Achieving Net Zero with a 649,848 Sq. Ft. Industrial Complex

Klas C. Haglid PE, RA, CEM

CEO & Founder of

Haglid Engineering and Associates, Inc.

649,848 Sq. Ft. Industrial Complex

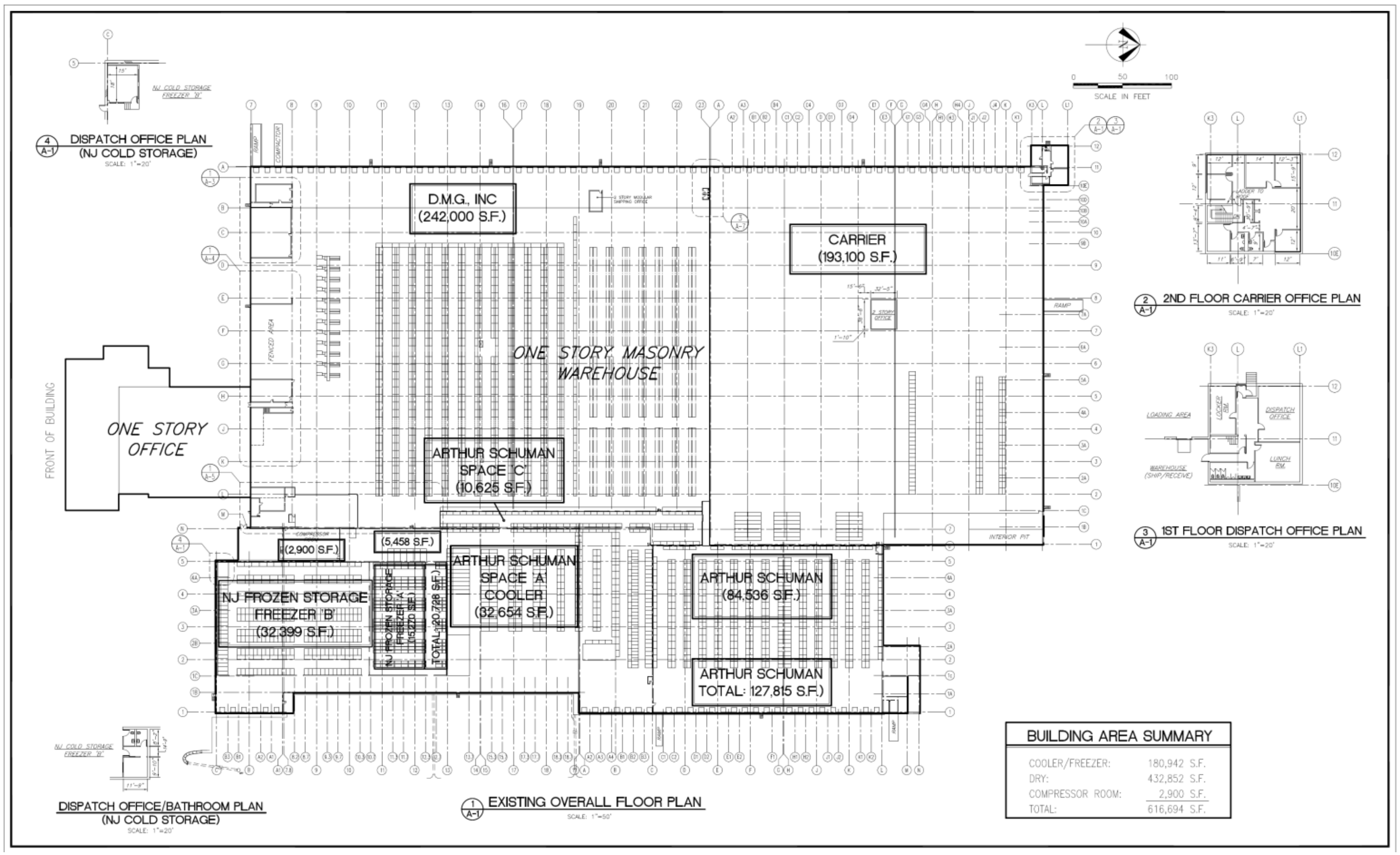
First Existing Building Emmy Award in Times Square – Manhattan, New York

1st Annual EBie Awards
By Urban Green Council ★ Favorite

Adjunct Prof. Klas Haglid, P.E., R.A, CEM - Bio

- ASHRAE Distinguished Service Award
- 2011 ASHRAE Handbook, HVAC Applications and Management, Chapter 37,– Author, Klas C. Haglid P.E. R.A.
- ASHRAE Standard 189.1, Corresponding Member
- GPC 32P - Sustainable, High Performance Operations & Maintenance, Voting Member, Contributing, Co-Author
- Technical Committee 5.5 - Air-To-Air Energy Recovery, Handbook Subcommittee Chairman, Past Chairman
- Technical Committee 7.6 - System Energy Utilization, Voting Member
- Technical Committee 7.8 - Owning and Operating Costs of Commercial Buildings, Past Chairman
- ASHRAE Standard 84-1991R, Voting Member
- Reviewed draft of ASHRAE Standard 84-1991R and provided engineering details for efficiency calculations.

Overall Floor Plan



Project Summary

Project Summary	
Total Project Area (sq. ft.)	649,848
Annual Energy Cost ($)	$1,691,278
Reduction from Baseline: Proposed (%)	38%
Reduction from Baseline: Actual (%)*	0%
Total Project Cost ($)	$3,196,418

*Achieved April 2012 – Net power to grid = 9108 kWh

Certificate of State Performance

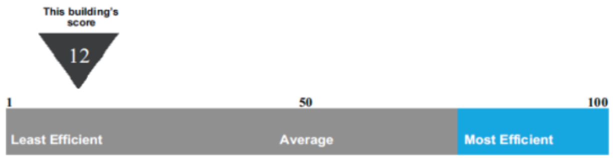
Statement of Energy Performance

2008

Avidan Managment Refrigeration
145 Talmadge Rd
Edison, NJ 08817

Portfolio Manager Building ID: 1937553

The energy use of this building has been measured and compared to other similar buildings using the Environmental Protection Agency's (EPA's) Energy Performance Scale of 1–100, with 1 being the least energy efficient and 100 the most energy efficient. For more information, visit energystar.gov/benchmark.



This building uses 213 kBtu per square foot per year.*

*Based on source energy intensity for the 12 month period ending December 2008

Buildings with a score of 75 or higher may qualify for EPA's ENERGY STAR.

I certify that the information contained within this statement is accurate and in accordance with U.S. Environmental Protection Agency's measurement standards, found at energystar.gov

Date of certification

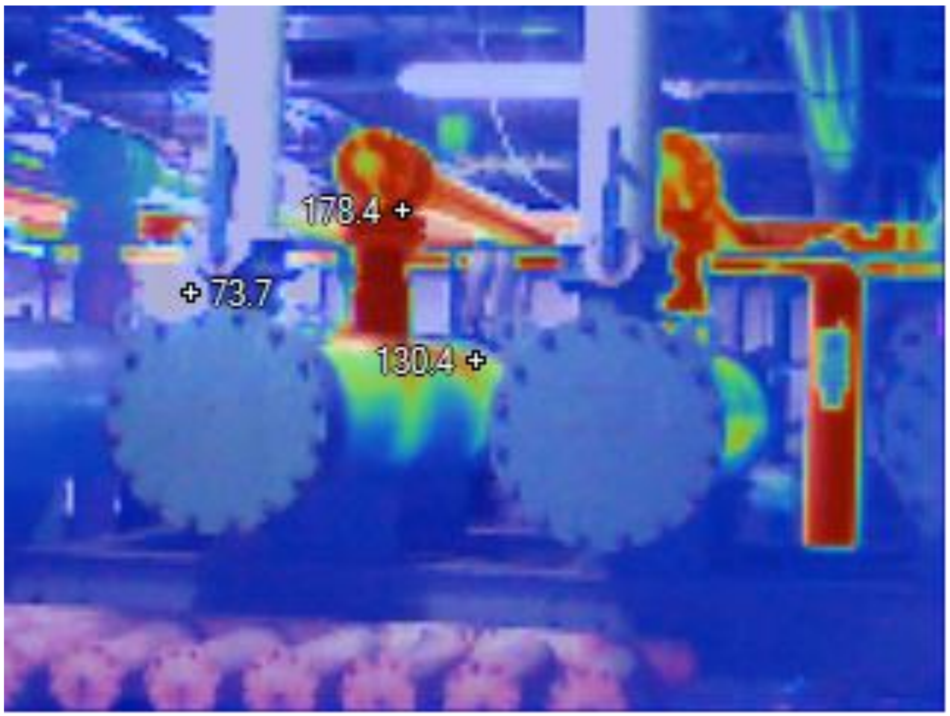
EPA United States Environmental Protection Agency

