

# ENERGY PERFORMANCE

TECHNICAL ENVIRONMENT SYSTEMS 2019-2020  
STUDY ON ENERGY PERFORMANCE OF BUILDINGS



A world map in a light gray tone serves as a background. Three blue circular markers are placed in East Asia, specifically in China, to indicate the study locations. The markers are arranged vertically, with Beijing at the top, Shanghai in the middle, and Guangzhou at the bottom.

- Beijing
- Shanghai
- Guangzhou

Professor: Behzad Najafi

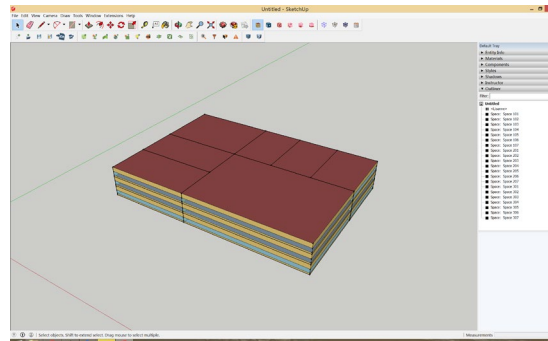
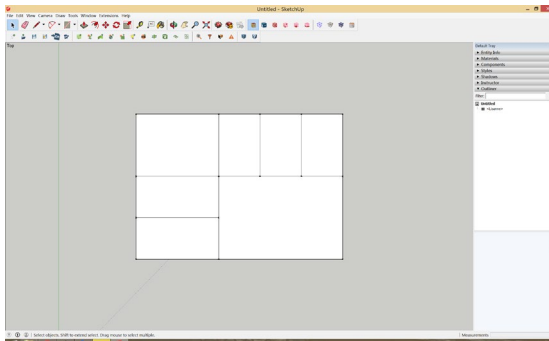
Team member:  
Lu Feng  
Yang Jun  
Guan Yixuan  
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# INTRODUCTION

## OBJECTIVE

- The objective of the experiment is to analyse the energy performance of a building in different conditions.
- The experiment is performed by calculating the energy consumption in different locations and material and then comparing the result to determine the important factors in energy performance.

## BUILDING



### Building Area

	Area [m2]
Total Building Area	21000.00
Net Conditioned Building Area	21000.00
Unconditioned Building Area	0.00

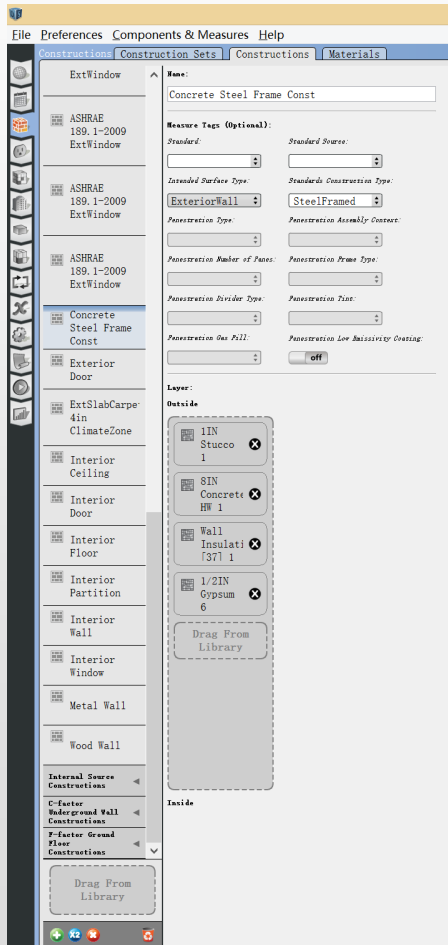
- We chose the layout of a conference building, whose total building area is 21000m<sup>2</sup>. There are 3 floors inside and each floor has 7 rooms (1 open space conference area, 6 conference rooms).
- To test the impact of Building introduction: It has three floors, and each floor is five-meter high. This commercial space is totally open and surrounded by glass and concrete.

