Building Energy Analysis
for a Multi-Family Residential Building
(Multi V™ II Water VRF Heat-Pump System)

Residential-Building Energy-Modeling Engineering Study VRF-ES-BF-001-US 012E03

Contents

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 II Water 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 II Water 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 II Water 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 1 packaged terminal air-conditioner (PTAC)

Introduction

This engineering case study explores the implementation of a LG Multi V II Water 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[1]. 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^2 of conditioned space. The building also included 17 residential spaces of approximately 19,246 ft^2. 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^2)
Corridor	2,969
Electrical/Mechanical	152
Elevator	443
Residential Area	19,246
Stairs	421
Total	23,231

[1] *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.

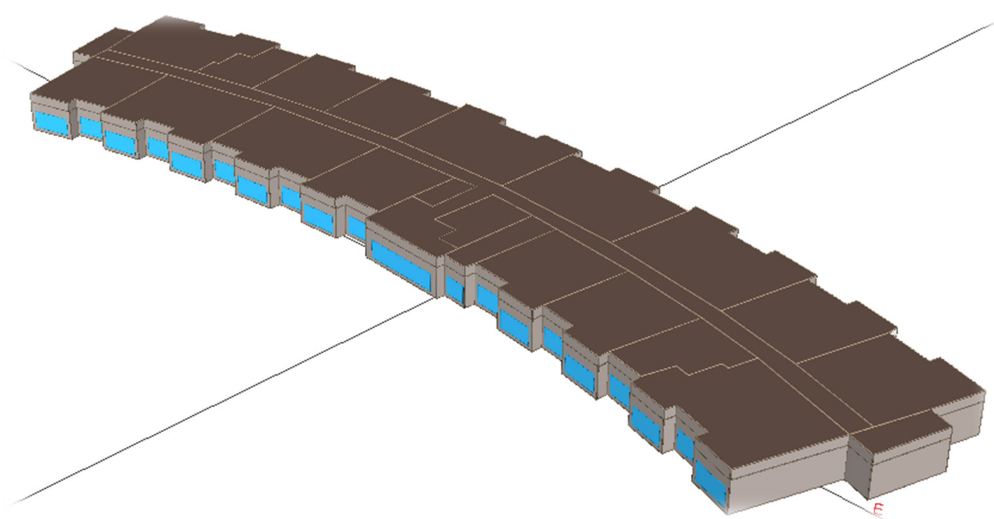

Figure 1: eQUEST rendering of subject building.

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 1 (Sys 1) packaged terminal air-conditioner (PTAC).
- 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 and to maintain humidity requirements. Although humidity typically is not controlled during unoccupied periods, avoiding mold and moisture is good practice. (See Table 4 for details about the specification of the baseline and proposed HVAC systems.).

Proposed Building

The proposed building models used Multi V II Water 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 II Water 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 II Water Heat Pump system could reduce operational costs while providing reliable heat in colder regions. The Multi V II Water 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 II Water with a vertical air handler indoor unit.

Component Comparison

Several components were considered and analyzed in the building model:

- Modeled sizes and efficiencies (code minimum efficiencies)
- Baseline building envelope
- Mechanical systems
- Domestic hot-water system
- Lighting system
- Receptacle load

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 one 650 MBH natural gas boiler, 18 PTAC 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 PTAC system (ASHRAE Type 1 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	PTAC Baseline System	Four-Pipe Fan-Coil Baseline System	LG Multi V II Water Heat Pump System
Cooling Tower	-	1×700 MBH Two-Speed Fan	1×700 MBH Two-Speed Fan
Chiller	-	600 MBH 4.45 COP	-
DX-Cooling	12.3 – (0.213× Cap/1000) EER		2×14–20 RT Heat Pump (EER : 16.0, not including fan power)

Table 5: Mechanical-System Air-Heating Characteristics

Component	PTAC Baseline System	Four-Pipe Fan-Coil Baseline System	LG Multi V II Water Heat Pump System
Gas-Fired Hot Water Boiler	600 MBH, η = 80%	600 MBH, η = 80%	600 MBH, η = 80%
Electrical Heating	Unit heater (electric resistance)	Unit heater (electric resistance)	Unit heater (electric resistance)
Heat Pump	-	-	2×14–20 RT heat pump (COP: 5, not including fan power)

Table 6: Mechanical-System Air-Handling Characteristics

PTHP Baseline System	Four-Pipe Fan-Coil Baseline System	LG Multi V II Water Heat Pump System
18×PTAC - 0.0003kW/cfm, constant speed 18×FCUs	18×FCUs (1.5–2 RT) -0.0003kW/cfm, Constant speed	-0.000121kW/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/ft²)	Same	ASHRAE 90.1-2007 (Table 9.5.1: *Lighting Power Densities Using the Building Area Method*)

Receptacle Load

Baseline and proposed receptacle equipment were as follows:

Table 9: Receptacle-Load Energy Characteristics

	Baseline	Proposed	Notes
Receptacle load	1.00 w/ft²	Same	ASHRAE 90.1-2007 (TABLE G3.1 *Modeling Requirements for Calculating Proposed and Baseline Building Performance*)

Utility Rate Sources

The study used the following sources for electrical and natural gas rates[2]:

Table 10: Utility Rate Sources

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

[2] Source: Data adapted from DOE-EIA and local utility companies

Results

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 II Water heat pump VRF systems, used an average of 48 kBTU per square foot of site energy each year. The whole-building energy cost savings realized with the building was 14% on average when compared to an ASHRAE standard 90.1-2007 System 1 PTAC. When comparing the energy cost used based the HVAC systems alone, that number jumped to 32% less on average. (See Figure 3 and Figure 4).

The whole-building energy cost savings realized with the Multi V II Water heat pump system was 15% on average when compared to four-pipe FCU with ASHRAE minimum efficiency. When comparing HVAC systems alone that number averaged 54%.

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).

