ASHRAE®

CHICAGO
2024 WINTER CONFERENCE AND AHR EXPO

January 20–24, 2024

Seminar 31 - Monday, January 22

Heat Pumps: a High Potential Solution to Decrease Operational CO_2 Emissions in Buildings

Cătălin Lungu

President

Mandate: 2022 - 2025

REHVA

Apartment Building | Corporate Building | Industrial Site | Hospital | Mall | Hotel | Congress Center & Institution | Cinema Theater | Airport

LERNING OBJECTIVES AND DISCLAIMER

Learning Objectives:

- Describe the main indicator used in Europe to assess the Building Global Warming Potential
- Explain the main indicators used in Europe to measure energy performance of buildings
- Compare and contrast the outcomes of three common primary energy indicator calculation approach
- Explain the meaning of on-site renewable energy generation and ambient heat in the primary energy calculation

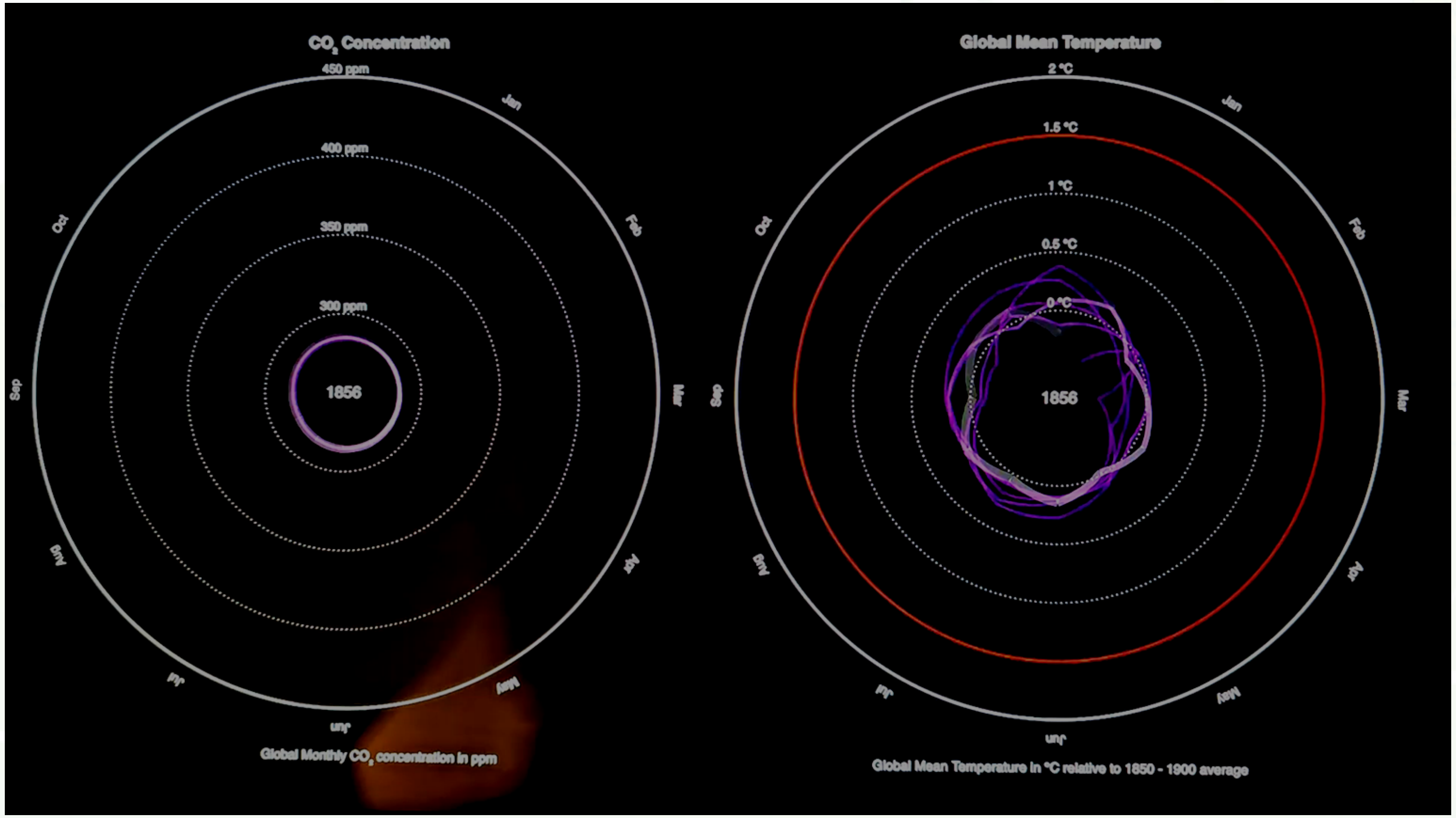
ASHRAE disclaimer:

ASHRAE is a Registered Provider with the American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to ASHRAE Records for AIA members. Certificates of Completion for non-AIA members are available on request.

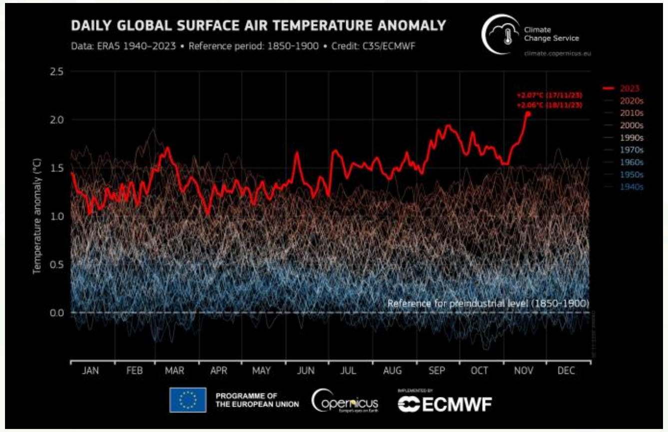
This program is registered with the AIA/ASHRAE for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA or any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

1. PREAMBULE

Is anyone in the room against decarbonization / sustainability ?



