Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

Comparative Study of Commercial Building Energy-Efficiency Retrofit Policies in Four Pilot Cities in China

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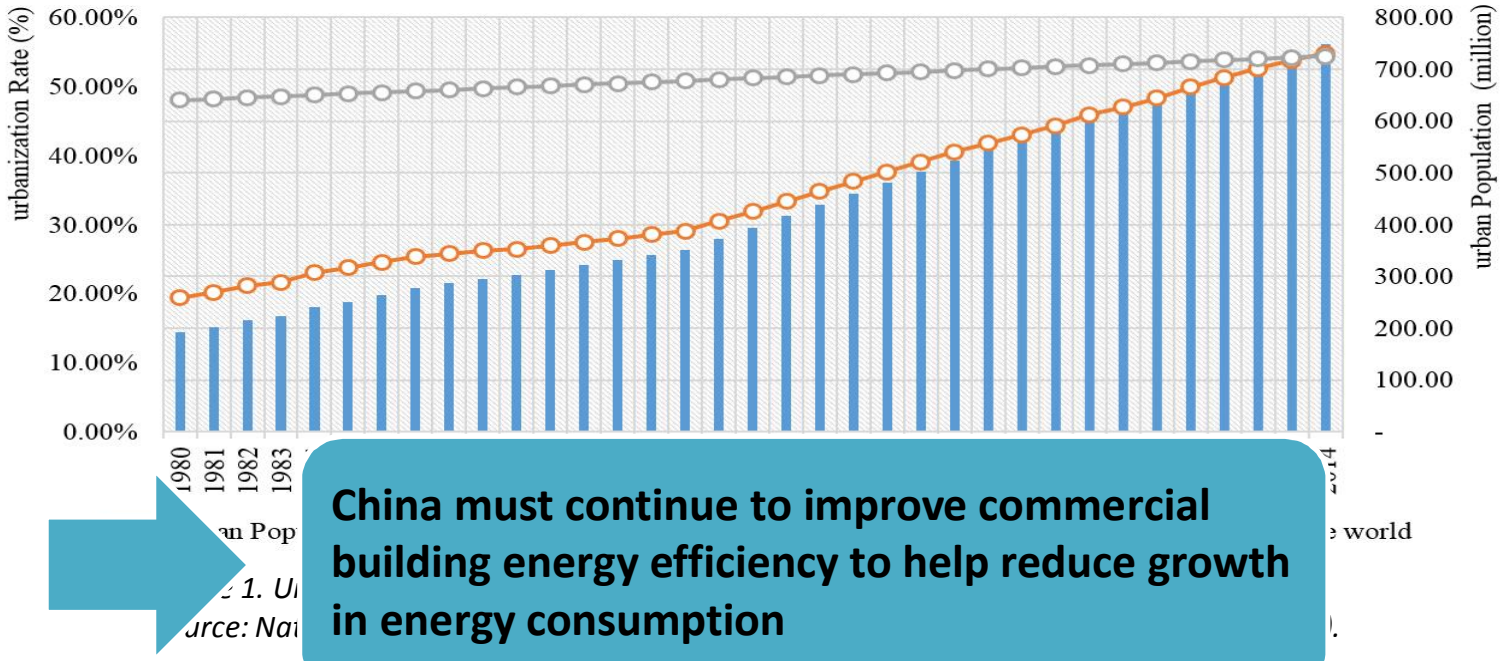
Background-I



China must continue to improve commercial building energy efficiency to help reduce growth in energy consumption

- From 1980 to 2014, the urban population in China increased from **191 million** to **749 million**, and the urbanization rate grew roughly by **1.02% annually**, from **19.4% to 54.8%** *(NBS 2013 and NNUP 2014)*
- From 1996 to 2012, total commercial floor space in China increased from **2.8 billion m^2 to 8.3 billion m^2** *(BEERC 2014)*
- In 2012, China's commercial buildings consumed more than **182 million tonnes coal equivalent**, accounting for **26.4%** of all building-sector energy use *(BEERC 2014)*
- A study done by the Energy Information Administration (EIA) projects that commercial building energy use will increase by **2.7%** per year in developing countries between **2007 and 2035**

Background-II

New Construction CB

- **1993,** the MOHURD issued an energy-efficiency standard for hotels (GB50189)
- **2005,** the standard was revised to include other types of commercial buildings. All new buildings are requested to be **50%** more efficient than a baseline of 1980s building characteristics.
- **2015,** the latest proposed revision would be **30%** more than the 2005 standard, i.e., equivalent to **65%** more efficient than the 1980s baseline.

