



Energy Assessment and Energy Modeling Analysis for The Metro, Kingston NY

Kosol Kiatreungwattana, PE, CEM, LEED AP

June 19, 2019



Objectives

- Identify energy efficiency/conservation measures to reduce electrical and thermal energy consumption.
- Conduct building energy simulation modeling analysis
- Investigate renewable energy options.

Summary of Activities

- Visual walk-through energy audit of The Metro, Kingston NY
- Collect and review data
- Energy simulation modeling and parametric analysis
 - Baseline
 - Energy Conservation Measures (ECMs)
 - Building envelope
 - Lighting
 - Plugloads
 - HVAC
- Solar PV analysis

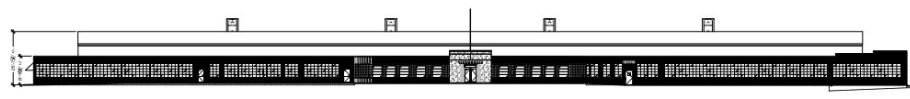
Baseline Building

1. 80,000 sf a single story with mezzanine area
2. CMU walls with without insulation
3. Poorly insulated roof
4. Single-pane windows
5. Simple packaged VAV system with hot water reheat
 - a. 9 EER efficiency
 - b. No economizer, no ERV
6. Basic hot water fuel oil boiler
 - a. 70% efficiency
7. Climate zone 5A, Albany NY - TMY3 weather data
8. Simulated as mix use non-residential
9. Fuel Oil: \$3.23/gallon
10. Electricity rate: \$0.13/kWh

CMU – concrete masonry unit
VAV – variable air volume
EER – energy efficiency ratio
TMY - typical meteorological year



Baseline Energy Model



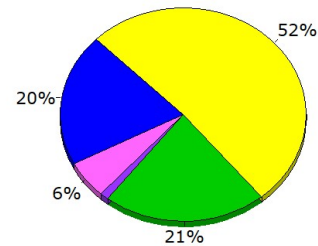
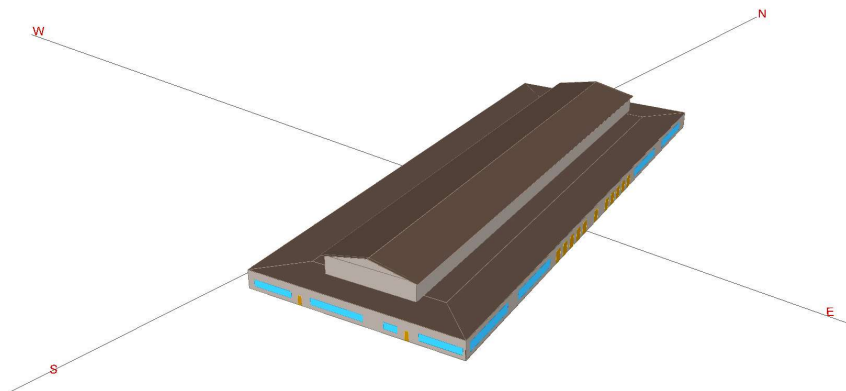
1 EXISTING EAST ELEVATION

SCALE 1/8" = 1'-0"

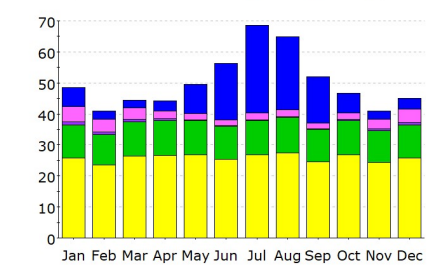


2 EXISTING NORTH ELEVATION - WITH BOILER HOUSE

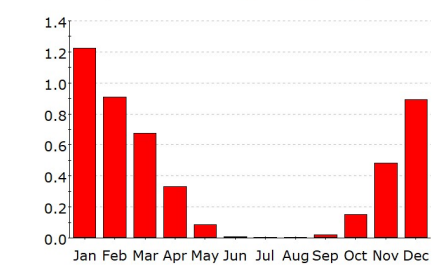
SCALE 1/8" = 1'-0"



(x000) **Electric Consumption (kWh)**



(x000,000,000) **Gas Consumption (Btu)**



- Area Lighting
- Task Lighting
- Misc. Equipment
- Exterior Usage
- Pumps & Aux.
- Ventilation Fans
- Water Heating
- Ht Pump Supp.
- Space Heating
- Refrigeration
- Heat Rejection
- Space Cooling

Normalized energy: 82.47 kBtu/sf/yr

Normalized cost: \$2.36/sf/yr

Building Envelope Measures Description

Wall

ECM 1: R-11.4 ci wall insulation (2012 IECC)