Date Generated: 01/14/2010

Sources for screening building projects

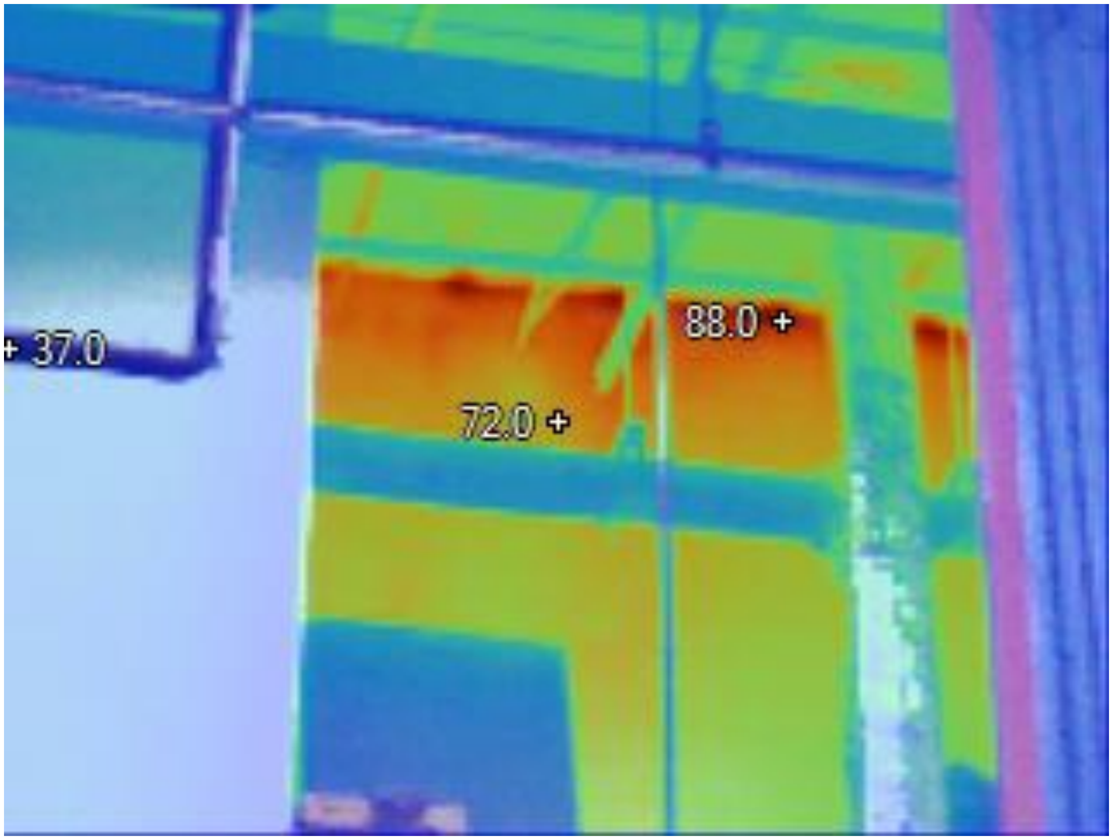
- EPA – Energy Star Benchmarking Portfolio Manager
  - Buildings with benchmarking scores under 50 are good candidates for ECMs (energy conservation measures).
  - Buildings with low R-value walls or high infiltration rates are good candidates for envelope upgrades.
- DOE – Building Usage Profiles
  - Buildings with very high heating rates for percentage of energy usage are generally good candidates for ECMS.

Mechanical Room Equipment Heat Loss



The Room temperature is at 73.7 °F is cooling the mechanical equipment from part of the refrigeration plant are at 178°F

ERM – Eliminate Thermal Bridges
Thermal Gain/Loss Between the Boiler Room and the Refrigerated Warehouse Area



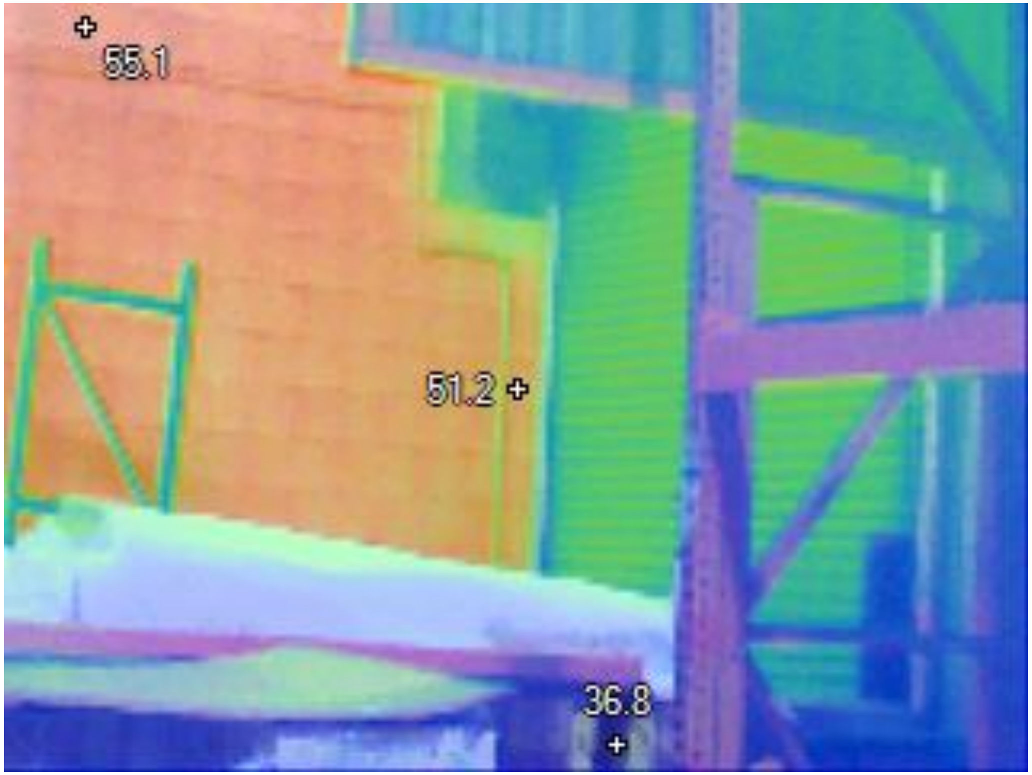
The industrial building has the boiler room which generates heat adjacent to the refrigerated warehouse

The Thermograph illustrates the heat transfer issue between the two room and makes it clear the necessity for better insulation in the separating wall

Envelope Solution

- Adding 4-6” of insulation in specific regions of the refrigeration spaces, up to R values = 38.
- The construction of a new wall approximately 15’ x 15’ located in between the Mechanical room and the Refrigerated space.
- This wall will provide ease of installation for insulation upgrade as well as seal the refrigerated space from piping and mechanical room heat.

Thermal gain/loss through the un-insulated wall between the refrigerated warehouse and the warehouse space with no refrigeration or air-conditioning



Envelope Solution

- The second wall will be constructed in between the two large temperature and humidity differences within the refrigerated warehouse space.
- Each wall will be constructed of 12” hollow concrete brick and covered with the proposed insulation towards the interior of refrigerated areas

Walls:

15’x15’ Mezzanine Wall:	$1,012.00
NJF/AS Barrier Wall:	$21,713.00
2” Insulation Upgrade:	$155,695.00
Total Wall Estimate:	**$178,420.00**

heat gain from lighting fixtures in refrigerator/freezer areas

The previous lighting fixtures did not only consume a tremendous amount of energy but produces undesired heat which proved to be a great cost factor

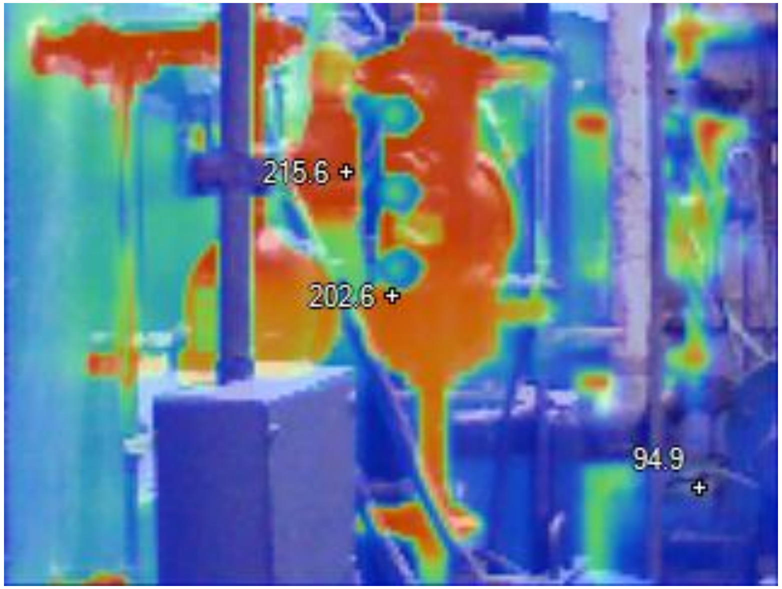
Lighting Solution

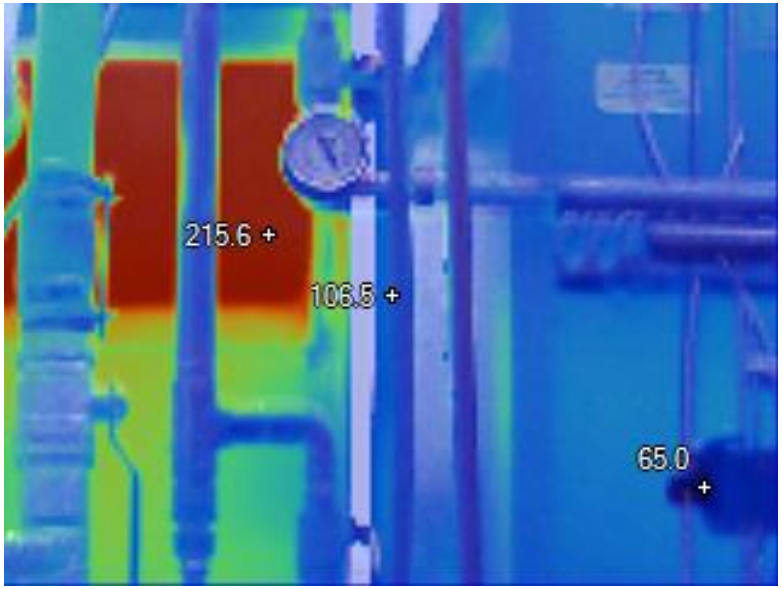
- Lighting controls for facility spaces and the proposed upgrades of lamps and fixtures

- Use high efficiency LED in freezer/ refrigerated areas can be used with occupancy sensor. LEDs have immediate start up.

