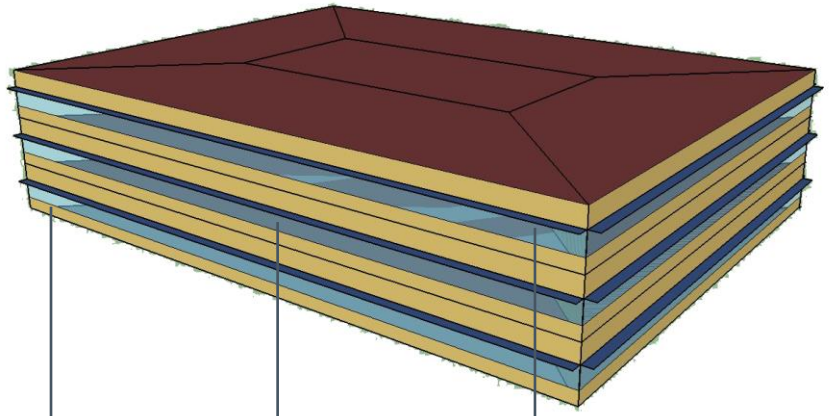
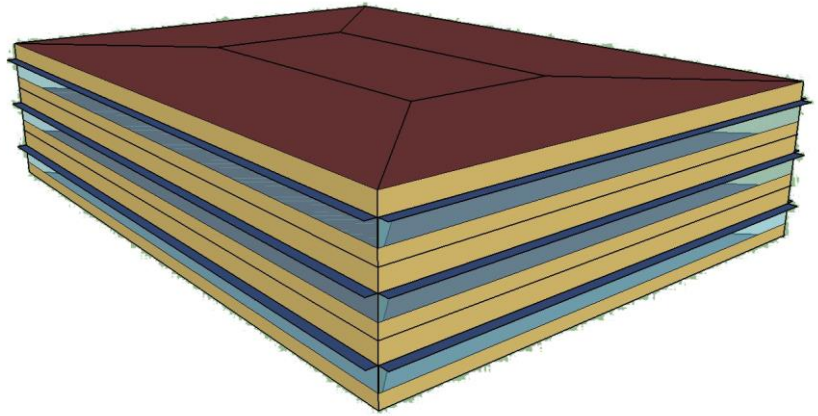
ENERGY PERFORMANCE

TECHNICAL ENVIROMENT SYSTEMS
STUDY ON ENERGY PERFORMANCE OF BUILDINGS

HE YUQIN
10549577/883106

PROF. RENZO.MARCHESI
PROF. BEHZAD NAJAFI





1F lobby

2F Open office

3F Rest room

In the project, I choose 3 positions in different climatic conditions, Piacenza, Mialno in Italy, and Shanghai in China. And in the building ,there are 3 floors , on the first floor is lobby, on the second floor is open office and on the third floor is rest room.

EXPERIMENTAL PROCEDURE

1. Using software Sketchup to complete a simple modle mass;
2. Using the software plug-in Openstudio, and then put the simple modle mass into the Openstudio;
3. Choosing three different cities as our site and three diferent materials of the wall;
4. Calculate the yearly heating and cooling. Recording the data of experiments. Then do the analysis and comparision between the data.

EXPERIMENTAL RESULT

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	2,549,315	kBtu
Total Building Area	29,036	ft^2
EUI (Based on Net Site Energy and Total Building Area)	87.80	kBtu/ft^2
OpenStudio Standards Building Type		

Building summary in Piacenza

Weather Summary

	Value
Weather File	Piacenza - ITA IGDG WMO#=160840
Latitude	44.92
Longitude	9.73
Elevation	440 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Weather summary in Piacenza

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	2,572,859	kBtu
Total Building Area	29,036	ft^2
EUI (Based on Net Site Energy and Total Building Area)	88.61	kBtu/ft^2
OpenStudio Standards Building Type		

Building summary in Milano

Weather Summary

	Value
Weather File	MILAN - ITA IWEC Data WMO#=160660
Latitude	45.62
Longitude	8.73
Elevation	692 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Weather summary in Milano

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	3,030,986	kBtu
Total Building Area	29,036	ft^2
EUI (Based on Net Site Energy and Total Building Area)	104.39	kBtu/ft^2
OpenStudio Standards Building Type		

Building summary in Shanghai

Weather Summary

	Value
Weather File	Shanghai Shanghai CHN CSWD WMO#=583620
Latitude	31.40
Longitude	121.45
Elevation	18 (ft)
Time Zone	8.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Weather summary in Shanghai

As can be seen from the above data, due to the different climatic conditions in three different places, the same type of construction results in a large difference in the energy consumption of the building.
Piacenza is a temperate climate with an elevation of 440, has the lowest EUI of three positions.
Milano is a a temperate climate with an elevation of 692, has the middle EUI of three positions.
Shanghai is a maritime subtropical monsoon climate with an elevation of 18, has the highest EUI of three positions.

