Buildings for office use

Energy efficiency guide

Worldwide solutions for energy efficiency

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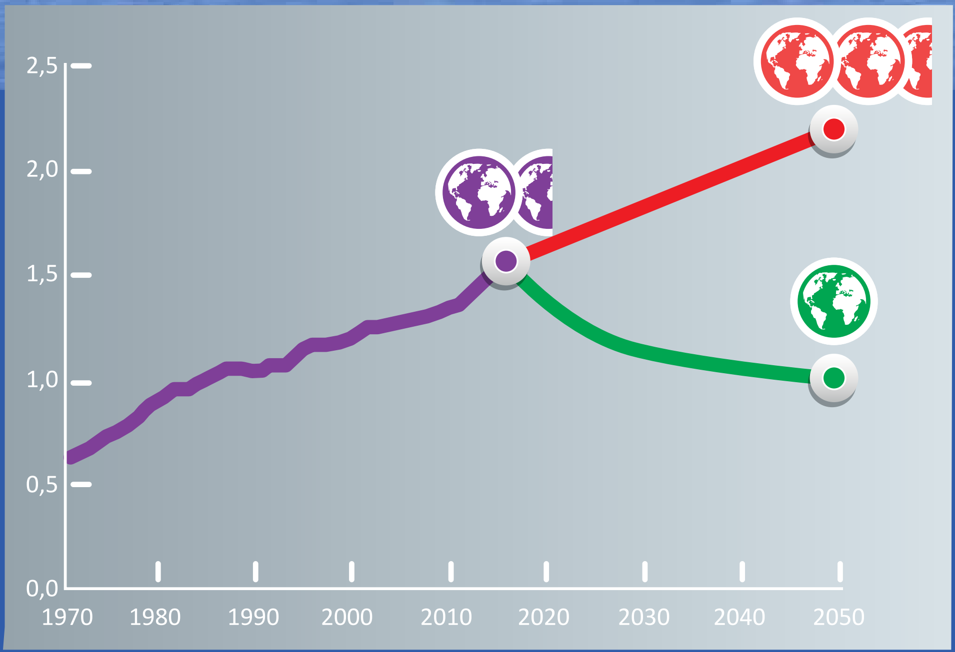
This famous proverb fully expresses the importance and attention that we all should put in preserving our precious planet for future generations.
The ecological footprint represents the impact of human activity, in terms of production of pollution and exploitation of natural resources, in the entire planet Earth.

To date, the equivalent of 1.5 planets is used each year and the United Nations has forecast that, with the current population growth trends, we will largely overcome the equivalent of 2 planets by 2050.

If we do not want to compromise the resources available to future generations, governments and institutions around the world must intervene urgently to bring exploitation back within the level of sustainability imposed by the Earth.
As part of the climate conference held in Paris in 2015 (COP21), it was shown that 78% of global energy consumption and 60% of CO_2 emissions are made by towns and urban centres.
In this scenario, the construction of energy-efficient buildings plays a fundamental role in reversing the trend of exploitation of natural resources.



Source: Global Footprint Network

"We do not inherit the Earth from our ancestors; we borrow it from our children. Our duty is to give it back"

In commercial and residential buildings, often, the predominant part of consumption is represented by the energy required for summer and winter air conditioning and for the necessary air renewal and treatment.

The designer's role is even more important when facing the energy challenges of the coming years and the study presented here is primarily an incentive to a systemic and comprehensive approach to the design of HVAC systems (Heating Ventilation and Air Conditioning).

The efficiency route

How can the maximum possible reduction in fuel consumption and emissions, be assessed in the design phase?

A large building is a complex "body" consisting of a large number of components and subsystems that interact with each other and with the external environment and that influence each other's performance.

Using simplified simulation models that neglect these dynamic interactions are likely to lead to assessments that are often far from the actual energy performance.

This guide shows a few examples of many results obtained from a major survey made by RHOSS in collaboration with researchers from the "**Department of Energy of the POLYTECHNIC OF TURIN**" and with the invaluable advice of Engineer Michele Vio (AiCARR past-president) for the identification of possible HVAC plant solutions to achieve the best energy performance.

nZEB

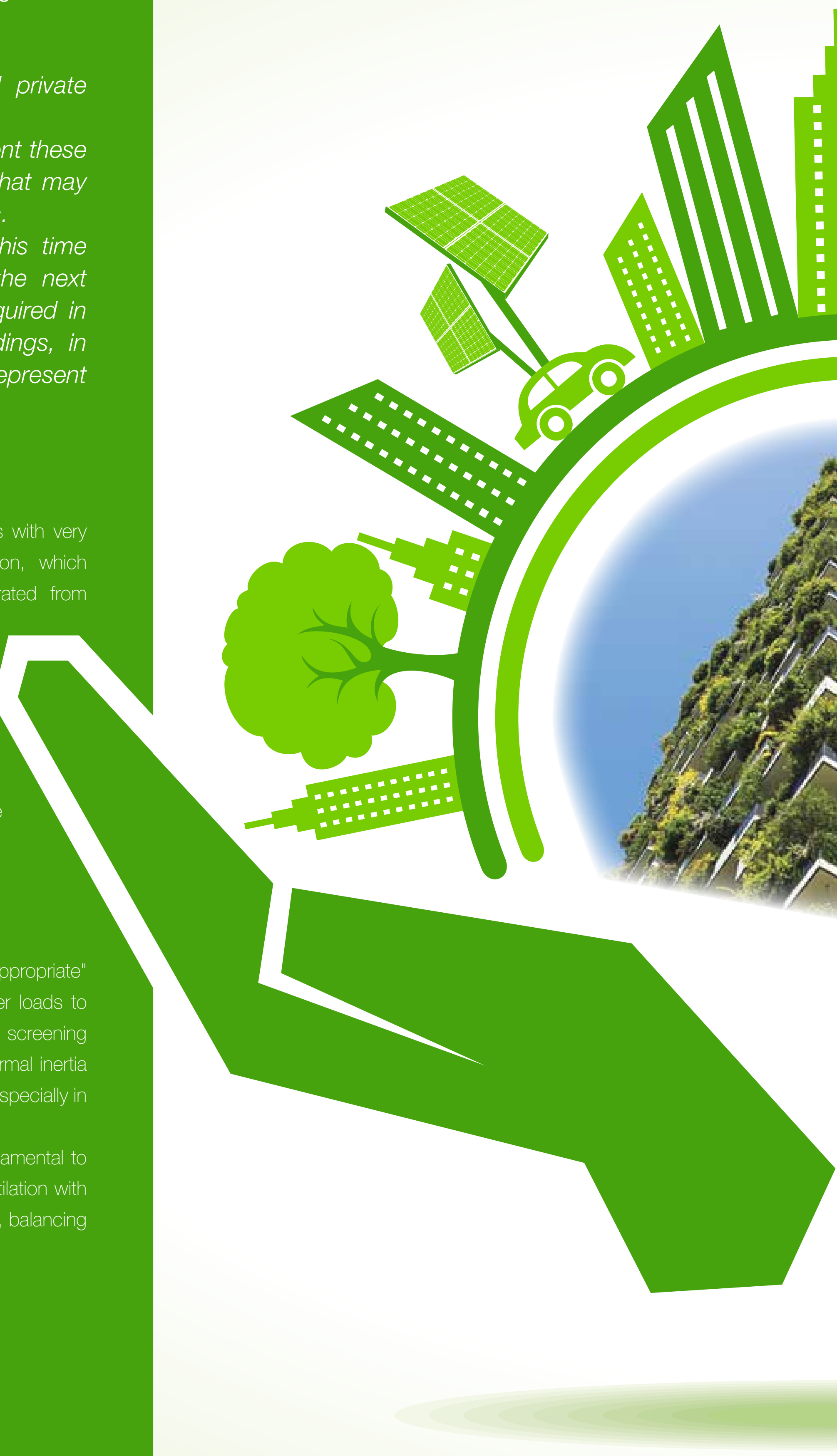
An important step towards improving the energy performance of buildings and containing the carbon dioxide emissions is represented, within the EU, by the European Directive on energy performance of buildings (EPBD 2010/31/EU). The directive states that all new buildings must meet the requirements of nZEB as from:

- *01/01/2019 for new public buildings*
- *01/01/2021 for all new public and private buildings*

Member States are required to implement these obligations within national regulations that may impose even more restrictive constraints.
Although the obligations required at this time concern only new constructions, in the next future the same obligations will be required in Italy and Europe for the existing buildings, in which the major structural constraints represent another technological challenge.