- **Lighting Project Cost = $281,700.00**

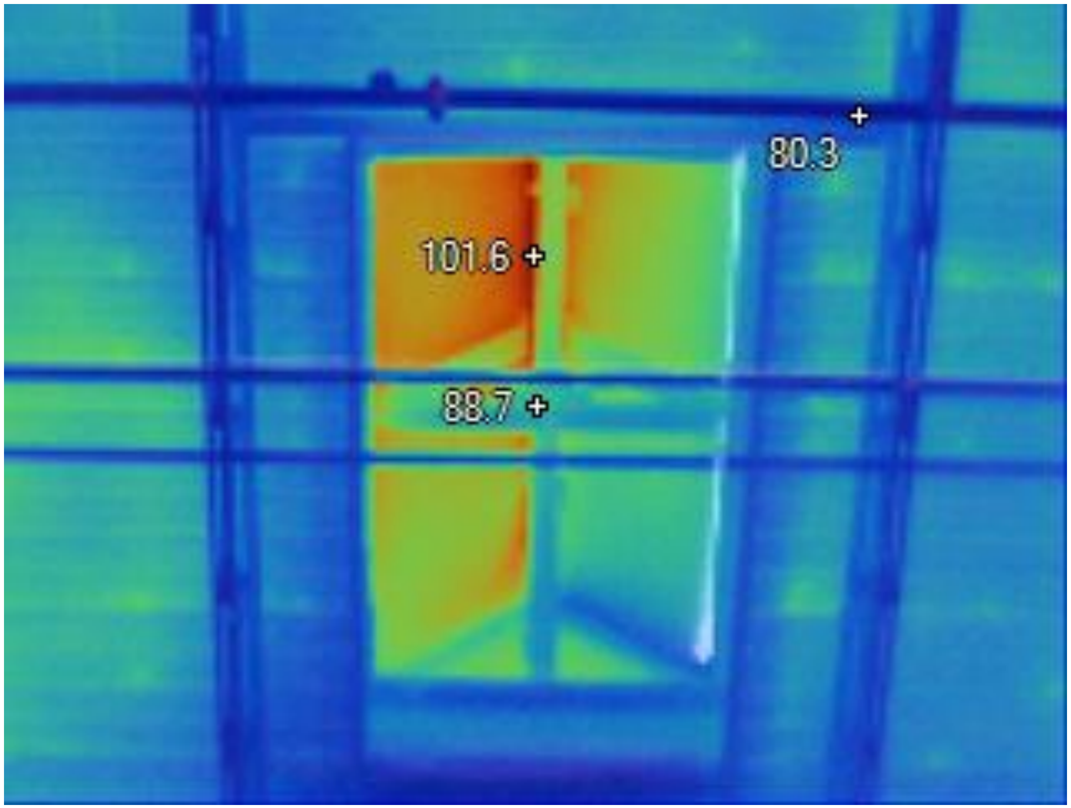
heat loss within the boiler and mechanical room.





Comfort issues in mechanical room, caused operator to find ways to cool with refrigerated areas

Heat Gain from the Skylights



- Thermal issues
- Fading of stock
- Reduced roof foot print for solar panels

Roofing Solution

- The Roof upgrade entailed improving previous construction to an overall construction of R-30+ above all Refrigerated Warehouse space.

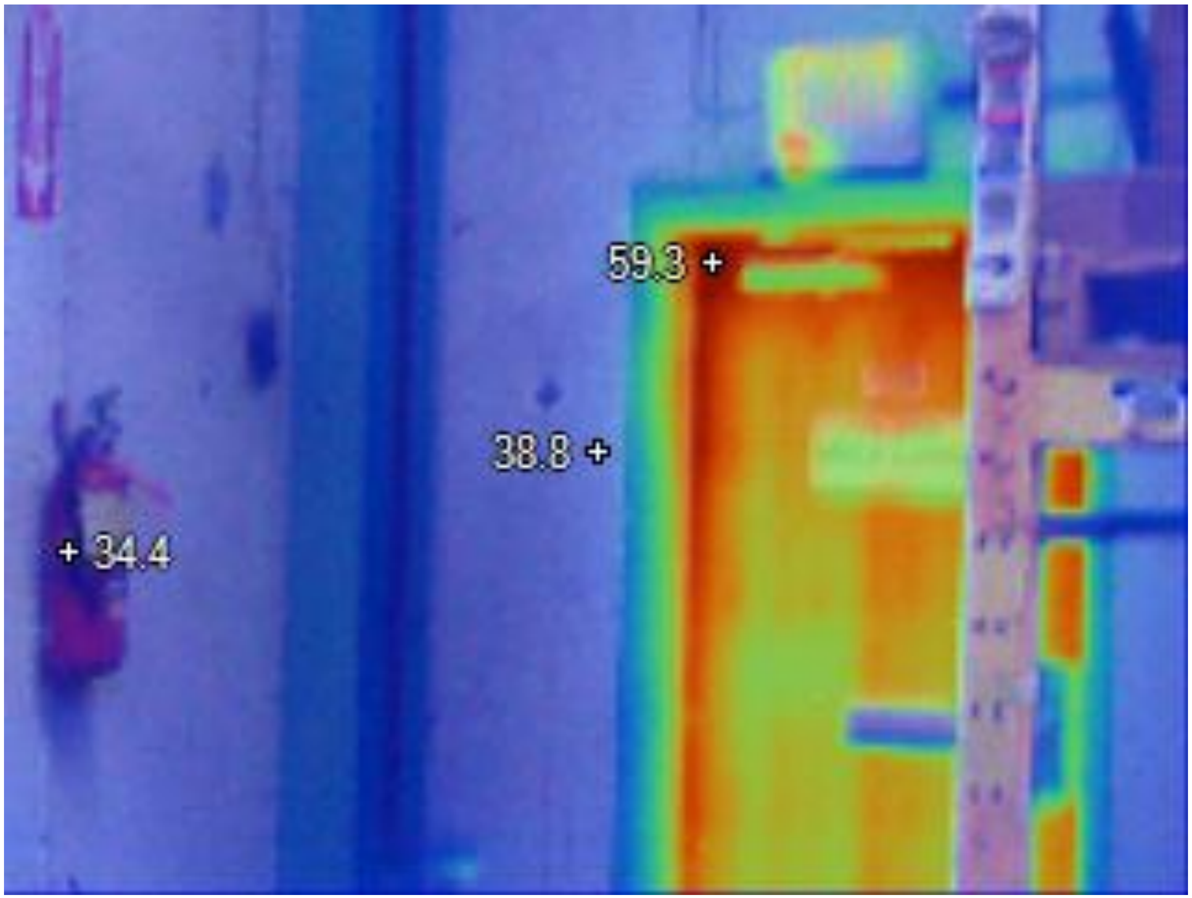
- The new construction must was coated with a reflected roof system to prevent heat absorption of solar radiation.

- Roof construction must be able to handle future Solar Power Generation implementation.

Roof:

