EnergyPro Building Energy Analysis

Assisted Living Building

MITSUBISHI ELECTRIC

HVAC Advanced Products Division

EnergyPro Building Energy Analysis

for an assisted living building

Project Scope

The purpose of the EnergyPro energy model was to evaluate the energy usage of a building installed with a CITY MULT VRFZ solution compared to that of a packaged terminal heat pump (PTHP) 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 system 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 energy model was to understand how CITY MULTI compared in terms of energy usage with standard HVAC systems in various climate zones.

Building Description

The simulated building chosen was a 25,000 square foot, single-story, assisted living facility containing private living areas, a dining hall, medical facilities, and lounges. The building was modeled in each of the different cities listed in the previous paragraph.

Building specifications such as floor plans, R-Values, U-Values, etc., followed what was typical for construction values in each of the areas specified. The building was modeled in EnergyPro, and four simulations were created: a CITY MULTI heat-recovery system, a packaged terminal heat pump 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

For the simulated assisted living facility, low-profile ducted indoor units were used in each of the private living areas. All the common areas were also served by ducted indoor units. Each room was considered one zone so that each occupant had control over their living space. A total of five CITY MULTI R-2 heat recovery outdoor units were installed. The outside air load was applied directly to each of the indoor units at the zone level.

PTHP Design Description

The simulated assisted living building was modeled with a packaged terminal heat pump with an efficiency of 10.7 EER (Energy Efficiency Ratio) and a HSPF (Heating Seasonal Performance Factor) of 7.5 serving each zone. The PTHP system handled both space conditioning and the outside air load. Each PTHP was equipped with electric strip heat for cold climate operation.

Water-source Heat Pump (WSHP) Design Description

To provide conditioning to the simulated assisted living facility, 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.

