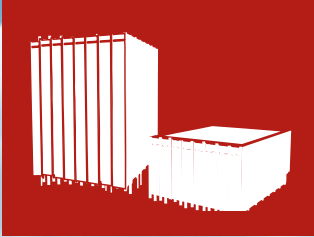


EnergyPro Building Energy Analysis

Nine-story Office Building



EnergyPro Building Energy Analysis

for an office building

Project Scope

The purpose of the EnergyPro energy model was to evaluate the energy usage of a building installed with a CITY MULTI VRFZ solution compared to that of a variable-air-volume (VAV) system, a water-source heat pump (WSHP) system, and a hot-water/chilled-water four-pipe fan coil system. The selected systems were then compared with the CITY MULTI VRFZ solution across the country: Atlanta, GA, Miami, FL, Boston, MA, New York City, NY, Chicago, IL, Dallas, TX, Los Angeles, CA, and Seattle, WA. The goal of the model was to understand how CITY MULTI HVAC compared in terms of energy usage with standard HVAC systems in various climate zones.

Building Description

The simulated building was a 145,000 square foot, nine-story engineering building with laboratories and classrooms on the first floor and offices on the top eight floors. Floors two through eight featured identical architectural layouts. The building had a main section with a north wing that provided east and west exposures, and a wing to the west of the main section offered north and south exposures.

Building specifications such as floor plans, R-Values, U-Values, etc., followed what was typical for construction values for the building type. The building was modeled in EnergyPro, and four simulations were created: a CITY MULTI heat-recovery system, a built-up rooftop variable-air-volume system, a boiler and chiller serving four-pipe fan coil units, and a water-source heat pump system. The non-HVAC energy usage such as lighting, plug loads, etc., were the same in all models (see the Engineering Assumptions Table for specifics).

All utility rates used in the savings analysis were obtained from www.eia.gov. The rates are provided in the Utility Rate Summary Table.

Mitsubishi Electric Design Description

A total of 19 CITY MULTI R2-Series heat recovery outdoor units were used in the building HVAC system design. Ceiling-cassette indoor units were used for most of the larger labs and classrooms on the first floor. For offices on the top eight floors, wall-mounted units were used where possible; for larger multi-room zones, ducted units were used. The first eight floors each featured two outdoor units with the units on each floor having the same capacity. One system supported each wing and half of the main section. For the top floor, three outdoor units were used. The outside air load was applied directly to each of the indoor units at the zone level.

VAV Design Description

The simulated office building was modeled with an 80% AFUE gas-fired hot-water boiler and a 0.717 KW/Ton water-cooled chiller serving a built-up VAV. The VAV system handled both space conditioning and the outside air load. Each of the zones used one VAV box specified with a 30% minimum airflow and a hot water reheat coil.



