

TECHNICAL ENVIRONMENTAL SYSTEMS

PROFESSOR

RENZO MARCHESI

BEHZAD NAJAFI

GROUP MEMBERS

Aya Abdelmoneim Moustafa Hussein (919552)

Dionisius Dino Briananto (913901)

Rahimeh Rameshi (914046)

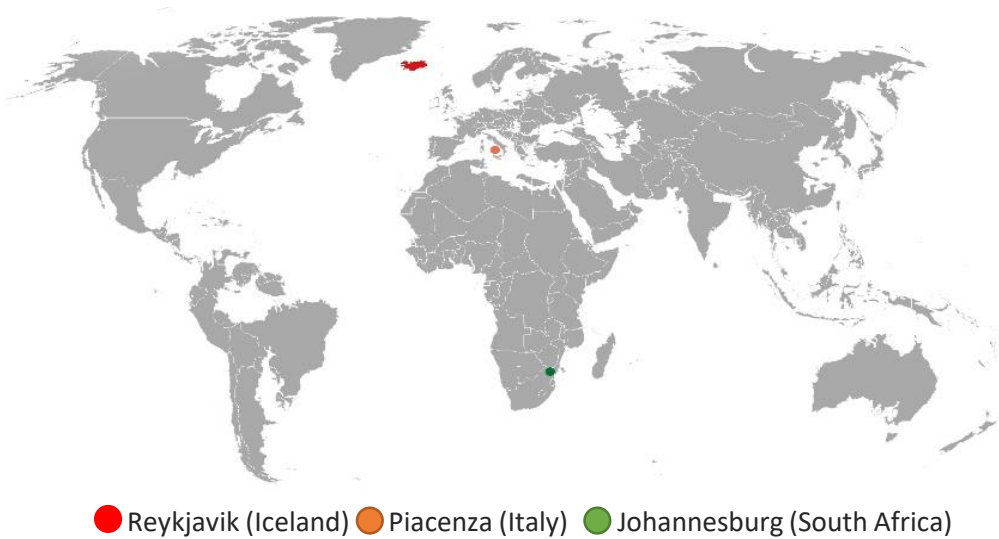
Dongni Zhang (904096)

CONTENT

- 1 / OVERALL INTRODUCTION
- 2 / PIACENZA (ITALY)-WOOD
- 3 / REYKJAVIK (ICELAND)-WOOD
- 4 / JOHANNESBURG (SOUTH AFRICA)-WOOD
- 5 / PIACENZA (ITALY)-CONCRETE
- 6 / REYKJAVIK (ICELAND)-CONCRETE
- 7 / JOHANNESBURG (SOUTH AFRICA)-CONCRETE
- 8 / PIACENZA (ITALY)-METAL
- 9 / REYKJAVIK (ICELAND)-METAL
- 10 / JOHANNESBURG (SOUTH AFRICA)-METAL
- 11 / COMPARISON and SUMMARY

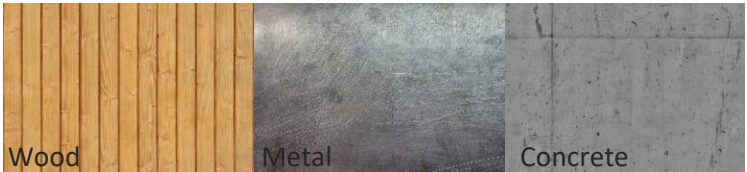
1 / OVERALL INTRODUCTION

In this research report, we choose three different cities with different weather condition, namely Reykjavik (Iceland), Piacenza (Italy) and Johannesburg (South Africa) as the experimental places. Among these, Reykjavik belongs to cold climate zone, Piacenza belongs to temperate area while Johannesburg is in tropical zone.



In another case, we choose wood, concrete and metal as different building materials, which have totally different properties.

