



# Energy Simulation Modeling Analysis for Central Firehouse, Kingston NY

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## 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

- Collect and review data
  - Building questionnaire
  - Baseline Implementation Report by Malcolm Pirnie Inc., November 2010
- Energy simulation modeling and parametric analysis
  - Calibrated baseline
  - Energy Conservation Measures (ECMs)
    - Building envelope
    - Lighting
    - HVAC
- Solar PV analysis

# Baseline Implementation Report - 2010

## Proposed and Implemented

Based on the report, here is a list of proposed and implemented measures:

### Building Envelope

- Energy efficient double-pane windows
- Weather-stripping for doors

### Lighting

- T-8 fluorescent and LED

### Domestic Hot Water Heater

- Gas-fired water heater

### HVAC

- Newer steam boiler

### Controls

- Non-programmable thermostat because the building is operated 24 hr/day, 7 days/week

HVAC – heating ventilating and air conditioning

# Baseline Building Assumptions

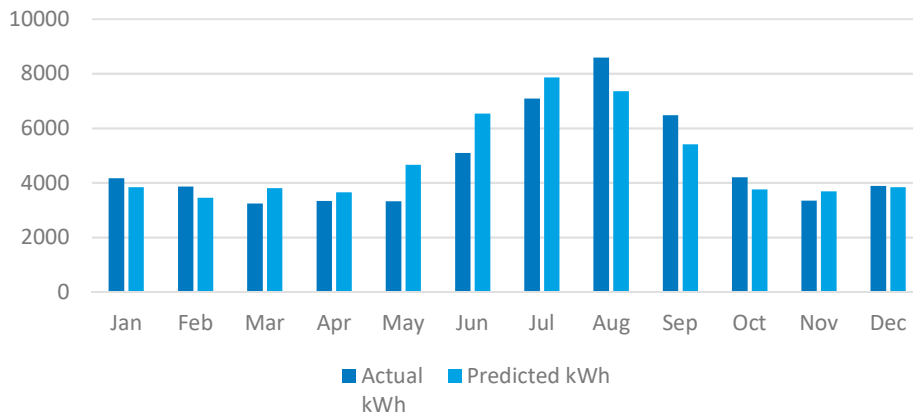
1. 10,140 sf, two-story building
2. Concrete masonry unit (CMU) walls
3. Membrane roof
4. Double-pane windows
5. 10 Occupants
6. T8 and LED interior lighting
7. Operate 24 hr/day, 7 days/week
8. Packaged terminal air conditioners (window AC units)
  - a. 12 SEER (assumed)
  - b. Partial cooling (May – Sep) for 2<sup>nd</sup> floor
9. Hydronic heating with a natural gas steam boiler
  - a. 55% efficiency (assumed)
10. Natural gas domestic hot water heater
11. Climate zone 5A, Albany NY - TMY3 weather data
12. Natural gas: \$1.08/therm
13. Electricity rate: \$0.12/kWh

CMU – concrete masonry unit  
SEER – seasonal energy efficiency ratio  
TMY - typical meteorological year



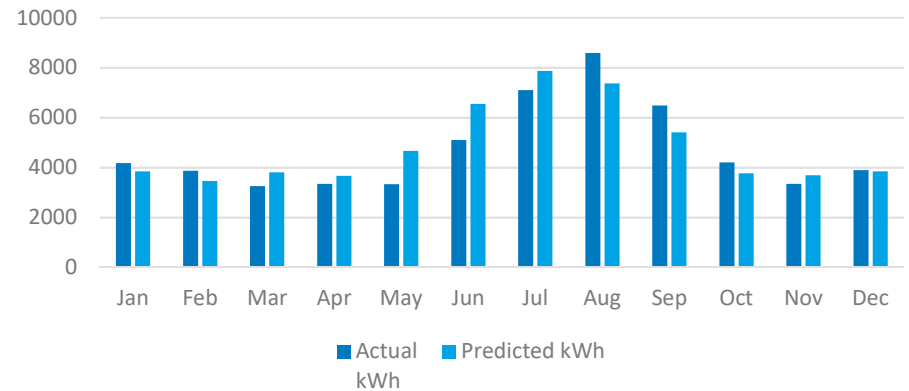
# Baseline Energy Model Calibration

Calibrated model: Actual vs Predicted Electricity Consumption (Therm)