# INTRODUCTION

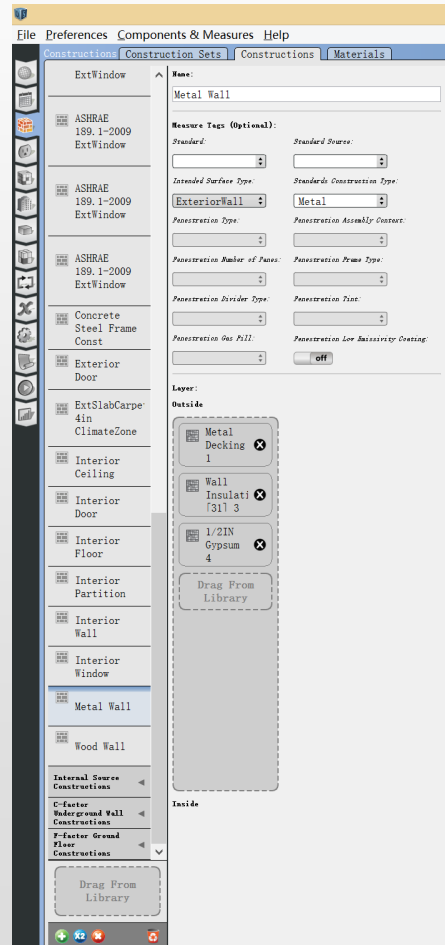
## MATERIAL

- The experiment will be performed on the following materials :1. Solid Concrete with Steel Frame; 2. Metal; 3. Wood

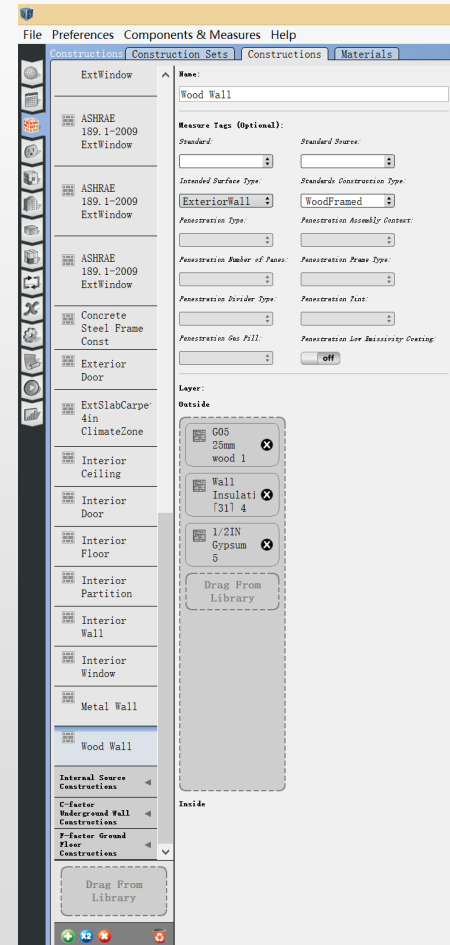
### Solid Concrete with Steel Frame



### Metal



### Wood

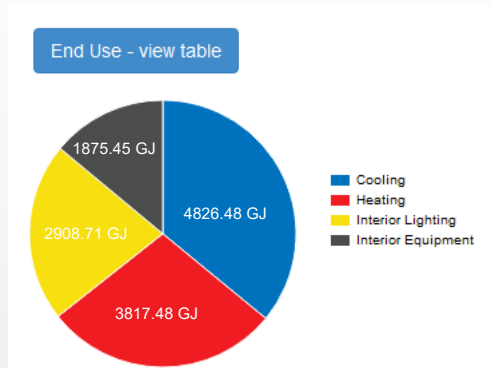


- To test the different factors on the energy consumption of the building, we changed two groups of input which are the material of the external wall (wood, metal and concrete) and the site.

