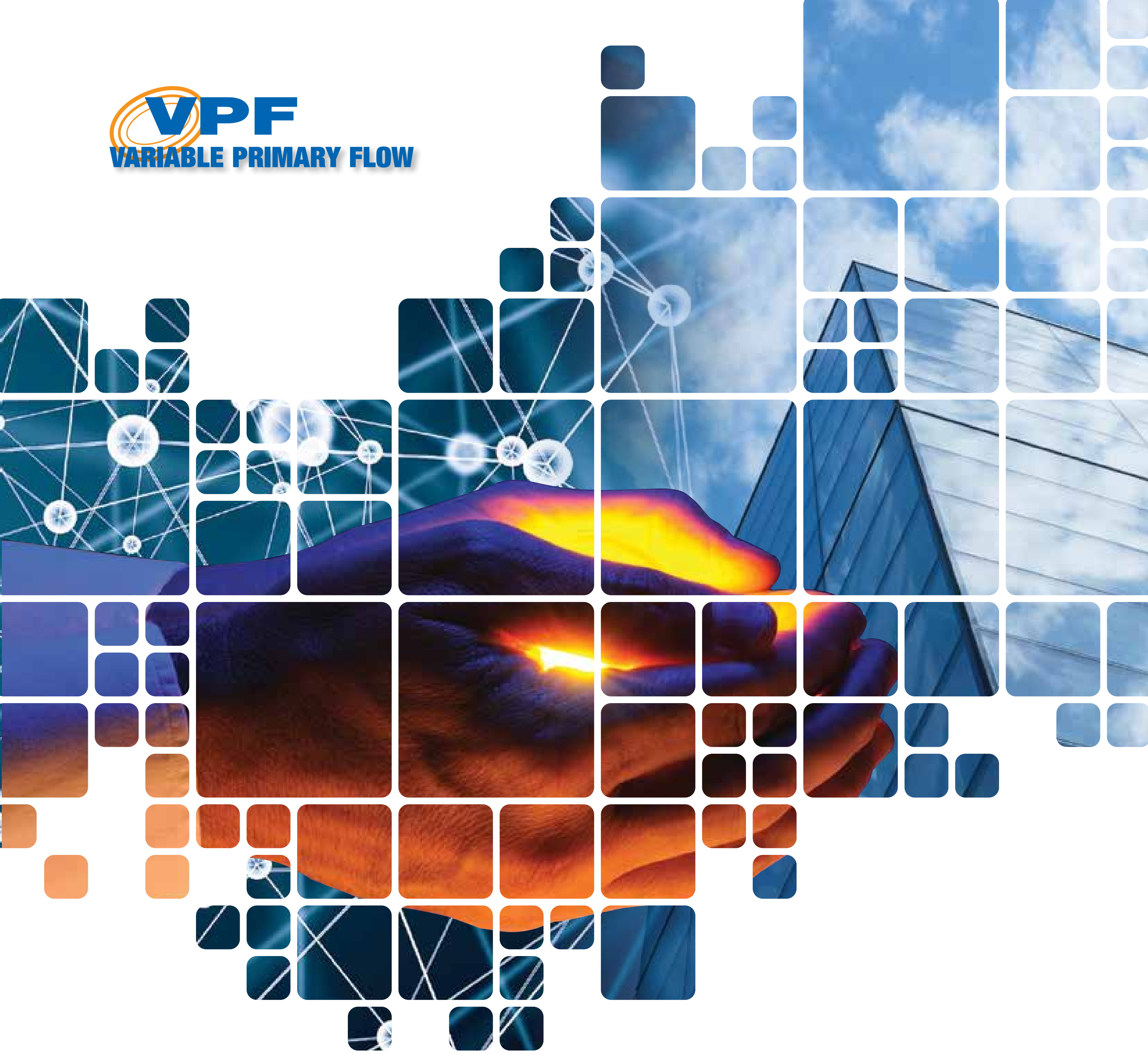
VPF
VARIABLE PRIMARY FLOW



VPF RHOSS: a step forward in the variable flow systems

RHOSS
CREATING YOUR COMFORT

VPF RHOSS: THE NEW BREAKTHROUGH IN PLANT ENGINEERING

The energy consumption of ancillary components in air conditioning systems (pumping, ventilation, etc) can no longer be neglected in the approach to NZEB design.
Consumption must be balanced with production of energy from renewable sources on site or nearby, so the new “equivalent photovoltaic surfaces” parameter becomes a fundamental indicator when comparing the different solutions.
Cooling systems with VPF (Variable Primary Flow), ideal for medium to large cooling capacities, represent an interesting alternative to the traditional constant flow systems.

The solution introduced by Rhoss offers benefits such as reduced energy consumption of the pumping groups with consequent cost savings, combined with reliability and simplified system management.
Using these systems significantly helps the building to achieve a better score in the LEED certification.

