Challenges in Air Con Heritage Bui

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The condition of monumental heritage buildings in use in New Delhi is deteriorating very fast needing immediate attention for preserving them for posterity. This article underlines the various causes of this deterioration and possible remedies by making improvements in the existing air conditioning systems.

A large number of heritage and monumental buildings are being used today as office buildings in Delhi due to their advantage of central location, availability of large spaces, usability, grandeur and tourist attraction. They have an imposing large stone structure, very thick walls, rooms, halls and corridors of double height, large domes, spacious lobbies, galleries and large open spaces. They have a basement, ground, first and second floors capable of accommodating a large number of important offices.

In earlier days the space inside these buildings remained cool during summers and warm during winters on its own, due to the insulation effect of thick stone walls, imposing height of the building and natural draft of air resulting in proper ventilation. In addition there was a provision of Evaporative Type of Air Cooling (ETAC) through centralised air-washers. There are hollow masonry ducts inside the walls for flow of cool air from air-washers to rooms.

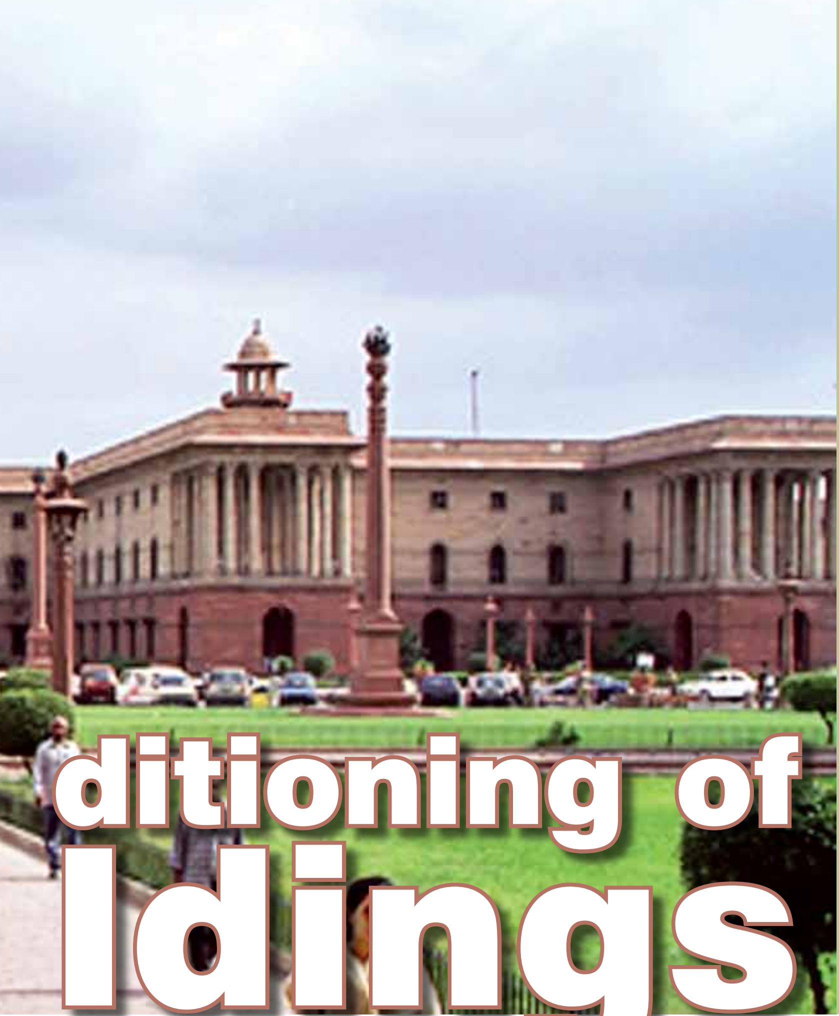
Problems of Heritage Buildings in Use

Population Pressure

Due to the increasing number and population of users of offices, most of the open spaces have been covered and a number of partitions have been created for additional office space unmindful of obstruction in ventilation and natural cooling or heating of the building.