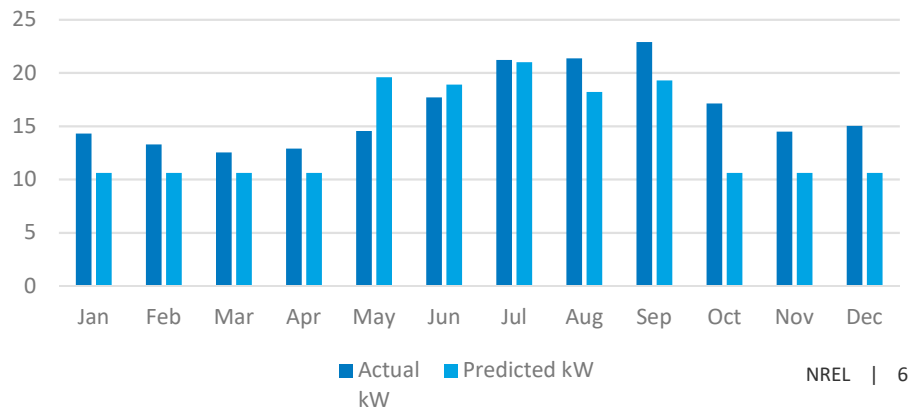


**Model was calibrated within 5% of actual billing data (2016-2019)**

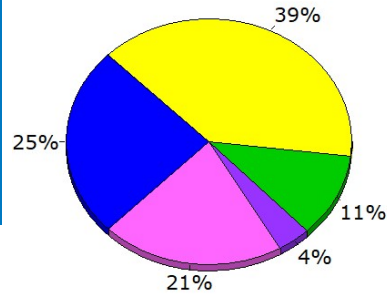
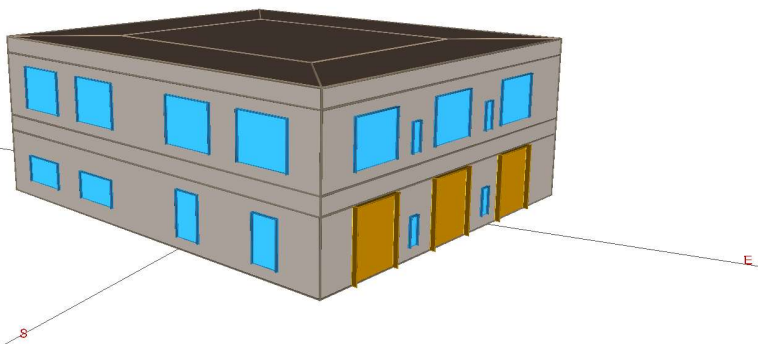
Calibrated model: Actual vs Predicted Electricity Consumption (kWh)



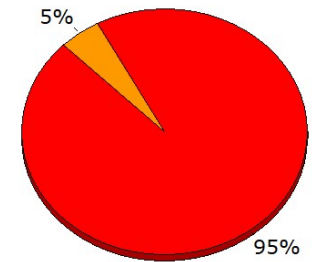
Calibrated model: Actual vs Predicted Electricity Demand (kW)



