THE DESIGN OF HYDRONIC HEATING AND COOLING SYSTEMS WITH A HIGH THERMAL HEAD

This document describes the main economic and energy advantages deriving from the design of hydronic heating and cooling plants with a high thermal head.
The direct consequence of the plant engineering approach is the reduction in the water flow rate circulating in the plant pipes, and as a result::

• The reduction in the diameter of the hydronic pipes of distribution, given the same distributed and concentrated pressure drops (economic savings in the initial investment);

• The reduction in the pumping expenses necessary to the movement of water heat carrier liquid, both during summer and winter operation (economic savings in plant operation).

The achievable reduction in expense, both during the initial phase as well as during operation, can be reinvested to perform other technical work in order to increase the energy efficiency of the building-plant system, use additional sources of renewable energy and/or install air purification systems (a very important topic considering the pandemic situation related to the spread of the SARS-COV2 virus).

Commercial Technical Service

AERMEC

CONTENTS

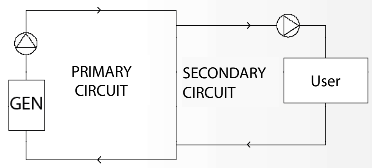
The purpose of the "Technical Focus" series is to offer an exemplification, for example, of the possible advantages deriving from the use of innovative Aermec solutions.
As the data and results presented in the publications refer to specific buildings and situations, they can also vary substantially depending on the applications and intended use. For this reason, the calculations and the considerations made in this document cannot in any way replace the design activities of a thermo-technical professional.
Aermec reserves the right to implement any and all modifications it deems necessary for product improvement at any time, as well as any modifications to the published data.

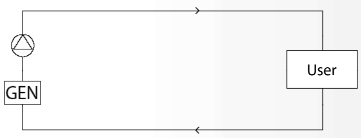
Chapter 1

INTRODUCTION

WHY SELECT HYDRONIC CLIMATE CONTROL SYSTEMS WITH A HIGH THERMAL HEAD ?

Designing the plants with a high thermal head does not jeopardise the safety of the generator or other components in the plant but makes it possible to maintain a high level of thermohygrometric comfort while increasing the efficiency of the entire system by reducing the initial investment and the relative operating costs.





$$P = \dot{m} \cdot c_p \cdot \Delta T$$

P = *heating-cooling power* $[kW]$
$\dot{m}$ = *water flow rate* $[kg/s]$
c_p = *specific heat* $\left[\frac{kJ \cdot kg}{K}\right]$
ΔT = *temperature differential* $[K]$

$$P = \frac{\dot{V} \cdot \Delta p}{\eta}$$

P = *pumping power* $[kW]$
$\dot{V}$ = *water flow rate* $[m^3/h]$
Δp = *useful static head* $[kPa]$
η = *pumping unit efficiency*

The attention increasingly placed on energy savings in the civil area have lead the experts in the thermo-technical area to study new solutions that make it possible to increase energy savings in climate control, ventilation and hot domestic water production systems. Aermec has reacted to this need by updating its catalogue with units equipped with advanced components (inverters, electronic control valves, alternative gases, evolved adjustments) and by promoting new solutions both for heating and cooling power generators (steam injection, polyvalents, free cooling, etc…) as well as plant terminals (fancoils with radiant effect, dual jet, etc…).

In addition to the solutions implemented by the manufacturers, also other professionals in the supply chain (designers, architects and installers) have had to adjust their design and construction selections to achieve the above-said objectives by analysing all the components that make up the building-plant system.
In hydronic plants, the heat carrier liquid distribution system cannot be exempted from this analysis, as it represents a considerable energy expense item.
This is why one of the main solutions used to reduce pumping expenses is represented by the use of variable speed circulation pumps that permit the modulation of the flow rate of water circulating in the plant.

The variable water flow rate plants can be divided into two macro categories:

• Double loop plants: characterised by a primary loop, maintained at a constant flow rate between the generator and hydraulic separators and a secondary loop, with a variable flow rate, between the separator and the terminals. These solutions do not present any criticalities for the generator exchangers, which are always crossed by the same water flow rate.

• Single loop plants: comprised of a single loop that has a variable flow rate based on the terminal power demand. They require a control system that manages the water flow rate in the generator to avoid problems related to the possible sudden variation in the water flow rate in heat pump exchangers and chillers.

The critical aspects of the second described solutions are related to the complexity of the control system and the possible sudden reduction of the water flow rate on the plant side exchanger of the generators. The risk is related to the possibility that the control system is not able to manage this variation when the request for heat and cooling power by the users is extremely variable. The risk is to generate considerable instability in the operation of heat and chiller pumps and, in the worst cases, cause the compressors to intake liquid coolant gas during cold operation.

These problems have led to studying and analysing other solutions that make it possible to achieve the same savings without altering the operation and useful life of the generators.

The alternative solution to plants with a variable flow rate in the primary loop is becoming more common and represented by plants with a high thermal head. This design logic involves dimensioning various components, considering a greater temperature differential between the supply and return of the heat carrier liquid, resulting in the reduction in the water flow rate circulating in the distribution system, which is kept constant in the primary loop.
For the sake of simplicity, we will call this technical solution "plants with high ΔT".

The technical-economic analysis of this document will show the comparative results between two different design solutions and point out the main advantages of the high ΔT solution for the case study of an office building, in which the ΔT = 8°C was replaced with the conventional ΔT = 5°C.
This increase in thermal head is limited and does not require the study of the geometry and the special heat exchange coils for the heat pumps and the fan coils.

With the other surrounding conditions equal, increasing the thermal head of the water and as a result the difference in the average logarithmic temperature between the two fluids (air/water) causes a slight reduction in dehumidification capabilities: if necessary, the size of the terminals should be optimised to guarantee the desired comfort conditions.

A comparison between the results of the two solutions ΔT = 5°C and ΔT = 8°C is presented, which shows that also with a small increase in the thermal head of the heat carrier liquid it is possible to obtain very interesting economic and energy savings.

Chapter 2

CASE STUDY - BUILDING OF REFERENCE

The building of reference is a newly constructed office building and has a surface area of 5600 m^2 divided into 5 levels, one of which is underground, dedicated to the parking garage and the technical equipment rooms. The building in this case study is located in London.

The specifications of the building envelope are provided below:

• The opaque vertical surfaces are comprised of a layer of 20 cm thick perforated blocks and a layer of 11 cm thick polystyrene foam (in addition to plaster inside and outside). These layers result in a total transmittance equal to 0.25 W/m^{2}K.