ECM 2: R-11.4 ci plus 2-inch ci (R-10) insulation

Roof

ECM 3: R-25 ci roof insulation (2012 IECC)

ECM 4: 6-inch rigid insulation roof (R-30) (Design)

Window

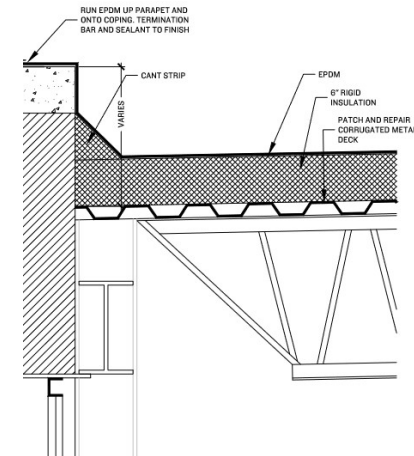
ECM 5: 0.38 U-factor, 0.40 SHGC (2012 IECC)

ECM 6: 0.25 U-factor, 0.40 SHGC (IG windows)

IECC – International Energy Conservation Code

ci – continuous

SHGC – solar heat gain coefficient



Building Envelope Measures Results

| | Baseline | Wall with R-11.4 ci IECC | Wall with R-11.4 ci + 2 inch insulation | Roof with R-25 ci IECC | Roof 6-inch rigid insulation (Design) | Window Double Pane IECC | Window Double pane IG |
|-------------------------|-----------|--------------------------|---|------------------------|---------------------------------------|-------------------------|-----------------------|
| Electricity (kWh) | 652,850 | 648,290 | 646,050 | 634,003 | 633,653 | 647,498 | 647,551 |
| Fuel Oil (gal) | 32,137 | 26,782 | 25,491 | 22,614 | 22,234 | 29,407 | 28,836 |
| Total MMBtu | 6,837.7 | 5,927.3 | 5,740.5 | 5,300.4 | 5,246.5 | 6,288.6 | 6,209.6 |
| Normalized kBtu/sf | 85.47 | 74.09 | 71.76 | 66.26 | 65.58 | 78.61 | 77.62 |
| % Energy Savings | 0 | 13% | 16% | 22% | 23% | 8% | 9% |
| Electricity Cost (\$) | 84,871 | 84,278 | 83,987 | 82,420 | 82,375 | 84,175 | 84,182 |
| Fuel Oil Cost (\$) | 103,803 | 86,506 | 82,336 | 73,043 | 71,816 | 94,985 | 93,140 |
| Total Energy Cost (\$) | 188,673 | 170,784 | 166,322 | 155,464 | 154,191 | 179,159 | 177,322 |
| Normalized Cost (\$/sf) | 2.36 | 2.13 | 2.08 | 1.94 | 1.93 | 2.24 | 2.22 |
| % Cost Savings | 0% | 9.5% | 11.8% | 17.6% | 18.3% | 5.0% | 6.0% |

Lighting and Plug Loads Measures



Lighting

ECM 7: 30% LPD¹ reduction
(High performance fixtures with LED)

Plug loads

ECM 8: 15% EPD² reduction
(Energy Star appliances and equipment)

¹ lighting power density (W/sf)

² equipment power density (W/sf)

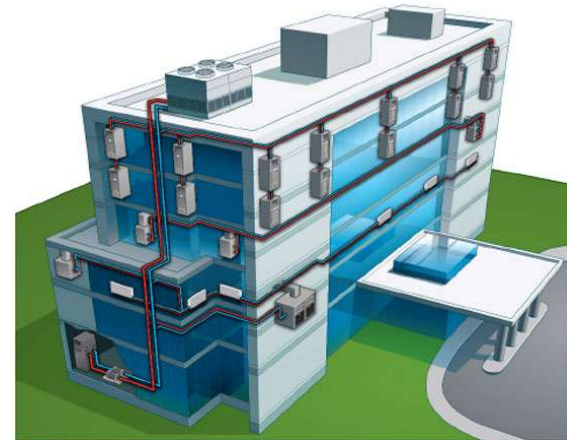
| | Baseline | ECM 7 Lighting 30% reduction | ECM 8 Plugloads 15% reduction |
|-------------------------|-----------|------------------------------------|-------------------------------------|
| Electricity (kWh) | 652,850 | 556,047 | 632,465 |
| Fuel Oil (gal) | 32,137 | 34,311 | 32,583 |
| Total MMBtu | 6,837.7 | 6,656.6 | 6,677.8 |
| Normalized kBtu/sf | 85.47 | 83.21 | 83.47 |
| % Energy Savings | 0 | 3% | 2% |
| Electricity Cost (\$) | 84,871 | 72,286 | 82,220 |
| Fuel Oil Cost (\$) | 103,803 | 110,825 | 105,243 |
| Total Energy Cost (\$) | 188,673 | 183,111 | 187,464 |
| Normalized Cost (\$/sf) | 2.36 | 2.29 | 2.34 |
| % Cost Savings | 0% | 2.9% | 0.6% |