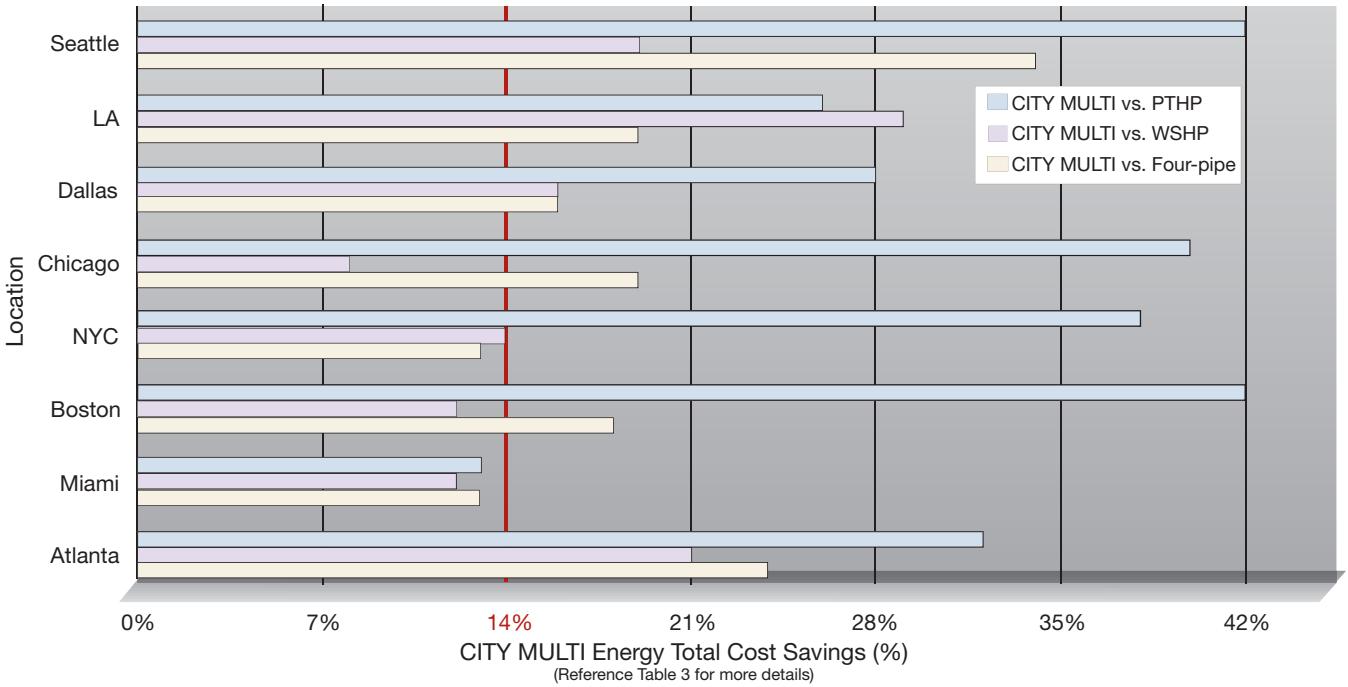
Four-pipe Design Description

To provide conditioning to the simulated assisted living facility, a chiller and boiler serving four-pipe fan coil units were modeled. A water cooled chiller with an efficiency of 1.1kw/ton was used. The chiller was served by a two-speed cooling tower, each and 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.

MITSUBISHI ELECTRIC
HVAC Advanced Products Division

CITY MULTI®
VRFZ TECHNOLOGY

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 std. 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 PTHP system as well as other system types.

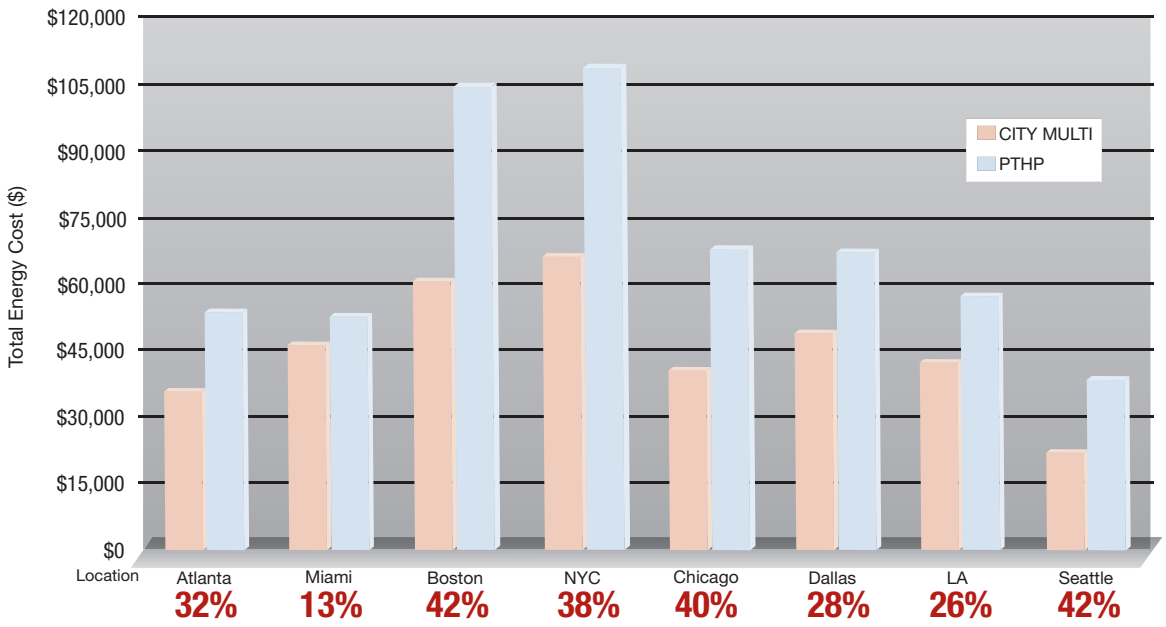
The reality in the assisted living community is that aging facilities and declining budget and resources makes it difficult to maintain and operate facilities

- according to a recent study conducted by Clear Seas Research.

Assisted living facilities appear to fall within two extremes: smaller facilities less than 20,000 square feet with an average of 2 floors and 31 rooms; or very large facilities that are more than 50,000 square feet with an average of 5 floors and 164 rooms.

