POLITECNICO
MILANO 1863

EnergyPlus

# FINAL PROJECT

# TECHNICAL ENVIRONMENTAL SYSTEMS

ACADEMIC YEAR 2019-2020

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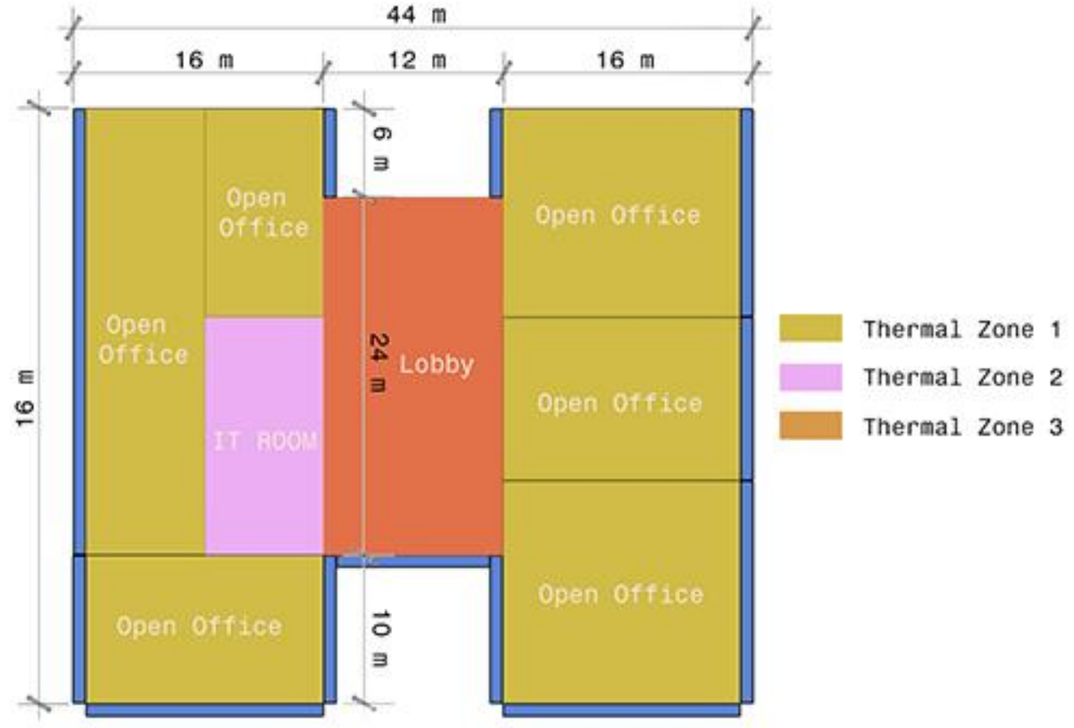
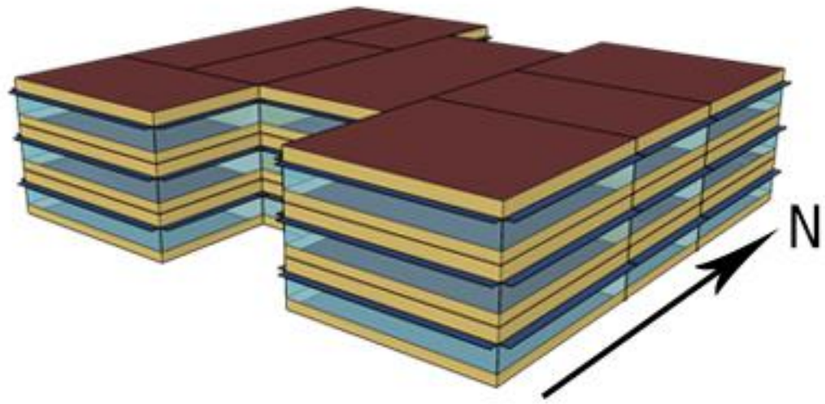
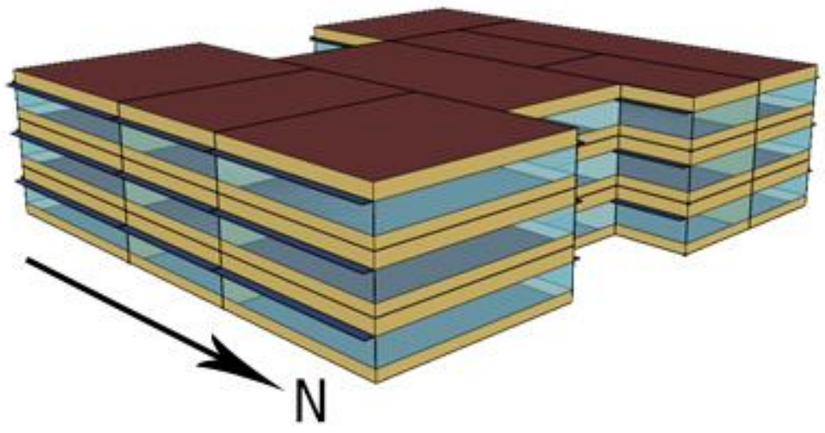
Locations

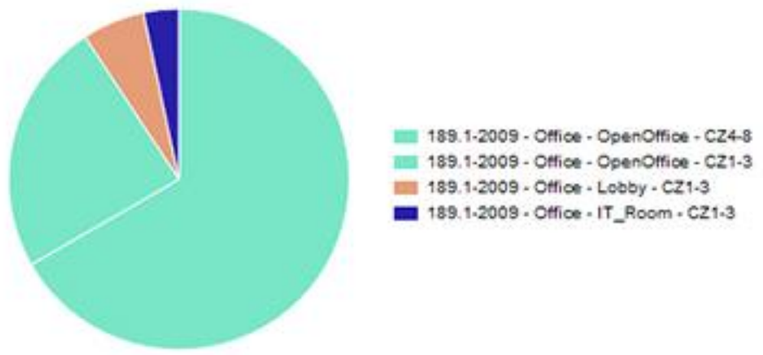
1-St. Petersburg 2-Paris 3-Riyadh




Plan(Thermal Zones)



