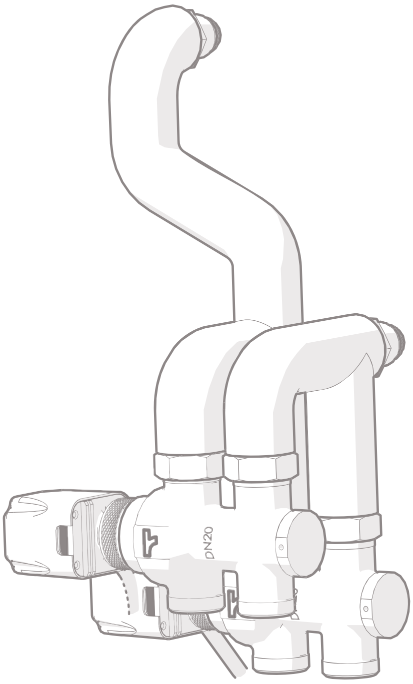
01/2013-EN

TECHNICAL FOCUS

THE NEW WAY TO PROVIDE COMFORT IN 4 PIPES SYSTEMS APPLICATIONS

COMFORT SOLUTIONS

The use of the Aermec VCF_X4 valve allows to carry out 4-pipe systems with traditional fan coil units, fitted with a single coil, providing an average energy saving of up to 30% (depending on the application), as well as a significant reduction in the cost of installation and materials required.



VCF_X4

This document presents the energy saving and economic advantages available with the use of the VCF_X4 valve specifically designed by Aermec for 4-pipe fan coil unit systems. These innovative 3-way valves are proposed as an alternative solution to the double traditional 3-way valves normally installed in 4-pipe systems with terminal units equipped with double coils. Through VCF_X4 valve considerable energy savings can be obtained, thank to the only one coil use for heating and cooling purposes. The best benefit of this solution takes place, especially in the winter, where is available of a larger heat exchanger area, rather than the usual secondary 1 row coil.
In this way the system is simplified and the installation requirements are reduced, as well as significantly improving the overall system efficiency. This allows the energy sources, particularly heat pumps, to operate with the highest seasonal energy efficiency levels reducing consequently the primary energy consumption, as well as an improvement in the system performance of the building-installation.

SUMMARY

Chapter 1
INTRODUCTION

In modern buildings for commercial sector, the systems using fan coil units with fresh air supply are becoming increasingly more common. This type of system allows the individual temperature control of each room, independently from the others, and a notable flexibility of use and operation.

With this type of system the possible hydraulic solutions are 2-pipe and 4-pipe. In 2-pipe systems the fan coil units are fitted with a single coil and are supplied with chilled water in the summer, and hot water during the winter. In this type of system it is not possible to meet simultaneous heating and cooling demands in different office spaces at the same time. The 4-pipe systems, typically having double coils in the fan coil unit, can respond to the heating and cooling demands of each space throughout the year, keeping simultaneously active the two hydraulic circuits serving these double coils.

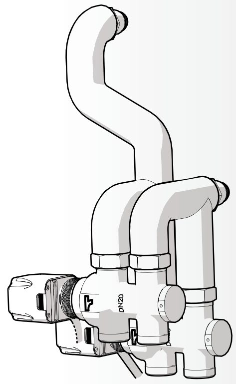
This type of system, besides being used in office applications, is also found in commercial sectors and particularly in shopping mall where there can be cooling demands even in the heating season.

WHY SELECT A 4-PIPE SYSTEM.

Main reasons to choose a 4-pipe system:

- Service sector buildings growth headed towards architectural solutions with large glazed areas and lightweight walls, characterised by a low thermal inertia.
- An increased demand in the flexibility of the use of space that creates a random component when defining loads.
- Performance flexibility and simplified plant: the possibility of extending the number of terminal units and hence the capacity of the installation.
- High levels of ambient comfort and air quality derived from the fact that the system has an elevated automatic adjustment to controlling simultaneous loads.
- Maximum energy efficiency: low energy consumption with the possibility of using high performance energy sources with heat recovery or multipurpose units.

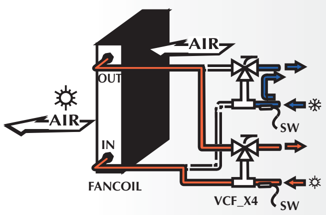
VCF_X4: THE PRODUCT



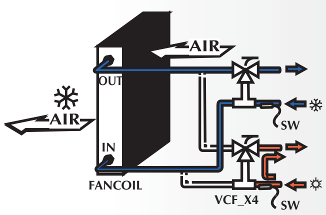
VCF_X4L:
Valve kit for left hand fan coil unit connections.

VCF_X4R:
Valve kit for right hand fan coil unit connections.

VCF_X4: THE OPERATING LOGIC



Heating mode operation.



Cooling mode operation.