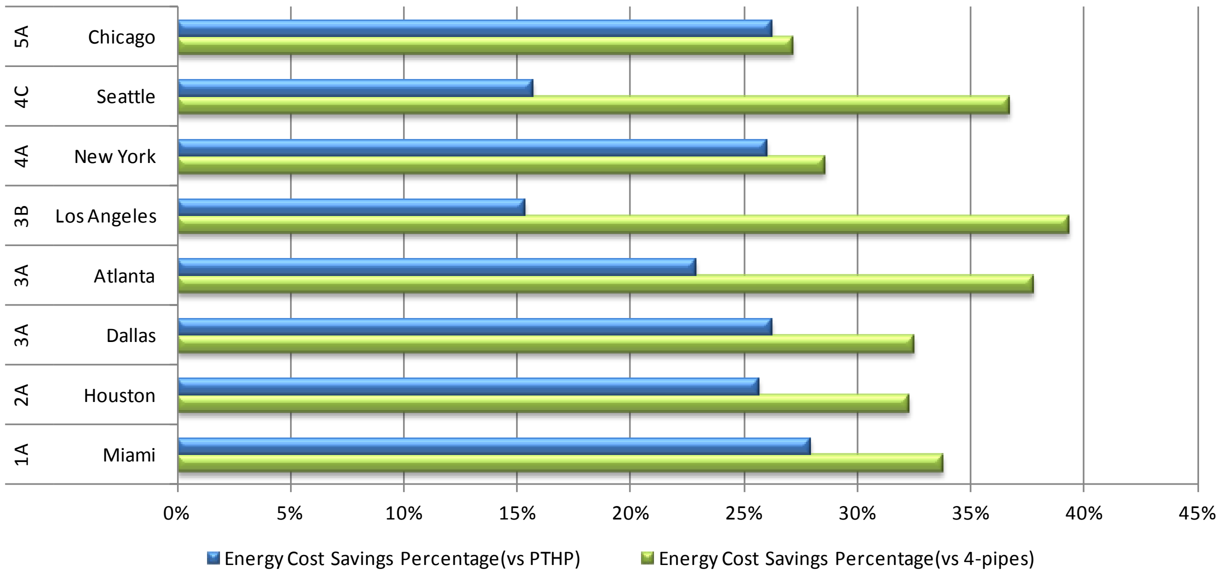

Figure 3 : LG Multi V II Water VRF systems whole-building energy cost savings (%).

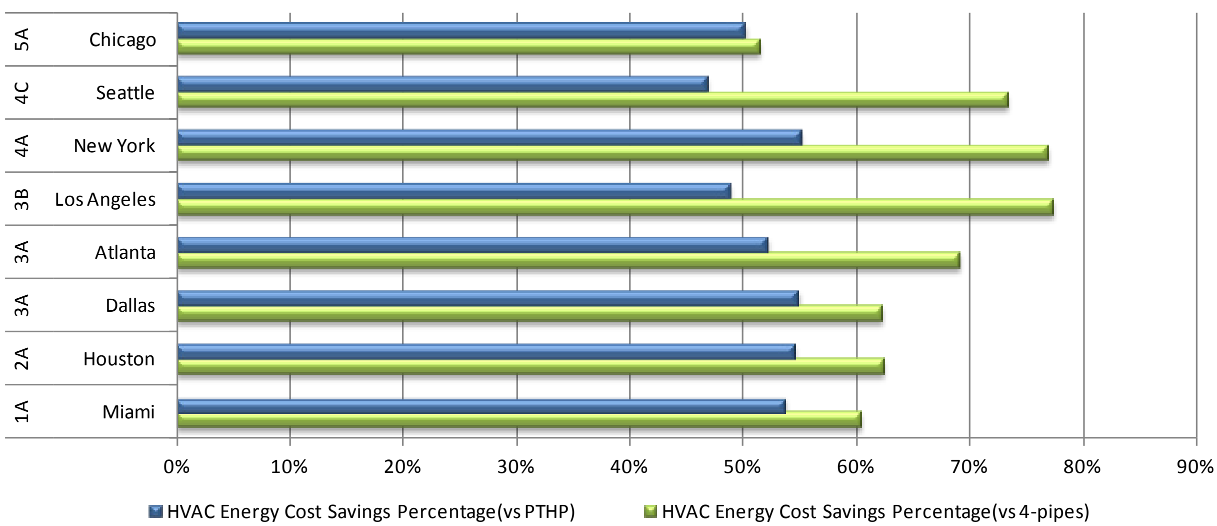

Figure 4 : LG Multi V II Water VRF systems HVAC energy cost savings (%).

Zone 1A (Miami) Results

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

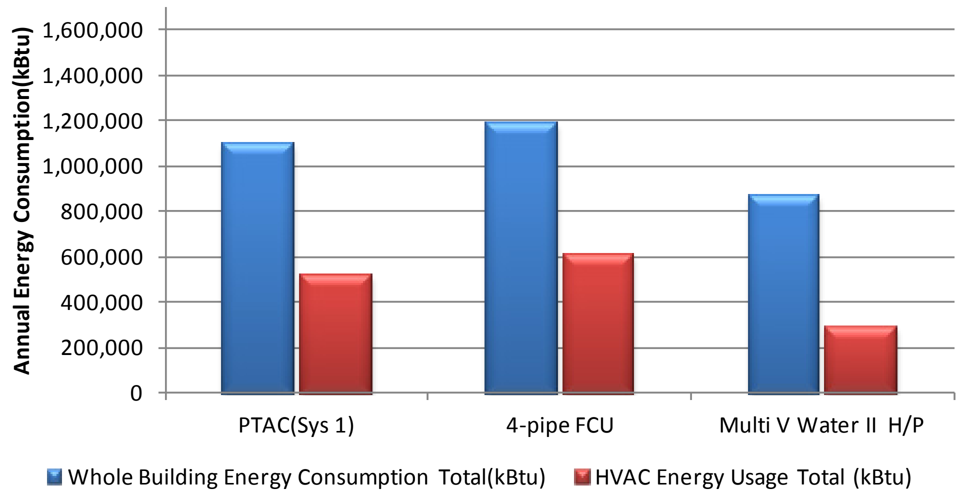

Figure 5: Miami annual energy consumption comparison.