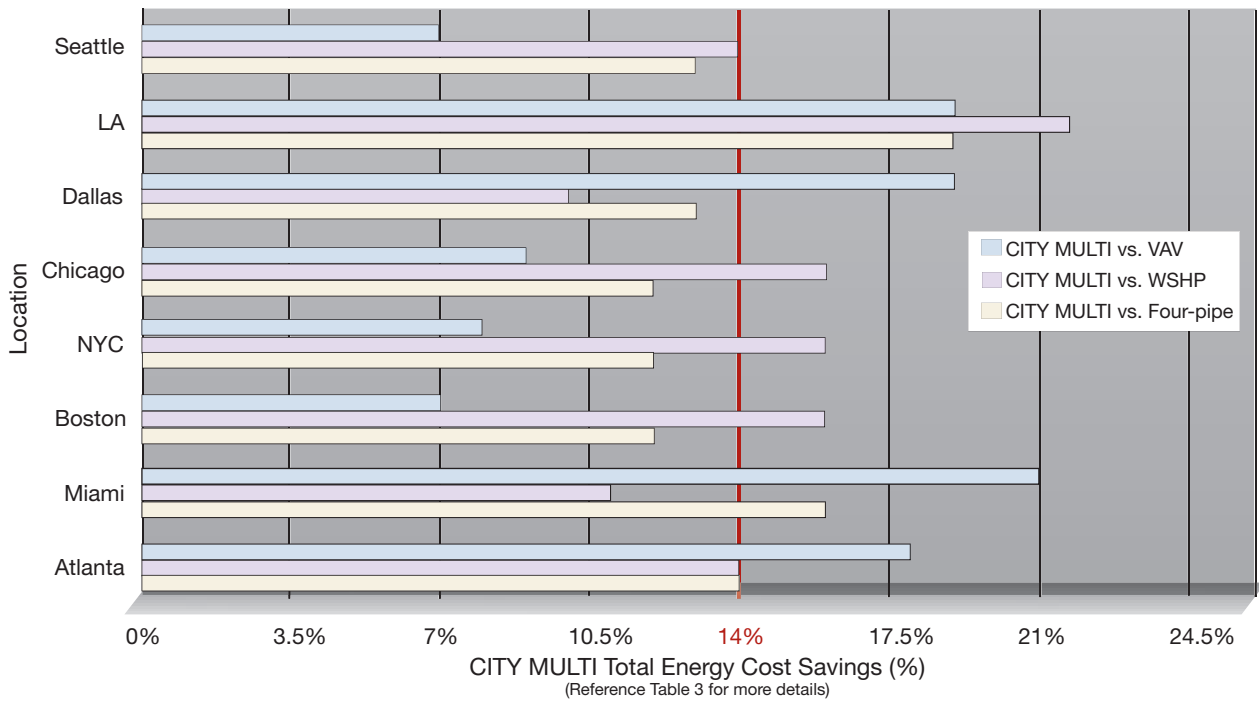
Water-source Heat Pump (WSHP) Design Description

To provide conditioning to the simulated office building, water-source heat pumps with a 15.4 EER and a 4.7 COP (Coefficient of Performance) were modeled. The water-source heat pumps were served by a two-speed cooling tower and a pump to circulate the water. A supplemental condensing boiler was attached to the condenser water loop to provide heat when the cooling tower could not maintain the water-loop temperature. The outside air was conditioned by the water-source heat pumps. A single heat pump was provided to serve each of the zones.

Four-pipe Design Description

To provide conditioning to the simulated office building, a chiller and boiler serving four-pipe fan coil units were modeled. Two water cooled screw chillers with an efficiency of 0.6kw/ton were used. The chillers were served by a two-speed cooling tower, and each was served by a set of pumps to circulate condenser water and chilled water. A condensing boiler with an efficiency of 91.5% provided hot water to the fan coil units. The outside air was conditioned by the fan coil units. A single fan coil unit served each of the zones.

CITY MULTI Total Energy Cost Savings



LEED® NC 2.2 and CITY MULTI

CITY MULTI VRFZ Systems are helpful in obtaining points for LEED® (Leadership in Energy and Environmental Design) Energy and Atmosphere credit 1. The U.S. Green Building Council (USGBC) developed the LEED® Green Building Rating System™ as a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.



Building energy savings can be demonstrated by performing a building energy model using the EnergyPro software available from EnergySoft, LLC. and comparing the building design with a baseline building as defined by ASHRAE 90.1-2004. EnergyPro is approved by the USGBC for EAc1 calculations. As shown below, the percentage of total energy savings relates directly to LEED credits.

LEED Points based on Total Energy Savings (EA Credit 1)		
New Buildings	Existing Building Renovations	Points
10.5%	3.5%	1
14%	7%	2
17.5%	10.5%	3
21%	14%	4
24.5%	17.5%	5
28%	21%	6
31.5%	24.5%	7
35%	28%	8
38.5%	31.5%	9
42%	35%	10