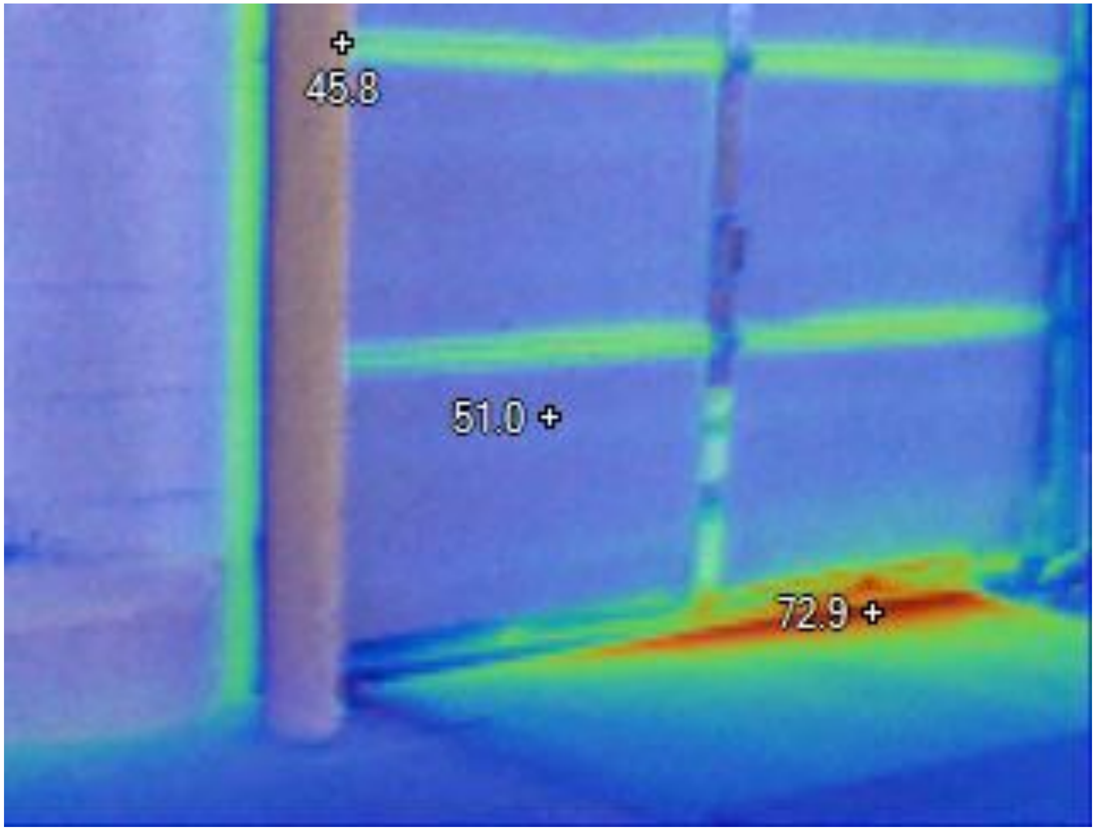
Skylights:	$ 5,000.00
Drains:	$5,200.00
R Value and Reflective Upgrade:	$1,506,938.00
Total Roofing Estimate = $ 1,517,138.00	
Total Envelope Upgrade =	**$ 1,842,860.00**

Heat gains from exterior doors



- Note: 38.8 °F wall temp. with the door at 59.3 °F
- Improve R-value of door and seals
- Reduce infiltration and thermal losses, latent loads

Heat gains from underneath exterior doors



Note: 72.9 °F infiltration of heat and humidity

Door Solutions

- Selected doors within the refrigeration areas were replaced and upgraded with new doors.
  - New doors will be tighter, have better thermal resistance, and be more easily accessed with the use of controls.

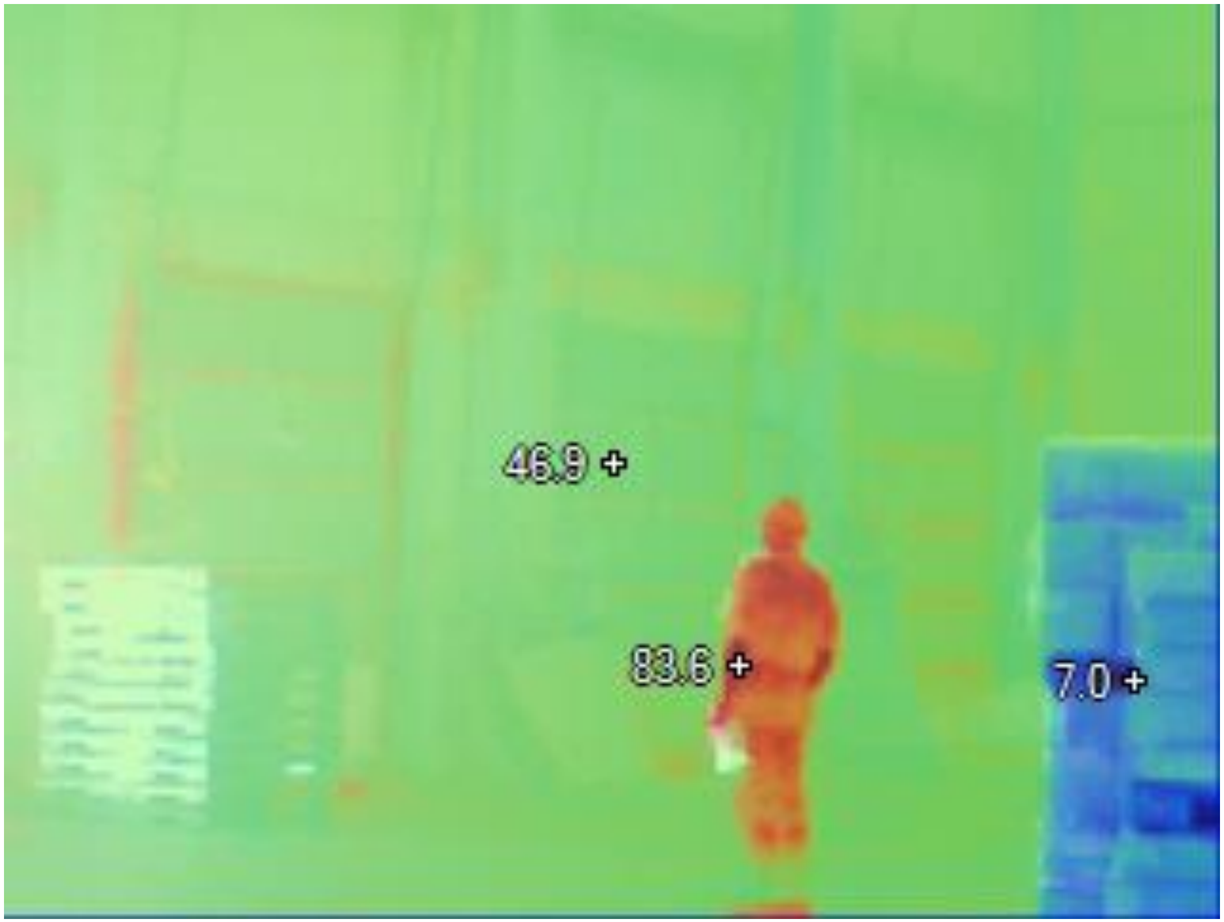
- Doors are high-speed opening and closing to prevent heat transfer of infiltration.

- All loading dock doors were equipped with Frommelt ® PITMASTER™ Under-leveler Seals and Lip Cornor Seals.

<u>Doors</u>:

Replacement Doors:	$ 86,692.00
Door Sealing:	$ 60,610.00

heat gain from occupants within the loading area outside the freezer space



HVAC Solution

- Energy recovery ventilation (ERV) will be implemented in combination with many of the rooftop unitary equipment serving the office space areas.

- Building Performance Equipment, Inc. ERVs will be the products used for these measures.

- All installations must be commissioned for proper flows.
  - Using variable speed drives for fan motors.

- Use existing exhaust system of the serviced areas whether it from the unitary equipment itself or dedicated exhaust fans, caps, goosenecks, etc.

Estimated Cost:	$232,846.93
Soft Costs:	$23,284.69
Management/Commissioning:	$23,284.69
Total ERV Estimate =	**$ 279,416.31**

Energy Recovery

Energy Recovery Ventilation Schedules											
		Winter		Summer		Actual	HX	Total Cooling	Total Heating		
EQUIP	Model No.	ºF DB	ºF WB	ºF DB	ºF WB	CFM	Eff	BTU/H	BTU/H	EER	SEER
ERV-1	(3) BPE-MIR-XE 2000	15	15	95	78	3,000	87	65,218	160,095	35.4	82.4
ERV-2	BPE-MIR-XE 2000	15	15	95	78	1,400	78	33,626	73,549	35.4	82.4
ERV-3	BPE-MIR-XE 2000	15	15	95	78	1,400	78	33,626	73,549	35.4	82.4
ERV-4	BPE-MIR-XE 1000	15	15	95	78	500	87	10,870	26,683	35.9	75.1
ERV-5	BPE-MIR-XE 500	15	15	95	78	240	88	5,275	12,908	31.5	75.7
ERV-6	(4) BPE-MIR-XE 2000	15	15	95	78	6,000	78	N/A	294,197	N/A	82.4

145 Talmadge Road - Edison, NJ 08817
All Weather Air Management (4)x 2,000 series

IF CURRENT FANS CAN SUPPLY FOR STATIC PRESSURE DROP

Fresh Air Supply			
Supply	Temp 1	OSA	Temp
Supply	Temp 2	Pre Cond	Temp
Exhaust Air Supply			
Exhaust	Temp 3	Bldg	Temp
Exhaust	Temp 4	Exhaust	Temp

Weather Data	Newark NJ
Ex Eff	80.00%
Evaporative Eff	0
Winter SP T3	72
Summer SP T3	72
Bld Equl Pt	50

Equipment Operation and Efficiencies				
Del. Heat Eff	0.8	Gas	2.5	KWh Elect/Thm
	1.53	$/Therm	0.13716	$/kWh
Del. Cool Eff	NA	Gas	1.4	KWh Elect/Ton
	1.53	$/Therm	0.13716	$/kWh
	Demand Savings		20	$/year

Heat Recovery Unit Flow Rates as balanced 1 =1			
Nominal CFM	Actual CFM	Supply Air	Exhaust Air
8000	5600	5600	5600
% of Nominal Rate =	70		