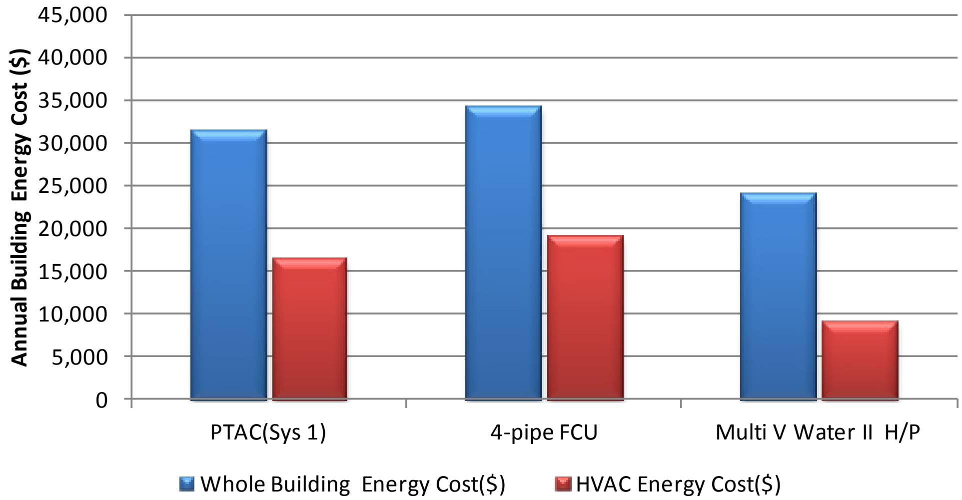

Figure 6: Miami annual building energy cost comparison.

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 1, PTAC) for the Multi V II heat pump VRF systems was 24%.

Table 11: Miami Annual Energy Consumption by End Use

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water 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	55,030
Space Heating	kWh	10	10	950
	Therms	152	276	160
Fans	kWh	46510	46,510	21,570
Pumps	kWh	100	40,770	3,010
Totals	kBTU	1,099,477	1,191,348	868,719

Table 12: Miami Estimated Annual Energy Use and Cost

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	267,590	290,870	199,730
	Gas (Therms)	1,865	1,989	1,872
	Total (kBTU)	1,099,477	1,191,348	868,719
Whole Building Energy Cost	$	31,450	34,142	24,064
	$/ft²	1.35	1.47	1.04
HVAC Energy Usage	Electricity (kWh)	148,420	171,700	80,560
	Gas (Therms)	151.9	276.3	159.7
	Total (kBTU)	521,599	613,470	290,841
HVAC Energy Cost	$	16,363	19,054	8,977
	$/ft²	0.70	0.82	0.39

Zone 2A (Houston) Results

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

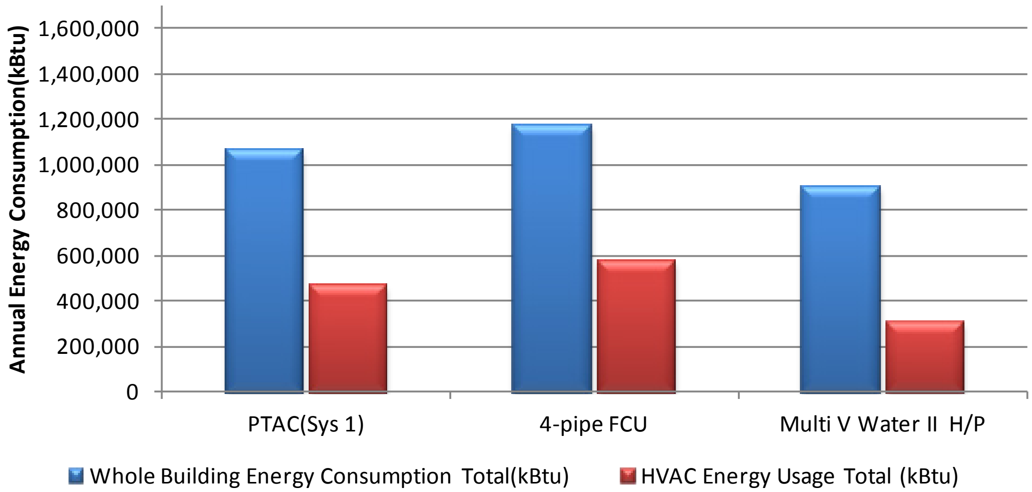

Figure 7: Houston annual energy consumption comparison.

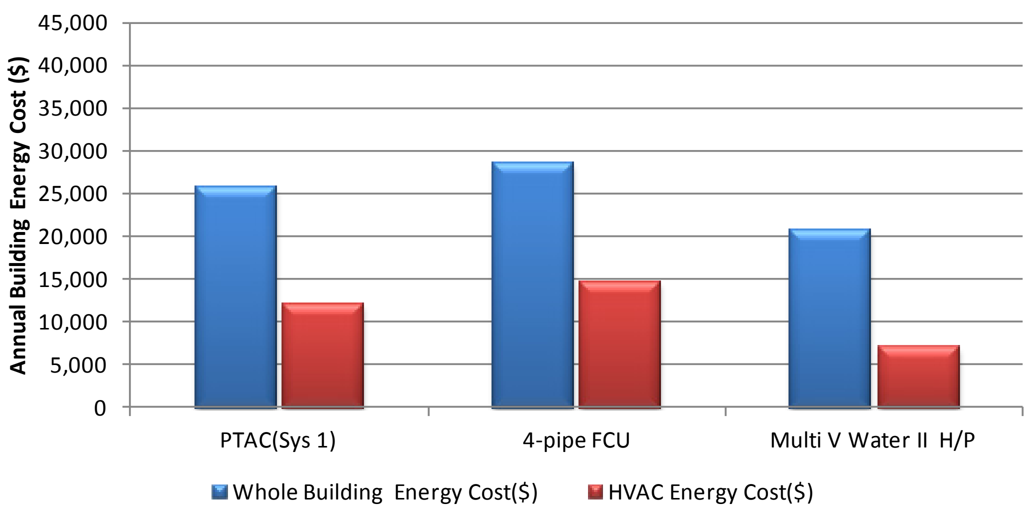

Figure 8: Houston annual building energy cost comparison.