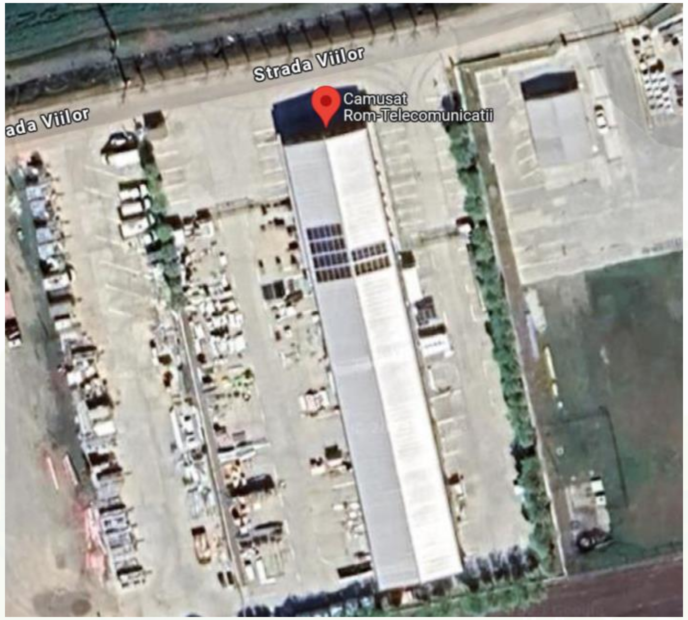
- 17th of Nov - the first day when global temperature was more than 2°C above 1850-1900 (or pre-industrial) levels, at 2,06°C (source Copernicus)



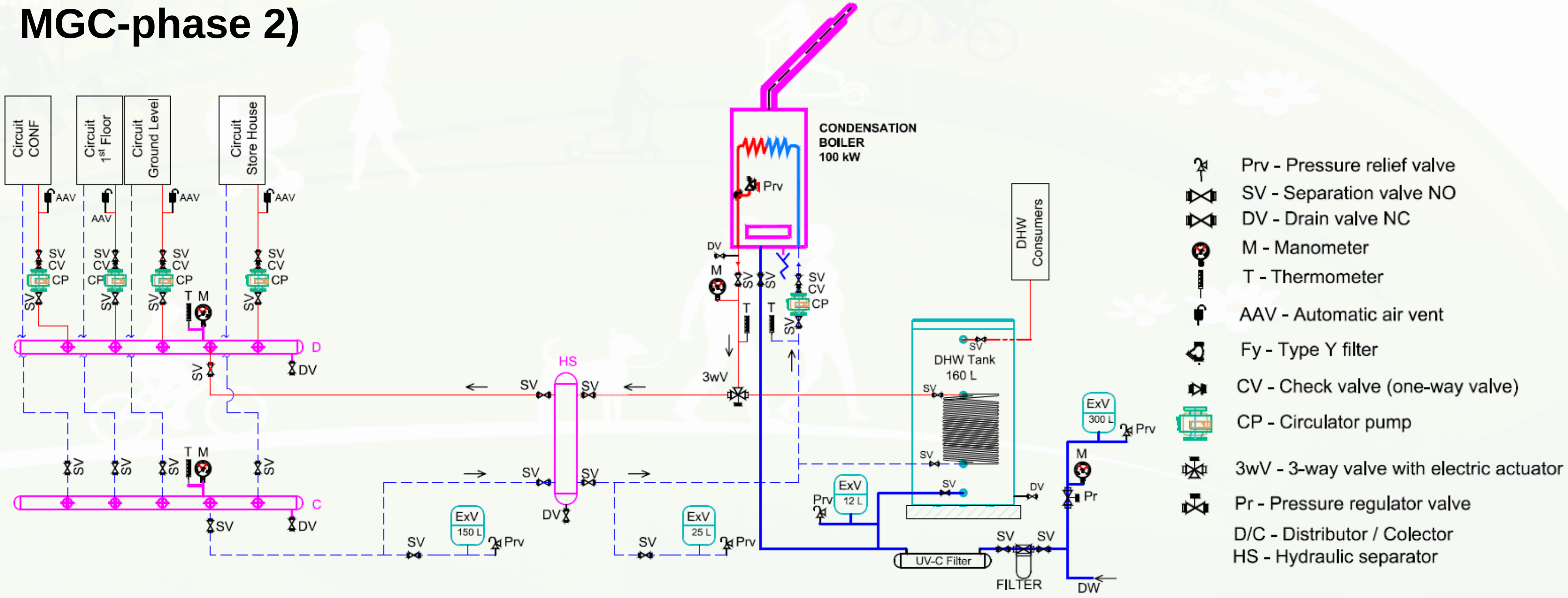
- even if all NDCs will be respected, the global CO_2 emissions +9%/2030 vs 2010, -2%/2030 vs 2019 compared with the reduction needed -43%/2030 vs 2019 (ie max +1,5°C) (source IPCC)

2. HVAC system design - problem definition

Source: google maps



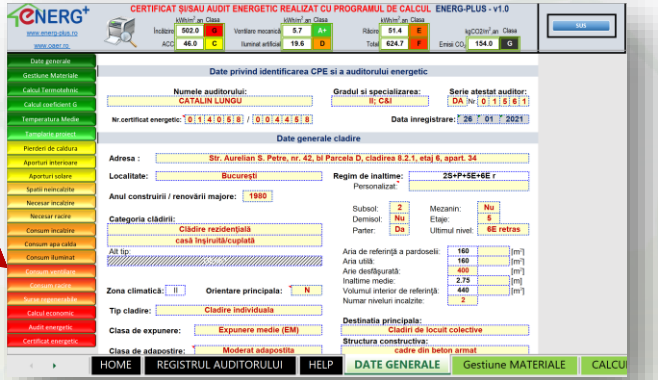
- office building (1250 m^2) + storing house (250 m^2), near Bucharest, G+1 floor
- roof – sandwitch pannels Lindab Roof of 60 mm, walls – sandwitch Lindab Wall of 80 mm (polyurethane), fenestration – Al profiles and low-e double glazing
- Heating+DHW with NG boiler 100 kW, cooling with split 40kW (27pcs A/C), PV pannels (19,44 kWp, 36 pcs, 540 Wp, ε=up to 20%)
- **MAIN OBJECTIVE: replace the boiler with heat pump(s) & find the optimal solution out of min 3 choices (i.e. find min delivered energy–phase 1 and MGC-phase 2)**



