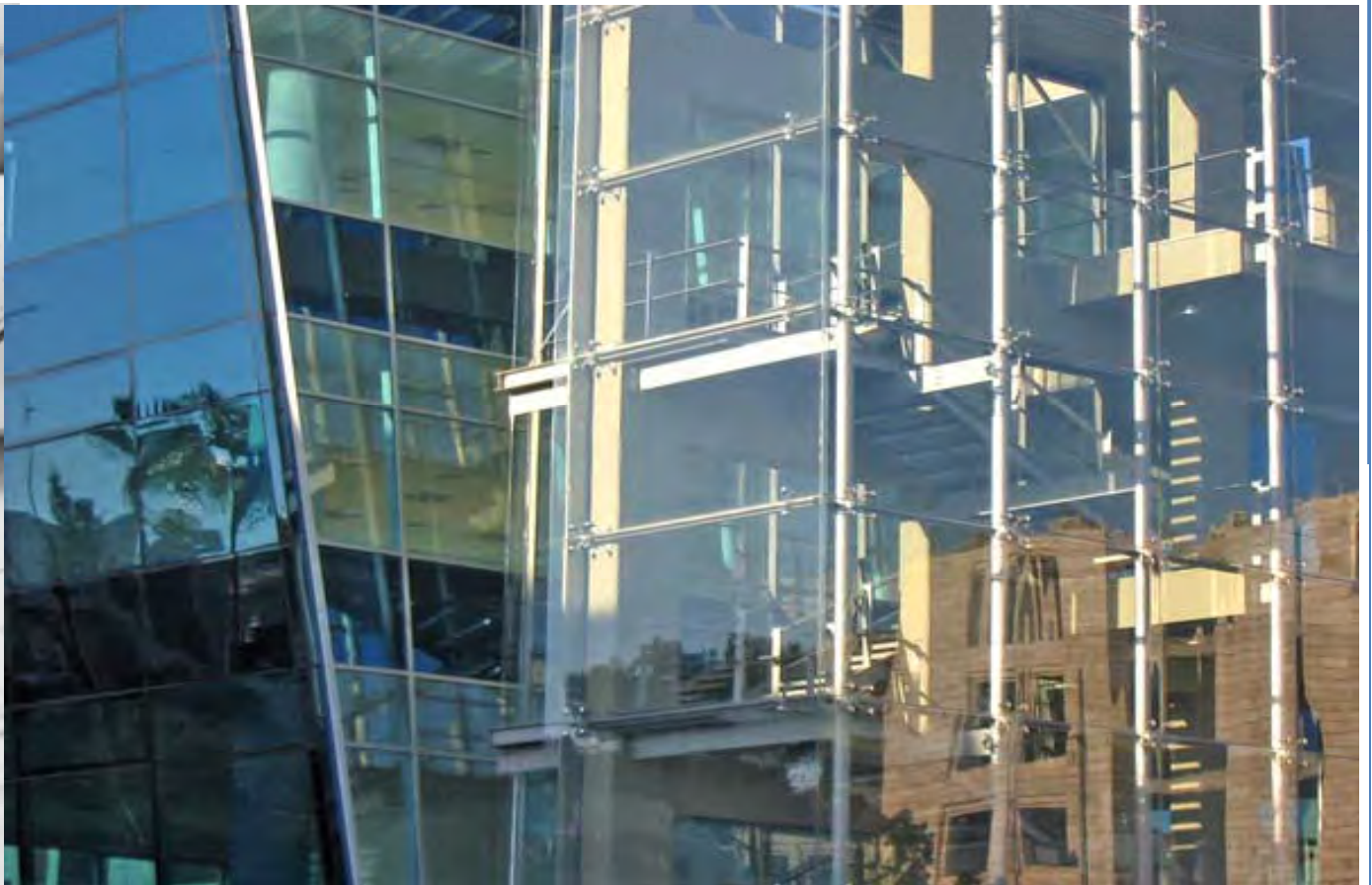




# The Clivet Enhanced Hydronic System

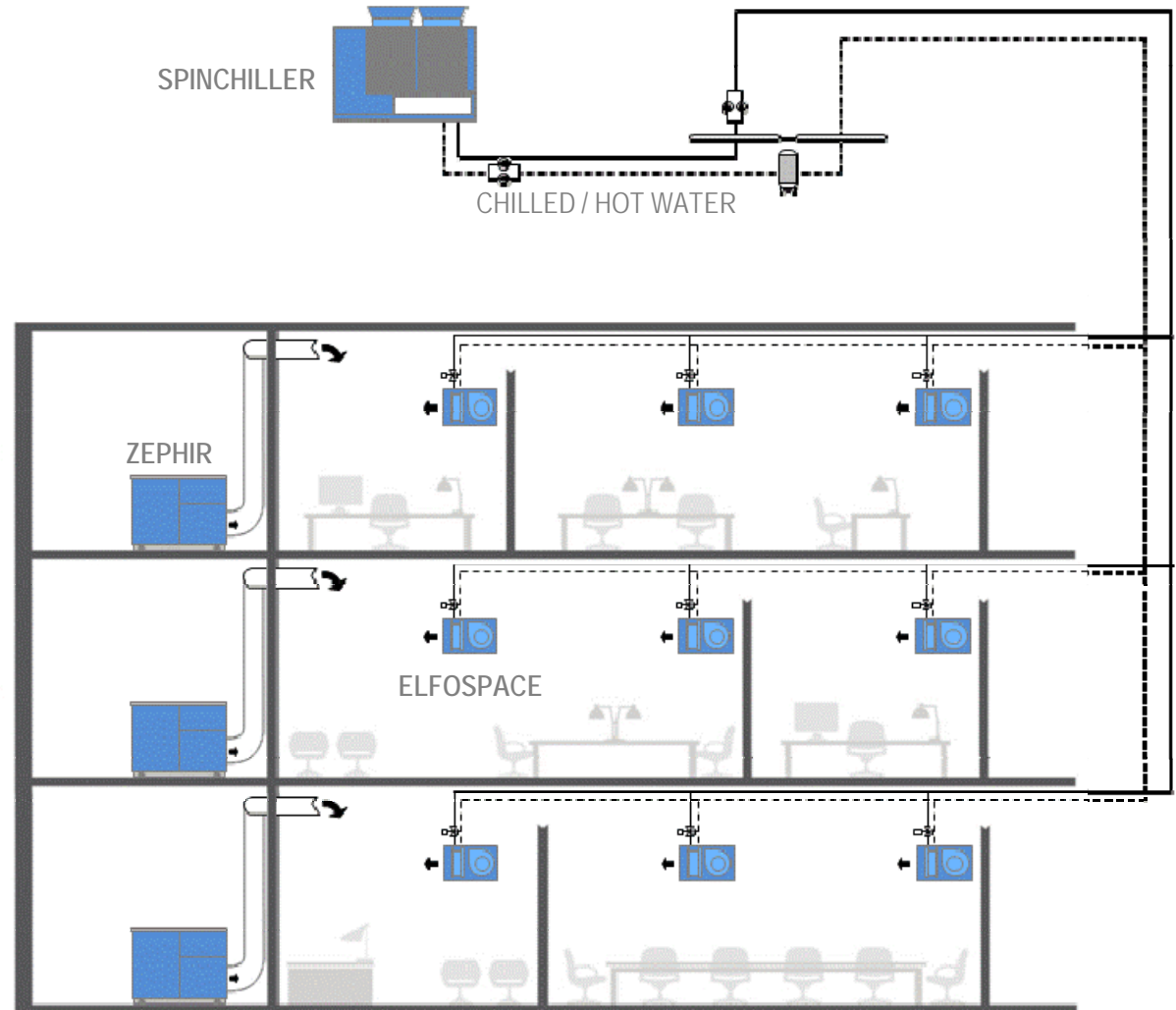
March 20th 2015



# WHAT'S THE ENHANCED HYDRONIC SYSTEM

The CLIVET Enhanced Hydronic System is a pre-configured modular system which is composed of three basic equipments:

- ZEPHIR<sup>3</sup> stand-alone System;
- SPINchiller<sup>3</sup> heat pump, air cooled or water cooled;
- ELFOspace fancoils.



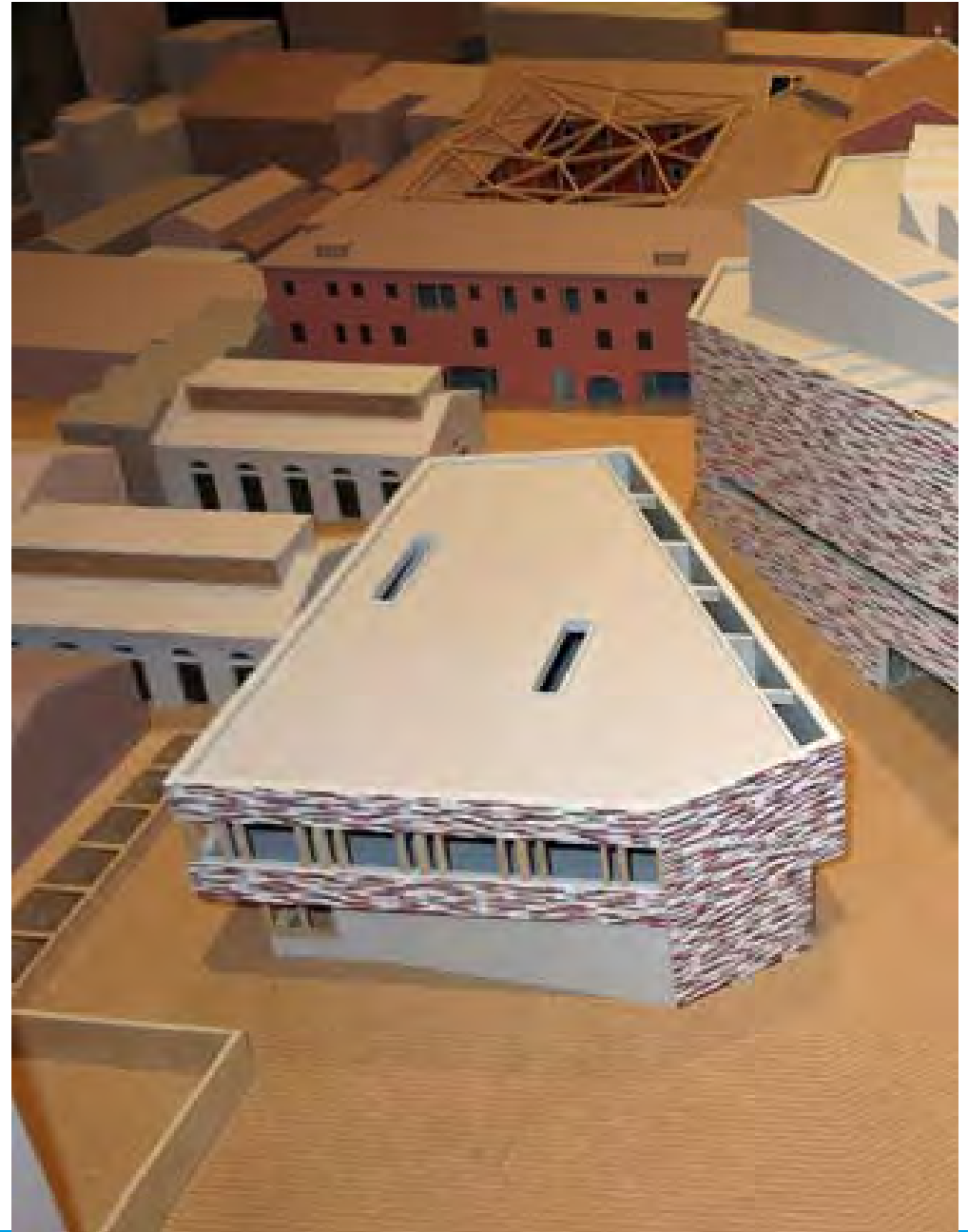
# THE CONSIDERED CASE: THE BUILDING

Case considered → office building with three floors and a total net area of 6,600 m<sup>2</sup>

The target analysis → determine the energy performance of CLIVET Enhanced Hydronic System Clivet, in terms of:

- *Primary energy consumption [kWhp]*
- *CO<sub>2</sub> emissions [kg]*
- *Energy cost [€]*

Compare it with the traditional solution



# THE CONSIDERED CASE: THE BUILDING

---

To get a complete overview, the energy analysis has been done on the same building in different conditions:

- *Climate: London, United Kingdom; Rome, Italy; Valencia, Spain; Krakow, Poland; Moscow, Russian Federation*
- *Heat recovery technology*
- *Cooling technology*
- *Heating technology*



# THE CONSIDERED CASE: THE CLIMATIC AREAS

You can identify here!



