）
Median temperature solar collector

蓄冷水箱（西侧2层部分,20t)
Thermal storage for Cooling

高温槽式集热器
High temperature solar collectors



蓄热水箱（西侧2层部分,40t)
Thermal storage for Heating



地源热泵打井（70口）
70 underground heat exchange boreholes

吸收式冷机
Solar driven absorption chiller

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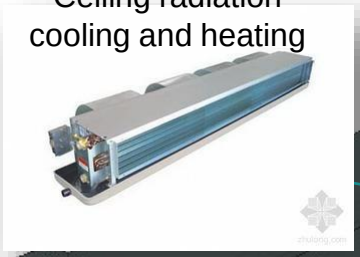
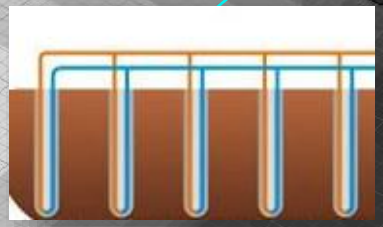
Technology – Mechanical System

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）
FCU using brushless dc motor

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



Free cooling using underground heat exchanger

太阳能板预热新风
Integrated Solar thermal system

磁悬浮冷机
magnetic suspension chiller

水冷多联机
Water cooled VRV

Technology – Intelligent Building

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展示中心
Control center

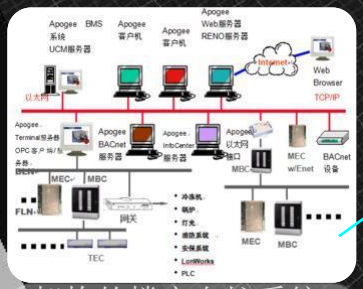
多种通讯协议与总线
Integration of multi-bus system

支持多种手持智能设备
Mobil device support

智能视频
Computer vision

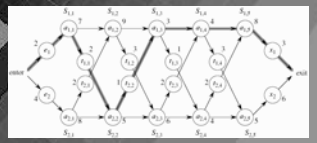
恒照度控制
Intelligent Lighting Control

云计算远程服务器
Cloud computing

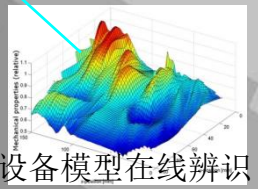


BS架构的楼宇自控系统
BA with BS Structure

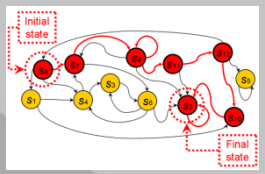
能源管理平台
Energy management system



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

Technology – Healthy Building

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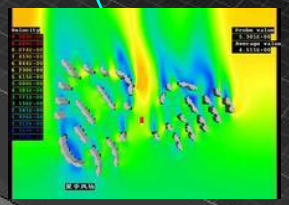

Technology – Water Use Reduction

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雨水渗透管
Water

节水感应龙头
Water saving faucet

空调凝水回收
Condensing water recycle

植被浅沟、雨水花园
Rain garden

本地免浇灌景观
Local plant need no irrigation

节水感应洁具
Water saving toilet

Technology – Recyclable Resources

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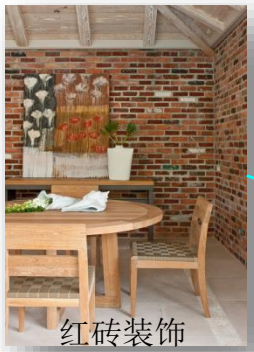
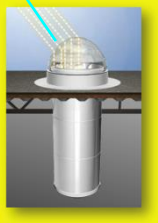


红砖装饰
Decoration with construction waste

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

Industry Partners (including US)