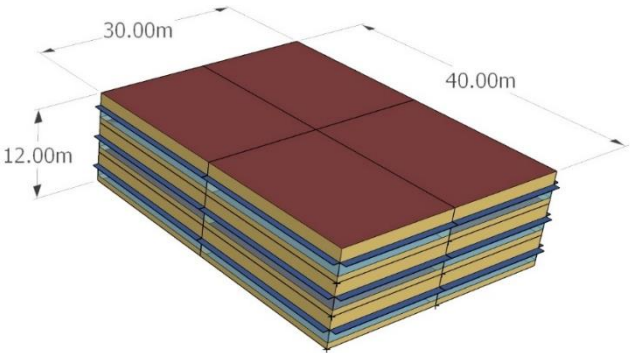
Based on a specific building, we attempt to make a comparison among these cities in case of using the same materials, then compare three different materials when the location of buiding is the same.



An office building is used as the experimental basement. It has three floors, and each floor is four-meter high. This official space is totally open and surrounded by glass.

Building Area

	Area [m2]
Total Building Area	2400.00
Net Conditioned Building Area	2400.00
Unconditioned Building Area	0.00



ENVELOPE

Window-Wall Ratio

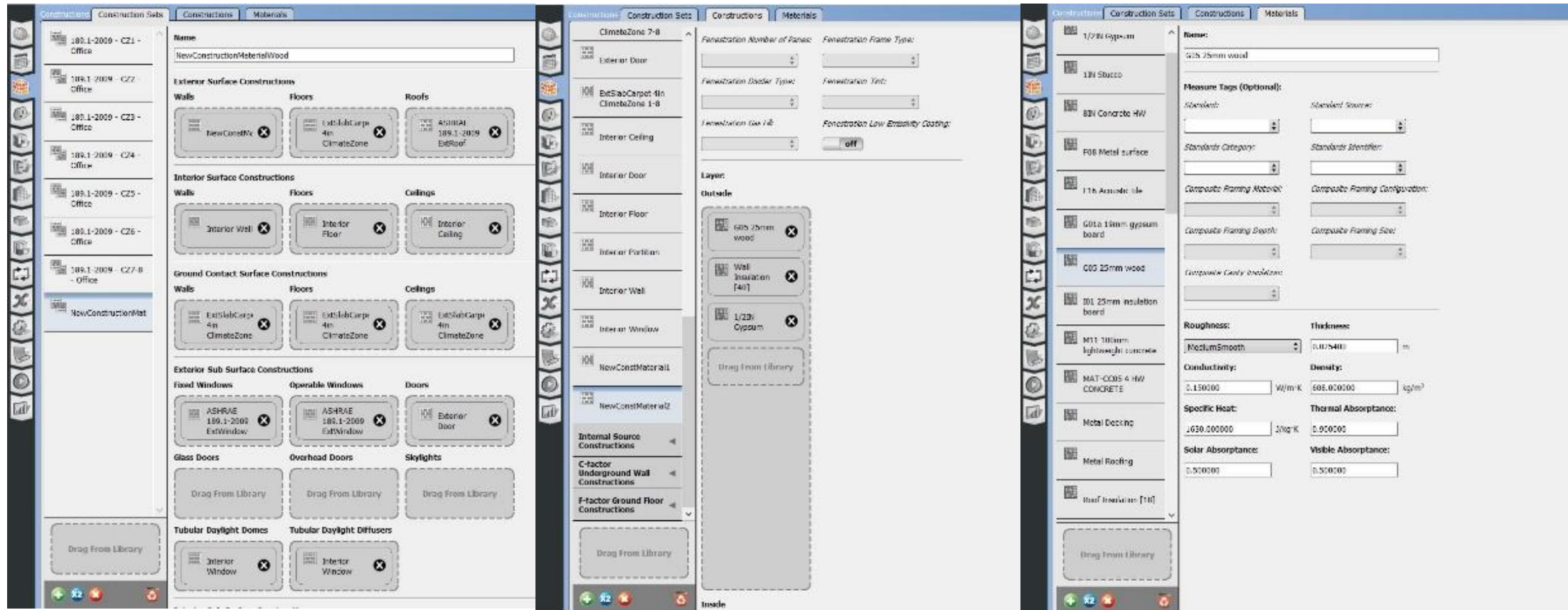
	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [m2]	1120.00	240.00	320.00	240.00	320.00
Above Ground Wall Area [m2]	1120.00	240.00	320.00	240.00	320.00
Window Opening Area [m2]	448.00	96.00	128.00	96.00	128.00
Gross Window-Wall Ratio [%]	40.00	40.00	40.00	40.00	40.00
Above Ground Window-Wall Ratio [%]	40.00	40.00	40.00	40.00	40.00