# Baseline Energy Model

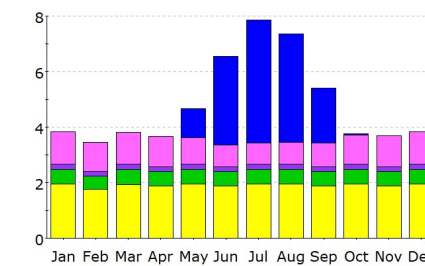


**Electricity**

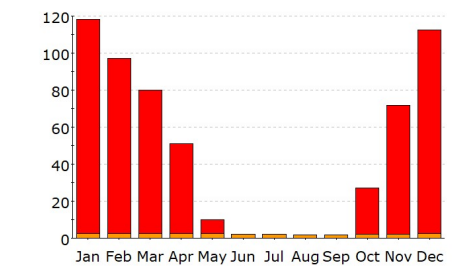


**Natural Gas**

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



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



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

**Normalized energy: 72.9 kBtu/sf/yr**

**Normalized cost: \$1.30/sf/yr**

# Investigated Energy Conservation Measures

## Building Envelope

**ECM 1:** High insulated roof at the end of life (currently 20 years old)

**ECM 2:** Weather stripping for doors and windows

## Lighting

**ECM 3:** Occupancy sensors

## Domestic Hot Water Heater

**ECM 4:** Hybrid heat pump water heater

## HVAC

**ECM 5:** Condensing hot water boiler and hot water temperature reset

**ECM 6:** Ductless split AC

**ECM 7:** Ductless mini-split heat pumps

## Controls

**ECM 8:** Programmable thermostat

## Renewable Energy

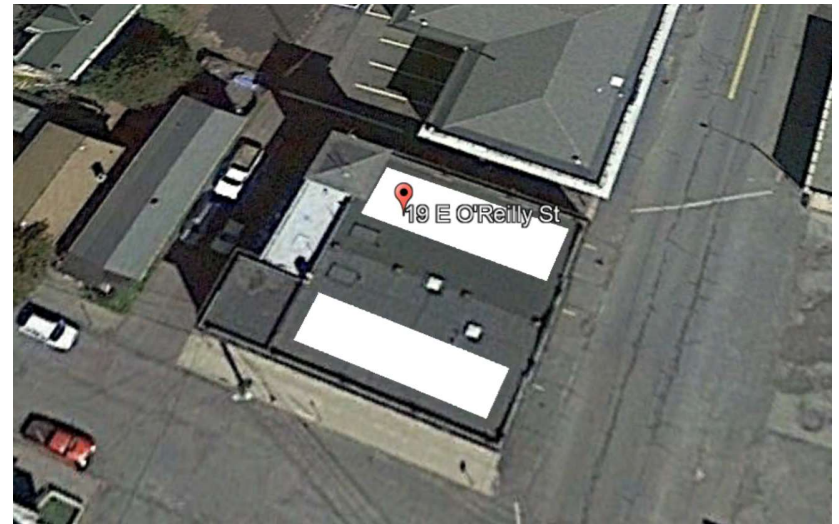
**ECM 9:** Roof-mounted solar PV system



# Solar PV Analysis

## Solar PV Inputs:

- 90% minimum annual solar access
- 20° panel tilt, flashed to roof
- Oriented 15° west of due south (195° Azimuth)
- Landscape panel orientation
- High efficiency PV modules (19% efficiency)
- PVWatts modeling
- Sizing at 19.2 kW



# PVWatts Analysis

## SYSTEM INFO

Modify the inputs below to run the simulation.

DC System Size (kW):  [i](#)

Module Type:  [i](#)

Array Type:  [i](#)

System Losses (%):  [i](#) [Loss Calculator](#)

Tilt (deg):  [i](#)

Azimuth (deg):  [i](#)

[+ 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:  [i](#)

Rate (\$/kWh):  [i](#)

RESTORE DEFAULTS

## Draw Your System

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



## RESULTS

[Print Results](#)

**24,650 kWh/Year\***

System output may range from 23,566 to 25,040 kWh per year near this location. [Click HERE](#) for more information.

Month	Solar Radiation ( kWh / m <sup>2</sup> / day )	AC Energy ( kWh )	Value ( \$ )
January	3.06	1,502	180
February	3.84	1,652	198
March	4.62	2,160	259
April	5.46	2,396	287
May	5.89	2,619	314
June	6.01	2,568	308
July	6.24	2,716	326
August	5.79	2,534	304
September	5.07	2,180	262
October	3.81	1,747	210
November	3.04	1,395	167
December	2.44	1,182	142
<b>Annual</b>	<b>4.61</b>	<b>24,651</b>	<b>\$ 2,957</b>

# ECM Results

		ECM 1	ECM 2	ECM 3	ECM 4	ECM 5	ECM 6	ECM 7	ECM 8	ECM 9
	Baseline	R-40 roof	Weather stripping	Occupancy Sensors	Hybrid heat pump hot water heater	Condensing HW boiler with reset	Ductless split AC	Ductless mini-split heatpumps	Programmable thermostat	19.2 kW Solar PV
Electricity (kWh)	57,898	57,949	54,411	55,380	66,998	57,898	53,175	108,684	57,507	33,248
Natural gas (therm)	5,754	5,658	5,477	5,819	5,481	4,028	5,754	273	5,518	5,754
Total MMBtu	773.0	763.6	733.4	770.9	776.8	600.4	756.9	398.2	748.1	688.9
Normalized kBtu/sf	76.23	75.30	72.33	76.03	76.60	59.21	74.64	39.27	73.77	67.94
<b>% Energy Savings</b>	<b>0</b>	<b>1%</b>	<b>5%</b>	<b>0%</b>	<b>0%</b>	<b>22%</b>	<b>2%</b>	<b>48%</b>	<b>3%</b>	<b>11%</b>
Electricity Cost (\$)	6,948	6,954	6,529	6,646	8,040	6,948	6,381	13,042	6,901	3,990
Natural gas Cost (\$)	6,214	6,111	5,915	6,285	5,919	4,350	6,214	295	5,959	6,214
Total Energy Cost (\$)	13,162	13,065	12,444	12,930	13,959	11,298	12,595	13,337	12,860	10,204
Normalized Cost (\$/sf)	1.30	1.29	1.23	1.28	1.38	1.11	1.24	1.32	1.27	1.01
<b>% Cost Savings</b>	<b>0%</b>	<b>0.7%</b>	<b>5.5%</b>	<b>1.8%</b>	<b>-6.1%</b>	<b>14.2%</b>	<b>4.3%</b>	<b>-1.3%</b>	<b>2.3%</b>	<b>22.5%</b>