Increase in Cooling Load and Office Equipments

The increasing use of computers, fax machines and other office equipments coupled with changing comfort requirements in the office environment have led to increasing need of air conditioning over the years, irrespective of the level of the officials or their entitlement for air conditioned office space. The evaporative type of cooling



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What is a Heritage Building?

"Heritage Building" means a building possessing architectural, aesthetic, historic or cultural values which is declared as Heritage Building by the Heritage Conservation Committee or any other competent authority in whose jurisdiction such a building is situated.

What is "Lutyen's Delhi"

Sir Edwin Lutyen was the British architect who planned the capital city of New Delhi for the British Raj when the capital was shifted from Calcutta to Delhi in the year 1911. The new city was not only to match the grandeur of the world's best cities but also merge with Indian architecture. He designed the splendid President House, Parliament House, North Block, South Block, Raj Path, India Gate, 112 bungalows including Teen Murti with magnificent sprawling green lawns, gardens, streams and fountains, wide roads and round-abouts and shady trees which were regal in their splendour. The construction of the city took about twenty years and was completed in the year 1931. The above areas are now popularly known as Central Vista and Lutyen's Bungalow Zone (LBZ). The Lutyen's Delhi is not only historically important due to its heritage value, but it acts as the lungs of the city due to its huge green cover of ecological importance making Delhi a unique city having its inner city cooler than the outer city. Seventy years later, it is on the endangered list of 100 sites published by the World Monuments Fund, New York.

has gradually given way to mushrooming window type of air conditioners (WTAC) and the split type of air conditioners (STAC) with passage of time.

Disfiguring and Defacing of Buildings

Increasing use of WTAC/STAC has resulted in disfiguring and blocking of elegant and aesthetic looking large-size beautifully carved grand wooden windows on exterior walls spoiling the outer appearance of the building which is very disappointing for the architects, heritage experts, conservationists and tourists visiting these buildings. There is a need to clear these window spaces and provide the original window shutters again to restore the glory of the buildings.

The condensate water from these air conditioners spilling all over on the exterior walls has damaged and defaced the texture of stones leaving ugly looking black scars all over. The outdoor units of split type air conditioners have blocked the large size wooden windows and the outside view from inside spoiling the exterior appearance.

Inconvenient Air Conditioning Systems

Many WTAC/STAC have been installed in corridors feeding adjacent rooms. This has resulted in undesirable spillage and littering of condensate water in corridors, blowing of undesirable hot air on the people passing through the corridors and chances of accidental hitting of the protruding part of window type of air conditioners in the corridors causing avoidable inconvenience and injury to the passersby.

Some conventional package type and central chilled water based air conditioning systems have also been provided in some buildings partially. But they have fixed time of operation. Some officials work during late hours or during holidays. But it is not possible to operate these huge air conditioning plants for one or two individual rooms during such odd times nor is it possible or economically viable to depute plant operators for such uncertainties. This has resulted in additional installation of window/

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split type of air conditioners in all such rooms to meet such contingencies compounding the problem further. Now, even during the normal working hours both the air conditioning systems are kept 'on' resulting in enormous undesirable additional burden on the electrical load with already over-loaded electric substations and distribution systems and avoidable energy consumption.

Senior officers are entitled for air conditioners whereas juniors are not. So desert coolers have been installed in the ante-rooms occupied by the assistants of the senior officers. The air of air conditioned space keeps mixing with the moist air of desert cooler through the connecting doors which is not desirable as both the systems operate on opposite principles – the window/split type air conditioners remove moisture from the air whereas the desert coolers add moisture in it. Desert coolers are a source of nuisance like spillage of water, noise, mosquitoes and dirt wherever they are installed in public buildings.

In the water based central air conditioning system the cooling towers installed on the roofs are a constant source of seepage of water spoiling the building. The nozzles of cooling towers are taken away by monkeys needing replacement quite frequently.

Shortage of Electricity and Water

There is an acute shortage of electricity and water in the city. In peak seasons we have to resort to planned load-shedding of electricity in these buildings. Sometimes diesel generators are pressed into service to meet essential and important electrical loads. In peak summers not only do we face acute shortage of electricity but also of water. It becomes difficult to meet even the requirement of bare minimum drinking water. In such a situation it becomes impossible to meet the make–up water requirement of water-based air conditioning plants.