VPF RHOSS Video

The solution to reduce pump energy consumption

Download the video:
http://www.rhoss.com/it/download/multimedia

Guide to the principles of LEED®

Leadership in Energy & Environmental Design

Download the complete document:
http://www.rhoss.com/it/download/depliant

Office building

Energy efficiency guide

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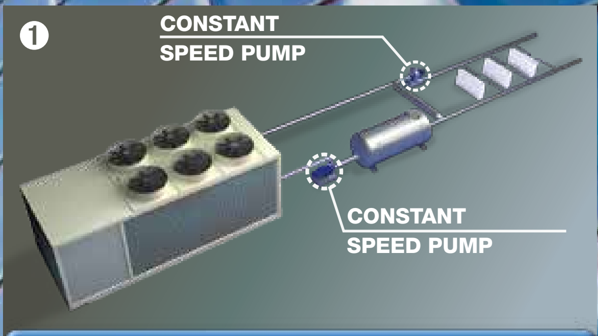
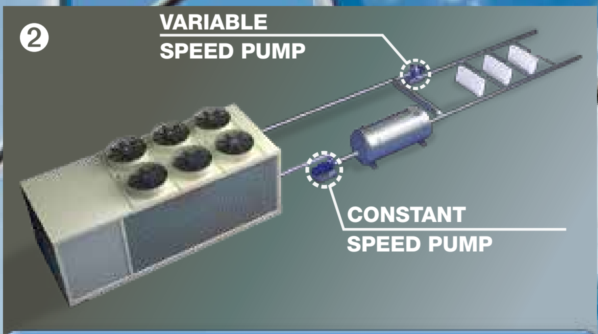
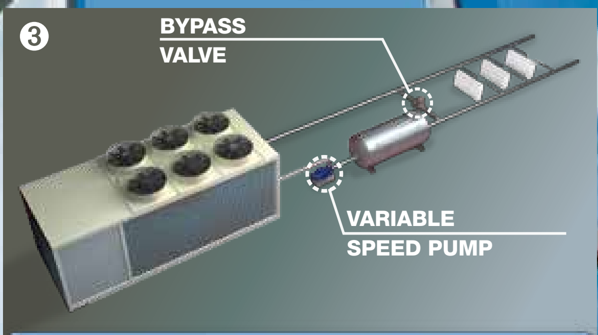
FOCUS AND VIDEO



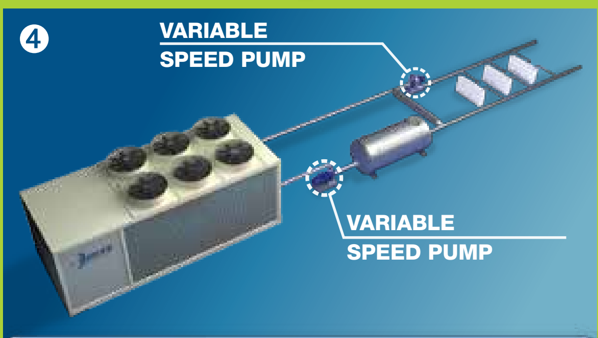
Primary - Secondary constant flow



Primary constant flow
Secondary variable flow



TRADITIONAL VPF:
Primary variable flow
+ bypass valve



VPF RHOSS:
Primary variable flow
Secondary variable flow

Systems and energy consumption

The energy consumption of ancillary components in air conditioning systems (pumping, ventilation, etc) can no longer be neglected in the approach to NZEB design.
Plants used in the past foresaw a primary loop (chiller side) and secondary loop (user side) both constant flow separated by a hydraulic decoupler which, on one hand, guaranteed function stability and reliability and, on the other, high energy consumption (figure 1).
Results can vary considerably from one building to the next; but pumping energy costs fluctuate between 20% and 40% of the consumption of chillers or heat pumps; and the percentage can reach 10% at building level.
Energy consumption can be reduced considerably by using variable water flow systems (VPF) instead of traditional constant flow systems. What is important is maintaining reliability and safety at maximum levels.

Traditional variable water flow systems

Variable water flow distribution systems, currently the most commonly used, have a primary loop with constant water flow and a secondary, variable flow one, separated by a hydraulic decoupler (figure 2). In this case, the biggest part of energy consumption related to pumping is linked to the constant flow pump
A way to reduce pumping consumption even more is to create a system with a single variable speed pump and a single primary loop with bypass pipe and bypass valve, (VPF Traditional – figure 3).
This system, used by some manufacturers, on the one hand partially reduces energy consumption, but on the other hand introduces risk of instability due to oscillations that can affect chiller reliability. The bypass valve, whilst ensuring the minimum flow through the evaporator, also represents the most critical component of the system.