• The horizontal opaque surfaces are comprised of 10 cm thick rigid rock mineral wool panels and two 15 cm thick layers of autoclaved aerated concrete (in addition to mortar inside and outside). The transmittance reached in this case is equal to 0.22 W/m^{2}K.

• The transparent surface are comprised of triple glazed glass with low emission surface treatment isolated with Argon gas, which has a transmittance of 1.2 W/m^{2}K.

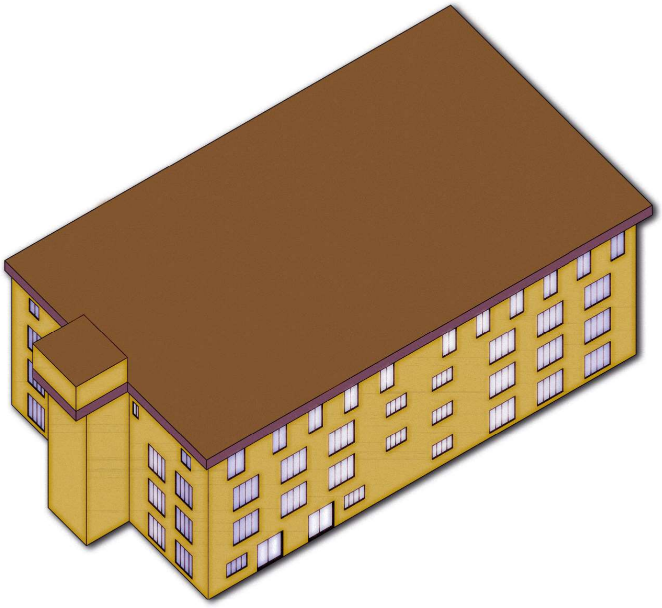


Figure 1
Axonometric view of the building.

The building has 4 levels above ground, divided as follows:

• Ground floor: entrance, three open space areas, each with a meeting room and executive office;

• 1st and 2nd floor: four open space areas, each with a meeting room and executive office;

• 3rd floor: single and double offices with the addition of two large meeting rooms and two recreational rooms.

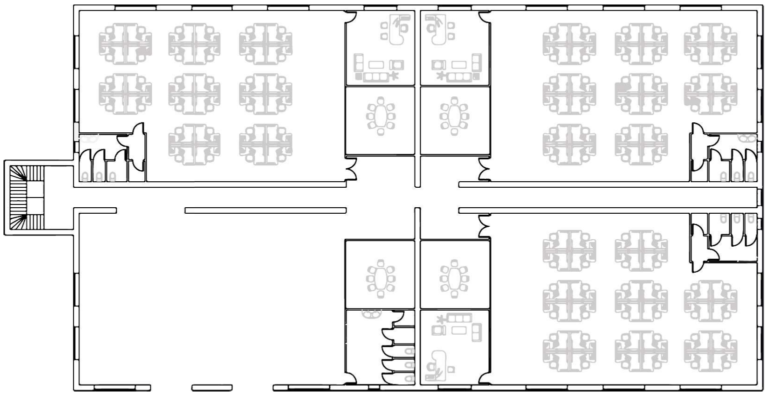


Figure 2
Ground floor layout

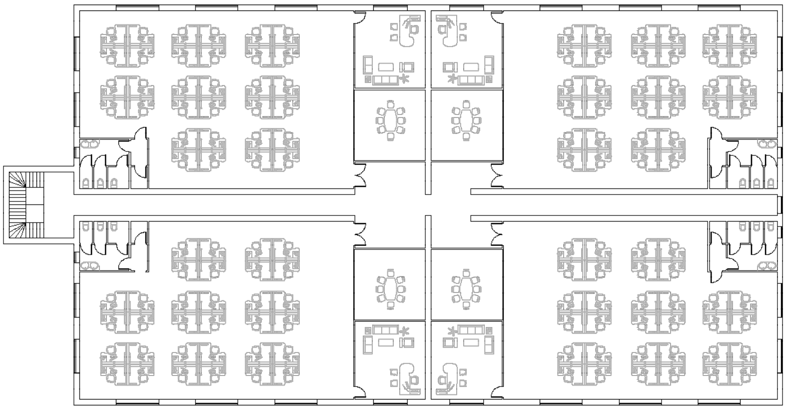


Figure 3
1st and 2nd floor layout

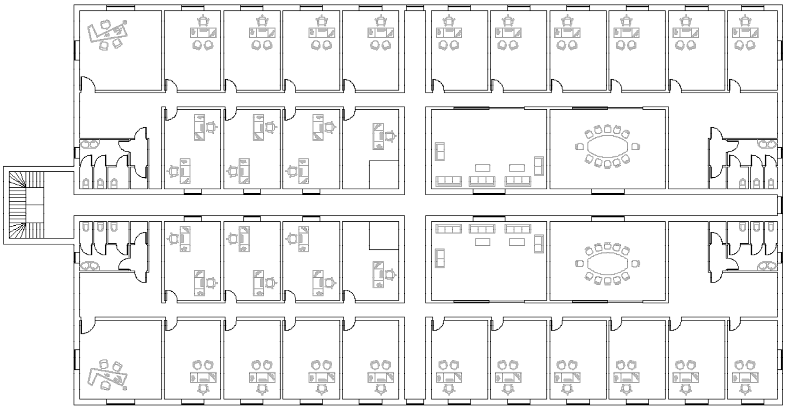
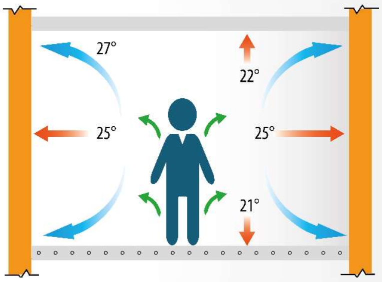


Figure 4
3rd floor layout

Chapter 3

THERMO-HYGROMETRIC WELLBEING
Psychophysical state in which a person expresses satisfaction with the thermal environment.

THERMAL ENVIRONMENT
A set of environmental parameters that define the thermal sensation experienced by a person exposed to certain thermo-hygrometric conditions.