What is nZEB?

nZEBs (nearly-Zero Energy Buildings) are buildings with very high energy performance, nearly no consumption, which is almost completely covered by energy generated from renewable sources, both on site and nearby.
The concept of “nearly-Zero” requires that the balance between energy consumption and production is near zero during a whole year, however, there will be times when the building will be active and others when it will be passive.
The energy performance is determined in accordance with Annex I of the directive.



How to design a nZEB

Primarily, the building's energy must be reduced: "appropriate" insulation in the building envelope allows the winter loads to be controlled, whereas properly designed solar screening combined with rational ecological use and high thermal inertia materials allow the summer loads to be contained, especially in the Mediterranean climate.
In order to minimize energy consumption, it is fundamental to use high efficiency systems, using mechanical ventilation with heat recovery as well as renewable energy sources, balancing the residual consumption as much as possible.

...a concrete step forward

Insulation and glass surfaces

A number of energy analyses have shown that, in buildings used as offices, thus having high internal loads, excessive thermal insulation in the building envelope leads to significant overheating with an increase in energy consumption for cooling air conditioning. Furthermore, for the same type of building, with equal thermal insulation and interior comfort requirements, the energy consumption of a mainly transparent envelope will be higher compared to a predeominant opaque one, as in this case the greater thermal inertia can mitigate the summer thermal loads.

nZEB certification and energy classification

The nZEB certification is carried out in compliance with the minimum requirements set forth by the various States of the European Union. For example, in Italy, for a building to be classified nZEB it must achieve better performance when compared to a "reference building", which must be simulated with the same geometry, the same type of surface and the same positioning as the original and must comply with the limit values set for some parameters that distinguish the building envelope and systems. Furthermore, it must also guarantee to cover part of the demand with renewable energy sources.

The energy classification, on the other hand, represents the amount of energy consumed per square metre in the building in one year. Therefore, there is no parallel between nZEB certification and energy classification with the consequent possibility of finding future buildings with a high energy rating but not nZEB certified or vice versa.

"Equivalent photovoltaic surface"

As described above, in nZEB buildings the reduced consumption must necessarily be balanced by the energy production from renewable sources on site or nearby. There are various technologies available to the designer to fulfil this obligation, however, that which is most widely used is certainly electricity generated by photovoltaic technology.

In this regard, with the aim to provide the reader with a tangible and contextualised indicator, during research activities it has been decided to represent the results of the energy simulations using a new parameter: the equivalent photovoltaic surface. This parameter has the advantage of effectively and immediately representing the energy benefit which can be achieved via the application of each plant solution.

Case study: building for office use

The analysed building is spread over seven floors above ground level and features a net air-conditioned floor area of about 11,620 m^2. The floor type, characterised by a surface area of about 1660 m^2 and a net interfloor height of 2.7 m consists of a central core occupied by distribution spaces and restrooms, and a perimetral part entirely occupied by offices. Two different glazing percentages are assumed, in order to simulate a predominantly opaque building (33% ratio) and a predominantly transparent building (60%). Three different levels of heat insulation are also present for the building envelope, with reference to the current minimum requirements in the middle level in the various international locations considered. With regards to the internal inputs, in addition to the load due to the presence of people, there are intended loads arising from electrical equipment for lighting, elevators, servers, printers and PCs, each with its weekly schedule. For consistent and comparable results to be obtained in the analyses, the environmental setpoints are set so as to have the same comfort conditions in the environment.

Compared plant solutions

8 different types of plant were compared for each building: 4 fresh air, 3 full air VAV and 1 with a ceiling radiant system. The decisive factors between the different types of systems are the Relative Humidity setting in the environment via the AHU cooling coil, the flow of fresh air (fixed or variable with the presence of people), the project temperature of the fan-coils and its variability during the season and the possible presence of a Free-Cooling system assisted by direct adiabatic cooling (DAC). In addition, for each plant solution, 6 different technologies have been considered for the heat recovery from the exhaust air and 8 different technologies for the chillers or heat pumps.

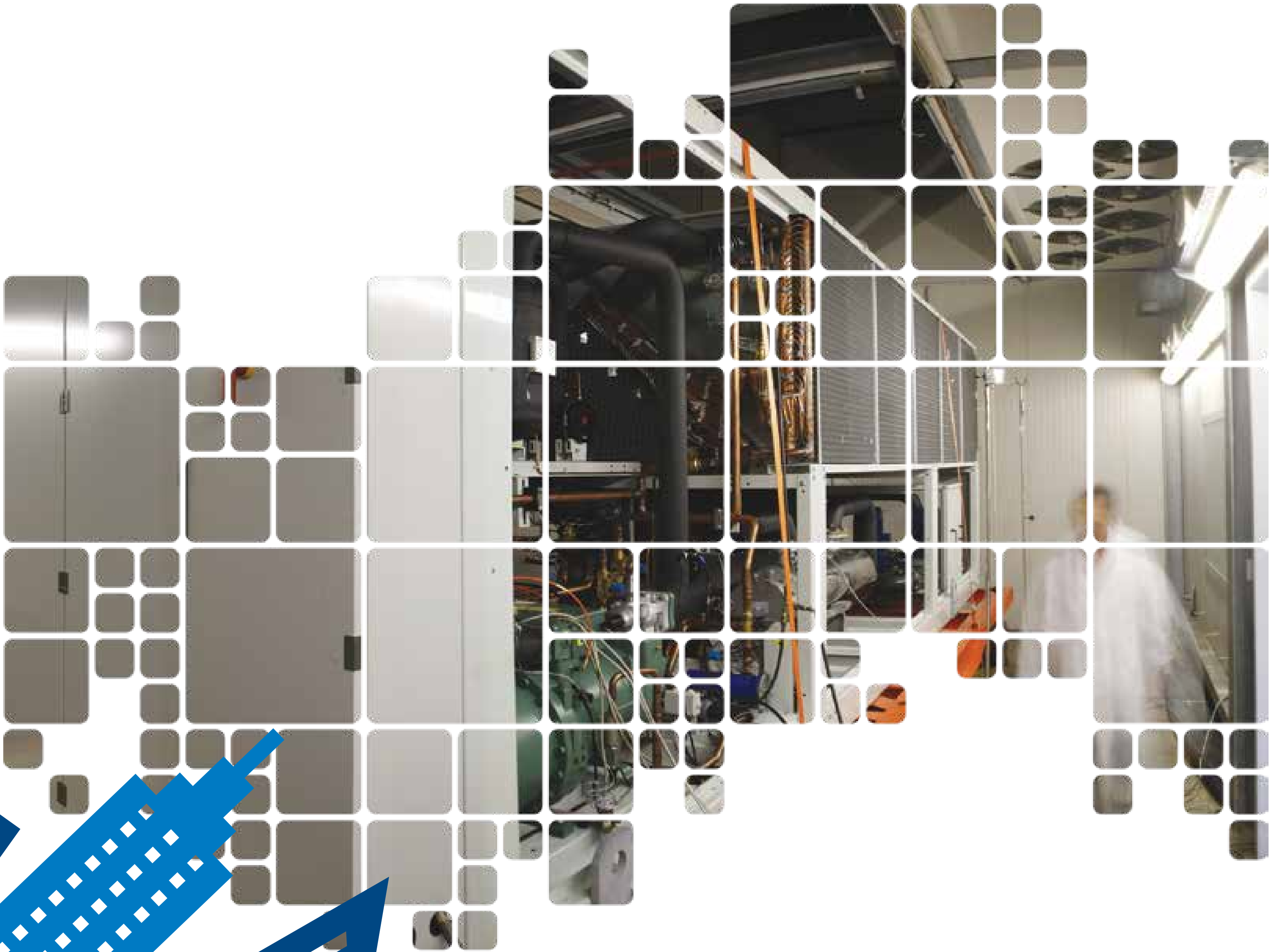
Systemic approach and advantages compared to other energy assessment methods

