



# **Building Energy Analysis for a Multi-Family Residential Building**

**(Multi V- III VRF Heat-Pump System)**



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**Legal Disclaimer:** The models described in this report are intended to demonstrate the potential cost-effectiveness of possible energy improvements for the new facilities. The choice of models was subject to LG Electronics CAC’s professional judgment in accordance with industry standards. The conclusions of this report do not guarantee actual energy costs or savings.

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# Executive Summary

LG Electronics U.S.A. Commercial Air-Conditioning (LG CAC) conducted an energy efficiency option analysis for a proposed multi-family residential building design. To provide a concrete basis for analysis, the building would be built in Department of Energy (DOE) climate zones, 1A, 2A, 3A, 3B, 4A, 4C, and 5A. This study explores the energy and resulting cost savings of operating a LG Multi V™ III Heat Pump Variable Refrigerant Flow (VRF) System instead of typical HVAC systems as represented by a baseline building described in *Leadership in Energy and Environmental Design (LEED®) for New Construction & Major Renovations™*.

LG CAC created several computer simulations of the proposed and baseline designs, all of which used the same floor plans, occupancy schedules, lighting power density, ventilation, and envelopes types. Only the mechanical systems and associated efficiencies differed for each simulation. The simulations demonstrated that the proposed designs using LG Multi V III Heat Pump VRF systems provided significant annual utility bill savings when compared to all LEED baseline and ASHRAE minimum efficiency building systems.

**Table 1: LG Multi V III Building Energy Savings**

Climate Zone	Savings*	Savings (%) *
1A, Miami	\$8,750	28%
2A, Houston	\$6,660	26%
3A, Atlanta	\$5,287	23%
3A, Dallas	\$6,936	27%
3B, Los Angeles	\$3,623	14%
4A, New York	\$10,473	30%
4C, Seattle	\$2,661	14%
5A, Chicago	\$6,847	30%

\*Compared to the LEED® baseline ASHRAE Standard System 2 packaged terminal heat pump (PTHP)

# Introduction

This engineering case study explores the implementation of a LG Multi V III Heat Pump VRF system in a typical new-construction multi-family residential building. Specifically, it compares the energy saving when compared to a baseline building as defined by the United States Green Building Council (USGBC®) LEED<sup>1</sup>. The study was conducted using a building model with the same physical properties and based on the exact same plans in seven different climates in eight cities:

- 1A, Miami
- 2A, Houston
- 3A, Atlanta
- 3A, Dallas
- 3B, Los Angeles
- 4A, New York
- 4C, Seattle
- 5A, Chicago

The subject building was single story with 23,231 ft<sup>2</sup> of conditioned space. The building also included 17 residential spaces of approximately 19,246 ft<sup>2</sup>. Conditioned space also included varying sizes and miscellaneous spaces, such as lobbies, mechanical and electrical rooms, and storage rooms. (See Table 2) The building was expected to be open 24/7 with traditional residential occupancy schedules. The buildings envelopes consisted of a mass wall with friction-fit insulation.

**Table 2: Residential Space Types and Sizes**

Space Type	Size (ft <sup>2</sup> )
Corridor	2,969
Electrical/Mechanical	152
Elevator	443
Residential Area	19,246
Stairs	421
Total	23,231

<sup>1</sup> US Green Building Council (USGBC®) LEED® Green Building Design and Construction 2009 Edition Design Manual.

# Modeling Approach

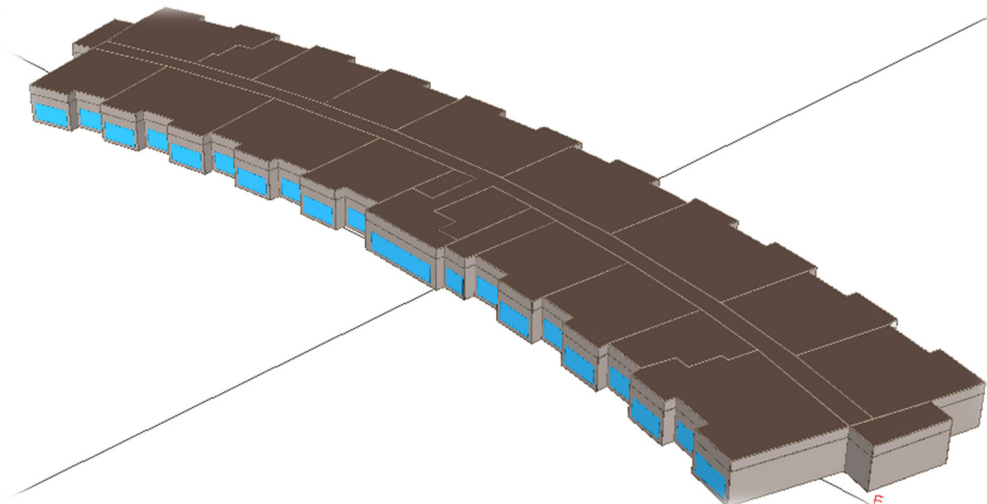
## Overview

To model the baseline and proposed design, LG CAC used the Quick Energy Simulation Tool (eQUEST) version 3.64. eQUEST is a 3-D building simulation program, which was developed under funding from the U.S. Department of Energy (<http://www.doe2.com/>) by James J. Hirsch & Associates. eQUEST performed energy and thermal calculations on an hour-by-hour basis for a typical one-year period, resulting in energy consumption model for both designs.

LG CAC gathered the following building information from the buildings' owner and design team:

- Envelope properties
- Floor plan and geometry
- HVAC components
- Lighting design
- Occupancy schedules

To determine savings, the energy consumption was compared to a building meeting but not exceeding LEED 2009 building baseline requirements.



**Figure 1: eQUEST rendering of subject building.**

## Baseline Building

The LEED design guide for multi-family residential buildings used building materials specified by ASHRAE Standard 90.1-2007. The specification included envelope U-values for walls, roofs, floors, and windows. Two baseline systems were developed consisting of multiple heating, ventilating, and HVAC systems:

- The first consisted of an ASHRAE Standard System 2 (Sys 2) packaged terminal heat pump (PTHP), which is a packaged terminal air-conditioner (PTAC) capable of both cooling and heating.
- The second consists of a four-pipe fan-coil system with an ASHRAE Standard 90.1-2007 minimum efficient chiller and boiler.

The building was assumed to be fully heated and cooled. Setup and setback schedules were implemented during unoccupied hours (nighttime), when the HVAC system was set to cycle to maintain temperature requirements for setup and setback. See Table 4 for details about the specification of the baseline and proposed HVAC systems.

## Proposed Building

The proposed building models used Multi V III Heat Pump VRF air-conditioning systems, which were designed for medium to large-scale facilities, such as commercial office buildings, hotels, hospitals, schools, and multi-family building. (See Figure 2). The Multi V III Heat Pump system featured superior energy efficiency and longer piping capabilities and was ARHI 1230 certified. Boosted by LG's high-side shell compressor, the system provided an increased inverter range for a better response to load matching. A Multi V III Heat Pump system could reduce operational costs while providing reliable heat in colder regions. The Multi V III Heat Pump system's advanced rapid start feature enabled the compressors to come on faster to meet startup load. The system's compact space-saving design and industry-leading piping capabilities provided the ultimate in design flexibility.



**Figure 2: Multi V III with a vertical air handler indoor unit.**

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## Component Comparison

Several components were considered and analyzed in the building model:

- Modeled sizes and efficiencies (code minimum efficiencies)
- Building envelope
- Mechanical systems
- Domestic hot-water system
- Lighting system
- Receptacle load
- Utility rate source

### Building Envelope

The model's building envelope characteristics followed the baseline values stipulated by:

- ASHRAE 62.1-2004
- ASHRAE 90.1-2007
- LEED for New Construction & Major Renovations

**Table 3: Building Envelope Characteristics**

Component	1A Miami	2A Houston	3A Atlanta	3A Dallas	3B Los Angeles	4A New York	4C Seattle	5A Chicago
Above Grade Exterior Walls (mass wall building)	0.580	0.151	0.123	0.123	0.123	0.104	0.104	0.090
Floors (Mass)	0.322	0.107	0.107	0.107	0.107	0.087	0.087	0.074
Opaque doors	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700
Roofs (Entirely Insulated)	0.063	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Skylights	None	None	None	None	None	None	None	None
Window Assembly U-factor	1.20	0.70	0.60	0.60	0.60	0.50	0.50	0.45
Window SHGC	0.25	0.25	0.25	0.25	0.25	0.40	0.40	0.40