CASE STUDY - PLANT OF REFERENCE

The main objective of a climate control plant is to guarantee suitable thermo-hygrometric conditions in the occupied spaces as well as the quality of the air for its occupants. It is also important to not forget comfort related to noise and lighting, which are fundamental for personal wellness.
This is evident especially in work areas, where various studies demonstrate a direct correlation between thermo-hygrometric wellbeing and work productivity. It is therefore very important to make a correct decision when selecting the type of plant suitable for this application.

In an office building, the following types of plant can be installed:

- All-air system;
- Hybrid hydronic air system;
- Hybrid direct expansion and air system.

The second system is presented in this case study: it is a hydronic system comprised of fan coils that are dimensioned to reduce the sensitive and latent loads created in the rooms to be air conditioned, in combination with an air system comprised of an AHU, one on each floor, in order to guarantee suitable air quality conditions.
This solution offers numerous advantages:

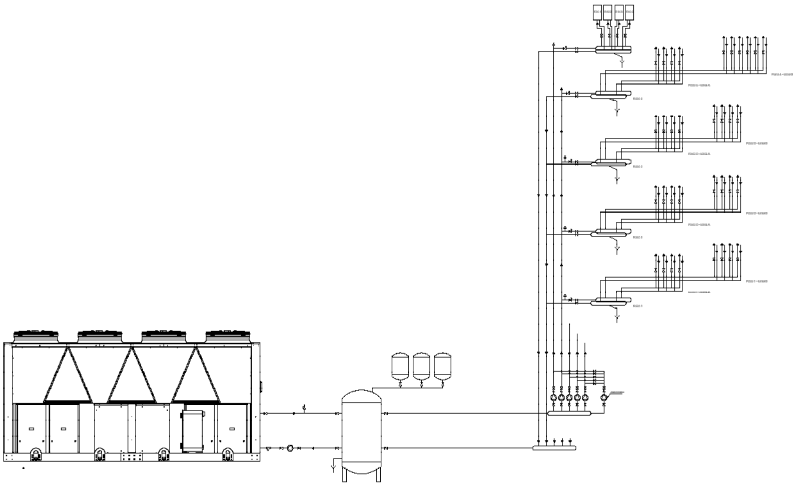
- High efficiency (by suitably selecting the supply temperatures);
- Reduced space occupied by the aeraulic distribution system (in comparison to an all-air system);
- Considerable operating flexibility (in comparison to a direct expansion system);
- Ability to integrate different energy sources (fossil and renewables) in the generation subsystem;
- Reduced ordinary/extraordinary maintenance costs (in comparison to a direct expansion solution).

As regards hydronic distribution, the system was developed with a double loop.

The primary loop is comprised of an air-water heat pump and all the hydraulic components necessary for its correct operation: suitably dimensioned inertial accumulation to ensure a sufficient content of water, safety devices (valves, expansion vessel, etc.) and a fixed speed circulation system.

The secondary loop is comprised of 5 different hydraulic circuits, each provided with its own variable speed circulation pump: four of them a column circuits that comprise the North East, North West, South East and South West backbones, whereas the column circuit dedicated to the air renewal system. In addition, there is a circuit equipped with a circulation pump used as a reserve.
By means of distribution to manifolds, each column supplies the wall-mounted or cassette type terminals for the floor in the section prepared in the various rooms (open space, single/double offices, meeting rooms), whereas the circuit dedicated to the ventilation system supplies the AHU coils.

Figure 5
Functional diagram of the water distribution system.



FCZI
Fan coil with Inverter technology

FCLI
Cassette type fan coils with Inverter technology

Hydronic terminals

The open-space areas and meeting rooms are air conditioned by cassette type inverter fan coils (Aermec FCLI series) that guarantee a stable temperature without occupying space on the ground, providing more freedom for changing the layout. The maximum height of the rooms is 3 m, therefore there are no problems related to the stratification of the air temperature during winter.
The selection was made for terminals with an inverter fan, which due to the continuous modulation of the speed permit a finer control of the setpoint and better acoustic performance. The single/double office area is air conditioned by floor-mounted vertical inverter fan coils (Aermec FCZI series). Also in this case, the selection for terminals equipped with an inverter fan was preferred in order to maximise acoustic comfort and minimise deviation from the set-point.