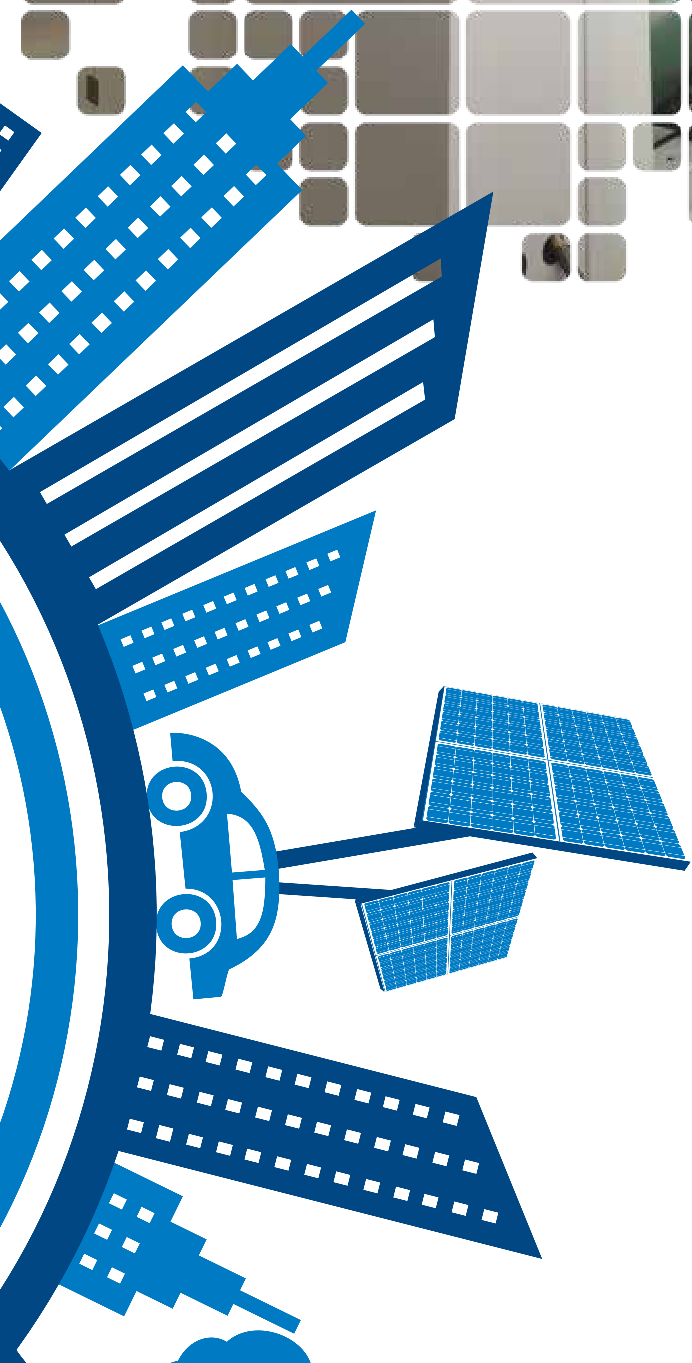
The dynamic simulation software, EnergyPlus™, together with a simulation tool of the system components based on data collected through test trials, was used for the research for the energy analysis. Compared to tools that use the nearly-stationary assessment method, using dynamic simulation software has allowed for in-depth analysis on an hourly basis, which considers the complex interactions of the building-plant system, optimising the performance of the system and assessing each design choice through an iterative process.

Fresh air or full air?

The research has shown that **both system choices are excellent and applicable** by the designer according to the specific requirements or present constraints.

DYNAMIC ENERGY ANALYSIS





RHOSS R&D Lab

The validity of any dynamic numerical simulation is based on 2 main elements:

- The accuracy and reliability of the data and mathematical models used
- The necessary expertise for the correct setting of the parameters and simulation modes

The dynamic mathematical models of all components included in the various system configurations have been developed in collaboration with researchers of the "Energy Department of the POLYTECHNIC OF TURIN".
The consolidated expertise and knowledge of the technologies proposed by RHOSS has been supported by the **actual operating data detected experimentally in the RHOSS R&D Lab**, one of the most important worldwide in size and quality.

NEXT AIR or ADV Custom

Air handling unit for "fresh air" control. **Indirect adiabatic** "recovery" with unidirectional **regenerative** recovery.

WinPower EXP

Air cooled **polyvalent** ecological system and **scroll hermetic compressors,** refrigerant **R410A**.

Fan-coils and fresh air handling

Variable air flow rate with **regulation on relative humidity** - Fan-coil with **variable flow temperature**.

RHOSS solution for an opaque building with medium insulation: best fresh air system

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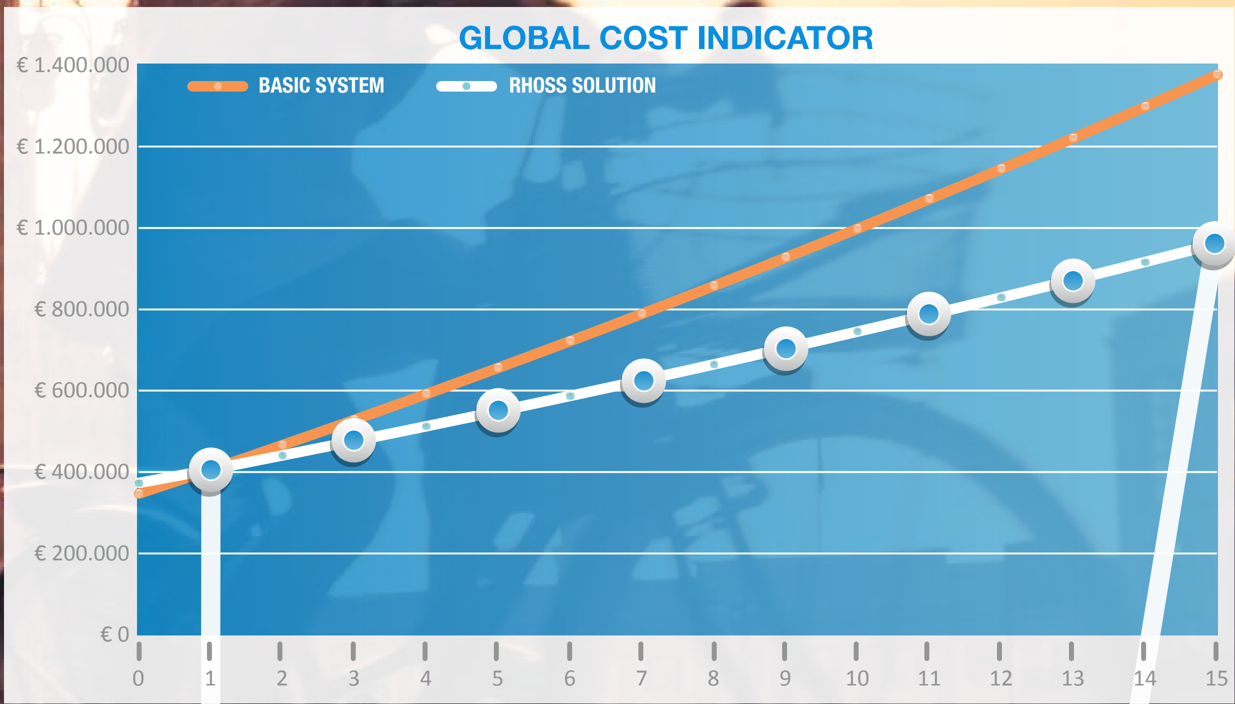
949 m² SAVED EQUIVALENT PHOTOVOLTAIC SURFACE

29 % REDUCED PRIMARY ENERGY CONSUMPTION

22 t/y REDUCED CO_2 EMISSIONS



NOTE:
indicator of estimated global cost using the following parameters:
- Electricity price 0.237 €/kWh
- Natural gas price 0.789 €/m³
- Annual maintenance incidence: 2.5% compared to the initial cost
- Estimated average inflation rate: 2.0%

The basic system consists of:
- Class A multi-scroll chiller with constant flow pump
- Modular condensing boiler with installation box
- Air handling unit with a constant flow with heat recovery unit efficiency > 73% (ErP 2018 ready)
- Fan-coil with EC fans at constant supply water temperature and flow rate

RETURN ON INVESTMENT TIME < 1.5 YEARS

GLOBAL SAVINGS IN 15 YEARS > 400,000 €

MILAN

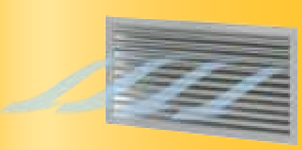
RHOSS solution for a glazed building with high insulation: best full air system

NEXT AIR or ADV Custom

Air handling unit for "full air" control. **Rotary** recovery with **enthalpic** wheel, **hygroscopic** treatment.