# THE CONSIDERED CASE: DESIGN DATA

Room load calculation → through a dynamic simulation software (LEED® approved)

Modeling of the system → through a 'bin method' year-round energy analysis

The number of persons, which is determined in accordance with current regulations, and lighting are kept constant.

Moreover, the relative humidity per each outside temperature bin is the same in all locations.

## Air conditioned space

Application	-	Offices
Net surface	m <sup>2</sup>	6.600
Height	m	3,0
Time operating of system in business hours	-	8am to 8pm from Monday to Friday
Time operating of system in attenuation	-	9pm to 7am from Monday to Friday Holidays 24h and Saturday

## Summer design, indoors

Temperature - business hours/ attenuation	°C / °C	25 / 28
Relative humidity - business hours/ attenuation	% / %	55 / 65
Supply air primary temperature - business hours/ attenuation	°C / °C	20 / OFF
Supply air primary relative humidity - business hours/ attenuation	g/kg	9,5 / OFF

## Winter design, outdoors

Temperature - business hours/ attenuation	°C / °C	20 / 18
Relative humidity - business hours/ attenuation	% / %	40 / 40
Supply air primary temperature - business hours/ attenuation	°C	22 / OFF
Supply air primary relative humidity - business hours/ attenuation	g/kg	not controlled

## Primary air

Attendace (0,12 persons/m <sup>2</sup> )	n°.	792
Air renewal (11 l/s per person)	m <sup>3</sup> /h	31.363

## Internal loads during business hours





Lighting	W/m <sup>2</sup>	5
Electrical equipment (PC, printers, etc.).	W/m <sup>2</sup>	5

# ENERGY ANALYSIS

We consider the following conversion factors, set equal for all climatic areas to obtain objective comparison parameters:

	Primary energy [kWhp]	CO <sub>2</sub> emissions [kg]	Cost management [€]
Electricity adsorbed [kWhe]	2,18 kWhp/kWhe	0,61 kgCO <sub>2</sub> /kWhe	0,15 EUR/kWhe
Methane Gas [Nm <sup>3</sup> ]	9,6 kWhp/Nm <sup>3</sup>	1,84 kgCO <sub>2</sub> /Nm <sup>3</sup>	0,80 EUR/Nm <sup>3</sup>

To better describe the individual behavior and compare all different functions, outputs have been grouped as:

- Production of cooling and heating capacity using electricity: compressor chiller/heat pump, external fans, relevant pumps for chilled/hot water, collectively called Electric Generator (diagrams: deep blue colour)  Electric Generator
- Production of heating capacity using fuel (methan gas): gas boiler and relevant pumps for hot water circulation, collectively called Gas Generator (diagrams: red colour)  Gas Generator
- Primary Air stand-alone capacity production: ZEPHIR3 compressors, collectively called ZEPHIR3 Thermodynamic circuit (diagrams: light blue colour)  ZEPHIR<sup>3</sup> Thermodynamic Circuit
- Primary Air circulation: supply fans, exhaust fans and enthalpy wheel drive motor, collectively called Handling fans (diagrams: green colour)  Handling fans

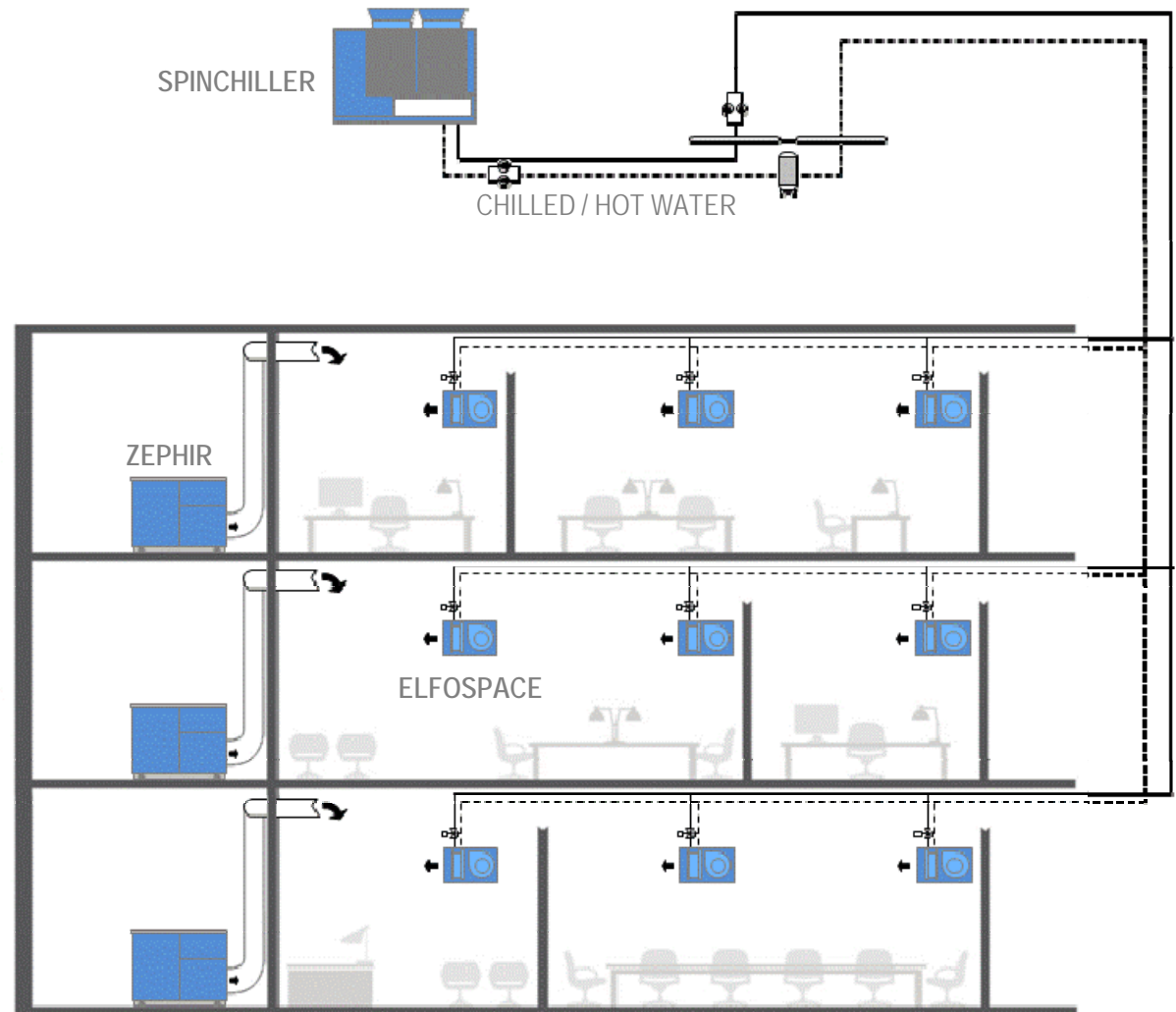
The analysis does not include fan coil motors, as they are invariant due to the same system design and operation in all scenarios



# SYSTEM SOLUTIONS COMPARED: Enhanced Hydronic System

The Enhanced Hydronic System from Clivet composed of :

- an air cooled SPINchiller<sup>3</sup> in heat pump configuration;
- n.8 x ZEPHIR<sup>3</sup> (SIZE3) of 4,000 m<sup>3</sup>/h;
- n.200 2-pipes ELFOSpace fancoils.

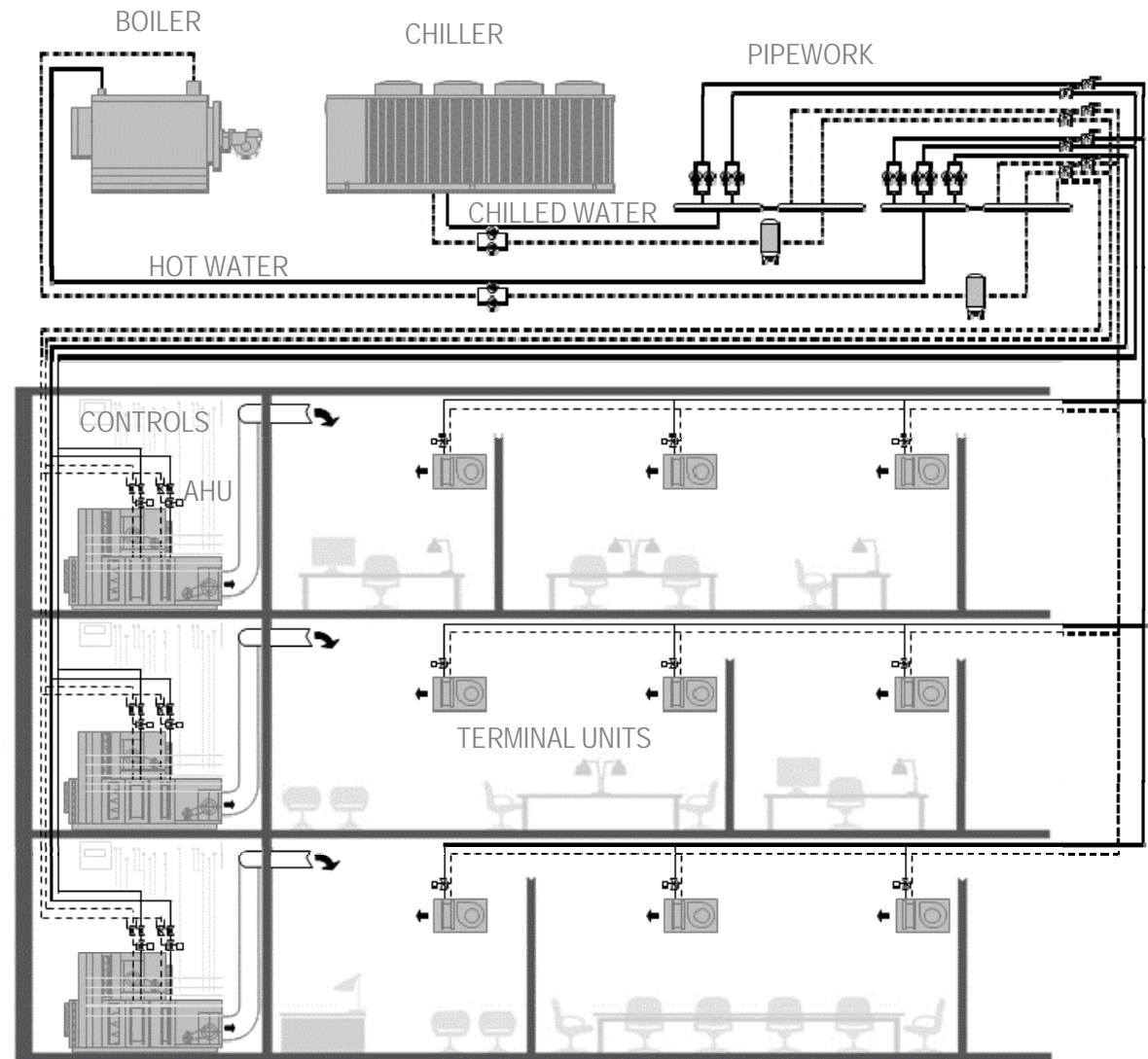




# SYSTEM SOLUTIONS COMPARED: the traditional solution

The traditional solution is composed of:

- an air cooled liquid chiller with screw compressors;
- an condensing boiler;
- n.8 air handling units for primary air treatment (supply air flow 4,000 m<sup>3</sup>/h each) with rotary enthalpy wheel recovery (minimum efficiency 70%),
- n.200 two-pipes fancoil units.