Shortage of Space

The conventional water based central air conditioning system needs sizable standby capacity for these buildings, requiring additional space, which is not available at any cost, and additional capital expenditure.

Ducting and False Ceiling Not Possible

To maintain the architectural grandeur and heritage value of these buildings, it is not possible to provide a false ceiling in rooms or corridors for air conditioning ducts. For the same reason air conditioning chilled water pipelines cannot be run through rooms or corridors spoiling the architectural beauty of the building. With the increasing requirement of office space and its acute shortage it is not possible to provide space for conventional central air conditioning plant, chilled water tanks, cooling towers, air-handling units, air-ducts and chilled water pipelines. It is difficult to meet its water requirement in the present scenario of water shortage in peak summers. It is difficult to dig the area surrounding these buildings which is rocky and full of different kinds of very important and essential service lines like water, sewer, drain, electric /telephone/ intercom/internet/communication/security cables etc.

Roof Cleaning and Seepage of Water

One of the heritage buildings is being used as museum/ memorial. It has very old large size package air conditioning plants covering a large useful precious space needed for day-to-day functioning of the museum and display of articles, paintings, pictures or books. There are huge insulated air ducts running on the roof covering a large area making the roof inaccessible for civil repair and maintenance work resulting in seepage of water in the building thus spoiling precious articles. They want to free the roof from ducts. But the conventional central air conditioning system has no satisfactory solution to their problems.

The Challenges Ahead

On one hand we are required to restore the originality of these heritage buildings which are deteriorating day by day due to the facts mentioned above and ageing. On the other hand we have to make them functional and comfortable for the users who are of very senior level and very demanding. It is a great challenge in itself especially for air conditioning engineers.

VRF Systems Make a Good Solution

Saving of Space, Electricity and Water

Fortunately, today we have availale Variable Refrigerant Flow (VRF) system which is the next generation intelligent energy efficient air conditioning system. It provides high efficiency heating/cooling and free capacity expansion. It has a very high potential of power saving with stepless capacity control, flexible/individual quality control, flexible indoor and outdoor units, comfor control, space saving potential, self diagnostic system, flexible and versatile system design features. Its indoor and outdoor units are compact, sleek, light-weight and elegant looking. Indoor units are of wall mounted type, ducted type or cassette type with provision of fresh air, fail-safe drain pump with special drain up mechanism, corded or cordless remote controllers requiring minimal ceiling space, thus, giving the architect or the interior designer the luxury of greater ceiling heights. The outdoor units can be placed in the balcony or on the terrace eliminating the need of a separate plant room.

Eco-friendly Green Technology

The eco-friendly refrigerant R-410A used does not contain chlorine making it harmless for the ozone layer. VRF system has a highly sophisticated electronic control centre to enable zone-wise climate control.

Modular

It is the state of art technology. It can be installed and

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commissioned in a phased manner without disturbing the existing areas which is a very important aspect for these occupied and highly functional buildings. It also has a heating option available for winters.

No Standby Required

It requires no separate standby capacity as its outdoor units have multiple compressors taking care of redundancy, thus, reducing the initial capital cost, reducing recurring maintenance cost and reducing space requirement and prohibitive cost of space for installation of the system. The different room-units of the same room can be connected to different outdoor units to increase the availability of standby capacity further. This has a great impact on the initial capital cost, making it much more economical when compared to conventional central air conditioning system.

No Operator Required

No plant operators are required as it has automatic microprocessor based operation, thus reducing the cost of operation and dependence on availability of operators on holidays or late hours or odd hours during working days. The user can operate even one unit of his room through his 'remote' at any point of time round the clock consuming energy only for that one particular unit although it is a part of a central air conditioning system consisting of numerous such room units and outdoor units due to its very versatile part load efficiency, which is not possible in the conventional central air conditioning plant where the entire plant has to be run even for feeding just one room consuming disproportionately large amount of energy and needing skilled operators.

Centralized Controller and BMS in VRF System

In VRF systems each indoor unit can be linked to a centralized controller using a single 2-core transmission cable which is not possible in the central plants. Similarly each indoor unit can be linked to Building Management System (BMS) by using an adaptor and 2-core cable which is also not possible in central plants.

