

# **REPORT / ENERGY PERFORMANCE**

2017-2018

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TECHNICAL ENVIRONMENTAL SYSTEMS

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1 / OVERALL INTRODUCTION

In this research report, we choose three different cities, namely Piacenza, Moscow and Rio de Janeiro, as the experimental places. Among these, Moscow belongs to cold climate zone, Piacenza belongs to temperate area while Rio de Janeiro 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.

Building introduction

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

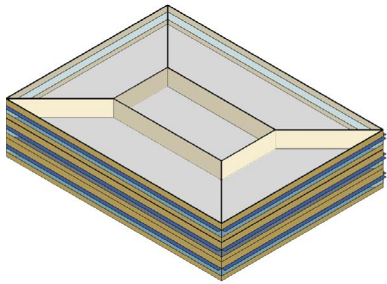
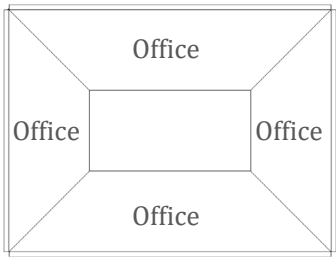
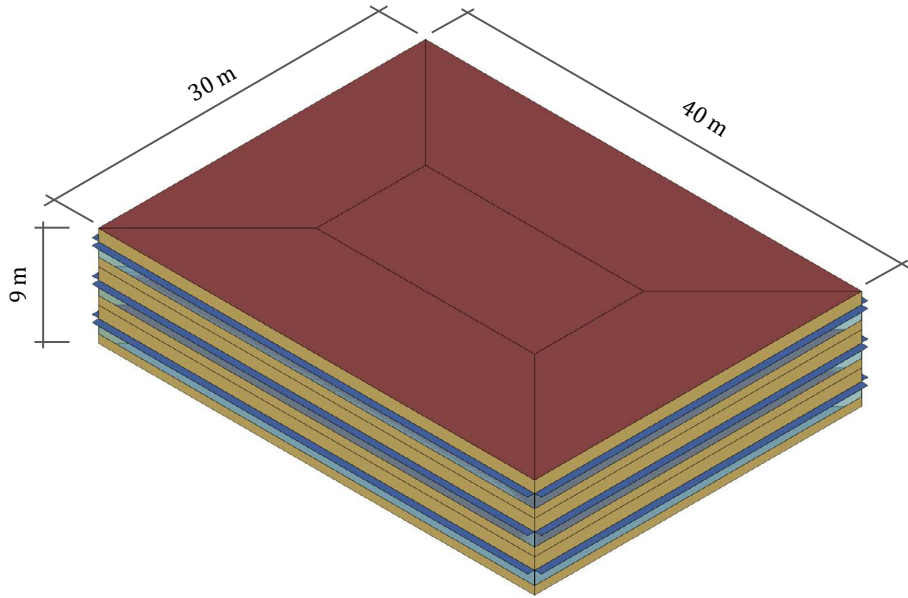
Building Area

	Area [m2]
Total Building Area	3600.00
Net Conditioned Building Area	3600.00
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]	1280.16	274.32	365.76	274.32	365.76
Above Ground Wall Area [m2]	1280.16	274.32	365.76	274.32	365.76
Window Opening Area [m2]	512.06	109.73	146.30	109.73	146.30
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-WOOD (AS THE BASE CASE)

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 concrete as the wall material.

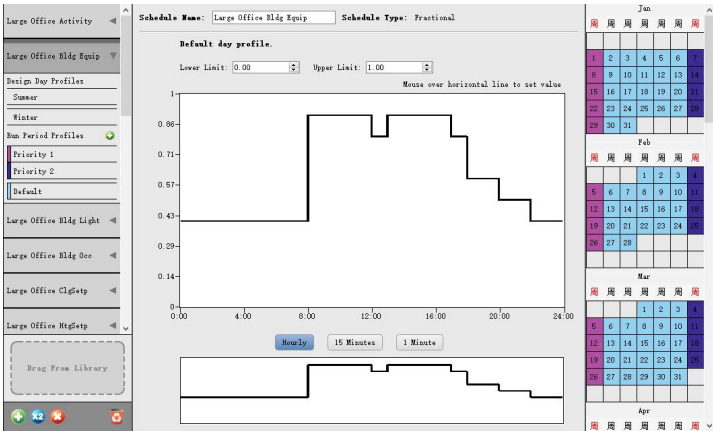
Program Version:EnergyPlus, Version 8.8.0-7c3bbe4830, YMD=2018.01.09 12:13