Existing CB

- During China's 12th Five-Year-Plan, aim to retrofit **60 million m^2** of commercial buildings **by the end of 2015**, reducing energy intensity in ordinary commercial buildings (< 20,000 m^2) by **10%** and in large-scale commercial buildings (≥ 20,000 m^2) by **15%**
- **2011,** selected 4 cities to carry out pilot commercial-building energy-efficiency retrofit programs

Background-III

Table 1. Four-city pilot commercial-building energy-efficiency retrofit program

		Policy details
Requirements		
Floor area target	✓	Minimum 4 million m^2 floor area
Time schedule target	✓	Completed within 2 years
Energy saving target	✓	Energy performance enhanced by 20%
Subsidy		
Subsidy amount	✓	20 RMB/m^2 for 4 million m^2 (80 million RMB/city)
Subsidy payment	✓	60% prepaid, 40% after inspection

Central government's policy

Cho

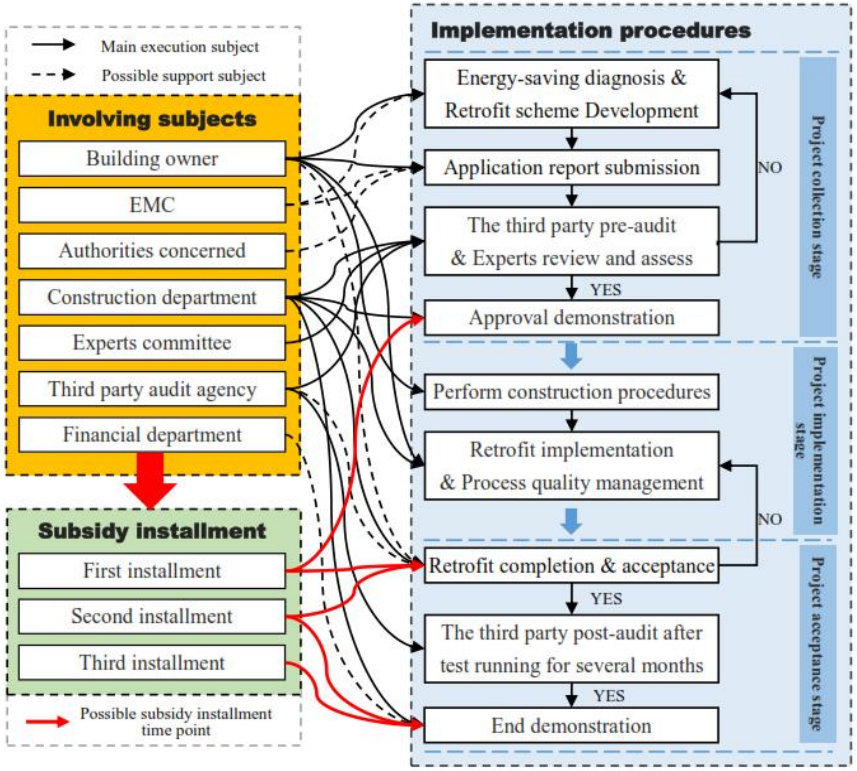
She

Table 2. Basic information on pilot cities and progress of energy-efficiency efforts

	Program details	Tianjin	Chongqing	Shenzhen	Shanghai
1	Pilot start date	8/2011	8/2011	8/2011	8/2012
2	Site investigation period	12/2013	1/2014	3/2014	4/2014
3	Location	north	southwest	south	east
4	Climate zone	cold	hot summer cold winter	hot summer warm winter	hot summer cold winter
5	Planned retrofit floor area (million m^2)	5.80	4.44	7.78	4.00
6	Current percent progress	64%	78%	60%	58%
7	Total demonstration projects	140		185	
8	Projects begun or completed		68	109	46
9	Social investment (million RMB)	242,87	>300,00		
10	Average energy savings	≥20%	≥20%	≈14%	≥20%