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 1, PTAC) for the Multi V II Water heat pump VRF systems was 19%.

Table 13: Houston Annual Energy Consumption by End Use

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water 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	34,220
Space Heating	kWh	40	40	5,960
	Therms	915	1,119	923
Fans	kWh	41260	41,260	19,140
Pumps	kWh	2,770	38,730	2,610
Totals	kBTU	1,070,551	1,176,598	903,813

Table 14: Houston Estimated Annual Energy Use and Cost

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	230,220	255,310	181,100
	Gas (Therms)	2,850	3,055	2,859
	Total (kBTU)	1,070,551	1,176,598	903,813
Whole Building Energy Cost	$	25,801	28,516	20,847
	$/ft²	1.11	1.23	0.90
HVAC Energy Usage	Electricity (kWh)	111,050	136,140	61,930
	Gas (Therms)	914.8	1119.2	923.4
	Total (kBTU)	470,383	576,430	303,645
HVAC Energy Cost	$	12,034	14,750	7,080
	$/ft²	0.52	0.63	0.30

Zone 3A (Atlanta) Results

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

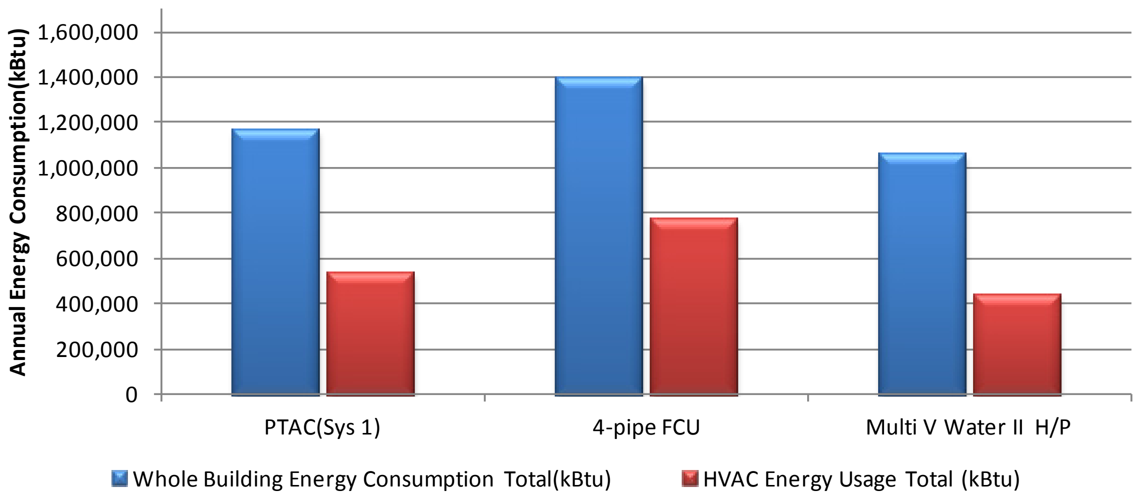

Figure 9: Atlanta annual energy consumption comparison.

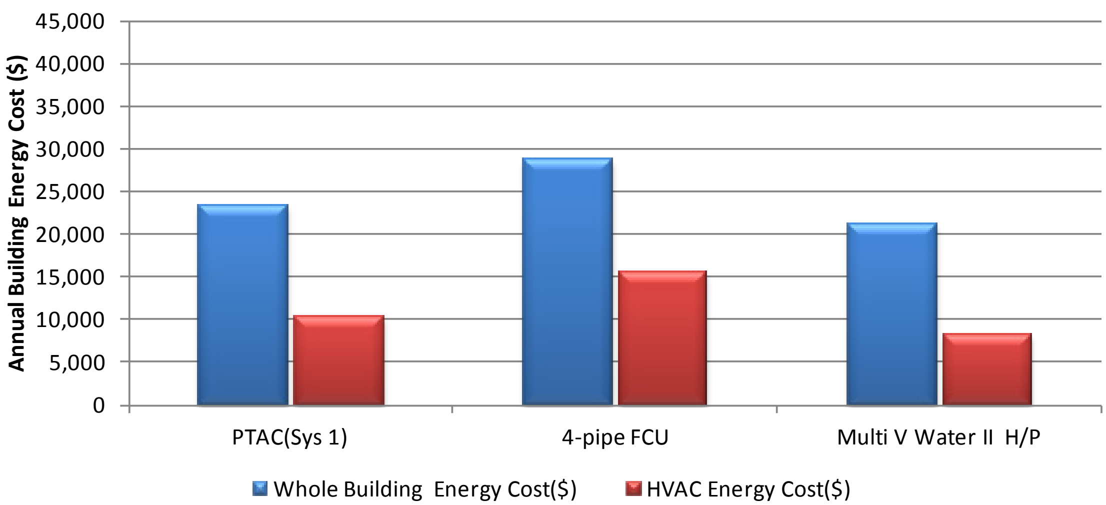

Figure 10: Atlanta annual building energy cost comparison.

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 1, PTAC) for the Multi V II Water heat pump VRF systems was 9%.

Table 15: Atlanta Annual Energy Consumption by End Use

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water 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	19,600
Space Heating	kWh	680	610	11,670
	Therms	2,486	2,998	2,178
Fans	kWh	38210	50,860	23,600
Pumps	kWh	3,440	46,560	10,300
Totals	kBTU	1,163,079	1,393,792	1,062,138

Table 16: Atlanta Estimated Annual Energy Use and Cost

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	204,900	257,530	184,340
	Gas (Therms)	4,640	5,151	4,332
	Total (kBTU)	1,163,079	1,393,792	1,062,138
Whole Building Energy Cost	$	23,442	28,690	21,267
	$/ft²	1.01	1.23	0.92
HVAC Energy Usage	Electricity (kWh)	85,730	138,360	65,170
	Gas (Therms)	2486.2	2997.6	2178.3
	Total (kBTU)	541,131	771,844	440,190
HVAC Energy Cost	$	10,420	15,672	8,244
	$/ft²	0.45	0.67	0.35