Figure 6
Hydronic distribution diagram
Ground floor

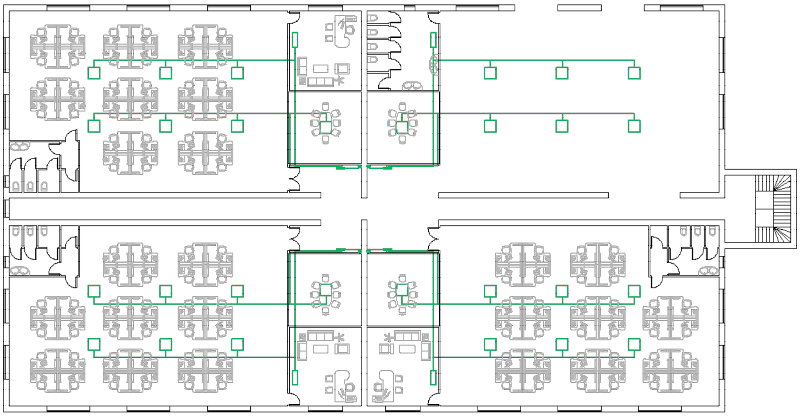


Figure 7
Hydronic distribution diagram
1st and 2nd floor

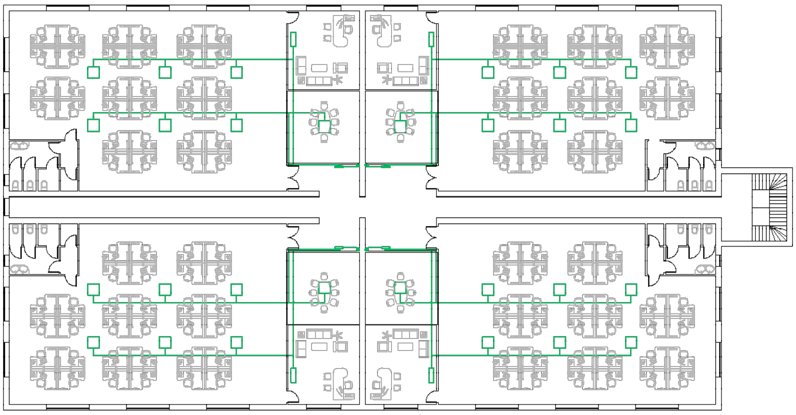
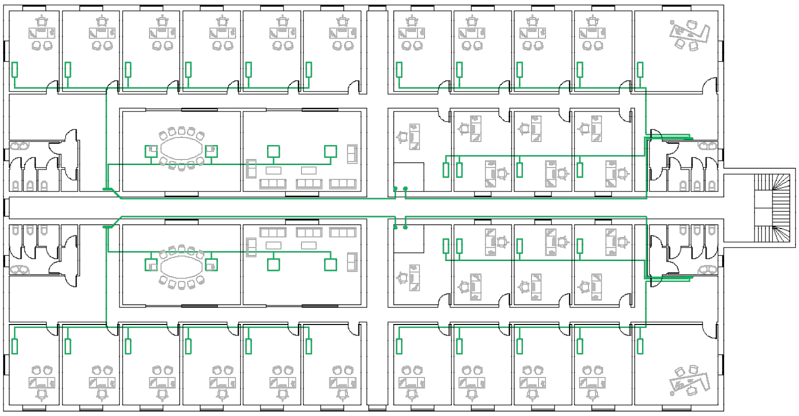


Figure 8
Hydronic distribution diagram
3rd floor



ERSR - High efficiency indoor or outdoor rotary heat recovery unit.

Class	ISO ePM_1	ISO $ePM_{2.5}$	ISO ePM_{10}	ISO COARSE
G3	/	/	/	> 80%
G4	/	/	/	> 90%
M5	/	/	> 50%	/
M6	/	50 - 65%	> 60%	/
F7	50 - 65%	65 - 80%	> 85%	/
F8	65 - 80%	< 80%	> 90%	/
F9	< 80%	< 95%	> 95%	/

Controlled mechanical ventilation

The air renewal system is comprised of 4 AHUs (Aermec ERSR series), one for each floor, that are installed on the roof.
They have the following characteristics:

• Processing of 4800 m^3/h of external air per floor (36 m^3/h per person) by electronically controlled plug-fans both on the delivery as well as on the intake side;

• Energy recovery subsystem comprised of an enthalpic rotary heat exchanger, which recovers both sensible and latent energy from the exhaust air that would otherwise be released outside;

• Supplementary air handling coils that deliver neutral air into the rooms resulting from the reduction of thermal loads due to ventilation;

• Air filtration subsystem comprised of F7 grade filters (within the scope of the health emergency, it should be evaluated if it is possible to install additional sanitation systems in the ducts, such as absolute filters, UV-C lamps and/or photocatalytic effect devices)

The unit also has an integrated control system.

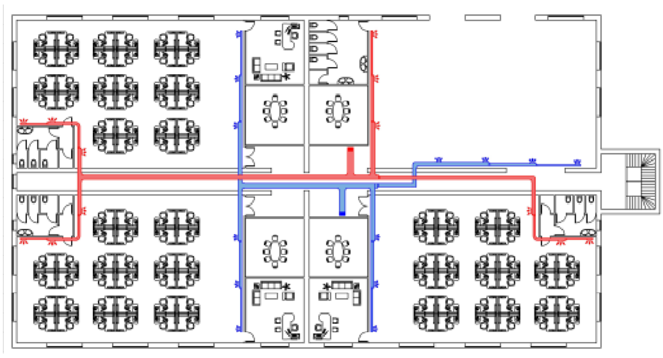


Figure 9
Aeraulic distribution diagram
Ground floor

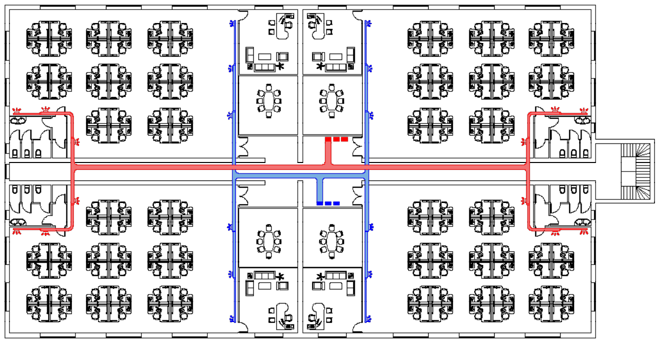


Figure 10
Aeraulic distribution diagram
1st and 2nd floor

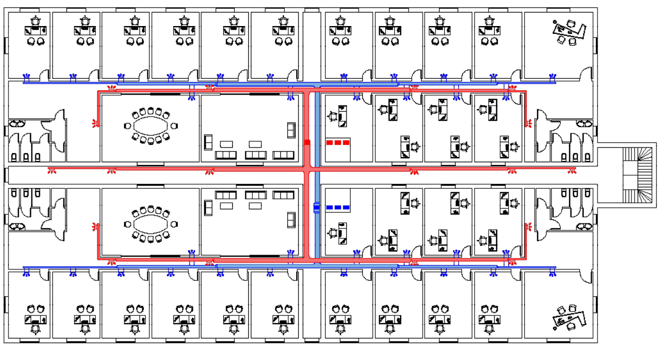


Figure 11
Aeraulic distribution diagram
3rd floor.

Generation system

Excluding the use of a chiller plus boiler solution, which is difficult to offer today for newly constructed buildings that have a high energy target, the selection is made for heat pump technology.
There are different types of heat pumps: with scroll or screw compressors with step or continuous modulation, with plate or tube exchangers, etc…
An initial analysis must be made for the selection of the heat pump based on the available source and the location of installation.
If ground water is available or if there is space to install geothermal probes, a valid option could be a water-water heat pump if the costs for the withdrawal and excavation are not too high. This solution is not only compact and silent, it is also more efficient in general.
The building is located in London: To make the case study as general as possible, it was assumed that the use of ground water as a heat source was not possible, and therefore the focus was placed on an air-water heat pump.

In some cases, due to a lack of technical space or acoustic-visual restrictions, the air-water units cannot be installed outdoors. To meet this need, Aermec has been offering indoor air-water units for many years (Aermec CL-H and NLC-H series) that are equipped with high head EC centrifugal fans that make it possible to install the units inside the technical equipment rooms, channelling the treated air outside. To be able to install these machines inside indoor technical equipment rooms, the space must be suitably aerated to prevent creating a vacuum in the room. It must be stressed that in the case of centrifugal fans, with the same capacity as axial fans, if greater head is supplied they generally absorb more electricity.