Implementation Procedures & Organizational Structures

Implementation procedures



Program organizational structure

Table 3. Program organizational structure in the four pilot cities

* EMC – energy management company

	Tianjin	Chongqing	Shenzhen	Shanghai
Dominant influence on progress – market vs. government	government	market	mixed	market
Dominant channel for collecting demonstration projects	government	market	market	market
Dominant retrofit entity	owner	EMC*	EMC*	EMC*

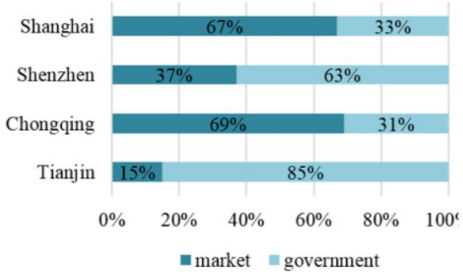


Figure 2. Demonstration project source

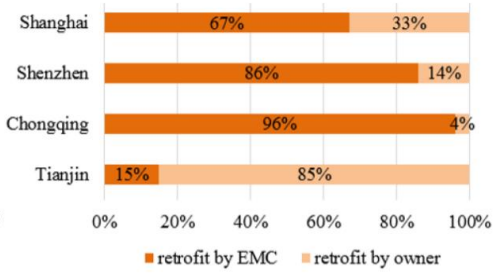


Figure 3. Retrofit entity distribution

Supportive Local-Government Policies-I

- Supportive local policies are vital to the success of the pilot cities' demonstration projects.
- In response to the central government subsidy of 20 RMB/m2 retrofitted, the four cities each developed individual financial support

Table 4. Subsidy policies in the four pilot cities

	Tianjin	Chongqing	Shenzhen	Shanghai
Subsidy				
Total local finance matching (million RMB)	20	80	120	800
Central subsidy : local subsidy	1:0.25	1:1	1:1.5	1:1
Energy-saving threshold				
Demonstration threshold	20%	20%	10%	20%
Subsidy threshold	20%	10%	10%	20%
Total subsidy intensity (RMB/m²)				
Minimum amount	20	17.5	21	20
Maximum amount	20	40	42	80
Subsidy installments	3	2	3	2
First installment	30%	50%	30%	50%
Second installment	30%	50%	50%	50%
Third installment	40%		20%	

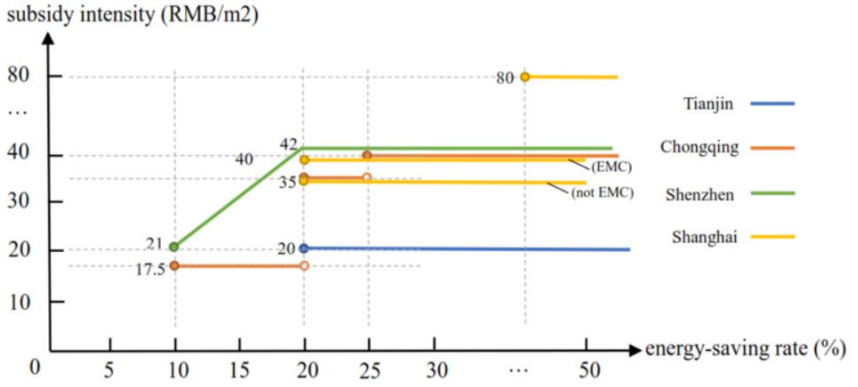


Figure 5. Relationship between subsidy and energy savings in the four pilot cities