TurboPOWER

Air cooled water chiller and **oil-free centrifugal compressors**, **R134a** or **R1234ze** refrigerant. High efficiency gas condensing boiler*.



Full air system

VAV system.
Regulation on relative humidity.

* Component not supplied by Rhoss.

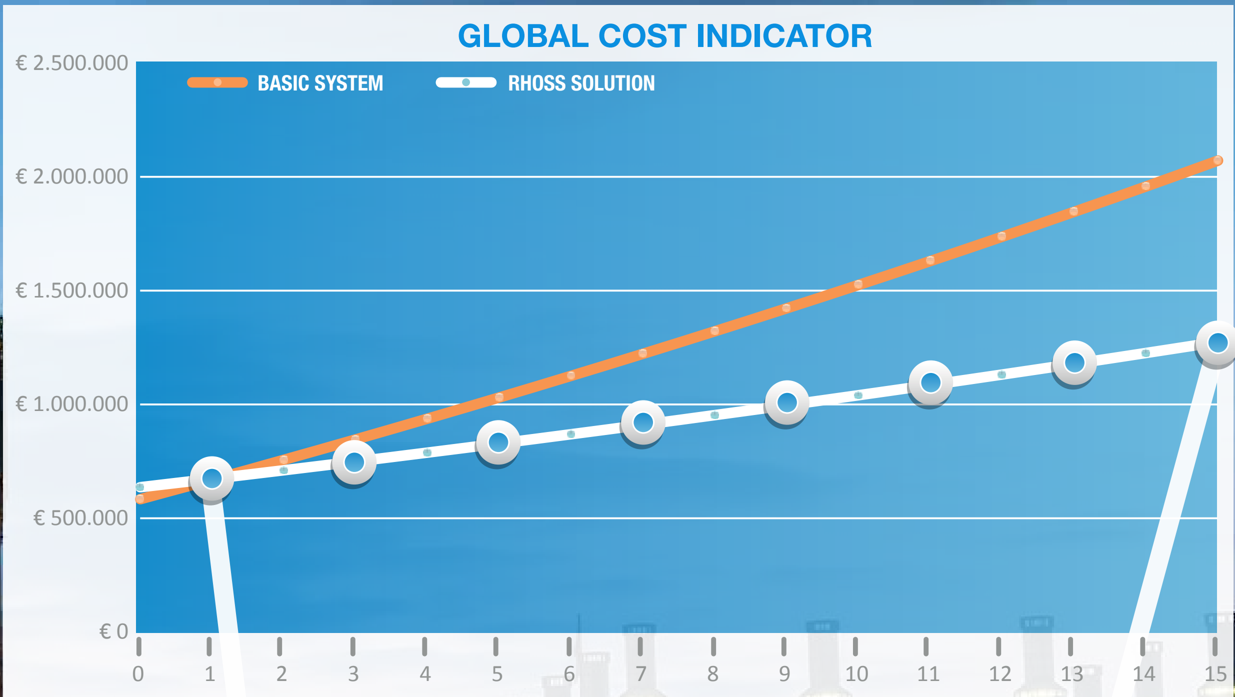
2448 m^2
SAVED EQUIVALENT PHOTOVOLTAIC SURFACE

47 %
REDUCED PRIMARY ENERGY CONSUMPTION

44 t/y
REDUCED CO_2 EMISSIONS

NOTE:
indicator of estimated global cost using the following parameters:
- Electricity price 0.176 €/kWh
- Natural gas price 0.726 €/m^3
- Annual maintenance incidence: 2.5% compared to the initial cost
- Estimated average inflation rate: 2.0%

The basic system consists of:
- Class A multi-scroll chiller with constant flow pump
- Modular condensing boiler with installation box
- Air handling units with a variable flow with heat recovery unit efficiency > 73% (ErP 2018 ready)



RETURN ON INVESTMENT TIME < 1.5 YEARS

GLOBAL SAVINGS IN 15 YEARS > 790.000 €

LONDON

NEXT AIR or ADV Custom

Air handling unit for "fresh air" control. **Indirect adiabatic** "recovery".

WinPower EXP

Air cooled **polyvalent** ecological system and **scroll hermetic compressors,** refrigerant **R410A**.

Fan-coils and fresh air handling

Variable air flow rate with **regulation on relative humidity** - Fan-coil with **variable flow temperature**.

RHOSS solution for an opaque building with high insulation: best fresh air system

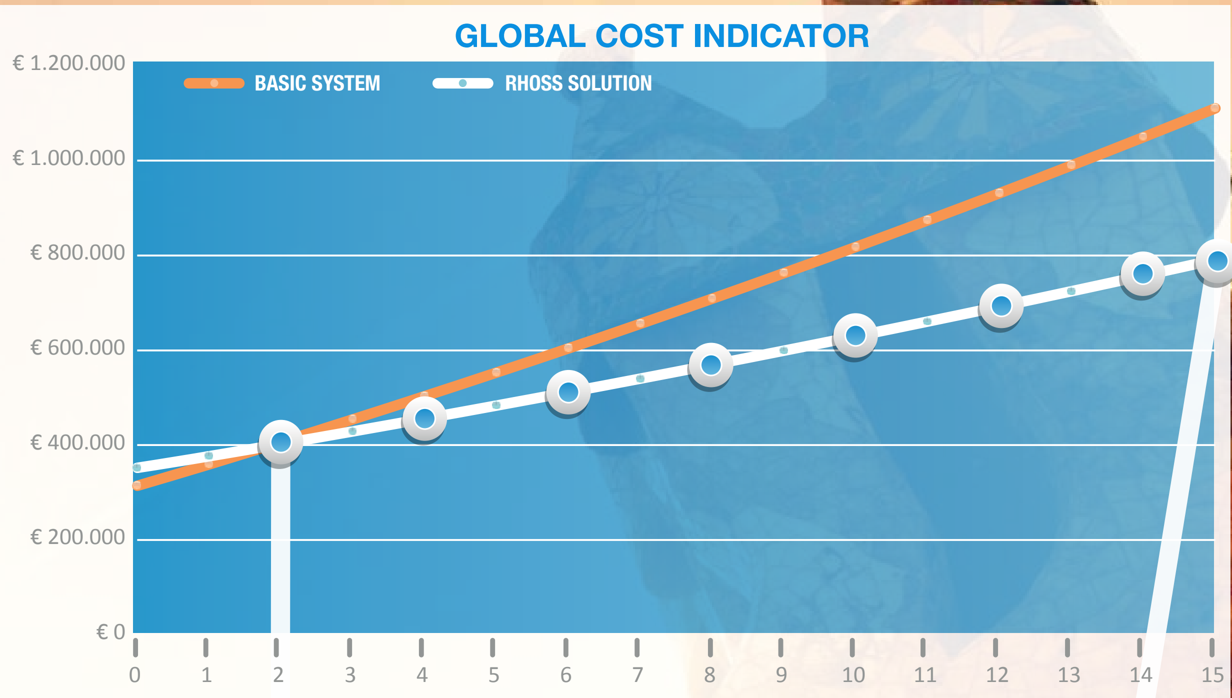
675 m²
SAVED EQUIVALENT PHOTOVOLTAIC SURFACE

38 %
REDUCED PRIMARY ENERGY CONSUMPTION

26 t/y
REDUCED CO² EMISSIONS

NOTE:
indicator of estimated global cost using the following parameters:
- Electricity price 0.191 €/kWh
- Natural gas price 0.671 €/m³
- Annual maintenance incidence: 2.5% compared to the initial cost
- Estimated average inflation rate: 2.0%

The basic system consists of:
- Class A multi-scroll chiller with constant flow pump
- Modular condensing boiler with installation box
- Air handling unit with a constant flow with heat recovery unit efficiency > 73% (ErP 2018 ready)
- Fan-coil with EC fans at constant supply water temperature and flow rate



RETURN ON INVESTMENT TIME
< 2 YEARS

GLOBAL SAVINGS IN 15 YEARS
> 300.000 €

BARCELONA

NEXT AIR or ADV Custom

Air handling unit for “fresh air” control. **Static crossed flow or rotary recovery** (sensible only).