## Mechanical Systems

The baseline mechanical systems included 18 PTHP units for the residential areas and electric unit heaters for stairs and common areas. The baseline case was modeled so that equipment efficiencies were based on minimum code requirements. Both the PTHP system (ASHRAE Type 2 LEED Baseline) and the four-pipe fan-coil chiller and boiler systems (ASHRAE minimum efficiency) were typical for this building size and type. The HVAC systems were as follows:

**Table 4: Mechanical-System Air-Cooling Characteristics**

Component	PTHP Baseline System	Four-Pipe Fan-Coil Baseline System	LG Multi V III Heat Pump System
Cooling Tower	-	1×700 MBH Two-Speed Fan	-
Chiller	-	600 MBH 4.45 COP	-
DX-Cooling	12.3 – (0.213× Cap/1000) EER		2×20 RT Heat Pump (EER : 14.0, not including fan power)

**Table 5: Mechanical-System Air-Heating Characteristics**

Component	PTHP Baseline System	Four-Pipe Fan-Coil Baseline System	LG Multi V III Heat Pump System
Gas-Fired Hot Water Boiler	-	600 MBH, $\eta = 80\%$	-
Electrical Heating	Electric resistance	Unit heater (electric resistance)	Electric resistance
Heat Pump	3.2 – (0.026× Cap/1000) COP	-	2×20 RT heat pump (COP: 4.6: not including fan power)



**Table 6: Mechanical-System Air-Handling Characteristics**

PTHP Baseline System	Four-Pipe Fan-Coil Baseline System	LG Multi V III Heat Pump System
18×PTHP - 0.0003kW/cfm, constant speed 18×FCUs	(1.5 to 2 RT)	-0.0003kW/cfm, constant speed 18× vertical air handling ducted indoor units (1.5 to 2 RT)

## Domestic Hot Water

Baseline and proposed domestic hot-water systems were as follows:

**Table 7: Domestic Hot-Water Characteristics**

Baseline System	Proposed System	Notes
Gas-fired storage water heater (750.0 gallons, 546 kBTU/hr, 0.8 Energy Factor)	Same	ASHRAE 90.1-2007 Table 7.8: Performance Requirements for Water Heating Equipment

## Interior Lighting

Baseline and proposed interior lighting were as follows:

**Table 8: Interior-Lighting Energy Characteristics**

Baseline System	Proposed System	Notes
Lighting power density (Average: 0.7 w/ft <sup>2</sup> )	Same	ASHRAE 90.1-2007 (Table 9.5.1: <i>Lighting Power Densities Using the Building Area Method</i> )

## Receptacle Load

Baseline and proposed receptacle equipment were as follows:

**Table 9: Receptacle-Load Energy Characteristics**

	Baseline	Proposed	Notes
Receptacle load	1.00 w/ft <sup>2</sup>	Same	ASHRAE 90.1-2007 ( TABLE G3.1 <i>Modeling Requirements for Calculating Proposed and Baseline Building Performance</i> )

## Utility Rate Sources

The study used the following sources for electrical and natural gas rates<sup>2</sup>:

**Table 10: Utility Rate Source**

Energy Source	1A Miami	2A Houston	3A Atlanta	3A Dallas	3B Los Angeles	4A New York	4C Seattle	5A Chicago
Electricity (\$/kWh)	0.109	0.101	0.089	0.101	0.121	0.155	0.070	0.086
Natural Gas (\$/therm)	1.224	0.894	1.122	0.894	0.853	1.212	1.243	0.914

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<sup>2</sup> Source: Data adapted from DOE-EIA and local utility companies

# Results

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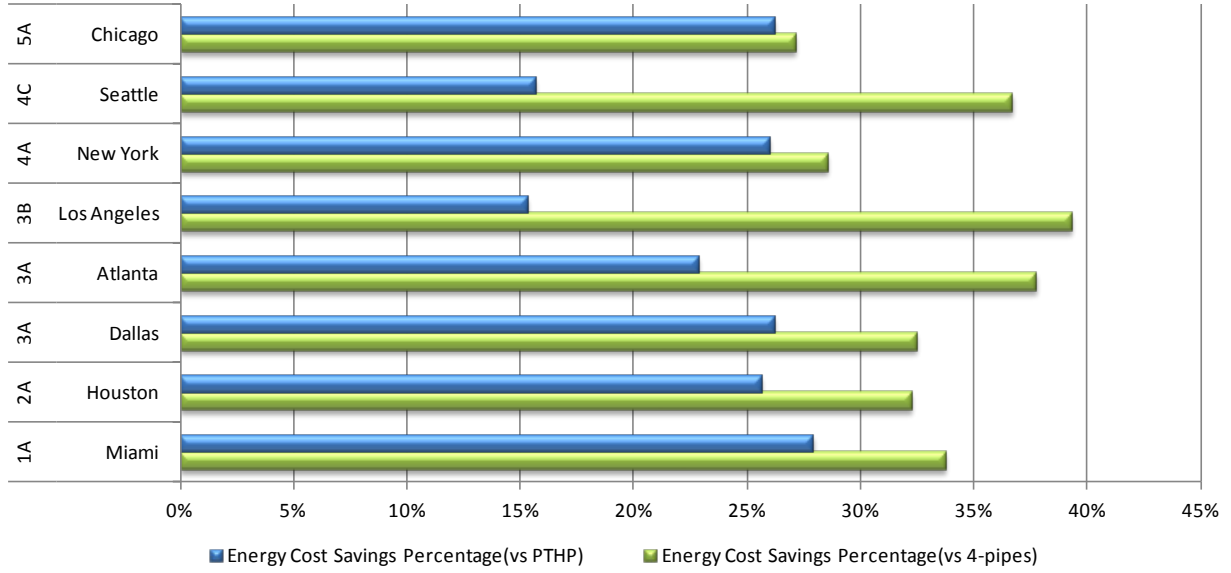
## Overview

According to the Commercial Building Energy Consumption Survey (CBECS), multi-family residential buildings in the United States consume an average of 69.8 kBtu per square foot of site energy each year. The study's purpose was to identify possible energy savings when employing an LG VRF HVAC system in such buildings. Our baselines for comparison were two typical systems that meet the minimum requirements of ASHRAE Standard 90.1-2007.

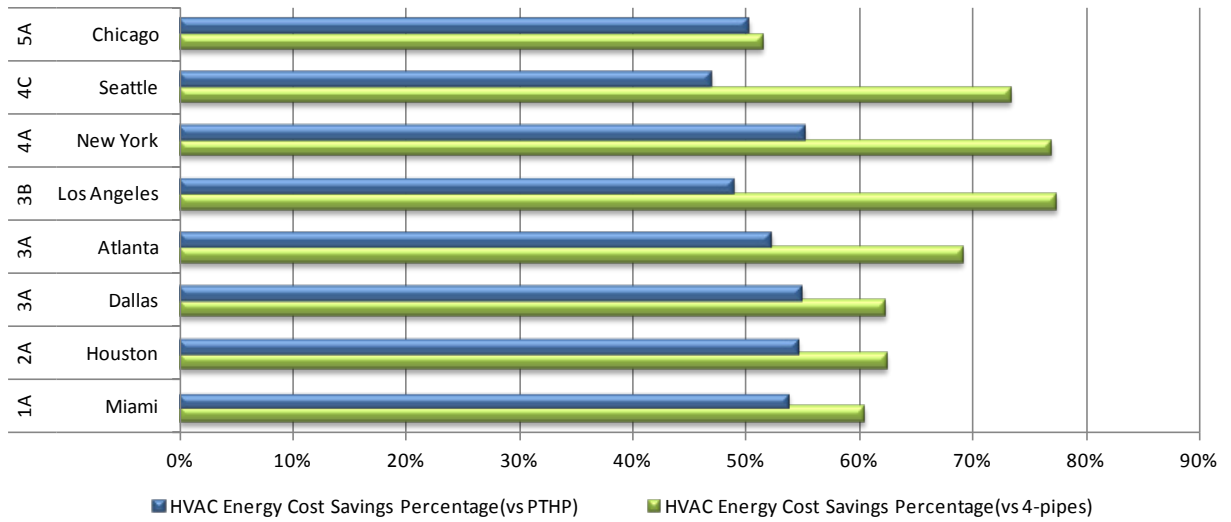
The proposed building, which employed Multi V III heat pump VRF systems, used an average of 35 kBtu per square foot of site energy each year. The whole-building energy cost savings realized with the building was 23% on average when compared to an ASHRAE standard 90.1-2007 System 2 PTHP. When comparing the energy cost used based the HVAC systems alone, that number jumped to 54% less on average. (See Figure 3 and Figure 4).