Profile of Energy Savings

Time of Year	Mid-pts	DB (F)	Total Hrs	OSA Temp 1	Solve Temp 2	Bldg Temp Temp 3	Exhaust Temp 4	Saved Btu per Hour	Annual Btu Saved
Summer	97.5	95 to 100	**6**	97.5	77.1	72.0	82.20	123,379	740,275
	92.5	90 to 95	**40**	92.5	76.1	72.0	80.20	99,187	3,967,488
Time	87.5	85 to 90	**122**	87.5	75.1	72.0	78.20	74,995	9,149,414
Cooling	82.5	80 to 85	**500**	82.5	74.1	72.0	76.20	50,803	25,401,600
	77.5	75 to 80	**620**	77.5	73.1	72.0	74.20	26,611	16,498,944
	72.5	70 to 75	**847**	72.5	72.1	72.0	72.20	2,419	2,049,062
Free Cooling	67.5	65 to 70	**671**	67.5	71.1	72.0	70.20	21,773	14,609,549
	62.5	60 to 65	**927**	62.5	70.1	72.0	64.40	45,965	42,609,370
	57.5	55 to 60	**600**	57.5	69.1	72.0	60.40	70,157	42,094,080
Winter	**52.5**	**50 to 55**	**730**	**52.5**	**68.1**	**69.0**	**53.4**	**(94,349)**	**(68,874,624)**
Time	**47.5**	**45 to 50**	**634**	**47.5**	**67.1**	**69.0**	**49.4**	**(118,541)**	**(75,154,867)**
Heating	**42.5**	**40 to 45**	**513**	**42.5**	**66.1**	**69.0**	**45.4**	**(142,733)**	**(73,221,926)**
	37.5	**35 to 40**	**1023**	**37.5**	**65.1**	**69.0**	**41.4**	**(166,925)**	**(170,764,070)**
	32.5	**30 to 35**	**734**	**32.5**	**64.1**	**69.0**	**37.4**	**(191,117)**	**(140,279,731)**
	27.5	**25 to 30**	**391**	**27.5**	**63.1**	**69.0**	**33.4**	**(215,309)**	**(84,185,741)**
	22.5	**20 to 25**	**195**	**22.5**	**62.1**	**69.0**	**29.4**	**(239,501)**	**(46,702,656)**
	17.5	**15 to 20**	**125**	**17.5**	**61.1**	**69.0**	**25.4**	**(263,693)**	**(32,961,600)**
	12.5	**10 to 15**	**47**	**12.5**	**60.1**	**69.0**	**21.4**	**(287,885)**	**(13,530,586)**
	7.5	**5 to 10**	**34**	**7.5**	**59.1**	**69.0**	**17.4**	**(312,077)**	**(10,610,611)**
	2.5	**0 to 5**	**1**	**2.5**	**58.1**	**69.0**	**13.4**	**(336,269)**	**(336,269)**
	-2.5	**-5 to 0**	**0**	**-2.5**	**57.1**	**69.0**	**9.4**	**(360,461)**	**-**
	-7.5	**-10 to -5**	**0**	**-7.5**	**56.1**	**69.0**	**5.4**	**(384,653)**	**-**

All Hours	8760	
Cooling Hrs =	2135	24.37%
Heating Hrs =	4427	50.54%

Total Cooling Saved (Btu) =	157,119,782
Peak Energy Savings ($) =	$ 288
Cooling Savings ($) =	$ 2,514
Total Cooling Energy Saved =	**$ 2,802.12**
Total Heating Saved (Btuh) =	(716,622,682)
Total Heating Saved (Therms) =	8,958
Total Heating Energy Saved (US Dollars) =	**$ 16,777.03**
Total Savings (US Dollars) =	**$ 19,579.15**
Cost of ERU and Installation (US Dollars) =	**$ 75,038.13**
Simple Payback (Years) =	**3.83**

Basic Installation of Energy Recovery Units

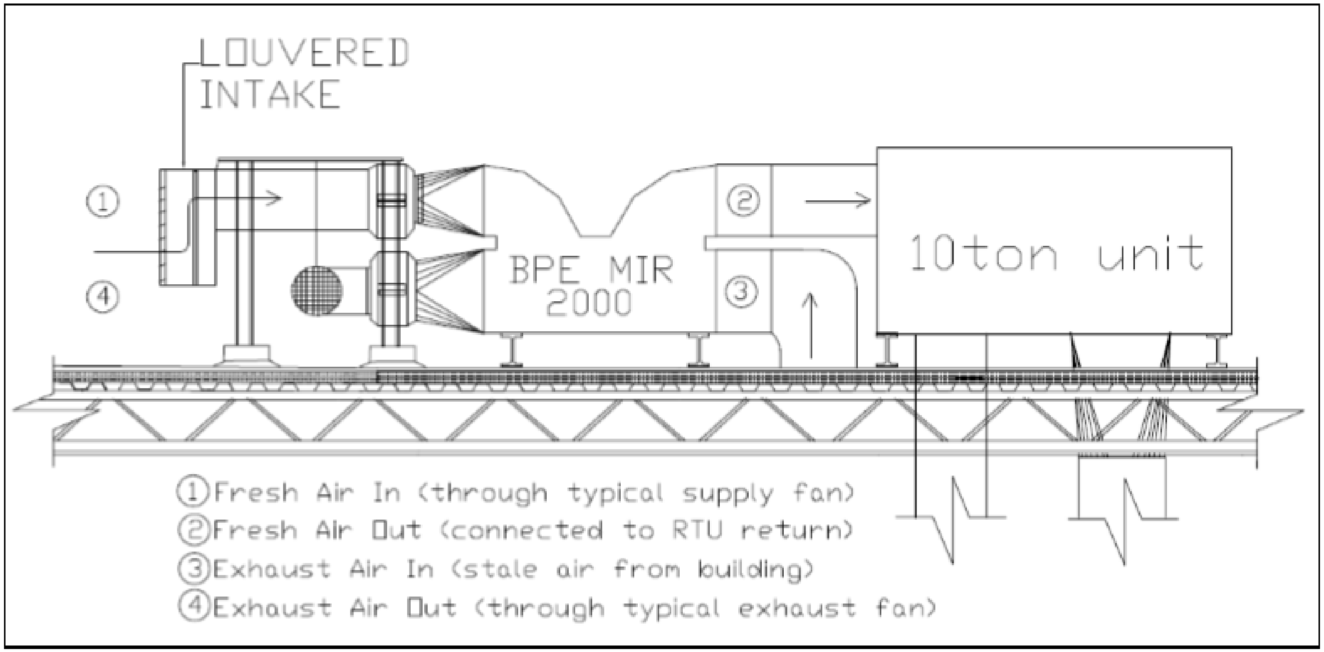


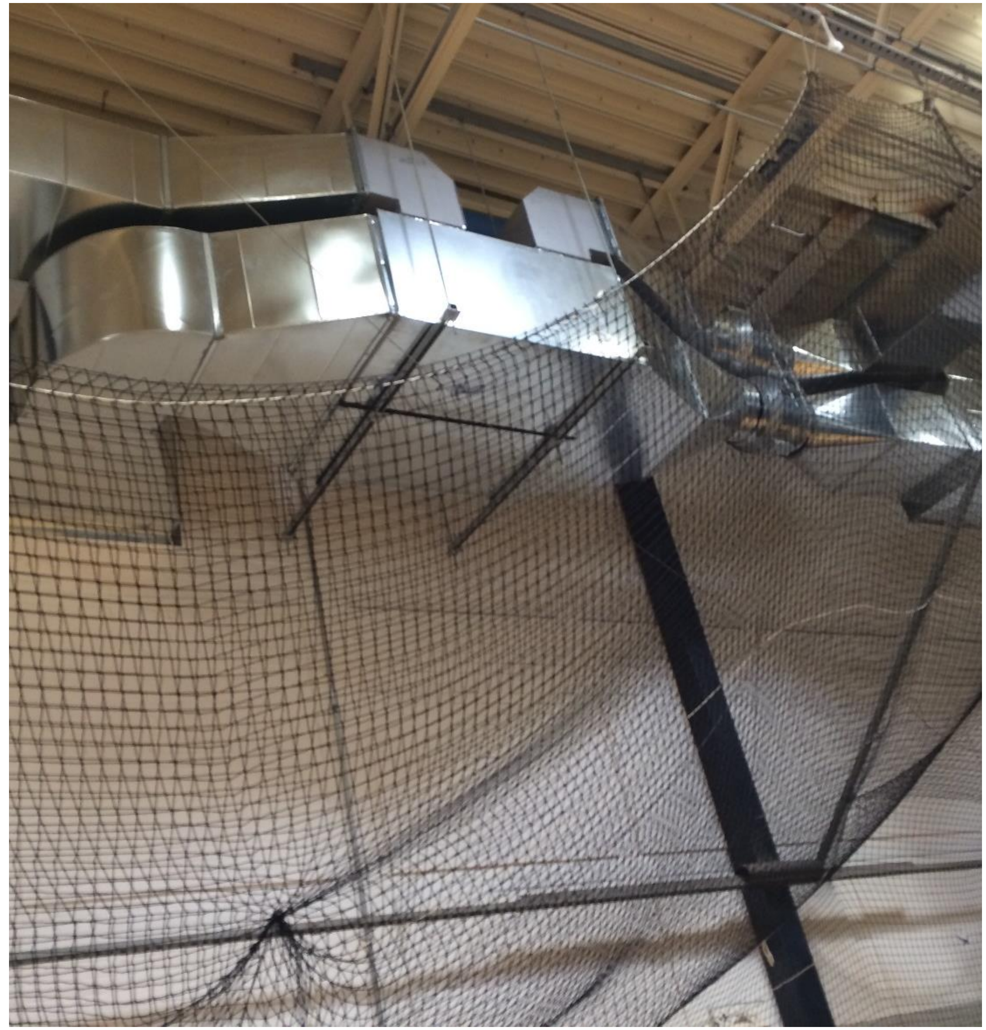
Fig.9 – Typical RTU Installation, Side View

Note: It is recommended that there be a minimum of 10 feet of separation, or the minimum required by code (whichever is higher), between points 1-(Fresh Air In) and 4-(Exhaust Air Out) in order to prevent cross contamination between the air streams. Installing hoods and/or an inlet screen are necessary to protect the duct openings from rain and animals. See Figure 7 for a detailed drawing of the louvered intake.