Lower Life-cycle Cost

No water is required for the system as it is air-cooled, thus eliminating the need of huge quantity of make water during peak summers when there is an acute scarcity of water. Indoor units can be selected based on the aesthetics of the room. No ducting is required for feeding conditioned air to individual rooms, thus, eliminating the need of false ceiling and space for ducts which is not permissible in these heritage buildings. 10 to 15 per cent energy saving on account of duct losses is achieved in the VRF system due to elimination or reduction in ducting. Individual room control (switching on/off and temperature control) is possible. Due to their excellent capacity control they have potential of energy saving on part loads which may be to the tune of 15 - 40 per cent. If we take all these factors together and attribute cost to savings on account of electricity, standby capacity, space, water, operation and maintenance, the life-cycle cost of the VRF system comes much lower than any other central air conditioning system today.

A detailed working of the annual ownership cost of VRF systems compared with split ACs and central chilled water plants is presented later in the article.

Available VRF Technologies

VRF air conditioning systems are available in two technologies :

(i) Inverter based technology.

(ii) Digital scroll compressor based technology.

The Inverter Based System allows capacity control of the indoor heating/cooling load by applying the optimized control algorithm using inverter compressor and constant speed compressor resulting in good load response, comfortable heating and cooling and energy saving.

In Digital Scroll Compressor Technology capacity is achieved by time averaging of loaded state and unloaded state of digital scroll compressor. It also allows the control to switch the compressor rapidly between its loaded and unloaded states. Digital Scroll is the next generation of modulation technology.

Misconceptions about VRF System

Threat of Toxic Refrigerant

Some people have expressed their concern about the entry of high pressure refrigerant in the conditioned area and imminent danger due to the harmful effect of toxic refrigerant. In VRF systems, refrigerant R-410A is used which is environment-friendly. VRF systems are tested at 500 psi pressure for the refrigerant gas in the pipeline. The pipeline materials are tested at a pressure of 1800 psi. Hence, there is no danger of any leakage of refrigerant in this system. However, the system being modular and the highest size of any modular unit being only 42 HP, the maximum amount of gas which may leak at a time will not be more than 35 kg. However, this gas is not toxic beyond the safe and permissible limits for human beings. Fresh air is constantly fed in the room through TFA units due to which, impact of this gas is further minimized. Over and above this, ductable units are also available which may be selected for keeping the refrigerant outside the conditioned area altogether, if so required.

Comparison with Split Type Air Conditioners

Some people consider VRF system comparable to split AC system. But VRF is a different kind of air conditioning system altogether which is very versatile. In VRF the maximum pipe length between indoor and outdoor unit can be as high as 150 meters, maximum height difference

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		VRF System 36 HP (30 TR)	Split AC 36 TR Installed 30 TR Working
1	Approx. initial cost in lacs	15.0	9.72
2A	Annual energy cost in lacs cost of power @ Rs./Kwh 6.5	3.5	8.2
2B	Cost of water @ Rs.0.1/Ltr.	NIL	NIL
3	Total operating cost (2A+2B)	3.5	8.2
4	Annual maintenance cost	0.90	0.79
5	Total ownership cost 3+4	4.4	9.0
6	Actual difference per annum (savings with VRF system)		4.58
	Payback		1.15 Years

Table 1 : Annual ownership cost comparison – VRF vs Split AC.

between indoor unit and outdoor unit up to 50 meters, and maximum height difference between indoor units up to 15 meters. It is capable of covering 12 floors of a building in one module. Higher floors can be covered by different modules of VRF as required. In case of split air-conditioners the outdoor units are required to be placed very close to their indoor units which is a limitation of this system. They are stand-alone type unitary air conditioners without fresh air facility available, in very small capacities without the feature of capacity modulation available in the VRF systems.

Table 1 shows the annual ownership cost comparison of a 30 ton VRF system and standard split ACs consisting of 20×1.5 ton units. Working details are shown in *Table 3*.