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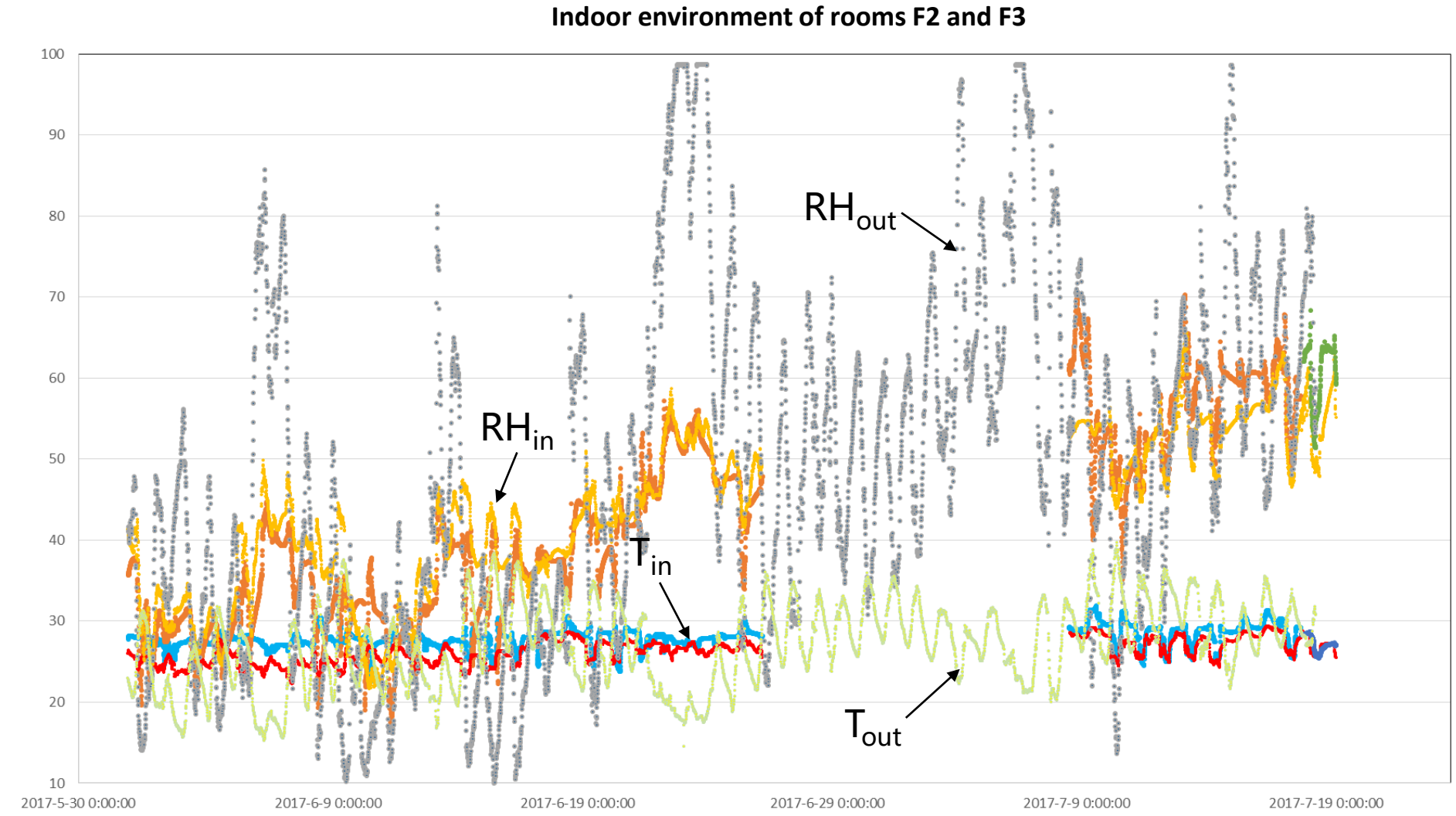