EXPERIMENTAL RESULT

Sizing Period Design Days

	Maximum Dry Bulb (F)	Daily Temperature Range (R)	Humidity Value	Humidity Type	Wind Speed (mph)	Wind Direction
PIACENZA ANN CLG .4% CONDNS DB=>MWB	91.58	21.42	72.86	Wetbulb [F]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS DP=>MDB	81.32	21.42	73.4	Dewpoint [F]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS ENTH=>MDB	86.54	21.42	32.2	Enthalpy [Btu/lb]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS WB=>MDB	86.18	21.42	76.28	Wetbulb [F]	5.14	90.0
PIACENZA ANN HTG 99.6% CONDNS DB	21.02	0.0	21.02	Wetbulb [F]	4.47	250.0
PIACENZA ANN HTG WIND 99.6% CONDNS WS=>MCDB	42.44	0.0	42.44	Wetbulb [F]	19.91	250.0
PIACENZA ANN HUM_N 99.6% CONDNS DP=>MCDB	38.3	0.0	11.66	Dewpoint [F]	4.47	250.0

Sizing period design days in Piacenza

Sizing Period Design Days

	Maximum Dry Bulb (F)	Daily Temperature Range (R)	Humidity Value	Humidity Type	Wind Speed (mph)	Wind Direction
MILANO-LINATE ANN CLG .4% CONDNS DB=>MWB	91.4	18.36	75.38	Wetbulb [F]	5.14	220.0
MILANO-LINATE ANN CLG .4% CONDNS DP=>MDB	83.3	18.36	74.3	Dewpoint [F]	5.14	220.0
MILANO-LINATE ANN CLG .4% CONDNS ENTH=>MDB	87.8	18.36	33.32	Enthalpy [Btu/lb]	5.14	220.0
MILANO-LINATE ANN CLG .4% CONDNS WB=>MDB	87.8	18.36	77.36	Wetbulb [F]	5.14	220.0
MILANO-LINATE ANN HTG 99.6% CONDNS DB	22.82	0.0	22.82	Wetbulb [F]	0.89	240.0
MILANO-LINATE ANN HTG WIND 99.6% CONDNS WS=>MCDB	47.84	0.0	47.84	Wetbulb [F]	23.04	240.0
MILANO-LINATE ANN HUM_N 99.6% CONDNS DP=>MCDB	36.14	0.0	11.3	Dewpoint [F]	0.89	240.0
PIACENZA ANN CLG .4% CONDNS DB=>MWB	91.58	21.42	72.86	Wetbulb [F]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS DP=>MDB	81.32	21.42	73.4	Dewpoint [F]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS ENTH=>MDB	86.54	21.42	32.2	Enthalpy [Btu/lb]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS WB=>MDB	86.18	21.42	76.28	Wetbulb [F]	5.14	90.0
PIACENZA ANN HTG 99.6% CONDNS DB	21.02	0.0	21.02	Wetbulb [F]	4.47	250.0
PIACENZA ANN HTG WIND 99.6% CONDNS WS=>MCDB	42.44	0.0	42.44	Wetbulb [F]	19.91	250.0
PIACENZA ANN HUM_N 99.6% CONDNS DP=>MCDB	38.3	0.0	11.66	Dewpoint [F]	4.47	250.0

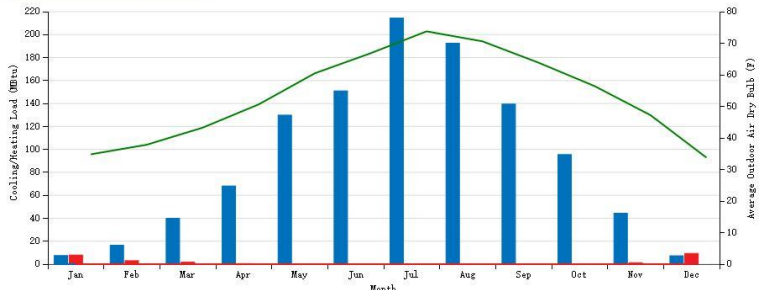
Sizing period design days in Milano

Sizing Period Design Days

	Maximum Dry Bulb (F)	Daily Temperature Range (R)	Humidity Value	Humidity Type	Wind Speed (mph)	Wind Direction
SHANGHAI ANN CLG .4% CONDNS DB=>MWB	94.82	9.9	80.78	Wetbulb [F]	8.05	250.0
SHANGHAI ANN CLG .4% CONDNS DP=>MDB	86.9	9.9	80.24	Dewpoint [F]	8.05	250.0
SHANGHAI ANN CLG .4% CONDNS ENTH=>MDB	90.86	9.9	38.61	Enthalpy [Btu/lb]	8.05	250.0
SHANGHAI ANN CLG .4% CONDNS WB=>MDB	90.5	9.9	82.4	Wetbulb [F]	8.05	250.0
SHANGHAI ANN HTG 99.6% CONDNS DB	28.58	0.0	28.58	Wetbulb [F]	6.93	270.0
SHANGHAI ANN HTG WIND 99.6% CONDNS WS=>MCDB	40.82	0.0	40.82	Wetbulb [F]	18.12	270.0
SHANGHAI ANN HUM_N 99.6% CONDNS DP=>MCDB	34.34	0.0	9.68	Dewpoint [F]	6.93	270.0