TurboPOWER

Air cooled water chiller and **oil-free centrifugal compressors**, **R134a** or **R1234ze** refrigerant. High efficiency gas condensing boiler*.

Fan-coils and fresh air handling

Variable air flow rate with **regulation on relative humidity** - Fan-coil with **variable flow temperature**.

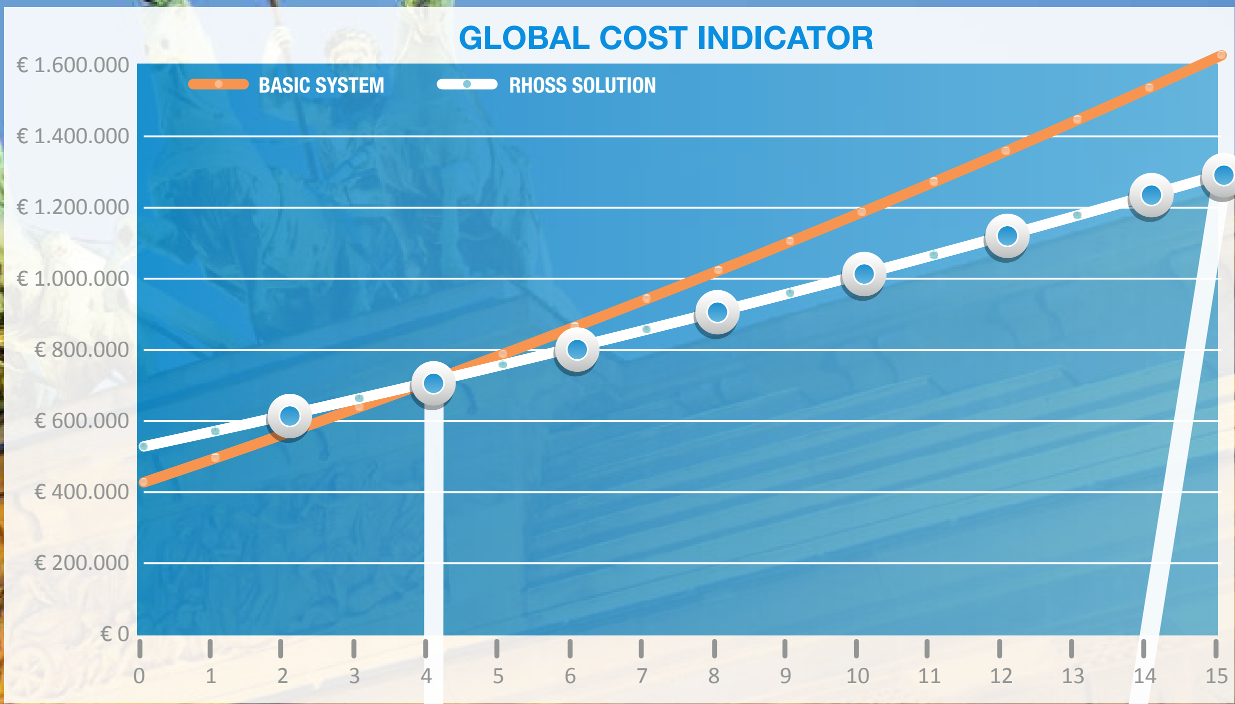
* Component not supplied by Rhoss.

RHOSS solution for a glazed building with high insulation: best fresh air system

1045 m^2
SAVED EQUIVALENT PHOTOVOLTAIC SURFACE

42 %
REDUCED PRIMARY ENERGY CONSUMPTION

41 t/y
REDUCED CO_2 EMISSIONS



NOTE:
indicator of estimated global cost using the following parameters:
- Electricity price 0.236 €/kWh
- Natural gas price 0.622 € / m^3
- Annual maintenance incidence: 2.5% compared to the initial cost
- Estimated average inflation rate: 2.0%

The basic system consists of:
- Class A multi-scroll chiller with constant flow pump
- Modular condensing boiler with installation box
- Air handling unit with a constant flow with heat recovery unit efficiency > 73% (ErP 2018 ready)
- Fan-coil with EC fans at constant supply water temperature and flow rate

RETURN ON INVESTMENT TIME
< 4 YEARS

GLOBAL SAVINGS IN 15 YEARS
> 300.000 €

BERLIN

RHOSS solution for an opaque building with medium insulation: best fresh air system

NEXT AIR or ADV Custom

Air handling unit for "fresh air" control. **Rotary** recovery with **enthalpic** wheel, **hygroscopic** treatment, with unidirectional **regenerative** recovery.

Z-Power HT

Air cooled tropicalised water chiller and **screw semi-hermetic compressors, R134a** refrigerant.

Fan-coils and fresh air handling

Variable air flow rate with **regulation on relative humidity** - Fan-coil with **variable flow temperature**.

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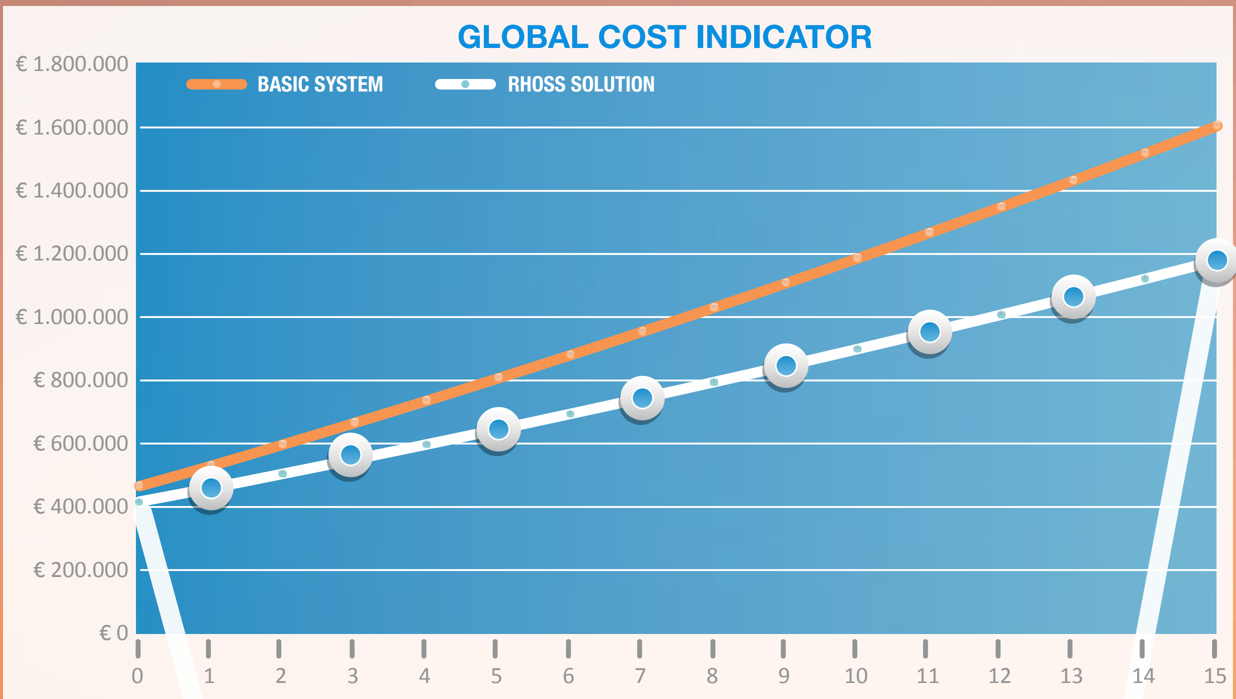
573 m^2
SAVED EQUIVALENT PHOTOVOLTAIC SURFACE

