Solar Energy Application for Zero Carbon Building Parks in China

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Contents



1.1 Target

- Target: Carbon peak(2030) and neutrality(2060), China
- Existing problems: Carbon emissions related to building > 38%, peak by 3.15 billion tons in 2038-2040, reduce by 2.72 billion tons in 2060.
- LANK WORK TO DO for zero carbon development!

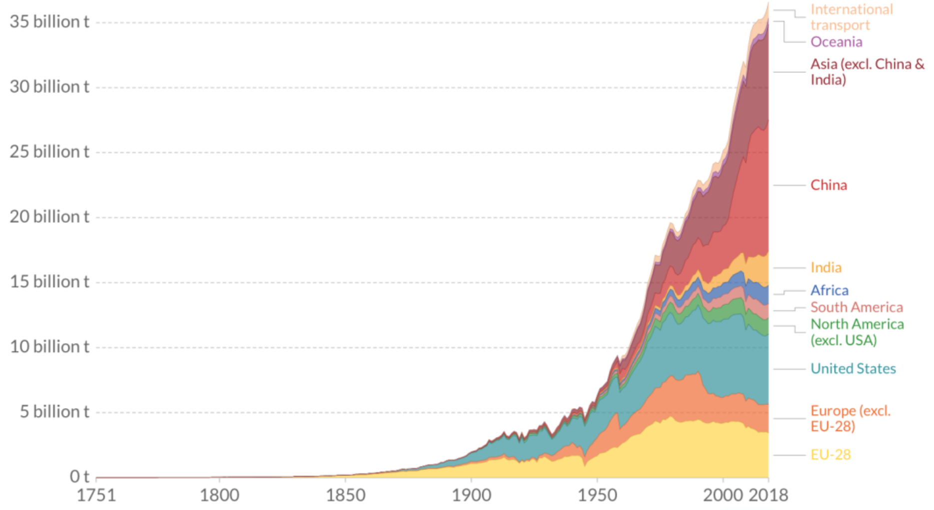
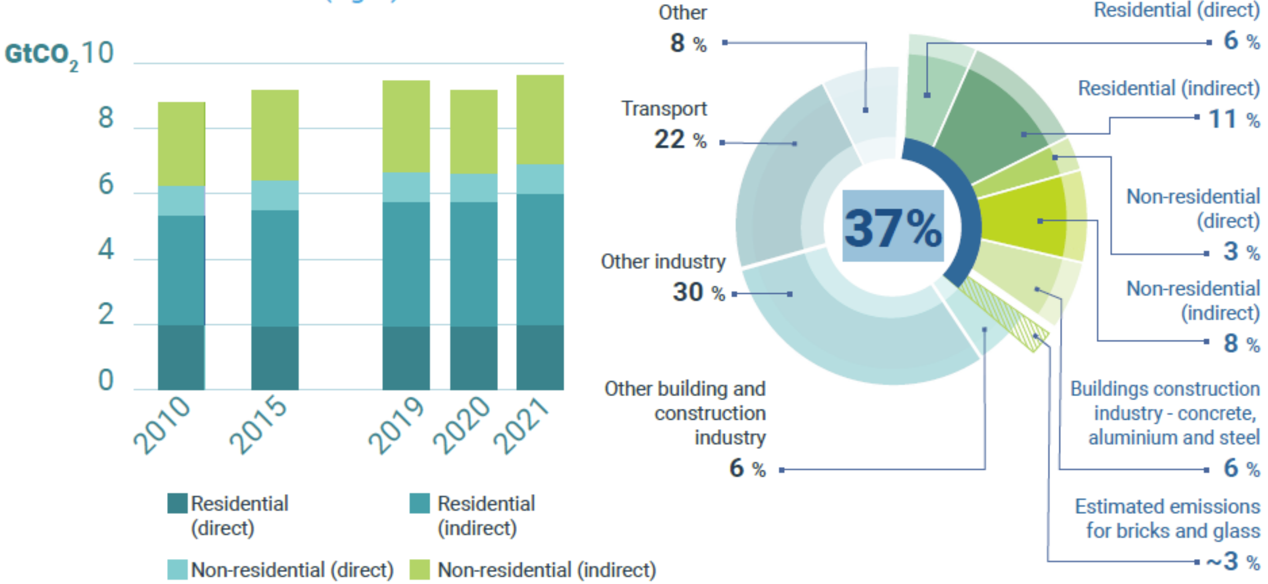


Figure 15. CO_2 emissions in buildings 2010-2021 (left) and share of buildings in global energy and process emissions in 2021 (right)



1.2 Policy

- The State Council, *Action Plan for Carbon Peak by 2030*
- The State Council, *Opinions on Carbon Peak and Carbon Neutralization Work*
- The General Office of the Central Committee, the General Office of the State Council, *Opinions on Promoting Green Development of Urban and Rural Construction*
- Ministry of Housing and Urban Rural Development, National Development and Reform Commission, *Implementation Plan for Carbon Peak in Urban and Rural Construction*

Level	Energy saving
Status	75%, 1980s compared
Ultra low energy building	82.5%, 1980s compared
Near zero energy building	86%, 1980s compared
Zero energy building	100%
Zero carbon building	Complete carbon balance
Zero carbon area (park, community…)	

Top-level design

Standards

Accounting methods

Industrialization

Engineering technology

……

DEVELOPING RAPIDLY!

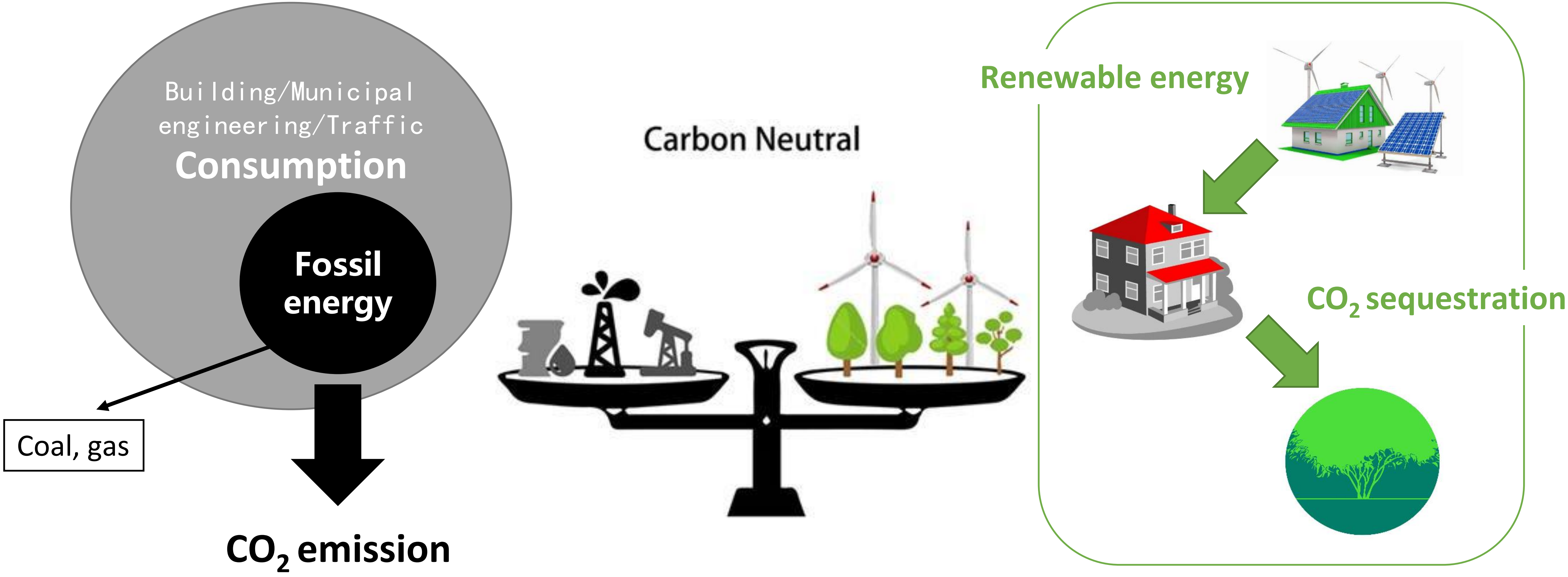
1.3 National standards

National standards related

Standard	Feature
GB 55015: ***General code for energy efficiency and renewable energy application in building***	**Mandatory standard for all provisions**
GB/T 51350: ***Technical standard for near zero energy buildings***	**Developments for near-zero energy buildings**
GB/T 51366: ***Standard for building carbon emission calculation***	**Unification of calculation methods**
Draft for Comment: ***Technical standard for zero-carbon building***	**First national standard for zero-carbon buildings**
GB/T 50801:***Evaluation standard for renewable energy application in buildings***	**Improved performance indexes of photovoltaic, photothermal and geothermal**
GB 50411: ***Standard for Acceptance of efficient building construction***	**Rules for energy-saving sharing projects**