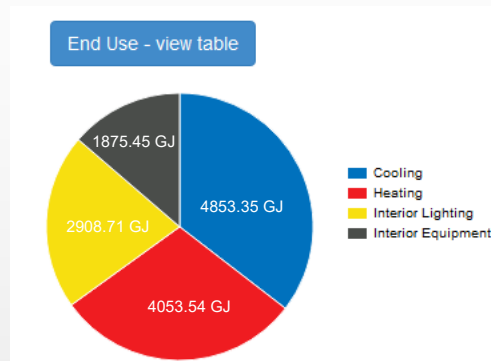
- So in the following report, we will analyze 5 situations that 1 type of wall build in 3 different cities, and 3 different walls in one city.

## ENERGY CONSUMPTION

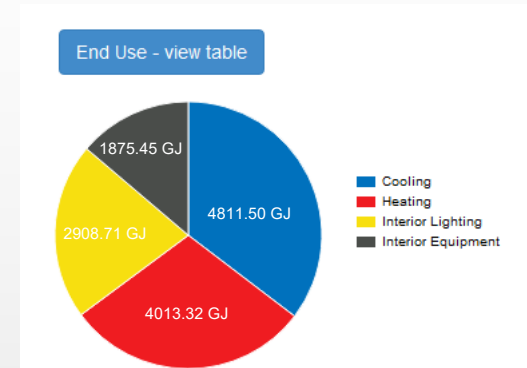
### Solid Concrete with Steel Frame (Basic One)



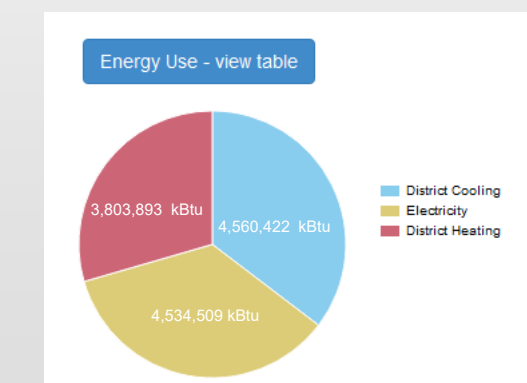
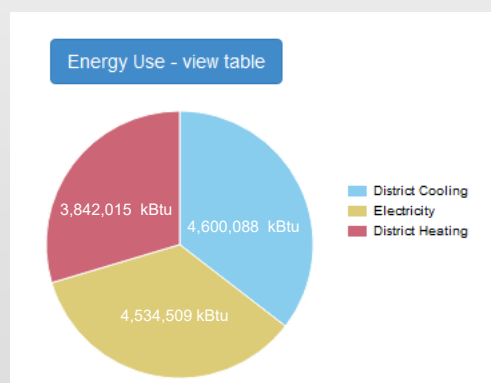
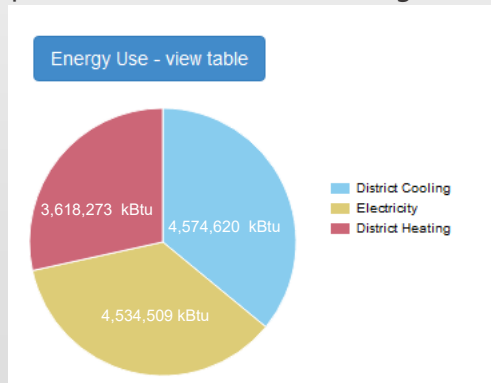
### Metal



### Wood



•The data from these pie charts shows that the energy output of three buildings with three kinds of walls in different materials in the same city, so the weather is the same. And we can see the consumption of energy is almost the same but still has some differences. For heating, metal consumes most and concrete with steel consumes least. As for cooling, the wood has a low consumption and the metal has the highest one.