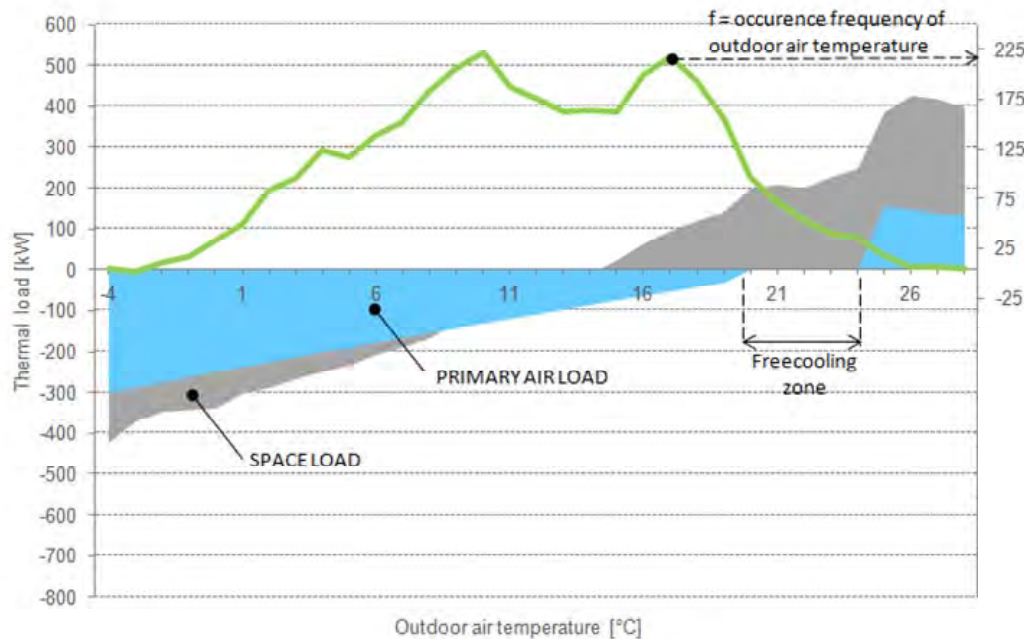


# ENERGY ANALYSIS IN LONDON



## COMPARISON WITH TRADITIONAL SYSTEM: SCREW STEPLESS COMPRESSOR

On the basis of the load profile were compared the following generators:



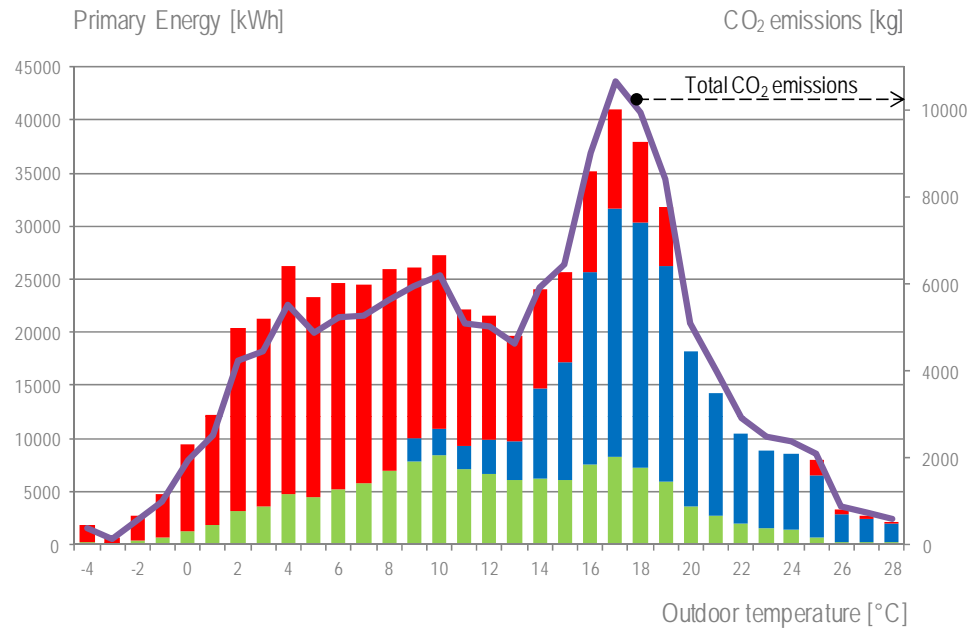
	CLIVET ENHANCED HYDRONIC SYSTEM	TRADITIONAL HVAC SYSTEM
Central Chilled Water	SPINchiller <sup>3</sup> WSA-N-XSC3 90.4 EXC Air-to-water heat pump Cooling 244 kW (A35 W7) EER 2,78 ESEER 3,94	Air cooled liquid Chiller Screw compressor, stepless control Cooling 370 kW (A35 W7) EER 3,1 ESEER 4,1 Q.ty 1
Central Hot Water	Heating 282 kW (A7 W45) COP 3,23 Q.ty 1	Gas condensing boiler Efficiency 102% Heating 320 kW Q.ty 1
Local Primary Air	ZEPHIR <sup>3</sup> SIZE 3 Exhaust air heat pump Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling 19,1 kW (A35 A25) Heating 20,7 kW (A7 A20) Recovery Thermodynamic Passive recovery pressure drop (per air stream) 0 Pa Q.ty 8	Air Handling Unit <i>bespoke equipment</i> Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling <i>from chiller</i> Heating <i>from boiler</i> Recovery Enthalpy wheel 70% Passive recovery pressure drop (per air stream) 120 Pa Q.ty 8

# ENERGY ANALYSIS IN LONDON

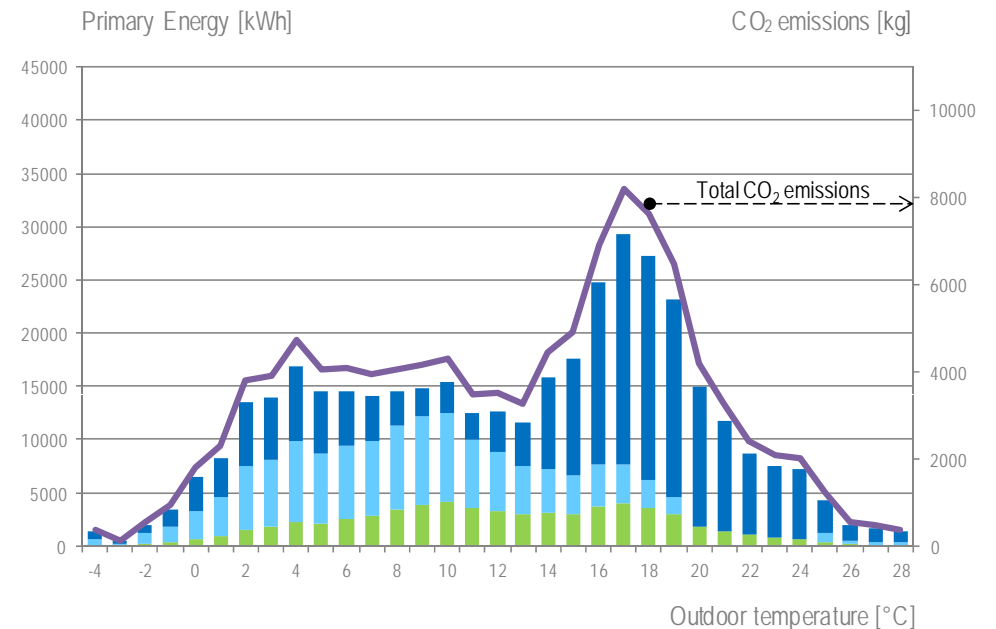


## Primary Energy Consumption and CO<sub>2</sub> Emissions

Traditional HVAC system



Clivet Enhanced Hydronic System



- Electric Generator
- Gas generator

- ZEPHIR<sup>3</sup> Thermodynamic Circuit
- Handling fans

# ENERGY ANALYSIS IN LONDON

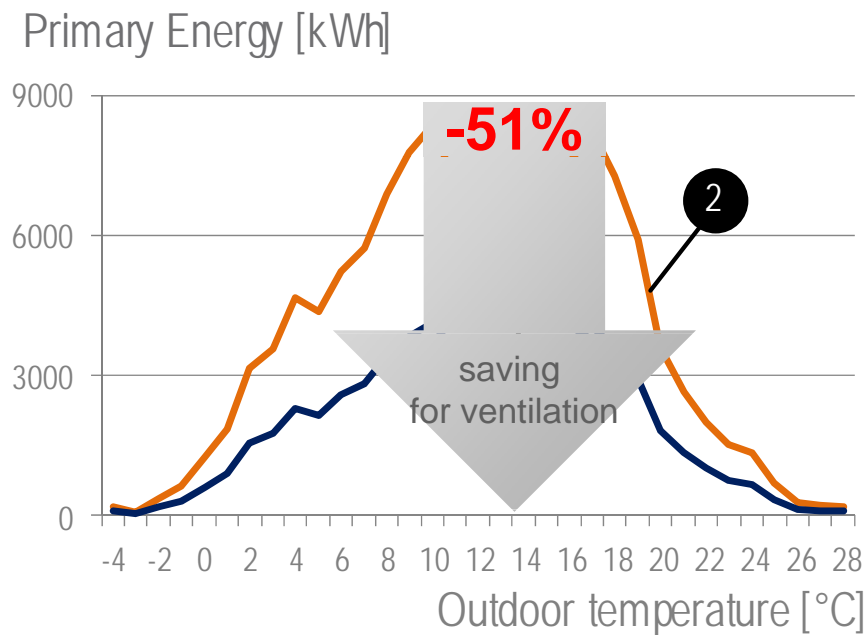


Primary Energy Consumption for ventilation and pumping in the air primary treatment