In this particular situation the decision was made to use a classic air-water pump from the Aermec NRB-H series, equipped with scroll compressors in a tandem configuration, brazed plate heat exchangers, finned coils and inverter axial fans in a V-block configuration. This solution is the most common for outdoor installations.

Figure 12
Annual hourly profile of the temperatures in London.

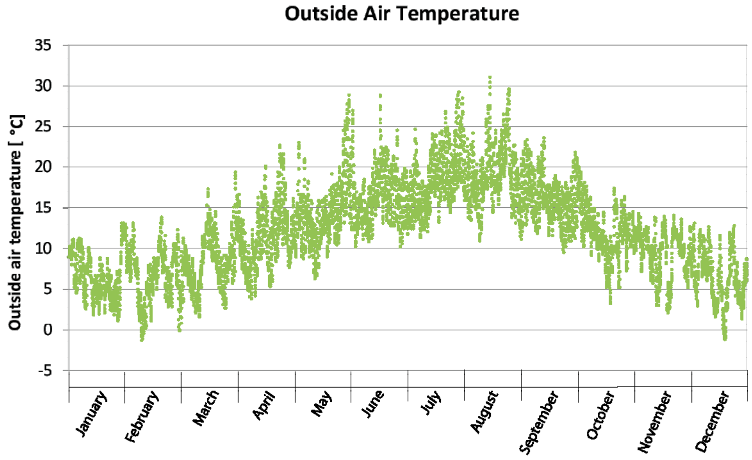
Figure 13
Annual calendar of plant activation.

Figure 14
Weekly plant activation calendar.

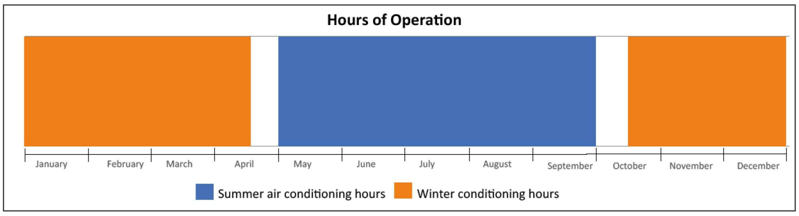
Chapter 4

CASE STUDY – CLIMATIC AND PLANT LOAD DATA

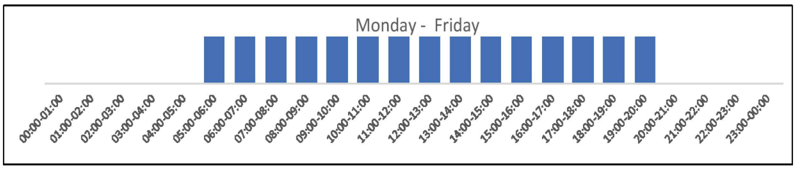
The analysed building is located in London.
The annual hourly climatic profile for the city of London is provided below in the diagram.



The heat pump operates in heating mode during the winter season from 15 October to 15 April, whereas it operates in cooling mode from 1 May to 30 September.



The plant is activated on work days for 15 hours a day, from 5 am to 8 pm. This schedule makes it possible to pre-heat the building in winter and pre-cool it in summer starting in the early hours of the morning in order to guarantee thermo-hygrometric comfort conditions to employees already when they arrive at work.



The total sensible and latent load, resulting from the sum of the loads of the individual rooms, was obtained by fixing the following thermo-hygrometric parameters in the rooms occupied by the employees:

- SUMMER: T = 26°C, RH = 50%
- WINTER: T = 20°C, RH = 50%

The calculation considered the following sensible heat flows:

- Transmission of heat through the opaque and transparent surfaces
- Radiation through the transparent surfaces
- Forced ventilation and aeration
- Inner loads due to persons and electric equipment

The latent loads, instead, are linked exclusively to the presence of persons in the rooms, ventilation and aeration.

Climatic zone D

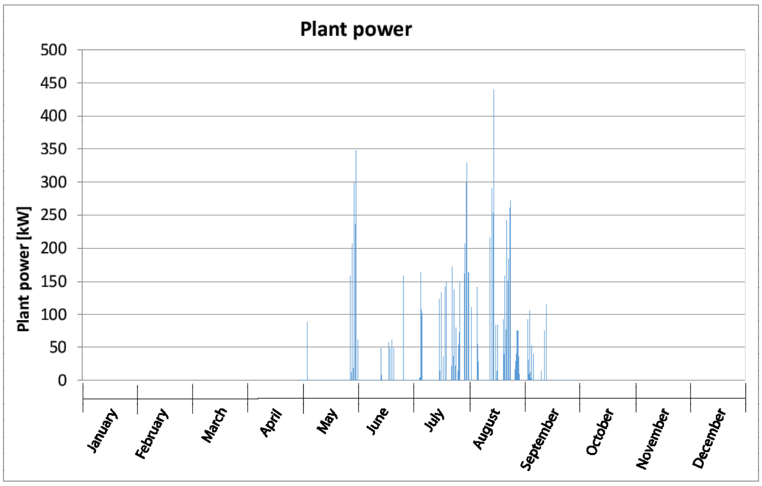


Figure 15
Annual hourly load profile of the plant when cooling.

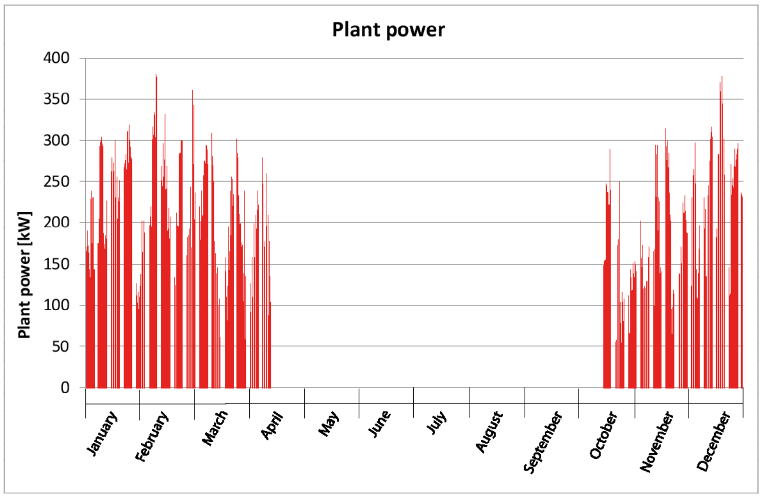


Figure 16
Annual hourly load profile of the plant when heating.