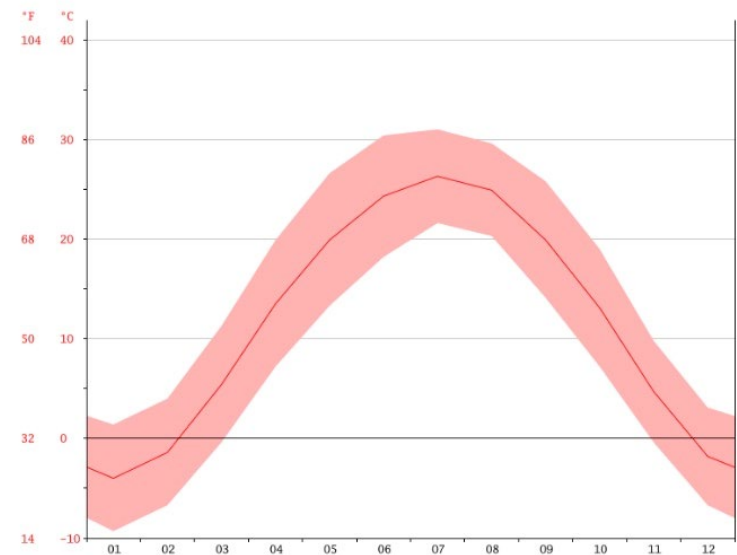
•The data from the three pie charts shows that the energy output of buildings with different materials in Beijing is almost the same but a little unequal due to the insulation property of the materials. According to the data of district heating energy, concrete with steel buildings is the lowest while metal building is the highest. When it comes to district cooling, the wood building consumes the least and the metal one consumes the most.

CLIMATE BEIJING: WEATHER BY MONTH

	January	February	March	April	May	June	July	August	Sep-tember	October	No-ember	December
Avg. Temperature (°C)	-4	-1.4	5.4	13.5	19.9	24.3	26.3	24.9	19.9	13.1	4.7	-1.8
Min. Temperature (°C)	-9.3	-6.7	-0.4	7.2	13.3	18.2	21.6	20.3	14.1	7.2	-0.4	-6.7
Max. Temperature (°C)	1.4	4	11.3	19.9	26.6	30.4	31	29.6	25.8	19	9.8	3.1
Avg. Temperature (°F)	24.8	29.5	41.7	56.3	67.8	75.7	79.3	76.8	67.8	55.6	40.5	28.8
Min. Temperature (°F)	15.3	19.9	31.3	45.0	55.9	64.8	70.9	68.5	57.4	45.0	31.3	19.9
Max. Temperature (°F)	34.5	39.2	52.3	67.8	79.9	86.7	87.8	85.3	78.4	66.2	49.6	37.6
Precipitation / Rainfall (mm)	4	5	9	21	32	75	195	192	51	16	7	3

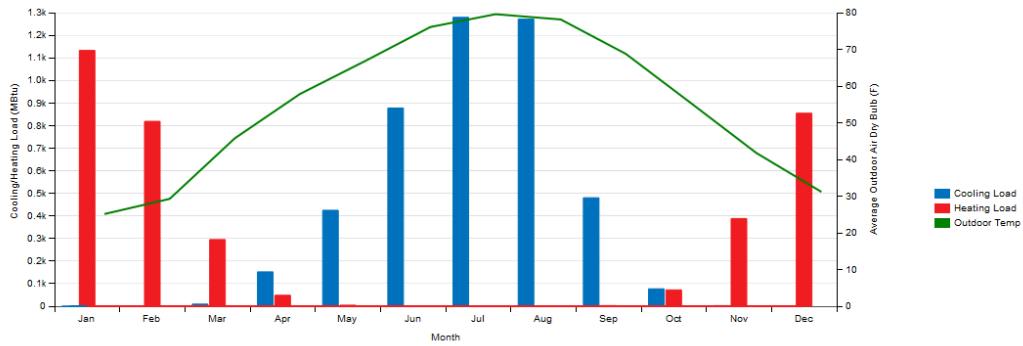
•There is a difference of 192MM of precipitation between the driest and wettest months. The variation in Temperatures throughout the year is 30.3 °C.