Chapter 2
VCF_X4: THE AERMEC SOLUTION FOR 4-PIPE SYSTEM

The traditional terminal unit used for 4-pipe solutions is the fan coil unit with double coil. This is supplied with a main larger coil (3 rows) for connection to the chilled water circuit, and a smaller coil (1 row) which is connected to the hot water circuit. Each coil has a 3-way or 2-way valve to control the water flow rate. The opening of the valve is controlled by the thermostat and regulates the output capacity, in heating or cooling, to balance the demands of the space being conditioned.

One of the fundamental limits of this solution is due to the size of the coils, and in particular, that of the heating coil (1 row), which cannot be increased due to space constraints. This requires the available single row to be supplied with water at medium or high temperatures, to satisfy the heating loads.

Aermec, forever concerned with energy savings, has provided a technical solution to resolve the problem mentioned above. With just one coil, of 3 or 4 rows, for each fan coil unit, and with the innovative VCF_X4 valve, this coil can be alternatively connected to the two water circuits. This allows the increased heat exchanger surface area to provide an improved efficiency in heating mode. Consequently, there is the possibility of supplying the coil with a reduced heating system. Advantages can be achieved in terms of energy savings, and hence economic savings, with traditional energy sources (condensing boilers) and particularly with heat pump units and multipurpose units.

"Daily Express" Head Office
London [UK]
Aermec: Reference Book

"Bellissimo" Business Centre
Sofia [Bulgaria]
Aermec: Reference Book

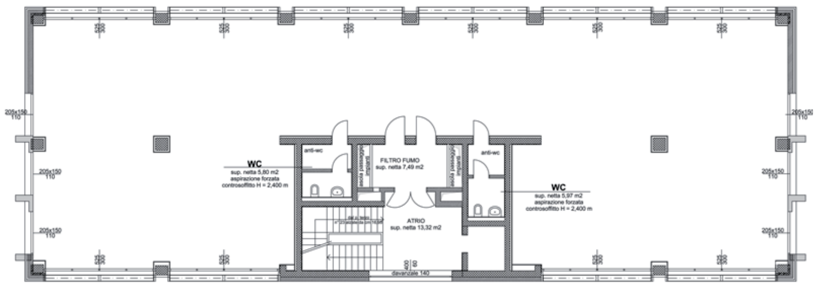
Chapter 3
THE VCF_X4 APPLICATION VALVE IN 4-PIPE SYSTEMS FOR GLAZED OFFICE BUILDINGS

The system considered consists of a typical installation for 4-pipe fan coil units and fresh air supply plant serving an externally glazed office building. To provide a complete overview the energy analysis has been made with the same type of design (building/system), simulated in three different European locations:

- Stockholm (climatic zone **Colder**)
- London (climatic zone **Average**)
- Rome (climatic zone **Warmer**)

The three reference locations allow us to analyse the building/system using three different climatic zones, as suggested in the standard EN 14825:2011:

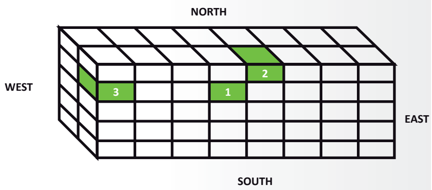
- Colder
- Average
- Warmer



The characteristics of the building are as follows:

- Each floor area is 576 m^2
- Each floor is 3 metres high
- There are 4 floors
- The building total gross air conditioned volume is 7000 m^3
- The building total floor area is 2300 m^2
- Each floor is constructed with 2 rows of offices
- All spaces are air conditioned.

Each office, which represents about the same floor area of 42 m^2, has the same occupancy profile of 5 people, normal office equipment such as printer, fax, etc. The heating and cooling loads have been calculated and classified into three types; within each type we summarise offices with similar characteristics for surface losses, evaluating the peak loads, also as a function of exposure. By way of example the peak loads of the offices with the greatest exposure are shown. The largest cooling loads occur to the spaces exposed west-south west.



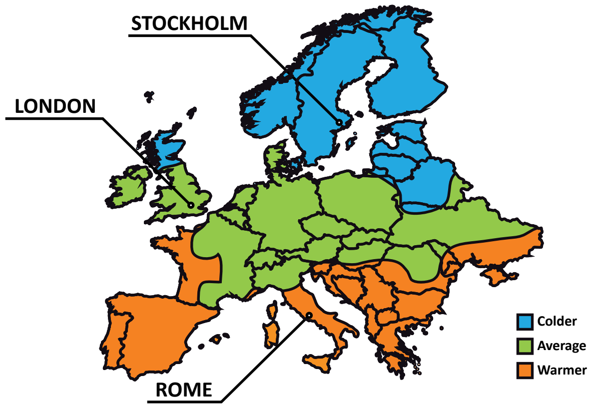
Configuration and location of office spaces for the building analysed.

Office type:	Characteristics:	Exposure:
1	Intermediate floor, confined on two sides by other air conditioned offices	West
2	Top floor, confined on two sides by other air conditioned offices	West
3	Intermediate floor, confined on one side by other air conditioned offices	South-West

Estimation of heating and cooling loads for each space

To offer a complete overview of the different climatic conditions the loads have been analysed for three representative climatic locations, as previously illustrated. The office analysed is an externally glazed building for office use, located in these three climatic zone, and is used for a total of 3560 hours per year (occupied from the hours of 06:00 to 20:00 for 254 days per year).