38 %
REDUCED PRIMARY ENERGY CONSUMPTION

87 t/y
REDUCED CO_2 EMISSIONS

GLOBAL COST INDICATOR



NOTE:
indicator of estimated global cost using the following parameters:
- Electricity price 0.100 €/kWh
- Annual maintenance incidence: 2.5% compared to the initial cost
- Estimated average inflation rate: 2.0%

The basic system consists of:
- Chiller with class A "stepless" screw compressor with constant flow pump
- Air handling unit with a constant flow with heat recovery unit efficiency > 73% (double rotary wheel ErP 2018 ready)
- Fan-coil with EC fans at constant supply water temperature and flow rate

RETURN ON INVESTMENT TIME 0 YEARS

GLOBAL SAVINGS IN 15 YEARS > 420.000 €

DUBAI

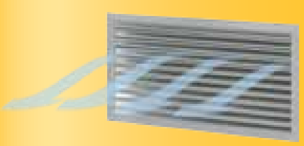
RHOSS solution for an opaque building with high insulation: best full air system

NEXT AIR or ADV Custom

Air handling unit for “full air” control. **Rotary** recovery with **enthalpic** wheel, **hygroscopic** treatment.

Z-Power VFD

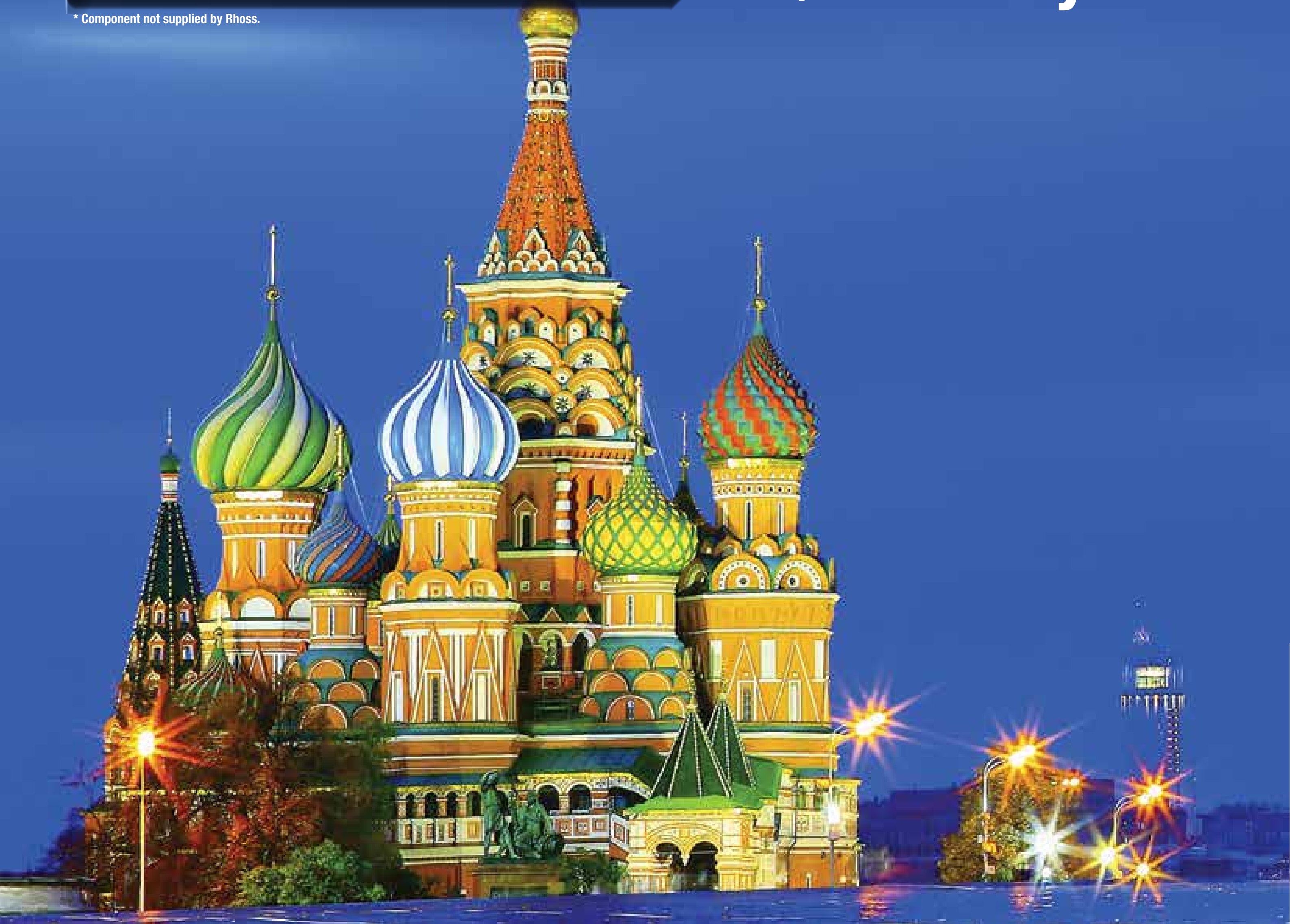
Air cooled water chiller and **screw semi-hermetic compressors, variable Vi and Inverter adjustment**, **R134a** refrigerant. High efficiency gas condensing boiler*.



Full air system

VAV system.
Regulation on relative humidity.

* Component not supplied by Rhoss.



1185 m²
SAVED EQUIVALENT PHOTOVOLTAIC SURFACE

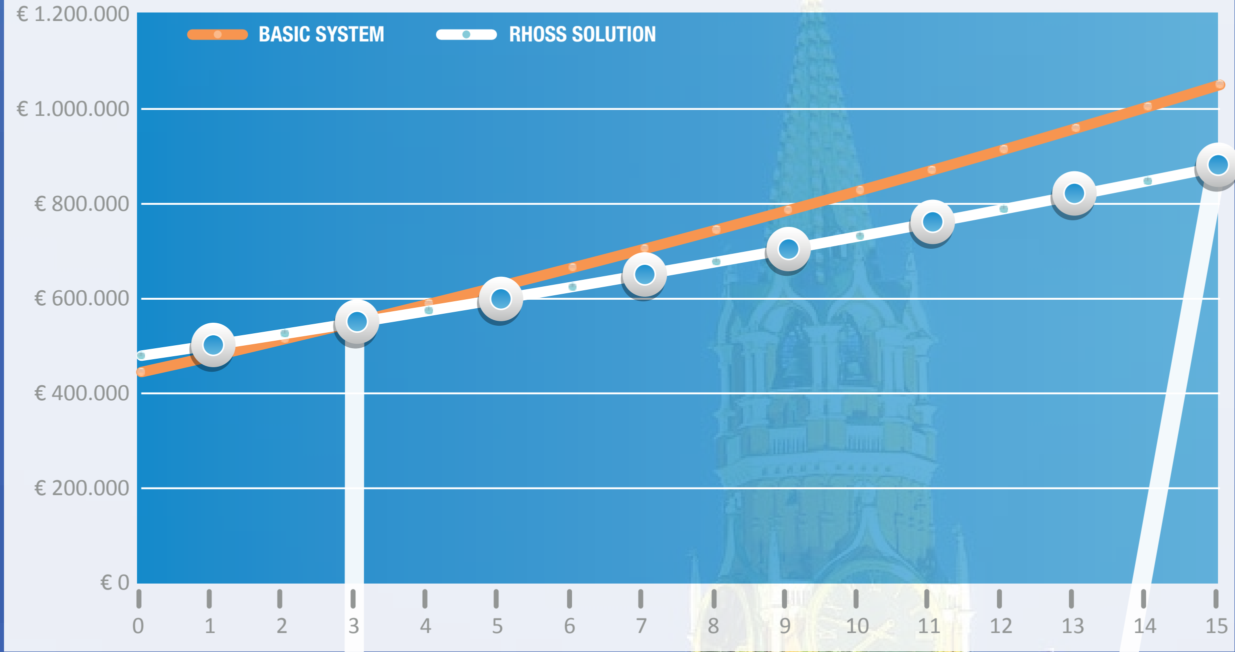
34 %
REDUCED PRIMARY ENERGY CONSUMPTION

22 t/y
REDUCED CO^2 EMISSIONS

NOTE:
indicator of estimated global cost using the following parameters:
- Electricity price 0.100 €/kWh
- Natural gas price 0.450 €/m³
- Annual maintenance incidence: 2.5% compared to the initial cost
- Estimated average inflation rate: 2.0%