Contents

2.1 Essences



Reduce

- total energy consumption
- Proportion of fossil fuels

Broaden

- Contribution of RE
- Carbon sink & trade

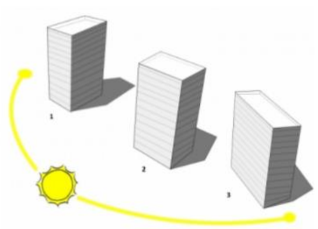
2.2 Zero carbon building

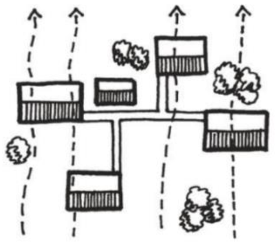
Passive methods

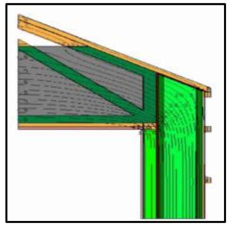
High performance enclosure

Energy efficient equipment

Renewable energy







Microclimate, ventilation, lighting

Thermal insulation, shading, thermal bridge, air tightness

HVAC sources, lighting, heat recovery, electrical appliances, control

Photovoltaics, photothermal, heat pumps

2.3 Zero Carbon Park

Energy station
Forms
- Centralized Systems
  - GSHP
  - Solar energy
- Decentralized Systems

Building
Energy saving
- Passive house
- Low-carbon energy
- Efficient equipment

Traffic
Vehicle
- New energy
- Optimize scheduling
- Optical storage and charging

Municipal engineering
Waste · **Lighting** · **Water**
- Vacuum pipe collection
- Garbage recycling
- Efficient lighting
- Intelligent PV street lamp
- Water-saving appliance
- Sewage treatment and recycling

Renewable energy
Thermal · **Power**
- Solar thermal
- Geothermal energy, biomass
- Photovoltaic
- Wind power

Sink
Afforestation
- Green plant coverage
  - Landscape building

Offset
Trading
- Trading
  - Carbon emissiong
  - Green electricity



2.4 RE applications

Solar PV

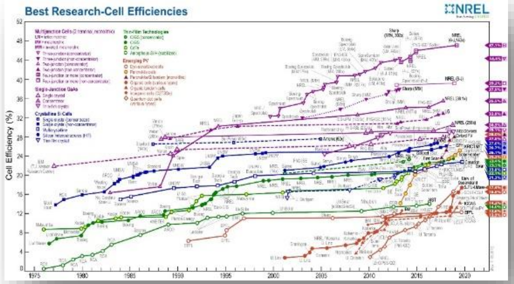
Zero-carbon: Carbon emissions including all electrical loads

BIPV collaborative : Special modeling & limited space

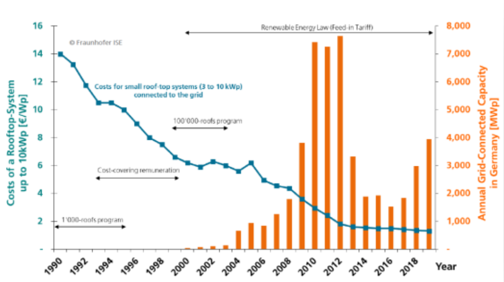
Renovation: limited renovation conditions and investment

Rules: Applicability, economy, green and beauty

Higher requirements for installed capacity, integration and active deployment.



PV performance



Generation cost

Mandatory

EcoTerra House

Limeil Brevannes School

"Le Charpak", IESC Cargese

ZEB@BCA Academy

LIMA

Green Office

2.4 RE applications

Solar thermal

- **Improved equipment performance**

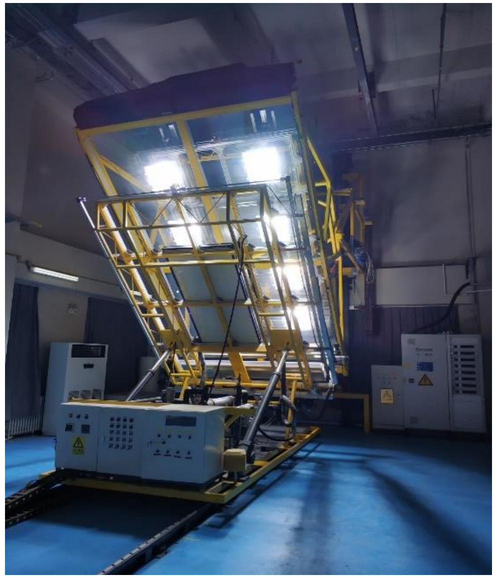
✓ High-efficiency selective absorption coating, large-size flat-plate collector, large-scale storage.

✓ Multi energy complementarity, medium and high temperature collection/storage, intelligent control.

- **Products to engineering, DHW to HVAC**

✓ Efficient solar space heating (Beijing, Hebei, Shanxi, Inner Mongolia, etc), fraction more than 70%.

✓ Solar district heating and seasonal storage projects operated successfully in high altitude areas.




GB

中华人民共和国国家标准

GB/T 6424—2021

平板型太阳能集热器

Flat plate solar collectors

2021-12-31 发布 2022-07-01 实施

国家市场监督管理总局
国家标准化管理委员会 发布


GB

中华人民共和国国家标准

GB/T 17581—2021

真空管型太阳能集热器

Evacuated tube solar collectors

2021-12-31 发布 2022-07-01 实施

国家市场监督管理总局
国家标准化管理委员会 发布

2.5 Building Electrification

- The State Council, *Action Plan for Carbon Dioxide Peaking Before 2030*

Building electrification

- **Transformation**
  - Cooking electrification
  - **DHW electrification**
  - **Heating electrification**
- **Improvement**
  - Flexible direct power supply and distribution
  - **PV, storage, DC, flexibility**
  - **Grid-interactive**

Power cleaning

- **Low-carbon electricity**
  - Hydropower
  - Biomass power
  - PV, wind power
  - Nuclear power
- **Efficiency**
  - Electrothermal conversion