HVAC Measures Description

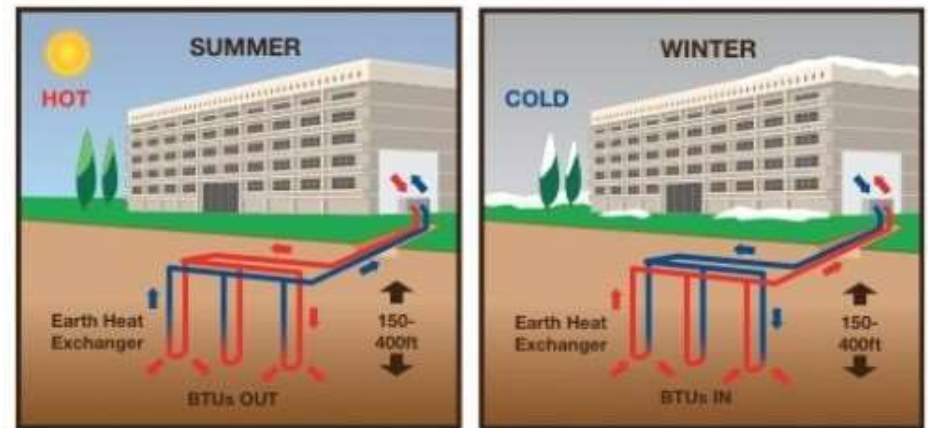
ECM 9: High efficiency Packaged VAV and condensing boiler

ECM 10: Water loop heat pump and condensing boiler

ECM 11: Ground-source heat pump



Water loop heat pump



Ground source heat pump

HVAC Measures Results

| | | ECM 9 | ECM 10 | ECM 11 |
|-------------------------|-----------|---|--|-------------------------|
| | Baseline | 14 EER PVAV_Cond Boiler_Economizer _ERV | WLHP_Cond Boiler_Economizer _ERV | GSHP_economizer _ERV |
| Electricity (kWh) | 652,850 | 680,748 | 941,002 | 809,377 |
| Fuel Oil (gal) | 32,137 | 22,214 | 4,342 | - |
| Total MMBtu | 6,837.7 | 5,404.5 | 3,813.9 | 2,762.4 |
| Normalized kBtu/sf | 85.47 | 67.56 | 47.67 | 34.53 |
| % Energy Savings | 0 | 21% | 44% | 60% |
| Electricity Cost (\$) | 84,871 | 88,497 | 122,330 | 105,219 |
| Fuel Oil Cost (\$) | 103,803 | 71,751 | 14,025 | - |
| Total Energy Cost (\$) | 188,673 | 160,248 | 136,355 | 105,219 |
| Normalized Cost (\$/sf) | 2.36 | 2.00 | 1.70 | 1.32 |
| % Cost Savings | 0% | 15.1% | 27.7% | 44.2% |

Combination Runs Description

ECM 12: High efficiency PVAV
& combo

ECM 13: Water loop heat
pump & combo

ECM 14: Ground source heat
pump & combo

Combo:

ECM 2: R-11.4 ci plus 2-inch ci (R-10) insulation

ECM 4: 6-inch rigid insulation roof (R-30)
(Design)

ECM 6: 0.25 U-factor, 0.40 SHGC (IG windows)

ECM 7: 30% LPD1 reduction (High performance
fixtures with LED)

ECM 8: 15% EPD2 reduction (Energy Star
appliances and equipment)

Combination Runs - Results

| | | ECM 12 | ECM 13 | ECM 14 |
|-------------------------|-----------|--|--------------------------------------|--------------------------|
| | Baseline | Combination with PVAV high EER_Cond Boiler | Combination with WLHP_Cond Boiler | Combination with GLHP |
| Electricity (kWh) | 652,850 | 512,488 | 733,114 | 571,038 |
| Fuel Oil (gal) | 32,137 | 9,651 | 1,457 | - |
| Total MMBtu | 6,837.7 | 3,088.1 | 2,704.1 | 1,948.9 |
| Normalized kBtu/sf | 85.47 | 38.60 | 33.80 | 24.36 |
| % Energy Savings | 0 | 55% | 60% | 71% |
| Electricity Cost (\$) | 84,871 | 66,623 | 95,305 | 74,235 |
| Fuel Oil Cost (\$) | 103,803 | 31,173 | 4,706 | - |
| Total Energy Cost (\$) | 188,673 | 97,796 | 100,011 | 74,235 |
| Normalized Cost (\$/sf) | 2.36 | 1.22 | 1.25 | 0.93 |
| % Cost Savings | 0% | 48.2% | 47.0% | 60.7% |