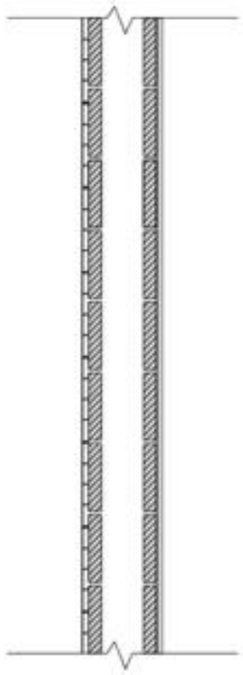




Space Typology

| Building Type | Commercial |
|---|---|
| Total Building Area | 1460 m2 |
| Gross Wall Area | 687.63 m2 |
| Gross Opening Area | 275.05 m2 |
| Gross Window-Wall Ratio | 40% (in all facades) |

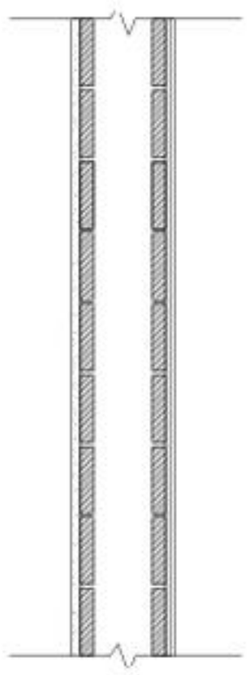
Building Data



Outside to Inside:
1- 20mm Aluminium Cladding
2- 20mm HW Concrete Blocks
3- 6mm Polystyrene Board
4- 13mm Gypsum Plaster

U-Value: 2.43 W/m2-K

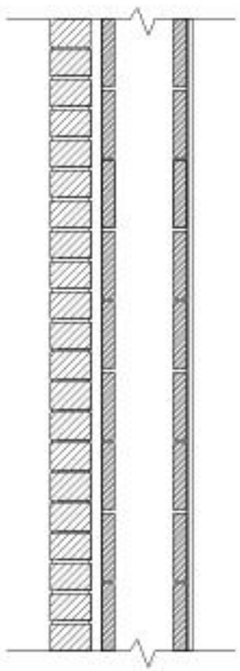
Exterior Wall 1(Base Case)



Outside to Inside:
1- 25mm Stucco
2- 250mm HW Concrete Blocks
3- 12mm Polystyrene Board
4- 13mm Gypsum Plaster

U-Value: 1.574 W/m2-K

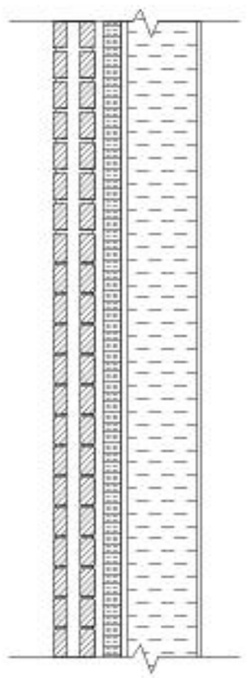
Exterior Wall 2



Outside to Inside:
1- 12mm Masonry Brick
2- 30mm Air Cavity
3- 3mm Vapor Barrier
4- 250mm HW Concrete Blocks
5- 8mm Fiberglass Batting Ins.
6- 13mm Gypsum Plaster

U-Value: 1.346 W/m2-K

Exterior Wall 3



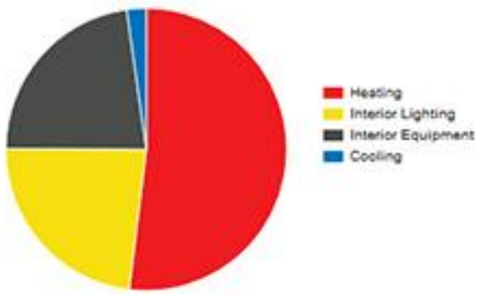
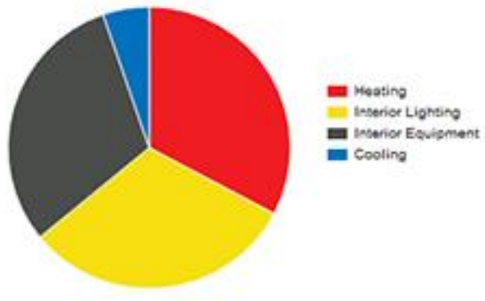
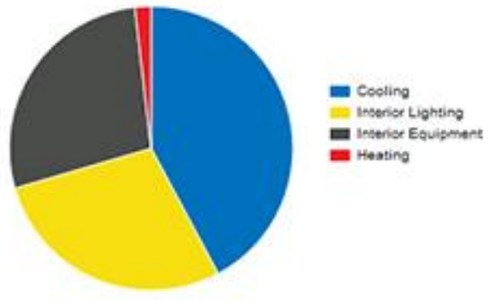
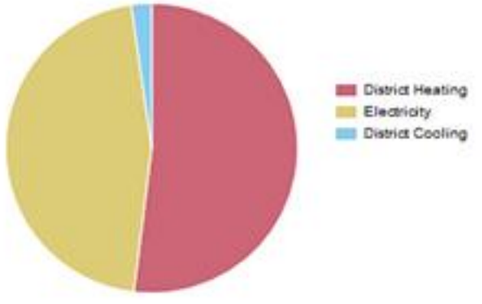
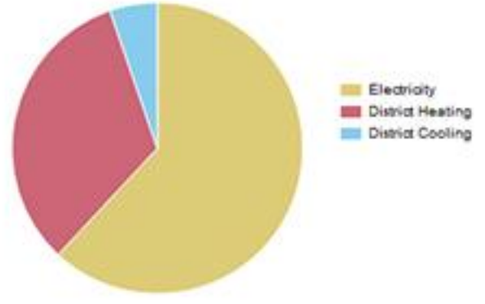
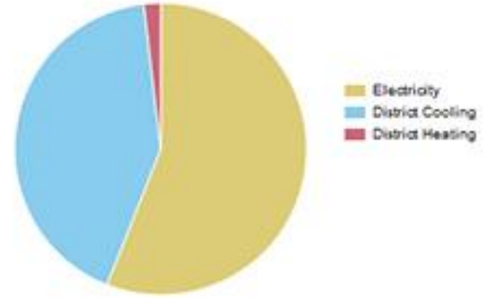
Outside to Inside:
1- 12mm Perforated Brick
2- 30mm Air Cavity
3- 12mm Polyurethane Rigid Foam
4- 3mm Vapor Barrier
5- 19mm Plywood Board
6- 200mm Wood Stud Wall
7- 13mm Gypsum Plaster