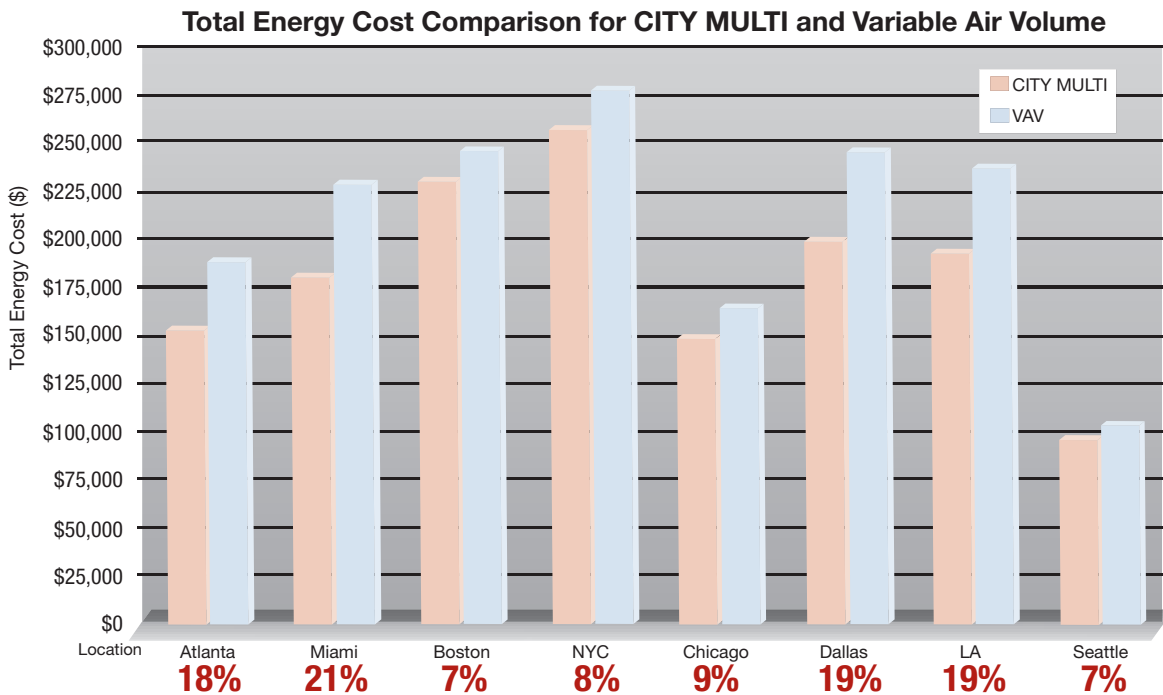
The graphs on the following page show the percentage savings of CITY MULTI VRFZ over the ASHRAE std. 90.1-2004 baseline which is the VAV system as well as other system types.

Among the architectural and engineering community, quality, reliability, and efficiency are the most important factors in system selection
- according to a recent study conducted by Clear Seas Research.



“The U.S. Environmental Protection Agency (EPA) estimates that if the energy efficiency of commercial and industrial buildings improved by 10%, the resulting reductions in greenhouse gas emissions would be equivalent to taking about 30 million vehicles off the road.”

- U.S. Environmental Protection Agency. “Facts About Energy Use in Commercial and Industrial Facilities.”
http://www.energystar.gov/index.cfm?c=learn_more.fast_facts (accessed November 2008).