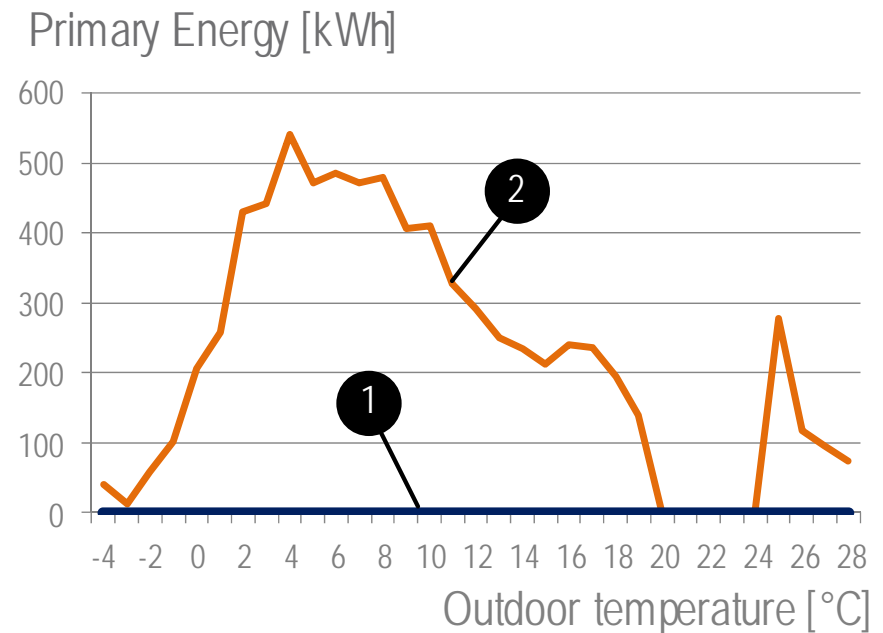
1 – ZEPHIR3

2- Traditional A.H.U. system

### Handling fans for Primary Air



### Water pumps for Primary Air

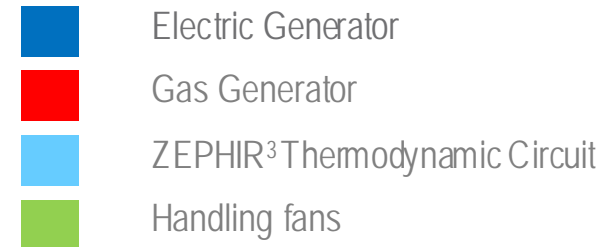
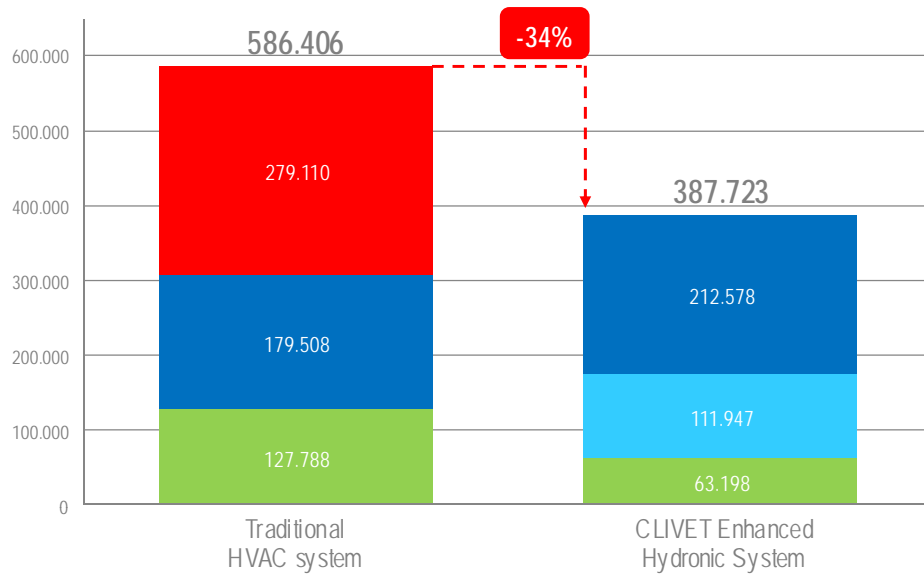




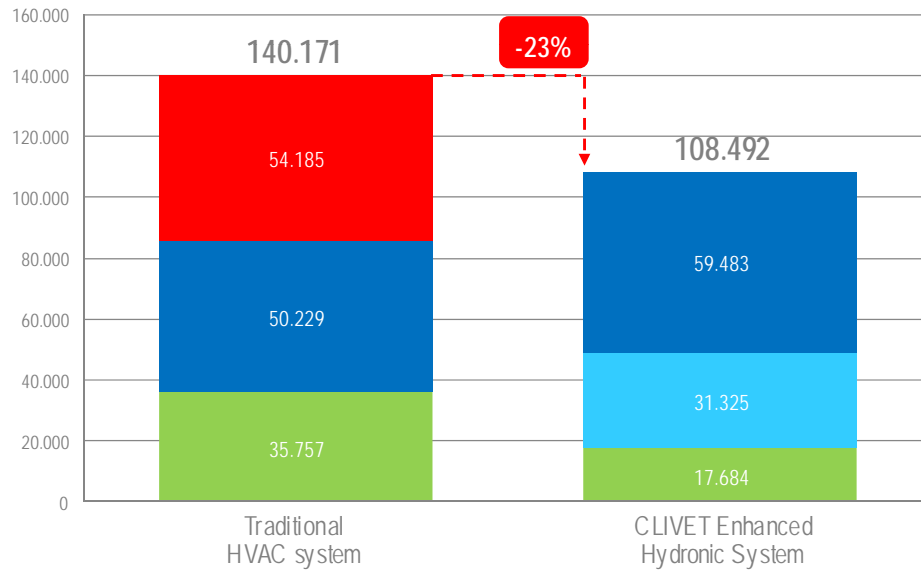
# ENERGY ANALYSIS IN LONDON - Overall consumption



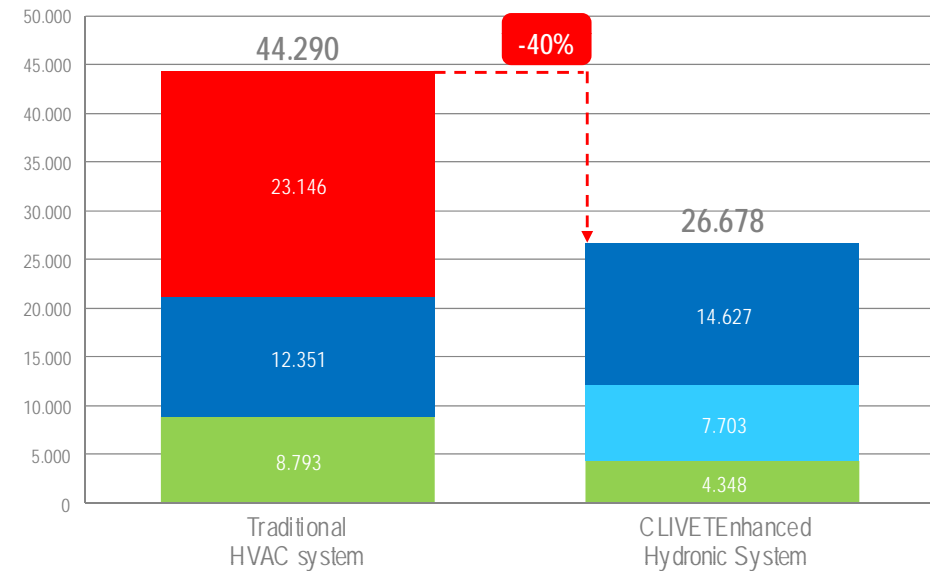
TOTAL PRIMARY ENERGY [kWh]



TOTAL CO<sub>2</sub> EMISSIONS [kg]



ENERGY COST [EUR]

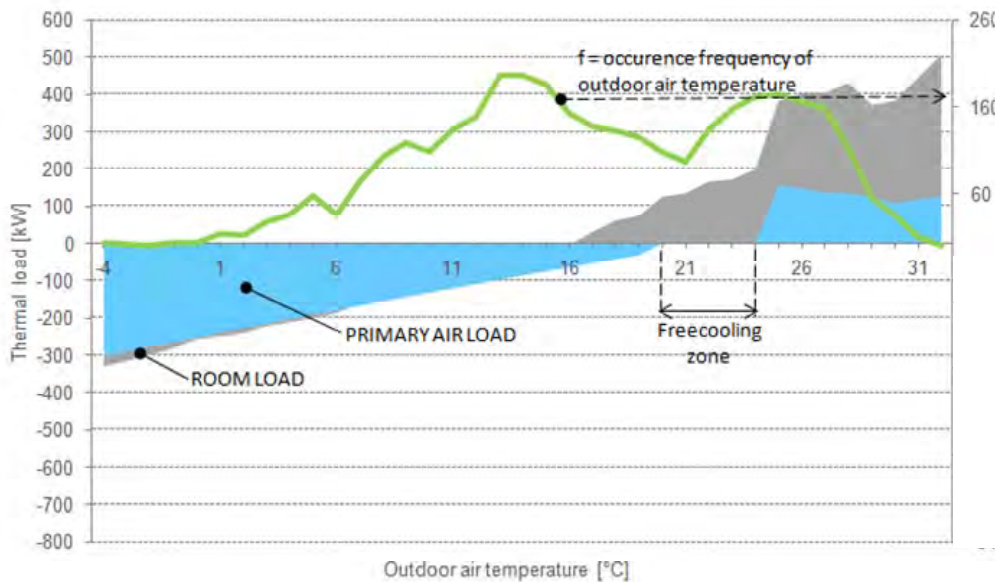


# ENERGY ANALYSIS IN ROME

## COMPARISON WITH TRADITIONAL SYSTEM: SCREW STEPLESS COMPRESSOR



On the basis of the load profile were compared the following generators:

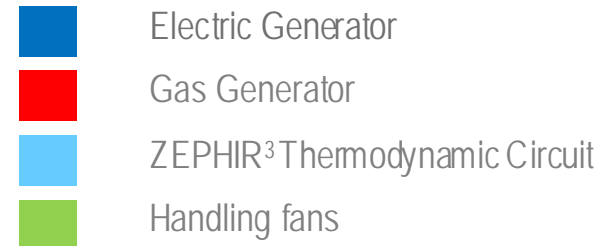
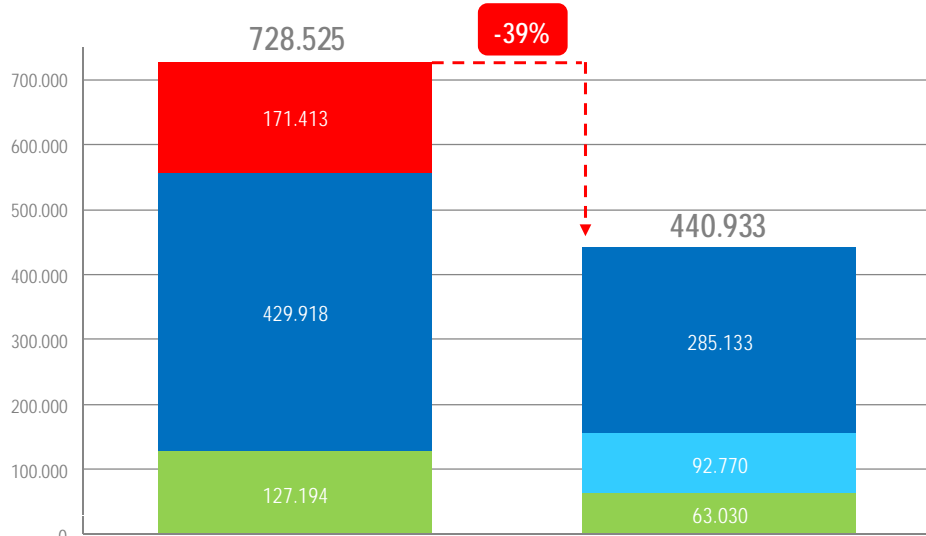


	CLIVET ENHANCED HYDRONIC SYSTEM	TRADITIONAL HVAC SYSTEM
Central Chilled Water	SPINchiller <sup>3</sup> WSAN-XSC3 140.4 EXC Air-to-water heat pump Cooling 371 kW (A35 W7) EER 2,74 ESEER 3,97	Air cooled liquid Chiller Screw compressor, stepless control Cooling 530 kW (A35 W7) EER 3,2 ESEER 4,1 Q.ty 1
Central Hot Water	Heating 424 kW (A7 W45) COP 3,30 Q.ty 1	Gas condensing boiler Efficiency 102% Heating 200 kW Q.ty 1
Local Primary Air	ZEPHIR <sup>3</sup> SIZE 3 Exhaust air heat pump Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling 19,1 kW (A35 A25) Heating 20,7 kW (A7 A20) Recovery Thermodynamic Passive recovery pressure drop (per air stream) 0 Pa Q.ty 8	Air Handling Unit <i>bespoke equipment</i> Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling <i>from chiller</i> Heating <i>from boiler</i> Recovery Enthalpy wheel 70% Passive recovery pressure drop (per air stream) 120 Pa Q.ty 8