The whole-building energy cost savings realized with the Multi V III heat pump system was 33% on average when compared to four-pipe FCU with ASHRAE minimum efficiency. When comparing HVAC systems alone that number averaged 67%.

Based on the average energy cost savings from the models, future projects would meet the LEED EA credit one prerequisite and qualify for about up to nine LEED points. The savings are detailed in the following figures and are further detailed in tables in the Annual Building Energy Consumption Comparisons and Annual Energy Consumption by End Use Summaries (See Table 11 to Table 17).



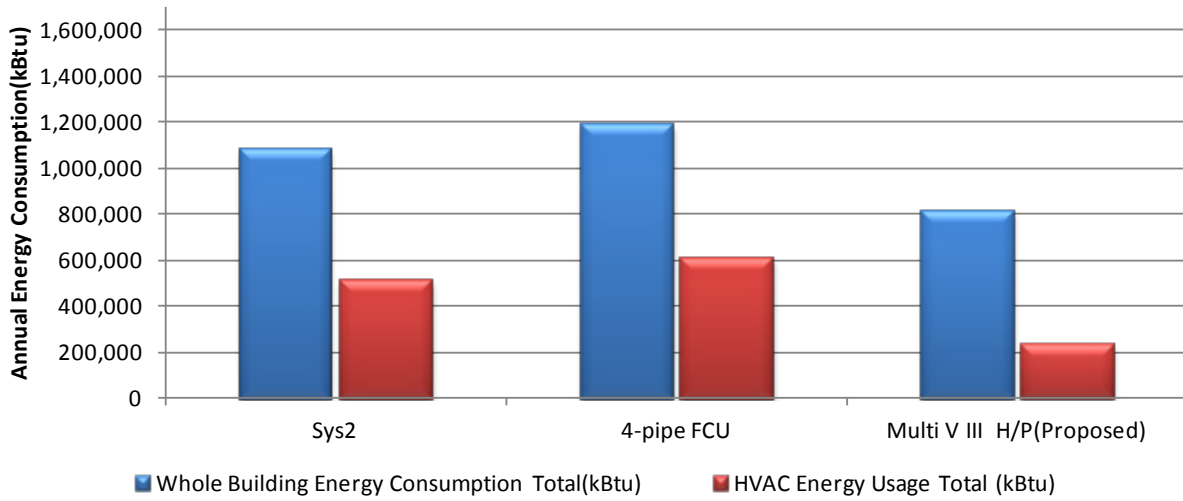
**Figure 3 : LG Multi V III VRF systems whole-building energy cost savings (%).**



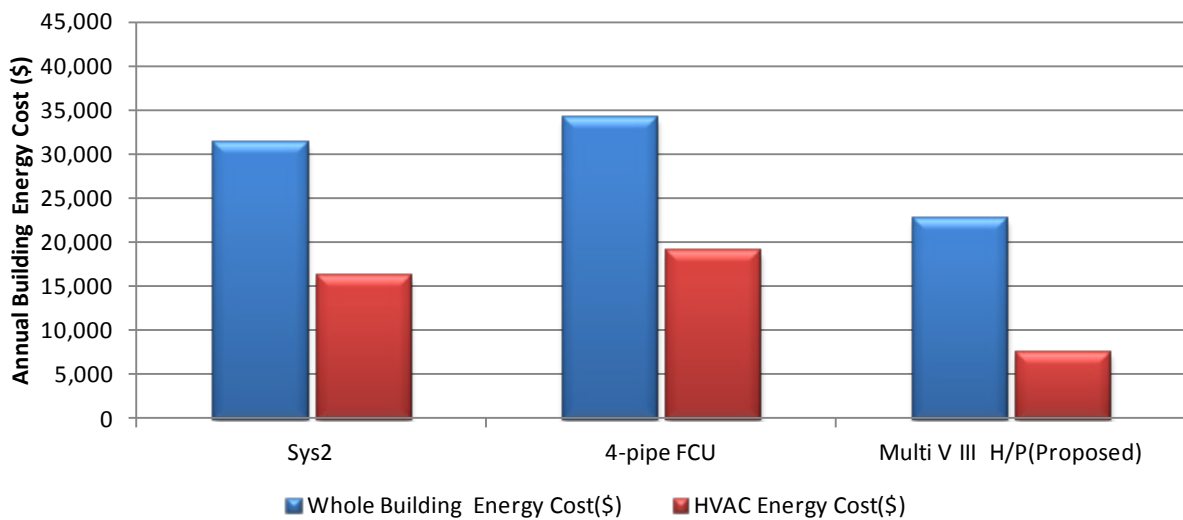
**Figure 4 : LG Multi V III VRF systems HVAC energy cost savings (%).**

## Zone 1A (Miami) Results

Energy consumption by end use for the Miami location (climate zone 1A) was as follows:



**Figure 5: Miami annual energy consumption comparison.**



**Figure 6: Miami annual building energy cost comparison.**

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 2, PTHP) for the Multi V III Heat Pump VRF systems was 28%.

**Table 11: Miami Annual Energy Consumption by End Use**

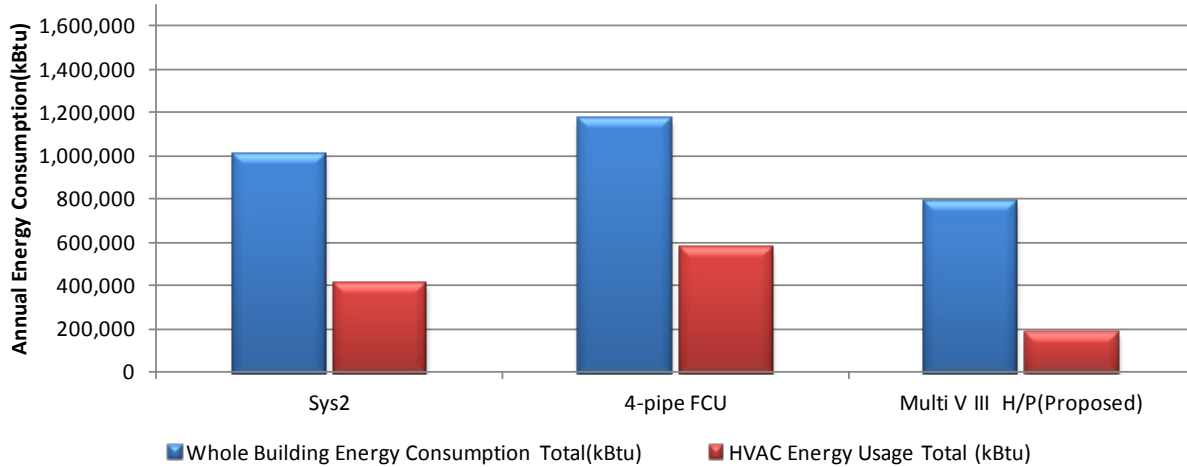
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Area Lights	kWh	33,230	33,230	33,230
Equipment	kWh	85,940	85,940	85,940
Hot Water	Therms	1,713	1,713	1,713
Space Cooling	kWh	101,800	84,410	46,530
Space Heating	kWh	1,100	10	1,040
	Therms	0	276	0
Fans	kWh	46,510	46,510	21,570
Pumps	kWh	0	40,770	0
Totals	kBTU	1,087,665	1,191,348	813,784