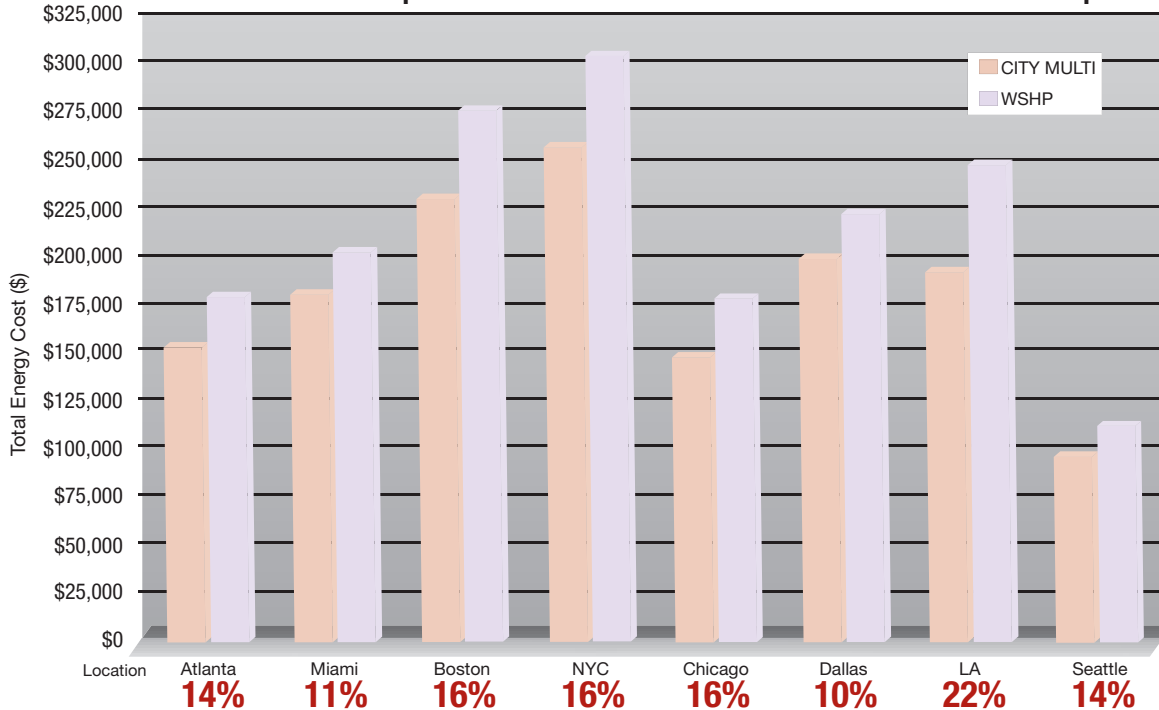


CITY MULTI as compared to VAV

A VAV system is the baseline defined by ASHRAE std. 90.1 2004 for this building size and type. Energy usage was calculated for the buildings using both systems. On average, the CITY MULTI system saw a total energy cost savings of 14% when compared with the VAV systems, and a 29% average savings when comparing HVAC energy cost.

The savings varied greatly based upon the modeled location and the applied local utility rates. Based on the average energy cost savings from the models, future projects would meet the LEED EA credit 1 prerequisite and qualify for two LEED points. Specific results for each city are in the Energy Usage Summaries (Tables 3, 4).

Total Cost Comparison for CITY MULTI and Water-source Heat Pump

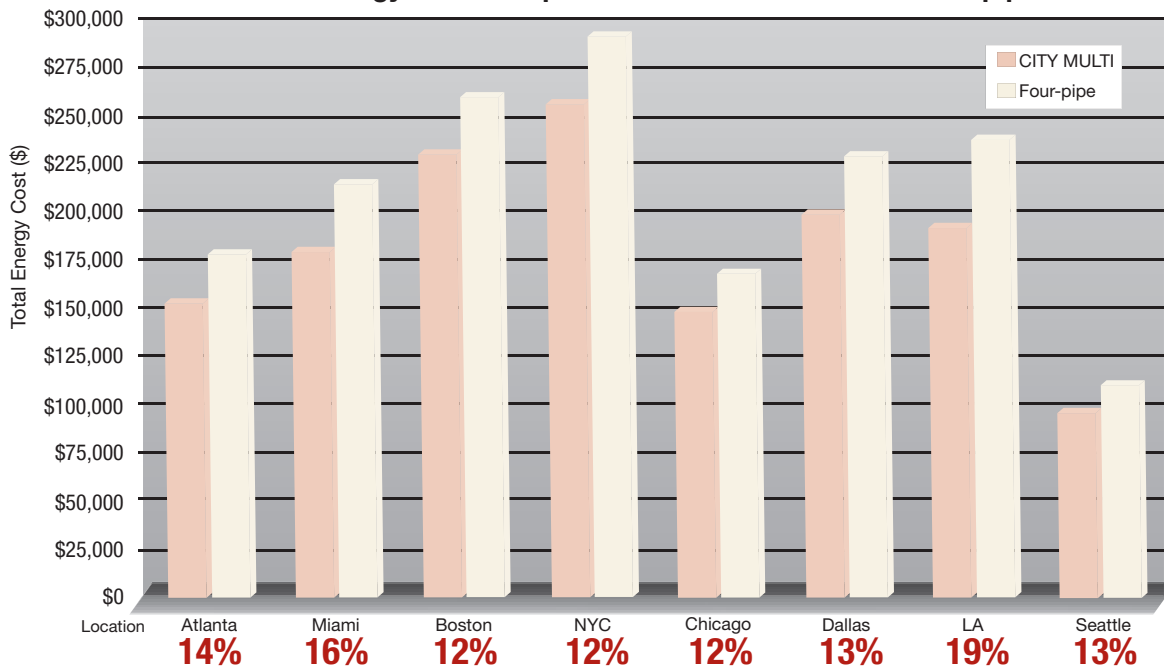


CITY MULTI as compared to WSHP

WSHP systems have recently become a popular choice to replace outdated HVAC systems. Energy usage was calculated for the buildings using both systems. The total energy cost savings realized with the CITY MULTI system was dramatic: 15% on average compared to a WSHP system.