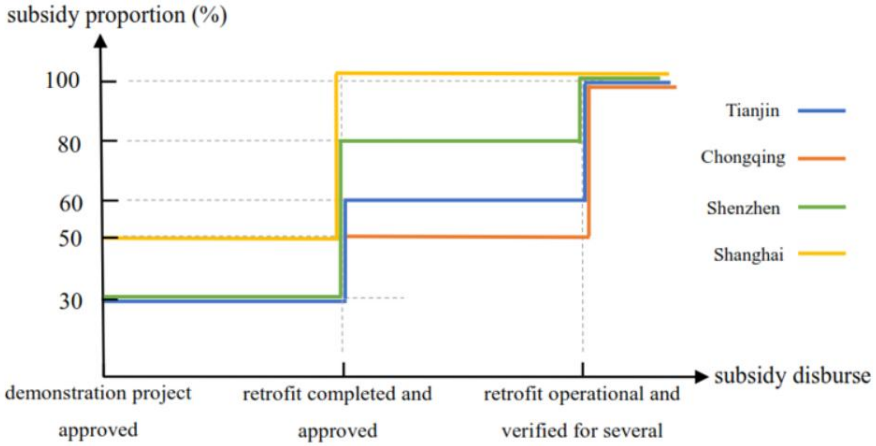
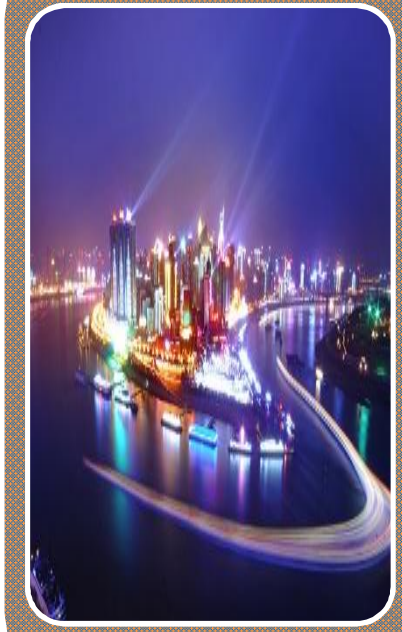


Figure 6. Subsidy installments in the four pilot cities

Supportive Local-Government Policies-II

Tianjin

- ✓ Local finance matching 20 million RMB for capacity building
- ✓ Subsidies paid in three installments: 30% when a project is approved, 30% when the retrofit is finished, and 40% when the energy savings are verified by a third-party auditor
- ✓ No particular incentive policies to encourage EMCs to carry out retrofit projects or to enhance the energy savings
- ➔ Only 15% of projects identified through the market with retrofits implemented by EMCs



Chongqing

- ✓ Give larger incentives to demonstration projects that pursue greater energy savings, as described by equation (1):

$$\text{subsidy amount (RMB/m2)} = \begin{cases} 0, when\ energy\ saving\ rate < 10\% \\ 17.5, when\ 10\% \le energy\ saving\ rate < 20\% \\ 35, when\ 20\% \le energy\ saving\ rate < 25\% \\ 40, when\ energy\ saving\ rate \ge 25\% \end{cases} \quad (1)$$

- ➔ 67 out of 68 had saved more than 20% over pre-retrofit energy use till our site survey
- ✓ To encourage use of EMCs for retrofit implementation, when an EMC carries out a retrofit, the EMC pays all of the retrofit cost and **receives 80%** of the government subsidy with the remaining **20% given to the building owner**
- ➔ 96% of demonstration projects were carried out by EMCs
- ✓ Subsidy paid in two installments: the first 50%, 35RMB/m2, is paid after the completed retrofit floor area and energy savings are verified by a third-party auditor. The second 50% is paid after the retrofitted building has **operated for at least 3 months**. The second installment has four tiers (like equation 1).

Supportive Local-Government Policies-III

Shenzhen

✓ Subsidy amount -- promote greater energy savings ➔ average saving is 14%

$$\text{subsidy amount} = 42\ (\text{RMB/m2}) * retrofit\ floor\ area\ (m2) * \alpha \quad (2)$$

$$\alpha = \begin{cases} \frac{energy\ saving\ rate}{20\%}, when\ 10\% \le energy\ saving\ rate < 20\% \\ 1\ , \quad when\ energy\ saving\ rate \ge 20\% \end{cases} \quad (3)$$

$$\text{subsidy amount (RMB/m2)} = \begin{cases} 0, when\ energy\ saving\ rate < 10\% \\ 21, when\ energy\ saving\ rate = 10\% \\ (21,42), when\ 10\% < energy\ saving\ rate < 20\% \\ 42, when\ energy\ saving\ rate \ge 20\% \end{cases} \quad (4)$$

✓ Required all government office building demonstration projects be carried out by EMCs

➔ 86% were implemented by EMCs (includes government and non-government buildings)

✓ Subsidy paid in three installments: 30% when a project is approved, 50% when the retrofit is finished, the final 20% installment is paid after a retrofit project operates for 1 year, and savings are verified by a third-party auditor.