**Table 12: Miami Estimated Annual Energy Use and Cost**

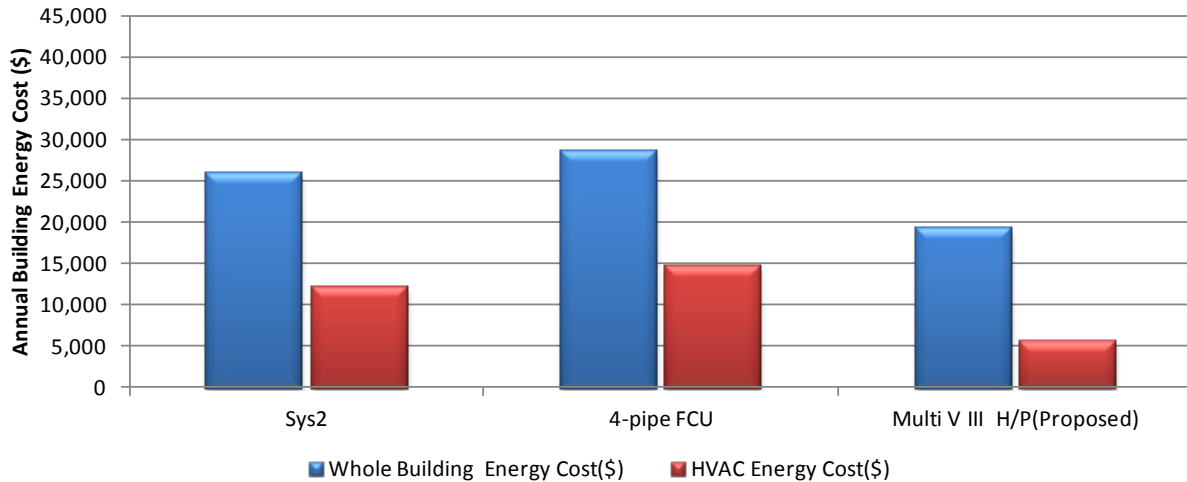
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	268,580	290,870	188,310
	Gas (Therms)	85,940	86,216	85,940
	Total (kBTU)	1,087,665	1,191,348	813,784
Whole Building Energy Cost	\$	31,372	34,142	22,622
	\$/ft <sup>2</sup>	1.35	1.47	0.97
HVAC Energy Usage	Electricity (kWh)	149,410	171,700	69,140
	Gas (Therms)	0	276	0
	Total (kBTU)	509,787	613,470	235,906
HVAC Energy Cost	\$	16,286	19,054	7,536
	\$/ft <sup>2</sup>	0.70	0.82	0.32

## Zone 2A (Houston) Results

Energy consumption by end use for the Houston location (climate zone 2A) was as follows:



**Figure 7: Houston annual energy consumption comparison.**



**Figure 8: Houston annual building energy cost comparison.**

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 2, PTHP) for the Multi V III Heat Pump VRF systems was 26%.

**Table 13: Houston Annual Energy Consumption by End Use**

Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Area Lights	kWh	33,230	33,230	33,230
Equipment	kWh	85,940	85,940	85,940
Hot Water	Therms	1,936	1,936	1,936
Space Cooling	kWh	66,980	56,110	29,040
Space Heating	kWh	12,660	40	6,940
	Therms	0	1,119	0
Fans	kWh	41,260	41,260	18,960
Pumps	kWh	0	38,730	30
Totals	kBTU	1,012,679	1,176,598	787,726

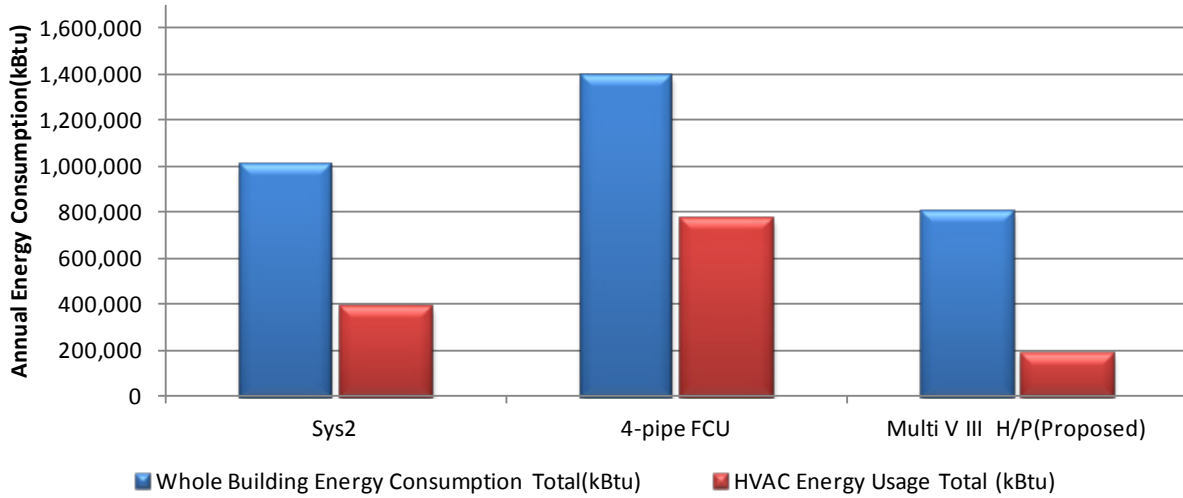
**Table 14: Houston Estimated Annual Energy Use and Cost**

Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	240,070	255,310	174,140
	Gas (Therms)	85,940	87,059	85,940
	Total (kBTU)	1,012,679	1,176,598	787,726
Whole Building Energy Cost	\$	25,978	28,516	19,318
	\$/ft <sup>2</sup>	1.12	1.23	0.83
HVAC Energy Usage	Electricity (kWh)	120,900	136,140	54,970
	Gas (Therms)	0	1,119	0
	Total (kBTU)	412,511	576,430	187,558
HVAC Energy Cost	\$	12,211	14,750	5,552
	\$/ft <sup>2</sup>	0.53	0.63	0.24

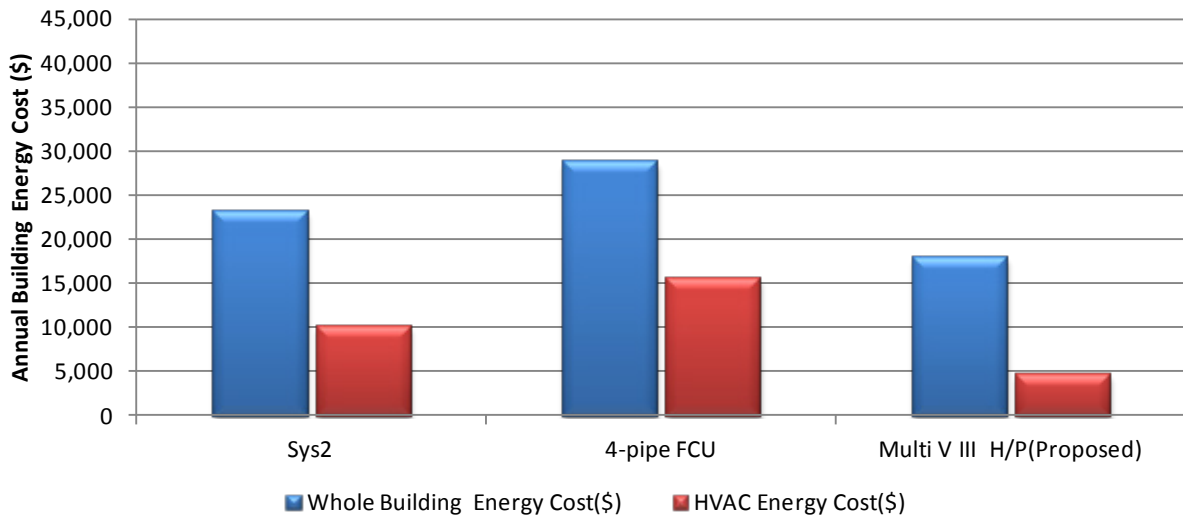


## Zone 3A (Atlanta) Results

Energy consumption by end use for the Atlanta location (climate zone 3A) was as follows:



**Figure 9: Atlanta annual energy consumption comparison.**



**Figure 10: Atlanta annual building energy cost comparison.**

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 2, PTHP) for the Multi V III Heat Pump VRF systems was 23%.

**Table 15: Atlanta Annual Energy Consumption by End Use**

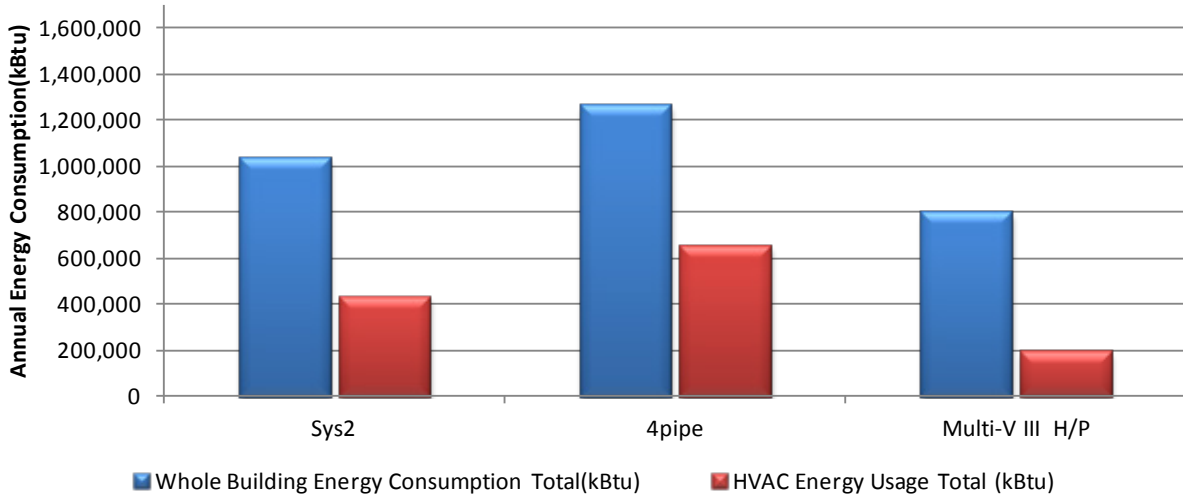
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Area Lights	kWh	33,230	33,230	33,230
Equipment	kWh	85,940	85,940	85,940
Hot Water	Therms	2,153	2,153	2,153
Space Cooling	kWh	43,400	40,330	16,030
Space Heating	kWh	38,760	610	14,700
	Therms	0	2,998	0
Fans	kWh	31670	50,860	23,600
Pumps	kWh	0	46,560	70
Totals	kBTU	1,010,336	1,393,792	807,561

