

BENEFITS AND COSTS OF MODULAR SOLUTION
MULTICHILL

MODULARITY



TECHNICAL FOCUS



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CONCLUSIONS

More and more frequently, designers have difficulty reconciling the need of the highest degree of reliability of system operation continuity with keeping the first investment costs down.

This is typical in **industrial** applications: if an issue with a chiller occurs, the operation is down until the chiller is fixed or replaced.

But even fast repairing considering stocking spare parts may not be acceptable to guarantee facility operation continuity.

For many process applications having a chiller down even for a short time is not acceptable at all. A redundant chiller for each unit would provide total redundancy, but also it results in an initial capital investment doubled with increased maintenance costs as well as double required floor space.

Moreover, from the **comfort** point of view, there would be an additional challenge to be faced. Many comfort applications are in residential or historical areas with limited space both on and around the area where the new large packaged chillers should be located. This is even worse when large cranes are needed, resulting in street closures and increased installation costs.

The modular design of MultiChill is the effective solution on both applications, bringing also additional benefits.

MultiChill allows connecting and managing up to 16 units in a local network. Up to 4 of these units can be hydraulically connected in parallel. Dedicated piping fast connections are also available to simplify system design and make installation faster and easier.

The key advantages of this modular system are:

✓ **Peace of Mind**

- + Reliability of the system operation by smart redundancy and back-up
- + Silent operation

✓ **Space and life-cycle cost savings**

- + Reduced installation costs and a smaller footprint of the chiller system
- + Unmatched part load performance due to the modular concept and inverter technology

✓ **Lifelong reliability and Scalability**

- + Operation rotation
- + Adaptability of the system to the future load requirements

CONFIGURATIONS

Three different functional versions are available: Chiller, Free-cooling Chiller and Heat Pump. It is possible to choose a system buffer tank and pump on board on all versions. The heat pump version can also be equipped with the 3-way valve on board for domestic hot water production.

COMBINATION CHART

Chiller + Free-Cooling	YES
Different sizes	YES
Pump and system tank on board	YES
Heat pump + Heat pump with DHW	YES

SEASONAL UNBALANCED LOADS

In many applications, full capacity is necessary only for short time during the year; as well, summer cooling loads and winter heating loads are different.

Different unit sizes can be combined together to meet the perfect combination to maximize efficiency and extend the modules lifespan.

In addition, in this case, the units can be equipped with a system buffer tank and a 3-way valve integrated on board. It is even possible to equip the modules with pumps on board if the modular system is configured with sizes of the same group 18.2-20.2 or the group 25.2-30.2-35.2.



Figure 1: example of different sizes combination

OPERATION ROTATION

The modules are rotated on a regular basis, regardless the operation mode.

This equalizes compressor run time and ensures that the back-up module is ready when necessary: the lifespan of the system is increased spreading the run time over several modules.

Start sequence



Stop sequence

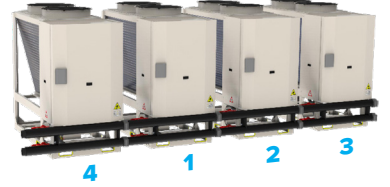
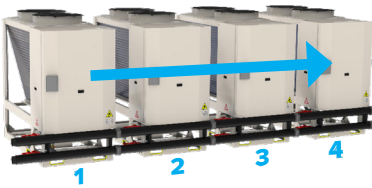


Figure 2: start and stop sequence logic.

Start and Stop of the system follows the logic «first in first out»: the first module to be activated is the first one to be deactivated. In this way subsequent modules respect the unload sequence according to the loading order.

1° start



2° start



3° start



Figure 3: rotation operation logic.

Starting sequence of the modules changes at every start-up to equalize the run time for each module: the loading sequence of each module is increased by one-step at every start-up.