The climatic zones show graphically in the adjacent map represent an indicative average European temperature.



Offices with 5 people, Stockholm:

Office	Heating load W	Total cooling load W	Sensible cooling load W
Office 1	3022	4157	3712
Office 2	4978	4736	4291
Office 3	6149	5130	4685

Offices with 5 people, London:

Office	Heating load W	Total cooling load W	Sensible cooling load W
Office 1	1738	4311	3866
Office 2	2862	4911	4466
Office 3	3536	5320	4875

Offices with 5 people, Rome:

Office	Heating load W	Total cooling load W	Sensible cooling load W
Office 1	1512	5539	5090
Office 2	2489	6489	6044
Office 3	3075	6782	6337

FCX 32 AS

FCX 32 AS
WITH VCF_X4 VALVE USED

FCX 32 P

FCX 32 P
WITH VCF_X4 VALVE USED

As a function of the peak loads in these offices the size of terminal unit (4-pipe fan coil units) are selected, based on three considered technical solutions:

a) FCX fan coil unit with 3 row chilled water coil and 1 row hot water coil and one VCF valve for each coil.
b) FCX fan coil unit with single 3 row coil and VCF_X4 valve.
c) FCX fan coil unit with single 4 row coil and VCF_X4 valve.

For the locations mentioned has been selected the size of fan coil unit to meet the peak heating and cooling load, at medium fan speed and double coils at 7°C/12°C chilled water, 45°C / 40°C hot water temperatures. From the same size of fan coil unit and at the same operating conditions, the performances for the technical solutions b) and c), using the valve VCF_X4, have been determined. The following table shows the data evaluated for Stockholm, which clearly shows that the solution b) with a single 3 row coil, thanks to the larger heat exchanger area, has a heating capacity greater than required. The solution c) with a 4 row coil, having an even greater surface area, has a greater cooling capacity than the previous two solutions and an even greater heating capacity.

Fan coil units selected performance (at medium speed)

	Fan coil units selected	P heating W (45°C/40°C)	P total cooling W (7°C/12°C)	P sensible cooling W (7°C/12°C)
Office 1, solution a	FCX 82 AS + BV 162 + VCF 43 + VCF 45	3135	5372	3777
Office 1, solution b	FCX 82 AS + VCF3X4	6342	5372	3777
Office 1, solution c	FCX 84 AS + VCF3X4	7018	7319	4873
Office 2, solution a	2 FCX 82 AS + 2 BV 162 + 2 VCF 43 + 2 VCF 45	3135 x 2	5372 x 2	3777 x 2
Office 2, solution b	2 FCX 82 AS + 2 VCF3X4	6342 x 2	5372 x 2	3777 x 2
Office 2, solution c	2 FCX 84 AS + 2 VCF3X4	7018 x 2	7319 x 2	4873 x 2
Office 3, solution a	2 FCX 82 AS + 2 BV 162 + 2 VCF 43 + 2 VCF 45	3135 x 2	5372 x 2	3777 x 2
Office 3, solution b	2 FCX 82 AS + 2 VCF3X4	6342 x 2	5372 x 2	3777 x 2
Office 3, solution c	2 FCX 84 AS + 2 VCF3X4	7018 x 2	7319 x 2	4873 x 2

This case gives the opportunity to reduce the feeding heating water temperature, compatible with a generated heating capacity to meet the load, for the single 3 row coil, and particularly for the single 4 row coil. In the latter case it is also possible to raise the chilled water temperature, with consideration for the total and latent cooling loads.

Particularly for the choice of the 4 row coil, the larger heat exchanger area ensures a comfortable supply air temperature in heating mode, even with particularly low water temperatures (35°C); the supply air temperatures exceeds 30°C for all unit sizes selected.

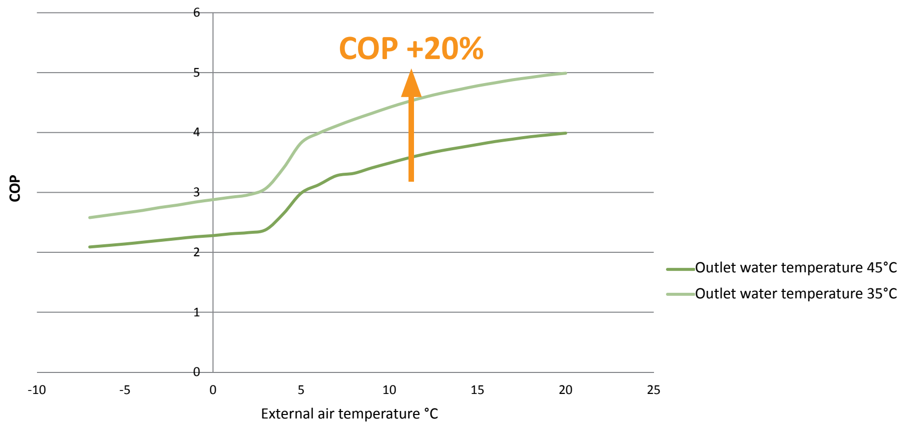
The table below summarises the supply water temperatures to the fan coil unit which have been considered. These values are the results of considerations made in arriving at the final identified values which are compatible with the loads to be satisfied.