3. HVAC system design – optimization procedure

1 Collect data (measured and rated monthly average outside temperature - ex METEONORM, measured delivered energy for H/C/DHW/L/V) and adjust measured energy consumption

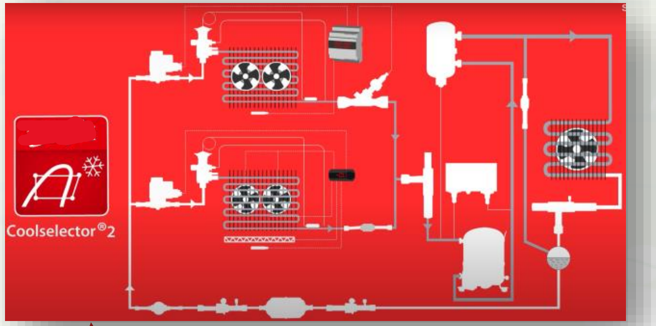
2 Estimate by calculation the heating/cooling season **[ENERG+]**



3 Normalize the monthly values of the measured delivered energy (heating/cooling), using DD method (winter and summer)

4 Select different options of HPs and HVAC systems (min3)

5 Use **COOLSELECTOR2** to estimate the theoretical COP/EER for real COP/EER (values from catalogue)



6 Find the regression equation for each HP and compute real monthly average COP/EER function of standard values of the monthly average outside temperature