Shanghai

✓ Subsidy amount --promote greater energy savings

$$\text{subsidy amount (RMB/m2)} = \begin{cases} 0, when\ energy\ saving\ rate < 20\% \\ 35, when\ energy\ saving\ rate \ge 20\%\ and\ not\ EMC \\ 40, when\ energy\ saving\ rate \ge 20\%\ and\ EMC \\ 80, when\ retrofit\ meet\ standard\ GB-50189 \end{cases} \quad (5)$$

✓ EMC: a same project, implemented by an EMC will receive a subsidy of 40 RMB/m2 and those not implemented by an EMC will only receive 35 RMB/m2

➔ 67% of the demonstration projects had been implemented by EMCs

✓ Subsidy paid in two installments: first 50% is paid after the retrofit application is approved, second 50% is paid after completion of the retrofit and M&V by a third party.

Local-Government Policies - Discussion

Subsidy level

- Market response to the subsidy level. The central government offered the same subsidy level across the board, the impact in each city is different because of variations in local economic conditions
- Local financial resources and the cost of retrofits that use local technical solutions should be taken into account when set subsidy level
- Linking the subsidy level to the energy saved, as has been done in Shenzhen, is effective; this can motivate demonstration projects to pursue greater energy savings

Subsidy installments

- The subsidy installments were paid at three critical milestones in all four pilot cities
- Making the first payment when a project is approved can provide start-up capital. The second payment is most commonly made when a retrofit is completed and approved. The third payment, after a retrofit has been operating and energy savings are verified, is the most effective for guaranteeing retrofit quality and actual energy savings

Subsidies to encourage EMC

- In Chongqing, the subsidy is the same whether an EMC participates or not, but the benefit sharing between the owner and the EMC differ. In Shanghai, the subsidy amount differs by 5 RMB/m^2 depending on whether an EMC is involved
- Chongqing's design saves money, is attractive for governments whose financial resources are limited

Subsidy calculation

- In addition to the current method of calculating subsidies based on retrofitted floor area, subsidies could depend on total retrofit cost, or could be based on the energy saved