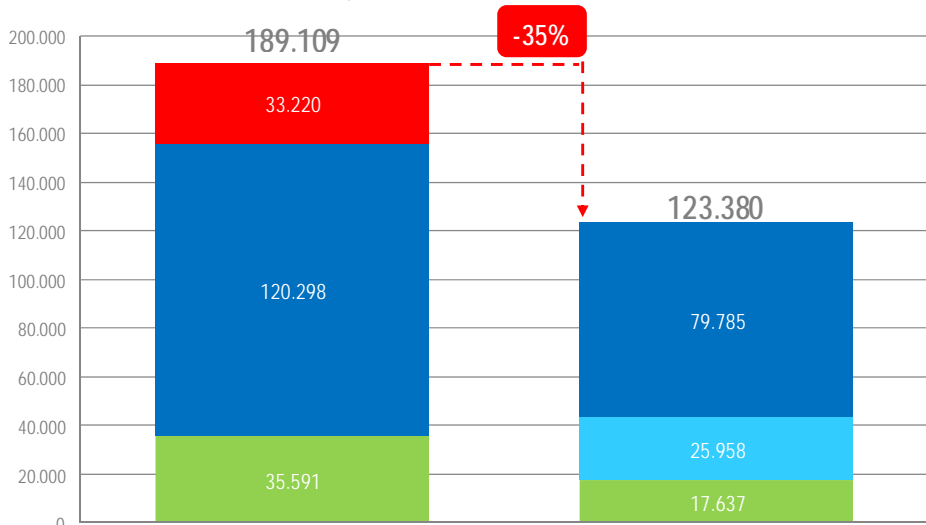
# ENERGY ANALYSIS IN ROME - Overall consumption



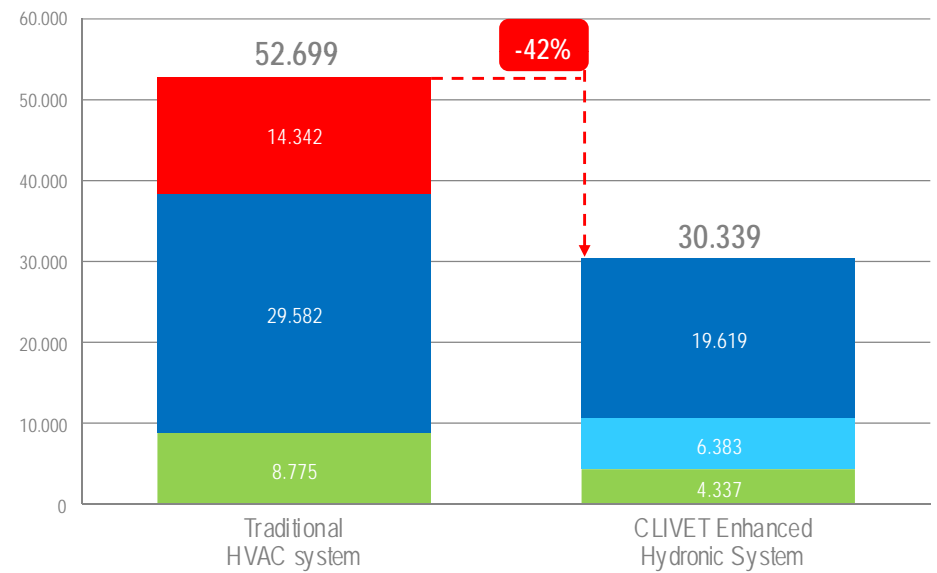
TOTAL PRIMARY ENERGY [kWh]



TOTAL CO<sub>2</sub> EMISSIONS [kg]



ENERGY COST [EUR]

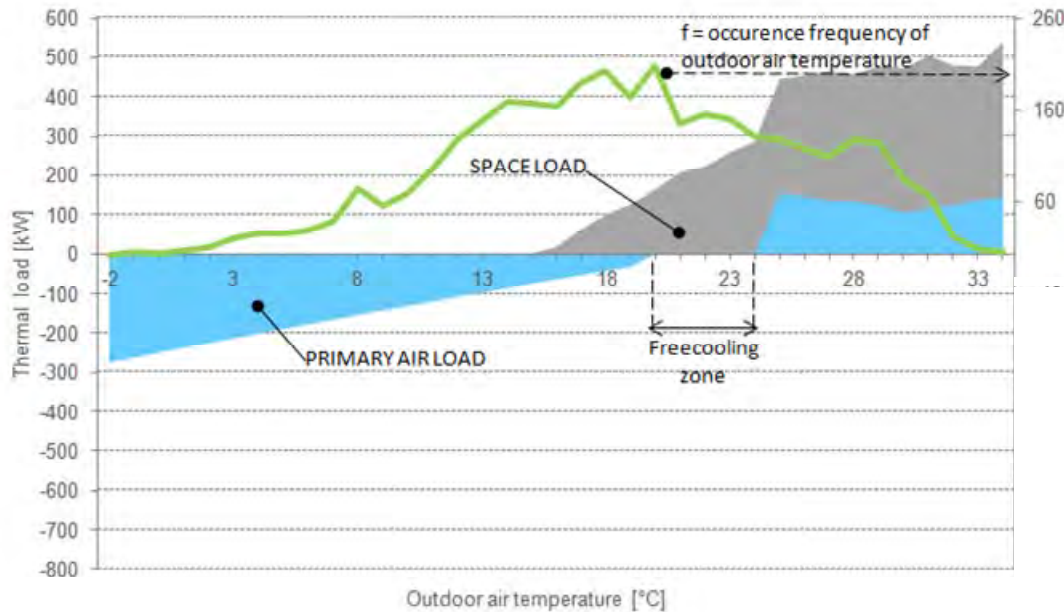


# ENERGY ANALYSIS IN VALENCIA

## COMPARISON WITH TRADITIONAL SYSTEM: SCREW STEPLESS COMPRESSOR



On the basis of the load profile were compared the following generators:



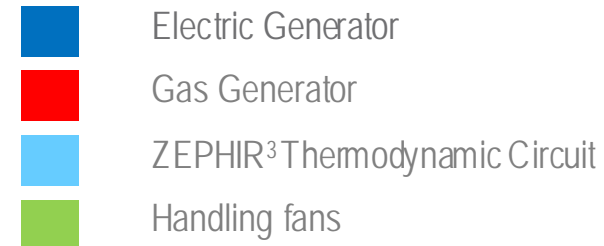
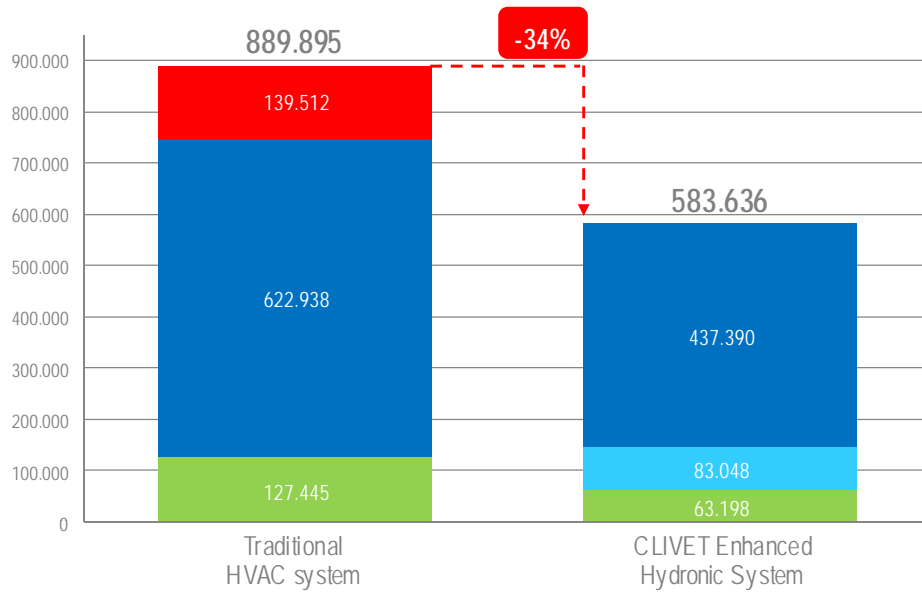
	CLIVET ENHANCED HYDRONIC SYSTEM	TRADITIONAL HVAC SYSTEM
Central Chilled Water	SPINchiller <sup>3</sup> WSA-N-XSC3 160.4 EXC Air-to-water heat pump Cooling 417 kW (A35 W7) EER 2,78 ESEER 4,09	Air cooled liquid Chiller Screw compressor, stepless control Cooling 560 kW (A35 W7) EER 3,1 ESEER 4,0 Q.ty 1
Central Hot Water	Heating 469 kW (A7 W45) COP 3,28 Q.ty 1	Gas condensing boiler Efficiency 102% Heating 130 kW Q.ty 1
Local Primary Air	ZEPHIR <sup>3</sup> SIZE 3 Exhaust air heat pump Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling 19,1 kW (A35 A25) Heating 20,7 kW (A7 A20) Recovery Thermodynamic Passive recovery pressure drop (per air stream) 0 Pa Q.ty 8	Air Handling Unit <i>bespoke equipment</i> Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling <i>from chiller</i> Heating <i>from boiler</i> Recovery Enthalpy wheel 70% Passive recovery pressure drop (per air stream) 120 Pa Q.ty 8



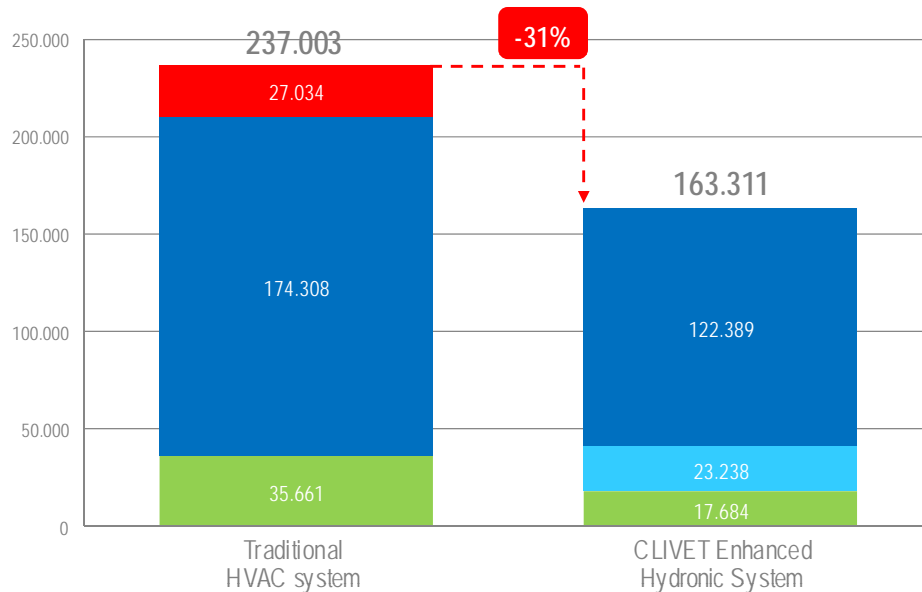
# ENERGY ANALYSIS IN VALENCIA - Overall consumption