U-Value: 0.241 W/m2-K

Exterior Wall 4

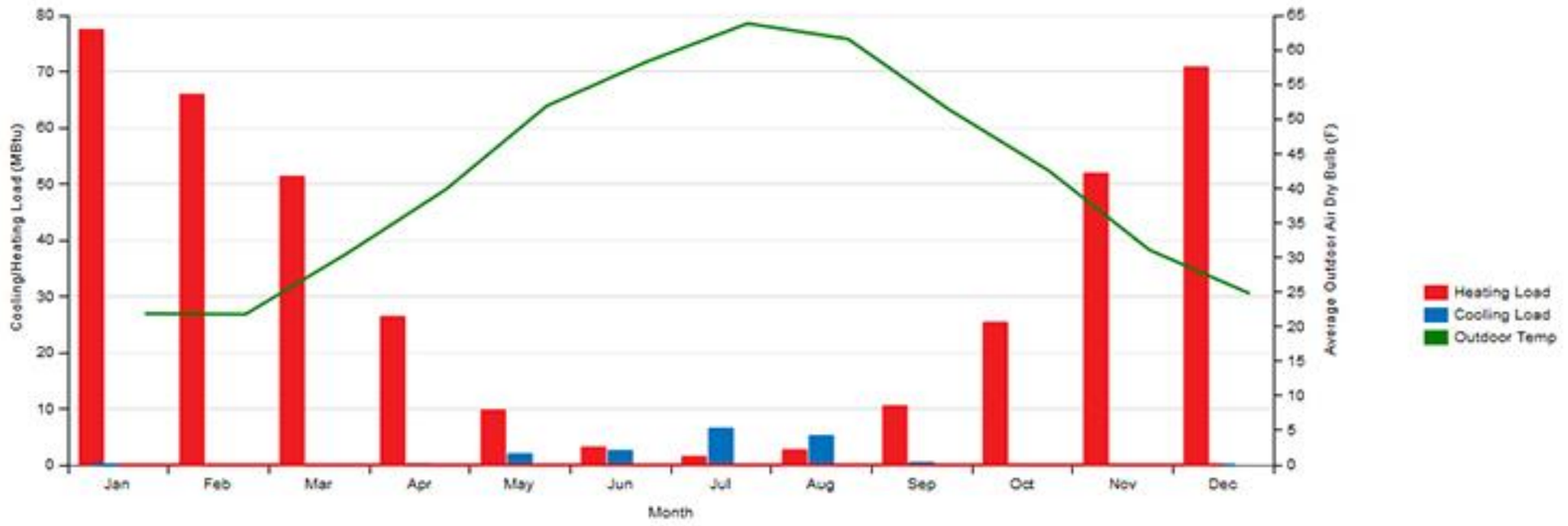
# Wall Sections

## END USE & ENERGY USE (BASE CASE IN 3 CITIES)

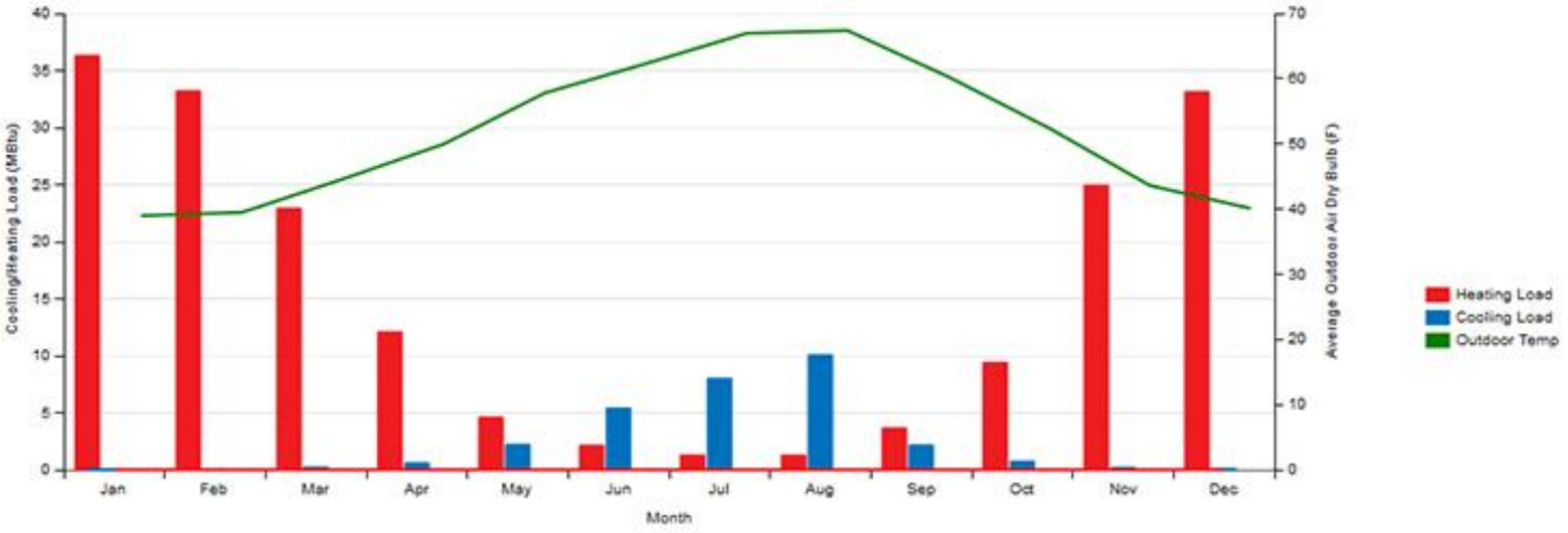
| LOCATION | ST. PETERSBURG | PARIS | RIYADH |
|---|---|---|---|
| Latitude: | 59.9343° N | 48.8566° N | 24.7136° N |
| Longtitude: | 30.3351° E | 2.3522° E | 46.6753° E |
| Average Annual Humidity: | 78% | 70% | 29% |
| Average Annual Min. Temperature: | -7.4 °C | 3.3 °C | 14.3 °C |
| Average Annual Max. Temperature: | 17.8 °C | 19.4 °C | 34.7 °C |
| Net Site Energy | 763,590 kBtu=805.63 GJ | 564,624 kBtu=595.71 GJ | 624,583 kBtu=658.97 GJ |
| End Use (Cooling) | 17,127 kBtu=18.7 GJ | 29,894 kBtu=31.54 GJ | 263,379 kBtu=27.88 GJ |
| End Use (Heating) | 396,699 kBtu=418.54 GJ | 184,967 kBtu=195.15 GJ | 11,431 kBtu=12.06 GJ |
| **END USE** |  |  |  |
| District Cooling | 17,127 kBtu=18.7 GJ | 29,894 kBtu=31.54 GJ | 263,379 kBtu=27.88 GJ |
| District Heating | 396,699 kBtu=418.54 GJ | 184,967 kBtu=195.15 GJ | 11,431 kBtu=12.06 GJ |
| **ENERGY USE** |  |  |  |