Problem in Drainage System

Some people have expressed doubts about the drainage system of indoor units and leakage of condensate water inside rooms. The VRF system has in-built features of having drain pumps in every room unit and drain piping which may be joined to a common header. No such problem of leakage of water has been experienced in this system.

De-rating of VRF System

Doubts have been expressed about the de-rating of the system at higher temperatures and exposure of the metal structure of the outdoor units to the sun. De-rating at higher temperatures is common in all air conditioning systems. There is nothing exclusive for VRF system in this regard. The system has been designed to take care of metal temperature of condenser on account of exposure to sun. It has been designed and tested for an ambient temperature as high as 52° C.

High Noise Level

Concern has been raised about the sound levels of VRF system which is unfounded. The outdoor units have a sound level of less than 60 db. The indoor units have

		Water Cooled Chiller 200 TRx3 2W + 1S	Air Cooled Chiller 220 TR x 3 2 W + 1S	VRF System 480 HP (400 TR)
1	Approx. Initial cost in lacs	225	225	210
2A	Annual energy cost in lacs cost of power @ Rs./ Kwh 6.5	56.0	80.6	51.3
2B	Cost of water @ Rs.0.1/Ltr.	10.80	NIL	NIL
3	Total operating cost (2A+2B)	66.8	80.6	51.3
4	Annual maintenance cost	10	11	12
5	Total ownership cost 3+4	76.8	91.6	63.3
6	Actual difference per annum (savings with VRF system)	13.5	28.3	

Table 2 : Annual ownership cost comparison – Central CHW System vs VRF

SPLIT AC SYSTEM						
OUTDOOR UNITS				TR		TOTAL TR
1.5 TR Cooling Only		NOS	20	1.5		30
OPERATING HOURS 10 Hrs / Day × 25 Days in Month × 12 Months = 3000 SAY 3000						
		LOAD		TOTAL SYSTEM		
Ambient as per ARI	TR		OP. HRS	IKW/TR	IKW	KW-HRS (UNITS)
Power Consumption of Splits	30.0	100%	3000	1.40	42	126000
			3000	TOTAL		126000
Effective / Net Power Consumption Considering. That Compressor will be working for 70 % of the total time						88200

VRF SYSTEM						
OUTDOOR UNITS				TR		TOTAL TR
15 TR (18 H.P.) Cooling Only		NOS	2	14.976		29.952
OPERATING HOURS 10 Hrs/Day × 25 Days in Month × 12 Months = 3000 SAY 3000						
		LOAD		TOTAL SYSTEM		
Ambient as per ARI	TR		OP. HRS	IKW/TR	IKW	KW-HRS (UNITS)
110°F (43.3°C)	30.0	100%	30	1.30	39	1170
100°F (37.8°C)	22.5	75%	1260	1.10	25	31185
90°F (32.2°C)	15.0	50%	1350	0.95	14	19237.5
80°F (26.6°C)	7.5	25%	360	0.82	6	2214
			3000	TOTAL		53806.5

LOAD	%HRS	
100	1%	as per ARI 550/590-98
75	42%	
50	45%	
25	12%	

Table 3 : Comparison of working details of a split AC system and a VRF system

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AIR-COOLED SCREW CHILLERS

CHILLER	220 TR X 3 NOS.	2W + 1S
PUMP CHW	15 HP X 3 NOS.	2W + 1S
AIR HANDLING UNITS (10000 CFM X 16 NOS.)	7.5 HP x 16 = 120 HP	

OPERATING HOURS
10 Hrs/Day × 25 Days in Month × 12 Months = 3000 SAY 3000

SCHEME	TR	LOAD	OP. HRS	CHILLER	CHW PUMP		AHU	TOTAL IKW	KW-HRS (UNITS)
				IKW/TR	IKW	IKW	IKW		
2W	440.0	100%	30	1.300	572	25	90	687.00	20610
2W at part Load	330.0	75%	1260	1.150	380	25	90	494.50	623070
2W at part Load	220.0	50%	1350	1.200	264	25	90	379.00	511650
1W at part Load	110.0	25%	360	1.200	132	12.5	90	234.50	84420
			3000		**TOTAL**				**1239750**