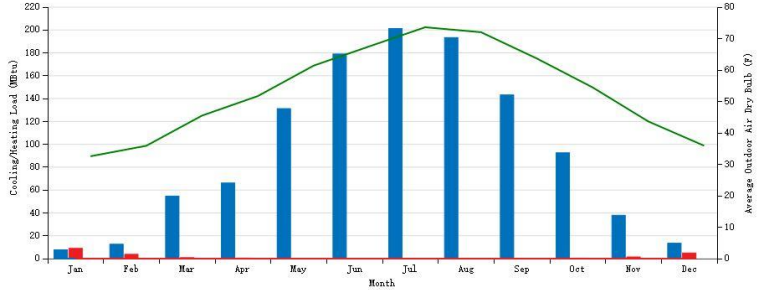
Sizing period design days in Shanghai

Monthly Load Profiles - view table



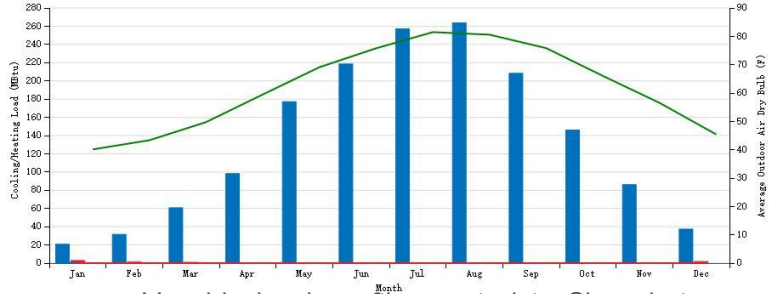
Monthly load profiles period in Piacenza