FAN COIL UNITS SUPPLY WATER TEMPERATURE

	T heating supply water	T cooling supply water
3 rows + 1 row, 2 valves	45°C	7°C
3 rows, VCF_X4 valve	35°C	7°C
4 rows, VCF_X4 valve	35°C	9°C

ESTIMATION OF INCREASING ENERGY EFFICIENCY FOR THE MULTIPURPOSE UNIT, MODEL NRP 0700 A4, IN HEATING MODE, WITH THE USE OF THE VCF_X4 VALVE THAT ALLOWS A REDUCTION IN SUPPLY WATER TEMPERATURE FROM 45°C TO 35°C.

HEATING OPERATION
Efficiency variations in heating operation for the multipurpose heat pump unit, model NRP 0700 A4, with change of external air temperature and leaving water setpoint.



Note:
In the example given a multipurpose 4-pipe unit, model NRP 0700 A4 has been used. Heating capacity 173 kW / COP 3.28 / Nominal conditions 40/45°C water, 7°C db ambient. Considering the required heating capacity, with a 4 row coil this can be achieved with a lower water temperatures. The change from a leaving water setpoint of 45°C to 35°C of the energy source, in heat pump mode, for the multipurpose unit NRP 0700 A4, results in an average efficiency increase of 20% (relating to full load COP), when evaluated with the change of external air temperature.

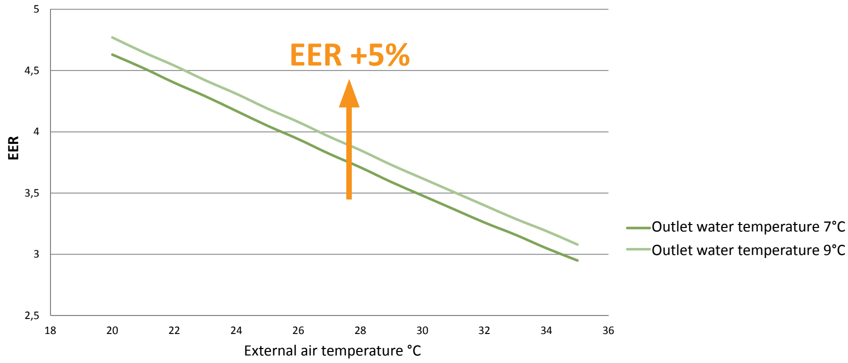
COOLING OPERATION

Efficiency variations in cooling operation for the multipurpose heat pump unit, model NRP 0700 A4, with change of external air temperature and leaving water setpoint.

BOILER EFFICIENCY CHART

Percentage capacity variation of the boiler as a function of the system water temperature.

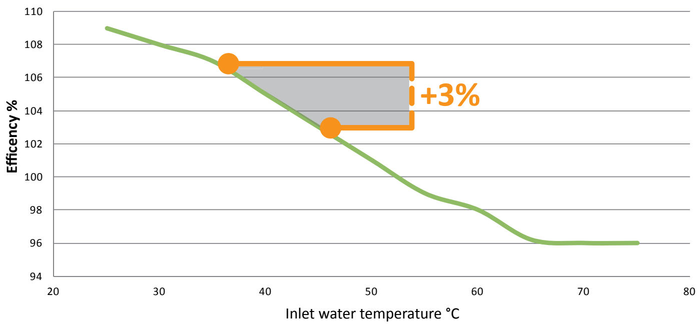
ESTIMATION OF INCREASING ENERGY EFFICIENCY FOR THE MULTIPURPOSE UNIT, MODEL NRP 0700 A4, COOLING MODE, WITH THE USE OF THE VCF_X4 VALVE THAT ALLOWS AN INCREASE IN SUPPLY WATER TEMPERATURE FROM 7°C TO 9°C.



Note:
In the example given a multipurpose 4-pipe unit, model NRP 0700 A4 has been used.
Cooling output 160 kW / EER 2.95 / Nominal conditions 12/7°C water, 35°C db ambient.
Similar to the earlier heating mode, it is possible to satisfy the cooling load by a temperature increase from 7°C to 9°C for the chilled water setpoint.
NRP 0700 A4 responds with an average increase of 5% in terms of EER.

Even the condensing boiler efficiency changes depending on the water temperature produced: going from 45°C to 35°C we get an average efficiency increase equivalent to 3%.

CONDENSING BOILER EFFICIENCY AS A FUNCTION OF RETURN WATER TEMPERATURE.