LOAD	%HRS	
100	1%	as per ARI 550/590-98
75	42%	
50	45%	
25	12%	

VRF SYSTEM

OUTDOOR UNITS			TR	TOTAL TR
35 TR (42 H.P.) Heating + Cooling	NOS	12	35	420
17.5 TR (21 H.P.) Heating + Cooling	NOS	1	17.5	17.5
				437.5

LOAD	%HRS	
100	1%	as per ARI 550/590-98
75	42%	
50	45%	
25	12%	

OPERATING HOURS
10 Hrs / Day × 25 Days in Month × 12 Months = 3000 SAY 3000

AMBIENT AS PER ARI	TR	LOAD	OP. HRS	TOTAL SYSTEM		KW-HRS (UNITS)
				IKW/TR	IKW	
110°F (43.3°C)	440.0	100%	30	1.30	572	17160
100°F (37.8°C)	330.0	75%	1260	1.10	363	457380
90°F (32.2°C)	220.0	50%	1350	0.95	209	282150
80°F (26.6°C)	110.0	25%	360	0.82	90	32472
			3000	**TOTAL**		**789162**

WATER-COOLED SCREW CHILLER

CHILLER	200 TR X 3 NOS.	2W + 1S
PRIMARY PUMP CHW	10 HP X 3 NOS.	2W + 1S
SECONDRY PUMP CHW	12.5 HP X 3 NOS.	2W + 1S
CONDENSER WATER PUMP incl CT fan	15 HP X 3 NOS.	2W + 1S
AIR HANDLING UNITS (10000 CFM X 16 NOS.)	120 HP	

OPERATING HOURS – 10 Hrs/Day × 25 Days in Month × 12 Months = 3000 SAY 3000

SCHEME	TR	LOAD	OP. HRS	CHILLER		PRIMARY CHW PUMP	SECONDRY CHW PUMP	NET AFTER SAVINGS with VFD	CDW PUMP	AHU	TOTAL IKW	
				IKW/TR	IKW	IKW	IKW	@30%	IKW	IKW		KW-HRS (UNITS)
2W	400.0	100%	30	0.720	288	15	18.75	13.125	22.5	90	428.63	12859
2W at part Load	300.0	75%	1260	0.650	195	15	18.75	13.125	22.5	90	335.63	422888
1W	200.0	50%	1350	0.720	144	7.5	18.75	13.125	11.25	90	265.88	358931
1W at part Load	100.0	25%	360	0.650	65	7.5	18.75	13.125	11.25	90	186.88	67275
			3000							**TOTAL**		**861953**

OPERATING HOURS – 10 Hrs/Day × 25 Days in Month × 12 Months = 3000 SAY 3000

LOAD	%HRS	
100	1%	as per ARI 550/590-98
75	42%	
50	45%	
25	12%	

TR	LOAD		
		OP. HRS	TOTAL TR
400.0	100%	30	12000
300.0	75%	1260	378000
300.0	50%	1350	405000
100.0	25%	360	36000
		3000	831000

Average load per hour $\frac{831000}{3000} = 277$

Table 4 : Comparison of working details of a central chilled water system with either air-cooled or water-cooled screw chillers and a VRF system

a sound level of about 31 db. On the other hand in case of a central chiller, the sound levels are in the vicinity of 85 db, due to which acoustic lining of the plant rooms is essential.

Comparison with Central Chiller System

Energy Saving on Part Loads :

Some people compare the efficiency in terms of cooling achieved per kW by screw chillers at their designed load with the VRF system at full load. It is not proper to compare just a component of the entire air conditioning plant namely screw chiller with the complete VRF system. It is also not proper to compare their performance only at full load. The conventional chiller based air conditioning plant has other major

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Table 5 : Comparison between Chilled Water Systems & Variable Refrigerant Flow Systems for Existing Buildings