BEIJING AVERAGE TEMPERATURE

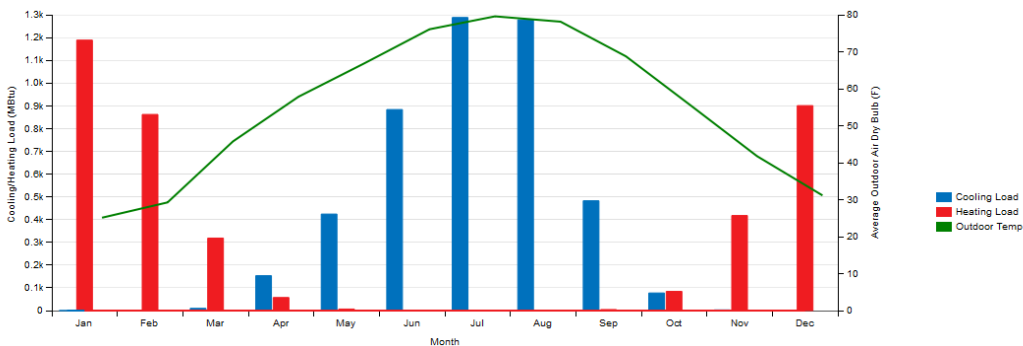


•July is the warmest month of the year. The temperature in July averages 26.3 °C. The lowest average temperatures in the year occur in January, when it is around -4 °C.

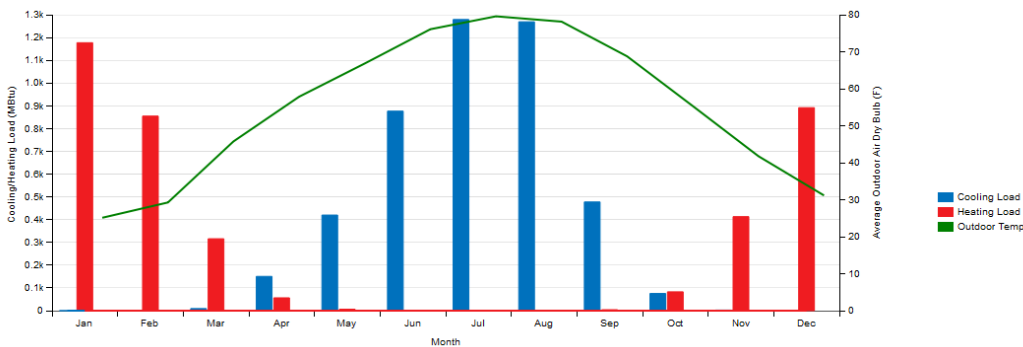
HVAC Load Profiles  
Solid Concrete with Steel Frame (Basic One)



Metal



Wood



RESULT | THREE MATERIALS IN BEIJING

THERMAL RESISTANCE

Solid Concrete with Steel Frame (Basic One)

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	75,347	7	19.96
Concrete Steel Frame Const	32,938	33	10.28

Metal

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	75,347	7	19.96
Metal Wall	32,938	33	4.88

Wood

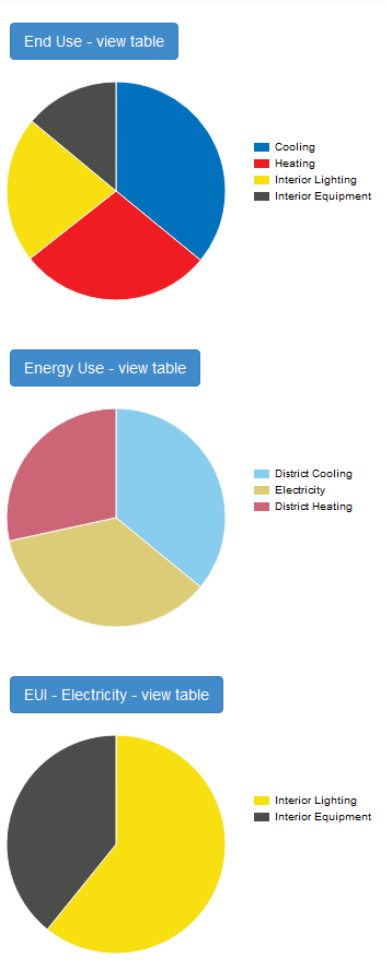
Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	75,347	7	19.96
Wood Wall	32,938	33	5.84