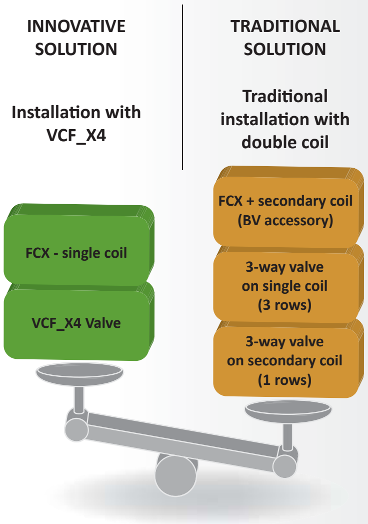
Note:
In the example given a floor mounted condensing boiler with modulating heating capacity has been used.

- Stockholm: 189 kW
- London: 112 kW
- Rome: 88 kW

Efficiency: 1.07 (reference lower heating capacity value of natural gas).

The simulations run for the other climatic locations considered lead to the same conclusions: the best energy efficiency solution is that with the VCF_X4 valve combined with the 4 row coil, supplied with hot water at 35°C and chilled water at 9°C.
This solution best exploits the advantages of the VCF_X4 valve, which will be quantified in the following paragraphs.

Chapter 4
ECONOMIC ADVANTAGES OF THE VCF-X4 VALVE SOLUTION COMPARED TO TRADITIONAL FAN COIL UNIT WITH DOUBLE COILS AND DOUBLE VALVES



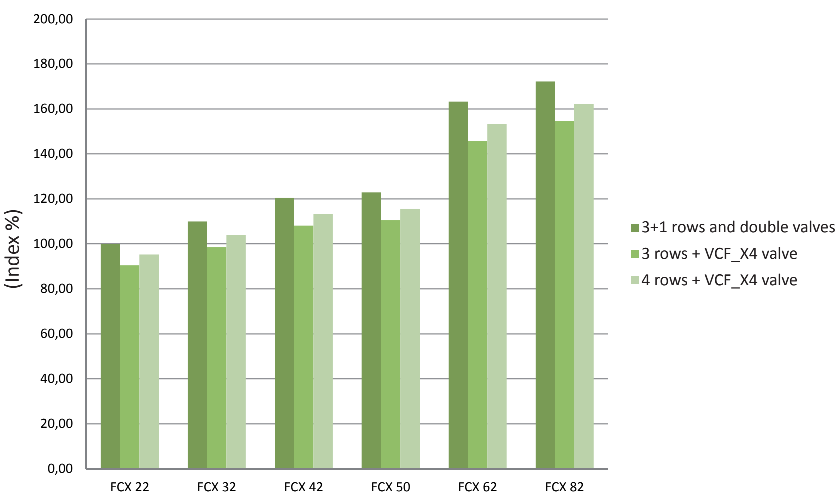
Uswally the use of higher energy efficiency solutions represents an economic investment; solutions that involve higher initial costs, but generate savings in the future thanks to less management costs. The investment is as so much advantageous as the sistem Life Cycle Cost (LCC) becomes little.

The use of fan coil units with a single 4 row coil, with the VCF_X4 valve, provides the customer with another advantage from the installation point of view: few resources are needed relating to the number of components. In the following tables the prices for the fan coil units in their available versions, with and without the VCF_X4 valve kit, are summarised and quantified, making reference also to the differences in installation cost.

INDEX % PRICE OF THE INSTALLED FAN COIL UNIT BASED ON UNIT SIZE (MATERIALS ONLY):

- FCX fan coil unit with double coil (3+1 rows) and double 3-way valve
- FCX fan coil unit with single coil (3 rows) and VCF_X4 valve
- FCX fan coil unit with single coil (4 rows) and VCF_X4 valve.

NOTE:
To give an idea of the economic advantage derived from using the VCF_X4 valve the value of a model FCX 22 fan coil unit, with 3 row single coil and supplementary 1 row coil, and their relative valves, is defined as the 100% value against which all the other values are referred. The chart does not represent price values, just the relative percentage depending on the models and configurations.



INSTALLATION FUNCTIONS:

Traditional double coil and double valve estimation:

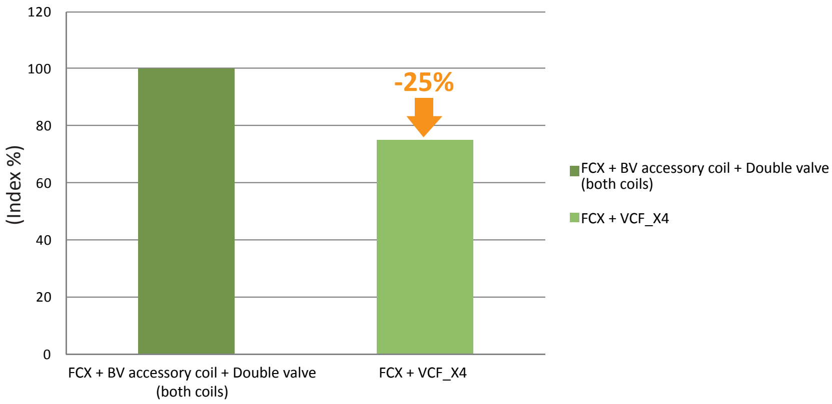
- Fit insulated pipes
- Fit valve assembly (**4** connections **x2**)
- Connect the system hydraulic pipes to the valve body (**x2**)
- Fit actuator to the valve body (**x2**)
- Fix air probes
- Connect the actuator electrical cables (**x2**) to the electronic circuit board/ panel.