VPF RHOSS

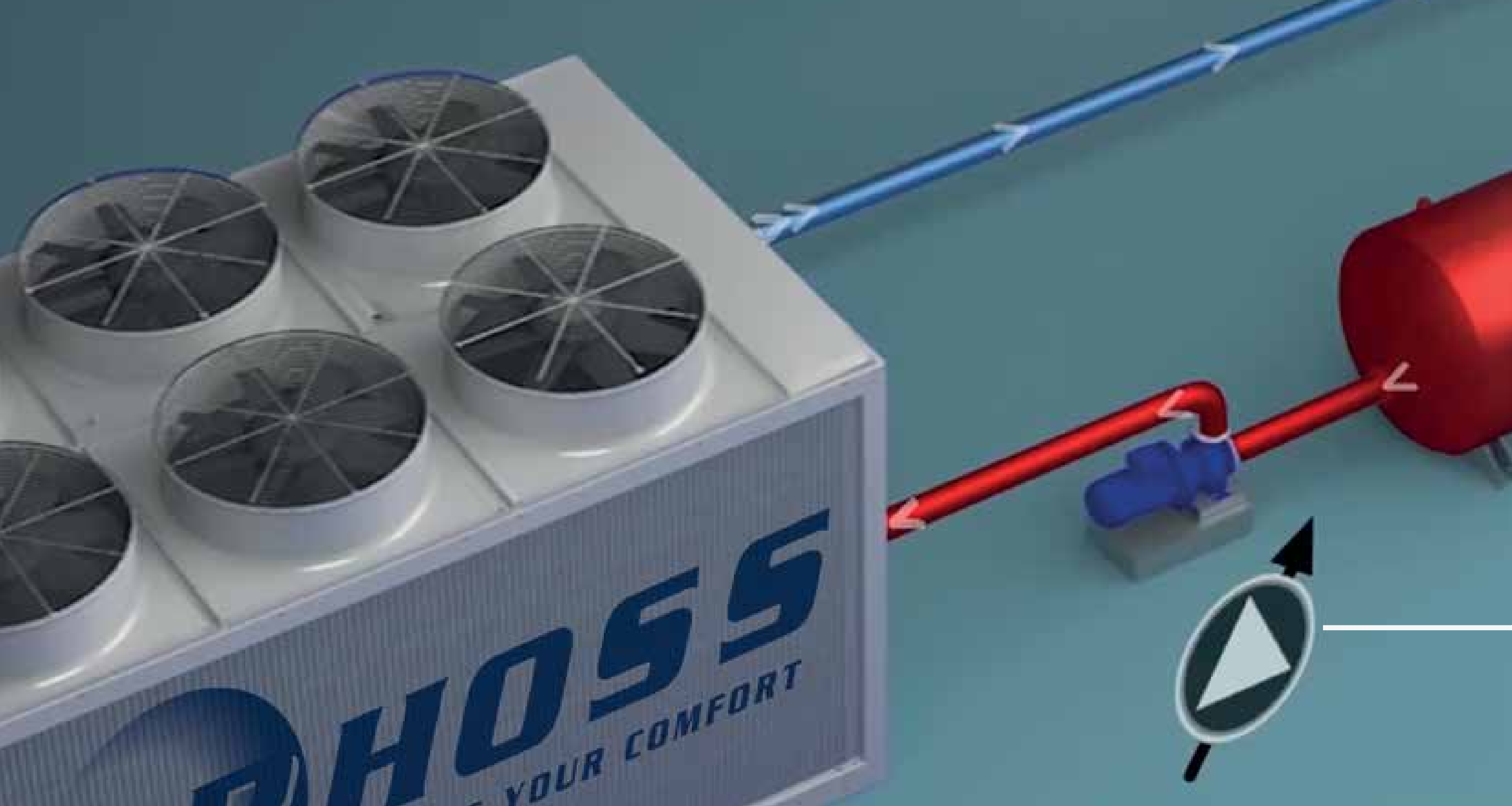
RHOSS, in the continuous research for advanced energy saving solutions, has introduced the VPF RHOSS into the market.
The solution proposed includes a primary/secondary system, both variable water flow, and a hydraulic decoupler (figure 4).
On the one hand, **the VPF RHOSS** further **increases pumping cost savings** compared to the traditional VPF and, on the other, eliminates the intrinsic critical issues, guaranteeing **high stability with no oscillation, increased reliability of the chiller and the system-plant components.**

The installation of several chillers in parallel benefits from the system solution offered by the VPF RHOSS, with simplified management, precision in the temperature of water supplied to utilities and reliability even when there are perturbations or fluctuations due to factors that are usually out of control.