# Combination 1

## Combination 1 with condensing boiler and ductless split AC

### **ECM 10:** Combination of 1, 2, 3, 4, 5, 6, 8, 9

ECM 1: High insulated roof at the end of life (currently 20 years old)

ECM 2: Weather stripping for door and windows

ECM 3: Occupancy sensors

ECM 4: Hybrid heat pump water heater

**ECM 5: Condensing hot water boiler and hot water temperature reset**

**ECM 6: Ductless split AC**

ECM 8: Programmable thermostat

ECM 9: Roof-mounted 19.2 kW solar PV system

## Combination 2

### Combination 2 with ductless mini-split heat pumps (All Electric)

#### **ECM 11:** Combination of 1, 2, 3, 4, 7, 8, 9

ECM 1: High insulated roof at the end of life (currently 20 years old)

ECM 2: Weather stripping for door and windows

ECM 3: Occupancy sensors

ECM 4: Hybrid heat pump water heater

**ECM 7: Ductless mini-split heat pumps**

ECM 8: Programmable thermostat

ECM 9: Roof-mounted 19.2 kW solar PV system



# ECM Combination Results

## Combination 1 with condensing boiler and ductless split AC

### **ECM 10:** Combination of 1, 2, 3, 4, 5, 6, 8, 9

- ECM 1: High insulated roof at the end of life (currently 20 years old)
- ECM 2: Weather stripping for door and windows
- ECM 3: Occupancy sensors
- ECM 4: Hybrid heat pump water heater

### **ECM 5: Condensing hot water boiler and hot water temperature reset**

### **ECM 6: Ductless split AC**

- ECM 8: Programmable thermostat
- ECM 9: Roof-mounted 19.2 kW solar PV system

## Combination 2 with ductless mini-split heat pumps (All Electric)

### **ECM 11:** Combination of 1, 2, 3, 4, 7, 8, 9

- ECM 1: High insulated roof at the end of life (currently 20 years old)
- ECM 2: Weather stripping for door and windows
- ECM 3: Occupancy sensors
- ECM 4: Hybrid heat pump water heater

### **ECM 7: Ductless mini-split heat pumps**

- ECM 8: Programmable thermostat
- ECM 9: Roof-mounted 19.2 kW solar PV system

	ECM 10	ECM 11
	<b>Combo 1 with condensing boiler, split AC, and solar PV</b>	<b>Combo 2 with ductless mini-split heat pumps, and solar PV</b>
Electricity (kWh)	32,520	77,948
Natural gas (therm)	3,755	-
Total MMBtu	486.5	266.0
Normalized kBtu/sf	47.98	26.24
<b>% Energy Savings</b>	<b>37%</b>	<b>66%</b>
Electricity Cost (\$)	3,902	9,354
Natural gas Cost (\$)	4,055	-
Total Energy Cost (\$)	7,958	9,354
Normalized Cost (\$/sf)	0.78	0.92
<b>% Cost Savings</b>	<b>39.5%</b>	<b>28.9%</b>

## Key Takeaways

- ECM 10 - combination with ductless split air conditioners and solar PV could achieve 37% energy use reduction and 40% energy cost reduction
- ECM 11 - all electric combination with ductless mini split heat pumps and solar PV could achieve 66% energy use reduction and 29% energy cost reduction
- Higher energy savings but lower cost savings due to fuel switching
- Cost of electricity per unit is much higher than natural gas
  - Electricity \$0.12/kWh
  - Natural gas \$0.04/kWh

Q&A  
Thank you

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