Zone 3A (Dallas) Results

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

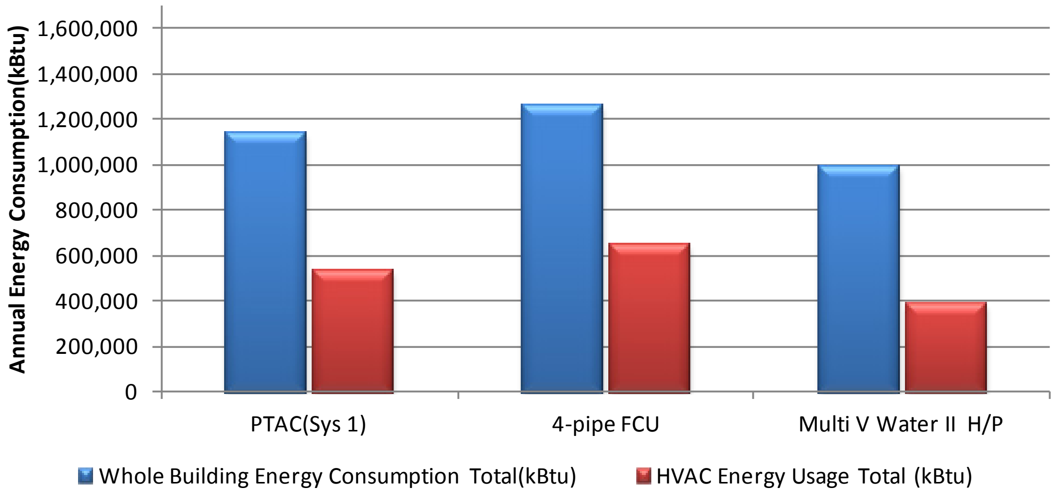

Figure 11: Dallas annual energy consumption comparison.

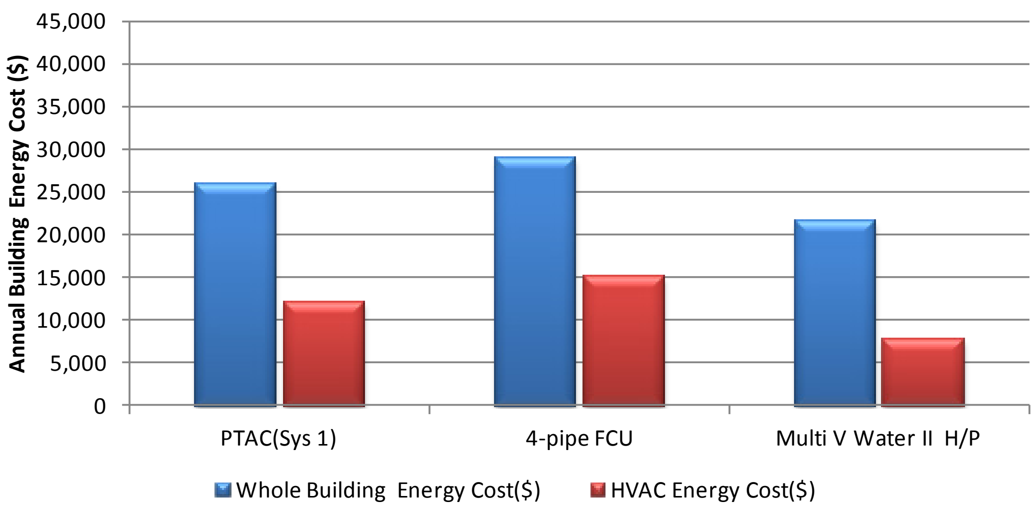

Figure 12: Dallas annual building energy cost comparison.

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 1, PTAC) for the Multi V II Water heat pump VRF systems was 16%.

Table 17: Dallas Annual Energy Consumption by End Use

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water 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	27,850
Space Heating	kWh	80	80	11,440
	Therms	1,767	2,061	1,771
Fans	kWh	41820	41,820	19,050
Pumps	kWh	2,870	38,770	2,750
Totals	kBTU	1,141,454	1,261,541	994,287

Table 18: Dallas Estimated Annual Energy Use and Cost

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	223,530	250,100	180,260
	Gas (Therms)	3,788	4,082	3,792
	Total (kBTU)	1,141,454	1,261,541	994,287
Whole Building Energy Cost	$	25,963	28,908	21,597
	$/ft^2	1.12	1.24	0.93
HVAC Energy Usage	Electricity (kWh)	104,360	130,930	61,090
	Gas (Therms)	1766.6	2060.9	1771.3
	Total (kBTU)	532,736	652,823	385,569
HVAC Energy Cost	$	12,120	15,066	7,754
	$/ft^2	0.52	0.65	0.33

Zone 3B (Los Angeles) Results

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

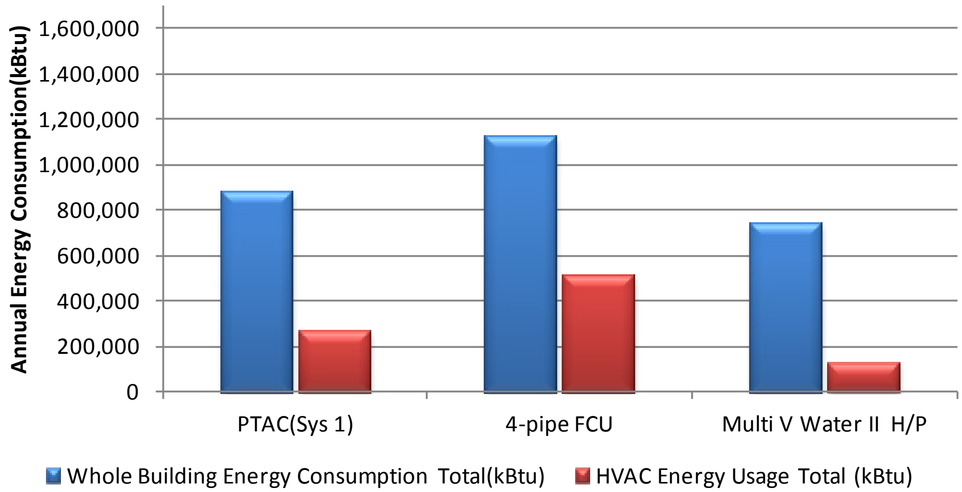

Figure 13: Los Angeles annual energy consumption comparison.