Carbon offset: carbon sink & trading

- Greening of urban and buildin
- Trading of Green electricity and carbon

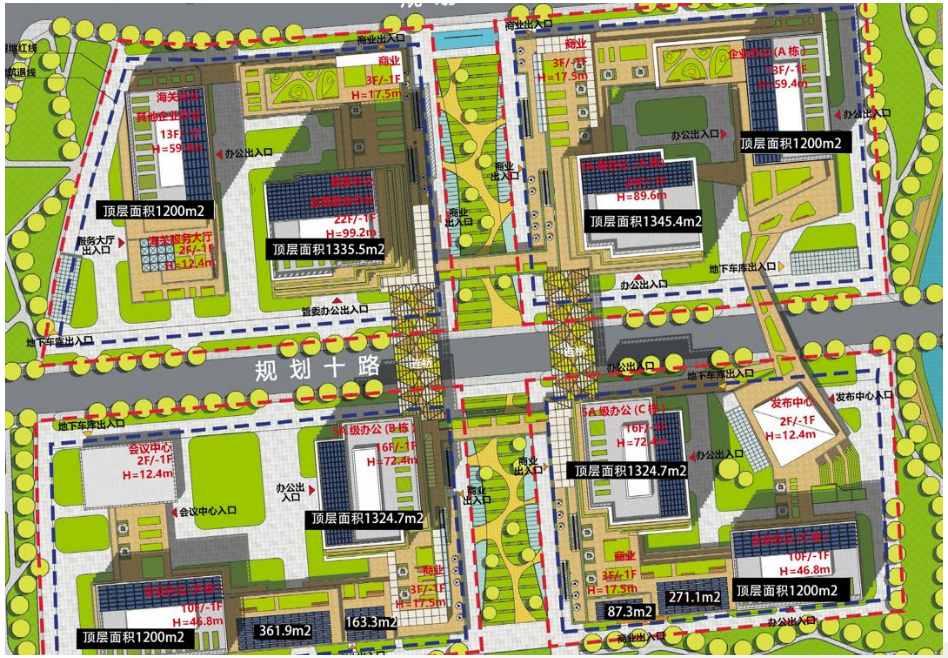


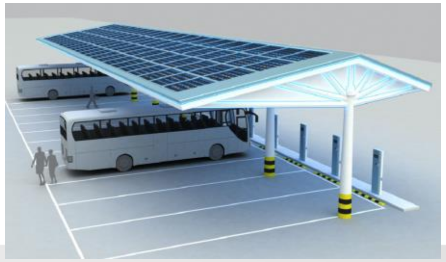
Contents



3.1 Collaborative design

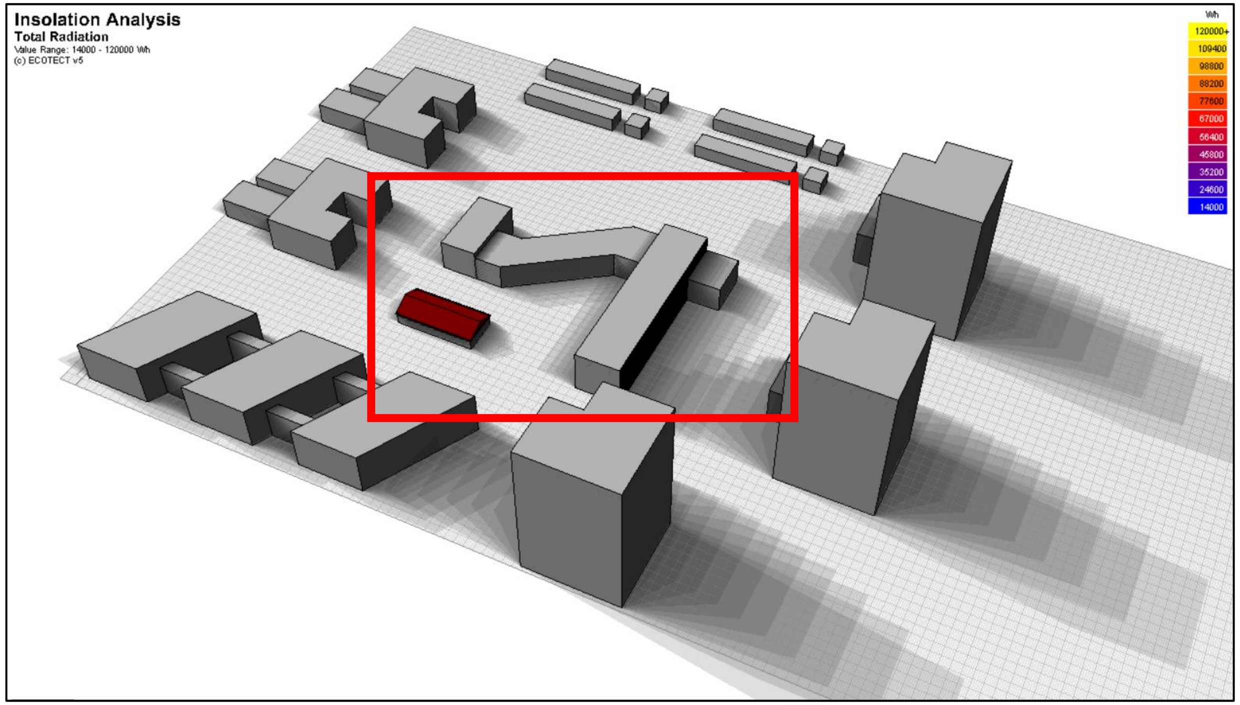
- Restrict the installed PV coverage of root.
- Take BIPV as highlight.
- Multi-dimensional layout of PV street lamps, seats, pavements, decorations.
- Power supply for municipal, traffic and centralized energy systems.

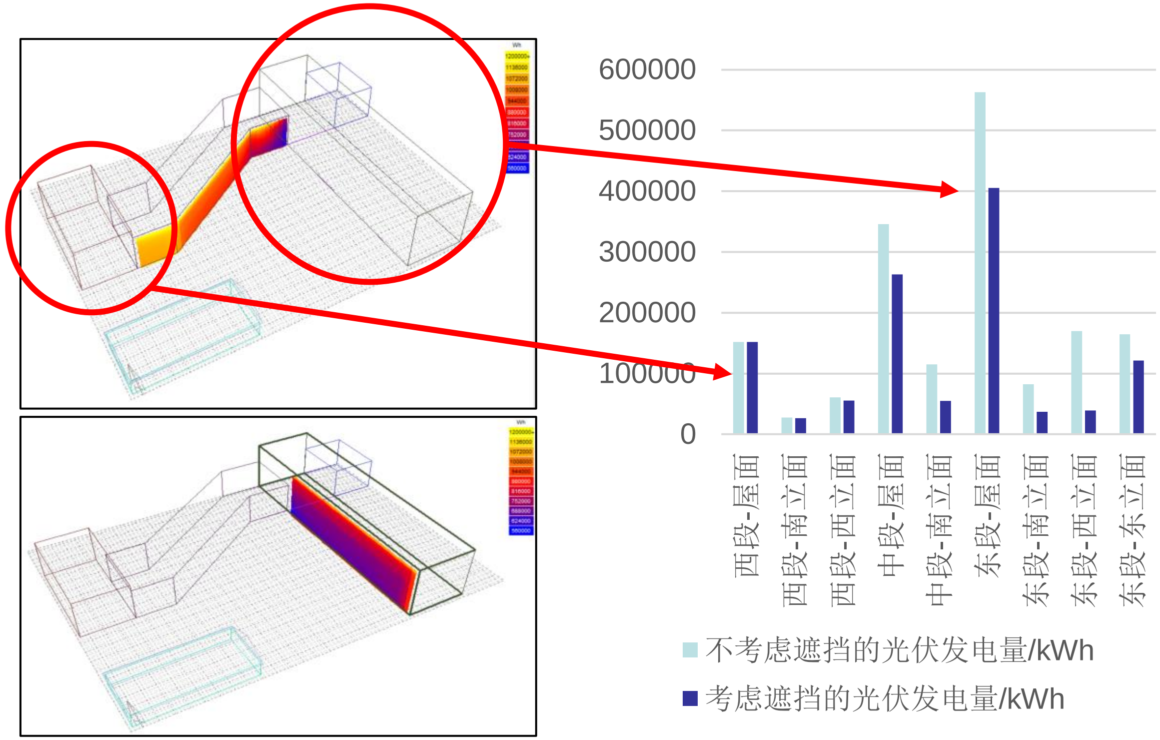




3.1 Collaborative design

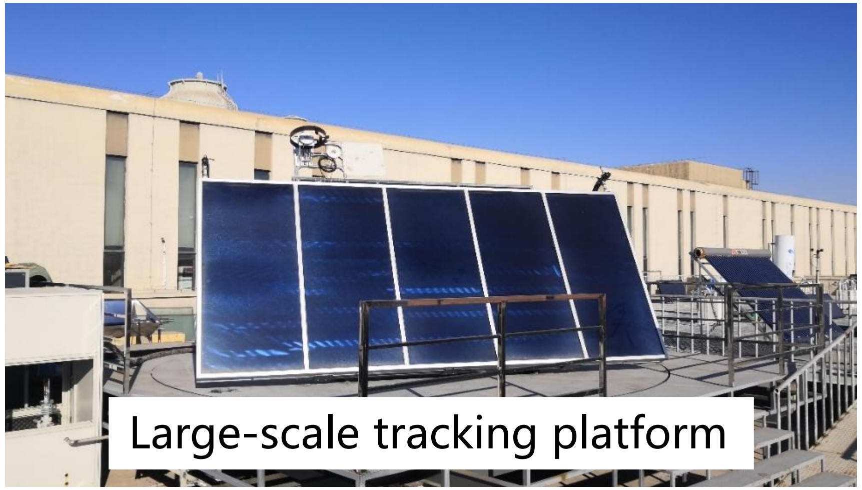
- Inevitable shelter by modeling and surroundings under compact space.
- 3D model for solar radiation analysis and power generation correction
- Optimization for technical economy, carbon emission and other indicators.