Chapter 5

ANALYSIS OF FIXED COSTS

To dimension the pipes used for hydronic distribution, for which a multi-layered type was selected, it is necessary to determine the water flow rate for each branch and fix the linear design pressure drop, which in this case was selected at 20-35 mm c.a./m. The water flow rate circulating in each brand of the hydronic system was calculated based on the definition of the supply temperature of the water to the terminals and the relative thermal head.

Table 1
Total cost of the pipes with ΔT=5°C.
*= £ per installed linear meter.

DIAMETER PIPES	LENGTH (m)	Linear cost MULTILAYER (£/m)*	Total cost MULTI-LAYER (£)
20/15	119	2.98	355
26/20	647	4,17	2.698
32/26	640	6.62	4.237
40/33	666	13.83	9.211
50/42	71	22,83	1.621
63/51	44	33,47	1.473
75/60	75	60,52	4.539
90/73	90	81,01	7.291
TOTAL			**£ 31,407**

Table 2
Total cost of the pipes with ΔT=8°C.
*= £ per installed linear meter.

DIAMETER PIPES	LENGTH (m)	Linear cost MULTILAYER (£/m)*	Total cost MULTILAYER (£)
20/15	697	2.98	2.077
26/20	454	4,17	1.893
32/28	1002	6.62	6.633
40/33	45	13.83	622
50/42	30	22,83	685
63/51	75	33,47	2.510
75/60	90	60,52	5.447
TOTAL			**£ 19,869**

A reduction in the pipe diameter involves, as a result, a reduction in the insulation required to limit the heat dispersions of the heat carrier liquid to the outside and prevent the formulation of condensate on the pipe surfaces.

By setting a standard thermal head (ΔT=5°C), the dimension of all the terminal coils is such to ensure the correct dissipation of load in the various rooms, but involves a higher supply capacity. By setting an increased thermal head (ΔT=8°C) the size of the cabinet type fan coils for the offices was optimised to ensure a suitable reduction in the latent load: this selection also makes it possible to lower the water flow rate circulating in the system with the same linear pressure drops.
This design measure makes it possible to both reduce the size of the circulation pumps as well as the section of the distribution pipes with insulation, which results in a considerable reduction in the initial investment costs, which could then be reinvested in higher energy efficiency solutions.

Table 3
Cost of the emission and distribution systems

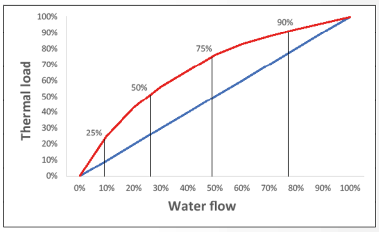
	Cost of plant elements HVAC ΔT=5°C (£)	Cost of plant elements HVAC ΔT=8°C (£)
FCLI 42	1,030 (n.20)	1,030 (n.20)
FCLI 62	1,083 (n.72)	1,083 (n.72)
FCZI 350	593 (n.42)	0
FCZI 400	0	614 (n.42)
ESRS 12	29,251 (n.4)	29,251 (n.4)
PIPES	31.407	19.869
INSULATING	7.573	6.189
PUMPS	3,360 (n.6)	3,007 (n.6)
TOTAL	**£ 299,628**	**£ 285,469**

The total savings achieved for this case study, as a result in the reduction in the pipe diameter, is equal to £ 14,159, which is 5% of the initially identified costs, when dimensioning the plant with ΔT=5°C, for distribution and emission systems.

Chapter 6

ANALYSIS OF VARIABLE COSTS

Whereas the ERSR rotary recovery units are regulated at a constant air flow rate based on the reading of the CO_2 concentration, to guarantee the necessary renewal air, the fan coils are managed by means of fan modulation. In particular, the room terminals adapt the processed air flow rate based on the deviation from the set point: when the desired temperature is reached in the room, the fans turn off and the 2-way valves are closed. As a result, the water flow rate in the secondary circuit varies based on the load.
By maintaining the same linear pressure drops, the reduction in the water flow rate makes it possible to achieve savings in the pumping expense during the entire operation of the plant. These savings increases when the operating conditions are more severe (high loads).



The plant subject of the case study has 4 rotary recovery units with a mixed coil and modulating valve as well as a total of 134 fan coils with a 2-way on-off valve.
For this reason, the trend of the water flow rate can be considered linear (blue line, figure to the side) based on the heating-cooling load required for the plant over the year.

By linearising the water flow rate based on the system loads, which in turn are directly proportional, the savings in pumping costs were initially calculated with the external air temperatures both in summer and in winter, adopting the new high ΔT design logic.

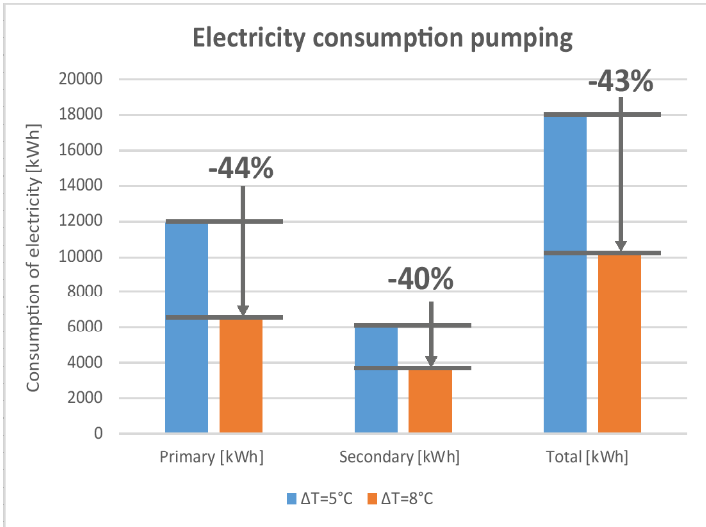


Figure 17
Percentage savings in electricity with a high ΔT.

The electricity connected to pumping expenses that is saved thanks to an increase in the thermal head to 8°C equals 7,792 kWh/year, which is 43% of what was originally indicated when dimensioned for ΔT=5°C.
Considering a cost of electricity of 0.17 £/kWh, the annual economic savings achieved by pumping the heat carrier liquid in the system amount to 1,325 £/year.