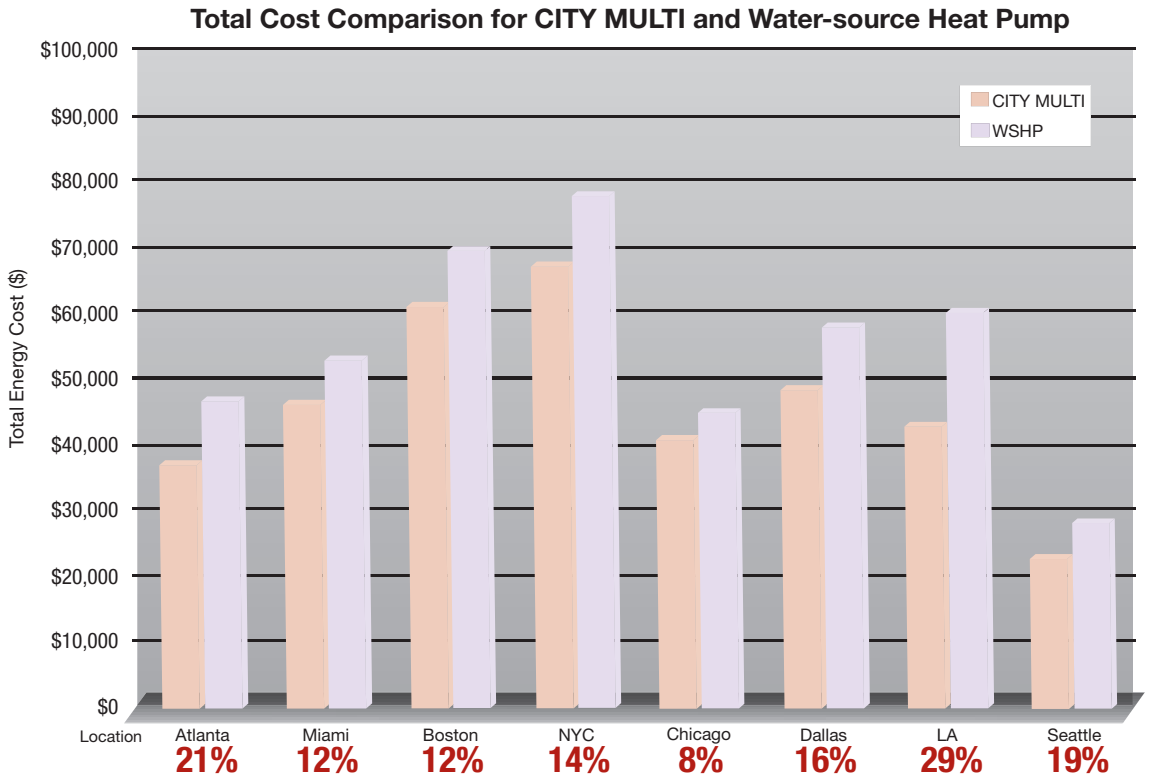
- according to a recent study conducted by Clear Seas Research.