3.2 Building fitted

Solar simulator



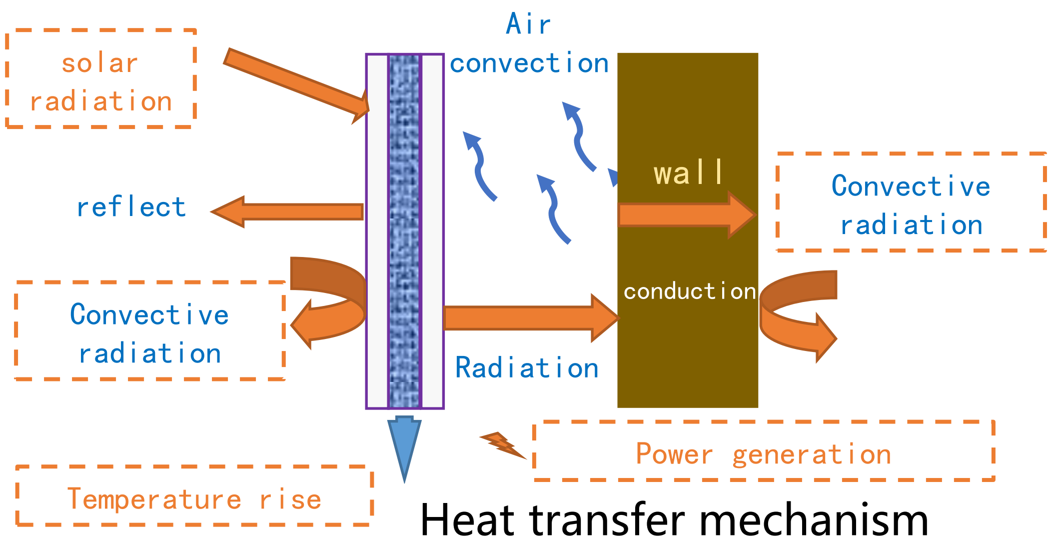
Large-scale tracking platform

Automatic tracking control

SBI combustion test

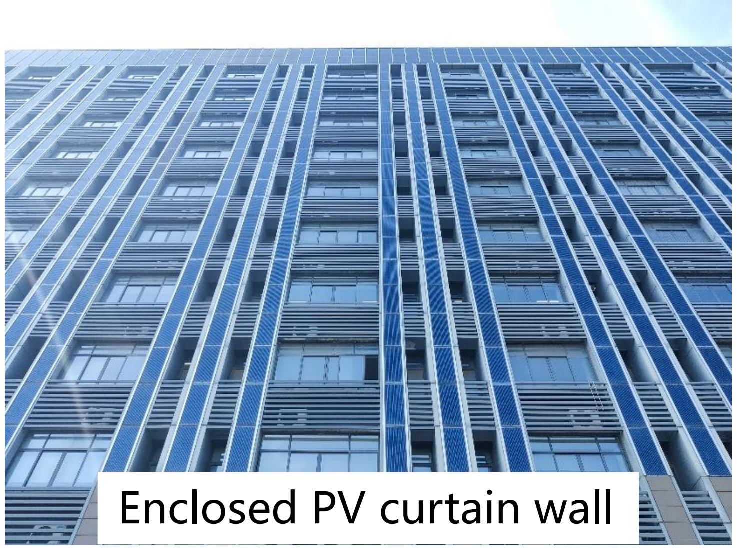
Spray environment test

3.2 Building fitted

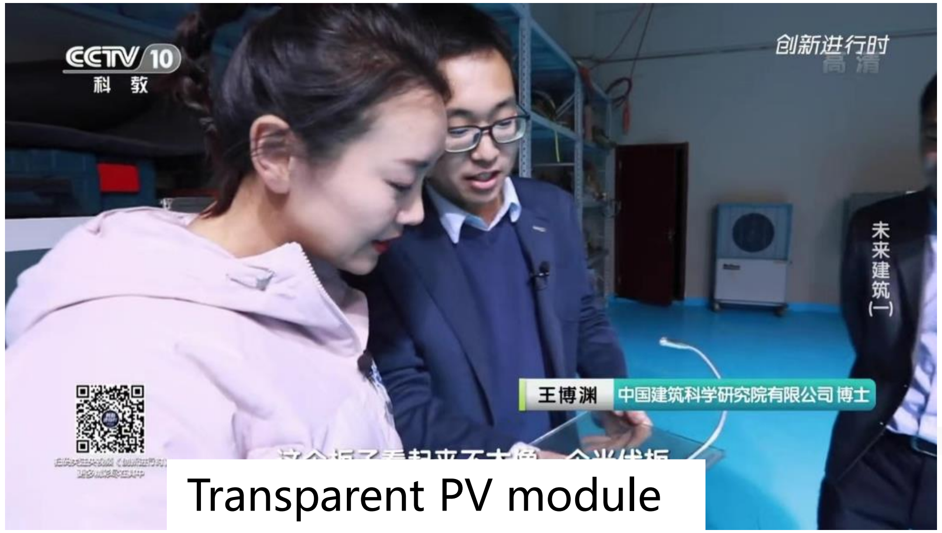


Heat transfer mechanism

Ventilation PV curtain wall



Enclosed PV curtain wall



Transparent PV module

Waste heat utilization

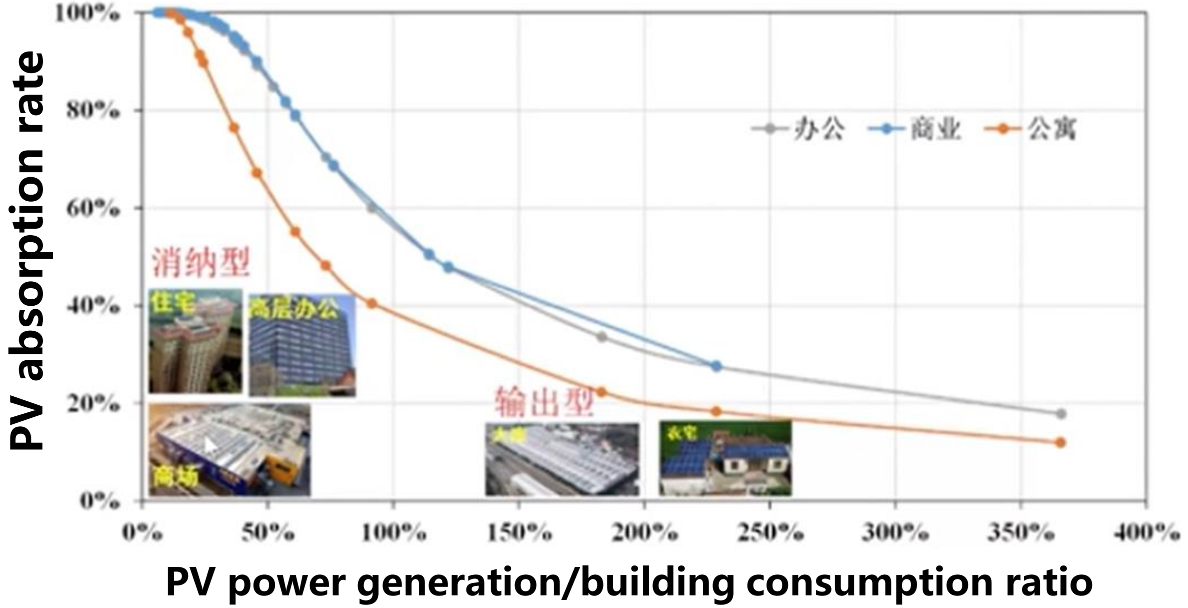
PVT modules

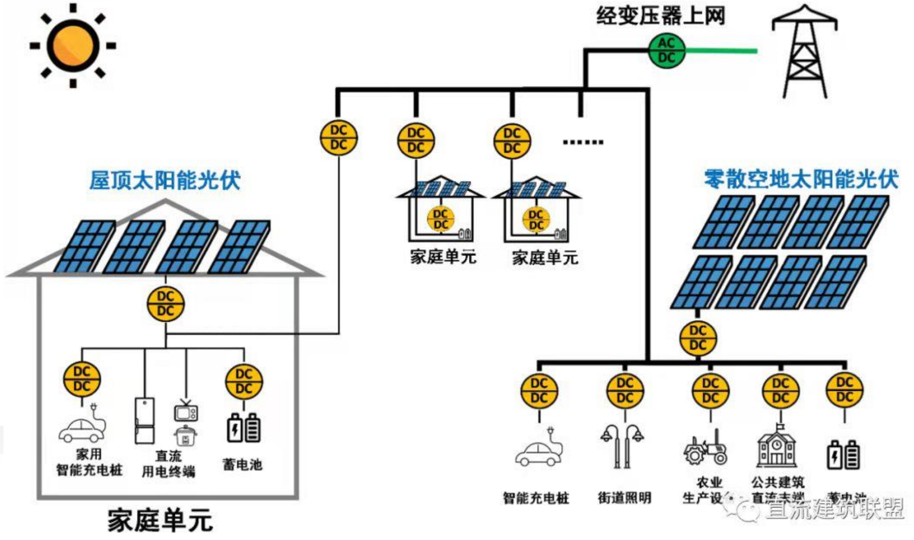
3.3 Flexible DC system