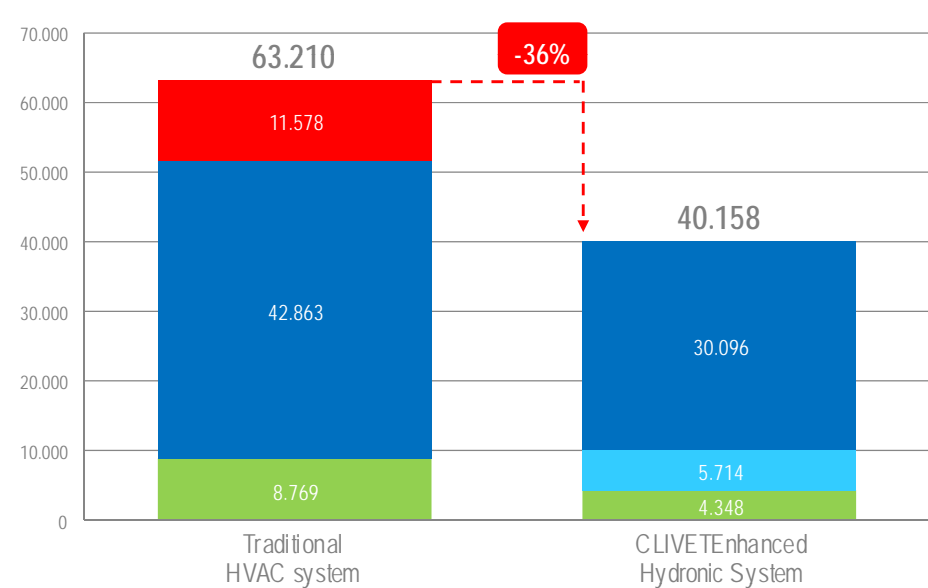
TOTAL PRIMARY ENERGY [kWh]



TOTAL CO<sub>2</sub> EMISSIONS [kg]



ENERGY COST [EUR]

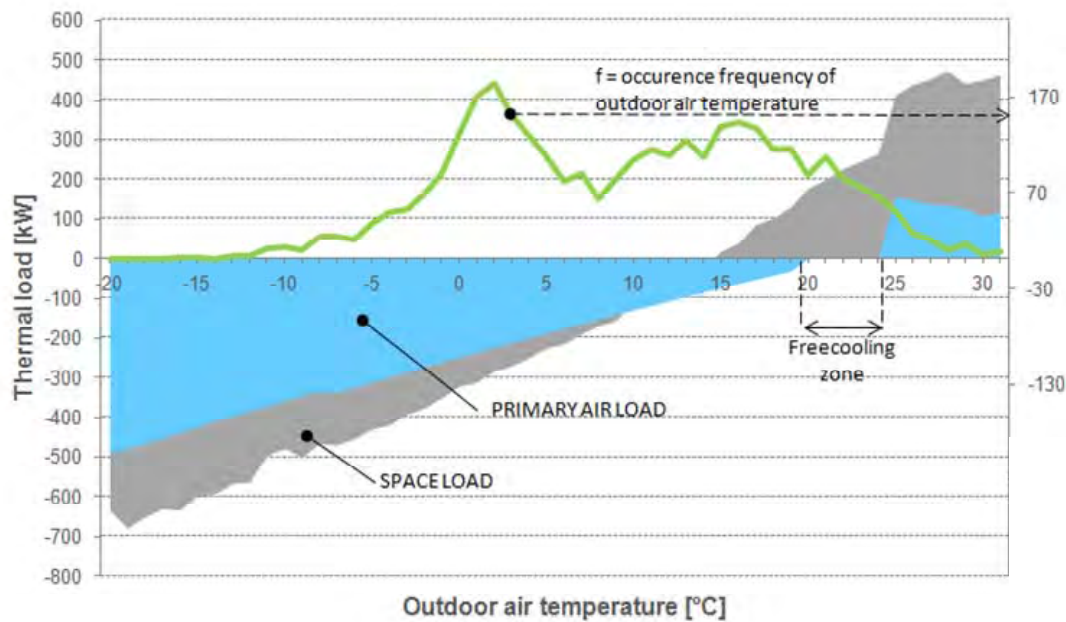


# ENERGY ANALYSIS IN KRAKOW



## COMPARISON WITH TRADITIONAL SYSTEM: SCREW STEPLESS COMPRESSOR

On the basis of the load profile were compared the following generators:

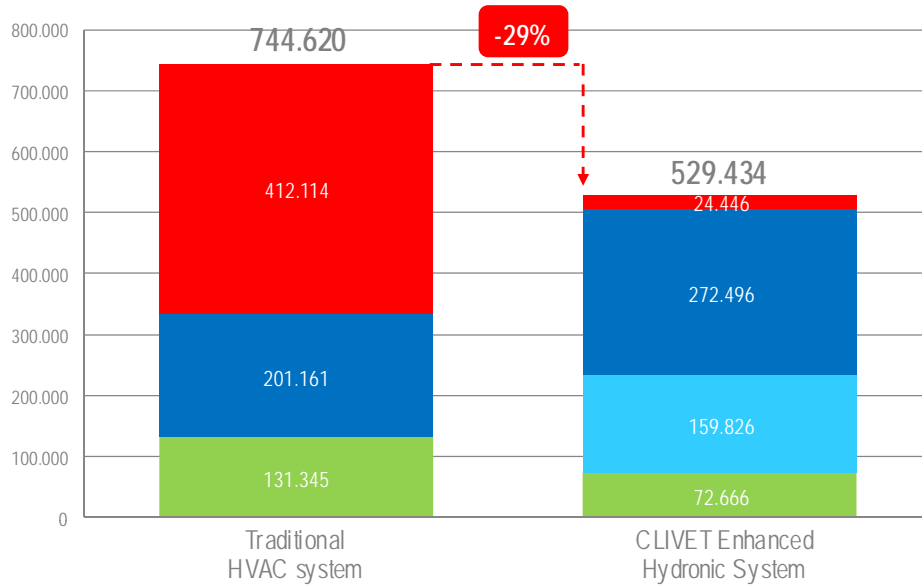


	CLIVET ENHANCED HYDRONIC SYSTEM	TRADITIONAL HVAC SYSTEM
Central Chilled Water	SPINchiller <sup>3</sup> WSAN-XSC3 120.4 EXC Air-to-water heat pump Cooling 323 kW (A35 W7) EER 2,74 ESEER 3,99	Air cooled liquid Chiller Screw compressor, stepless control Cooling 480 kW (A35 W7) EER 3,2 ESEER 4,0 Q.ty 1
Central Hot Water	Heating 376 kW (A7 W45) COP 3,31 Q.ty 1 Gas condensing boiler Efficiency 102% Heating 280 kW Q.ty 1	Gas condensing boiler Efficiency 102% Heating 500 kW Q.ty 1
Local Primary Air	ZEPHIR <sup>3</sup> SIZE 3 Exhaust air heat pump Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling 19,1 kW (A35 A25) Heating 20,7 kW (A7 A20) Recovery Thermodynamic Passive recovery pressure drop (per air stream) 0 Pa 'Hydronic recovery device for extended operating range' Q.ty 8	Air Handling Unit <i>bespoke equipment</i> Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling from chiller Heating from boiler Recovery Enthalpy wheel 70% Passive recovery pressure drop (per air stream) 120 Pa Q.ty 8

# ENERGY ANALYSIS IN KRAKOW - Overall consumption

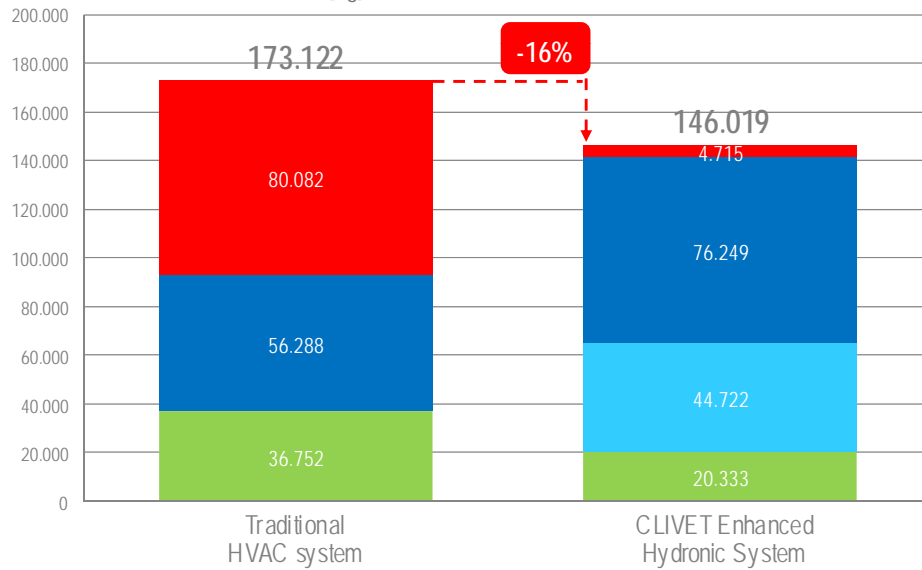


TOTAL PRIMARY ENERGY [kWh]

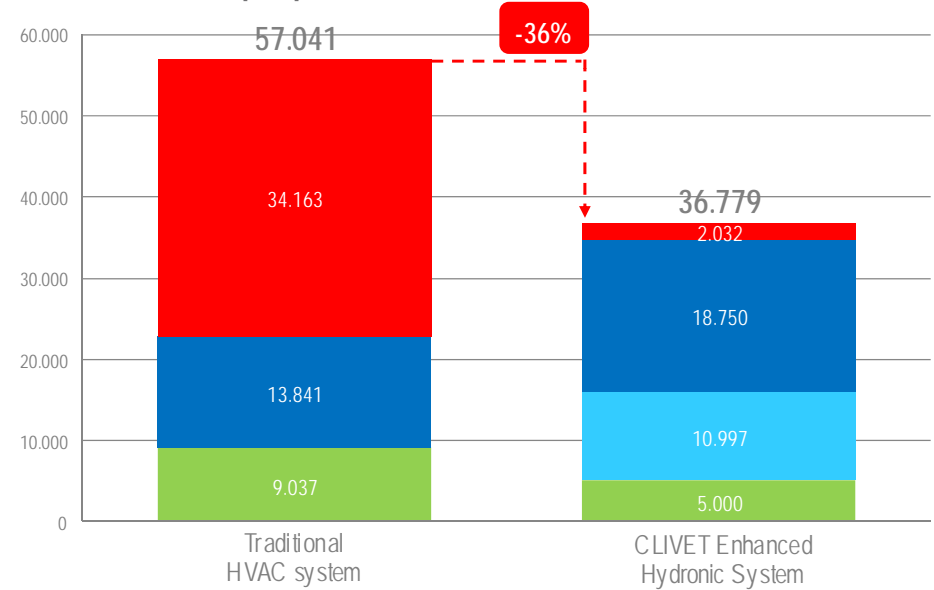


- Electric Generator
- Gas Generator
- ZEPHIR<sup>3</sup> Thermodynamic Circuit
- Handling fans

TOTAL CO<sub>2</sub> EMISSIONS [kg]



ENERGY COST [EUR]