8000 cfm Modular Energy Recovery System. Photo provided by BPE

BPE- XE-MIR-4000 Unit for High School Gym

1. BPE Energy Recovery Modules are modular.
2. 50 cfm to 20,000 cfm modules
3. 20,000 cfm modules are man portable and can be assembled by two men in 4 hours and will fit though a 36 inch door.
4. This BPE-XE-MIR -4000 provides enough fresh air for a High School Gym or several hundred people!
5. The power requirements are less than one handheld hair dryer!
6. No additional heating or cooling is needed!



BPE-XE-MIR-2000

1. **BPE-XE-MIR-2000 have the lowest profile of any 2000 cfm unit on the market**
2. **This unit fits in between standard roof trusses.**
3. **BPE Energy Recovery Units are test by Edison Testing Laboratories to be over 91% thermally efficient and are considered by leading experts to be the most efficient and effective energy recovery ventilators in the world**
4. **No moving parts, nothing to fail.**
5. **Can be installed in tandem for over 98% thermal efficiency for artic or -40 degree F outdoor air conditions.**

BPE-XE-MIR-650 installed in Machine Shop

CNC Cutting Shop

1. BPE ERVs take no floor space and handle dehumidification for water cooled CNC area.
2. Fresh air is supplied with fabric duct.
3. No additional inline heating or cooling is used or needed.
4. 47% saving on heating build compared to just traditional venting
5. **Complete return on investment in <u>under one year!</u>**

BPE – Wall mounted installation

1. Faster and easier to install than traditional HVAC systems.

2. BPE-XE-MIR-500 installs typically in 4 hours.

3. BPE can provide prewired fans with built in speed controllers with three prong plugs. Only outlet needed!

BPE units typically fit into most ceilings

BPE units take **no** floor space

1. A BPE-XE-MIR-2000 only uses 2 feet of head space.
2. Typically fits in a ceiling grid.
3. Get instant fresh air at a fraction of the cost of heating and cooling outdoor fresh air.
4. Install with hangers in 20 minutes, add fans and ductwork!
5. No additional heating and cooling equipment needed in most applications.

ETL – Intertek Test

1. Test has more outdoor air than exhaust air. Unit is actually running at over 95% thermal effectiveness.
2. 91.5% thermal effectiveness is typical for actual installed units in classrooms.
3. Units have no moving parts and early unit show no signs of degradation or maintenance issues after 15 years.
4. Notice very low pressure drop of 0.25 inches of water column.
5. Twice the energy recovery at 10% of the energy cost is not 20 x as high an EER.
6. EERs as high as 126 have been documented

Tests

erformance Data at 50 SCFM/Summer Conditions

Outdoor Air		
	Dry-bulb, °F	89.85
	Wet-bulb, °F	65.20
	Standard Airflow, SCFM	57
Return Air		
	Dry-bulb, °F	74.00
	Wet-bulb, °F	60.40
	Standard Airflow, SCFM	49
Test Unit ΔP (inches H20)		
	Outdoor Air – Supply Air (1 – 2)	0.25
	Return Air – Exhaust Air (3 – 4)	0.25
	Supply Air – Return Air (2 – 3)	0.00
	Exhaust Air – Atmosphere (4-ATM)	0.00
Thermal Effectiveness		
	Sensible Effectiveness, %	91.50
	Barometric Pressure, in. Hg	29.21

Measure Cost & Savings

	Measure	Installed Cost (incl. design)	Annual Energy Savings				Demand Savings	Annual O&M Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	Steam MMBtu	Other MMBtu	kW	$	$	years	years	$	%
1	Energy Recovery Ventilation	$298,847	81,343	2,946	0	0	41.8	$0	$53,555	20	5.58	$497,916	17.2%
2	Lighting Upgrade	$228,940	764,007	0	0	0	115.5	$22,673	$104,669	15	2.19	$1,020,592	45.6%
3	Refrigeration Controls	$237,268	1,180,409	0	0	0	60.9	$0	$134,172	10	1.77	$907,246	55.9%
4	Envelope Upgrade (Wall,Doors)	$1,446,361	824,141	3,626	0	0	807.8	$0	$241,513	20	5.99	$2,146,735	15.8%
5	White Roof	$420,000	451,419	1,336	0	0	339.0	$0	$64,419	20	6.52	$538,392	14.3%
6	Office Waste Heat Measure	$275,002	583,253	0	0	0	0	$0	$51,911	18	5.30	$438,957	17.9%
	CM Fees	$290,000	*Overall project management, all fees associated with specific measures should be noted above.*										
	Partner Fees	$0	*Per Partner Contract*										
	TOTALS	$3,196,418	3,884,572	7,908	0	0	1,365.0	$22,673	$650,239		4.92	$5,259,838	18.9%

*IRR = Internal Rate of Return – 2011 ASHRAE Handbook – HVAC Applications – Owning and Operating Costs, page 37.11 – Klas C. Haglid - Author

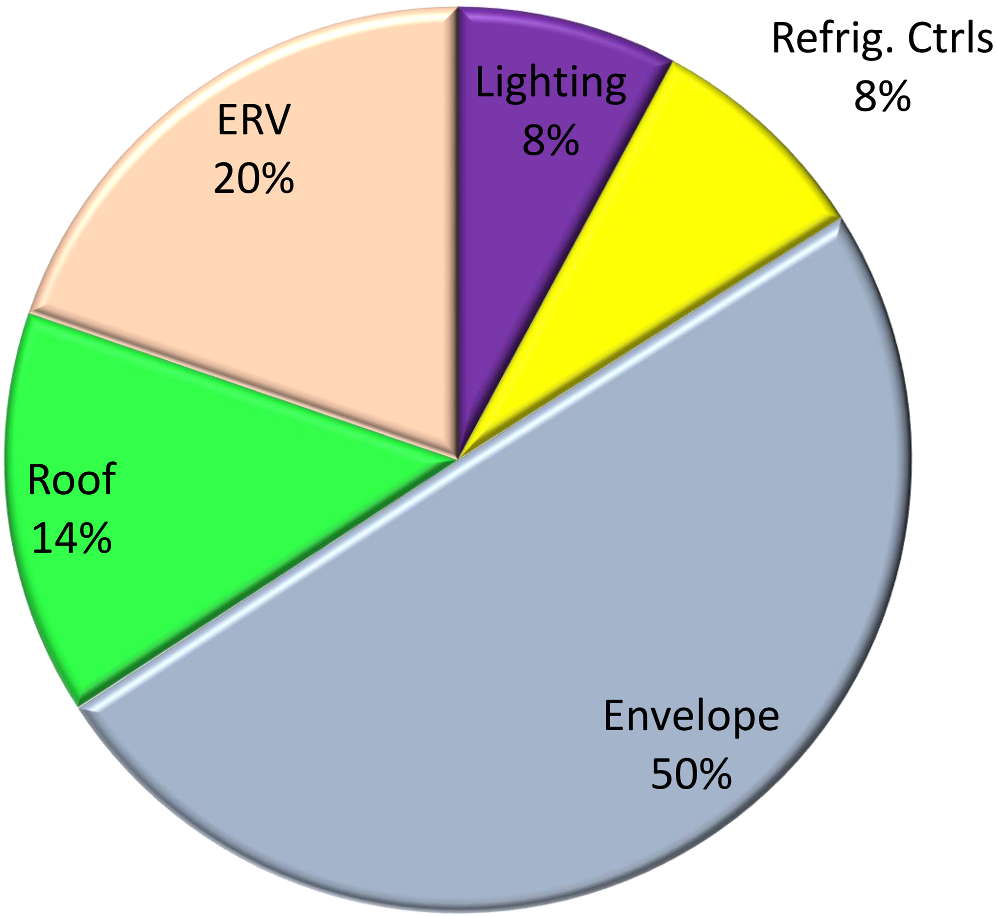
Summary of P4P Program Metrics

	Annual Consumption*	Projected Savings	% Savings
Electricity (kBtu)	36,362,346	13,254,161	36%
Natural Gas (kBtu)	15,949,674	7,908,028	50%
District Steam (kBtu)	0	0	0%
Other (kBtu)	0	0	0%
Source Energy Use Intensity ($kBtu/ft^2$)	213.0	80.86	
Source Energy Use Reduction			38%