Monthly Load Profiles - view table



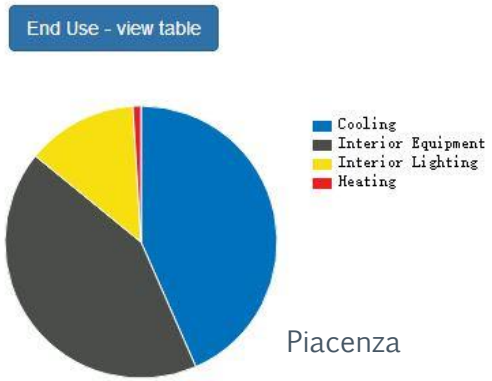
Monthly load profiles period in Milano

Monthly Load Profiles - view table

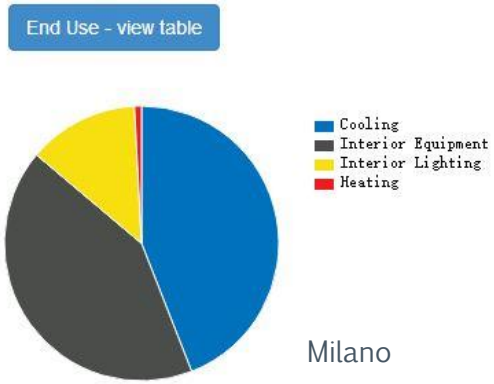


Monthly load profiles period in Shanghai

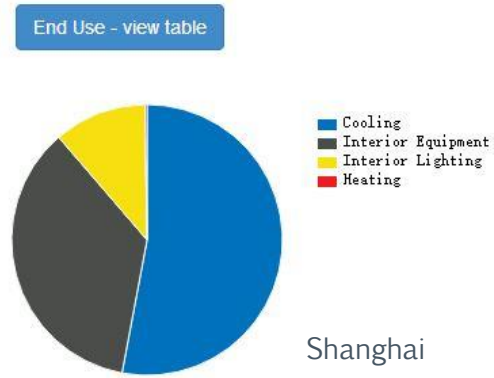
EXPERIMENTAL RESULT



Piacenza

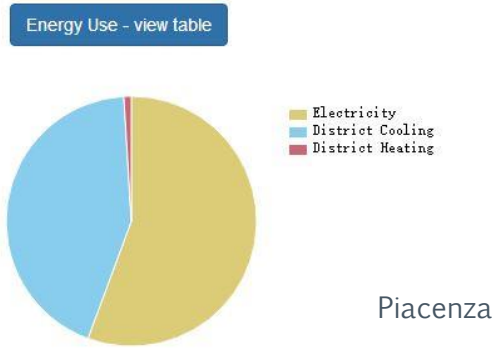


Milano

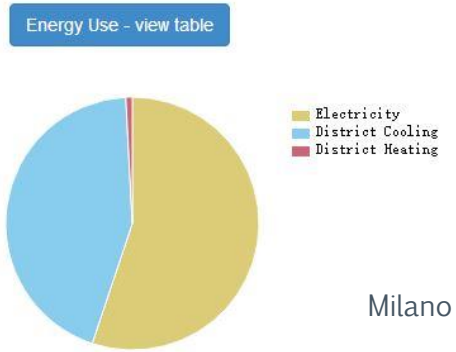


Shanghai

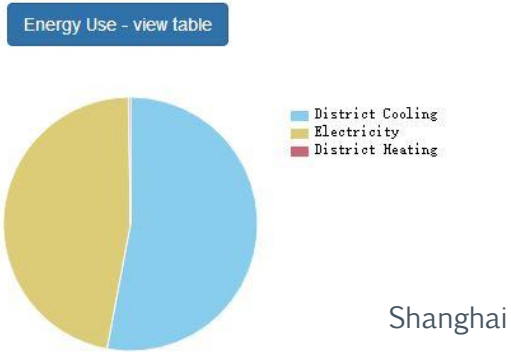
The data from the three pie charts shows that the energy output of the same building in different sites is very different due to the weather and the temperature. The distribution of energy is concentrated due to the change of climate and the control of indoor temperature. The proportion of interior equipment and the interior lighting, as the internal needs, are stable in three sites.