**Table 16: Atlanta Estimated Annual Energy Use and Cost**

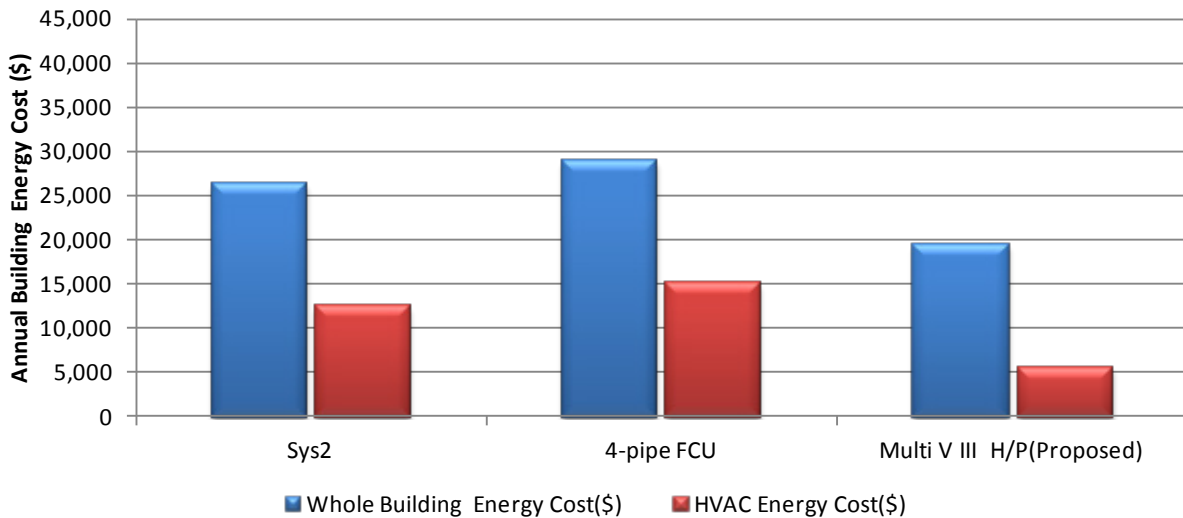
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	233,000	257,530	173,570
	Gas (Therms)	85,940	88,938	85,940
	Total (kBTU)	1,010,336	1,393,792	807,561
Whole Building Energy Cost	\$	23,152	28,690	17,865
	\$/ft <sup>2</sup>	1.00	1.23	0.77
HVAC Energy Usage	Electricity (kWh)	113,830	138,360	54,400
	Gas (Therms)	0	2998	0
	Total (kBTU)	388,388	771,844	185,613
HVAC Energy Cost	\$	10,131	15,672	4,842
	\$/ft <sup>2</sup>	0.44	0.67	0.21

## Zone 3A (Dallas) Results

Energy consumption by end use for the Dallas location (climate zone 3A) was as follows:



**Figure 11: Dallas annual energy consumption comparison.**



**Figure 12: Dallas annual building energy cost comparison.**

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 2, PTHP) for the Multi V III Heat Pump VRF systems was 26%.

**Table 17: Dallas Annual Energy Consumption by End Use**

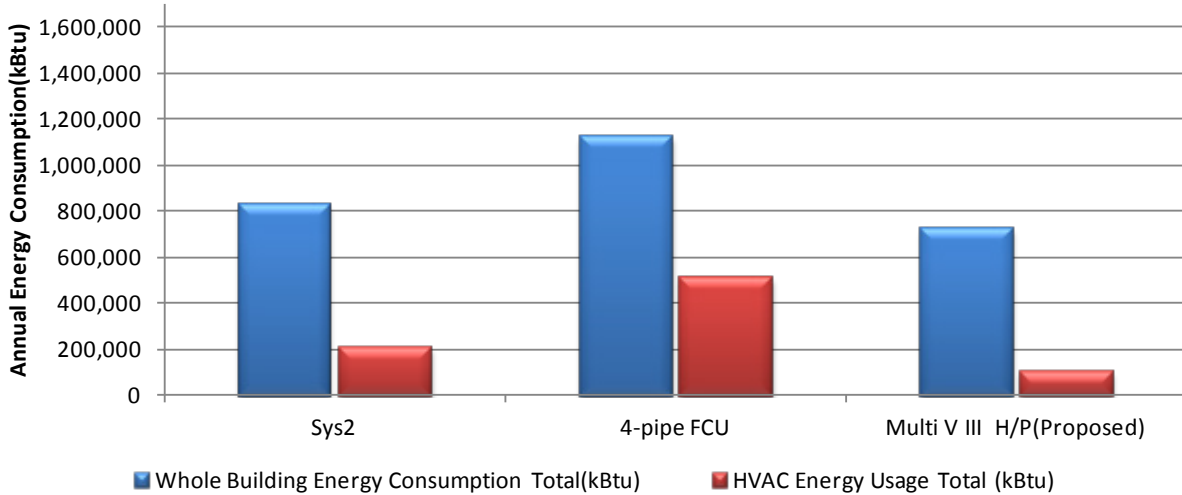
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Area Lights	kWh	33,230	33,230	33,230
Equipment	kWh	85,940	85,940	85,940
Hot Water	Therms	2,021	2,021	2,021
Space Cooling	kWh	59,590	50,260	25,170
Space Heating	kWh	23,590	80	12,090
	Therms	0	2,061	0
Fans	kWh	41820	41,820	19,050
Pumps	kWh	0	38,770	20
Totals	kBTU	1,035,218	1,261,541	800,916

**Table 18: Dallas Estimated Annual Energy Use and Cost**

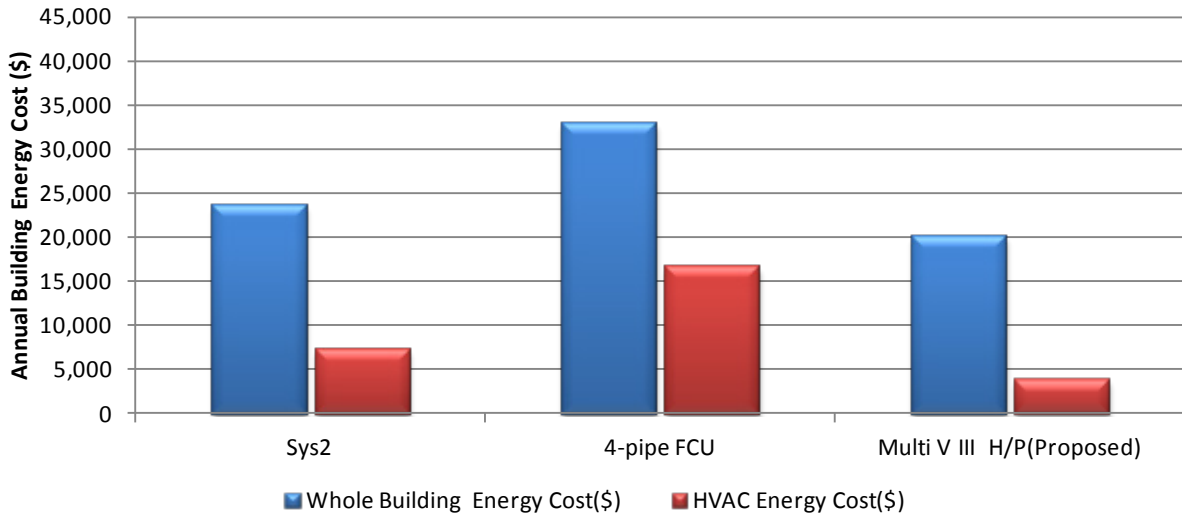
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	244,170	250,100	175,500
	Gas (Therms)	85,940	88,001	85,940
	Total (kBTU)	1,035,218	1,261,541	800,916
Whole Building Energy Cost	\$	26,469	28,908	19,533
	\$/ft <sup>2</sup>	1.14	1.24	0.84
HVAC Energy Usage	Electricity (kWh)	125,000	130,930	56,330
	Gas (Therms)	0	2061	0
	Total (kBTU)	426,500	652,823	192,198
HVAC Energy Cost	\$	12,625	15,066	5,689
	\$/ft <sup>2</sup>	0.54	0.65	0.24

## Zone 3B (Los Angeles) Results

Energy consumption by end use for the Los Angeles location (climate zone 3B) was as follows:



**Figure 13: Los Angeles annual energy consumption comparison.**



**Figure 14: Los Angeles annual building energy cost comparison.**

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 2, PTHP) for the Multi V III Heat Pump VRF systems was 15%.