2 / PIACENZA (ITALY)-WOOD

As the base case of this research, we put this office building in Piacenza and use wood as the material of exterior wall.

The images below show the procedure of setting wood as the wall material.

Procedure of setting the material of exterior wall



The tables below show the situation of energy consumption, the red parts present the consumption (GJ) and power (W) of heating and cooling.

Program Version:EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 08:21
Tabular Output Report in Format: HTML
Building: Building 1
Environment: RUN PERIOD 1 ** Piacenza - ITA IGDG WMO##=160840
Simulation Timestamp: 2018-12-16 08:21:02

Report: Annual Building Utility Performance Summary
For: Entire Facility
Timestamp: 2018-12-16 08:21:02
Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	1258.88	524.53	524.53
Net Site Energy	1258.88	524.53	524.53
Total Source Energy	3509.98	1462.49	1462.49
Net Source Energy	3509.98	1462.49	1462.49

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	17-JUL-06:10	04-DEC-06:10	-
Heating	0.00	0.00	0.00	0.00	256460.92	0.00
Cooling	0.00	0.00	0.00	150842.40	0.00	0.00

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	349.44	0.00
Cooling	0.00	0.00	0.00	299.74	0.00	0.00

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
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

3 / REYKJAVIK (ICELAND)-WOOD

In case of using the same material, we put the building in Reykjavik.

The tables below show the situation of energy consumption, the red parts present the consumption (GJ) and power (W) of heating and cooling.

Program Version: EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 08:09

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 ** REYKJAVIK - ISL IWECC Data WMO#=040300

Simulation Timestamp: 2018-12-16 08:09:16

Report: Annual Building Utility Performance Summary

For: Entire Facility

Timestamp: 2018-12-16 08:09:16

Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	1466.67	611.11	611.11
Net Site Energy	1466.67	611.11	611.11
Total Source Energy	5025.18	2093.82	2093.82
Net Source Energy	5025.18	2093.82	2093.82

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	856.09	0.00
Cooling	0.00	0.00	0.00	0.88	0.00	0.00

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	28-JUL-15:00	13-MAR-06:10	-
Heating	0.00	0.00	0.00	0.00	266764.10	0.00
Cooling	0.00	0.00	0.00	19470.05	0.00	0.00

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
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

4 / JOHANNESBURG (SOUTH AFRICA)-WOOD

In case of using the same material, we put the building in Johannesburg.

The tables below show the situation of energy consumption, the red parts present the consumption (GJ) and power (W) of heating and cooling.

Program Version: EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 08:33

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 ** JOHANNESBURG - ZAF IWECC Data WMO#=#683680

Simulation Timestamp: 2018-12-16 08:33:59

Report: **Annual Building Utility Performance Summary**

For: **Entire Facility**

Timestamp: **2018-12-16 08:33:59**

Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	1042.39	434.33	434.33
Net Site Energy	1042.39	434.33	434.33
Total Source Energy	2497.23	1040.51	1040.51
Net Source Energy	2497.23	1040.51	1040.51

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	42.82	0.00
Cooling	0.00	0.00	0.00	389.86	0.00	0.00

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	02-MAR-15:00	24-JUL-06:10	-
Heating	0.00	0.00	0.00	0.00	184146.41	0.00
Cooling	0.00	0.00	0.00	92768.68	0.00	0.00