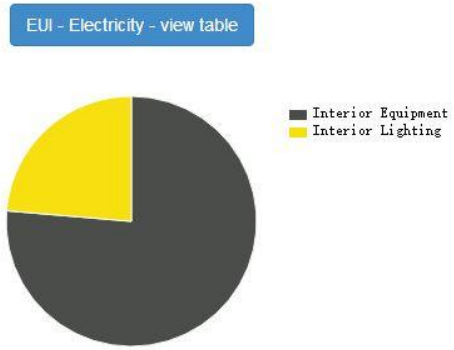
Piacenza

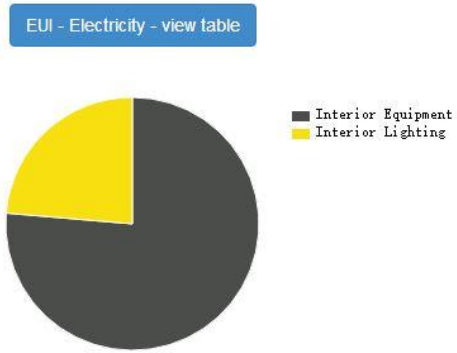


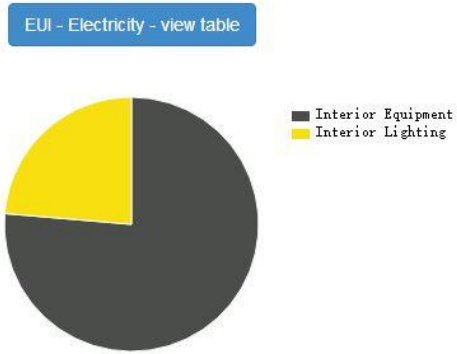
Milano



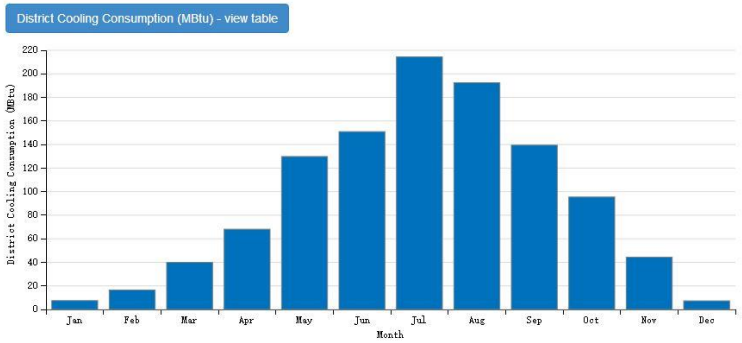
Shanghai



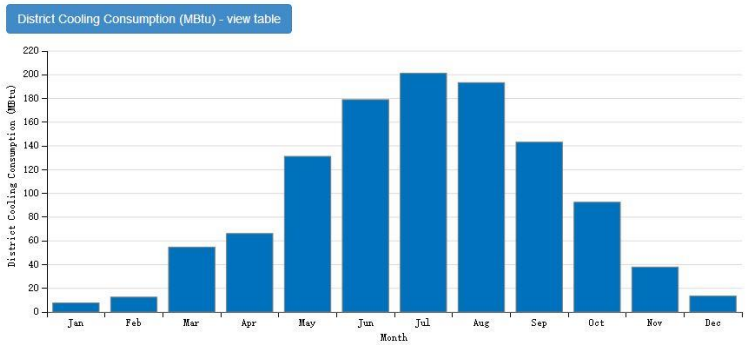




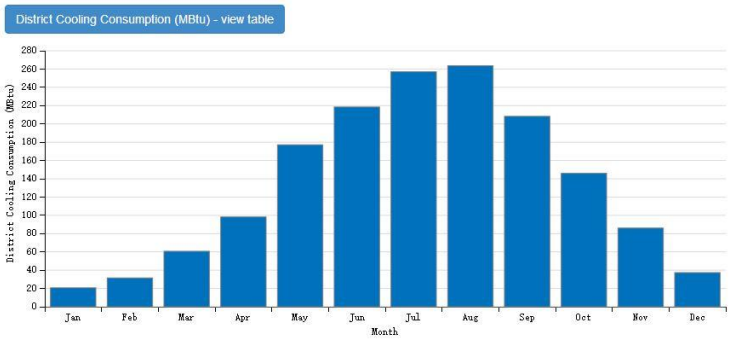
EXPERIMENTAL RESULT



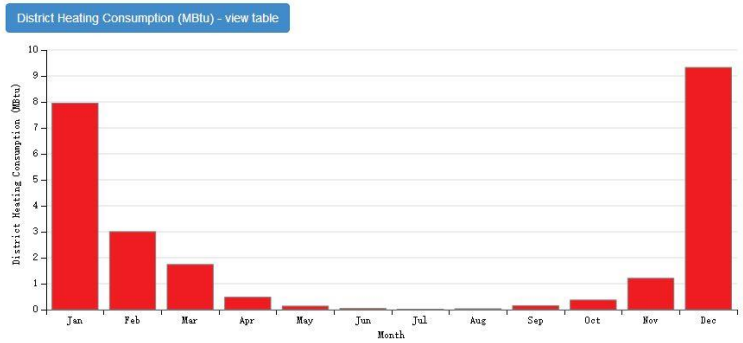
District cooling consumption(MBtu) in Piacenza



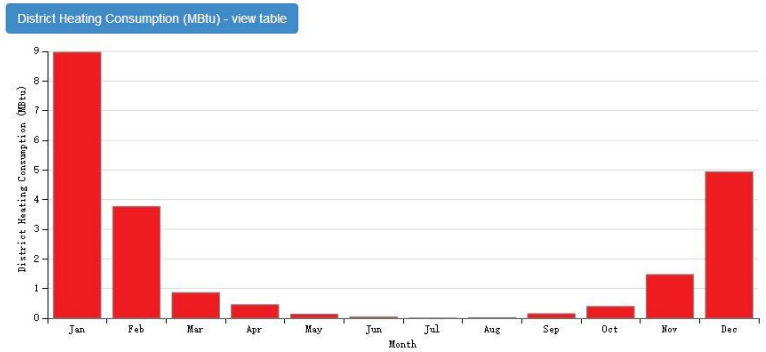
District cooling consumption(MBtu) in Milano



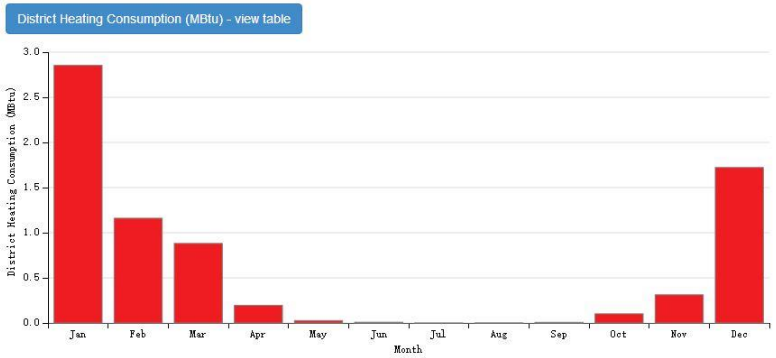
District cooling consumption(MBtu) in Shanghai



District heating consumption(MBtu) in Piacenza



District heating consumption(MBtu) in Mialno



District heating consumption(MBtu) in Shanghai

The consumption of cooling load in Piacenza and Milano are normal due to the temperature difference and seasonal variation. Normally it can reach a peak of energy consumption in July.For Shanghai, the peak of energy consumption is from June to September.
The consumption of heating load in Shanghai,the heating would stop from May to October.The heating in two months , January and December, would reach the peak.The heating load would be also continuous during the whole year in Piacenza and Milano.

EXPERIMENTAL RESULT

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	2549315.2	87.8	87.8
Net Site Energy	2549315.2	87.8	87.8
Total Source Energy	5748463.6	198.0	198.0
Net Source Energy	5748463.6	198.0	198.0

Site and Source energy in Piacenza

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	2572859.1	88.6	88.6
Net Site Energy	2572859.1	88.6	88.6
Total Source Energy	5765040.7	198.5	198.5
Net Source Energy	5765040.7	198.5	198.5

Site and Source energy in Milano

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	3030986.6	104.4	104.4
Net Site Energy	3030986.6	104.4	104.4
Total Source Energy	6213007.4	214.0	214.0
Net Source Energy	6213007.4	214.0	214.0

Site and Source energy in Shanghai

Site to Source Energy Conversion Factors

	Site=>Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

From the table of site to source conversion factors, it gives us the different proportion of 4 factors.Site to source conversion factor can help us to see each index clearly. The electricity and district heating are the highest, the electricity is 3.167,district heating is 3.613.While the natural gas and district cooling are not that high, natural gas is 1.084 and the district cooling is 1.056.