The basic system consists of:
- Class A multi-scroll chiller with constant flow pump
- Modular condensing boiler with installation box
- Air handling unit with a constant flow with heat recovery unit efficiency > 73% (ErP 2018 ready)

GLOBAL COST INDICATOR



RETURN ON INVESTMENT TIME < 3 YEARS

GLOBAL SAVINGS IN 15 YEARS > 170.000 €

MOSCOW

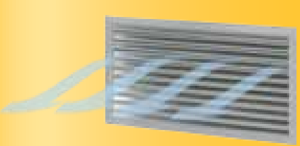
RHOSS solution for an opaque building with high insulation: best full air system

NEXT AIR or ADV Custom

Air handling unit for “fresh air” control.
Static crossed flow or rotary recovery (sensible only).

Y-Pack EXP

Air cooled **polyvalent** ecological system and **scroll hermetic compressors,** refrigerant **R410A**.



Full air system

VAV system.
Regulation on relative humidity.
Direct adiabatic cooling.

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1205 m² SAVED EQUIVALENT PHOTOVOLTAIC SURFACE

35 % REDUCED PRIMARY ENERGY CONSUMPTION

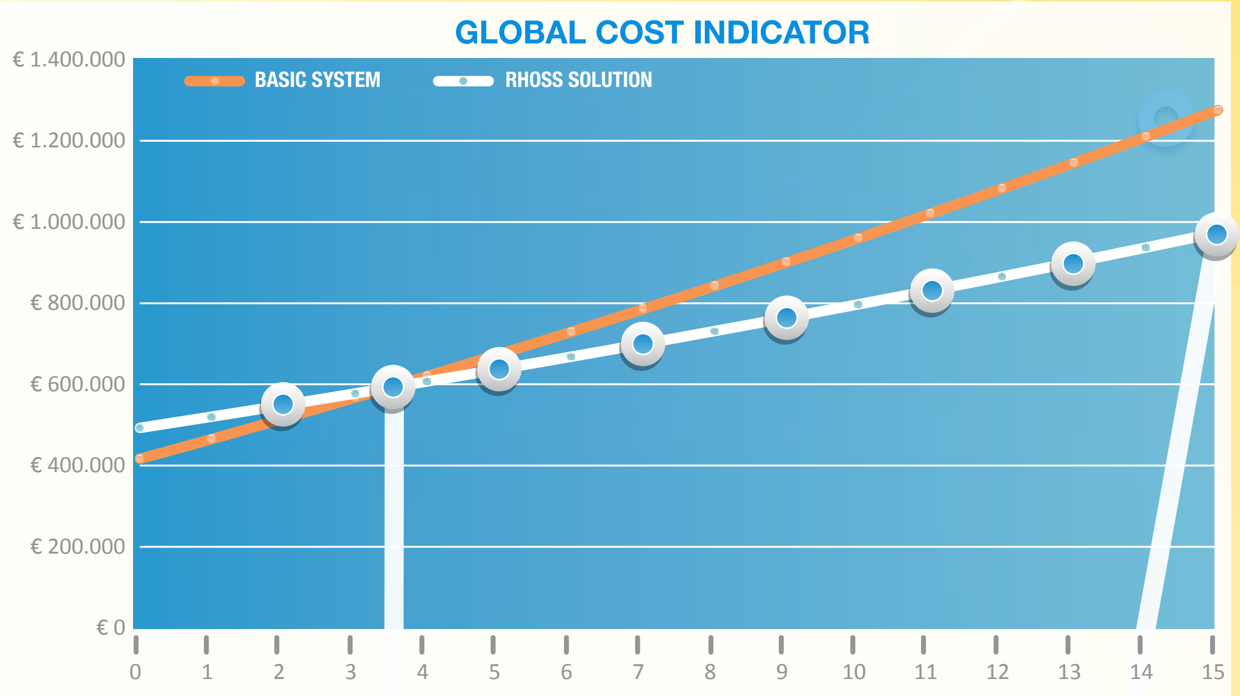
25 t/y REDUCED CO_2 EMISSIONS

NOTE:
indicator of estimated global cost using the following parameters:

- Electricity price 0.139 €/kWh
- Natural gas price 0.733 €/m^3
- Annual maintenance incidence: 2.5% compared to the initial cost
- Estimated average inflation rate: 2.0%

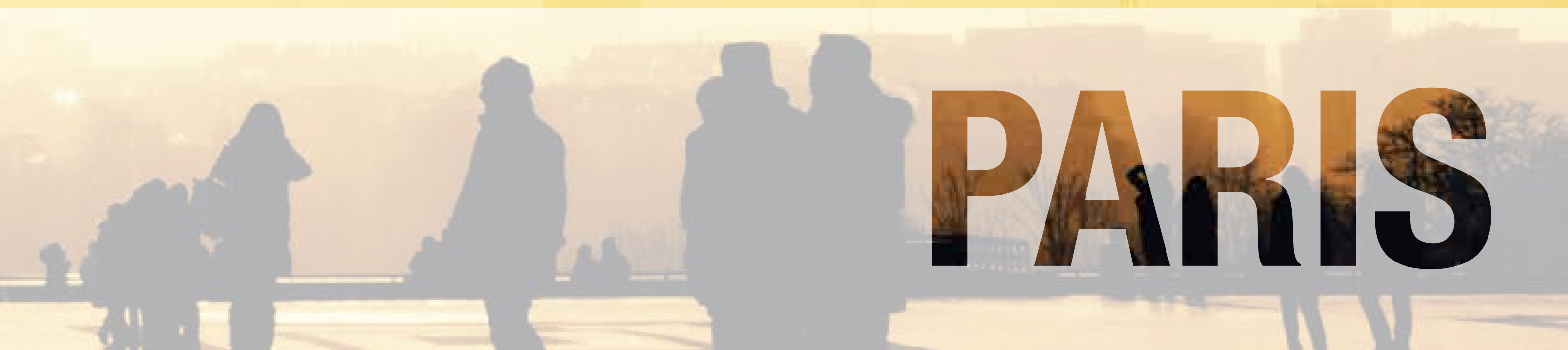
The basic system consists of:

- Class A multi-scroll chiller with constant flow pump
- Modular condensing boiler with installation box
- Air handling unit with a constant flow with heat recovery unit efficiency > 73% (ErP 2018 ready)