VPF RHOSS: THE MOST EFFICIENT SOLUTION TO REDUCE PUMPING CONSUMPTION

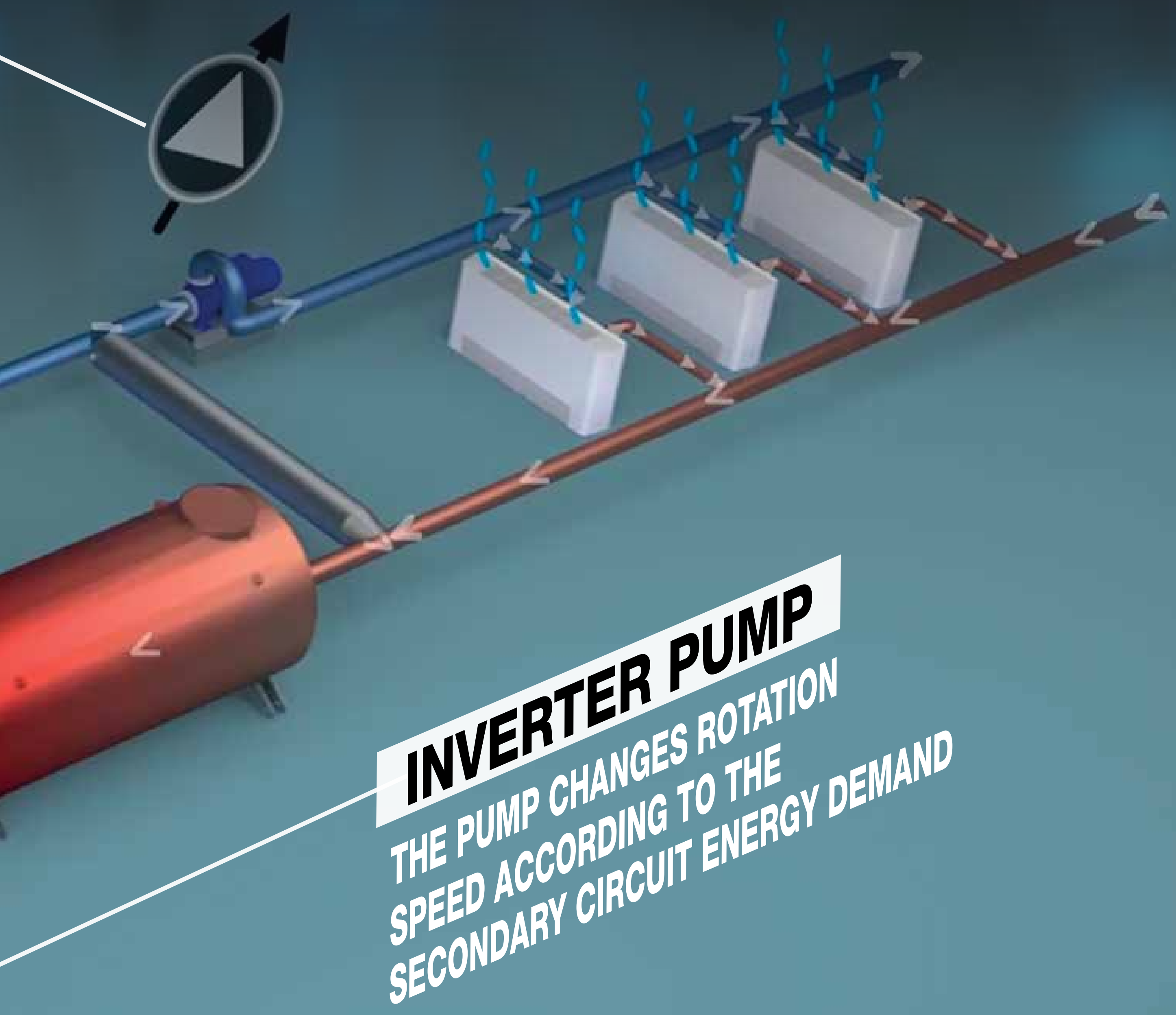
INVERTER PUMP

THE PUMP CHANGES ITS ROTATION SPEED ACCORDING TO THE USERS' LOAD DEMAND



- High stability with no oscillation
- High chiller and heat pumps reliability
- High reliability of system-plant components
- **Pump energy consumption reduced up to 90%**

The reduction of water flow allows saving energy needed for pumping. In the VPF RHOSS, reduction in consumption is tangible and creates the difference with traditional VPF systems.
The chillers and heat pumps can accept a water flow variation through the evaporators as long as it remains within a certain interval and the transition is not too fast.
The VPF RHOSS allows, with great flexibility, the variation of the secondary loop flow (user side) according to the load request and there are no limits to modulation except for those related to the pump itself.
The pump in the primary loop (chiller side) decreases the flow when the plant load drops; in parallel with the secondary loop pump at the beginning, stopping the modulation then when the minimum safety value set has been reached.
Any oscillation and pendulation in the water flow is then managed in the decoupler without affecting the operation and the reliability of the chiller.

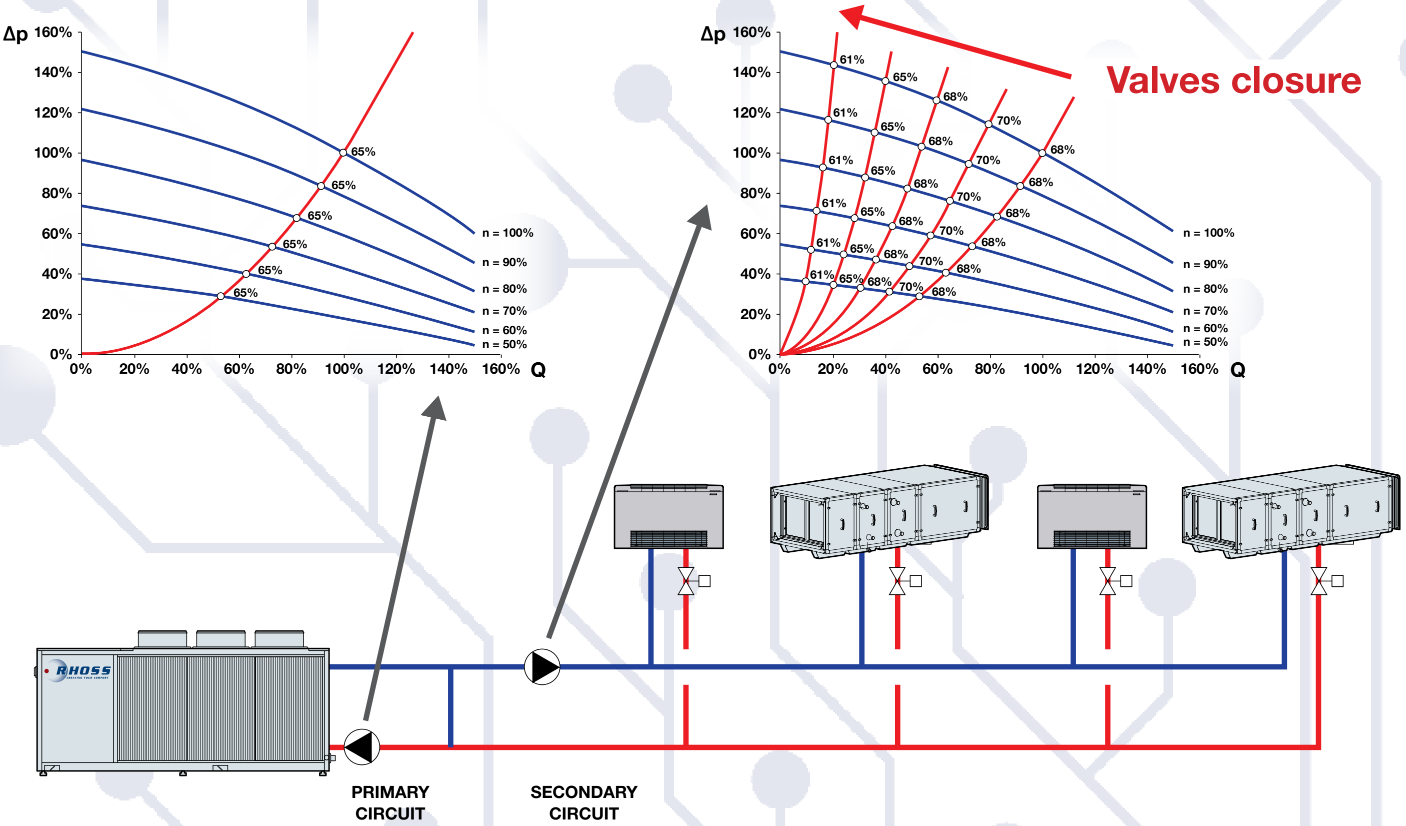


TECHNICAL ANALYSIS OF THE BENEFITS OF VPF RHOSS

Constant circuit geometry = accurate control of water flow and maximum energy savings

The VPF Rhoss solution introduces the inverter managed primary/ secondary system, both with variable flow. The primary loop pump regulates the flow based on the load to reduce pumping power input [P= f (Q)3].
This important decrease is only valid for the VPF RHOSS where the primary loop has fixed geometry (see figure below).