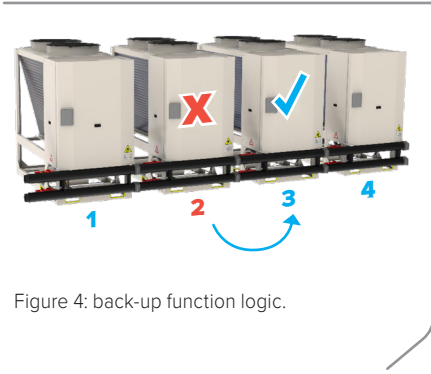


Figure 4: back-up function logic.

BACK-UP

Many applications require a permanent continuity of the system operation. According to the particular application or process, it can be either mandatory to supply full capacity or enough to supply partial capacity.

Both situations are satisfied with the back-up function of the modular system. If one module has a malfunction or need maintenance, the other modules provide back-up so that the system can continue to work. The separate power supply of the modules and the independent refrigerant circuit for each module provide a true back-up solution.

Back-up function can be activated automatically for each module of the system, independently from its setup. For safety reason, this function is disabled in some critical situations (i.e. control failure on module addressed “0”, disconnection of user interface or between modules, failure of the leaving water temperature sensor on the supply header).

PUMPS ON BOARD

The modular system can be equipped with an external pumping station or instead each module can have its own inverter driven pump with a non-return valve on-board.

In particular, this second solution enhances the benefits of modularity. When a module is not active, its pump is switched off, which results in lower energy consumption for part-load pumping. Thanks also to the non-return valve, the module is not affected by the water flow so undesired mixed temperatures are avoided. In addition, reliability is increased as more pumps are available and water flow is guaranteed in case of malfunction or maintenance of a pump.

To apply this configuration, the system has to be hydraulically balanced and the modules have to be of the same group of sizes 18.2-20.2 or 25.2-30.2-35.2.

Detailed information on how to set-up the system is available in the technical documentation.

BENEFITS ON REDUNDANCY

To grant the system reliability MultiChill modular chillers do not require a like-for-like redundancy in chiller plant design as in conventional chiller plants. Instead, when a non-modular chiller is used as the main 180 kW unit, as in the example below, the same capacity would also be required as a back-up.

With MultiChill, two modules can still operate even if one module goes down, continuing normal operation at full capacity. This reduces the back-up capacity requirement, resulting in a significant cost saving.

Redundancy is achieved providing one extra refrigeration circuit that can be used to back-up the other refrigeration circuits in the system. Separate electrical feeds increase the safety of the system even more.

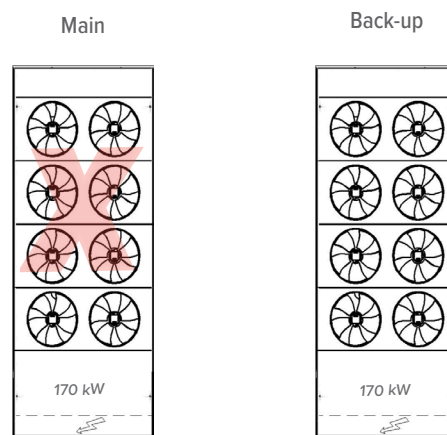


Figure 5: System 1 includes a non-modular chiller where same capacity is required for back-up.

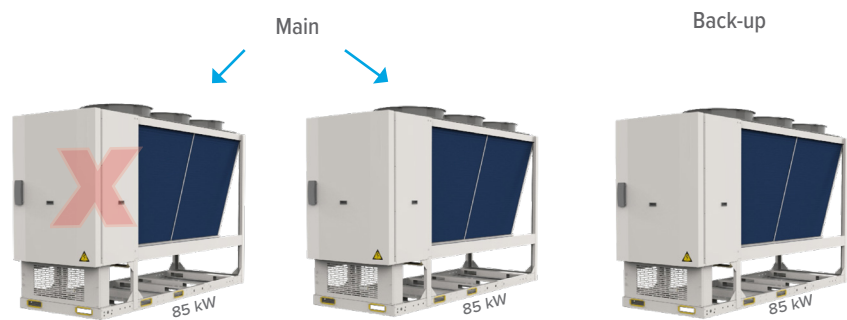


Figure 6: System 2 is based on three modules where real redundancy is done with one back-up module.