Case Study: Chongqing Retrofit Technical Solutions and Cost-Benefit Analysis

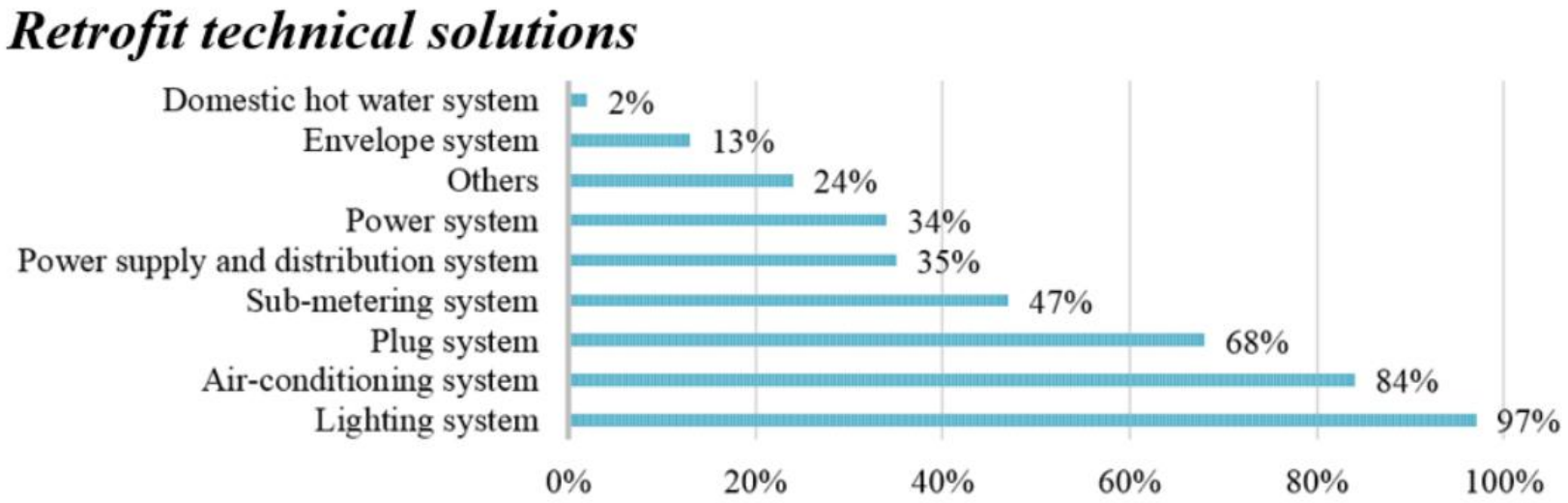


Figure 7. Building systems receiving energy-efficiency retrofits in Chongqing

（quantitative analysis on 68 completed and approved demonstration projects in Chongqing）

- Lighting system was the most common retrofit (97%)
- The second most common retrofit was air conditioning systems (84%)
- The least-common retrofit was domestic hot water (2%) and envelope system (13%)

Case Study: Chongqing Retrofit Technical Solutions and Cost-Benefit Analysis

Cost-benefit analysis

- The subsidies cover approximately 20% to 40% of total retrofit cost in average
- Cost is highest for shopping malls due to the complex system
- Schools have low cooling energy demand thus retrofit cost also low