Site to Source Energy Conversion Factors

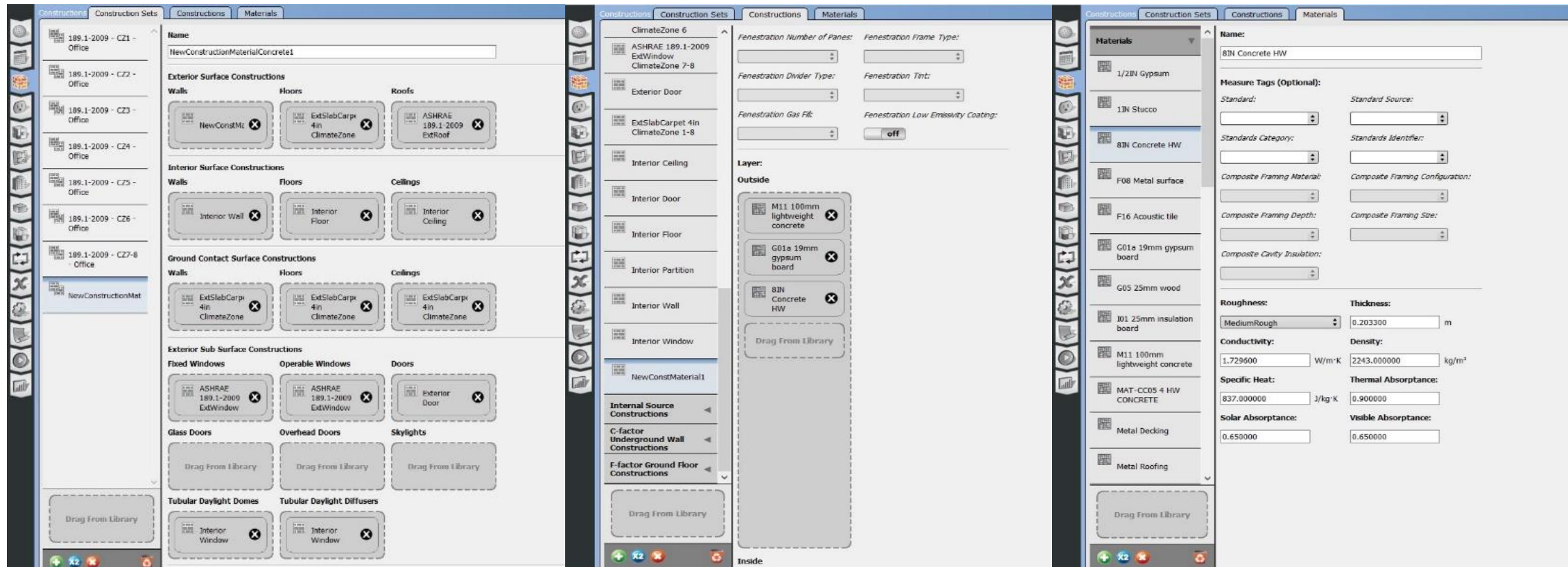
	Site=>Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

5 / PIACENZA (ITALY)-CONCRETE

In case of putting this building in Piacenza, we use concrete as the material of exterior wall.

The images below show the procedure of setting concrete as the wall material.

Procedure of setting the material of exterior wall



The tables below show the situation of energy consumption, the red parts present the consumption (GJ) and power (W) of heating and cooling.

Program Version:EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 07:47
 Tabular Output Report in Format: HTML
 Building: Building 1
 Environment: RUN PERIOD 1 ** Piacenza - ITA IGDG WMO#=160840
 Simulation Timestamp: 2018-12-16 07:47:15

Report: Annual Building Utility Performance Summary
 For: Entire Facility
 Timestamp: 2018-12-16 07:47:15
 Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	1346.63	561.09	561.09
Net Site Energy	1346.63	561.09	561.09
Total Source Energy	3870.44	1612.68	1612.68
Net Source Energy	3870.44	1612.68	1612.68

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	454.15	0.00
Cooling	0.00	0.00	0.00	282.77	0.00	0.00

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	13-JUL-06:10	04-DEC-06:10	-
Heating	0.00	0.00	0.00	0.00	267452.20	0.00
Cooling	0.00	0.00	0.00	181698.05	0.00	0.00

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
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

6 / REYKJAVIK (ICELAND)-CONCRETE

In case of putting this building in Reykjavik, we use concrete as the material of exterior wall.