From the table of Site and Source Energy, we can find that the building in Shanghai has the highest Site Energy, the total energy is 3030986.6 kBtu.And the Piacenza is 2549315.2 kBtu, the Milano is 2572859.1 kBtu.
Total source energy is another important measure of site and source energy.Total source energy in Piacenza is 5748463.6 kBtu,in Milano is 5765040.7 kBtu, in Shanghai is 6213007.4 kBtu, which is the highest in three positions.

DIFFERENT MATERIAL ANALYSIS

Concrete

Steel

Wood

In the project, I chose wood, steel, and concrete, this three different materials, analyze the building situation in Shanghai, I compared and analyzed the data of using different materials under the same building in Shanghai, and concluded the difference between different materials through the data.

EXPERIMENTAL RESULT

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	3030986.6	104.4	104.4
Net Site Energy	3030986.6	104.4	104.4
Total Source Energy	6213007.4	214.0	214.0
Net Source Energy	6213007.4	214.0	214.0

Site and Source energy (Concrete)

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	3027460.5	104.3	104.3
Net Site Energy	3027460.5	104.3	104.3
Total Source Energy	6208012.4	213.8	213.8
Net Source Energy	6208012.4	213.8	213.8

Site and Source energy (Steel)

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	3029318.4	104.3	104.3
Net Site Energy	3029318.4	104.3	104.3
Total Source Energy	6210789.7	213.9	213.9
Net Source Energy	6210789.7	213.9	213.9

Site and Source energy (Wood)

From the Site and Source energy, we could find that different materials in Shanghai ,concrete has the highest Total Site Energy and Total Source Energy, there are 3030986.6kBtu and 6213007.4kBtu.But we can conclude that the building of different materials in Shanghai has little effect on these pieces of data.

EXPERIMENTAL RESULT

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	51	1306	627	1957	1614	995	2210	0	0	0	0	0	0	70.5 (F)
THERMAL ZONE 2	0	0	0	0	137	180	316	525	686	4644	569	1703	0	0	0	0	75.2 (F)
THERMAL ZONE 3	0	0	0	0	0	13	61	172	248	4892	291	3083	0	0	0	0	76.7 (F)

Concrete

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	423	422	657	695	707	616	558	583	702	556	462	2379	63.7 (%)
THERMAL ZONE 2	954	915	863	1674	1778	971	909	663	33	0	0	0	44.3 (%)
THERMAL ZONE 3	1428	808	1067	1623	1428	860	462	851	228	5	0	0	43.1 (%)

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	44	1317	656	1967	1626	967	2183	0	0	0	0	0	0	70.4 (F)
THERMAL ZONE 2	0	0	0	0	93	195	273	526	708	4696	594	1675	0	0	0	0	75.2 (F)
THERMAL ZONE 3	0	0	0	0	0	8	53	146	251	4900	294	3108	0	0	0	0	76.8 (F)

Steel

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	424	429	660	688	712	612	547	568	686	546	458	2430	63.8 (%)
THERMAL ZONE 2	970	927	853	1653	1724	915	926	737	55	0	0	0	44.4 (%)
THERMAL ZONE 3	1440	801	1062	1615	1410	872	463	861	231	5	0	0	43.1 (%)

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	49	1319	649	1965	1617	961	2200	0	0	0	0	0	0	70.4 (F)
THERMAL ZONE 2	0	0	0	0	109	193	291	531	708	4670	583	1675	0	0	0	0	75.2 (F)
THERMAL ZONE 3	0	0	0	0	0	12	54	160	249	4898	302	3085	0	0	0	0	76.7 (F)

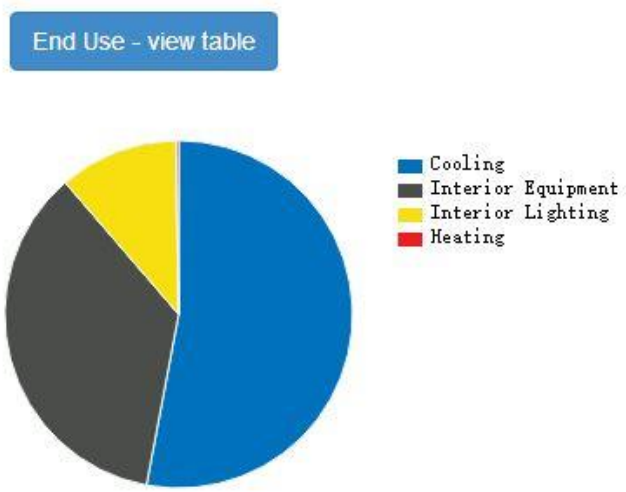
Wood

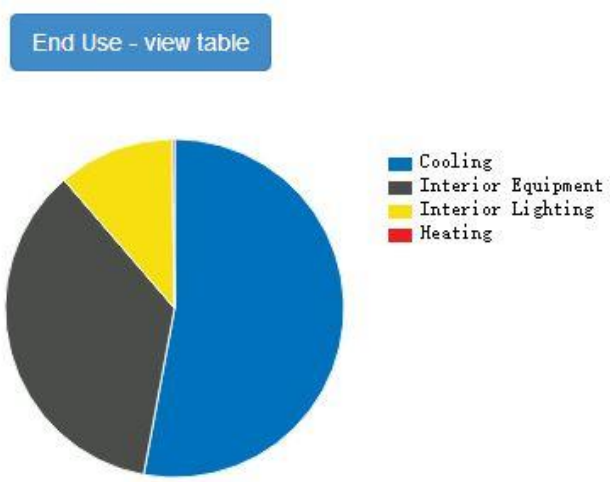
Humidity (Table values represent hours spent in each Humidity range)