Retrofit Cost

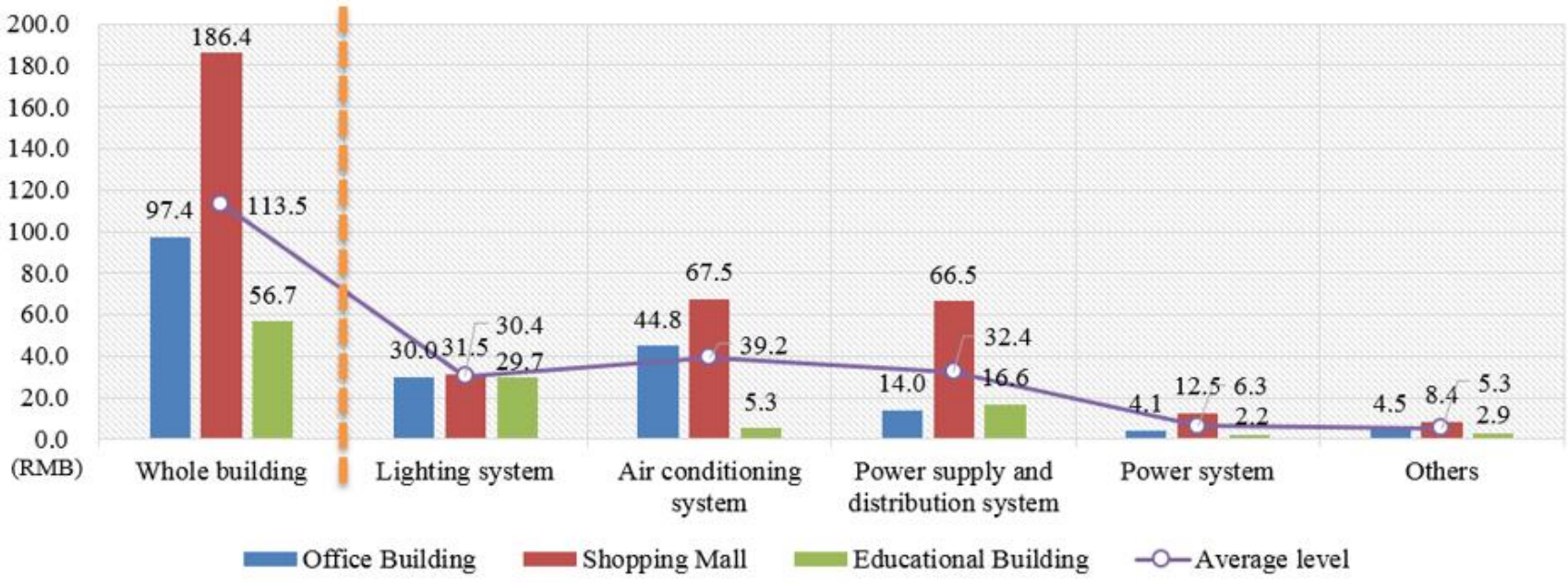


Figure 8. Retrofit cost for five building systems in three typical buildings in Chongqing

Case Study: Chongqing Retrofit Technical Solutions and Cost-Benefit Analysis

- The cost reduction highest in shopping malls
- Lighting system and air conditioning has the biggest potential
- Schools have low energy cost reduction due to the low use

Annual Cost Savings

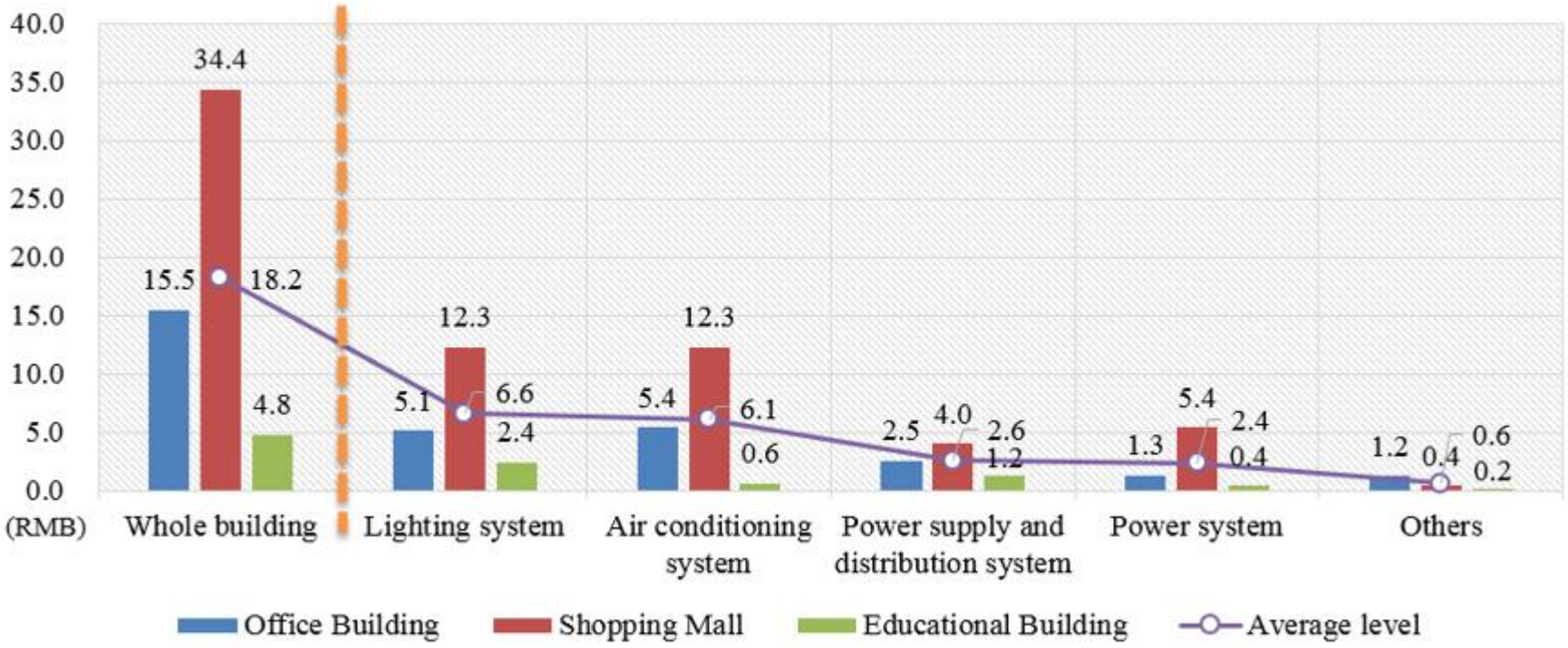


Figure 9. Annual savings from retrofits of five systems in three typical buildings in Chongqing