S.No.	Criteria / Basis	CHILLED WATER SYSTEMS	VARIABLE REFRIGERANT FLOW SYSTEM
1	Civil & Building Design	Need to access and ascertain capability of the civil structure to take additional equipment load like chillers, pumps, CT, AHU etc.	Generally would be easy to place on the terrace or outside the building since the equipments are modular and smaller in size
2	Installation	It is not possible to execute the job without evacuating the people from the premises since major work is involved within the building.	Jobs can be planned and executed in a zone / floor-wise manner without complete evacuation of the premises.
3	False Ceiling	False ceiling is must	False ceiling can be avoided with high wall type indoor units (In heritage buildings and low ceiling height buildings where false ceiling can't be done VRF system is the only possibility)
4	Heating & Cooling	In Delhi, summer cooling and winter cooling is essential. With chilled water system, separate heaters are required which is generally not conducive to health.	This provides cooling as well as reverse cycle heating. System is also more efficiencent in comparison to heaters, thus resulting in huge power saving.
5	Electrical infrastructure	Requirements of heavy electrical equipments / HV - network - to operate higher installed capacity chillers for screw / centrifugal chillers >500 TR with higher operating voltage 3.3/6.6 KV	Heavy electrical equipments are not required as all VRF systems operate at 415V/3ph/50Hz only
6	Interior false ceiling heights	Typically, ducts and chilled water piping would result in low head room within the premises.	Refrigerant piping being smaller in size, ensures that enough head room is available inside the premises.
7	Operational Efficiency	Partload efficiency not very good. In a big building when only small area is occupied during late evening or on holidays, Running of Chilled Water System is highly uneconomical	Lowest part load even 10% can be managed and controlled resulting in substantial power savings. Ruuning a small area only out of total big installation is possible with very low power consumption
8	Humidification	Humidity can be augmented in winters through separate humidification system	Humidity can be augmented in winters through separate humidification system
9	Dehumidification	Standard dehumidification	Better dehumidification due to direct cooling of air with refrigerant gas
10	Power Consumption	The system IKW results in 1.1 KW/TR at full load (with the most efficient centrifugal chillers with IKW/TR as low as 0.6) which goes to as high as 2.1 KW/TR at 50% Load	The system IKW is 1.2 KW/TR at full load and goes as low as 0.82 KW/TR at 25% load resulting in power savings at part loads
11	Installation feasibility	Work needs to be carried out in one go, or in case done on phased manner will disturb whole area and calls for shutdown of whole system for commissioning, ducting is not avoidable	Machines can installed in phased manner, expansion will not disturb the existing areas and no shutdown required for commissioning, ducting can be avoided with high wall type and cassette type indoor units
12	Space	Plant room required for keeping the chiller, pumps, electrical panel etc., also AHU rooms are required	No plant room required
13	System Redundancy	Stand by unit is required including chiller, pumps etc. In case of failure of chiller the air-conditioning gets affected to the tune of 25%-50% depending upon plant size	No separate standby required. built in standby. each outdoor has multiple compressors. In case of any compressor failure, it hardly affects the total system capacity
14	Water Requirement	If looking for water-cooled system with low power consumption, water source and availability in adequate quantity to be assessed. Also reqular consumption of water increases the operational cost.	No water required for the entire operation. The system is designed for 52°C able to provide much higher efficiency at partloads equal to a water cooled system.
15	Operation and Maintenance	Required manpower to operate and maintain the chiller during operating hours	No manpower required to maintain on day-to-day basis. Fully operated and maintained through one man computer control. Basic services such as cleaning of coil and filters are more than sufficient to maintain the system
16	Thermal Storage	In case of power failure the large quantity of water available in chilled water piping acts as thermal storage and conditioned space will continue to have air-conditioning (if AHU's fan motor can be run on standby supply) for 25-30 minutes depending upon size of installtion	In case of power failure the cooling will stop immediately.
17	Power failures and Standby	In case of power failures, backup power requirements, location of gensets, cooling system, exhaust arrangements have to be made for the full building. In the absence of large power supply, standby arrangement, total chiller breakdown and total cooling failure, solution for change over to partload/ specific area cooling solution.	Depending upon the backup power quanity, essential areas can only be operated to maintain cooling. e.g. hospitals - all ICU's, operation theatres etc, leaving common areas without cooling
18	Control and Operation	Will require more of power cabling network from units to chillers and to control room.	No separate plant / control room is required and can be controlled through a PC and all indoor / outdoor units are independently powered and network done by two core communication cable.