Absorption rate: Inverse function (∫ PV power generation/∫ building consumption)

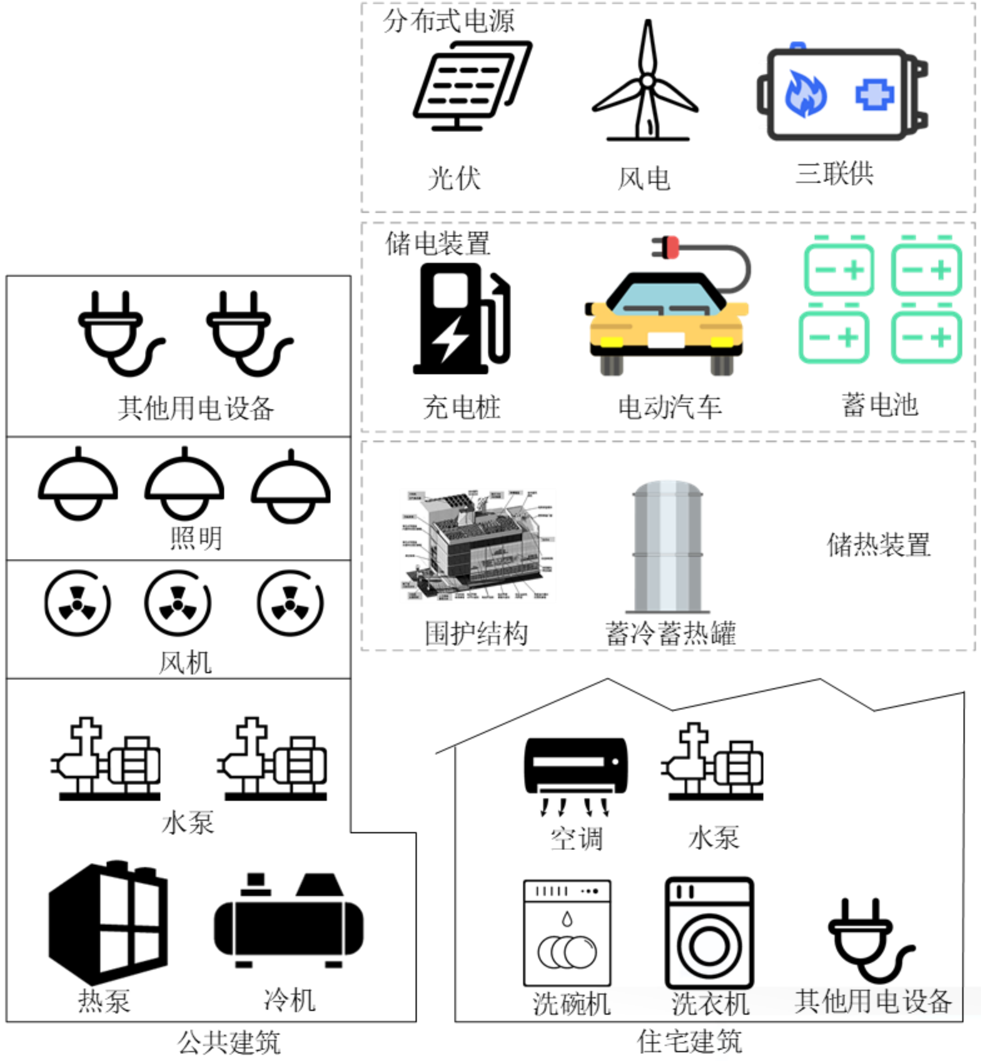
Core of the problem: Responsiveness of building demand to PV power generation

Solution: collaborative optimization of PV, storage, direct current and flexibility.





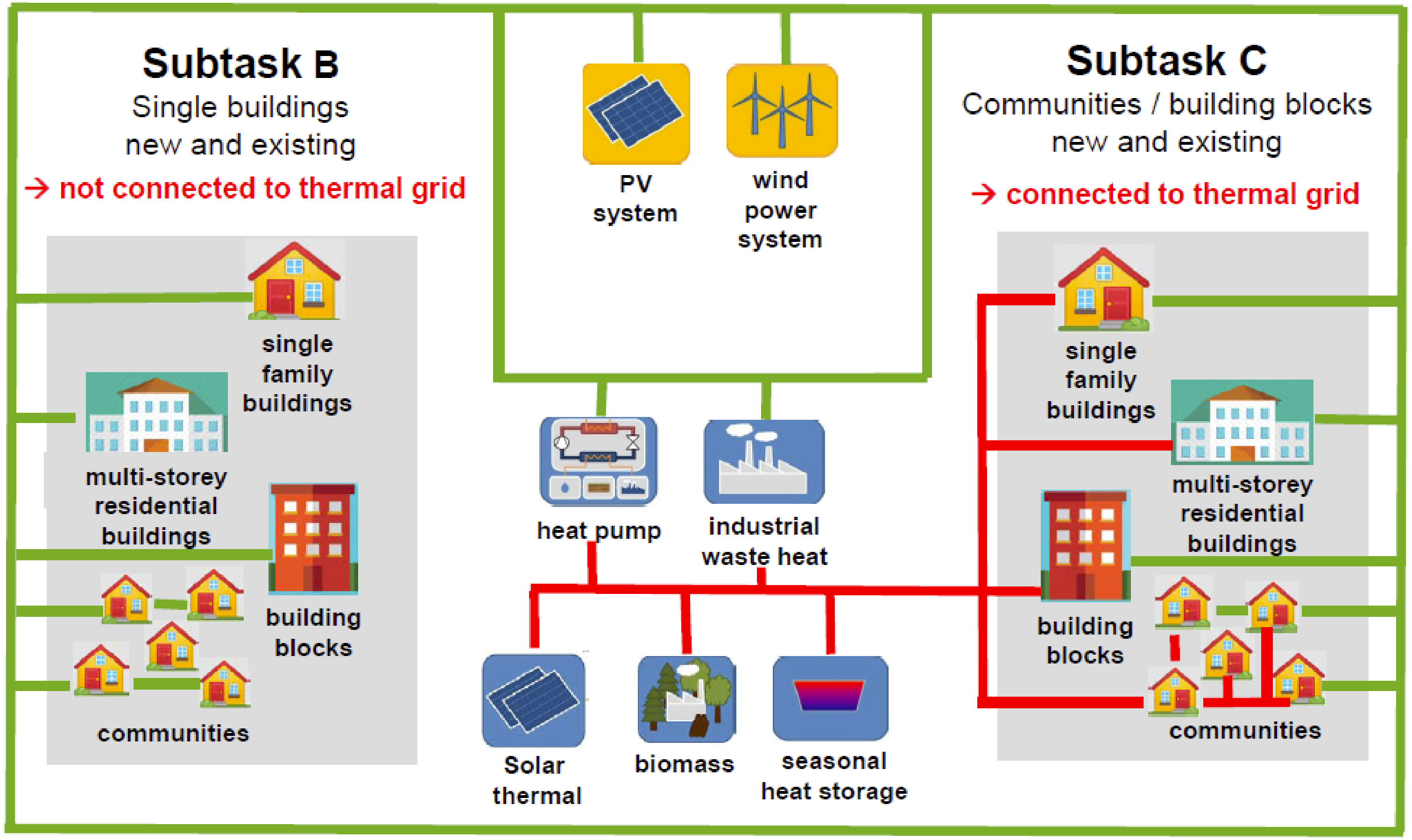
3.3 Flexible DC system



1. Envelope structure and heat storage
2. Heat and cold storage
3. Adjustable equipment HVAC system
4. Battery & electric vehicle.
5. Equipment capable for demand changed
6. Switching sources of distributed system