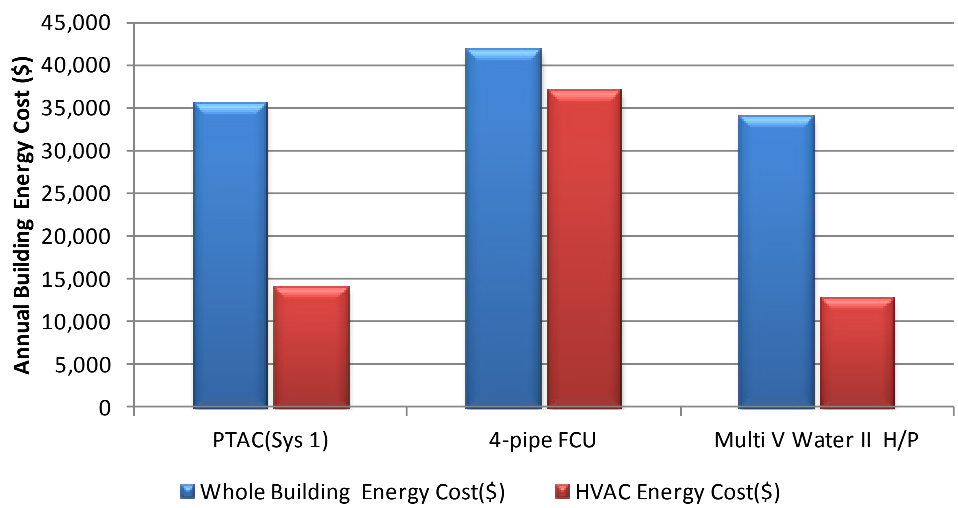

Figure 14: Los Angeles annual building energy cost comparison.

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 1, PTAC) for the Multi V II Water heat pump VRF systems was 21%.

Table 19: Los Angeles Annual Energy Consumption by End Use

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water 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	6,150
Space Heating	kWh	0	0	870
	Therms	167	514	151
Fans	kWh	37850	51,480	23,880
Pumps	kWh	4,460	50,600	930
Totals	kBTU	883,312	1,128,869	741,372

Table 20: Los Angeles Estimated Annual Energy Use and Cost

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	192,140	253,930	151,000
	Gas (Therms)	86,107	86,454	2,262
	Total (kBTU)	883,312	1,128,869	741,372
Whole Building Energy Cost	$	25,192	32,964	20,200
	$/ft²	1.08	1.42	0.87
HVAC Energy Usage	Electricity (kWh)	72,970	134,760	31,830
	Gas (Therms)	166.9	514.2	151.2
	Total (kBTU)	265,664	511,221	123,724
HVAC Energy Cost	$	8,972	16,744	3,980
	$/ft²	0.39	0.72	0.17

Zone 4A (New York) Results

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

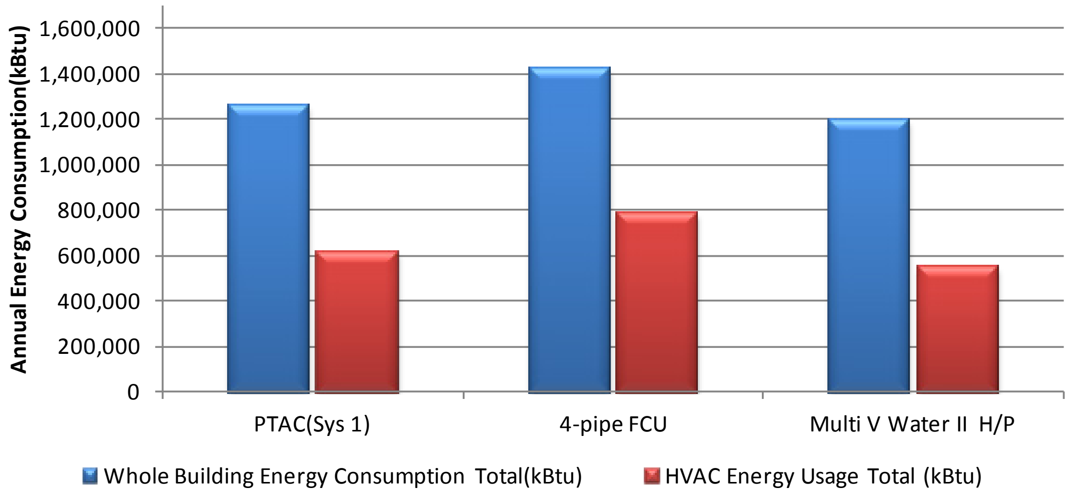

Figure 15: New York annual energy consumption comparison.

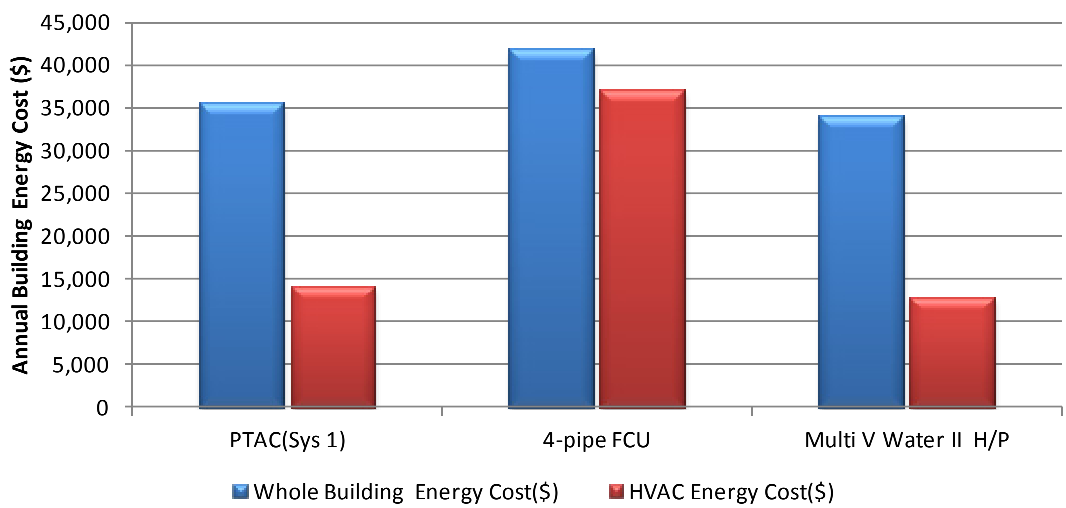

Figure 16: New York annual building energy cost comparison.