In the other cases or with traditional VPF, circuit geometry varies continuously and thus energy saving drops because the previous ratio is no longer applicable. The direct correlation as between water flow and pump rpms is also lost. (reference "HVAC systems with variable primary flow: analysis on energy potential saving" – 50th international AICARR Conference MATERA 2017).



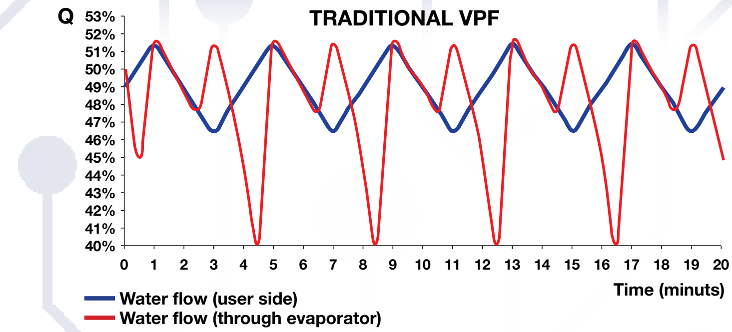
The concept is highlighted in the calculation formula below; it shows that the power absorbed by a pump varies mainly with the flow processed (Q) and the related head (Dp) and both dimensions depend on the pump rotation speed (n).

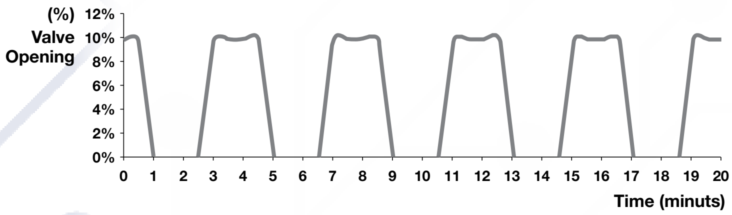
The third discriminating dimension is the pump efficiency (η). This dimension is also only constant for pump modulation if the curve characteristic of the hydraulic circuit does not change (primary VPF RHOSS).

$$\mathbf{P} = \frac{\dot{m}\,\Delta p}{\rho\,\eta} = \frac{\overset{kn}{Q}\,\overset{yn^2}{\Delta p}}{\eta} = \frac{f\,\mathbf{(n)^3}}{\eta}$$

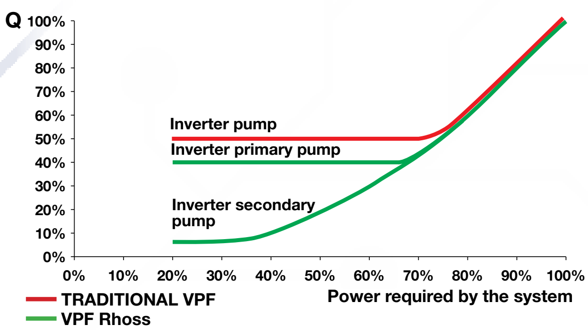
Operating stability and guarantee of reliability

The decrease in pumping power input is linked to the water flow variation based on the load required by the system.
Some conditions must be guaranteed: in particular, respect of the minimum water flow of the evaporator which is at 40-50% of nominal. This water flow rate is reached at about 80%-75% of the nominal cooling plant load and the flow must remain constant below that level.
For traditional VPF, the bypass valve guarantees the minimum flow in the evaporator and its operation becomes more complex when a low number of terminal units is installed in the system (ref. AICARR Handbook for Hydronic design).
The systems could also have physiological flow oscillations due to the dynamics or valve regulation or any malfunctioning.
Tests carried out in the Rhoss R&D laboratory proved that at 50% of nominal chiller water flow with traditional VPF, even with proper set-up of the bypass valve and minimum flow oscillations in the system loop, very wide oscillations in the real chiller flow were experienced, exceeding by far the limits allowed for the evaporator (reference "HVAC systems with variable primary flow: analysis on energy potential saving" – 50th international AICARR Conference MATERA 2017).





The VPF RHOSS system overcomes these critical issues as the primary loop is independent of any secondary loop oscillation thanks to the hydraulic decoupler. So the pumps can operate correctly to enable real energy savings.



Optimised management of more units connected in parallel

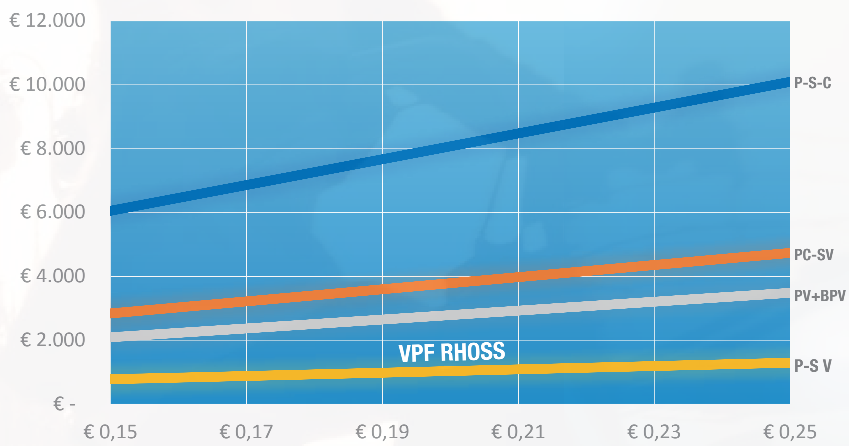
Management of several chillers or heat pumps connected in a hydraulic parallel, operating in a variable water flow system, could be complex due to the presence of multiple regulating parts with different reaction times for closure, opening and modulation (mainly valves and pumps).
With traditional VPF, these transitory phenomena show their maximum critical issues during the chiller restarting stage after stand-by, as the pump restart times are not always the same as those of the by-pass valve. The resulting reduction in water flow of the chiller operating at the time can create serious danger for possible liquid strokes to compressors (ref. AICARR Handbook for Hydronic design).
With several chillers connected in hydraulic parallel, the VPF RHOSS solution becomes the safest, most reliable and effective way to design and manage the system because there is no by-pass valve and the hydraulic decoupler is introduced and guarantees the minimum water flow for the evaporator.