Redundancy with modular system is cost effective in most applications. Doubtless, this applies when the traditional solution is based on a redundant equipment to provide 100% back-up capacity, as shown in Case study 1. Modular solution is convenient also when compared to a partial redundant system, such as a single unit with double refrigeration circuit, as shown in Case study 2.

CASE STUDY 1

It is considered a process application where the full capacity of 170 kW must be provided even if one module goes down to guarantee the system continuity. With traditional solutions, two packaged units of 170 kW each have to be installed: one as main unit and the other one for full back-up if there is a failure. The Airedale modular solution is based on three modules of 85 kW each to match the required capacity: two modules as main, unit one as back-up.

MultiChill modular solution presents a 26% price saving compared to the traditional solution.

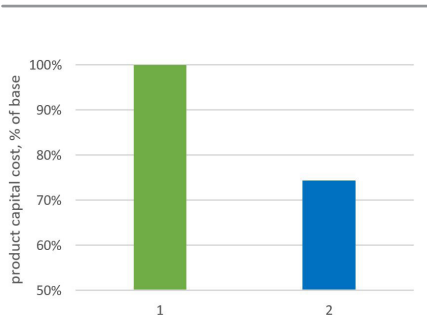


Figure 7: System 1 includes two 170 kW monoblock dual circuit chillers, one as a back-up, while System 2 is based on three modules including hydraulic connections (ref. AMODX and CCKMUX)

CASE STUDY 2

Not all systems strictly require redundancy, but system continuity even at low capacity is mandatory, as in comfort applications.

In this example, design load is 170 kW and the system must provide continuity even in the case of a circuit failure.

With a traditional system, this is fulfilled with a 170 kW packaged unit with two independent circuits.

Airedale modular solution proposes two single-circuit modules, of 85 kW capacity each for a total capacity provided of 170 kW.

In both cases, if a failure occurs to a single circuit, half of the full capacity is still provided.

In addition, in this case MultiChill modular solution is competitive, as the capital cost is equivalent.

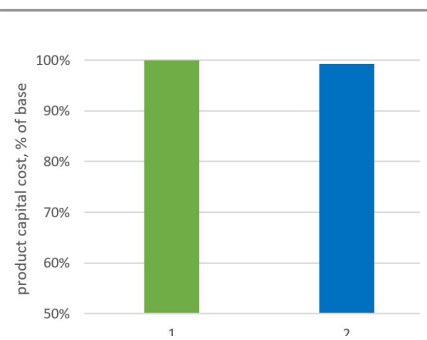


Figure 8: System 1 includes one 170 kW monoblock dual circuit chillers, while System 2 is based on two modules including hydraulic connections (ref. AMODX and CCKMUX)

In those applications, requiring redundancy, as seen before, space constraints and handling conditions become very often an important problem to solve.

Usual assumption is that the less units we have, the smaller is the space occupied. However, as it will be demonstrated below, using MultiChill modular approach reduces the space requirements and also, lifting and installation are simplified.

In fact, each module can be positioned in a bank of up to four hydraulically connected modules, and each one can be equipped with pump and system tank on board for a maximum space saving. Thanks to a design especially developed for modularity, clearances among the modules are reduced to 500 mm, still allowing the possibility of an easy maintenance. The hydraulic connection provided by Airedale makes installation very simple and fast.

MultiChill modular design results in space saving when compared to traditional chillers in the same configuration.

CASE STUDY 3

According to Case study 1, a process application requires the full capacity of 170 kW to guarantee the system continuity even if one module goes down. The real space requirements must include clearances.

With 40% space saving, MultiChill modular solution is the perfect solution for the most challenging applications with strict space constraints and redundancy features needed.