# MONTHLY HAVC LOAD PROFILE (BASE CASE IN 3 CITIES)

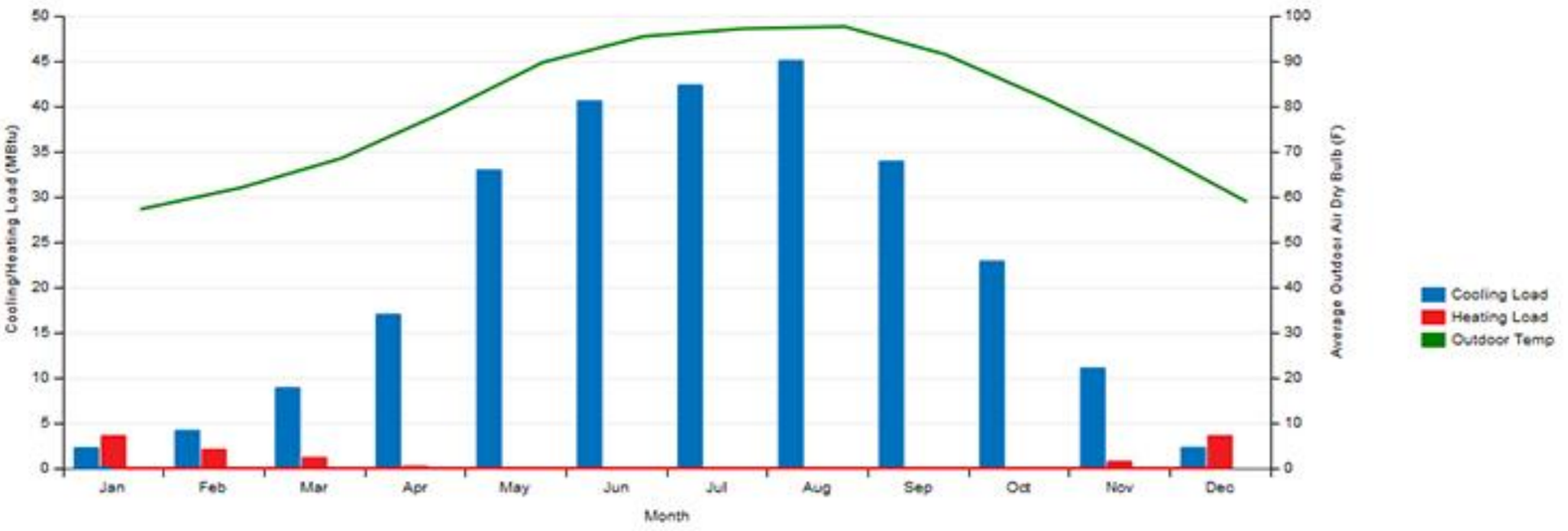
## ST. PETERSBURG



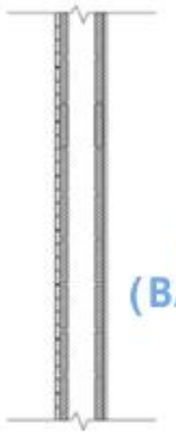

## PARIS




## RIYADH



# SITE AND SOURCE ENERGY (kBtu/ft2 & GJ)



## WALL 1 (BASE CASE)

Site and Source Energy

| | Total Energy (kBtu) | Energy Per Total Building Area (kBtu/ft^2) |
|---|---|---|
| Total Site Energy | 624583.0 | 39.7 |
| Net Site Energy | 624583.0 | 39.7 |
| Total Source Energy | 1427061.9 | 90.8 |
| Net Source Energy | 1427061.9 | 90.8 |

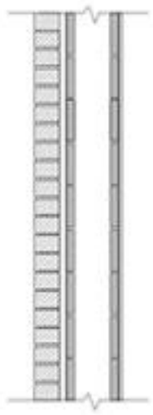
| | Total Energy [GJ] | Energy Per Total Building Area [MJ/m2] | Energy Per Conditioned Building Area [MJ/m2] |
|---|---|---|---|
| Total Site Energy | 658.97 | 451.35 | 451.35 |
| Net Site Energy | 658.97 | 451.35 | 451.35 |
| Total Source Energy | 1505.63 | 1031.25 | 1031.25 |
| Net Source Energy | 1505.63 | 1031.25 | 1031.25 |

## WALL 2

Site and Source Energy

| | Total Energy (kBtu) | Energy Per Total Building Area (kBtu/ft^2) |
|---|---|---|
| Total Site Energy | 622042.9 | 39.6 |
| Net Site Energy | 622042.9 | 39.6 |
| Total Source Energy | 1420569.4 | 90.4 |
| Net Source Energy | 1420569.4 | 90.4 |

| | Total Energy [GJ] | Energy Per Total Building Area [MJ/m2] | Energy Per Conditioned Building Area [MJ/m2] |
|---|---|---|---|
| Total Site Energy | 656.29 | 449.51 | 449.51 |
| Net Site Energy | 656.29 | 449.51 | 449.51 |
| Total Source Energy | 1498.78 | 1026.56 | 1026.56 |
| Net Source Energy | 1498.78 | 1026.56 | 1026.56 |

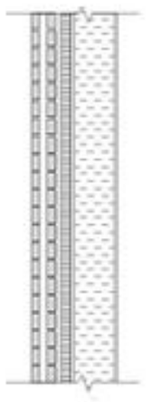


## WALL 3

Site and Source Energy

| | Total Energy (kBtu) | Energy Per Total Building Area (kBtu/ft^2) |
|---|---|---|
| Total Site Energy | 607749.8 | 38.7 |
| Net Site Energy | 607749.8 | 38.7 |
| Total Source Energy | 1407281.0 | 89.5 |
| Net Source Energy | 1407281.0 | 89.5 |

| | Total Energy [GJ] | Energy Per Total Building Area [MJ/m2] | Energy Per Conditioned Building Area [MJ/m2] |
|---|---|---|---|
| Total Site Energy | 641.21 | 439.18 | 439.18 |
| Net Site Energy | 641.21 | 439.18 | 439.18 |
| Total Source Energy | 1484.76 | 1016.96 | 1016.96 |
| Net Source Energy | 1484.76 | 1016.96 | 1016.96 |