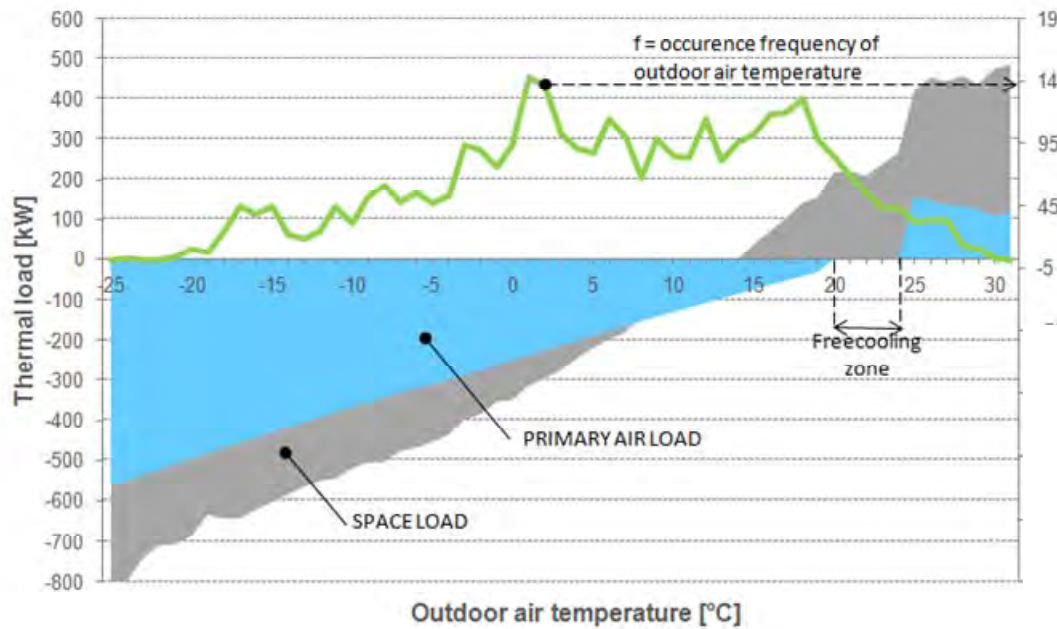


# ENERGY ANALYSIS IN MOSCOW



## COMPARISON WITH TRADITIONAL SYSTEM: SCREW STEPLESS COMPRESSOR

On the basis of the load profile were compared the following generators:



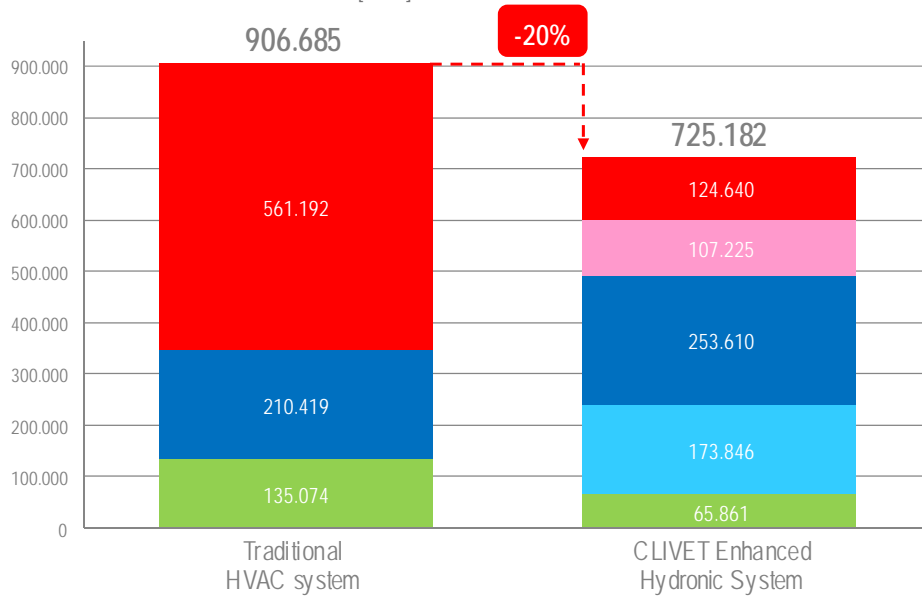
	CLIVET ENHANCED HYDRONIC SYSTEM	TRADITIONAL HVAC SYSTEM
Central Chilled Water	SPINchiller <sup>3</sup> WSAN-XSC3 140.4 EXC Air-to-water heat pump Cooling 371 kW (A35 W7) EER 2,74 ESEER 3,97	Air cooled liquid Chiller Screw compressor, stepless control Cooling 480 kW (A35 W7) EER 3,2 ESEER 4,0 Q.ty 1
Central Hot Water	Heating 424 kW (A7 W45) COP 3,30 Q.ty 1 Gas condensing boiler Efficiency 102%	Gas condensing boiler Efficiency 102% Heating 600 kW Q.ty 1
Local Primary Air	ZEPHIR <sup>3</sup> SIZE 3 Exhaust air heat pump Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling 19,1 kW (A35 A25) Heating 20,7 kW (A7 A20) Recovery Thermodynamic Passive recovery pressure drop (per air stream) 0 Pa EXTRAPOWER-H Q.ty 8	Air Handling Unit <i>bespoke equipment</i> Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling from chiller Heating from boiler Recovery Enthalpy wheel 70% Passive recovery pressure drop (per air stream) 120 Pa Q.ty 8



# ENERGY ANALYSIS IN MOSCOW - Overall consumption

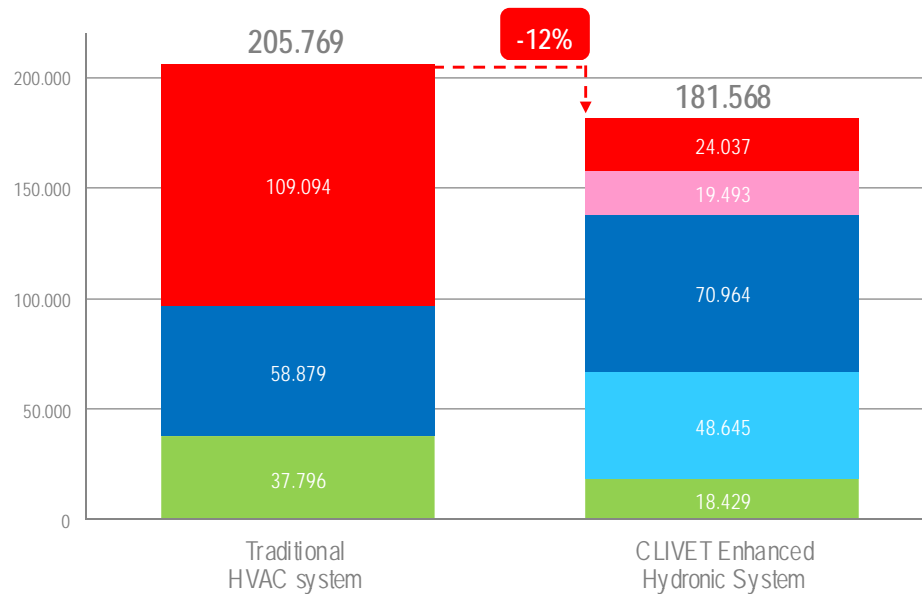


TOTAL PRIMARY ENERGY [kWh]

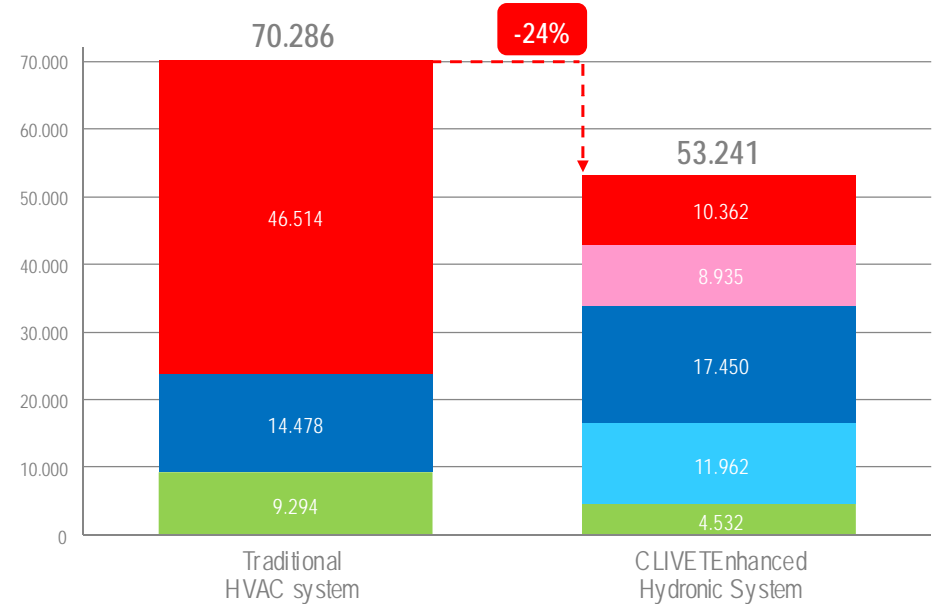


- Electric Generator
- Gas Generator
- ZEPHIR<sup>3</sup> Thermodynamic Circuit
- Handling fans
- EXTRAPOWER-H

TOTAL CO<sub>2</sub> EMISSIONS [kg]



ENERGY COST [EUR]

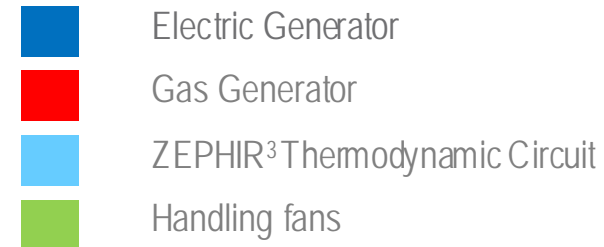
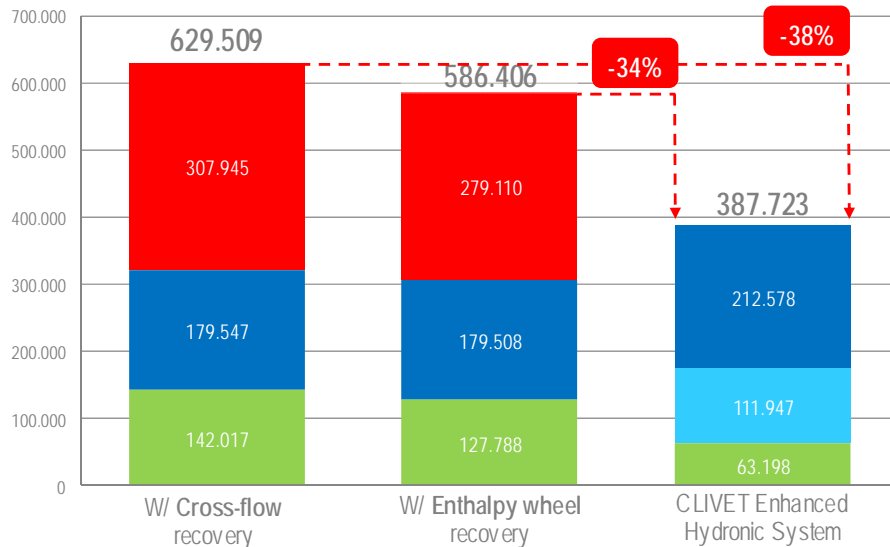