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 1, PTAC) for the Multi V II Water heat pump VRF systems was 4%.

Table 21: New York Annual Energy Consumption by End Use

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water 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	10,660
Space Heating	kWh	1,340	1,300	23,850
	Therms	4,212	4,599	3,766
Fans	kWh	27,770	34,710	16,120
Pumps	kWh	2,530	33,230	1,760
Totals	kBTU	1,260,967	1,429,518	1,196,883

Table 22: New York Estimated Annual Energy Use and Cost

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	177,250	215,310	171,560
	Gas (Therms)	6,562	6,949	6,115
	Total (kBTU)	1,260,967	1,429,518	1,196,883
Whole Building Energy Cost	$	35,427	41,796	34,007
	$/ft^2	1.52	1.80	1.46
HVAC Energy Usage	Electricity (kWh)	58,080	96,140	52,390
	Gas (Therms)	4212.2	4599.1	3765.5
	Total (kBTU)	619,389	787,940	555,305
HVAC Energy Cost	$	14,108	36,990	12,684
	$/ft^2	0.61	1.59	0.55

Zone 4C (Seattle) Results

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

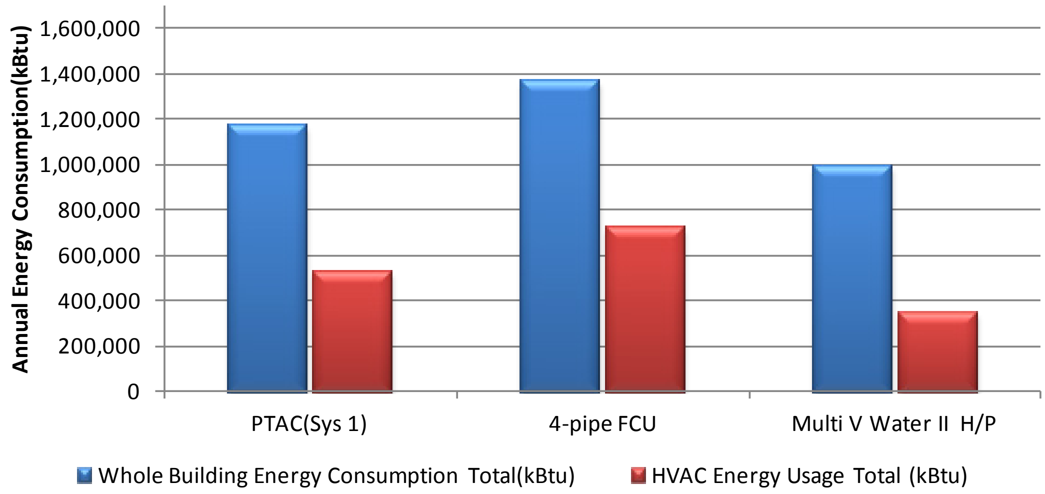

Figure 17: Seattle annual energy consumption comparison.

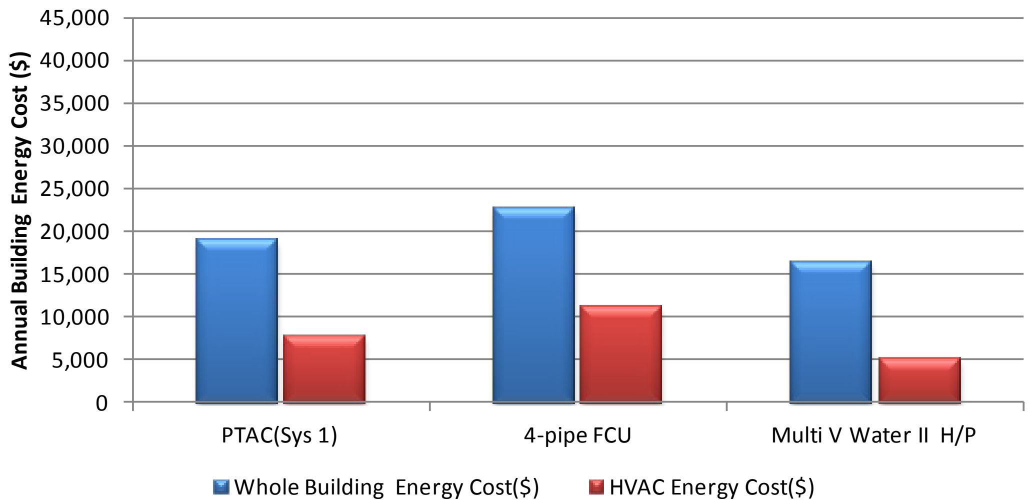

Figure 18: Seattle annual building energy cost comparison.

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 1, PTAC) for the Multi V II Water heat pump VRF systems was 15%.