Total Energy Cost Comparison for CITY MULTI and Packaged Terminal Heat Pump



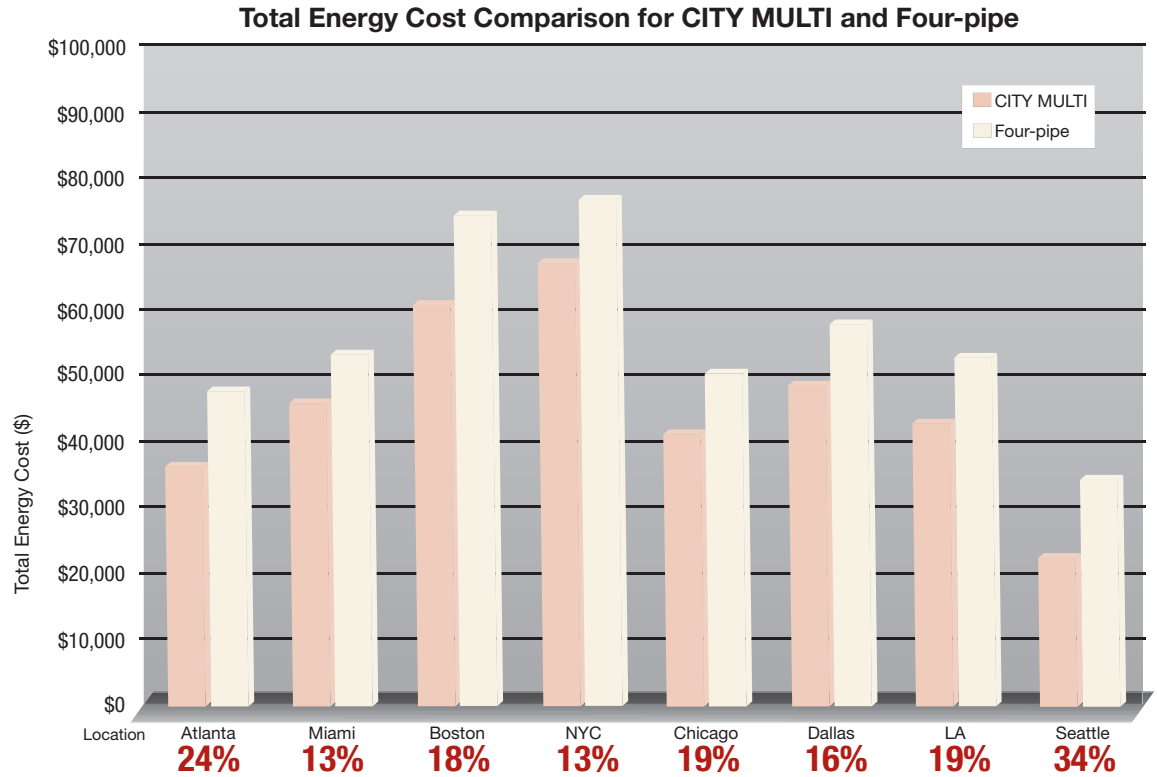
CITY MULTI as compared to PTHP

A PTHP system is baseline defined by ASHRAE 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 an energy cost savings of 33% when compared with the VAV systems, and a 43% 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 seven LEED points. Specific results for each area have been detailed in the Energy Usage Summaries (Tables 3, 4).



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: 16% on average compared to a WSHP system. When comparing the energy cost used by the HVAC systems alone, CITY MULTI was 24% less on average. The savings are detailed in the Energy Usage Summaries (Tables 3, 4).



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 20% when compared to a four-pipe fan coil unit system and a 28% average savings when comparing HVAC energy cost. Savings were fairly constant across all locations. Savings for each location are detailed in the Four-Pipe Fan Coil Unit Energy Cost Savings graph, and are further detailed in the Energy Usage Summaries (Table 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: 0.58 SHGC: 0.53
Walls	Construction: Wood frame Insulation: R-13 Total Assembly U-Value: 0.095
Roof	Construction: R-19 Roof over Metal Deck Insulation: R-15 Total Assembly U-Value: 0.065 Reflectivity: 0.7
CITY MULTI VRFZ system	A CITY MULTI R2-Series heat recovery system with ducted units.
Packaged PTHP HVAC system	Packaged Terminal Heat Pump, 10.7 EER, 7.5 HSPF and backup electric strip heat.
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, an air cooled chiller with an efficiency of 1.1kw/ton. All pumps were sized per ASHRAE std. 90.1-2004 recommendations.
Miscellaneous Loads	Lighting: 1.0 Watts/ft^2 Plug load: 0.5 Watts/ft^2
Schedules	Standard ASHRAE 90.1 Profile and Operation Schedules
Utility Rates	See Utility Rate Summary Table

Temperature control continues to be the biggest challenge in providing a comfortable environment for assisted living facility residents and patients. The most common complaint from residents is the temperature is too hot or too cold.