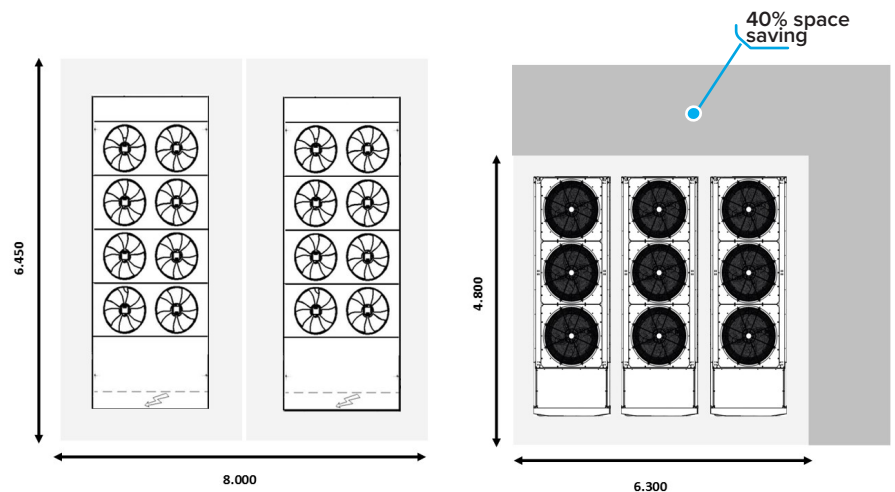


Figure 9: The traditional system (left) includes two 170 kW monoblock dual circuit chillers on a total floor area of 52 m². The modular System (right) is based on three modules, on a total floor area of 30 m².

CASE STUDY 4

Considering now a typical comfort application requiring 170 kW at full load, described in Case study 2, the system continuity must be guaranteed even at lower capacity. Also in this case, the real space requirements must include clearances.

A **20% space saving** points out that MultiChill modular solution that the modular solution may bring a space saving even when compared to a package unit installation, differently from general perception.

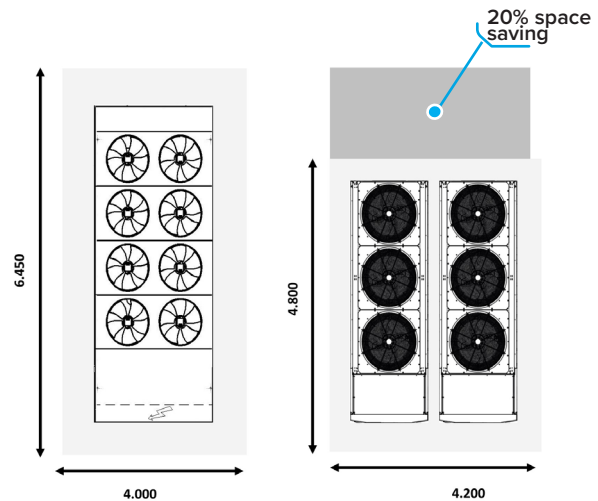


Figure 10: The traditional system (left) includes one 170 kW monoblock dual circuit chillers on a total floor area of 26 m². The modular System (right) is based on two modules, on total floor area of 20 m².

SCALABILITY

A modular approach perfectly fits with the potential increase load demands in HVAC systems.

Designer can closely match the specified equipment from the beginning, keeping the possibility to easy and quickly meet changing capacity demands of the building with a staged installation.

As well, redundancy requirements are minimised so equipment is less likely to be over-sized, resulting in a more effective first investment that can be adjusted over the time. Fast hydraulic connections and on-stock modules makes scalability a fast and effective solution at any time.

Energy efficiency is a key challenge due to strict regulations, strong environmental awareness and the focus on reducing operating costs. Silent operation is also a top driver. Their combination depends on application and individual system design; nevertheless two typical scenarios show that the performance of the Airedale modular solution is effective in both terms of efficiency and sound.

In both scenarios, as in most applications, the part-load operating requirements are perfectly suited to modular system technology of Airedale, resulting in superior seasonal efficiency and quiet operation.