7 Compute the electric energy consumption delivered by the grid or by a mixture grid-PV + use **PVSYST**

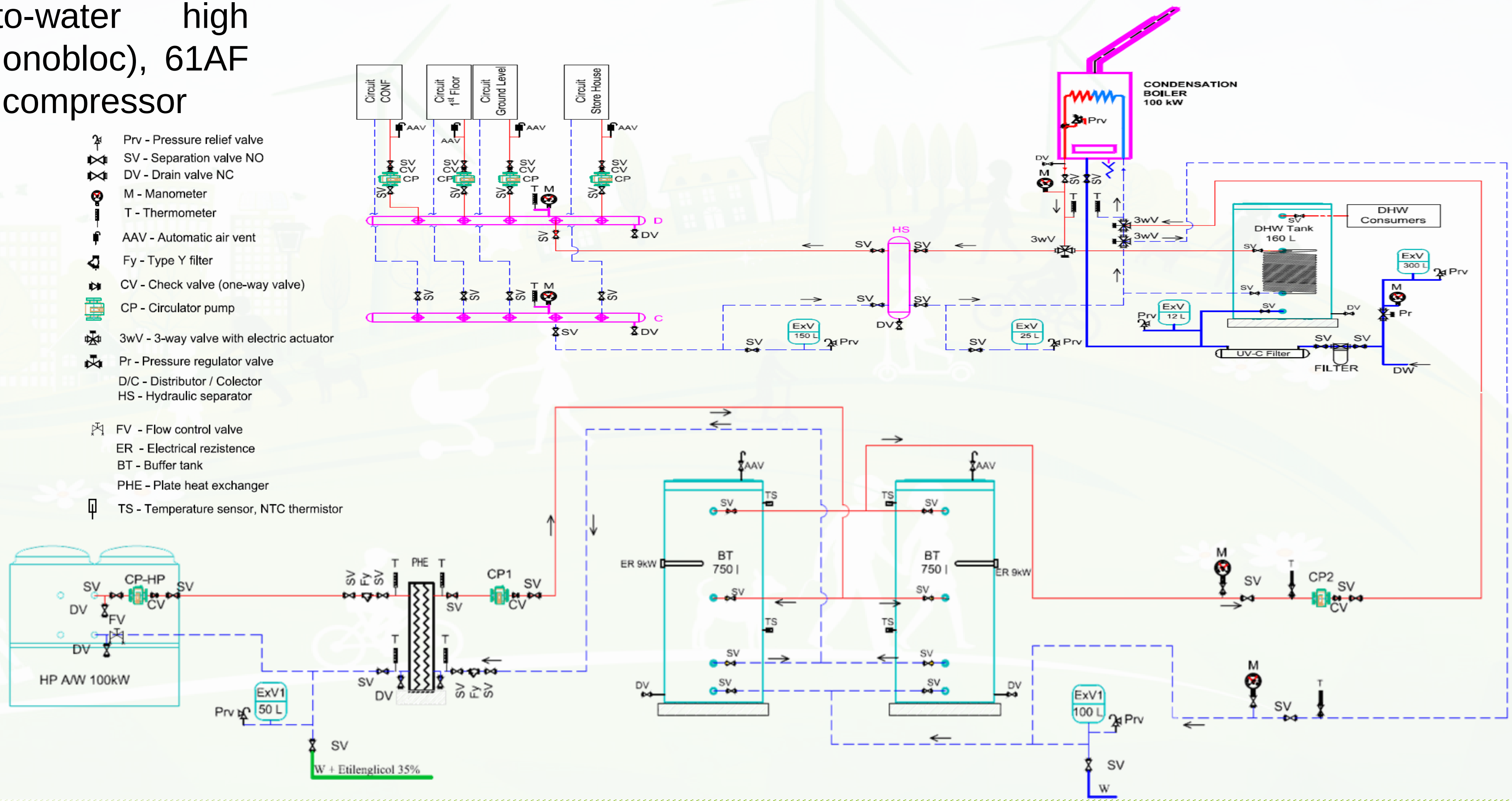
PVSYST PHOTOVOLTAIC SOFTWARE

8 Compute the primary energy consumption and the CO_2e emissions

3. HVAC system design – optimization procedure

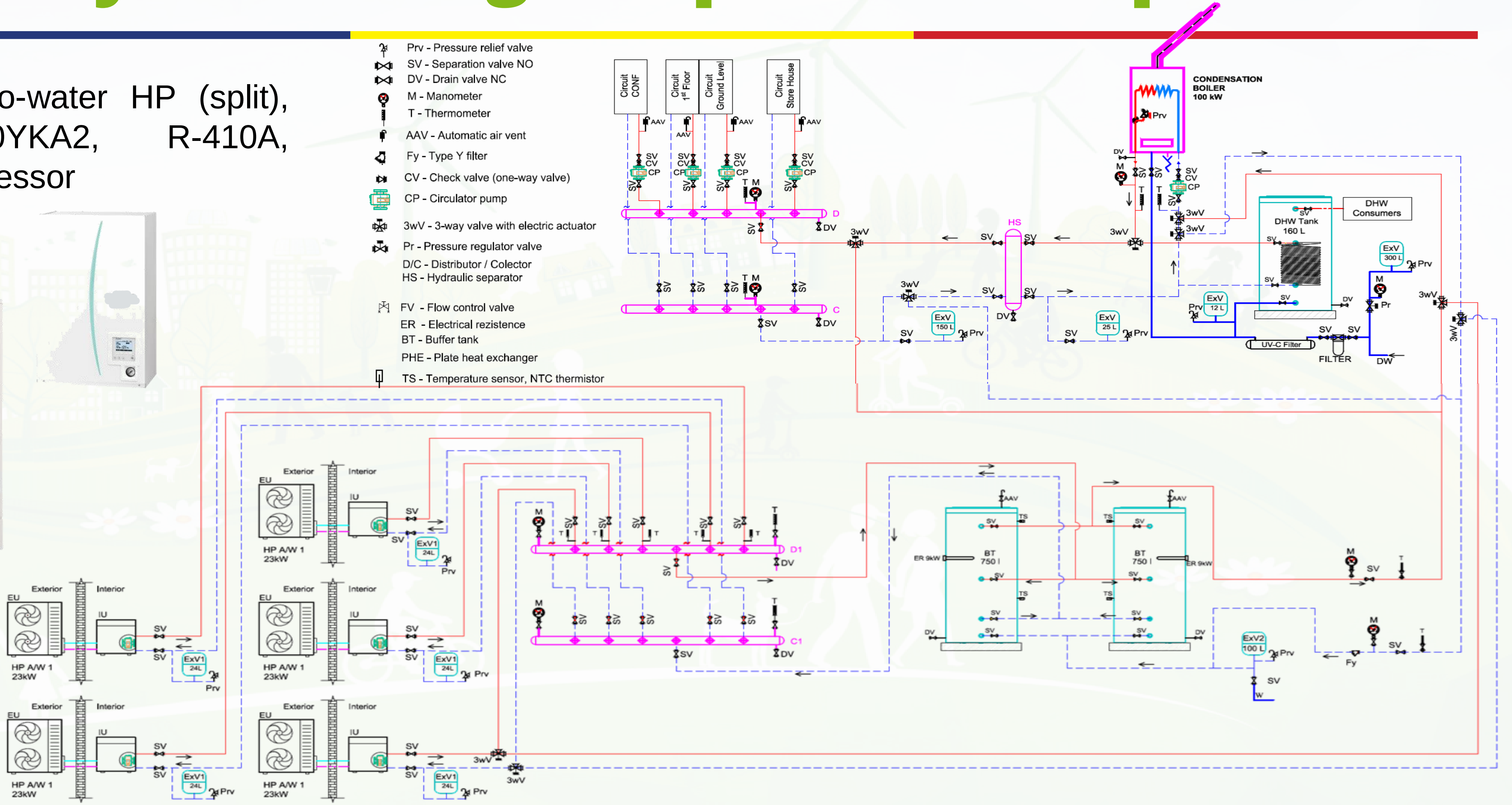
CASE 1: Air-to-water high temperature HP (monobloc), 61AF 105, R-407C, scroll compressor

- Prv - Pressure relief valve
- SV - Separation valve NO
- DV - Drain valve NC
- M - Manometer
- T - Thermometer
- AAV - Automatic air vent
- Fy - Type Y filter
- CV - Check valve (one-way valve)
- CP - Circulator pump
- 3wV - 3-way valve with electric actuator
- Pr - Pressure regulator valve
- D/C - Distributor / Colector
- HS - Hydraulic separator
- FV - Flow control valve
- ER - Electrical rezistence
- BT - Buffer tank
- PHE - Plate heat exchanger
- TS - Temperature sensor, NTC thermistor