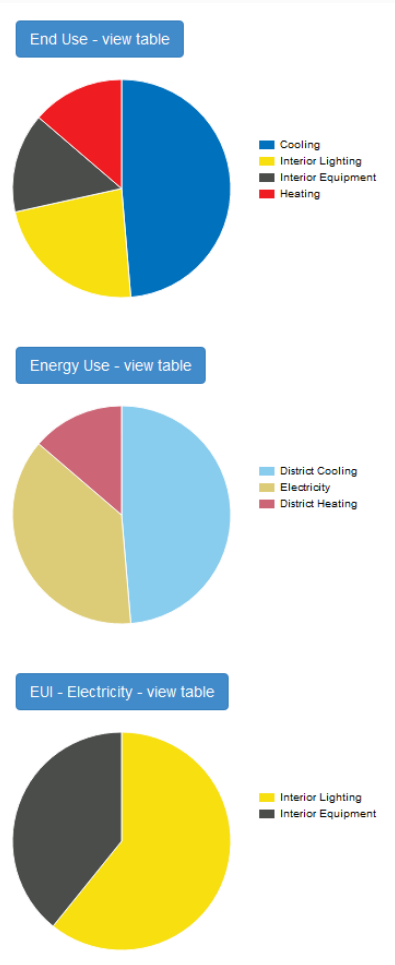
•From the above data, we can see that, in Beijing, due to the different construction of the buildings, the thermal resistances are different. The concrete exterior wall has 10.28 ft^2\*h\*R/Btu thermal resistance, while the value of metal external wall is 4.88 ft^2\*h\*R/Btu, and the wood one is 5.84 ft^2\*h\*R/Btu.

## ENERGY CONSUMPTION

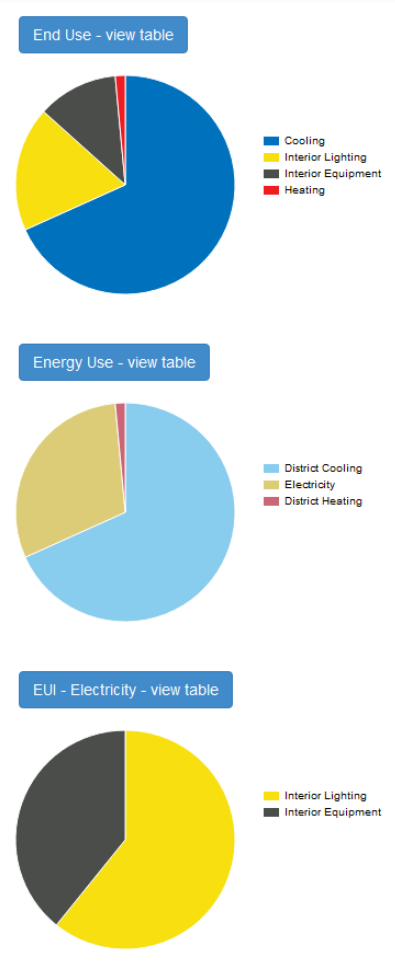
### Beijing



### Shanghai



### Guangzhou



The data shows that the energy output is similar in different cities, but there are some differences due to the weather and temperature.

Average temperature of Beijing is lower than Shanghai and Guangzhou, so the heating energy is higher in Beijing. Meanwhile, temperature of Guangzhou is higher than Shanghai and Beijing, so the heating energy is lower in Guangzhou.

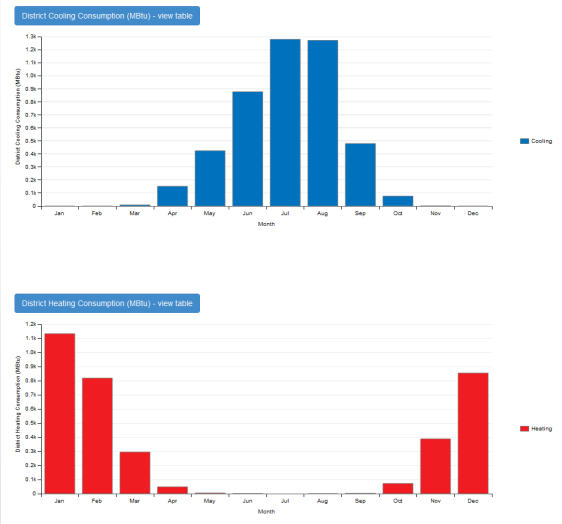
Heating is inversely proportional to temperature, and cooling is directly proportional to temperature.