up to **232 m²**
EQUIVALENT PHOTOVOLTAIC SURFACE SAVED

up to **87 %**
REDUCTION IN PRIMARY ENERGY CONSUMPTION

up to **15 t/a**
REDUCTION OF EMISSIONS OF CO_2

ANNUAL PUMPING - OFFICES



P-S-C Constant primary and secondary system
PC - SV Constant primary and variable secondary system
PV+BPV Variable primary system and bypass valve
P-S V VPF RHOSS: variable primary and secondary systems

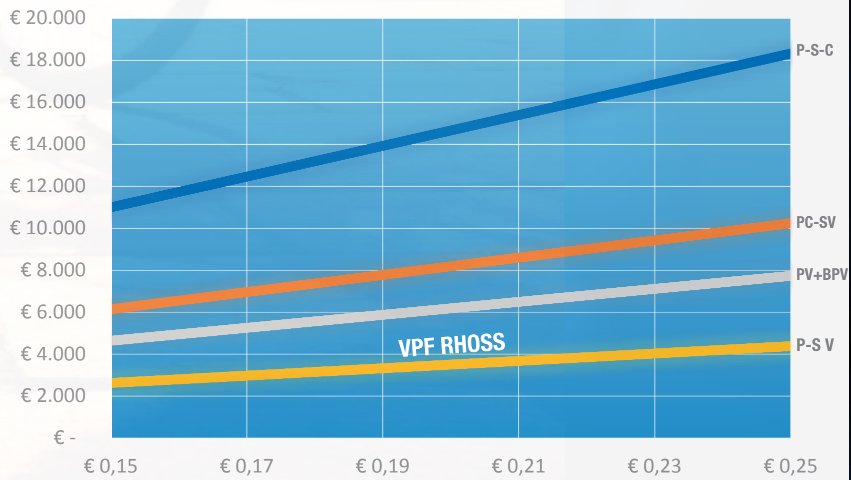
NOTE:
Graph of the annual costs based on the €/kWh energy cost considering:
- reference building - 7 floor office building with net air conditioned surface of 11600 m²;
- envelope insulation as prescribed by law;
- the equipment used is an EXP polyvalent system for air conditioning application.

up to **368 m²**
EQUIVALENT PHOTOVOLTAIC SURFACE SAVED

up to **76 %**
REDUCTION IN PRIMARY ENERGY CONSUMPTION

up to **24 t/a**
REDUCTION OF EMISSIONS OF CO_2

ANNUAL PUMPING - HOTEL



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MILAN

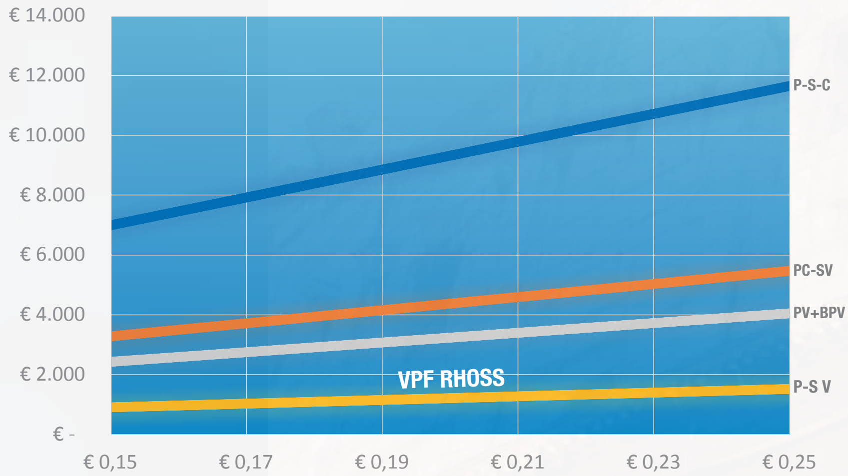
ROME

up to **240 m²**
EQUIVALENT PHOTOVOLTAIC SURFACE SAVED

up to **87 %**
REDUCTION IN PRIMARY ENERGY CONSUMPTION

up to **18 t/a**
REDUCTION OF EMISSIONS OF CO_2

ANNUAL PUMPING - OFFICES



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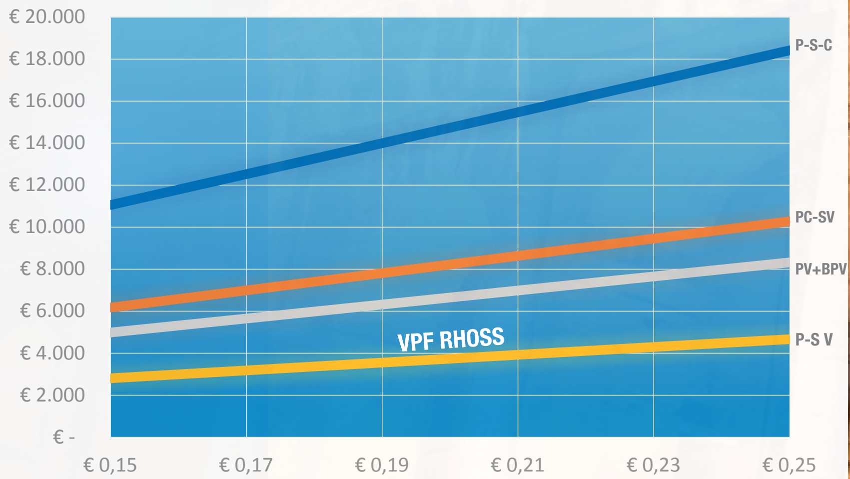
up to **326 m²**
EQUIVALENT PHOTOVOLTAIC SURFACE SAVED