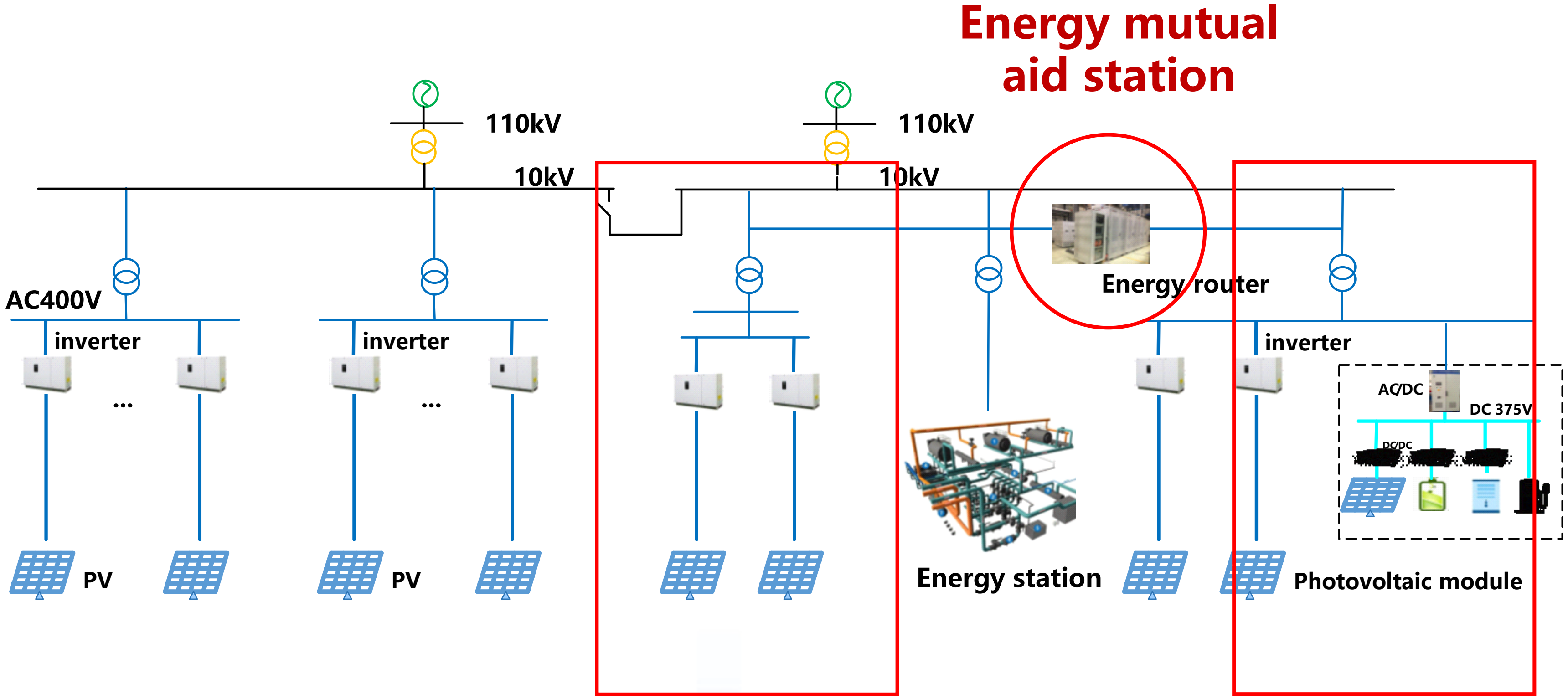
3.4 Park, community microgrid

- PV system as power producer for buildings as well as parks.
- Local solar thermal, heat pump or centralized energy station coupled with PV system.
- Energy frequently interconnected.



3.4 Park, community microgrid

- Energy routing with ‘building blocks’ as the unit.
- Green electricity directional interaction in different blocks.
- Eliminate time sequence difference between power generation and consumption.



Block A

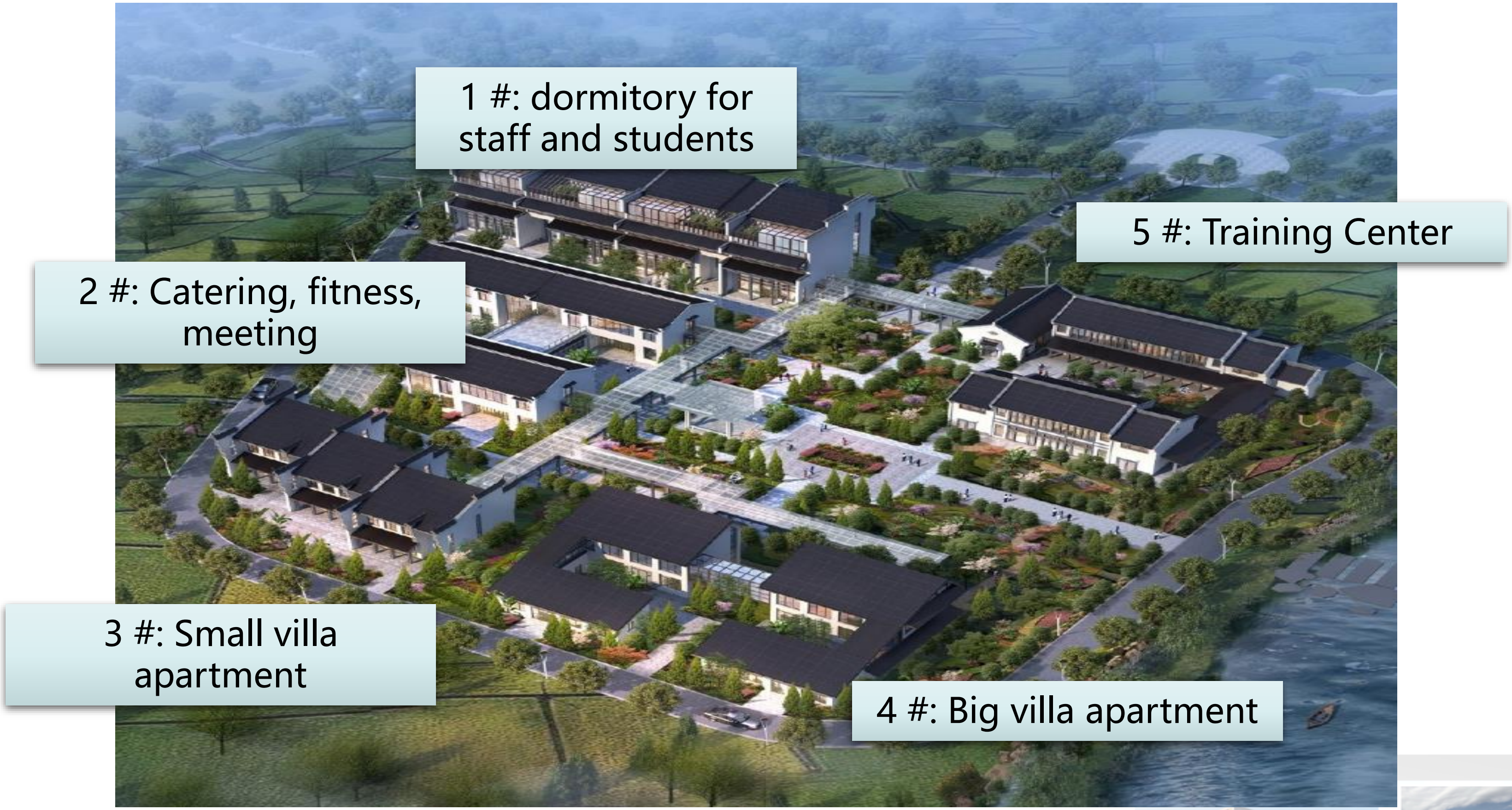
Block B



Contents

5.1 Introduce

- Project located in Wuhan City, 5 buildings, 6843m^2 building area in total.
- Buildings with various function and Chinese architectural styles.