It can be seen from the charts that at the EUI of three sites are almost the same, with similar proportion of electricity.

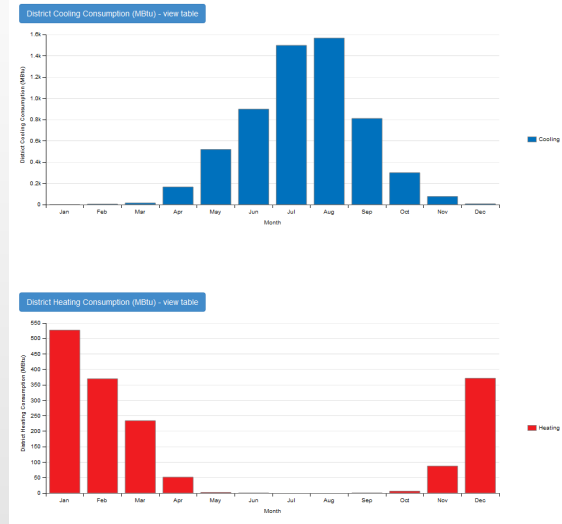
Proportion of heating and cooling in the end use and energy use charts are the same. But because the use of interior equipment needs electricity, the proportion in energy use is a little bit more than proportion in other charts.

## ENERGY CONSUMPTION

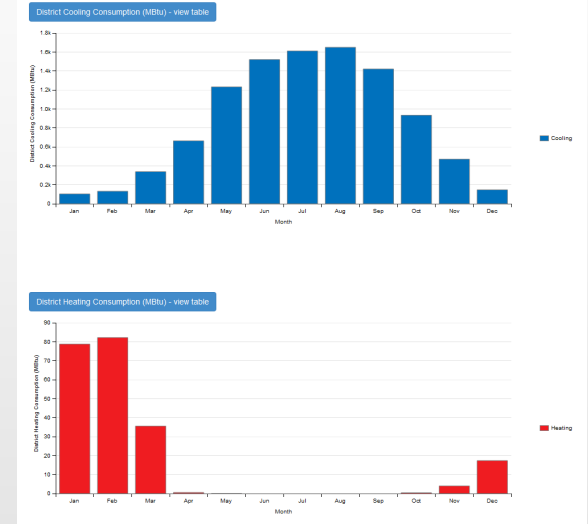
### Beijing



### Shanghai



### Guangzhou



•The cooling consumption in three cities are normal due to seasonal variation. Normally its higher in April till November and will peak in July - August. In other months are more uniform. Beijing and Shanghai have no cooling need in December till February. Guangzhou have cooling needs all the year.

•Consumption of heating load is continuous in every city. But the trend is the same, during summer the load is extremely low than other months. Three cities had almost no heating demand between May till September.



# CONCLUSION

## THREE MATERIALS IN BEIJING

Material	[GJ]	Beijing	Total
Concrete	Cooling	4826.48	8643.96
	Heating	3817.48	
Metal	Cooling	4853.35	8906.89
	Heating	4053.54	
Wood	Cooling	4811.50	8824.82
	Heating	4013.32	

- Regarding the energy performance of the building with different construction properties.

- CONCRETE overall has the lowest energy consumption.

- METAL is the best for cooling and heating.

- WOOD heating and cooling are at a medium level.

## CONCRETE WITH STEEL IN THREE CITIES

	Beijing	Shanghai	Guangzhou
Cooling	4826.48	6184.43	10785.62
Heating	3817.48	1742.46	231.01
Total	8643.96	7926.89	11016.63

- There are differences in loads in the three cities even with the same elements. Weather is most important variable that caused the variety. A place that is too cold or too hot will cost more energy.

- For the cooling, Beijing has the lowest requirement, while Guangzhou is the highest.

- For the heating, Beijing is the highest and Guangzhou is the lowest.