Chapter 7

ENERGY ANALYSIS OF THE HEATING-COOLING PLANT

The economic savings achieved thanks to the increase in the thermal head in the plant can be reinvested immediately in more efficient technical solutions: an increase in the insulation of the opaque and transparent surfaces, led lighting, increase in the solar heating manifolds for the production of DHW, high-efficiency generators, radiant effect fan coils, etc…
The Aermec heat pumps can be configured in versions other than the standard version in order to further improve the acoustic and energy performance of the generation system. A high efficiency solution permits a decrease in energy consumption while increasing the power delivered by the heat pump.
The standard air/water heat pump that was identified for the plant is NRB2000XH°°°°°00.
This is a bi-circuit unit with scroll compressors, electronic lamination valves, brazed plate plant side heat exchanger, ventilating V-block structure with axial fans and finned coils comprised of copper pipes and aluminium fins.
The generator was dimensioned to handle the peak load both in summer and in winter:

Table 4
Summer and winter peak loads

SEASON	EXTERNAL DESIGN TEMPERATURE (°C)	PEAK POWER (KW)
Summer	35	440
Winter	0	380

Figure 18
Aermec NRB-H series heat pumps

The standard machine is aligned, under design conditions, with the thermal power required for the plant during winter (380 kW), whereas it is overabundant for summer: with the external air at 35°C, this guarantees a cooling power of 502 kW.

The alternative solution to increase the energy efficiency of the generation system is to reinvest a part of the obtained savings in the high-efficiency version NRB2000XHA°°°°00. This solution makes it possible to provide the plant with 409 kW when heating 548 kW when cooling at the design conditions.

Considering that the high-efficiency heat pump is overabundant when operating both in summer as well as in winter, it is possible to consider selecting a smaller size to further increase the margin of savings in terms of energy as well as the initial investment. To simplify this economic analysis, the selection was made to keep the same generator size.

Figure 19
Electric absorption in cooling mode.

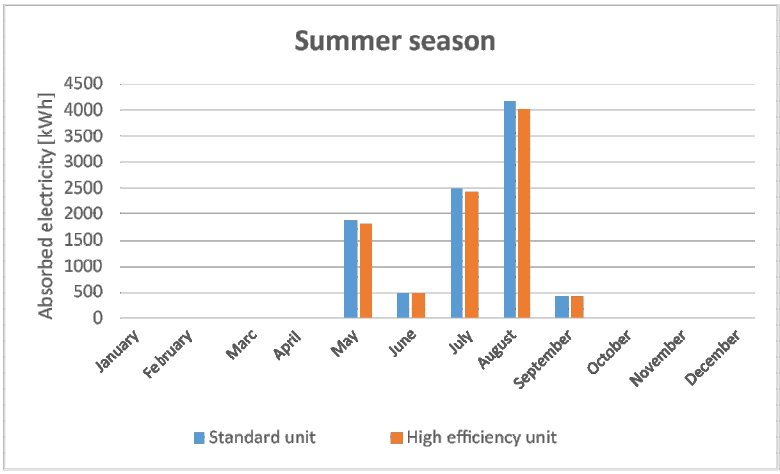


Figure 20
Electric absorption in heating mode.

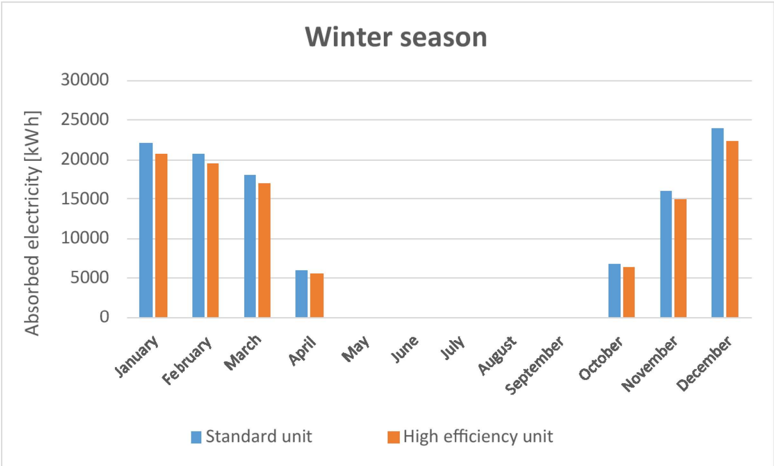
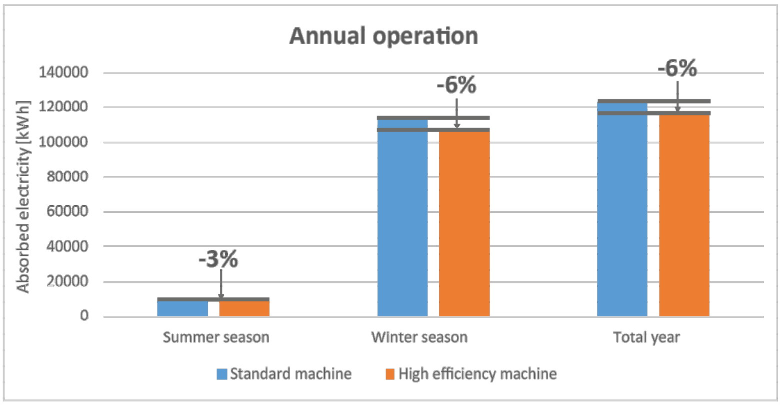
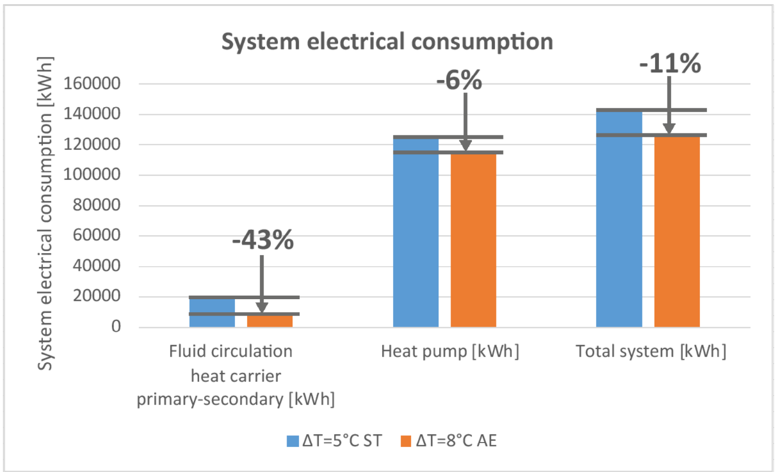


Figure 21
Annual electrical absorption of the generation system.