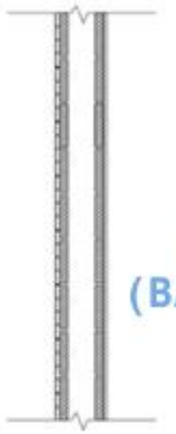
## WALL 4

Site and Source Energy

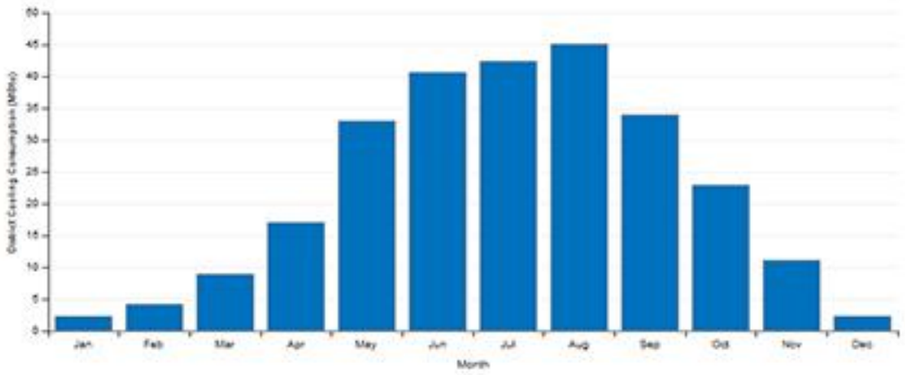
| | Total Energy (kBtu) | Energy Per Total Building Area (kBtu/ft^2) |
|---|---|---|
| Total Site Energy | 582490.5 | 37.1 |
| Net Site Energy | 582490.5 | 37.1 |
| Total Source Energy | 1381538.2 | 87.9 |
| Net Source Energy | 1381538.2 | 87.9 |

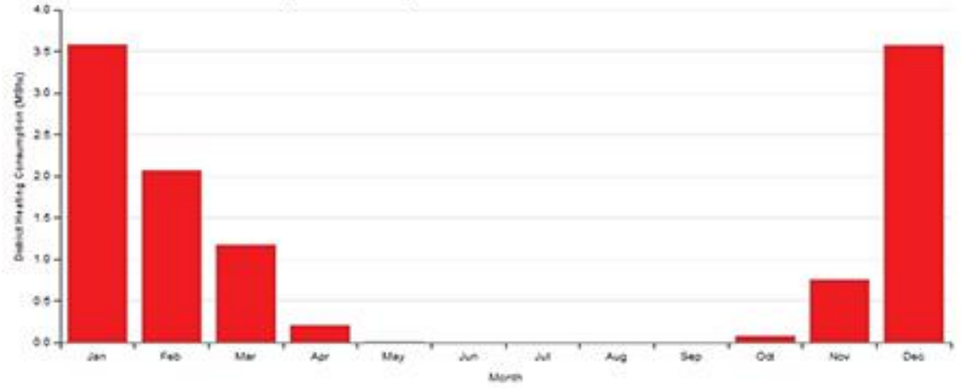
| | Total Energy [GJ] | Energy Per Total Building Area [MJ/m2] | Energy Per Conditioned Building Area [MJ/m2] |
|---|---|---|---|
| Total Site Energy | 614.56 | 420.93 | 420.93 |
| Net Site Energy | 614.56 | 420.93 | 420.93 |
| Total Source Energy | 1457.60 | 998.36 | 998.36 |
| Net Source Energy | 1457.60 | 998.36 | 998.36 |

# DISTRICT COOLING & HEATING CONSUMPTION (MBtu)

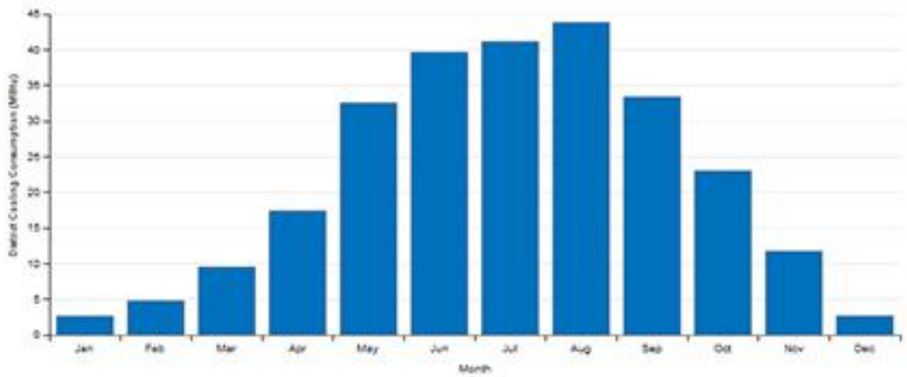


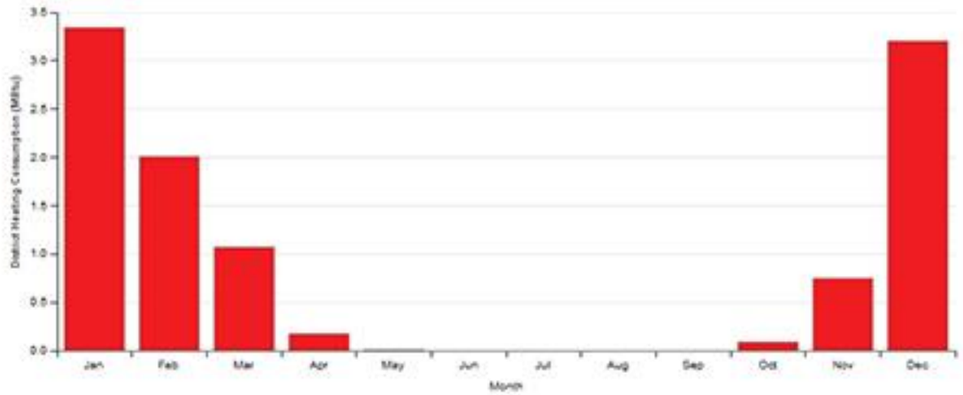
WALL 1
(BASE CASE)