up to **75 %**
REDUCTION IN PRIMARY ENERGY CONSUMPTION

up to **24 t/a**
REDUCTION OF EMISSIONS OF CO_2

ANNUAL PUMPING - HOTEL



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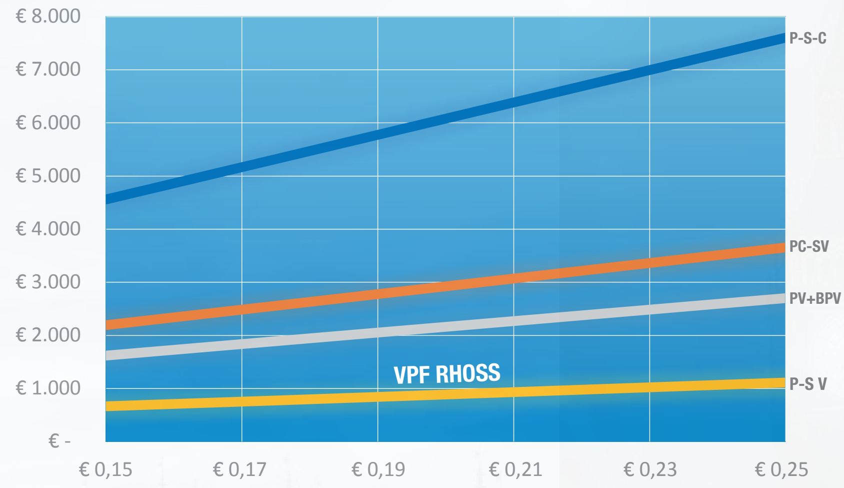
up to **191 m²** — EQUIVALENT PHOTOVOLTAIC SURFACE SAVED

up to **85 %** — REDUCTION IN PRIMARY ENERGY CONSUMPTION

up to **11 t/a** — REDUCTION OF EMISSIONS OF CO_2

ANNUAL PUMPING - OFFICES



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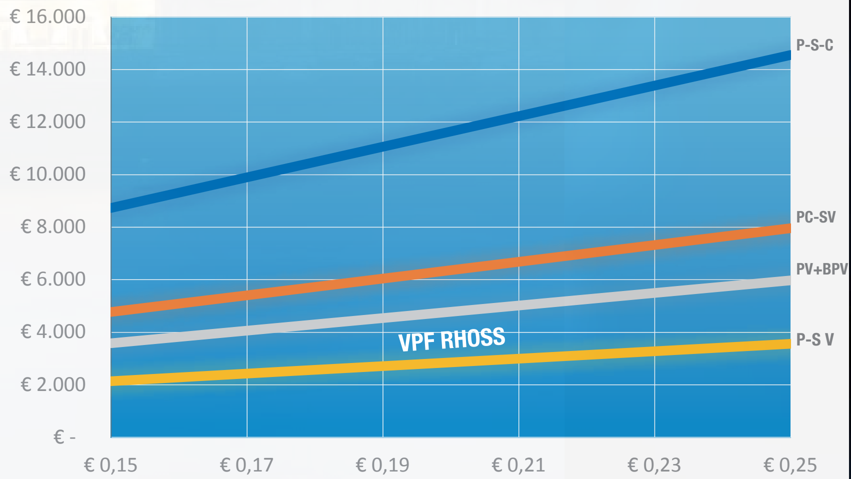
up to **324 m²** — EQUIVALENT PHOTOVOLTAIC SURFACE SAVED