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 \*\* Piacenza - ITA IGDG WMO#=160840

Simulation Timestamp: 2018-01-09 12:13:28



Procedure of setting the material of exterior wall

ConstructionsConstruction SetsConstructionsMaterials

189.1-2009 - CZ1 - Office

189.1-2009 - CZ5 - Office

Walls

Floors

Roofs

Exterior Surface Constructions

Interior Surface Constructions

Ground Contact Surface Constructions

Exterior Sub Surface Constructions

Fixed Windows

Operable Windows

Doors

Drag From Library

ConstructionsConstruction SetsConstructionsMaterials

189.1-2011 Nonres 7  
Ext Wall Mass 8in  
Solid Concrete with  
Steel frame

90.1-1999 Nonres B2  
Ext Wall Wood-Framed  
and Other

Air Wall

ASHRAE 189.1-2009  
ExtRoof IEAD  
ClimateZone 1

ASHRAE 189.1-2009  
ExtRoof IEAD  
ClimateZone 2-5

ASHRAE 189.1-2009  
ExtRoof IEAD  
ClimateZone 7-8

ASHRAE 189.1-2009  
ExtRoof Metal  
ClimateZone 6

ASHRAE 189.1-2009

Walls

Floors

Roofs

Exterior Surface Constructions

Interior Surface Constructions

Ground Contact Surface Constructions

Exterior Sub Surface Constructions

Fixed Windows

Operable Windows

Doors

Drag From Library

ConstructionsConstruction SetsConstructionsMaterials

Metal Decking

Metal Siding

Roof Insulation [18]

Roof Insulation [21]

Roof Membrane

Wall Insulation [2]

Wall Insulation [32]

Wood Siding

Measure Tags (Optional):

Standard:

Standards Category:

Composite Framing Material:

Composite Framing Depth:

Composite Cavity Insulation:

Roughness:

Conductivity:

Specific Heat:

Solar Absorbance:

Standard Source:

Standards Identifier:

Composite Framing Configuration:

Composite Framing Size:

Thickness:

Density:

Thermal Absorbance:

Visible Absorbance:

2 / PIACENZA-WOOD (AS THE BASE CASE)

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

Report: Annual Building Utility Performance Summary

For: Entire Facility

Timestamp: 2018-01-09 12:13:28

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	5859.62	1627.67	1627.67
Net Site Energy	5859.62	1627.67	1627.67
Total Source Energy	13240.04	3677.79	3677.79
Net Source Energy	13240.04	3677.79	3677.79

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

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	25.22	0.00
Cooling	0.00	0.00	0.00	2523.83	0.00	0.00
Interior Lighting	2841.44	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	469.14	0.00	0.00	0.00	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	-	-	11-JUL-16:00	04-DEC-06:10	-
Heating	0.00	0.00	0.00	0.00	271182.79	0.00
Cooling	0.00	0.00	0.00	148674.12	0.00	0.00
Interior Lighting	34526.32	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	24761.30	0.00	0.00	0.00	0.00	0.00



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

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 8.8.0-7c3bbe4830, YMD=2018.01.09 13:21

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 \*\* MOSCOW - RUS IVEC Data WMO#=276120

Simulation Timestamp: 2018-01-09 13:21:52

### Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	5217.97	1449.44	1449.44
Net Site Energy	5217.97	1449.44	1449.44
Total Source Energy	12778.39	3549.55	3549.55
Net Source Energy	12778.39	3549.55	3549.55

### 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

### 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	109.56	0.00
Cooling	0.00	0.00	0.00	1797.84	0.00	0.00
Interior Lighting	2841.44	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	469.14	0.00	0.00	0.00	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-16:19	18-FEB-06:10	-
Heating	0.00	0.00	0.00	0.00	318988.87	0.00
Cooling	0.00	0.00	0.00	120783.29	0.00	0.00
Interior Lighting	34526.32	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	24761.30	0.00	0.00	0.00	0.00	0.00

#### 4 / RIO DE JANEIRO-WOOD

In case of using the same material, we put the building in Rio de Janeiro.

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 8.8.0-7c3bbe4830, YMD=2018.01.09 13:33

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 \*\* Rio de Janeiro-Vila Militar RJ BRA INMET WMO#=-868790

Simulation Timestamp: 2018-01-09 13:33:41

#### Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	7406.15	2057.26	2057.26
Net Site Energy	7406.15	2057.26	2057.26
Total Source Energy	14808.19	4113.39	4113.39
Net Source Energy	14808.19	4113.39	4113.39

#### 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

#### 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	0.01	0.00
Cooling	0.00	0.00	0.00	4095.57	0.00	0.00
Interior Lighting	2841.44	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	469.14	0.00	0.00	0.00	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-FEB-13:00	15-JUL-06:10	-
Heating	0.00	0.00	0.00	0.00	136890.99	0.00
Cooling	0.00	0.00	0.00	164261.43	0.00	0.00
Interior Lighting	34526.32	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	24761.30	0.00	0.00	0.00	0.00	0.00

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.