3. HVAC system design – optimization procedure

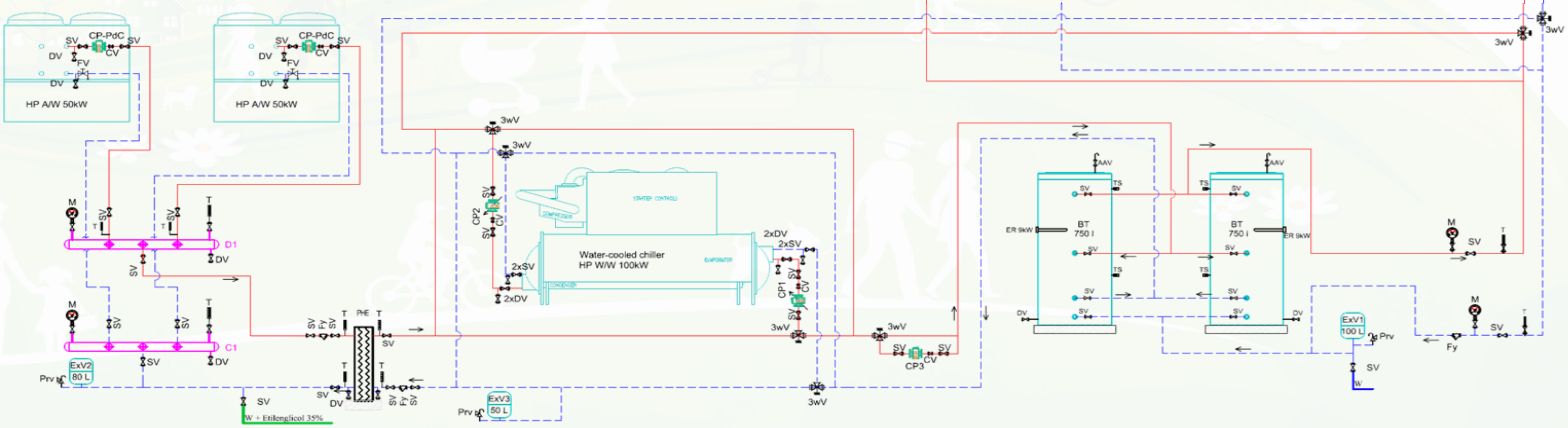
CASE 2: Air-to-water HP (split), PUHZ-SHW230YKA2, R-410A, injection compressor



3. HVAC system design – optimization procedure

CASE 3: Air-to-water + water-to-water HP, cascade

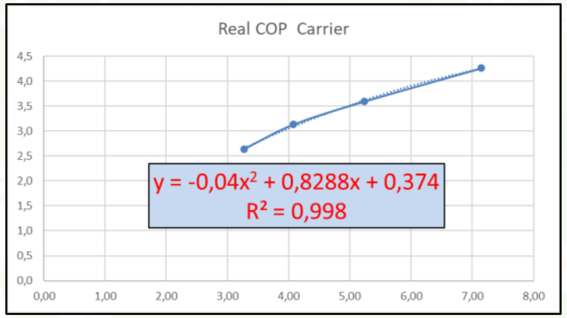
Prv - Pressure relief valve
SV - Separation valve NO
DV - Drain valve NC
M - Manometer
T - Thermometer
AAV - Automatic air vent
Fy - Type Y filter
CV - Check valve (one-way valve)
CP - Circulator pump
3wV - 3-way valve with electric actuator
Pr - Pressure regulator valve
D/C - Distributor / Colector
HS - Hydraulic separator
FV - Flow control valve
ER - Electrical rezistence
BT - Buffer tank
PHE - Plate heat exchanger
TS - Temperature sensor, NTC thermistor

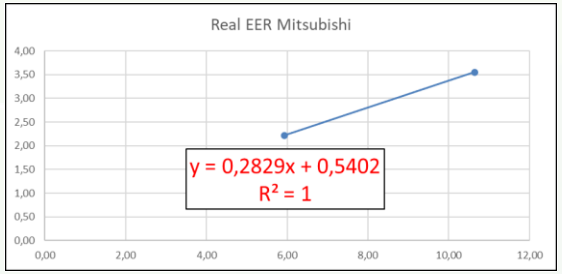


3. HVAC system design – optimization procedure

Heat Pump Producer & short description	Heat Pump Code	Refrigerant type	Rated Heating Capacity [kW]	COP W35/A7	COP W45/A7	COP W55/A7	COP W65/A7	Rated Cooling Capacity [kW]	EER (A35/W7)	EER (A35/W18)
CARRIER, high-temperature monobloc air-to-water heat pumps with integrated hydraulic module, scroll compressors, -20/65grdC	61AF 105	R-407C	102	4.26	3.59	3.13	2.64	-	-	-
MITSUBISHI, air-to-water heat pump, split type, Zubadan injection compressor, -25/65grdC	PUHZ-SHW230YKA2	R410A	23	3.65	3,02	2,47	-	20	2,22	3,55
MAXA, reversible inverter heat pump with steam injection, scroll compressors	i-HP/LT 0250	R410A	47,78	3,93	3,33		-	36,1	2,9	3,8
TRANE, water to water heat pumps, helical-rotary compressor	RTSF 050 G	R1234ze	204	5,75	4,5	3,74	3,02	184	5,03	-