When comparing the energy cost used by the HVAC systems alone, CITY MULTI was 32% less on average. The savings seen are detailed in the Energy Usage Summaries (Tables 3, 4).

Total Energy Cost Comparison for CITY MULTI and Four-pipe



CITY MULTI as compared to Four-pipe

A four-pipe fan coil unit system is a standard HVAC package used in many building types. Energy usage was calculated for the buildings using both systems. On average, the total energy cost savings realized with the CITY MULTI system was 14% when compared to a four-pipe fan coil unit system and a 31% average

savings when comparing HVAC energy cost. The chiller efficiency exceeded the ASHRAE 90.1 standard by 0.1kw/ton. Savings were fairly constant across all locations and are detailed in the Energy Usage Summaries (Tables 3, 4).

Engineering Assumptions

Weather Profile based on locations shown in the ASHRAE Design Temperature table.

Item	Design Assumption
Building Area	As defined by the provided plans
Glass selection	Double Thermal Break Clear U-Value: 0.5 SHGC: 0.7
Walls	Construction: Metal frame Insulation: R-15 Total Assembly U-Value: 0.095
Roof	Construction: R-19 Roof over Metal Deck Insulation: R-19 Total Assembly U-Value: 0.045 Reflectivity: 0.7
CITY MULTI VRFZ system	A CITY MULTI R2 heat recovery solution was used with 19 outdoor units. Multiple indoor unit styles were chosen to meets the needs of the space.
Built-up VAV HVAC system	Built Up VAV, Centrifugal Chiller 0.717 kw/ton, with hot water reheat provided by a hot water boiler at 91.5% Efficiency. All pumps were sized per ASHRAE std. 90.1-2004 recommendations
Water-source Heat Pump HVAC system	Water-source heat pumps served by a two-speed cooling tower and a 91.5 % efficient supplemental boiler. The heat pumps have an efficiency of 15.4 EER and a COP of 4.7. All pumps were sized per ASHRAE std. 90.1-2004 recommendations.
Four-pipe Fan Coil Unit HVAC system	Fan Coil Units served by a 91.5% efficient boiler, water-cooled screw chillers with an efficiency of 0.6kw/ton and a two-speed cooling tower. All pumps were sized per ASHRAE 90.1-2004 recommendations.
Miscellaneous Loads	Plug: 1.0 Watts/ft ² Lighting: 1.0 Watts/ft ²
Schedules	Standard ASHRAE 90.1 Profile and Operation Schedules
Utility Rates	See Utility Rate Summary Table

Professionals serving the office design and building community rank energy savings as significantly more important than other cost factors such as maintenance costs, warranty coverage and initial cost of equipment.

- according to a recent study by Clear Seas Research.



Table 1. Utility Rate Summary

	Atlanta	Miami	Boston	NYC	Chicago	Dallas	LA	Seattle
Electric (\$/KWH)	0.1117	0.1174	0.177	0.1975	0.1094	0.1394	0.1498	0.0775
Gas (\$/Therm)	1.356	1.492	1.507	1.298	1.112	1.063	1.153	1.109

Table 2. ASHRAE Design Temperature

	Atlanta	Miami	Boston	NYC	Chicago	Dallas	LA	Seattle
Summer DB 0.40%	93	91	91	91	91	100	85	85
Summer MWB 0.40%	75	71	73	74	74	74	64	65
Winter DB 99.6%	18	46	7	11	-6	17	43	23