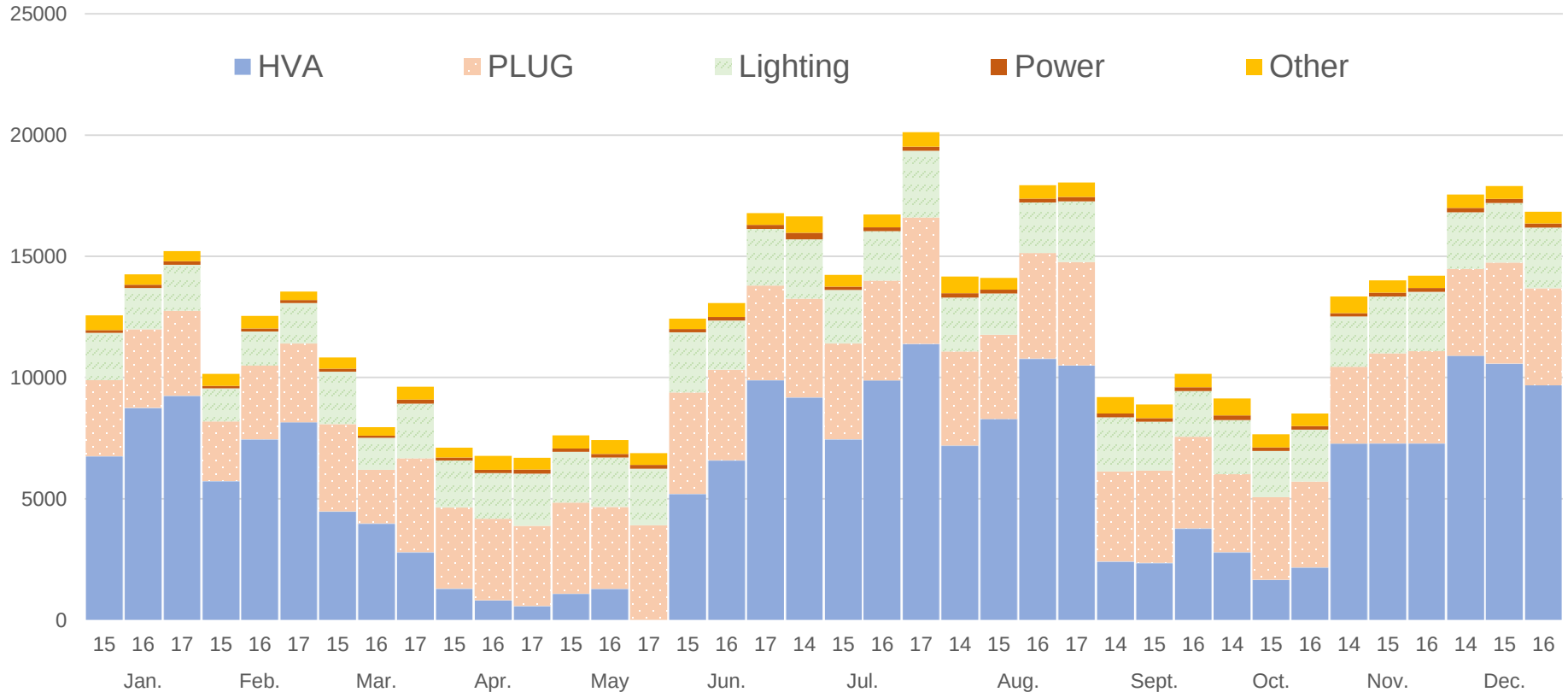
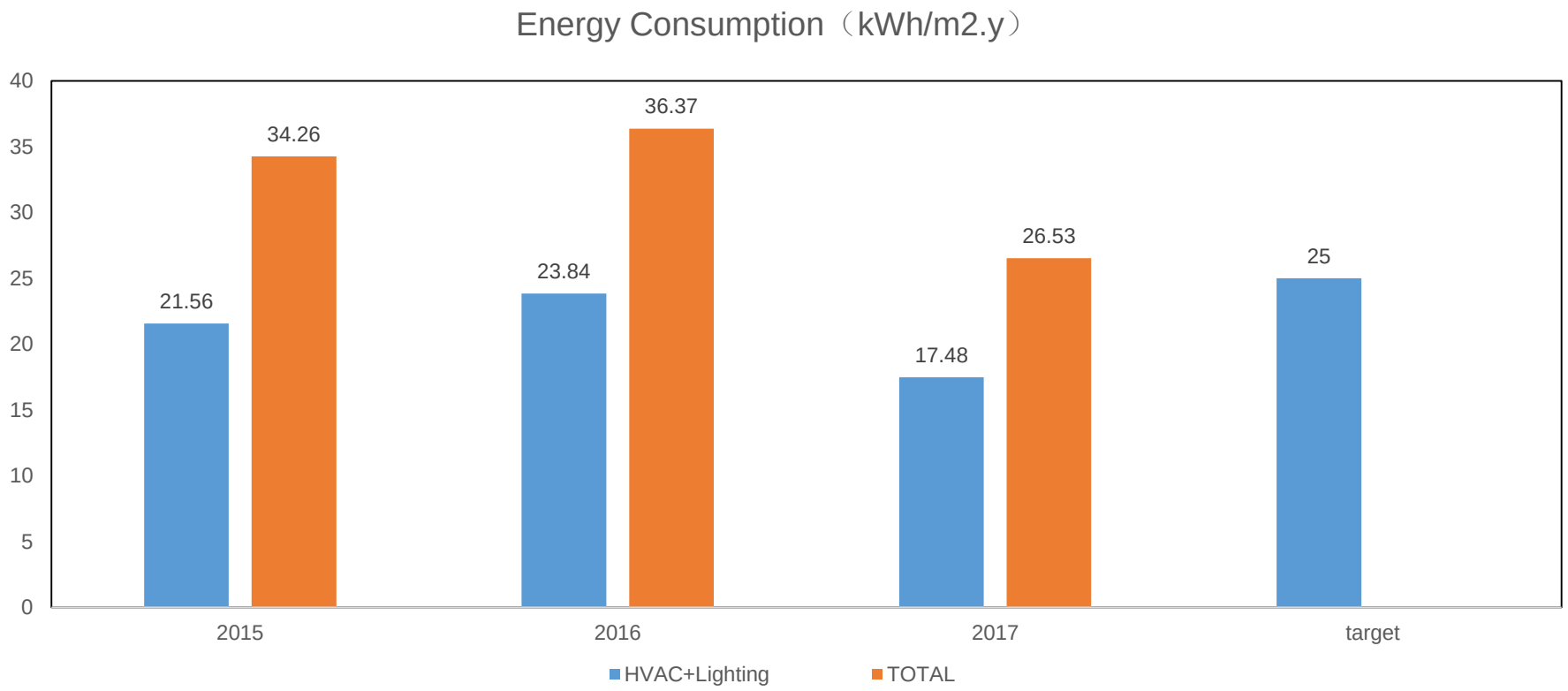
Indoor Environment of the CABR NZEB v.s. Outdoor