The tables below show the situation of energy consumption, the red parts present the consumption (GJ) and power (W) of heating and cooling.

Program Version:EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 08:36

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 ** REYKJAVIK - ISL IWECC Data WMO#040300

Simulation Timestamp: 2018-12-16 08:36:29

Report: Annual Building Utility Performance Summary

For: Entire Facility

Timestamp: 2018-12-16 08:36:29

Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	1466.67	611.11	611.11
Net Site Energy	1466.67	611.11	611.11
Total Source Energy	5025.18	2093.82	2093.82
Net Source Energy	5025.18	2093.82	2093.82

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	856.09	0.00
Cooling	0.00	0.00	0.00	0.88	0.00	0.00

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	28-JUL-15:00	13-MAR-06:10	-
Heating	0.00	0.00	0.00	0.00	266764.10	0.00
Cooling	0.00	0.00	0.00	19470.05	0.00	0.00

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
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

7 / JOHANNESBURG (SOUTH AFRICA)-CONCRETE

In case of putting this building in Johannesburg, we use concrete as the material of exterior wall.

The tables below show the situation of energy consumption, the red parts present the consumption (GJ) and power (W) of heating and cooling.

Program Version:EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 08:27

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 ** JOHANNESBURG - ZAF IWECC Data WMO#=-683680

Simulation Timestamp: 2018-12-16 08:27:54

Report: Annual Building Utility Performance Summary

For: Entire Facility

Timestamp: 2018-12-16 08:27:54

Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	995.18	414.66	414.66
Net Site Energy	995.18	414.66	414.66
Total Source Energy	2470.42	1029.34	1029.34
Net Source Energy	2470.42	1029.34	1029.34

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	51.82	0.00
Cooling	0.00	0.00	0.00	333.66	0.00	0.00

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	02-MAR-15:00	24-JUL-06:10	-
Heating	0.00	0.00	0.00	0.00	186637.35	0.00
Cooling	0.00	0.00	0.00	87871.22	0.00	0.00