Table 3. Total Energy Usage Summary

		Atlanta	Miami	Boston	NYC	Chicago	Dallas	LA	Seattle
CITY MULTI	Total KWH	1,376,292	1,541,315	1,303,672	1,304,796	1,367,492	1,435,016	1,290,881	1,251,024
	Total Therm	0	0	0	0	0	0	0	0
	Total MMBTU	4,699	5,263	4,451	4,455	4,669	4,900	4,408	4,271
	Total Cost	\$153,731	\$180,950	\$230,749	\$257,697	\$149,603	\$200,041	\$193,374	\$96,954
VAV	Total KWH	1,624,226	1,921,049	1,291,879	1,349,589	1,369,420	1,736,142	1,573,736	1,203,037
	Total Therm	4,668	2,368	12,219	9,603	12,499	3,912	1,981	9,677
	Total MMBTU	6,012	6,796	5,633	5,568	5,926	6,319	5,571	5,075
	Total Cost	\$187,755	\$229,064	\$247,076	\$279,008	\$163,713	\$246,176	\$238,029	\$103,967
WSHP	Total KWH	1,577,488	1,722,754	1,509,469	1,518,706	1,543,724	1,592,623	1,658,905	1,424,250
	Total Therm	1,124	3	5,954	4,003	7,383	689	3	2,348
	Total MMBTU	5,498	5,882	5,749	5,586	6,009	5,507	5,664	5,098
	Total Cost	\$177,729	\$202,255	\$276,148	\$305,140	\$177,093	\$222,744	\$248,507	\$112,983
Four-pipe	Total KWH	1,570,457	1,831,709	1,401,777	1,441,685	1,448,492	1,642,087	1,596,731	1,356,955
	Total Therm	2,387	25	8,751	6,301	9,851	1,663	184	5,211
	Total MMBTU	5,601	6,256	5,661	5,553	5,931	5,773	5,470	5,154
	Total Cost	\$178,656	\$215,079	\$261,302	\$292,911	\$169,419	\$230,674	\$239,402	\$110,943
MMBTU Savings	CM vs. VAV	22%	23%	21%	20%	21%	22%	21%	16%
	CM vs. WSHP	15%	11%	23%	20%	22%	11%	22%	16%
	CM vs. Four-pipe	16%	16%	21%	20%	21%	15%	19%	17%
Cost Savings	CM vs. VAV	18%	21%	7%	8%	9%	19%	19%	7%
	CM vs. WSHP	14%	11%	16%	16%	16%	10%	22%	14%
	CM vs. Four-pipe	14%	16%	12%	12%	12%	13%	19%	13%

Table 4. HVAC Only Energy Usage Summary

		Atlanta	Miami	Boston	NYC	Chicago	Dallas	LA	Seattle
CITY MULTI	Total KWH	512,126	677,149	439,506	440,630	503,326	570,850	426,715	386,858
	Total Therm	0	0	0	0	0	0	0	0
	Total MMBTU	1,749	2,312	1,501	1,505	1,719	1,949	1,457	1,321
	Total Cost	\$57,204	\$79,497	\$77,793	\$87,024	\$55,064	\$79,576	\$63,922	\$29,981
VAV	Total KWH	760,060	1,056,883	427,713	485,423	505,254	871,976	709,570	338,871
	Total Therm	4,668	2,368	12,219	9,603	12,499	3,912	1,981	9,677
	Total MMBTU	3,062	3,845	2,683	2,618	2,975	3,369	2,621	2,125
	Total Cost	\$91,229	\$127,611	\$94,119	\$108,336	\$69,174	\$125,712	\$108,578	\$36,994
WSHP	Total KWH	713,322	858,588	645,303	654,540	679,558	728,457	794,739	560,084
	Total Therm	1,124	3	5,954	4,003	7,383	689	3	2,348
	Total MMBTU	2,548	2,932	2,799	2,635	3,059	2,556	2,714	2,147
	Total Cost	\$81,202	\$100,803	\$123,191	\$134,468	\$82,554	\$102,279	\$119,055	\$46,010
4-Pipe	Total KWH	706,291	967,543	537,611	577,519	584,326	777,921	732,565	492,789
	Total Therm	2,387	25	8,751	6,301	9,851	1,663	184	5,211
	Total MMBTU	2,650	3,306	2,711	2,602	2,980	2,823	2,520	2,204
	Total Cost	\$82,129	\$113,627	\$108,345	\$122,239	\$74,880	\$110,210	\$109,950	\$43,970
MMBTU Savings	CM vs. VAV	43%	40%	44%	43%	42%	42%	44%	38%
	CM vs. WSHP	31%	21%	46%	43%	44%	24%	46%	38%
	CM vs. Four-pipe	34%	30%	45%	42%	42%	31%	42%	40%
Cost Savings	CM vs. VAV	37%	38%	17%	20%	20%	37%	41%	19%
	CM vs. WSHP	30%	21%	37%	35%	33%	22%	46%	35%
	CM vs. Four-pipe	30%	30%	28%	29%	26%	28%	42%	32%