Innovative Aermec system with single VCF_X4 valve estimation:

- Fit insulated pipes
- Fit valve assembly (**6** connections)
- Connect the system hydraulic pipes to the valve body
- Fit actuators to the valve bodies
- Fix air probes
- Connect the actuator electrical cables to the electronic circuit board/panel.

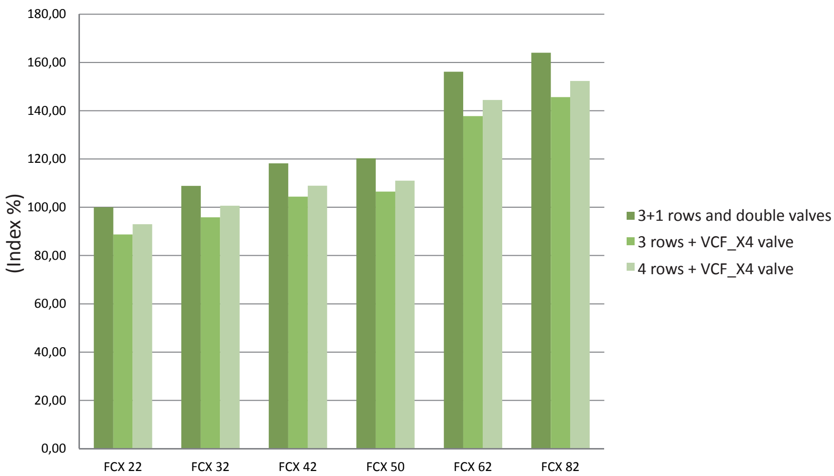
NOTE:
The graph shows an indication of the economic estimation including the average costs of installation for fan coil units.
The values are compared against the smallest FCX 22 fan coil unit with double coil and double valve, represented as the 100% baseline.

ESTIMATION OF INSTALLATION TIME SAVINGS FOR UNIT WITH VCF_X4 VALVE (INSTALLATION LABOUR ONLY)



The installation time for fan coil units with a single coil and the VCF_X4 valve are less than the traditional solutions with double coils and hence double valve.
An estimation made on installation tests carried out by qualified personnel shows a saving of 25% in time compared to that required to connect the traditional solution with double valves and related actuators.

INDEX % COMPREHENSIVE (LABOUR + MATERIALS)



Summarising, the new Aermec VCF_X4 valve solution brings to reduction in number of components required and in assembly time of the unit. The evaluated 25% reduction in site installation time results in increased efficiency and competitiveness compared to traditional solutions.

NRP 0750 A4

Multipurpose NRP unit
Unit designed for 4-pipe systems, capable to provide simultaneously heating and cooling capacities in any proportion to satisfy each requirement.

Application examples:
- Shopping mall
- Multi-use buildings
- Hotels
- Business centres

Chapter 5
SELECTION OF THE ENERGY SOURCES FOR HEATING AND COOLING

Basing on the peak building loads we proceed to choose the energy sources.

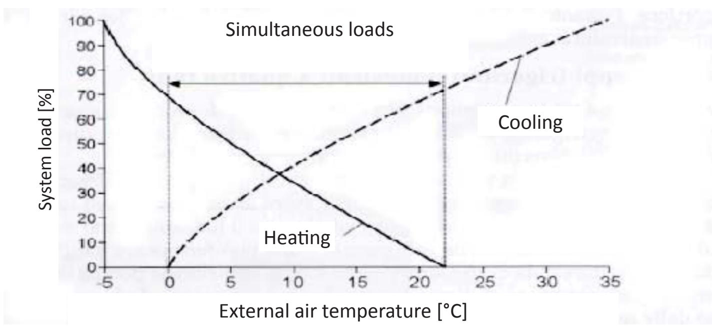
Two solutions are considered:
- Traditional solution, with air-water chiller and condensing boiler.
- Higher energy efficiency solution, with multipurpose Aermec unit, series NRP, for 4-pipe systems.

Energy sources heating-cooling

City	P cooling kW	P heating kW	Traditional solution	High efficiency solution
Stockholm	161	191	NRL 0650 A + boiler	NRP 0650 A4
London	168	116	NRL 0700 A + boiler	NRP 0700 A4
Rome	209	93	NRL 0800 A + boiler	NRP 0800 A4

In the calculation of the peak loads and for all the partial loads, the fresh air AHU has been calculated considering its coils fed with water at the same temperature of fancoils.

The energy cost, CO_2 emissions and primary energy requirements for the three climatic zones has been evaluated for the variations in peak heating and cooling load, as a function of external air temperature, as shown in the graph below.