**Table 19: Los Angeles Annual Energy Consumption by End Use**

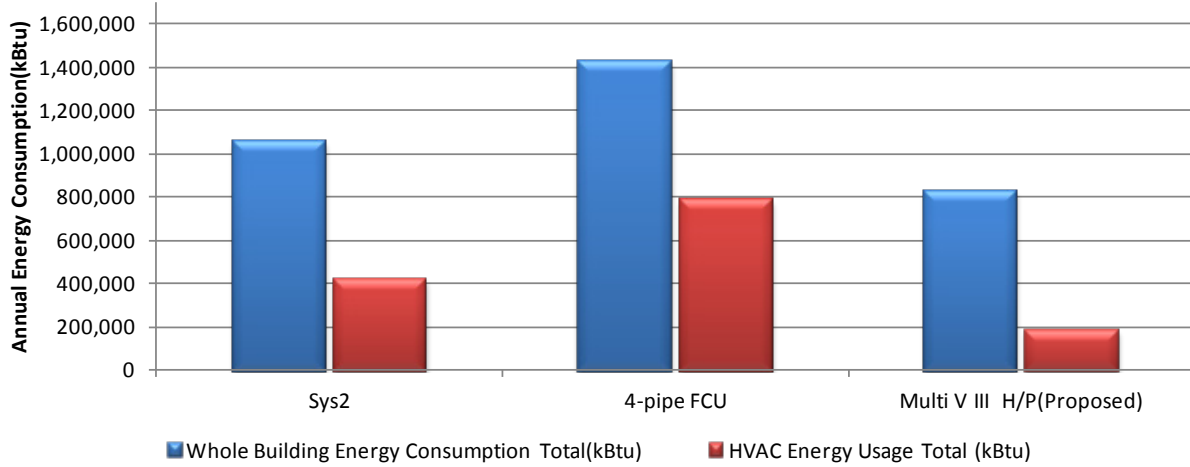
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Area Lights	kWh	33,230	33,230	33,230
Equipment	kWh	85,940	85,940	85,940
Hot Water	Therms	2,110	2,110	2,110
Space Cooling	kWh	30,660	32,680	6,410
Space Heating	kWh	1,350	0	1,070
	Therms	0	514	0
Fans	kWh	29320	51,480	23,880
Pumps	kWh	0	50,600	20
Totals	kBTU	826,906	1,128,869	724,717

**Table 20: Los Angeles Estimated Annual Energy Use and Cost**

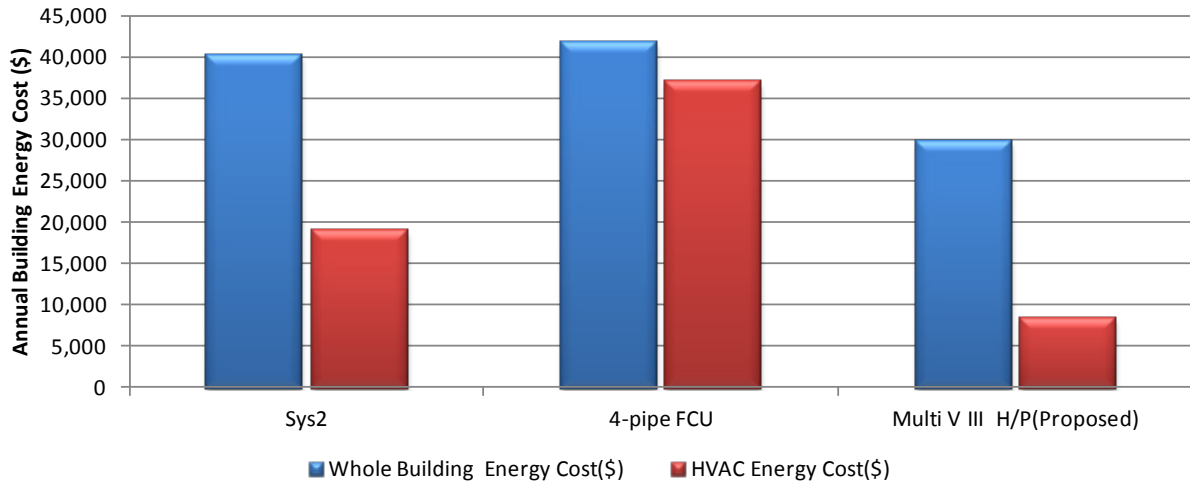
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	180,500	253,930	150,550
	Gas (Therms)	85,940	86,454	85,940
	Total (kBTU)	826,906	1,128,869	724,717
Whole Building Energy Cost	\$	23,640	32,964	20,017
	\$/ft <sup>2</sup>	1.02	1.42	0.86
HVAC Energy Usage	Electricity (kWh)	61,330	134,760	31,380
	Gas (Therms)	0	514	0
	Total (kBTU)	209,258	511,221	107,069
HVAC Energy Cost	\$	7,421	16,744	3,797
	\$/ft <sup>2</sup>	0.32	0.72	0.16

## Zone 4B (New York) Results

Energy consumption by end use for the New York location (climate zone 4A) was as follows:



**Figure 15: New York annual energy consumption comparison.**



**Figure 16: New York annual building energy cost comparison.**

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 2, PTHP) for the Multi V III Heat Pump VRF systems was 26%.

**Table 21: New York Annual Energy Consumption by End Use**

Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Area Lights	kWh	33,230	33,230	33,230
Equipment	kWh	85,940	85,940	85,940
Hot Water	Therms	2,350	2,350	2,350
Space Cooling	kWh	26,440	26,900	8,570
Space Heating	kWh	72,690	1,300	30,380
	Therms	0	4,599	0
Fans	kWh	23540	34,710	16,120
Pumps	kWh	0	33,230	20
Totals	kBTU	1,060,128	1,429,518	829,545

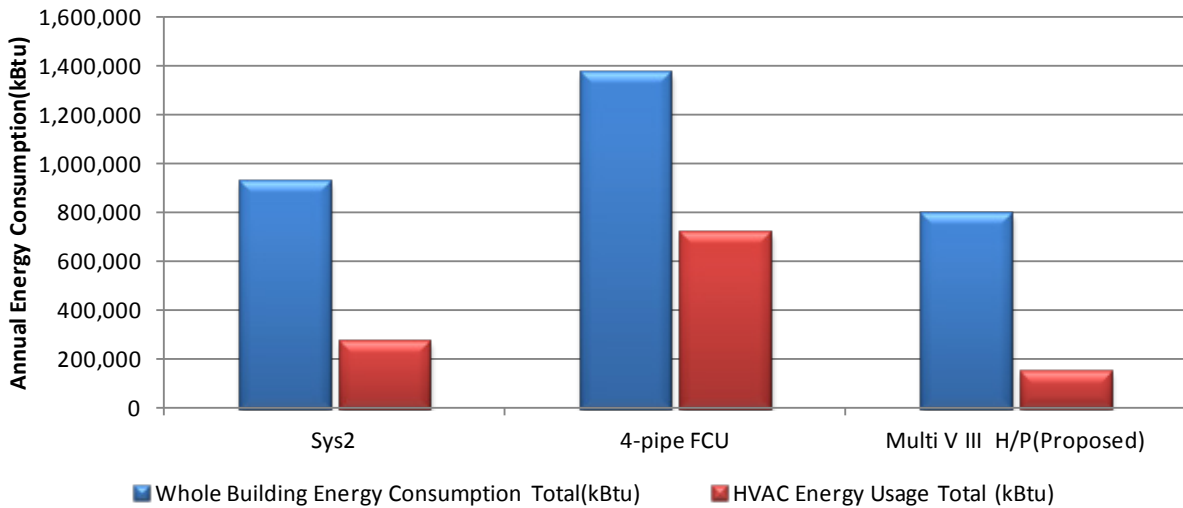
**Table 22: New York Estimated Annual Energy Use and Cost**

Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	241,840	215,310	174,260
	Gas (Therms)	85,940	90,539	85,940
	Total (kBTU)	1,060,128	1,429,518	829,545
Whole Building Energy Cost	\$	40,333	41,796	29,860
	\$/ft <sup>2</sup>	1.74	1.80	1.29
HVAC Energy Usage	Electricity (kWh)	122,670	96,140	55,090
	Gas (Therms)	0	4599	0
	Total (kBTU)	418,550	787,940	187,967
HVAC Energy Cost	\$	19,014	36,990	8,539
	\$/ft <sup>2</sup>	0.82	1.59	0.37

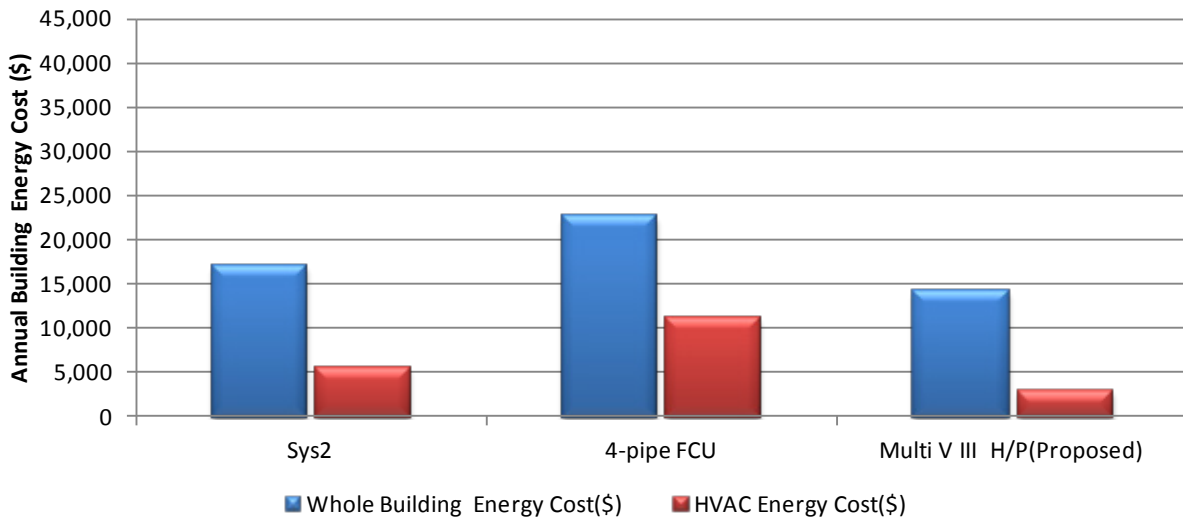


## Zone 4C (Seattle) Results

Energy consumption by end use for the Seattle location (climate zone 4C) was as follows:



**Figure 17: Seattle annual energy consumption comparison.**



**Figure 18: Seattle annual building energy cost comparison.**

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 2, PTHP) for the Multi V III Heat Pump VRF systems was 16%.

**Table 23: Seattle Annual Energy Consumption by End Use**

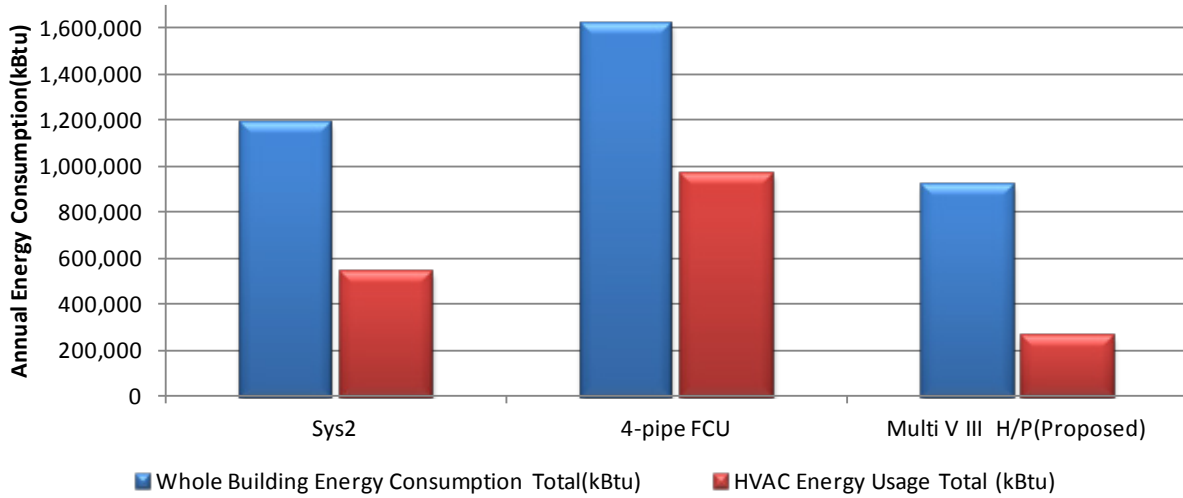
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Area Lights	kWh	33,230	33,230	33,230
Equipment	kWh	85,940	85,940	85,940
Hot Water	Therms	2,412	2,412	2,412
Space Cooling	kWh	9,550	16,480	1,450
Space Heating	kWh	49,760	560	25,410
	Therms	0	4,340	0
Fans	kWh	21790	34,920	16,210
Pumps	kWh	0	32,840	40
Totals	kBTU	924,551	1,371,176	794,929

**Table 24: Seattle Estimated Annual Energy Use and Cost**

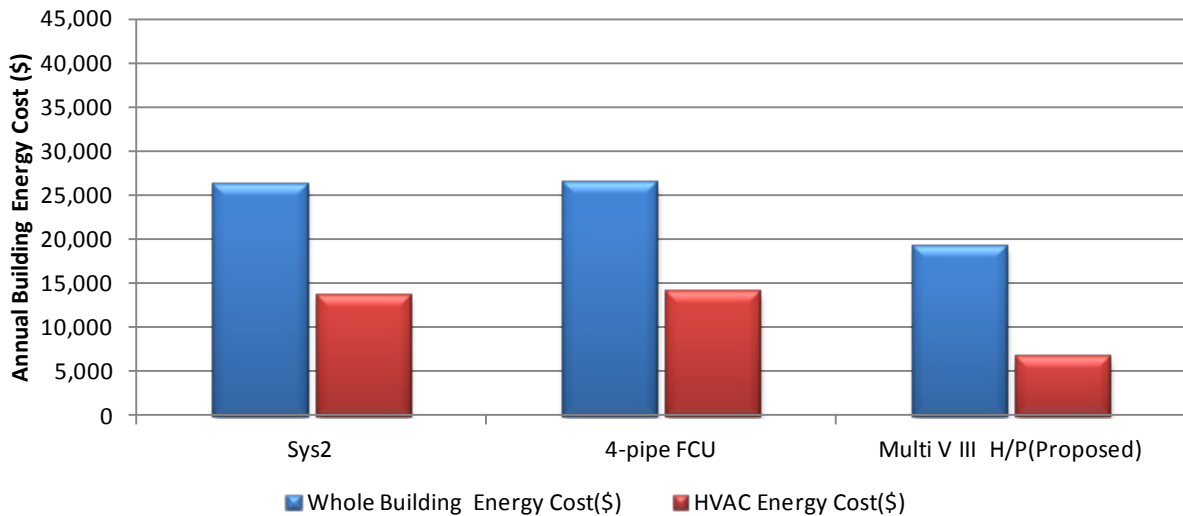
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	200,270	203,970	162,280
	Gas (Therms)	85,940	90,280	85,940
	Total (kBTU)	924,551	1,371,176	794,929
Whole Building Energy Cost	\$	17,018	22,671	14,357
	\$/ft <sup>2</sup>	0.73	0.98	0.62
HVAC Energy Usage	Electricity (kWh)	81,100	84,800	43,110
	Gas (Therms)	0	4340	0
	Total (kBTU)	276,713	723,338	147,091
HVAC Energy Cost	\$	5,677	11,331	3,018
	\$/ft <sup>2</sup>	0.24	0.49	0.13

## Zone 5A (Chicago) Results

Energy consumption by end use for the Chicago location (climate zone 5A) was as follows:



**Figure 19: Chicago annual energy consumption comparison.**



**Figure 20: Chicago annual building energy cost comparison.**

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 2, PTHP) for the Multi V III heat pump VRF systems was 26%.