up to **76 %** — REDUCTION IN PRIMARY ENERGY CONSUMPTION

up to **19 t/a** — REDUCTION OF EMISSIONS OF CO_2

ANNUAL PUMPING - HOTEL



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LONDON

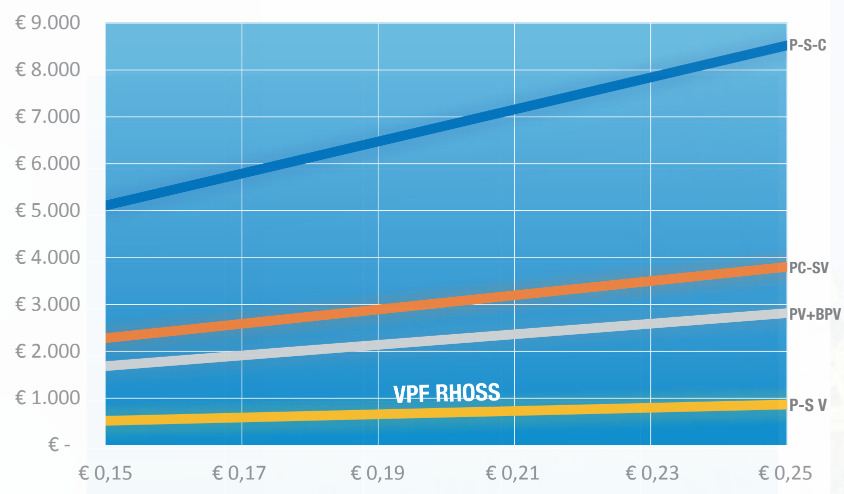
BERLIN

up to 234 m² EQUIVALENT PHOTOVOLTAIC SURFACE SAVED

up to 90 % REDUCTION IN PRIMARY ENERGY CONSUMPTION

up to 13 t/a REDUCTION OF EMISSIONS OF CO_2

ANNUAL PUMPING - OFFICES



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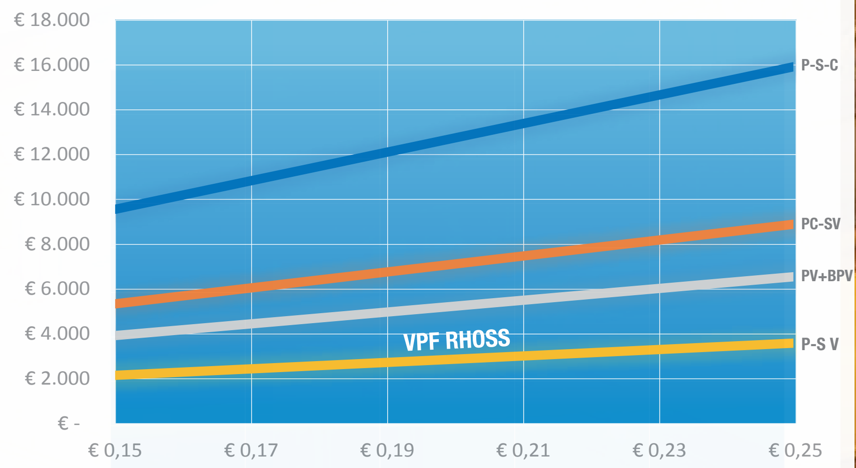
up to 378 m² EQUIVALENT PHOTOVOLTAIC SURFACE SAVED

up to 77 % REDUCTION IN PRIMARY ENERGY CONSUMPTION

up to 21 t/a REDUCTION OF EMISSIONS OF CO_2

ANNUAL PUMPING - HOTEL



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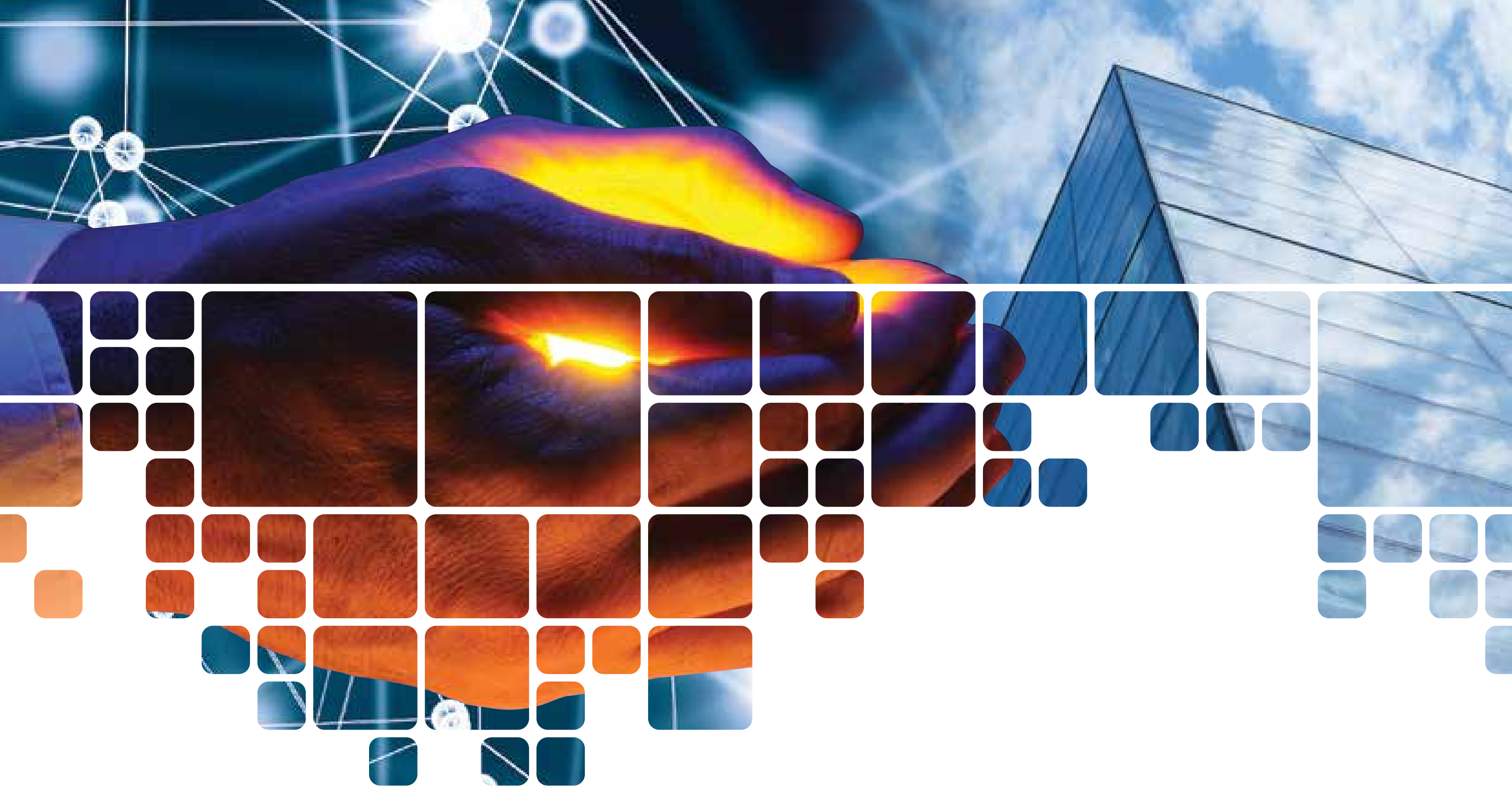

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