Site to Source Energy Conversion Factors

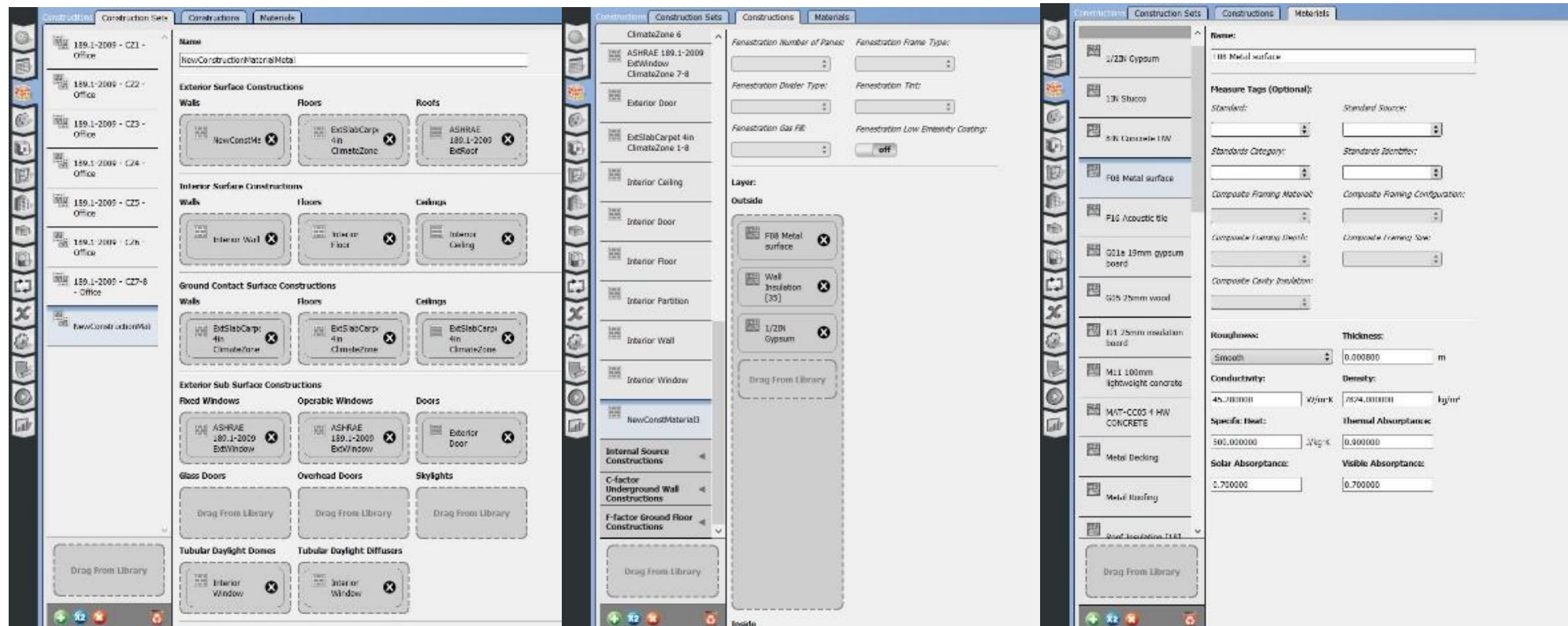
	Site=>Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

8 / PIACENZA (ITALY)-METAL

In case of putting this building in Piacenza, we use metal as the material of exterior wall.

The images below show the procedure of setting metal as the wall material.

Procedure of setting the material of exterior wall



The tables below show the situation of energy consumption, the red parts present the consumption (GJ) and power (W) of heating and cooling.

Program Version:EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 07:54
 Tabular Output Report in Format: **HTML**
 Building: **Building 1**
 Environment: RUN PERIOD 1 ** Piacenza - ITA IGDG WMO#=160840
 Simulation Timestamp: 2018-12-16 07:54:16

Report: **Annual Building Utility Performance Summary**
 For: **Entire Facility**
 Timestamp: 2018-12-16 07:54:16
 Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	1297.96	540.82	540.82
Net Site Energy	1297.96	540.82	540.82
Total Source Energy	3624.37	1510.16	1510.16
Net Source Energy	3624.37	1510.16	1510.16

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	17-JUL-06:10	04-DEC-06:10	-
Heating	0.00	0.00	0.00	0.00	261805.59	0.00
Cooling	0.00	0.00	0.00	146617.58	0.00	0.00

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	378.03	0.00
Cooling	0.00	0.00	0.00	310.23	0.00	0.00

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
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

9 / REYKJAVIK (ICELAND)-METAL

In case of putting this building in Reykjavik, we use metal as the material of exterior wall.

The tables below show the situation of energy consumption, the red parts present the consumption(GJ) and power(W) of heating and cooling.

Program Version:EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 08:37

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 ** REYKJAVIK - ISL IWE C Data WMO#=040300

Simulation Timestamp: 2018-12-16 08:37:20

Report: Annual Building Utility Performance Summary

For: Entire Facility

Timestamp: 2018-12-16 08:37:20

Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	1466.67	611.11	611.11
Net Site Energy	1466.67	611.11	611.11
Total Source Energy	5025.18	2093.82	2093.82
Net Source Energy	5025.18	2093.82	2093.82

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	28-JUL-15:00	13-MAR-06:10	-
Heating	0.00	0.00	0.00	0.00	266764.10	0.00
Cooling	0.00	0.00	0.00	19470.05	0.00	0.00

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	856.09	0.00
Cooling	0.00	0.00	0.00	0.88	0.00	0.00

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
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

10 / JOHANNESBURG (SOUTH AFRICA)-METAL

In case of putting this building in Johannesburg, we use metal as the material of exterior wall.