Solar PV Analysis

Solar PV Inputs:

- 90% minimum annual solar access
- 10 tilt panel tilt
- Oriented 15 east of due south (165° Azimuth)
- Landscape panel orientation
- 1' row-to-row spacing
- Standard efficiency PV modules
- Aurora Solar and PVWatts modeling

Aurora Solar Modeling



PVWatts Analysis

SYSTEM INFO

Modify the inputs below to run the simulation.

DC System Size (kW): ⓘ
 Module Type: ⓘ
 Array Type: ⓘ
 System Losses (%): ⓘ Loss Calculator
 Tilt (deg): ⓘ
 Azimuth (deg): ⓘ

RESTORE DEFAULTS

Draw Your System

Click below to customize your system on a map. (optional)



+ Advanced Parameters

RETAIL ELECTRICITY RATE

To automatically download an average annual retail electricity rate for your location, choose a rate type (residential or commercial). You can change the rate to use a different value by typing a different number.

Rate Type: ⓘ
 Rate (\$/kWh): ⓘ

RESULTS

Print Results

237,470 kWh/Year*

System output may range from 227,021 to 241,222 kWh per year near this location.
 Click [HERE](#) for more information.

| Month | Solar Radiation (kWh / m ² / day) | AC Energy (kWh) | Value (\$) |
|---------------|---|--------------------|------------------|
| January | 2.57 | 13,055 | 1,697 |
| February | 3.40 | 15,187 | 1,974 |
| March | 4.32 | 20,867 | 2,713 |
| April | 5.29 | 23,723 | 3,084 |
| May | 5.90 | 26,536 | 3,450 |
| June | 6.13 | 26,350 | 3,425 |
| July | 6.31 | 27,483 | 3,573 |
| August | 5.67 | 25,008 | 3,251 |
| September | 4.76 | 20,742 | 2,696 |
| October | 3.43 | 16,045 | 2,086 |
| November | 2.60 | 12,291 | 1,598 |
| December | 2.03 | 10,185 | 1,324 |
| Annual | 4.37 | 237,472 | \$ 30,871 |

Combination Runs with Solar PV

ECM 15: High efficiency PVAV & combo & 200 kW solar PV

ECM 16: Water loop heat pump & combo & 200 kW solar PV

ECM 17: Ground source heat pump & combo & 200 kW solar PV

| | | ECM 15 | ECM 16 | ECM 17 |
|-------------------------|-----------|---|--|------------------------------|
| | Baseline | Combination with PVAV high EER_Cond Boiler and PV | Combination with WLHP_Cond Boiler and PV | Combination with GLHP and PV |
| Electricity (kWh) | 652,850 | 275,018 | 495,644 | 333,568 |
| Fuel Oil (gal) | 32,137 | 9,651 | 1,457 | - |
| Total MMBtu | 6,837.7 | 2,277.9 | 1,893.9 | 1,138.7 |
| Normalized kBtu/sf | 85.47 | 28.47 | 23.67 | 14.23 |
| % Energy Savings | 0 | 67% | 72% | 83% |
| Electricity Cost (\$) | 84,871 | 35,752 | 64,434 | 43,364 |
| Fuel Oil Cost (\$) | 103,803 | 31,173 | 4,706 | - |
| Total Energy Cost (\$) | 188,673 | 66,925 | 69,140 | 43,364 |
| Normalized Cost (\$/sf) | 2.36 | 0.84 | 0.86 | 0.54 |
| % Cost Savings | 0% | 64.5% | 63.4% | 77.0% |

Q&A
Thank you

Contact Information

| Name | Position | Email | Phone Number |
|------------------------|-----------------|--|--------------|
| Kosol Kiatreungwattana | Senior Engineer | Kosol.Kiatreungwattana@nrel.gov | 303-384-7918 |
| James Salasovich | Senior Engineer | James.Salasovich@nrel.gov | 303-384-7383 |
| Megan Day | Project Lead | Megan.Day@nrel.gov | 303-275-3261 |
| Ella Zhou | Project Lead | Ella.Zhou@nrel.gov | 303-275-3293 |

| Name | Position | Email | Phone Number |
|--------------|----------|--|--------------|
| Chuck Snyder | | csnyder@rupco.org | |
| Kendra Home | | khome@rupco.org | |