5.2 Energy saving design

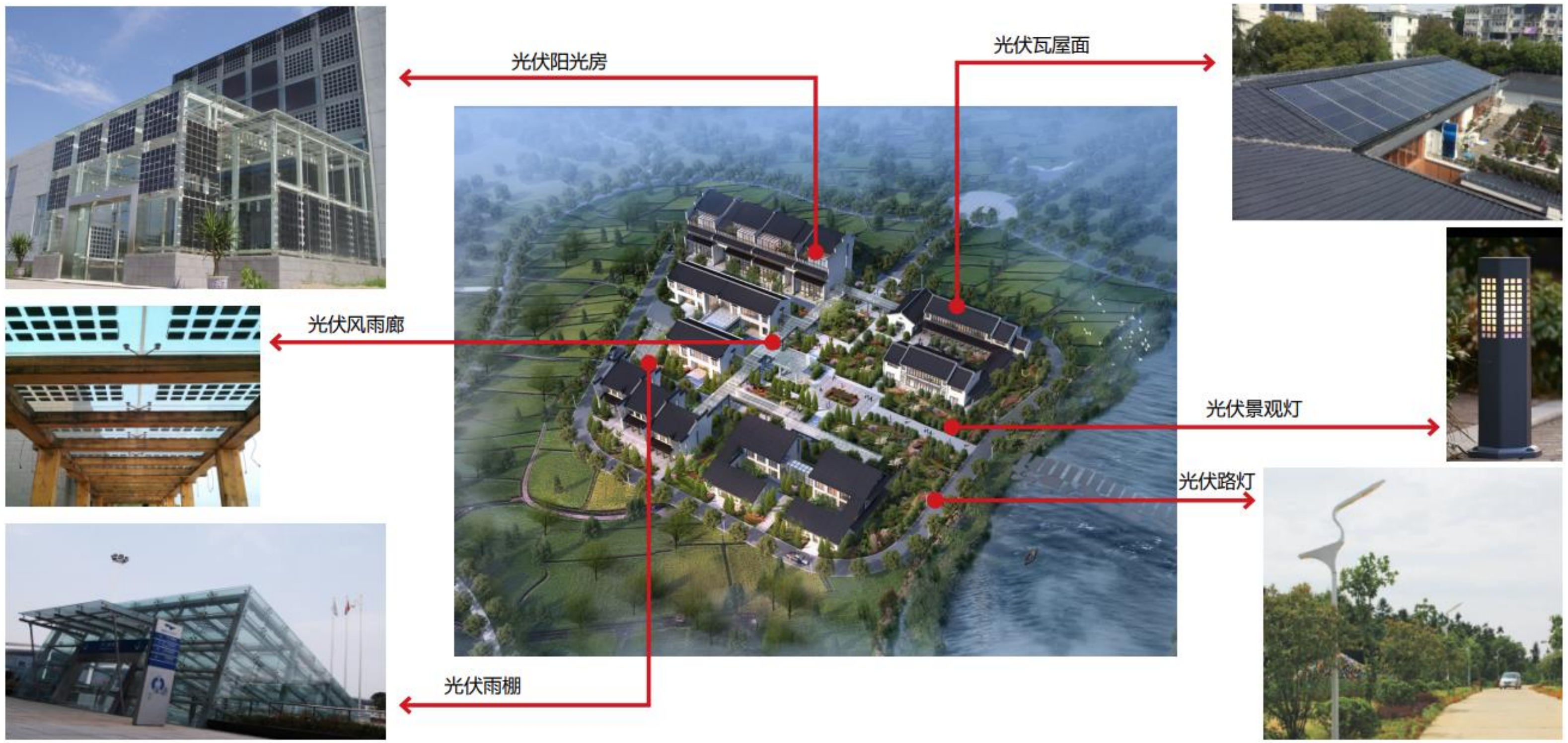
- Natural ventilation and natural lighting fully adopt.
- BIPV used sunshine room and external shading.
- Proper rather than extreme thermal insulation (Inorganic thermal insulation mortar & XPS board).
- High-efficiency VRV air conditioner, electric water heater and ASHP shower system.
- Frequency conversion control according to demand.

5.3 PV application

- High proportion of multi scene installed photovoltaic, 486kWp.
- Conversion efficiency > 19% (single crystal), >16%(polycrystalline).
- Inclined support PV array on flat roof, for generation as well as beauty (20 ° south slope, reducing installation of north slope).

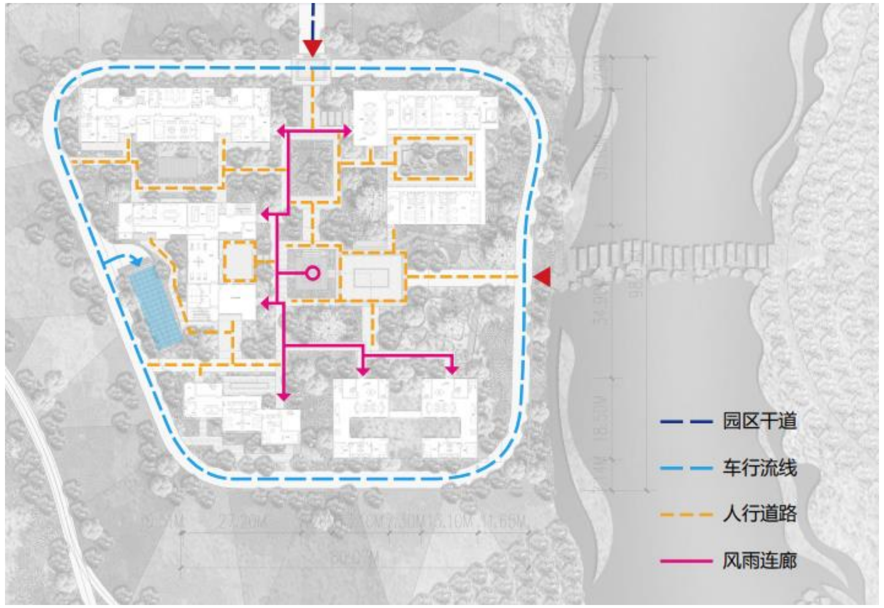
5.3 PV application

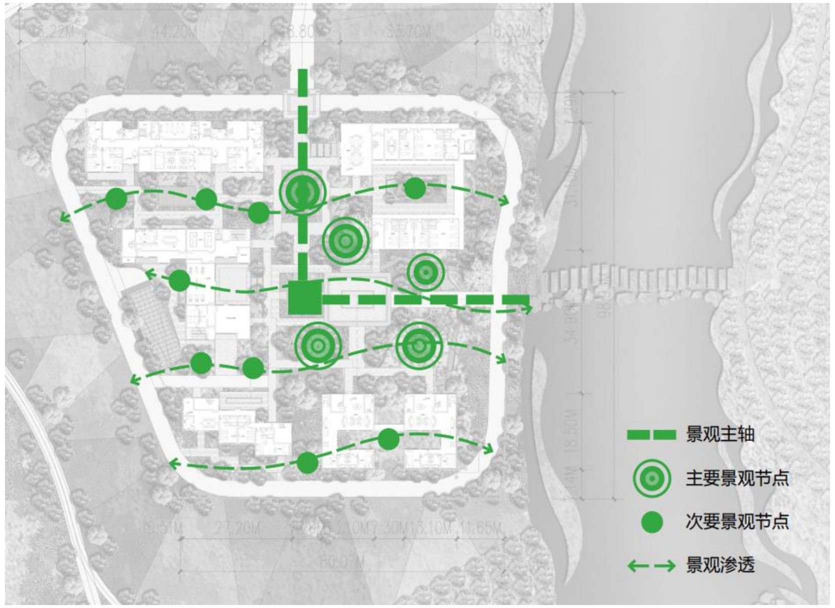
- 100% electrified.
- Equipped with PV corridor, street lamps, garage ceiling and other facilities.
- Household as well as industrial energy storage systems.
- Optical storage and charging integrated micro grid.