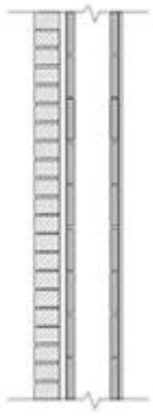


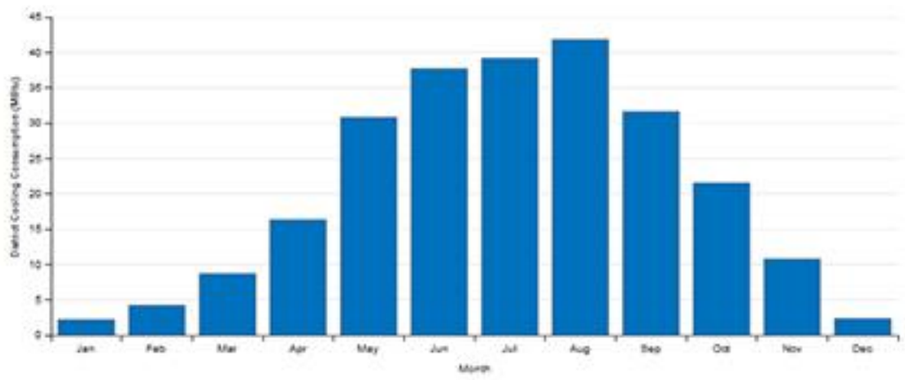

WALL 2

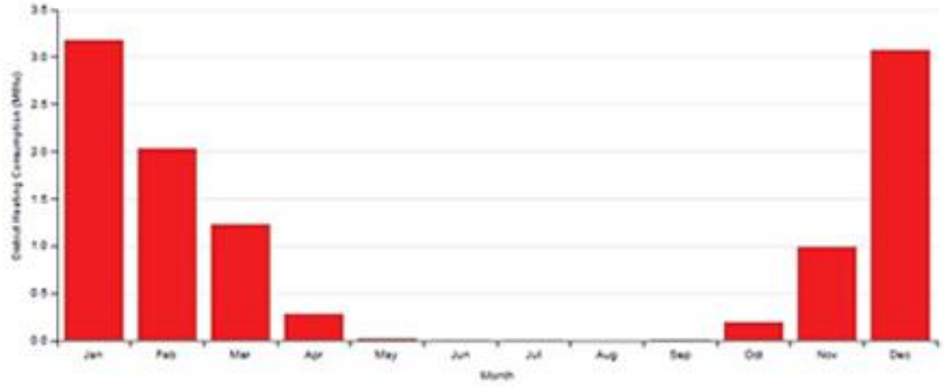


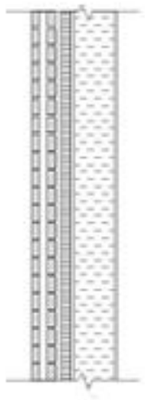



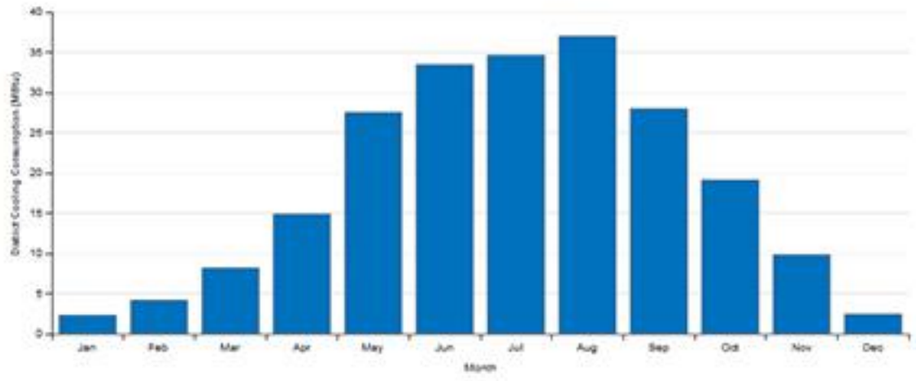
WALL 3

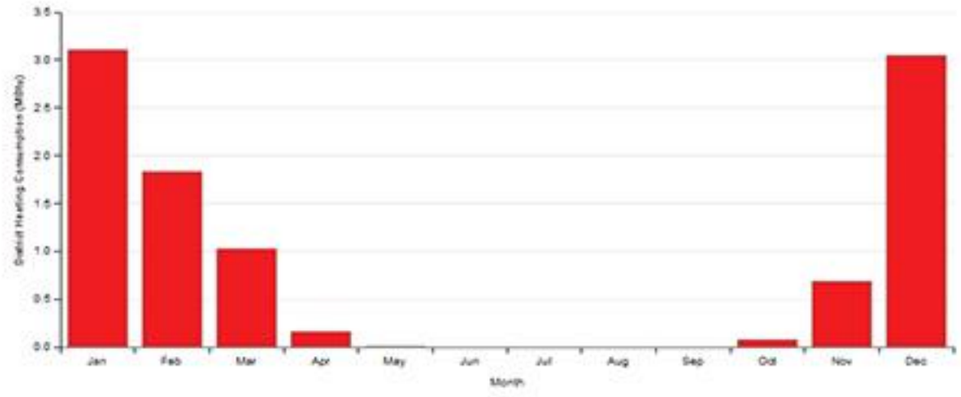


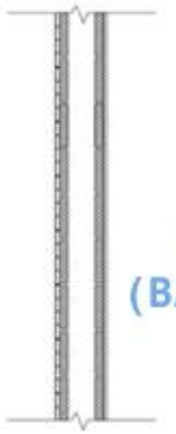



WALL 4

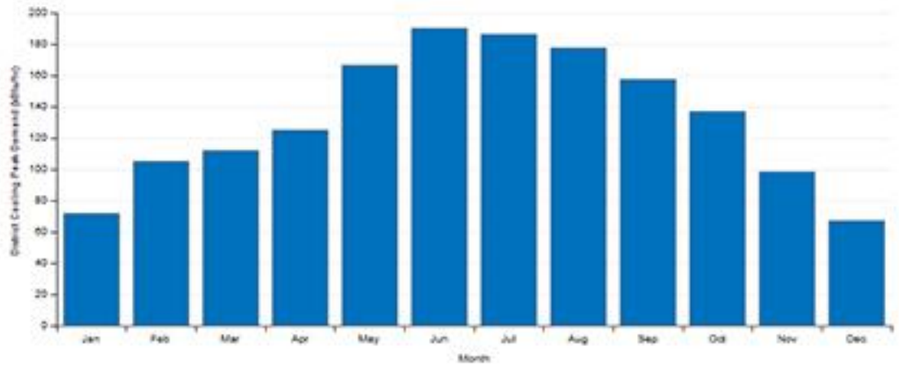


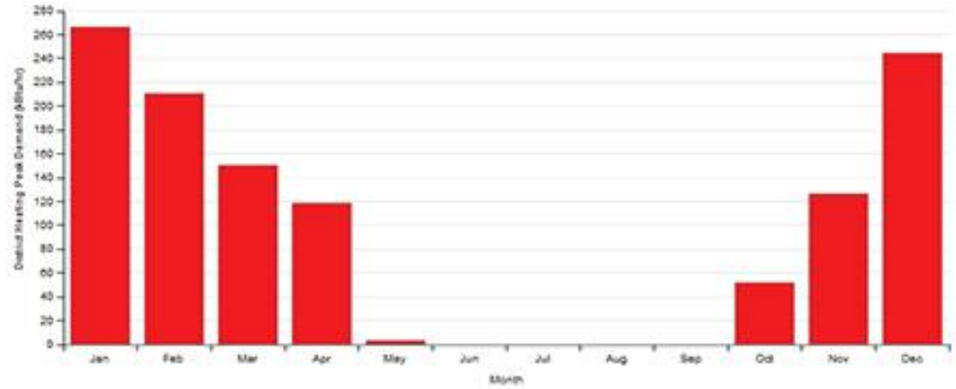



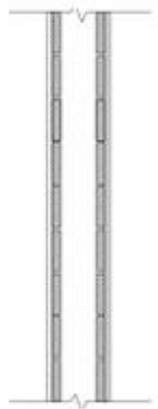
# DISTRICT COOLING & HEATING PEAK DEMAND (kW)



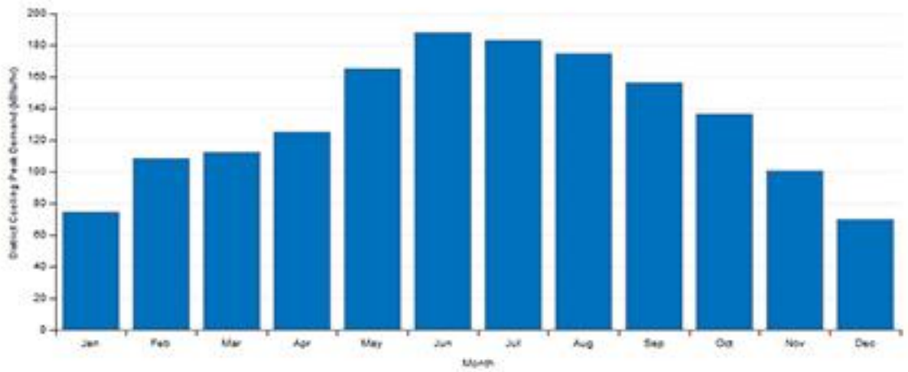
WALL 1
(BASE CASE)