RETURN ON INVESTMENT TIME < 3.5 YEARS

GLOBAL SAVINGS IN 15 YEARS > 300.000 €



WORLDWIDE SOLUTIONS

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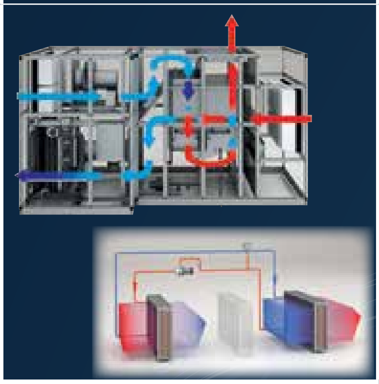
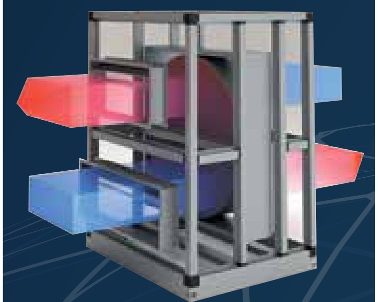
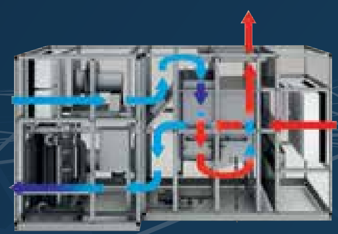
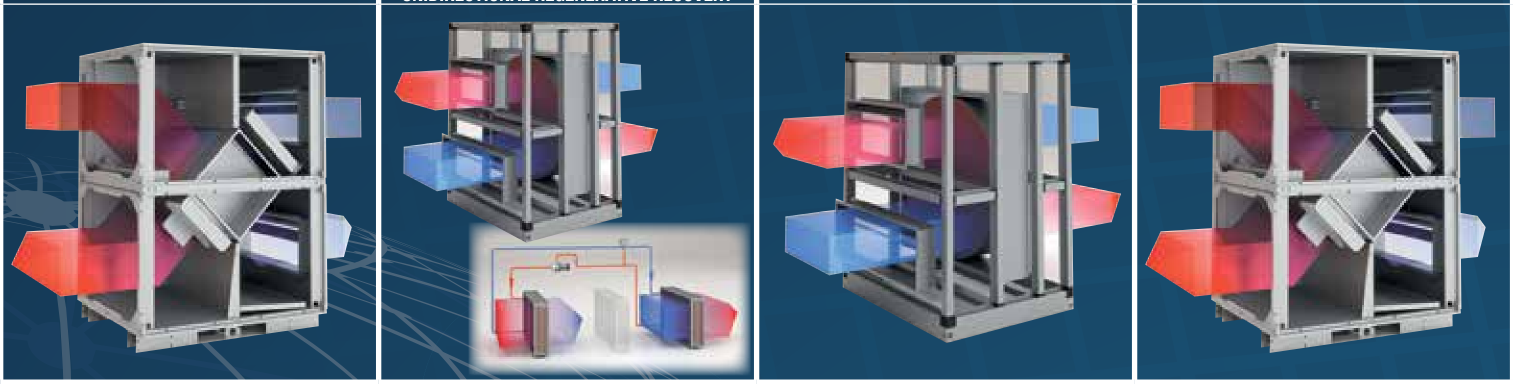
	MILAN	LONDON	BARCELONA
			
	INDIRECT ADIABATIC RECOVERY WITH UNIDIRECTIONAL REGENERATIVE RECOVERY	ROTARY RECOVERY WITH ENTHALPIC WHEEL, HYGROSCOPIC TREATMENT	INDIRECT ADIABATIC RECOVERY
AHU AIR HANDLING UNIT			
	WINPOWER EXP - POLYVALENT, SCROLL HERMETIC COMPRESSORS, R410A	TURBOPOWER - WATER CHILLER, OIL-FREE CENTRIFUGAL COMPRESSORS, R134a/R1234ze	WINPOWER EXP - POLYVALENT, SCROLL HERMETIC COMPRESSORS, R410A
CHILLERS / HEAT PUMPS			
	FAN-COILS AND FRESH AIR HANDLING	FULL AIR SYSTEM - VAV	FAN-COILS AND FRESH AIR HANDLING
SYSTEM TERMINAL UNITS			

FOR ENERGY EFFICIENCY

BERLIN	DUBAI	MOSCOW	PARIS
STATIC CROSSED FLOW OR ROTARY RECOVERY (SENSIBLE)	ROTARY RECOVERY WITH ENTHALPIC WHEEL, HYGROSCOPIC TREATMENT, WITH UNIDIRECTIONAL REGENERATIVE RECOVERY	ROTARY RECOVERY WITH ENTHALPIC WHEEL, HYGROSCOPIC TREATMENT	STATIC CROSSED FLOW OR ROTARY RECOVERY (SENSIBLE)



TURBOPOWER - WATER CHILLER, OIL-FREE CENTRIFUGAL COMPRESSORS, R134a/R1234ze	Z-POWER HT - TROPICALISED WATER CHILLER, SCREW SEMI-HERMETIC COMPRESSORS, R134a	Z-POWER VFD - WATER CHILLER, SCREW SEMI-HERMETIC COMPRESSORS, R134a, INVERTER, Vi VARIABLE	Y-PACK EXP - POLYVALENT, SCROLL HERMETIC COMPRESSORS, R410A

FAN-COILS AND FRESH AIR HANDLING	FAN-COILS AND FRESH AIR HANDLING	FULL AIR SYSTEM - VAV	FULL AIR SYSTEM - VAV DIRECT ADIABATIC COOLING

Significant conclusions

THERE IS NOT A “COPY & PASTE” PLANT

The main result is that there is no single ideal system which can be applicable to all situations.
Each type of building set in a different climate, gives priority to a specific system which behaves better than the others.

POLYVALENT UNITS: A WINNING TECHNOLOGY

The technology of polyvalent units offers excellent performance basically in all situations. The simultaneous generation of hot and cold fluids, recovering one of the two from the other production, maximises energy efficiency of the system and reduces the return of investment time. The analysis has shown amazing results in the refurbishment of lightly insulated buildings.

ENTHALPIC BUT NOT ONLY

Enthalpic heat recovery units can recover the energy of exhaust air not only for the sensible value (temperature) but also for the latent value (humidity). Their excellent performance in VAV systems does seem to be equally compelling in fresh air applications due to frequent partialisation to reach the humidity set point that penalises the potential additional sensible recovery.

INSULATION IS GOOD BUT DO NOT EXAGGERATE

Thermal insulation of the building is advantageous to a certain limit, beyond which the energy consumption reverses the trend and returns to increase as the internal loads increase the cooling demand. This effect is evident for all locations considered with the only exception Dubai, where, due to the high temperatures and project conditions, it is always convenient to insulate.

AHU REGULATION: NEVER AT A FIXED POINT!

Setting the cooling coil supply temperature at a "fixed point" in air handling units wastes energy, especially if the summer project conditions of the environments require Relative Humidity = 55%, as recommended by the European standards for energy efficiency. Regulation on the actual relative humidity always saves energy!

FRESH AIR OR ALL-AIR?

All-air VAV systems, taking advantage of the free-cooling, obtain the best performance provided that the air side pressure drops are limited, thereby minimising the fan consumption. Equally good performance is achieved with fan coil systems and fresh air with optimised control. Both plant choices are consequently excellent and applicable by the designer according to the specific requirements or constraints.

MATCHMAKING

A careful combination of the type of heat recovery from the exhaust air and technology of the units allows the maximum load peaks to be significantly reduced and the consumption to be optimized. You can therefore reduce the size of the units with considerable economic benefit which will significantly shorten the return on investment even to zero, as in the case of Dubai.

SCROLL, SCREW OR CENTRIFUGAL?

Continuous technological evolution of the compressors used in the refrigerant units makes any direct comparison temporary. The analysis has confirmed the importance to keep high efficiency, especially at low load. All the technologies mentioned, if managed properly, can achieve excellent performances. Centrifugal compressors with magnetic levitation, in particular, are more sensitive to the careful integration into the building-plant system.

PERFECTION IS MADE OF DETAILS

The production of hot and chilled water at a variable temperature, the change of the flow and lastly, the correct sizing of the water content are aspects to be taken into consideration. These important project details, managed with particular attention, can actually minimise the energy consumption of the building.

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A highly specialised offer of air-conditioning products and systems supported by the utmost attention paid to customer needs and aimed at sustainable development adequate for green building technologies.
Experience and expertise at the service of specialists.

THE IDEAL PARTNER FO


RELIABILITY
TECHNICAL ASSISTANCE
QUALITY
RESEARCH AND DEVELOPMENT
OR FUTURE CHALLENGES

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K10542EN ed.1 - 09.16

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