# LONDON – Effect of heat recovery

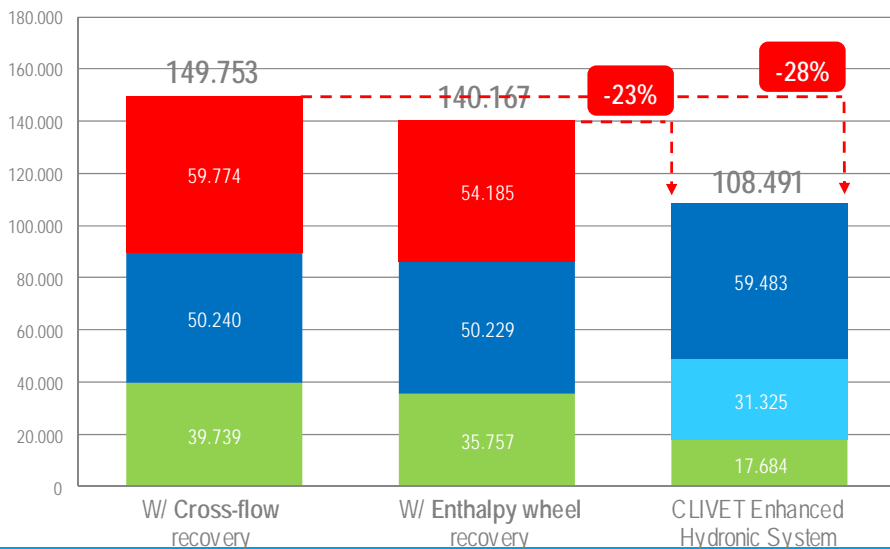


Effect of passive cross-flow heat exchanger in air primary treatment in replacement to wheel enthalpy

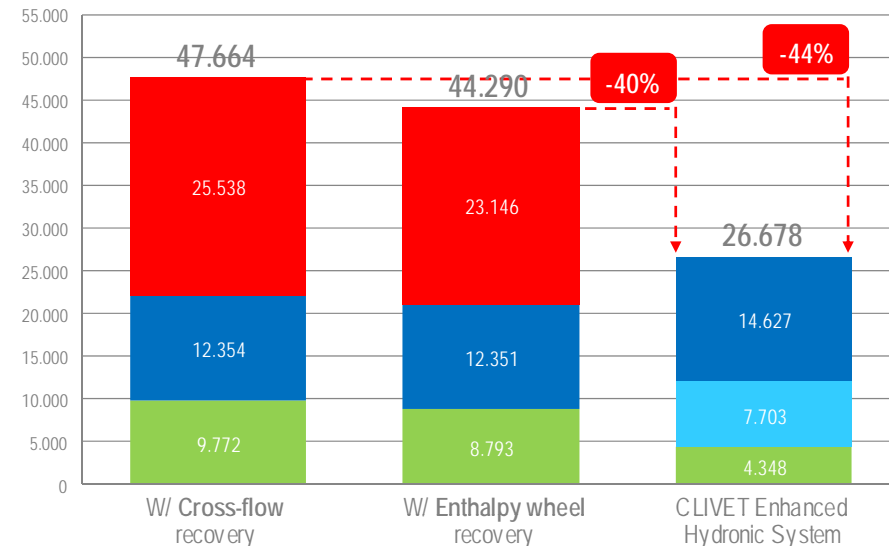
TOTAL PRIMARY ENERGY [kWh]



TOTAL CO<sub>2</sub> EMISSIONS [kg]



ENERGY COST [€]

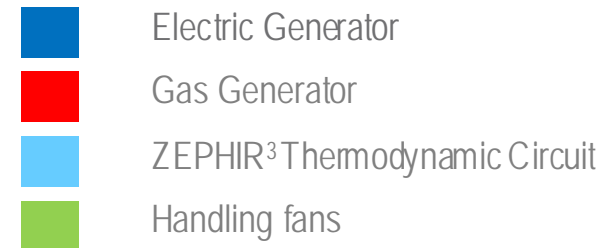
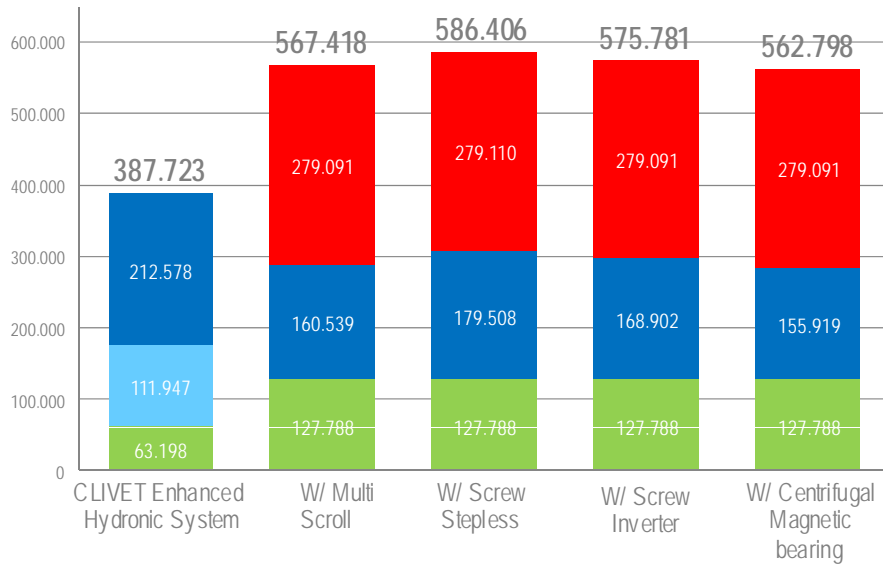


# LONDON – Effect of cooling technology

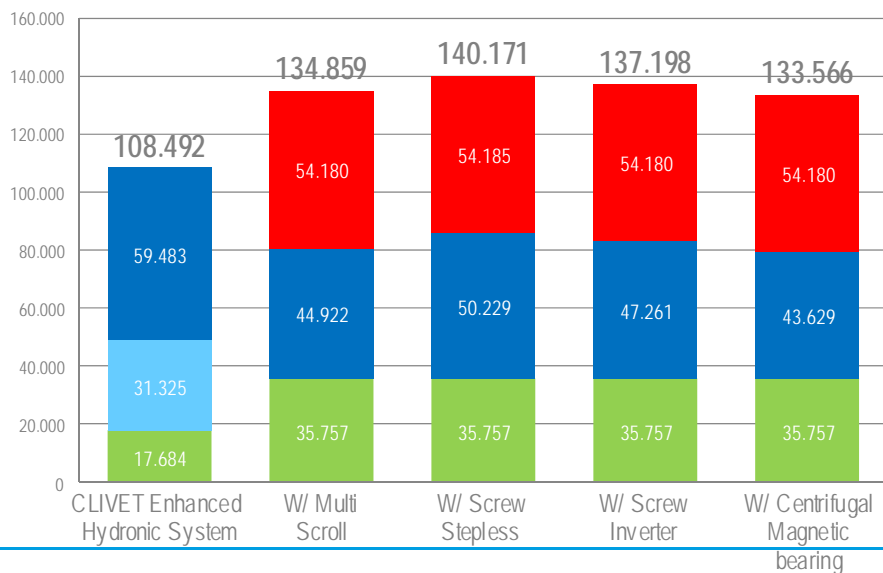


Effect of different cooling technology of the electric generator for traditional solutions

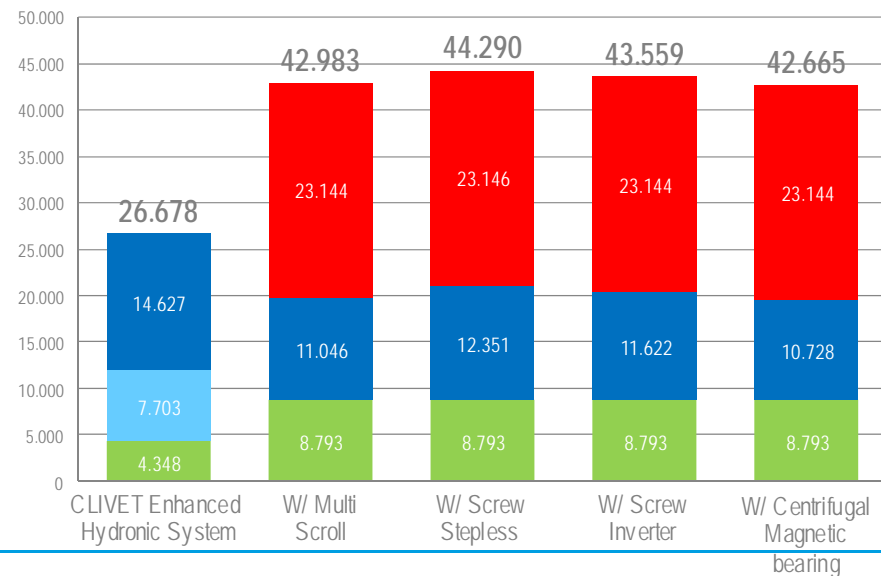
TOTAL PRIMARY ENERGY [kWh]



TOTAL CO<sub>2</sub> EMISSIONS [kg]



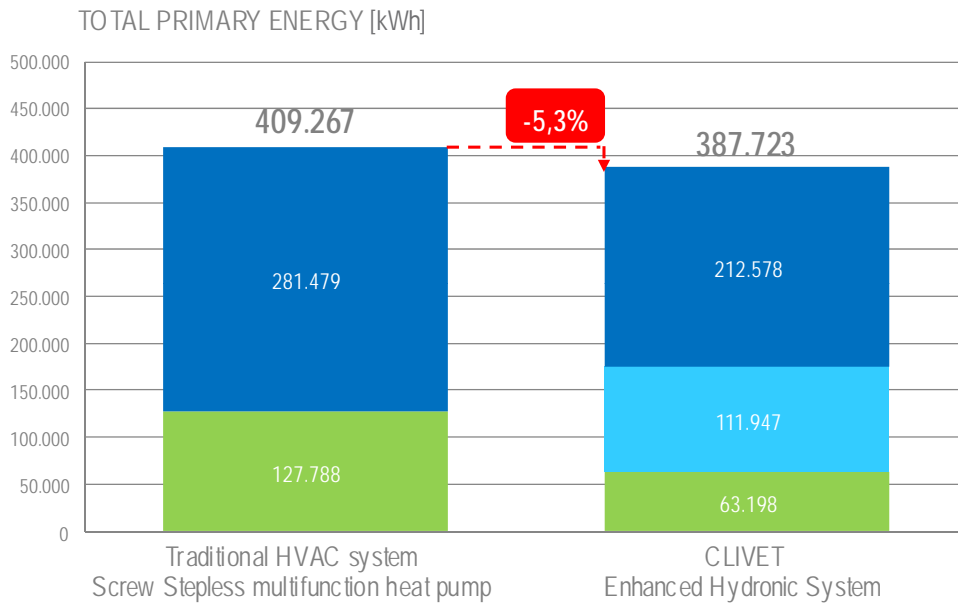
ENERGY COST [EUR]



# LONDON – Effect of heating technology



Effect of different heating technology of the gas generator for traditional solutions



	CLIVET ENHANCED HYDRONIC SYSTEM	TRADITIONAL HVAC SYSTEM
Central Chilled Water	SPINchiller <sup>3</sup> WSAN-XSC3 90.4 EXC Air-to-water heat pump Cooling 244 kW (A35 W7) EER 2,78 ESEER 3,94	<b>Multifunction</b> air sourced heat pump Screw compressor, stepless control Cooling 550 kW (A35 W7) EER 3,11 ESEER 3,72
Central Hot Water	Heating 282 kW (A7 W45) COP 3,23 Q.ty 1	Heating 570 kW (A7 W45) COP 3,69 Q.ty 1
Local Primary Air	ZEPHIR <sup>3</sup> SIZE 3 Exhaust air heat pump Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling 19,1 kW (A35 A25) Heating 20,7 kW (A7 A20) Recovery Thermodynamic Passive recovery pressure drop (per air stream) 0 Pa Q.ty 8	Air Handling Unit <i>bespoke equipment</i> Airflow 4000 m <sup>3</sup> /h (1100 l/s) Cooling <i>from chiller</i> Heating <i>from boiler</i> Recovery Enthalpy wheel 70% Passive recovery pressure drop (per air stream) 120 Pa Q.ty 8



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