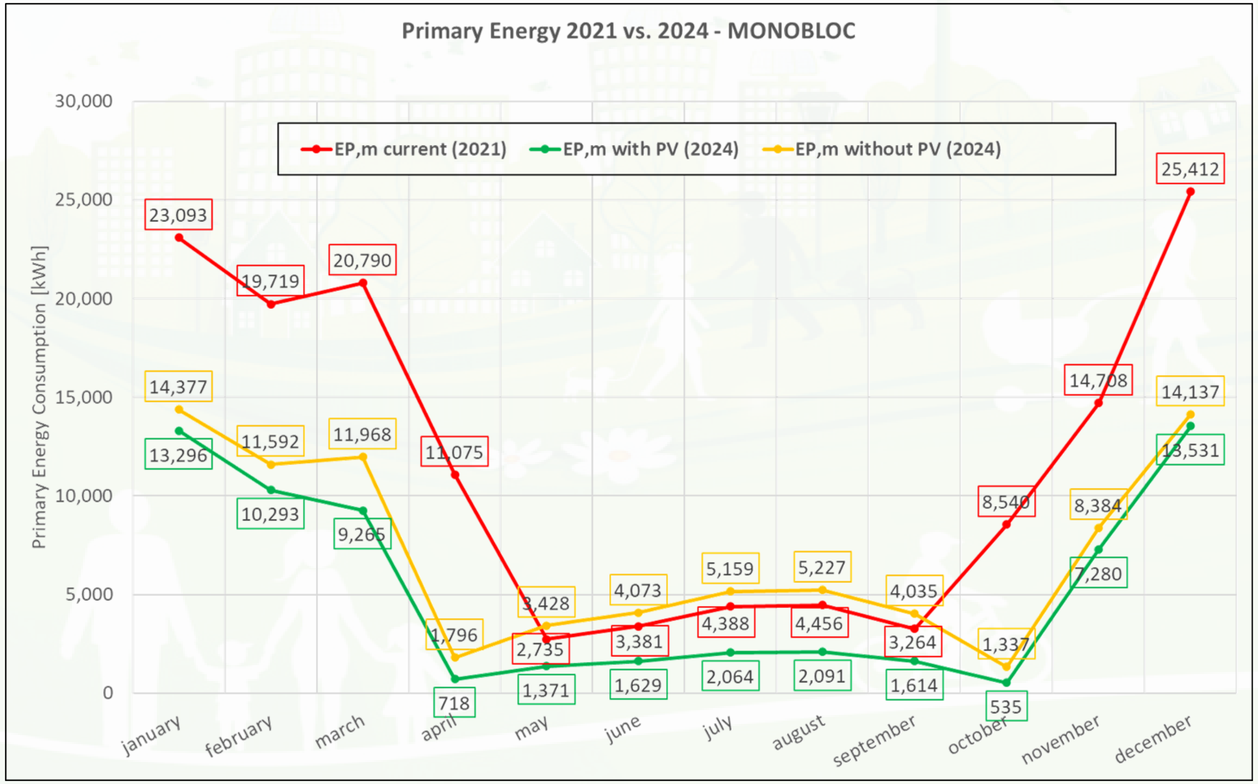
Month	ϴ [grdC] standardized	COP				EER		
		Case 1	Case 2	Case 3		Case 1	Case 2	Case 3
				Stage 1	Stage 2			-
Jan	-1,2	2,45	1,78	3,50	4,69	2,9	-	-
Feb	1,2	2,53	1,87	3,66	4,69	2,9	-	-
March	5,6	2,57	1,92	3,74	4,69	2,9	-	-
April	11,3	2,74	2,12	4,16	4,69	2,9	-	5,37
May	17,5	2,78	2,15	-	-	2,9	5,86	4,26
June	21,4	2,78	2,15	-	-	2,9	4,23	3,66
July	23,4	2,78	2,15	-	-	2,9	3,35	3,61
Aug	22,5	2,78	2,15	-	-	2,9	3,29	4,88
Sept	16,8	2,78	2,15	-	-	2,9	5,14	-
Oct	11,1	2,78	2,15	4,25	4,69	2,9	-	-
Nov	5,2	2,66	2,15	3,95	4,69	2,9	-	-
Dec	-0,2	2,49	2,02	3,58	4,69	2,9	-	