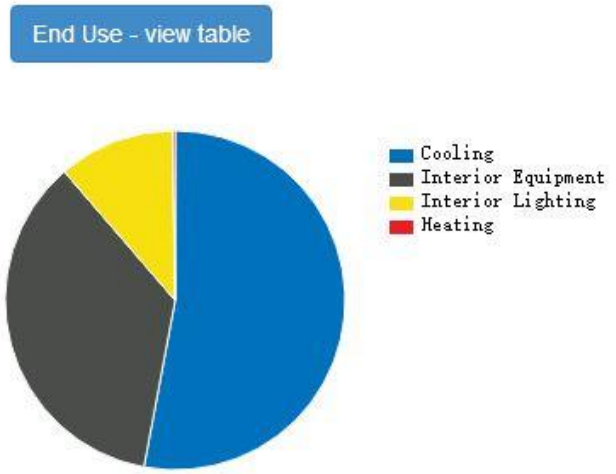
Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	423	425	663	681	725	609	555	584	685	541	463	2406	63.8 (%)
THERMAL ZONE 2	964	913	853	1672	1741	920	921	721	55	0	0	0	44.4 (%)
THERMAL ZONE 3	1435	803	1064	1616	1410	874	462	862	229	5	0	0	43.1 (%)

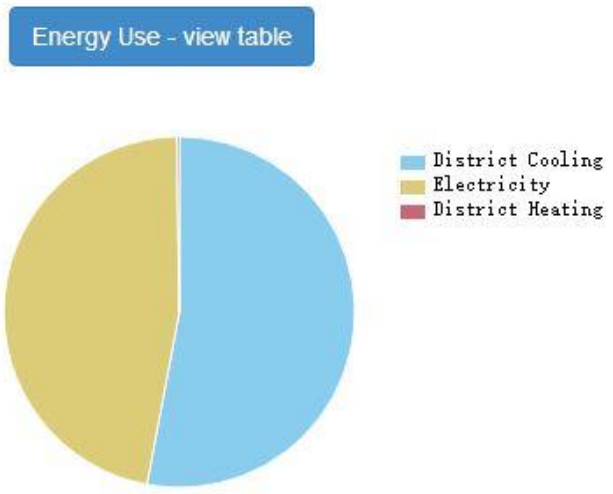
From this zone conditions, we can see three different materials of temperature and humidity have little difference between the data.

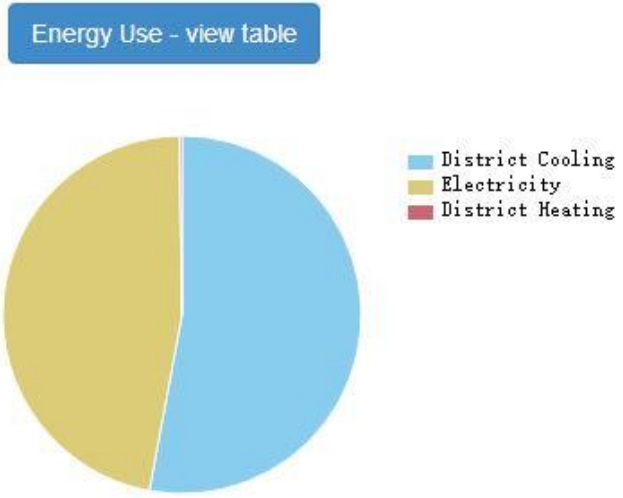
EXPERIMENTAL RESULT

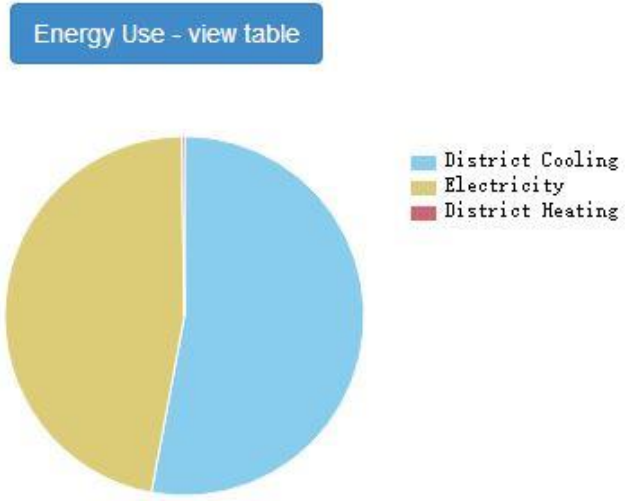












This three pie charts shows the End use and Energy use of three different materials in Shanghai,we can see that there are almost same but a little difference in data.According to the data of district heating erergy, wood building is the highest.For the cooling, also the wood building consume the most and the concrete one cosume the least.