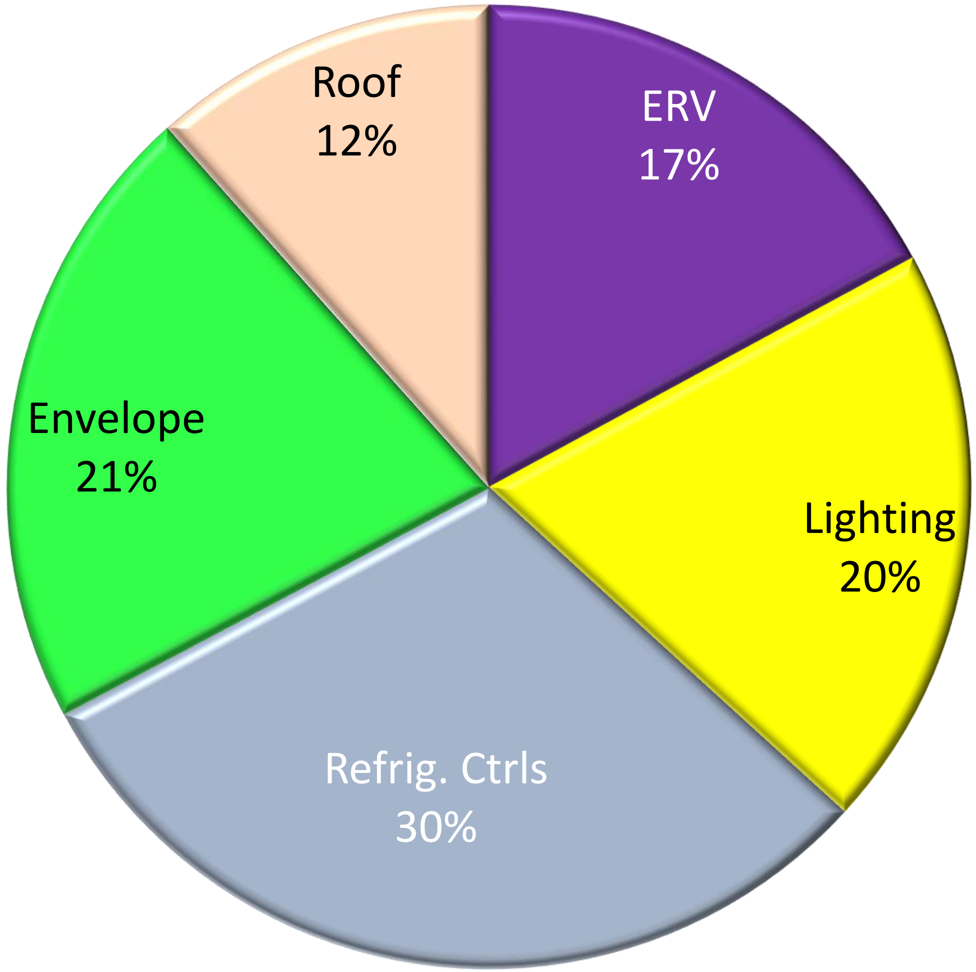
Total Investment ($)	$3,196,418
Annual Savings ($)	$650,239
Internal Rate of Return (IRR)	18%
Simple Payback (yrs)	4.92
Initial Benchmark Score*	12

* Consumption values and initial benchmark score from portfolio Manager Statement of Energy Performance Report