5.4 Other methods

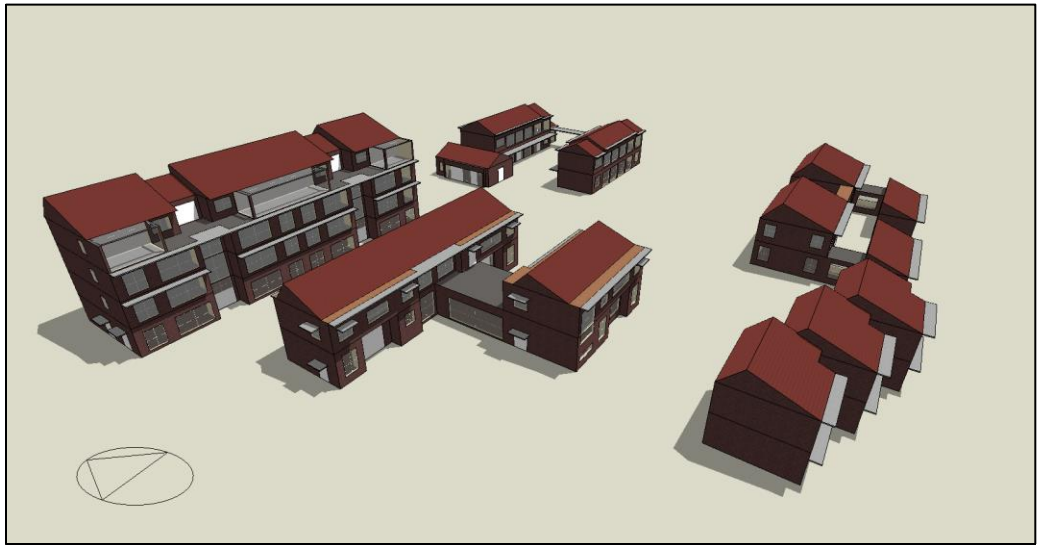
- ☐ Lighting, sewage and garbage treatment of park.
- ✓ Energy-saving fluorescent lamps, with inductive ballasts with compensation.
- ✓ High efficiency pumps, water-saving appliances, self closing and induction flushing valves.
- ☐ Promote electrical vehicles through PV charging.
- ☐ Expand greening for carbon sink and living comfort as well.

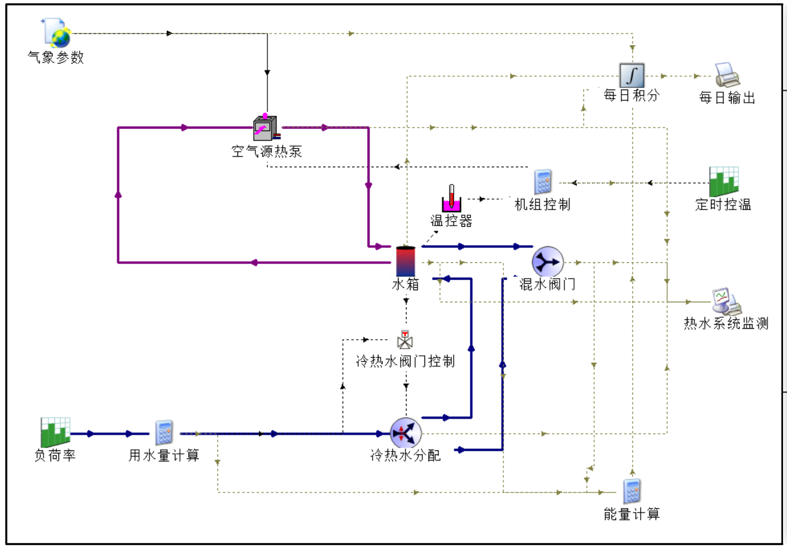


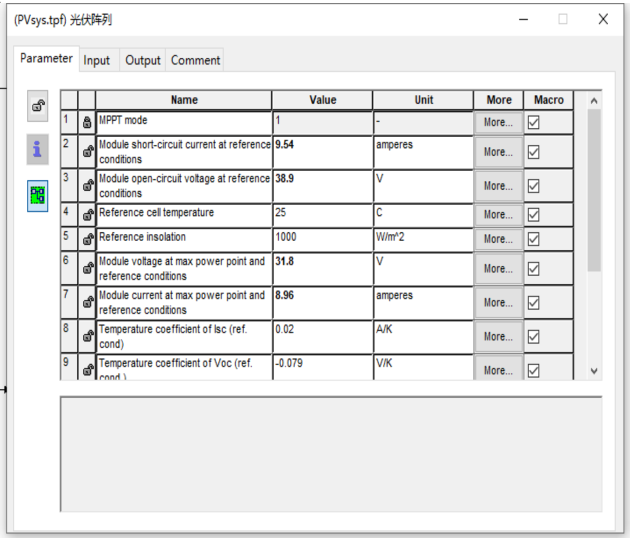


5.5 Detailed calculation

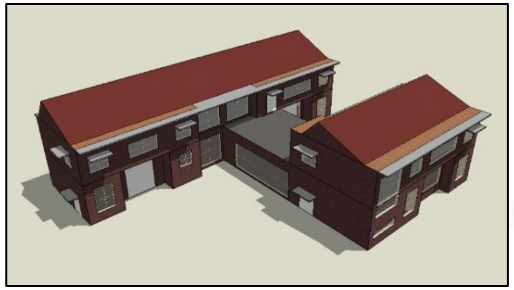
- Simulation by 3D visualization, considering the space, location and interaction.
- Fine simulation based on the Energy Plus computing core.
- TRNSYS models of VRV HVAC, ASHP DHW system and BIPV system.

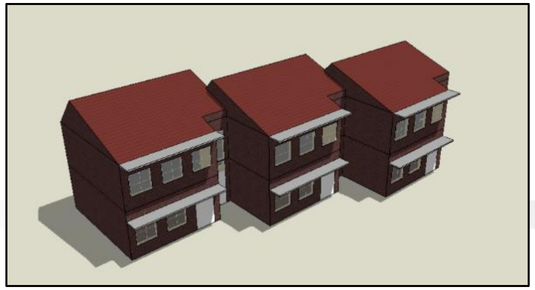


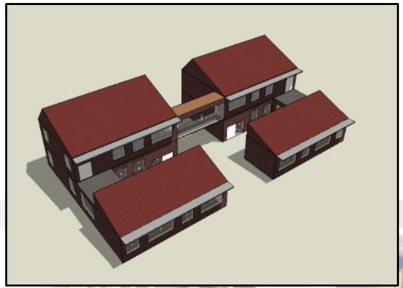


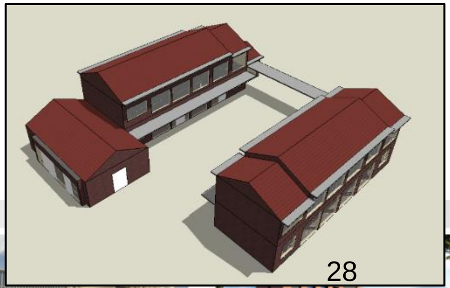


	Name	Value	Unit	More	Macro
1	MPPT mode	1	-	More...	☑
2	Module short-circuit current at reference conditions	9.54	amperes	More...	☑
3	Module open-circuit voltage at reference conditions	38.9	V	More...	☑
4	Reference cell temperature	25	C	More...	☑
5	Reference insolation	1000	W/m^2	More...	☑
6	Module voltage at max power point and reference conditions	31.8	V	More...	☑
7	Module current at max power point and reference conditions	8.96	amperes	More...	☑
8	Temperature coefficient of Isc (ref. cond)	0.02	A/K	More...	☑
9	Temperature coefficient of Voc (ref. cond.)	-0.079	V/K	More...	☑









5.5 Detailed calculation

Project	Unit	Proportion
Annual carbon emission		
Buildings	tCO_2	81.23%
Transportation	tCO_2	0.36%
Municipal engineering	tCO_2	18.41%
Total	tCO_2	100%
Annual carbon reduction		
Renewable energy	tCO_2	98.09%
Green space	tCO_2	1.91%
Total	tCO_2	100%

THANKS FOR LISTENING

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China Academy of Building Research