EXPERIMENTAL RESULT

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	12,917	5	24.73
ASHRAE 189.1-2009 ExtWall Mass ClimateZone 5	8,268	12	11.76

Base surface construction (Concrete)

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
189.1-2009 Nonres 4B Ext Wall Steel-Framed	8,268	12	17.45
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	12,917	5	24.73

Base surface construction (Steel)

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
189.1-2009 Nonres 4B Ext Wall Wood-Framed and Other	8,268	12	14.90
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	12,917	5	24.73

Base surface construction (Wood)

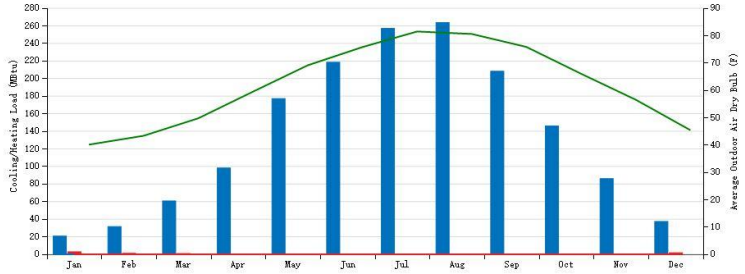
From the Base surface construction of three different materials in Shanghai, we can see that the thermal resistance are different.The concrete wall in R Value has 11.76m2*K/W while the steel and wood wall has 24.73m2*K/W.

EXPERIMENTAL RESULT

Monthly Load Profiles - view table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	40.1	43.4	49.7	59.5	69.1	75.8	81.5	80.6	75.8	66.0	56.5	45.4
Cooling Load (MBtu)	20.72	31.54	60.72	98.23	177.19	218.52	257.04	263.62	208.3	145.99	86.08	37.36
Heating Load (MBtu)	2.85	1.16	0.88	0.2	0.03	0.01	0.0	0.0	0.01	0.1	0.31	1.72

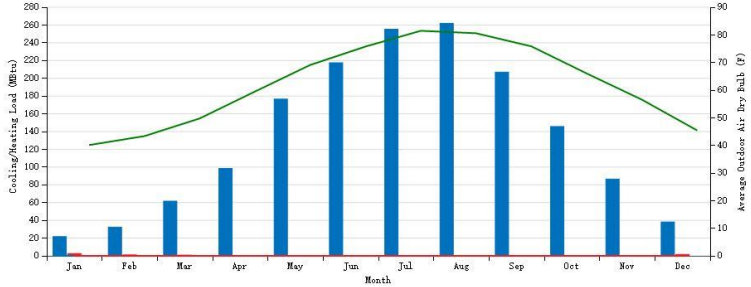
Monthly load profiles (Concrete)



Monthly Load Profiles - view table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	40.1	43.4	49.7	59.5	69.1	75.8	81.5	80.6	75.8	66.0	56.5	45.4
Cooling Load (MBtu)	21.66	32.33	61.6	98.4	176.57	217.46	255.21	261.89	206.91	145.65	86.47	38.16
Heating Load (MBtu)	2.57	1.08	0.82	0.21	0.04	0.01	0.0	0.0	0.01	0.11	0.32	1.6

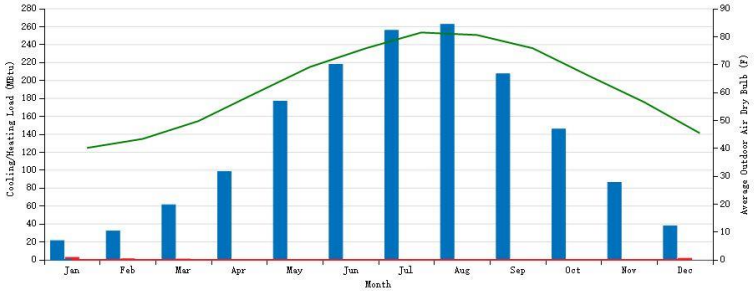
Monthly load profiles (Steel)



Monthly Load Profiles - view table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	40.1	43.4	49.7	59.5	69.1	75.8	81.5	80.6	75.8	66.0	56.5	45.4
Cooling Load (MBtu)	21.38	32.11	61.37	98.38	176.86	217.91	255.89	262.53	207.42	145.8	86.3	37.89
Heating Load (MBtu)	2.72	1.13	0.86	0.21	0.04	0.01	0.0	0.0	0.01	0.11	0.33	1.68

Monthly load profiles (Wood)



From the data of monthly load profiles about different materials in building, we can see that the heating and cooling load of HVAC is the same,and the heating load is more lower than cooling load in winter.

THANK YOU !