**Table 25: Chicago Annual Energy Consumption by End Use**

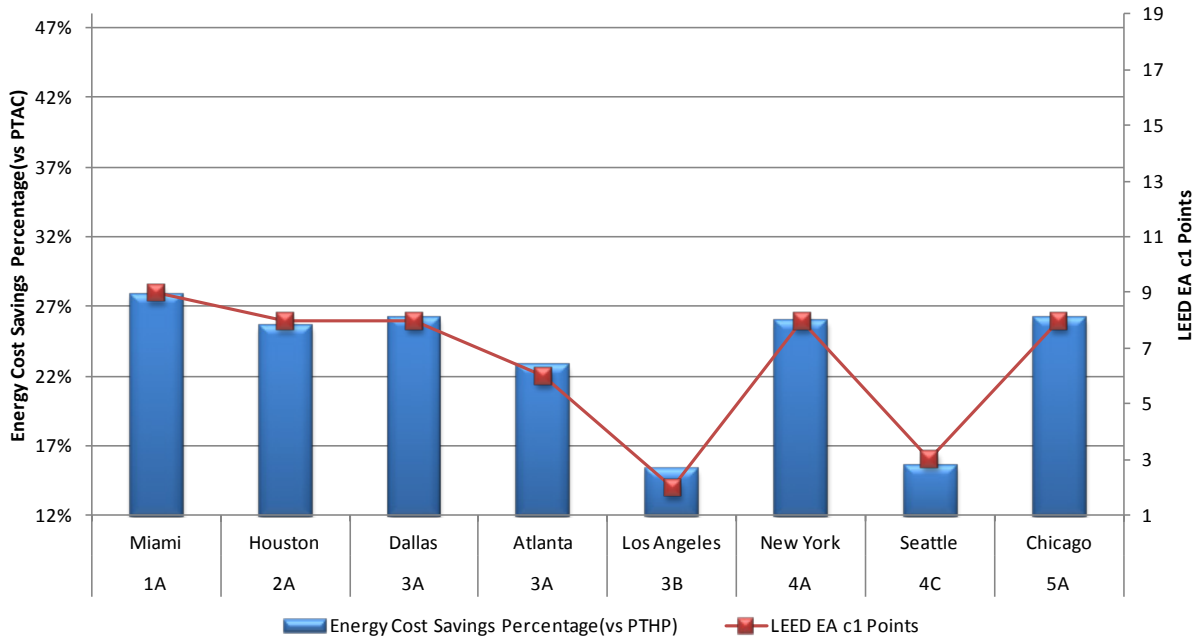
Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Area Lights	kWh	33,230	33,230	33,230
Equipment	kWh	85,940	85,940	85,940
Hot Water	Therms	2,473	2,473	2,473
Space Cooling	kWh	20,570	23,340	9,600
Space Heating	kWh	112,810	2,380	38,900
	Therms	0	6,474	0
Fans	kWh	25070	34,780	30,230
Pumps	kWh	0	33,080	110
Totals	kBTU	1,194,489	1,620,593	922,860

**Table 26: Chicago Estimated Annual Energy Use and Cost**

Consumer	Units	System 2 (PTHP)	Four-pipe Fan-Coil Unit	Multi V III Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	277,620	212,750	198,010
	Gas (Therms)	85,940	92,414	85,940
	Total (kBTU)	1,194,489	1,620,593	922,860
Whole Building Energy Cost	\$	26,136	26,473	19,289
	\$/ft <sup>2</sup>	1.13	1.14	0.83
HVAC Energy Usage	Electricity (kWh)	158,450	93,580	78,840
	Gas (Therms)	0	6474	0
	Total (kBTU)	540,631	966,735	269,002
HVAC Energy Cost	\$	13,627	13,965	6,780
	\$/ft <sup>2</sup>	0.59	0.60	0.29

# LEED for New Construction and Major Renovations

The LEED 2009 Green Building Rating Systems are voluntary, consensus-based, and market-driven. Based on proven technology, they evaluate environmental performance from a whole-building perspective over a building’s life cycle, providing a standard for what constitutes a green building in design, construction, and operation. The LEED rating system provides a complete framework for assessing building performance and meeting sustainability goals. Based on a system of prerequisites and credits, referring to ASHRAE standards, LEED projects earn points during the certification process, and then are awarded certification levels.



**Figure 21 LG Multi V III energy cost savings and potential LEED Points**

Percentage energy cost saving in the proposed building performance rating compared with the baseline building performance rating. The baseline building performance according to ASHRAE Standard 90.1-2007 is calculated using a simulation model for the whole building project. The minimum energy cost-savings percentage for each point threshold is as follows:

**Table 27: LEED Minimum Energy Cost-Savings Percentage**

New Building	Existing Building	Renovation Points
12%	8%	1
14%	10%	2
16%	12%	3
18%	14%	4
20%	16%	5
22%	18%	6
24%	20%	7
26%	22%	8
28%	24%	9
30%	26%	10
32%	28%	11
34%	30%	12
36%	32%	13
38%	34%	14
40%	36%	15
42%	38%	16
44%	40%	17
46%	42%	18
48%	44%	19

The Multi V III VRF air conditioning system is engineered for sustainable green buildings and provides many opportunities for designers to meet LEED prerequisites and earn credit points. We recommend the following actions to maximize LEED points for New Construction certification when using Multi V VRF systems:

**Table 28: LEED Points for Energy and Atmosphere**

Credit	Intent	Points
Prerequisite 2	Establish the minimum energy efficiency for the proposed building to reduce environmental and economic impacts of excessive energy use.	N/A
Prerequisite 3	Establish the minimum refrigerant management to reduce stratospheric ozone depletion.	N/A
Credit 1	Recognize enhanced energy efficiency beyond the minimum for the proposed building, reducing the environmental and economic impacts of excessive energy use.	1 to 19
Credit 4	Recognize refrigerant management beyond the minimum, reducing stratospheric ozone depletion and demonstrating early compliance with the Montreal Protocol.	2

Multi V III VRF systems help meet the prerequisites or acquire points because:

- Multi V III systems meet or exceed ASHRAE Standard 90.1-2007.
- Multi V III systems use environmentally friendly R410A refrigerant.
- Multi V III systems offer exceptional energy performance by using state-of-the-art controls, high-efficiency variable-speed fan assemblies, and a combination of variable and constant speed compressors.

To maximize LEED energy and atmosphere points, we recommend selecting heat recovery equipment options and using our Eco V Heat Recovery Ventilator.

**Table 29: LEED Points for Indoor Environmental Quality**

Credit	Intent	Points
Prerequisite 1	Establish the minimum indoor air quality that contributes to occupant comfort and wellbeing.	N/A
Credit 1	Recognize ventilation system monitoring that promotes occupant comfort and wellbeing.	1
Credit 2	Recognize additional outdoor-air ventilation that promotes occupant comfort and wellbeing.	1
Credit 3.2	Recognize remediation plans for air quality issues resulting from construction or renovation, increasing occupant comfort and wellbeing.	1

Multi V III VRF systems help meet the prerequisites or acquire points because:

- The modular design of Multi V III systems uses multiple indoor units, allowing the designer to provide individualized control for each occupant.
- The Multi V III's building management controllers and communication gateways make it easy to monitor energy usage and control system operations based on building usage or indoor air quality.
- All Multi V systems have standardized sound test data.

To maximize LEED indoor environmental quality points, we recommend using our Eco V Heat Recovery Ventilator.

# References

## **ANSI/ASHRAE/IESNA Standard 90.1-2007**

- Table 5.5-1 Building Envelope Requirements for Climate Zone 1–5
- Table 6.8.1A: Electronically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements
- Table 6.8.1B Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements
- Table 6.8.1C Water Chilling Packages—Minimum Efficiency Requirements
- Table 6.8.1G Performance Requirements for Heat Rejection Equipment
- Table 7.8: Performance Requirements for Water Heating Equipment
- Table 9.5.1: Lighting Power Densities Using the Building Area Method

## **Electricity and Natural Gas Rates**

- EPA EnergyStar (Portfolio Manager Overview), [www.energystar.gov](http://www.energystar.gov)
- U.S. Energy Information Administration,  
<http://www.eia.gov/electricity/data.cfm> and  
[http://www.eia.gov/energyexplained/index.cfm?page=natural\\_gas\\_prices](http://www.eia.gov/energyexplained/index.cfm?page=natural_gas_prices)

## **Background and General Information**

- U.S. Green Building Council, LEED for New Construction & Major Renovations
- EnergyStar Multifamily High Rise Program
- U.S. DOE, Buildings Energy Data Book 2010,  
<http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=2.1.11>