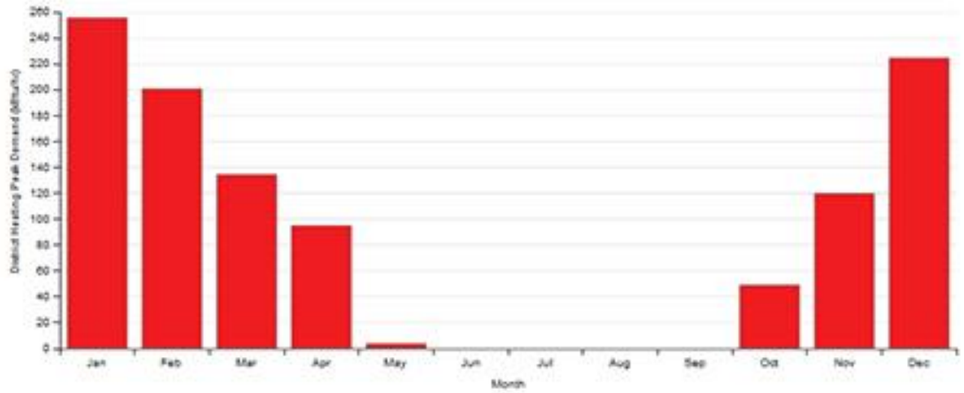


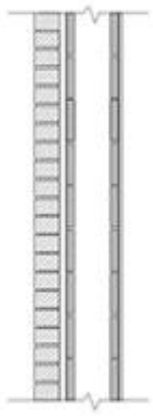



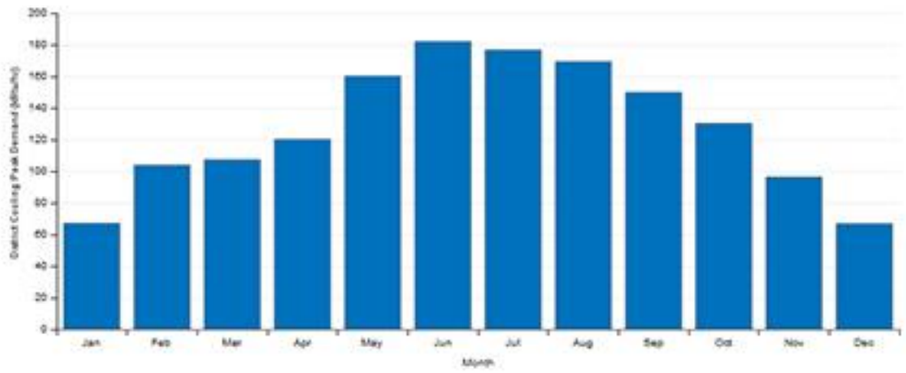
WALL 2

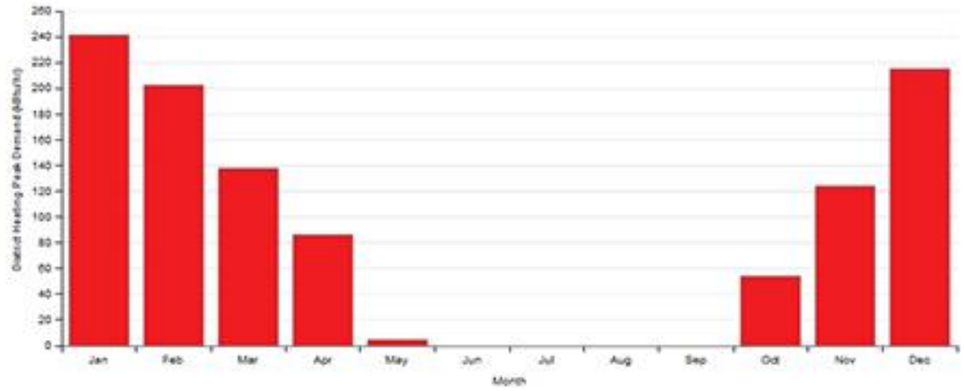


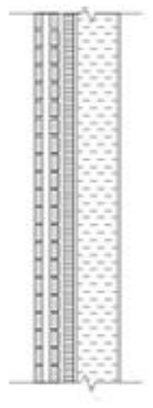



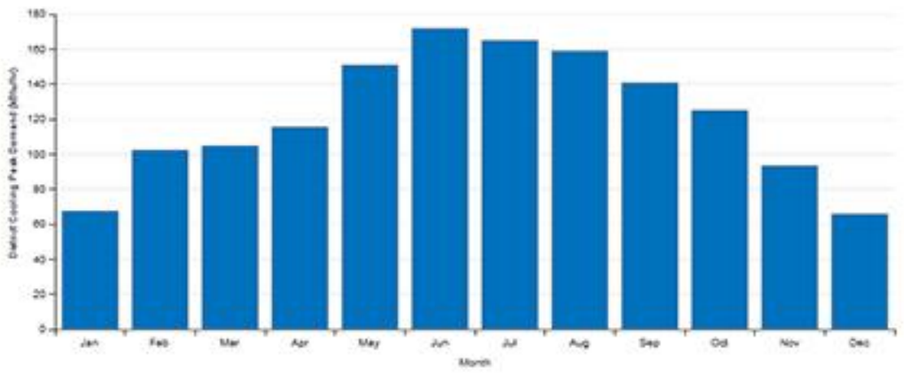
WALL 3

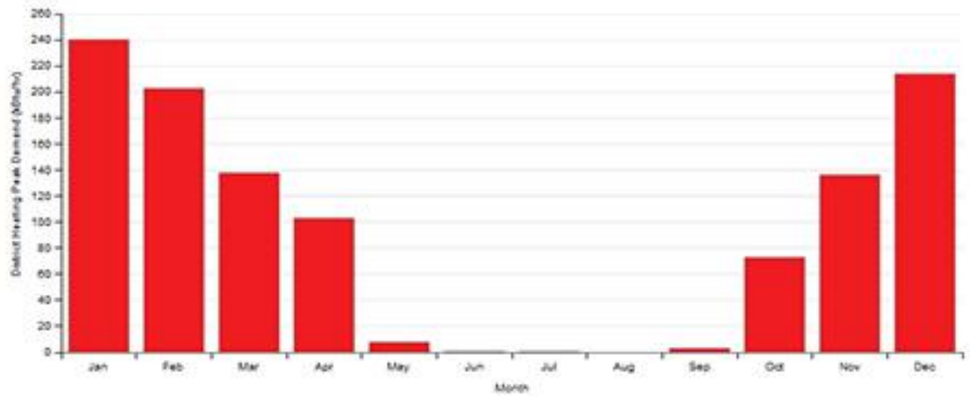


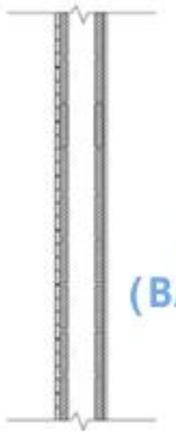



WALL 4



# UTILITY USE PER CONDITIONED FLOOR AREA (MJ/m2)

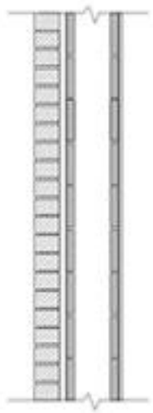


## WALL 1 (BASE CASE)

| | Electricity Intensity [MJ/m2] | Natural Gas Intensity [MJ/m2] | Additional Fuel Intensity [MJ/m2] | District Cooling Intensity [MJ/m2] | District Heating Intensity [MJ/m2] | Water Intensity [m3/m2] |
|---|---|---|---|---|---|---|
| Lighting | 127.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HVAC | 0.00 | 0.00 | 0.00 | 190.33 | 8.26 | 0.00 |
| Other | 125.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 252.76 | 0.00 | 0.00 | 190.33 | 8.26 | 0.00 |

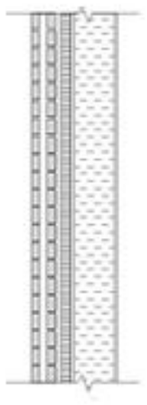
## WALL 2

| | Electricity Intensity [MJ/m2] | Natural Gas Intensity [MJ/m2] | Additional Fuel Intensity [MJ/m2] | District Cooling Intensity [MJ/m2] | District Heating Intensity [MJ/m2] | Water Intensity [m3/m2] |