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components like primary chilled water pumps, secondary chilled water pumps, condenser pumps, cooling tower fans, AHU blower fan, AHU pump etc apart from the chiller which keep consuming considerable amount of energy on constant basis irrespective of the actual air conditioning load on the system. Due to variation of temperature from morning to evening and at night, from day to day and month to month and variation in occupancy, air conditioning plants run on part loads in the vicinity of 40 – 75%, most the time. On part loads the conventional chiller based air conditioning systems become relatively inefficient compared to the VRF systems which are capable of saving 15 – 40% of energy on part loads. On the contrary, on part loads the energy consumption in Chiller system increases and its response to changes in loads is very slow.

Table 2 shows the annual ownership cost comparision of a 400 ton VRF system and a central chilled water system of the same capacity consisting of screw chillers, either water cooled or air cooled. Working details are shown in *Table 4*.

Temperature Control Precision :

The Chiller system is found totally incapable of maintaining precision in controlling temperatures in individual rooms at different levels as per requirement of different individuals whereas in a VRF system individuals can set their room temperatures according to their own choice and change it at their will through their 'remote' and different rooms can be set at different temperature.

In a VRF system each indoor unit can achieve a very precise temperature control of +/– 0.5°C whereas the Chiller system is capable of achieving control of only +/–2°C.

Use of VFD :

Some people are of the opinion that very efficient Chiller systems are available in the market and we can use Variable Frequency Drives (VFDs) with them to achieve energy saving comparable to VRF systems. First of all, the VFD systems are very costly. Secondly, the energy saved by them in various drives will be much less than VRF systems in which part load operation is possible from 10% to 100% of full load in steps of 1% variation in capacity.

Maintenance :

Problem due to Modular Nature : Some people have opined that the maintenance of VRF system is difficult and costly due to its modular nature. Since the VRF system is in modular composition, it is easier and simpler to maintain it. The entire area need not be shut down for this purpose as in the case of Chiller system. The cost of maintenance is not higher. Its installation and commissioning can also be done in phases without disturbing the entire area due to its modular nature which is not possible in the Chiller system.

Difficulty in Cleaning of Filters : Some people have pointed out that cleaning of filters and maintenance of indoor units of VRF system from inside the rooms is difficult and disturbing to the user. But no such problem has been faced practically so far. Cleaning/maintenance can be done on any holiday or even during working days before or after office hours or when the room is not in use quite easily. However, ductable units are also available in VRF system, which can be kept outside the room and there is no requirement for entering into the rooms altogether for maintenance.

Problem of Electro-magnetic Interference :

An issue has been raised about the undesirable electromagnetic interference by the VRF system. In fact, the Digital Scroll Compressor based VRF systems have no such problems as no harmonics are produced.

Conclusion

To preserve the heritage character and grandeur of these buildings, neither ducting nor false ceiling in the corridors and rooms are permitted, nor running of exposed large size insulated chilled water pipe lines for central air conditioning. Moreover there is no space available for providing central air conditioning plant, air-handling unit rooms or cooling towers. The availability of a huge quantity of make-up water for chilled water system and cooling towers is also a big question mark in the present day scenario of all-round water scarcity in Delhi. It is also difficult to run chilled water pipelines around the buildings due to rocky nature of the ground, stone structure and multiplicity of essential services in the form of the pipelines/ducts/cables etc. existing around the buildings.

Providing central air conditioning in these prestigious buildings has remained a challenge for the air conditioning engineers so far. This challenge has now been accepted by the VRF based central air conditioning system which does not require ducting, false ceiling, water and space for a plant room and air handling unit rooms. It does not require space for large size insulated chilled water pipelines. It has best energy efficiency on part loads. It is capable of saving energy from 15 to 40% in varying ambient/occupancy/inside conditions during daytime and also from season to season. The existing masonry ducts in the rooms available from top of the building can be used for refrigerant/fresh air/humidification piping which will not be visible. The aesthetic look and design features of this system are an architects' delight.

(*Note : The views expressed here by the author are purely in his personal capacity and have no connection with his official functioning or official policies*.) ❖