- 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

MITSUBISHI ELECTRIC
HVAC Advanced Products Division

CITY MULTI®
VRFZ TECHNOLOGY

Table 3. Total Energy Usage Summary

		Atlanta	Miami	Boston	NYC	Chicago	Dallas	LA	Seattle
CITY MULTI	Total KWH	327,544	394,246	345,981	340,823	377,983	349,940	285,819	294,174
	Total Therm	0	0	0	0	0	0	0	0
	Total MMBTU	1,119	1,346	1,182	1,164	1,291	1,195	976	1,005
	Total Cost	$36,586	$46,284	$61,238	$67,312	$41,351	$48,781	$42,815	$22,798
PTHP	Total KWH	484,330	455,223	594,362	553,644	629,345	488,212	387,910	503,714
	Total Therm	0	0	0	0	0	0	0	0
	Total MMBTU	1,654	1,555	2,030	1,891	2,149	1,667	1,325	1,720
	Total Cost	$54,099	$53,443	$105,202	$109,344	$68,850	$68,056	$58,108	$39,037
WSHP	Total KWH	410,931	449,361	381,443	387,588	390,889	412,031	399,990	355,123
	Total Therm	489	0	1,461	1,125	1,757	383	66	704
	Total MMBTU	1,452	1,535	1,449	1,436	1,511	1,445	1,373	1,283
	Total Cost	$46,564	$52,754	$69,717	$78,008	$44,717	$57,844	$59,994	$28,302
Four-pipe	Total KWH	344,971	448,345	301,698	314,178	316,554	376,397	343,660	280,339
	Total Therm	6,928	411	14,150	11,744	14,576	5,531	1,230	11,583
	Total MMBTU	1,871	1,572	2,445	2,248	2,539	1,839	1,297	2,116
	Total Cost	$47,927	$53,248	$74,724	$77,293	$50,839	$58,349	$52,898	$34,571
MMBTU Savings	CM vs. PTHP	**32%**	**13%**	**42%**	**38%**	**40%**	**28%**	**26%**	**42%**
	CM vs. WSHP	**23%**	**12%**	**18%**	**19%**	**15%**	**17%**	**29%**	**22%**
	CM vs. Four-pipe	**40%**	**14%**	**52%**	**48%**	**49%**	**35%**	**25%**	**53%**
Cost Savings	CM vs. PTHP	32%	13%	42%	38%	40%	28%	26%	42%
	CM vs. WSHP	21%	12%	12%	14%	8%	16%	29%	19%
	CM vs. Four-pipe	24%	13%	18%	13%	19%	16%	19%	34%

Table 4. HVAC Only Energy Usage Summary

		Atlanta	Miami	Boston	NYC	Chicago	Dallas	LA	Seattle
CITY MULTI	Total KWH	203,579	270,281	222,016	216,858	254,018	225,975	161,854	170,209
	Total Therm	0	0	0	0	0	0	0	0
	Total MMBTU	696	923	758	741	868	772	553	582
	Total Cost	$22,740	$31,731	$39,297	$42,829	$27,790	$31,501	$24,246	$13,191
PTHP	Total KWH	360,365	331,258	470,397	429,679	505,380	364,247	263,945	379,749
	Total Therm	0	0	0	0	0	0	0	0
	Total MMBTU	1,231	1,131	1,606	1,467	1,726	1,244	902	1,297
	Total Cost	$40,253	$38,890	$83,160	$84,862	$55,289	$50,776	$39,539	$29,431
WSHP	Total KWH	286,966	325,396	257,478	263,623	266,924	288,066	276,025	231,158
	Total Therm	489	0	1,461	1,125	1,757	383	66	704
	Total MMBTU	1,029	1,111	1,026	1,013	1,087	1,022	949	860
	Total Cost	$32,717	$38,201	$47,775	$53,526	$31,155	$40,564	$41,425	$18,695
Four-pipe	Total KWH	221,006	324,380	177,733	190,213	192,589	252,432	219,695	156,374
	Total Therm	6,928	411	14,150	11,744	14,576	5,531	1,230	11,583
	Total MMBTU	1,448	1,149	2,022	1,824	2,116	1,415	874	1,693
	Total Cost	$34,081	$38,695	$52,783	$52,811	$37,278	$41,068	$34,324	$24,965
MMBTU Savings	CM vs. PTHP	43%	18%	53%	49%	50%	38%	39%	55%
	CM vs. WSHP	32%	17%	26%	27%	20%	24%	42%	32%
	CM vs. Four-pipe	52%	20%	63%	59%	59%	45%	37%	66%
Cost Savings	CM vs. PTHP	44%	18%	53%	50%	50%	38%	39%	55%
	CM vs. WSHP	30%	17%	18%	20%	11%	22%	41%	29%
	CM vs. Four-pipe	33%	18%	26%	19%	25%	33%	24%	47%

*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. EPBROSALB-7-09 V2
For more information visit www.mehvac.com

Please recycle.

Mitsubishi Electric Advanced Products Division
3400 Lawrenceville Suwanee Road
Suwanee, GA 30024
Phone: 888-467-7546 Fax: 800-658-1458