Program Version:EnergyPlus, Version 8.8.0-7c3bbe4830, YMD=2018.01.09 12:13

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 \*\* Piacenza - ITA IGDG WMO#=160840

Simulation Timestamp: 2018-01-09 12:13:28

Procedure of setting the material of exterior wall

ConstructionsConstruction SetsConstructionsMaterials

189.1-2009 - CZ1 - Office

189.1-2009 - CZ5 - Office

Name

189.1-2009 - CZ1 - Office

Exterior Surface Constructions

Walls

Floors

Roofs

189.1-2011 Nonres 7 Ext Wall Mass 8in Solid Concrete with Steel frame

ASHRAE 189.1-2009 Ext Wall Wood-Framed and Other

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5

ASHRAE 189.1-2009 ExtWindow ClimateZone 1

ASHRAE 189.1-2009 ExtWindow ClimateZone 4-5

Exterior Door

Interior Surface Constructions

Walls

Floors

Ceilings

Interior Wall

Interior Floor

Interior Ceiling

Ground Contact Surface Constructions

Walls

Floors

Ceilings

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1-2

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1-2

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1-2

Exterior Sub Surface Constructions

Fixed Windows

Operable Windows

Doors

ASHRAE 189.1-2009 ExtWindow ClimateZone 1

ASHRAE 189.1-2009 ExtWindow ClimateZone 1

Exterior Door

Layer:

Outside

Normalweight concrete

G01 13mm gypsum board

MAT-CC05 4 HW CONCRETE 1

MAT-CC05 4 HW CONCRETE 1

Metal Decking

Roof Insulation [18]

Roof Insulation [21]

Drag From Library

Constructions

189.1-2011 Nonres 7 Ext Wall Mass 8in Solid Concrete with Steel frame

90.1-1999 Nonres B2 Ext Wall Wood-Framed and Other

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5

ASHRAE 189.1-2009 ExtWindow ClimateZone 1

ASHRAE 189.1-2009 ExtWindow ClimateZone 4-5

Exterior Door

Drag From Library

ConstructionsConstruction SetsConstructionsMaterials

G05 25mm wood

I01 25mm insulation board

M11 100mm lightweight concrete

MAT-CC05 4 HW CONCRETE

MAT-CC05 4 HW CONCRETE 1

Metal Decking

Roof Insulation [18]

Roof Insulation [21]

Drag From Library

Measure Tags (Optional):

Standard:

Standard Source:

Standards Category:

Standards Identifier:

Composite Framing Material:

Composite Framing Configuration:

Composite Framing Depth:

Composite Framing Size:

Composite Cavity Insulation:

Roughness:

Thickness:

Conductivity:

Density:

Specific Heat:

Thermal Absorptance:

Solar Absorptance:

Visible Absorptance:

Rough

0.101600 m

1.311000 W/m · K

2240.000000 kg/m³

836.800000 J/kg · K

0.900000

0.850000

0.850000



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

#### Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	5721.33	1589.26	1589.26
Net Site Energy	5721.33	1589.26	1589.26
Total Source Energy	13167.53	3657.65	3657.65
Net Source Energy	13167.53	3657.65	3657.65

#### 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

#### 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	53.95	0.00
Cooling	0.00	0.00	0.00	2356.80	0.00	0.00
Interior Lighting	2841.44	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	469.14	0.00	0.00	0.00	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	-	-	12-JUL-16:00	04-DEC-06:10	-
Heating	0.00	0.00	0.00	0.00	267201.87	0.00
Cooling	0.00	0.00	0.00	144357.59	0.00	0.00
Interior Lighting	34526.32	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	24761.30	0.00	0.00	0.00	0.00	0.00



6 / PIACENZA-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.