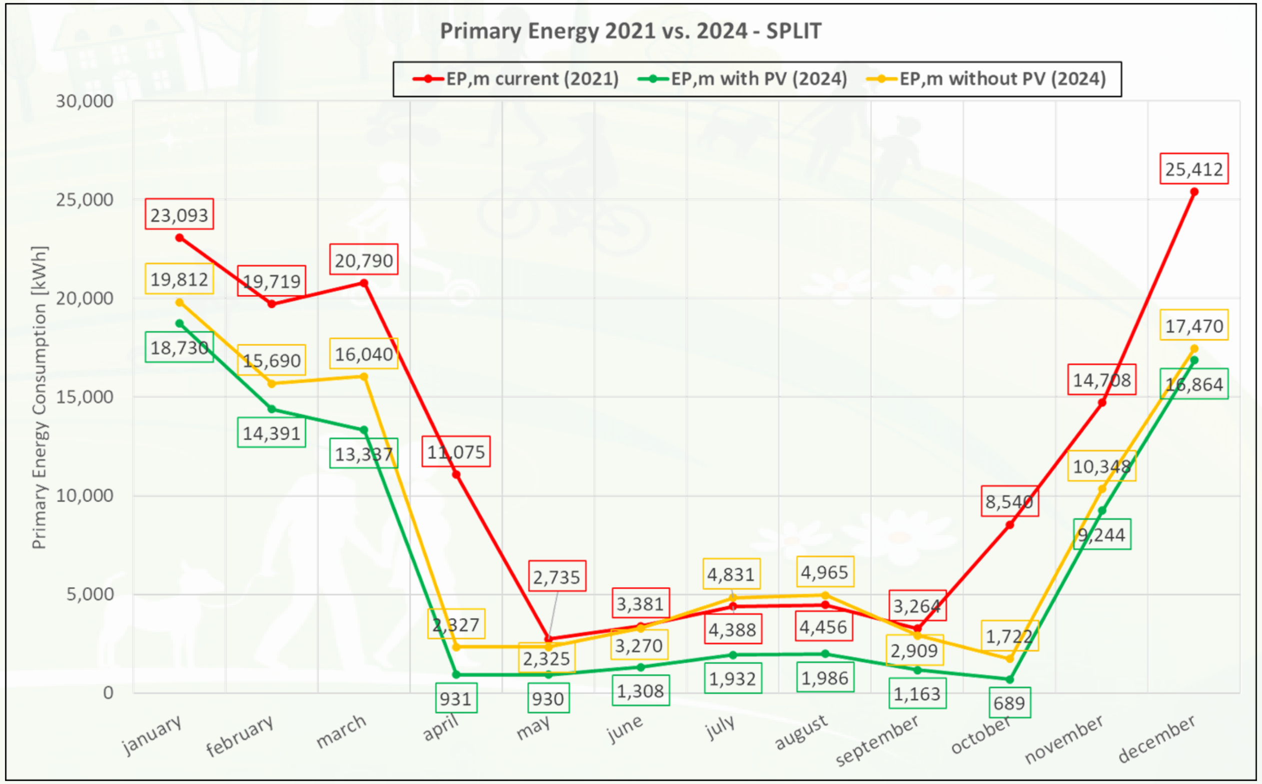


4. Results

CASE 1 – monobloc HP (1pc)
-23%/-57% PE & -37/-68% CO2e, yearly

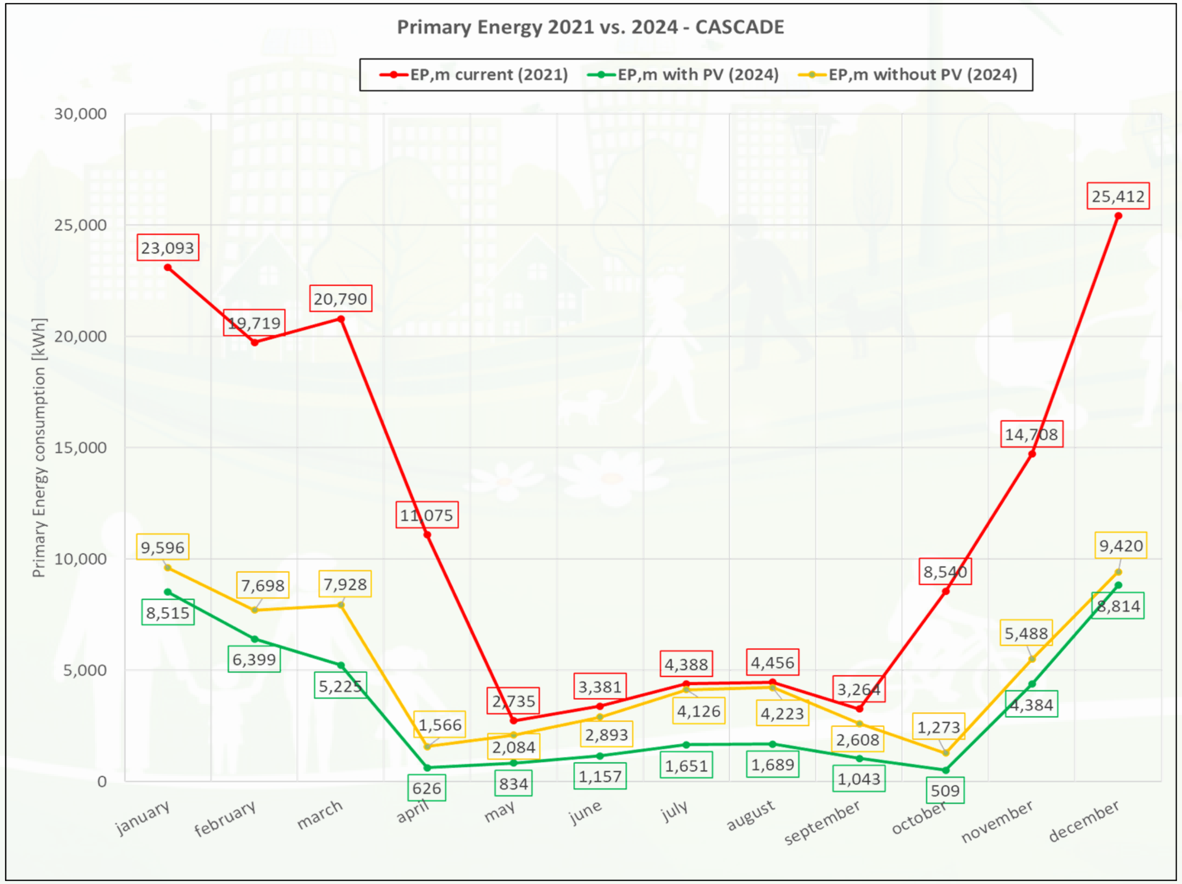


CASE 2 – split air-to-water HPs (5 pcs)
-24%/-53% PE & -41/-68% CO2e, yearly

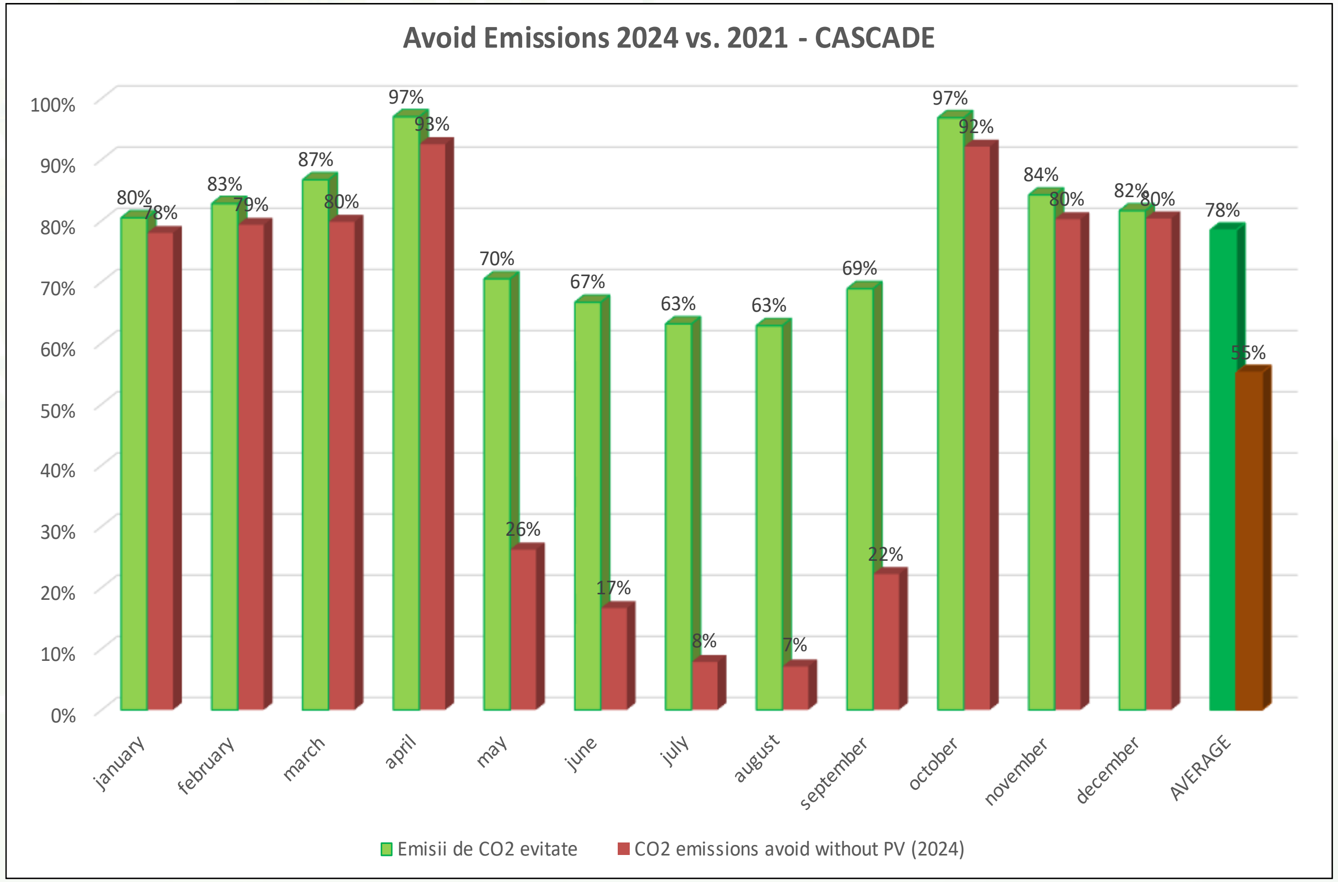


4. Results

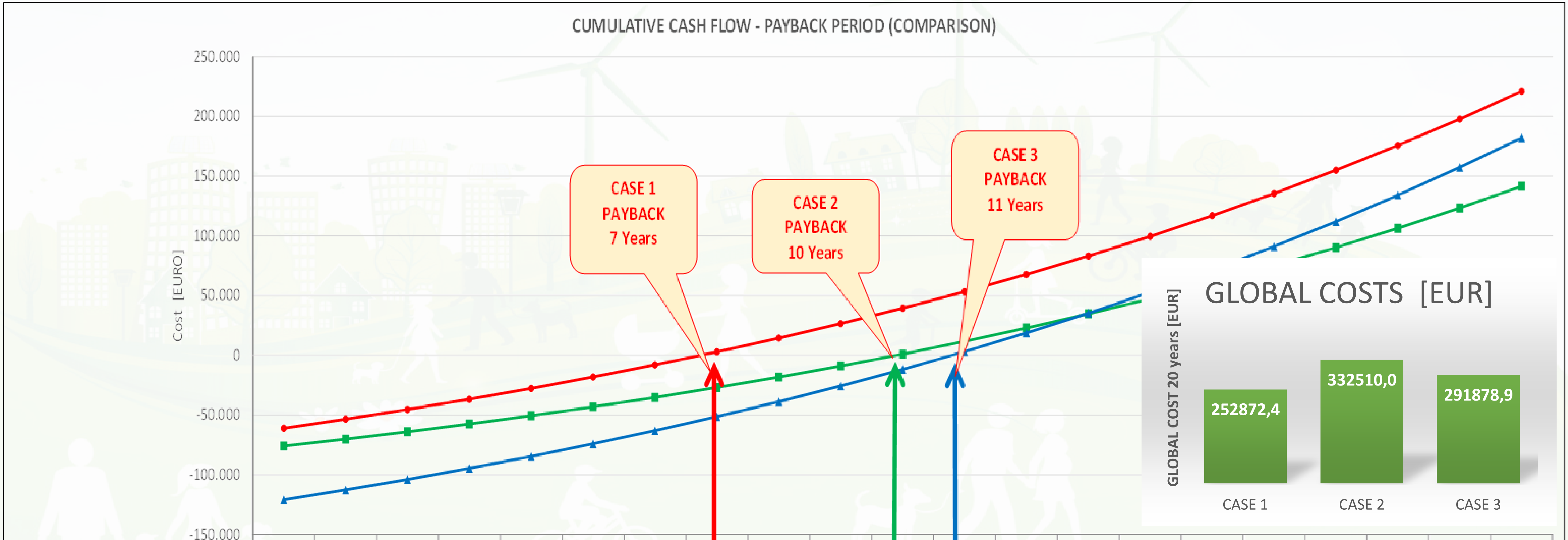
CASE 3 – cascade HP system -46%/-71% annual EP



CASE 3 – cascade HP system -55%/-78% avoided CO_2e, yearly



4. Results



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cash Flow (SYSTEM 1 - MONOBLOC)	-60987	-53394	-45340	-36796	-27733	-18119	-7921	2899	14377	26554	39474	53181	67725	83157	99531	116906	135343	154908	175670	197704	221088
Cash Flow (SYSTEM 2 - SPLIT)	-75919	-70120	-63964	-57430	-50493	-43129	-35310	-27009	-18196	-8839	1097	11648	22851	34747	47381	60797	75045	90178	106249	123319	141450
Cash Flow (SYSTEM 3 - CASCADE)	-120991	-112653	-103824	-94477	-84580	-74100	-63005	-51256	-38815	-25642	-11692	3079	18721	35285	52826	71401	91073	111906	133969	157335	182081

5. Conclusions and perspectives

- ❖ No building renovation before boiler replacement (usual case with minimum investment)
- ❖ The current procedure – based on simplified hypothesis (calculated number of operating days and constant COP/EER per month etc.)
- ❖ Monthly calculation using EPB standards (perspective-implementing an hourly method)
- ❖ HP can benefit from existing PV, but even without PV the replacement was profitable
- ❖ This procedure – a first step for an automated calcution procedure to find the OGC for NZEB or for refurbished buildings
- ❖ Further investigations for higher heating and cooling capacities

Questions ?
Thank you !

SAVE THE EARTH !

Associate Professor Cătălin Lungu, PhD
president@rehva.eu, catalin.lungu@utcb.ro