The annual energy savings obtained when opting for a high-efficiency heat pump instead of the standard heat pump amount to 7,256 kW/year, which is 6% of the electric absorption connected to the generation system, which equals 1,233 £/year (0.17 £/kWh).
By analysing the initial investment costs, it can be seen that the savings of £ 14,159 £ resulting from dimensioning the distribution system with ΔT=8°C is able to completely absorb the extra cost of the high-efficiency heat pump (£ 11,616).
To summarise, for this case study £ 2,543 are saved by opting for a system dimensioned with ΔT=8°C and with a high-efficiency heat pump with respect to a solution with ΔT=5°C and a standard heat pump.
In addition to this reduction in cost, which is obtained before the plant starts its life cycle, there are also pumping and generation energy savings.

Figure 22
Overall system energy savings.



The following economic savings can be achieved during the life cycle of the plant:

- Pumping energy expense savings: £ 1,325/year
- Savings in generator absorption: £ 1,233/year
- **Total savings: £ 2,558/year**

When considering a plant life cycle of 10 years, the net savings obtained from system operation equals £ 25,580, to which the £ 2,543 that were saved initially must be added. The total savings amount to £ 28,123 in 10 years.

Chapter 8

ECONOMIC ANALYSIS: NET PRESENT VALUE (NPV)

$$VAN = \sum_{t=1}^{n} \frac{NFC_t}{\left(1+WACC\right)^t} - I_0$$

$$NFC_t = \left(1-t\right) \cdot R \cdot \left(1+i\right)^n$$

$$WACC = (1-t) \cdot \frac{D}{D+E} \cdot k_d + \frac{E}{D+E} \cdot k_e$$

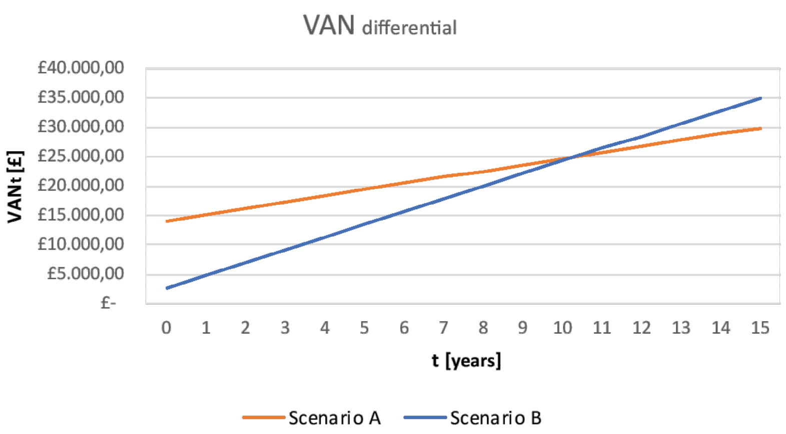
Key:
NFC_t = Net Cash Flow t-th
WACC = Discount rate = 2.1%
I_0 = Initial investment
i = Inflation rate = 2%
R = Savings obtained every year
n = t-th year
t = Tax rate= 20%
D = Debt capital = 50%
E = Own capital = 50%
k_d = Cost of debt capital = 1%
k_e = Expected return on own capital =4%

To check the effective economic convenience of the choices made in this document, the NPV (Net Present Value) was calculated, which makes it possible to calculate the present value of the future earnings obtained thanks to the initial investment. This result is obtained by making use of a series of parameters that indicate if the capital spent for the initial investment derives from own funds or from third-party financing. Furthermore, the NPV considers the inflation rate and the tax rate to discount the cash flows.
Considering that switching to a higher ΔT involves an initial net economic savings, and it is possible to insert an initial savings in the NPV evaluation, to which is then added the various annual savings, instead of the initial investment cost.
There are two calculation scenarios:

SCENARIO A
The entire initial savings are kept (£ 14,159). This is in addition to the annual savings of approx. £ 1,325 £ due to the reduction in pumping expenses.
Finally, the analysis leads to a PNV calculated for 10 years of £ 24,700.

SCENARIO B
The initial profit is no longer the entire saved amount resulting from the reduction in the diameters of the pipes and the insulation, as the increase in the cost of the high-efficiency heat pump must be reduced with respect to the standard solution, equal to £ 11,616. The starting base is therefore equal to £ 2,543, to which is added the annual savings obtained due to the reduction in the pumping expenses and a reduction in the electricity expenses needed to power the generator for an overall total of £ 2,558/year.
The PNV calculation for 10 years results in a value of £ 24,280

Figure 23:
Differential PNV



Overall the calculation of the PNV for 10 years is very similar for the two scenarios. The main difference is related to the way in which the earnings flow: in the first case, the initial savings are higher whereas they are lower annually; in the second case, the initial savings are lower, whereas the annual earnings are higher.

If considering a useful life cycle of a plant that is longer than 10 years and the value of the financial parameters (k_d = Cost of debt capital - k_e= Expected return on own capital) is lower than what was previously considered, scenario B would be preferable.

Chapter 9

CONCLUSIONS

The case study covered in this document, which refers to a newly constructed office building in London, demonstrates how a plant engineering selection with a thermal head increased to 8°C, instead of the standard 5°C, makes it possible to obtain considerable economic and energy advantages without changing plant reliability.

The main benefits to emphasise are:

- **A reduction in the fixed initial investment costs** thanks to a reduction in the pipe diameters, a decrease in the insulation needed for the pipes, a smaller size of the accessory distribution components and a reduction in the size of the circulation pumps. The achieved savings can be reinvested immediately in solutions that guarantee higher energy efficiency for the system.

- **A reduction in the operating costs of the distribution system**, which is mainly related to the lower pumping expenses (less circulating water flow rate) and partially to the lower transmission losses thanks to a reduction in the exchange surface between the pipes and the surrounding environment.

- **A reduction in the CO_2 released to the atmosphere** during construction, operation and disposal of the plant.

- **Reliability** ensured by the lack of complex control systems, which are instead required by variable flow rate solutions on the primary loop used today for the reduction of pumping expenses.

Aermec S.p.A. via Roma 996 - 37040 Bevilacqua (VR) Italy
T. +39 0442 633111 F. +39 0442 93577
sales@aermec.com
www.aermec.com