The tables below show the situation of energy consumption, the red parts present the consumption (GJ) and power (W) of heating and cooling.

Program Version:EnergyPlus, Version 8.9.0-eba93e8e1b, YMD=2018.12.16 08:31

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 ** JOHANNESBURG - ZAF IWECC Data WMO#=683680

Simulation Timestamp: 2018-12-16 08:31:53

Report: Annual Building Utility Performance Summary

For: Entire Facility

Timestamp: 2018-12-16 08:31:53

Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	1060.36	441.81	441.81
Net Site Energy	1060.36	441.81	441.81
Total Source Energy	2530.16	1054.23	1054.23
Net Source Energy	2530.16	1054.23	1054.23

End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	48.28	0.00
Cooling	0.00	0.00	0.00	402.37	0.00	0.00

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	District Heating [W]	Water [m3/s]
Time of Peak	02-JAN-08:09	-	-	02-MAR-15:00	24-JUL-06:10	-
Heating	0.00	0.00	0.00	0.00	187057.74	0.00
Cooling	0.00	0.00	0.00	97149.39	0.00	0.00

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
Steam	0.300
Gasoline	1.050
Diesel	1.050
Coal	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

After using three different materials for exterior walls in three different cities, we summarized our experiment.

Regarding the consumption (GJ) and power(W) of heating and cooling, the tables in the following pages show the comparison.

Among these, red stands for the maximum when yellow presents the minimum.

Comparison A

Three different places

	PIACENZA-Italy Wood	REYKJAVIK-Iceland Wood	JOHANNESBURG-South Africa Wood
District Heating [GJ]	349.44	856.09	42.82
District Cooling [GJ]	299.74	0.88	389.86
District Heating Load [W]	256460.92	266764.10	184146.41
District Cooling Load [W]	150842.40	19470.05	92768.68

This table demonstrates the district heating and cooling system, and also district heating load and cooling load when we use wood as the same material in three different cities namely, Piacenza (Italy), Reykjavik (Iceland) and Johannesburg (South Africa).

As it is shown in the table, district heating [GJ] and district heating load [W] in Johannesburg (south Africa) have the minimum result respectively, 42.82 and 184146.68 and Reykjavik (Iceland) has the maximum proportion of district heating [GL] with 856.09, and district heating load [W] with 266764.10 among the other cities.

In terms of district cooling [GJ] and district cooling load [W], among the other 2 items Reykjavik (Iceland) has the minimum property with 0.88 [GJ] and 19470.05 [W]. Piacenza (Italy), with a high range has the maximum property for district cooling load [W] and Johannesburg (South Africa) with 389.86 [GJ] has the maximum amount for district cooling.

Comparison B

Three different Materials

	WOOD PIACENZA-Italy	CONCRETE PIACENZA-Italy	METAL PIACENZA-Italy
District Heating [GJ]	349.44	454.15	378.03
District Cooling [GJ]	299.74	282.77	310.23
District Heating Load [W]	256460.92	267452.20	261805.59
District Cooling Load [W]	150842.40	181698.05	146617.58

This table illustrates the district heating and cooling and also district heating load and cooling load in Piacenza (Italy) by using different materials such as wood, concrete and metal.

According to the table, concrete in Piacenza has the maximum proportion for district heating [GJ], and district heating and cooling load [W] among metal and wood but for district cooling [GJ] has the minimum limit (282.77 GJ). Using wood for exterior wall in Piacenza has the minimum amount for district heating [GJ] and district heating load [W] compared with metal and concrete. Metal has the maximum proportion in district cooling (310.23 GJ) but the minimum amount for district cooling load (146617.58 GJ).

Overall, it is clear that the consumption of energy is changed by using different materials, and the order of insulation performance, from strong to weak, is concrete, metal and wood.