|---|---|---|---|---|---|---|
| Lighting | 127.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HVAC | 0.00 | 0.00 | 0.00 | 189.57 | 7.95 | 0.00 |
| Other | 125.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 252.76 | 0.00 | 0.00 | 189.57 | 7.18 | 0.00 |



## WALL 3

| | Electricity Intensity [MJ/m2] | Natural Gas Intensity [MJ/m2] | Additional Fuel Intensity [MJ/m2] | District Cooling Intensity [MJ/m2] | District Heating Intensity [MJ/m2] | Water Intensity [m3/m2] |
|---|---|---|---|---|---|---|
| Lighting | 127.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HVAC | 0.00 | 0.00 | 0.00 | 178.74 | 7.69 | 0.00 |
| Other | 125.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 252.76 | 0.00 | 0.00 | 178.74 | 7.69 | 0.00 |



## WALL 4

| | Electricity Intensity [MJ/m2] | Natural Gas Intensity [MJ/m2] | Additional Fuel Intensity [MJ/m2] | District Cooling Intensity [MJ/m2] | District Heating Intensity [MJ/m2] | Water Intensity [m3/m2] |
|---|---|---|---|---|---|---|
| Lighting | 127.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HVAC | 0.00 | 0.00 | 0.00 | 160.22 | 7.18 | 0.00 |
| Other | 125.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 252.76 | 0.00 | 0.00 | 160.22 | 7.95 | 0.00 |