INVERTER MODULES

MultiChill features the full DC inverter technology: modules in the system can be operated at frequency ranges in which the efficiency of each module is at its peak. Optimum frequency control of each module increases the efficiency of the system in all load conditions.



Figure 11: different operation behaviour at part load (50% of installed capacity) for a non-inverter modular system (left) and Full DC inverter system (right)

CASE STUDY 5

A popular application highlighting this technology benefits is a multi-space building with central plant chiller and low attendance even at design ambient conditions. This happens frequently in office spaces when remote working must be temporary used.

At given ambient and water conditions, the load variation must be balanced by the system in the most efficient way.

The same behaviour may apply in industrial processes when chilled water is provided to different users with high load diversity.

Compared with a packaged dual circuit multiscroll chiller, the modular combination of four MultiChill keeps optimal energy efficiency at part load operation, thanks to the combination of automatic cascade function and full DC inverter technology. In addition, it can perform capacity control down to 8% off the design load, for maximum energy conservation.

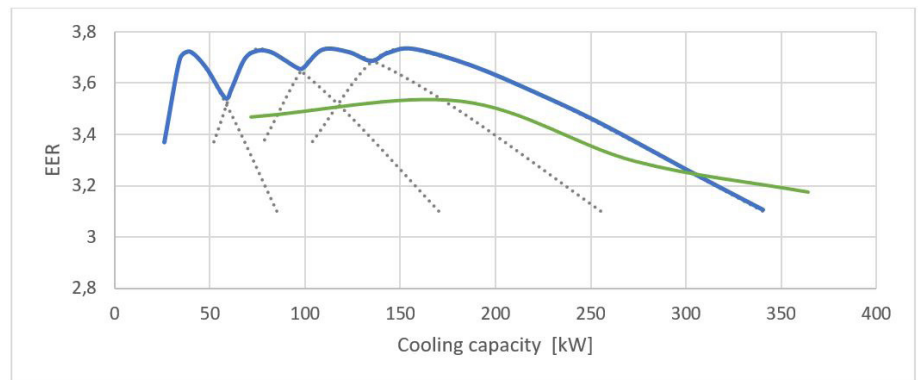


Figure 12: Based on 340 kW design load (A35/W7), the packaged solution includes one monoblock dual circuit chiller (green line), while System 2 is based on the combination of four modules (blue line)

APPLICATION		PACKAGED SOLUTION	MODULAR SOLUTION	
Load (%)	Load (kW)	EER (kW/kW)	EER (kW/kW)	Modules on duty
100	340	3.17	3.11	4
75	255	3.29	3.44	4
50	170	3.53	3.67	4
25	128	3.47	3.69	2
8	27	-	3.37	1

CASE STUDY 6

A more common application occurs when the same multi-space building with central plant chiller of Case 5 presents a typical seasonal load profile.

At given attendance, ambient and water conditions change according to the season and the load variation must be balanced by the system in the most efficient way.

The considered load profile is given by the EN 14825:2018 regulation for SEER calculation.

The modular combination of four MultiChill results in a higher energy efficiency at part load operation compared with a packaged dual circuit multiscroll chiller. In addition, in these different conditions it can perform to a capacity 60% lower than the minimum of the packaged unit.

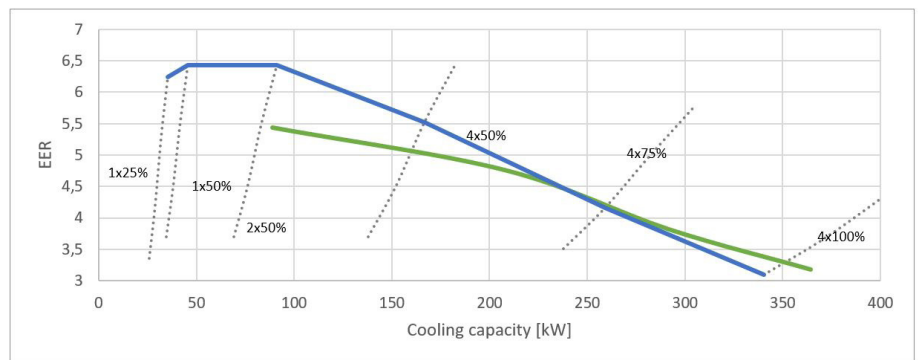


Figure 3: Based on 340 kW design load (A35/W7), the packaged solution includes one monoblock dual circuit chiller (green line), while System 2 is based on the combination of four modules (blue line)