*CITY MULTI is abbreviated as 'CM' in the above tables.

CITY MULTI®

VRFZ TECHNOLOGY



Advantages of CITY MULTI over Comparable Systems

The EnergyPro model demonstrated that CITY MULTI systems offer reduced energy costs because of part-load efficiency and the ability to simultaneously cool and heat. CITY MULTI R2-Series heat recovery systems can simultaneously cool and heat different zones, which allows energy to be recovered from one zone and used in another, resulting in a huge increase in efficiency and energy savings over all of the compared systems.

There are some major areas in which the CITY MULTI system offers an advantage over other systems:

- 1. Initial Cost:** CITY MULTI systems consist of an outdoor unit, an indoor unit in each zone, a BC controller (R2-Series only), refrigerant piping, and a very simple controls system. A four-pipe fan coil unit system includes a boiler, chiller, fan coil units, pumps, hot water piping, chilled water piping, a controls system, etc. A water-source heat pump system includes a cooling tower, supplemental boiler, condenser water piping, condenser water pumps, heat pumps, a controls system, etc. The reduced equipment required and ease of installation makes the CITY MULTI a superior first cost solution.
- 2. Comfort:** One of the biggest advantages that CITY MULTI VRFZ solutions have over other systems is the increased comfort level for the occupants. VRFZ technology allows indoor units to operate at the precise level necessary to maintain room temperature which, when combined with the powerful controls system, allows the occupants to experience consistent comfort throughout the day.
- 3. Quiet Operation:** CITY MULTI indoor and outdoor units operate at low sound levels; for example, a 20-ton outdoor unit operating at high speed has a sound level of 63 dB(A). Some indoor models have an operating sound level in the low 20 dB(A)s range, depending on fan speed and duct design. For contrast, the sound level for normal conversation is approximately 60 dB(A).
- 4. Installation Space:** CITY MULTI systems do not require a mechanical room. Outdoor units can be installed outside either on grade or the roof and piped directly to indoor units, eliminating the need for pumps. Depending on the type of indoor unit, they can be installed in plenum spaces, on walls, or in the ceiling. Refrigerant piping is routed to the BC controller, also located in the plenum space, and then to the outdoor unit.
- 5. Installation Time:** Because there are fewer components in a CITY MULTI system, the time it takes for installation is much shorter than for other systems. An indoor unit can be mounted and piped from the BC controller in hours.
- 6. Flexibility:** The zoning capabilities of CITY MULTI systems allow for one indoor unit to be taken offline without affecting other indoor units. An outdoor unit can also be shut down and affect only a few zones. However with other systems if an air-handling unit should fail, or a component of the central mechanical system should fail (chiller, cooling tower or pumps) a large portion, if not all, building conditioning would be lost.
- 7. Versatility:** CITY MULTI systems offer a choice of inside air handlers: ducted, wall-mounted, ceiling-mounted, and floor-mounted. Many other systems only offer limited indoor unit selections.
- 8. Efficiency:** CITY MULTI R2-Series systems have the ability to recover energy when simultaneously cooling and heating, thereby reducing energy and increasing operating efficiency. Variable refrigerant flow zoning technology also allows CITY MULTI to automatically adjust to changing loads in each zone, maintaining the required temperature levels and operating at a lower cost.
- 9. Maintenance:** CITY MULTI systems require significantly less maintenance; typically only requiring filter changes. CITY MULTI systems have a life expectancy of 15 to 20 years. Water-source heat pump systems require regular maintenance to maintain the compressor and keep the system functioning properly.



Form No. EPBROSFFBLD-7-09 V2

For more information visit www.mehvac.com



Please recycle.

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