Table 23: Seattle Annual Energy Consumption by End Use

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water 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	1,110
Space Heating	kWh	610	560	9,400
	Therms	3,814	4,340	2,473
Fans	kWh	29880	34,920	17,730
Pumps	kWh	2,500	32,840	630
Totals	kBTU	1,174,425	1,371,176	993,642

Table 24: Seattle Estimated Annual Energy Use and Cost

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	161,710	203,970	148,040
	Gas (Therms)	6,227	6,752	4,885
	Total (kBTU)	1,174,425	1,371,176	993,642
Whole Building Energy Cost	$	19,060	22,671	16,435
	$/ft^2	0.82	0.98	0.71
HVAC Energy Usage	Electricity (kWh)	42,540	84,800	28,870
	Gas (Therms)	3814	4340	2473
	Total (kBTU)	526,586	723,338	345,804
HVAC Energy Cost	$	7,719	11,331	5,095
	$/ft^2	0.33	0.49	0.22

Zone 5A Chicago Results

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

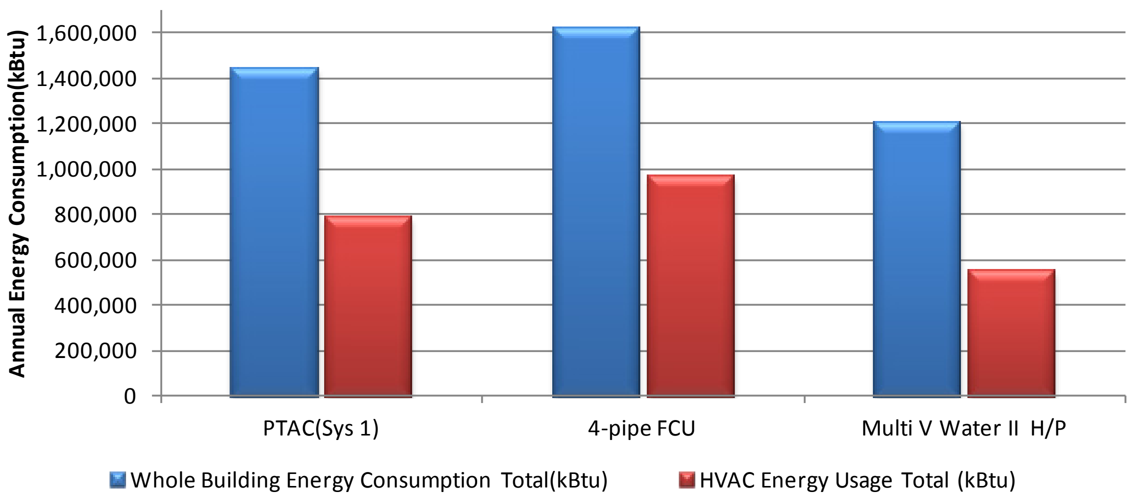

Figure 19: Chicago annual energy consumption comparison.

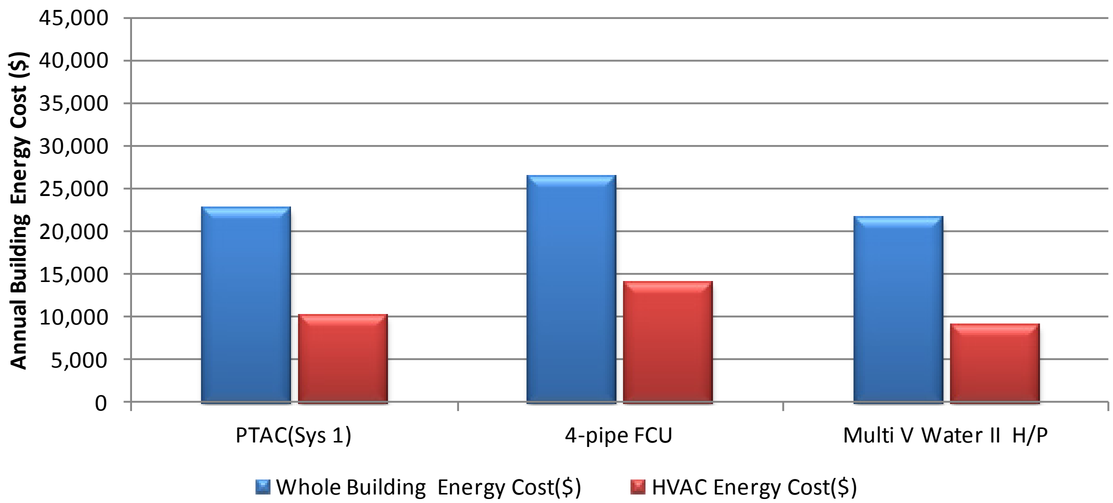

Figure 20: Chicago annual building energy cost comparison.

The following tables summarize the energy usage and cost savings for the different cases. The whole building energy cost savings over the baseline (Sys 1, PTAC) for the Multi V II Water heat pump VRF systems was 4%.

Table 25: Chicago Annual Energy Consumption by End Use

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water 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	7,640
Space Heating	kWh	2,430	2,380	47,620
	Therms	6,066	6,474	2,979
Fans	kWh	28980	34,780	14,560
Pumps	kWh	2,590	33,080	3,930
Totals	kBTU	1,446,631	1,620,593	1,203,343

Table 26: Chicago Estimated Annual Energy Use and Cost

Consumer	Units	System 1 (PTAC)	Four-pipe Fan-Coil Unit	Multi V II Water Heat Pump
Whole Building Energy Consumption	Electricity (kWh)	173,740	212,750	192,920
	Gas (Therms)	8,538	8,947	5,451
	Total (kBTU)	1,446,631	1,620,593	1,203,343
Whole Building Energy Cost	$	22,746	26,473	21,574
	$/ft^2	0.98	1.14	0.93
HVAC Energy Usage	Electricity (kWh)	54,570	93,580	73,750
	Gas (Therms)	6065.8	6474.4	2978.5
	Total (kBTU)	792,773	966,735	549,485
HVAC Energy Cost	$	10,237	13,965	9,065
	$/ft^2	0.44	0.60	0.39

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.

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 II Water 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 II Water systems help meet the prerequisites or acquire points because:

- Multi V II Water systems meet or exceed ASHRAE Standard 90.1-2007.
- Multi V II Water systems use environmentally friendly R410A refrigerant.
- Multi V II Water 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 II Water systems help meet the prerequisites or acquire points because:

- The modular design of Multi V II Water systems uses multiple indoor units, allowing the designer to provide individualized control for each occupant.
- The Multi V II Water'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
- U.S. Energy Information Administration, http://www.eia.gov/electricity/data.cfm and 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