Program Version:EnergyPlus, Version 8.8.0-7c3bbe4830, YMD=2018.01.09 12:13

Tabular Output Report in Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 \*\* Piacenza - ITA IGDG WMO#=160840

Simulation Timestamp: 2018-01-09 12:13:28

Procedure of setting the material of exterior wall

ConstructionsConstruction SetsConstructionsMaterials

189.1-2009 - CZ1 - Office

189.1-2009 - CZ5 - Office

189.1-2009 - CZ1 - Office

189.1-2009 - CZ5 - Office

Exterior Surface Constructions

WallsFloorsRoofs

189.1-2009 Nonres 1A Ext Wall 4in ClimateZone 1-8

189.1-2009 Nonres 1A Ext Wall 4in ClimateZone 1-8

189.1-2009 ExtRoof IEAD ClimateZone 1

Interior Surface Constructions

WallsFloorsCeilings

Interior Wall

Interior Floor

Interior Ceiling

Ground Contact Surface Constructions

WallsFloorsCeilings

4in ClimateZone 1-8

4in ClimateZone 1-8

4in ClimateZone 1-8

Exterior Sub Surface Constructions

Fixed WindowsOperable WindowsDoors

189.1-2009 ExtWindow ClimateZone 1-8

189.1-2009 ExtWindow ClimateZone 1-8

Exterior Door

ConstructionsConstruction SetsConstructionsMaterials

189.1-2009 Nonres 1A Ext Wall Metal Building

90.1-1999 Nonres B2 Ext Wall Wood-Framed and Other

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1

ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5

ASHRAE 189.1-2009 ExtWindow ClimateZone 1

ASHRAE 189.1-2009 ExtWindow ClimateZone 4-5

Exterior Door

Layer: Outside

Metal Siding

Wall Insulation [32]

1/2IN Gypsum

Drag From Library

ConstructionsConstruction SetsConstructionsMaterials

Metal Decking

Metal Siding

Roof Insulation [18]

Roof Insulation [21]

Roof Membrane

Wall Insulation [2]

Wall Insulation [32]

Wood Siding

Drag From Library

Measure Tags (Optional):

Standard:Standard Source:

Standards Category:Standards Identifier:

Composite Framing Material:Composite Framing Configuration:

Composite Framing Depth:Composite Framing Size:

Composite Cavity Insulation:

Roughness:Thickness:

Smooth0.001500 m

Conductivity:Density:

44.960000 W/m · K7688.860000 kg/m³

Specific Heat:Thermal Absorptance:

410.000000 J/kg · K0.900000

Solar Absorptance:Visible Absorptance:

0.2000000.200000

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

#### Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	5836.18	1621.16	1621.16
Net Site Energy	5836.18	1621.16	1621.16
Total Source Energy	13213.76	3670.49	3670.49
Net Source Energy	13213.76	3670.49	3670.49

#### 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

#### 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	24.62	0.00
Cooling	0.00	0.00	0.00	2500.98	0.00	0.00
Interior Lighting	2841.44	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	469.14	0.00	0.00	0.00	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	-	-	12-JUL-16:00	04-DEC-06:10	-
Heating	0.00	0.00	0.00	0.00	270155.26	0.00
Cooling	0.00	0.00	0.00	144407.10	0.00	0.00
Interior Lighting	34526.32	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	24761.30	0.00	0.00	0.00	0.00	0.00

## 7 / COMPARISON AND SUMMARY

Regarding the consumption(GJ) and power(W) of heating and cooling, the tables below show the comparison. Among these, yellow stands for the maximum when red presents the minimum.

Comparison A - three different places

	Piacenza-Wood	Moscow-Wood	Rio de janeiro-Wood
District Heating [GJ]	25.22	109.56	0.01
District Cooling [GJ]	2523.83	1797.84	4095.57
District Heating Load [W]	271182.79	318988.87	136890.99
District Cooling Load [W]	148674.12	120783.29	164261.43

### Summary A

In this table, we can easily see that, in case of using the same material, Moscow presents the maximum for District Heating [GJ] and District Heating Load [W] and stands for the bottom for District Cooling [GJ] and District Cooling Load [W], when Rio de Janeiro shows the opposite situation. So the order of heating consumption, from more to less, is Moscow, Piacenza and Rio, and the same order of cooling consumption is Rio, Piacenza and Moscow.

It can be summarized that the consumption of energy is changed with the temperature of different places, which means lower temperature needs more consumption of heating and higher temperature needs more consumption of cooling.

Comparison B - three different materials of exterior wall

	Piacenza-Wood	Piacenza-Concrete	Piacenza-Metal
District Heating [GJ]	25.22	53.95	24.62
District Cooling [GJ]	2523.83	2356.8	2500.98
District Heating Load [W]	271182.79	267201.87	270155.26
District Cooling Load [W]	148674.12	144357.59	144407.1

### Summary B

From this table, obviously, most of numbers of Piacenza-Wood show the maximum while the majority of Piacenza-Concrete stand for the minimum. So we can get that the order of insulation performance, from strong to weak, is concrete, metal and wood.