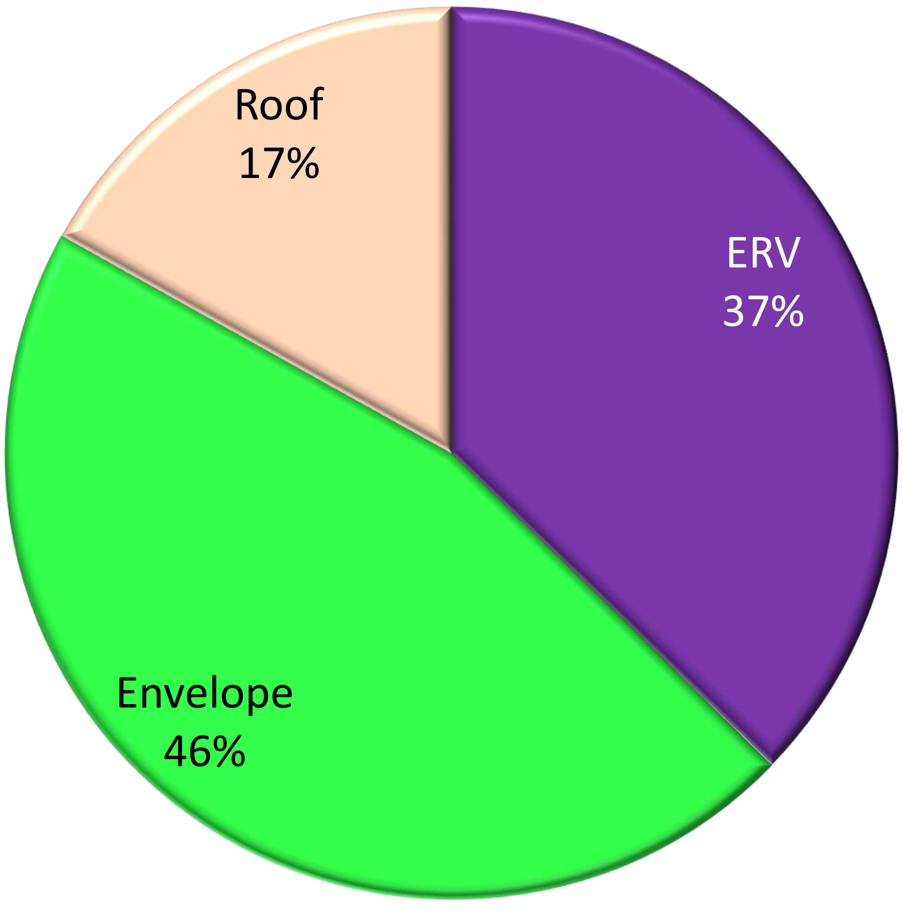
Cost of Installation



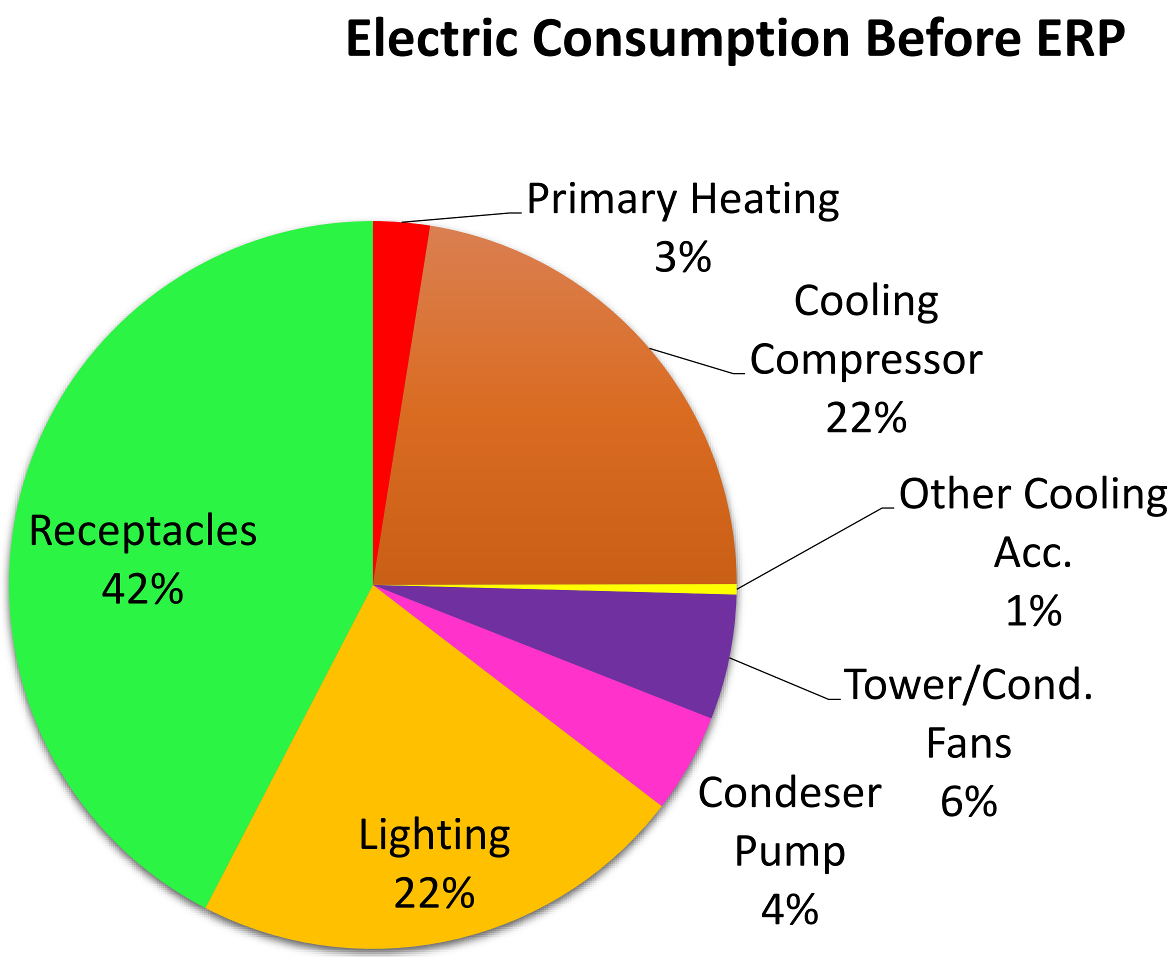
Annual Electric Energy Saved



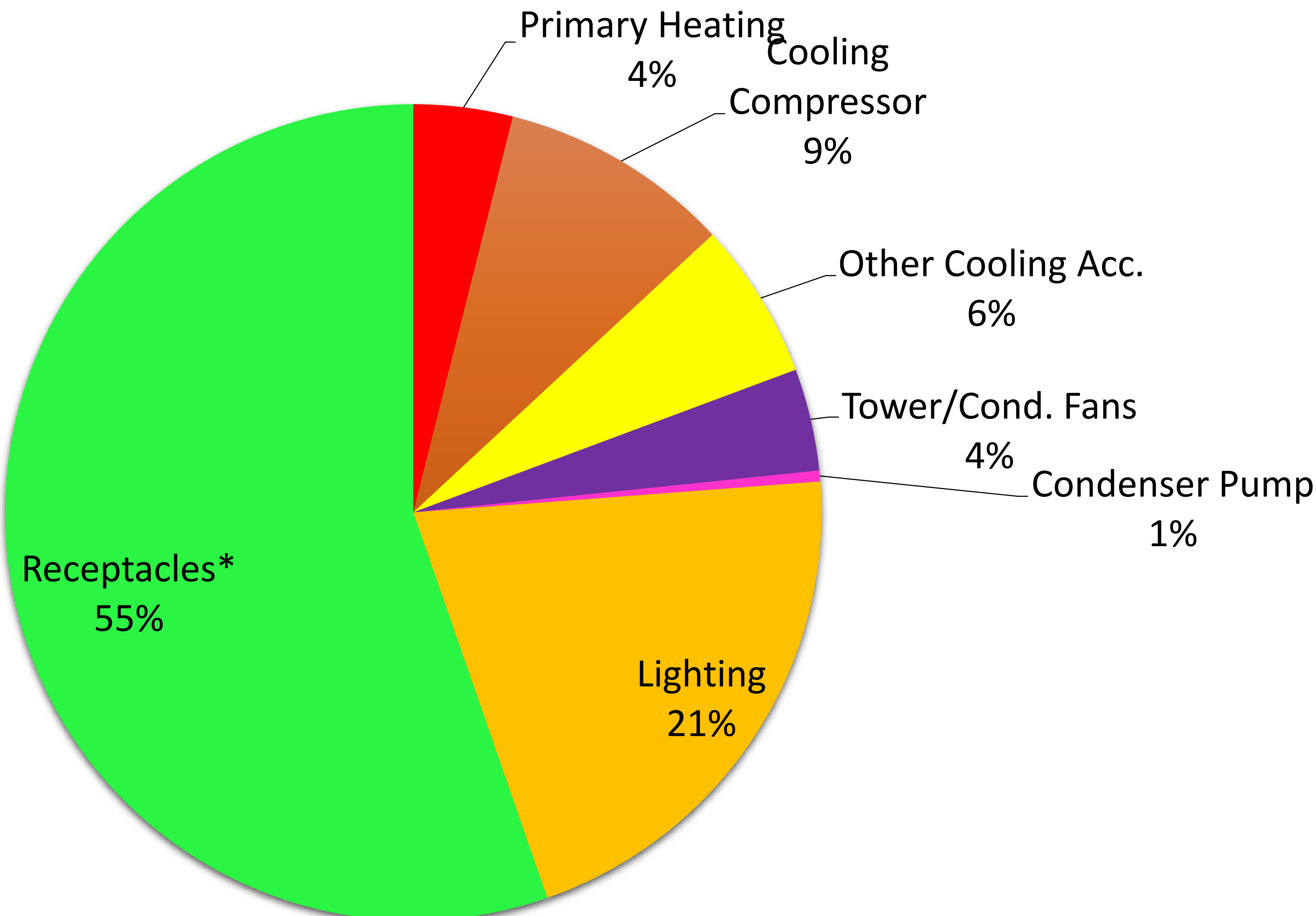
Annual Gas Energy Saved



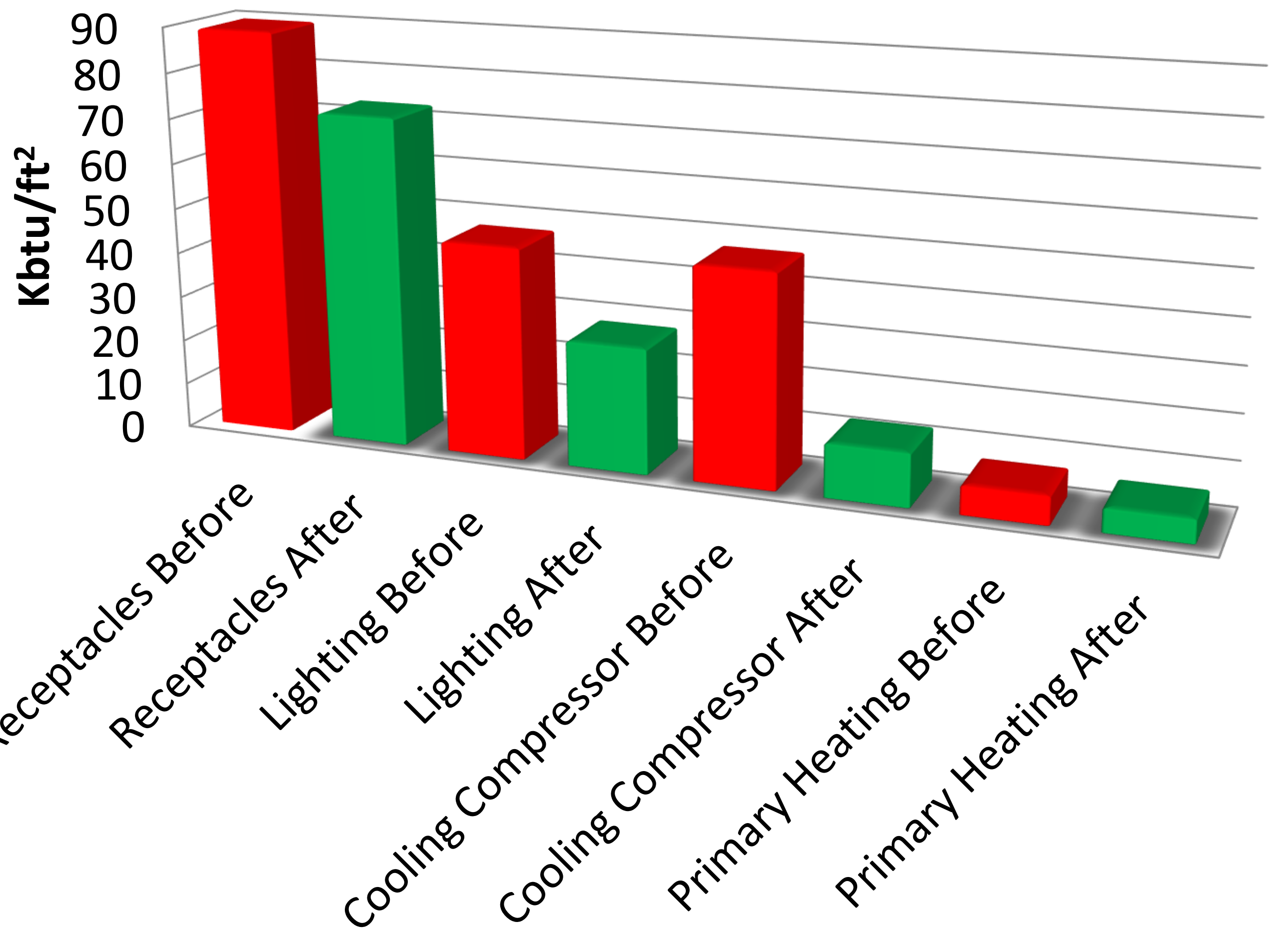
Electric Energy Consumption Before ERP



Electric Energy Consumption After ERP



Energy Consumption in Kbtu/ft^2 Before and After ERP



After all ecm upgrades and 4.4 Megawatt Solar array

- April 2012, the subject building produced 9,214 kwh more than it consumed.
- The building became Net Zero and produced slightly more power than it used.
- California has adopted Net Zero as the Basis of Design for new permitted construction in 2020!

After all Ecms Construction

Questions

- 1. A Net Zero Building is defined as:
- A. Buildings with no energy consumption.
- B. Will be the basis of design for new construction in California as of 2020.
- C. A building that generates as much power as it consumes with solar electric, hydroelectric or some other form of onsite power generation.
- D. All of the Above.

Questions

- 2. What state or area already has Net Zero as a basis of design?
- A. New York
- B. Delaware
- C. California
- D. Alaska
- E. All of the Above.

Questions

- 3. Using a Thermal Imaging system is a good method to?
- A. See through walls.
- B. Evaluate large walls or roof thermal performance.
- C. Wall measurement.
- D. Both A and B

Questions

- 4**.** What is a good source for evaluating national energy usage trends or building usage trends?

- A. Local Code Officials

- B. EPA-Energy Star Benchmarking

- C. DOE

- D. Both B and C

Questions

- 5. What needs to be included to make a very large industrial complex a good candidate for a Net Zero Building Project?:
- A. High Performance building envelope with reduce air infiltration.
- B. Energy Recovery.
- C. High Efficiency Lighting.
- D. High Performance HVAC with well commissioned controls.
- E. All of the above.