Annual power consumption of the CABR NZEB

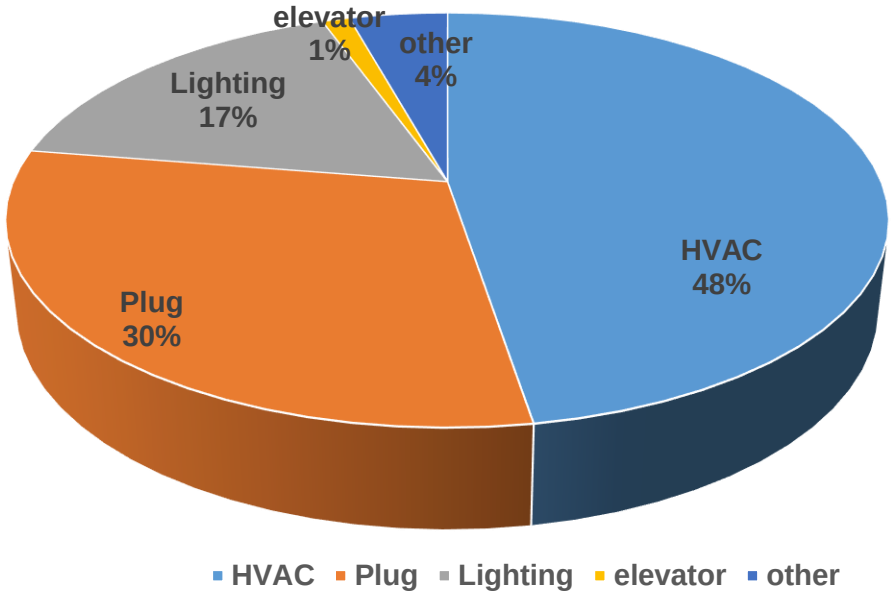


Annual power consumption of the CABR NZEB



Summary of the CABR NZEB

- 2017 the weather condition is the worst of the recent 4 years, while the indoor temperature keeps ~26 ℃
- As the continues commissioning, the HVAC system energy consumption keep decreasing in the past years;
- The overall annual energy consumption of 2015-2016 is 35.3 kwh/(m^2.y), which is pretty good of office buildings (average 80-100kwh/m^2.y in Beijing).
- The HVAC (48%)and the plugin(30%) take the biggest percentage in the energy pie, which means they have the most energy saving potential.



Conclusions and future work

- Passive ultra-low energy building is the next step of China building energy efficiency, which is the consensus in the government and industry.
- The building operation energy consumption are sensitive to the occupants' behavior and operating strategy.
- Most good practices of ultra-low energy building projects are located in severe cold and cold climate zones. There is great room for development and research on the technical roadmap of ultra-low energy buildings in southern China.

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Thank You for listening!

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