APPLICATION		PACKAGED SOLUTION	MODULAR SOLUTION	
CONDITIONS (°C)	LOAD (KW)	EER (KW/KW)	EER (KW/KW)	MODULES ON DUTY
A35/W7	340	3.17	3.11	4
A30/W8.5	260	3.78	4.16	4
A25/W10	170	4.97	5.52	4
A20/W11.5	90	5.88	6.43	2

SILENT OPERATION

MultiChill modular solution is effective in both terms of efficiency and low sound level in comparison with a package chiller solution.

A bank of the same modules presents a sound level that is similar to the single one. Therefore, the MultiChill modular system sound operation is often quieter than a package chiller with the same capacity.

In addition, MultiChill features two silent modes, silent and super silent, that can be activated or scheduled also in the modular configurations: the sound level can be reduced at any time **up to 13 dB(A)**, with a capacity reduction of only 12%.

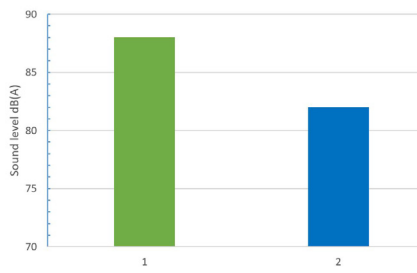


Figure 14: System 1 includes one 140 kW monoblock dual circuit chiller, while System 2 is based on two modules.

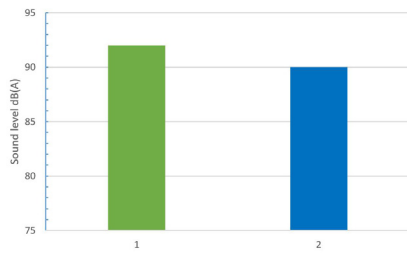


Figure 15: System 1 includes one 300 kW monoblock dual circuit chiller, while System 2 is based on four modules.

The modularity of MultiChill allows connecting and managing up to 16 units also of different sizes in a local network and up to 4 units hydraulically connected in parallel. It offers a great opportunity both in comfort applications in residential or historical areas with limited space and in industrial applications, where it is fundamental to grant facility operation continuity.

The analysis of six case studies has highlighted the following strengths and advantages deriving from the use of modular units compared to the realization of plants using full-capacity redundancy, as usually done:

- ✓ **High reliability with a first investment reduced by 26%** thanks to a smart redundancy. The modularity results also effective when system **continuity** is required **at lower capacity**, compared to a double-circuit unit solution.
- ✓ **Space saving up to 40%**. Smaller modules allow a smaller floor space and are easier to handle. The provided hydraulic connections simplify and speed up the installation.
- ✓ **High-energy efficiency, both at full and part load**. The high efficiency granted by the full-DC inverter technology can be increased by the modularity, allowing the system to modulate down to 8% of full load. This is particular useful in office spaces when remote working must be temporary used.
- ✓ **Acoustic comfort**
MultiChill modularity allows very low sound levels, which can be further decreased with the silent and super silent modes **up to 13 dB(A)**.
- ✓ **Adaptability**
The modular design allows adapting the system to future load requirements and developments, giving the possibility to easy and quick meet changing capacity demands of the building with a staged installation.

The products described in this manual are compliant with Eurovent.

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Head Office
Airedale International Air Conditioning Ltd
Leeds Road
Rawdon
Leeds LS19 6JY
Tel: +44 (0) 113 2391000
Fax: +44 (0) 113 2507219
E-mail enquiries@airedale.com
Web www.airedale.com