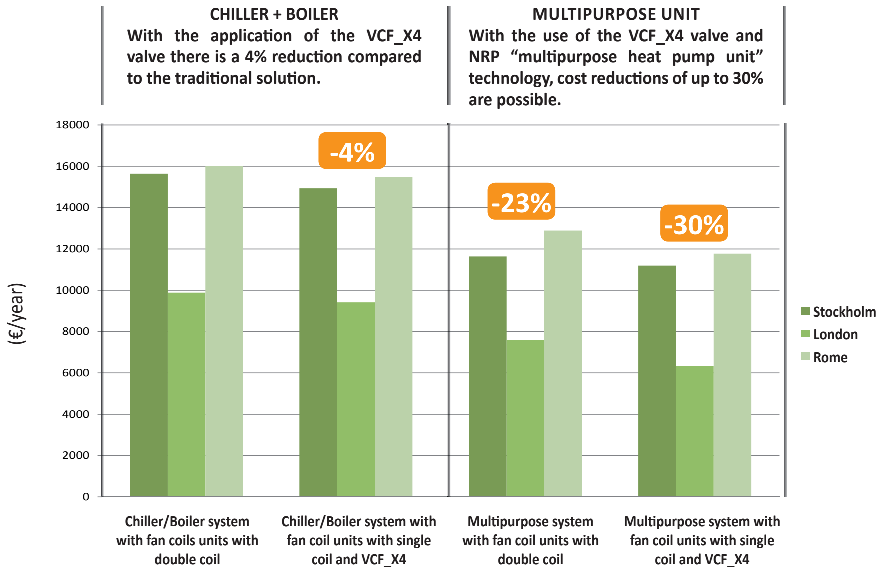


Note:
The graph is from "air-conditioning with radiant systems" - Author "M. Vio"

The 4-pipe multipurpose unit provides the heating and cooling requirements throughout the year, with COP/EER varying as a function of external air temperature and water temperature produced. It also has the advantage of heat recovery during periods of simultaneous heating and cooling loads. The efficiency with which these simultaneous loads are achieved is measured in terms of the Total Efficiency Ratio TER. This provides an improved performance compared to traditional solution of 4-pipe chiller/boiler systems.

RESULTS:
Operating costs, on an annual basis, for the three considered locations.

ESTIMATION OF OPERATING COSTS (€/YEAR)



Note:
For the calculation of annual operating costs it is mainly energy costs that have been considered. In the calculation the following values were used:

OPERATING COSTS (SOURCE EUROSTAT)

	€/Nm³	€/kWh
Stockholm	0.598	0.083
London	0.299	0.104
Rome	0.374	0.167

Note:
In the case of Stockholm, given the possibility of reaching extremely low external temperatures (-20°C), for the high efficiency solution it is necessary to provide a boiler, to be used in replacement of the multipurpose unit on the heating circuit. Such "HYBRID" system is used to optimise efficency, operating the boiler in place of the multipurpose unit with external temperatures below 0°C (at which values there is no cooling load).

The possibility of lowering the heating water temperature, and slightly increasing the chilled water temperature, involves energy and economic savings for any type of energy source; this effect is more significant for heat pump units or multipurpose unit than for condensing boilers.
Lowering the water temperature produced by 10°C has a greater effect on the COP of a heat pump unit (plus 20 ÷ 25% on COP), or on the TER of the multipurpose unit compared to the effect it has on a good condensing boiler of 3 to 4% (for more information see the chart on page 8).

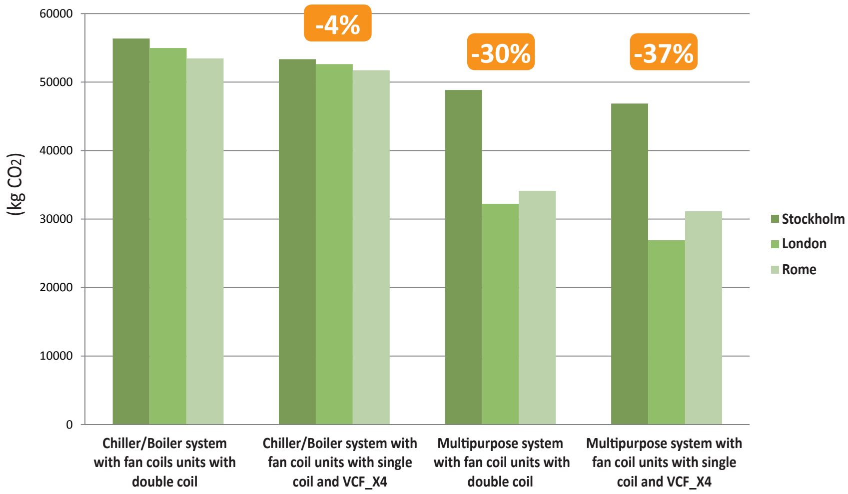
The results for the CO_2 emissions are shown in the following table. The calculations are made taking into consideration:

- 1.968 kg CO_2 emitted for the combustion of 1 Nm^3 of natural gas.
- 0.442 kg CO_2 emitted for 1 kWh electrical input.