Case Study: Chongqing Retrofit Technical Solutions and Cost-Benefit Analysis

Static Payback

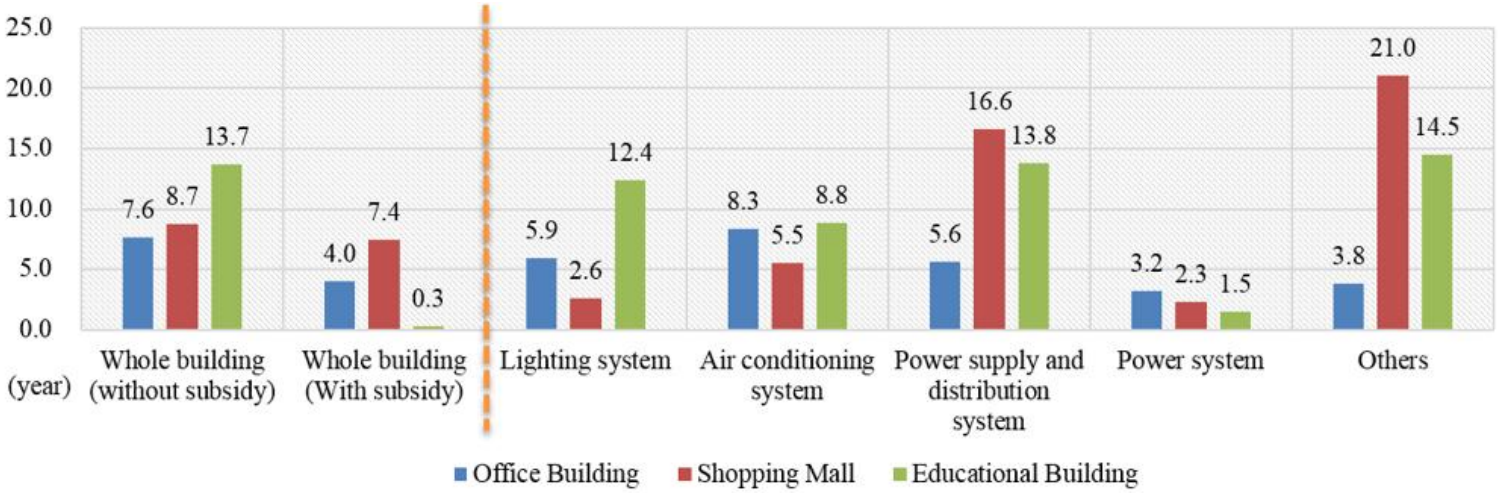


Figure 10. Static payback for retrofits in three types of commercial buildings in Chongqing.

- Although the subsidy only accounts for 20-40% of cost, it can significantly shorten the payback period for schools and office buildings.
- The subsidy has not substantially impacted the cost benefit for shopping malls.
- Lighting retrofit is economic for schools and office buildings, AC retrofit has more economic benefit for shopping malls.

Conclusions and Recommendations

Conclusions

1. central-government subsidies can drive local matching funding for energy-efficiency retrofits and thus stimulate market investments
2. key outcomes of the demonstration projects should be the identification of the retrofit technical solutions and business models that are best suited to the local stock of existing commercial buildings in each area

Recommendations for Policy Design

1. Subsidy intensity should be linked to the cost of local technical solutions
2. Linking the subsidy level to the energy savings achieved can encourage building owners/EMCs to pursue greater energy savings than they might in the absence of such an incentive
3. Linking the subsidy level to EMC can effectively promote EMC participation in the retrofit market
4. Paying subsidies in installments linked to clearly defined milestones can help ensure retrofit quality and achievement of target energy savings

Thank You ！

Q & A ?