RESULTS:

Annual savings of CO2 environ-mental emissions.

ESTIMATION OF THE ANNUAL CO2 EMISSIONS

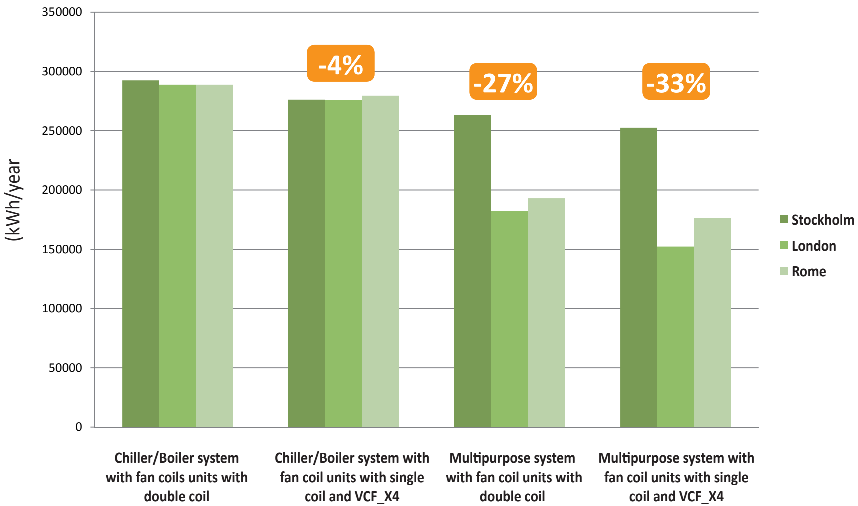


Note:
Conversion coefficients come from iea International Energy Agency

RESULTS:

The percentage reduction of primary energy achieved with the use of the new VCF_X4 valve can be used to define a hypothetical energy efficiency class improve-ment for the building.

ESTIMATION OF THE PRIMARY ENERGY USE kWh/YEAR



Note:
Energy conversion factors considered: 1 kWh electrical = 2.5 kWh of primary energy; 1 Nm^3 of methane = 9.943 kWh of primary energy. Values referred to in European Directive 2009/28/CE.

Summarising, there is important evidence concerning the energy cost in operating of the building: going from the chiller/boiler system with double coil and double 3-way valves and compared with the same system with single coil fan coil unit and VCF_X4 valve, the reduction in energy costs is 4%. This percentage increases significantly using single unit energy source like the multipurpose, Aermec series NRP. The reductions in operating costs for the building reduces by 23% in the case of the NRP unit with fan coil unit with double coil and double valve. This reduction improves to 30% for the best solution using the multipurpose NRP unit with single coil fan coil unit and VCF_X4 valve. Similarly, for this last solution there is a reduction of 37% for the CO2 emissions compared to the traditional solution.

Chapter 6
CONCLUSIONS

This Technical Focus highlights the potentials of the VCF_X4 accessory. From the analysis done the following considerations can be summarised:

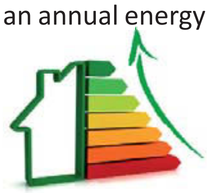
Reference Chapter 4
Price positioning of the fan coil unit with VCF_X4 valve compared to traditional fan coil units with double coil.

Reduction of initial costs compared to the traditional solution: VCF_X4 brings to an average reduction of 5 ÷ 7%, depending on size of terminal unit considered. This value has been calculated compared to a reference baseline of a traditional solution with fan coil unit with double coil and double valve (for example, FCX 50 fan coil unit), against a terminal unit with 4 rows and the new VCF_X4 valve installed (for example, FCX 54 fan coil unit). The innovative Aermec way of doing 4-pipe systems brings initial cost savings starting from the installation. These savings will be further improved thanks to the operating cost reductions.

Reference Chapter 5
Selection of the energy sources for heating and cooling.

Operating cost reductions: in terms of energy cost savings it emerges that a system using a condensing boiler and chiller will get cost reductions around 4% just through the application of the VCF_X4 valve, compared to the solution of fan coil units with double coil and double valve. When choosing the multipurpose unit the system efficiency increase significantly: energy savings become around 30%. Opting for the multipurpose unit with fan coil equipped with the new Aermec VCF_X4 valve allows roughly 7% in operating cost reductions.

Building energy class improvement: the most efficient solution of a terminal unit equipping VCF_X4 valve together with a multipurpose unit, allows an annual energy saving of around 33%, compared to the chiller/boiler system working with a fan coil unit with double coil. This aspect may result in a better building energy class achievement.



Reduction of CO_2 emissions: in terms of environmental impact the most efficient solution of VCF_X4 in combination with multipurpose unit gives a reduction of CO_2 emissions of an average value ranging between 37% and 30%, depending on the European city considered, while providing an average reduction of 4% for the VCF_X4 valve solutions with traditional chiller/boiler system.

TVCFX4UY_00

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