WP4 Simulations at building and district level

Rossano Scoccia, PhD (POLIMI)

Heat4COOL project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 723925

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2. Tasks, deliverables and milestones completed M1-M54. Focus on M37-M54
3. Planned use of PMs
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WP4 Tasks

- Pre-retrofit assessment of the pilot sites (***Task 4.1***)

- Modelling, sizing and evaluation of the H4C solutions in the four pilot sites (***Task 4.2***)

- Post-retrofit assessments and guidelines of the integrated Heating&Cooling equipment, RES solutions and wastewater heat recovery system (***Task 4.3***)

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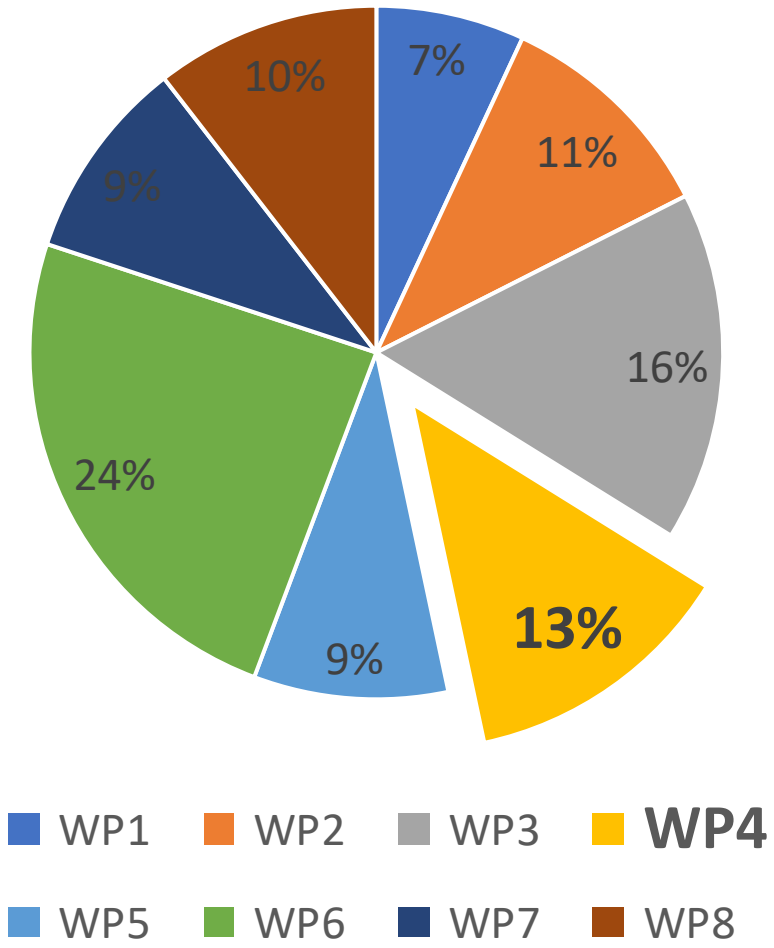
WP4 planned PMs



Partners	WP4
POLIMI	30
FAHR	3.5
Thermowatt	5
HYPERTECH + WVT	7
TECNALIA	15
Sunamp	5
BALKANIKA	10
SOLINTEL	7
SYMELEC	11
IZNAB	3
HSLU	6
Tot PMs	102.5

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Task 4.1: Pre-retrofit assessment of the pilot sites (M7-M24)

- **Deliverables:**

	Title	Resp.	Type	Due date	Status
D4.1	First energy audit	Balkanika	Rep	M15	Approved

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Task 4.2: Modelling, sizing and evaluation of the H4C solutions in the four pilot sites (M7-M24)

- **Deliverables:**

	Title	Resp.	Type	Due date	Status
D4.2	Modelling, sizing and evaluation of the H&C renovation approach in pilot site 1	Polimi	Rep	M24	Approved
D4.3	Modelling, sizing and evaluation of the H&C renovation approach in pilot site 2	Polimi	Rep	M24	Approved
D4.4	Modelling, sizing and evaluation of the H&C renovation approach in pilot site 3	Polimi	Rep	M24	Approved
D4.5	Modelling, sizing and evaluation of the H&C renovation approach in pilot site 4	Polimi	Rep	M24	Approved
D4.7	Modelling, sizing and evaluation of the Solar assisted AHP system in Toledo	FAHR		M54	Submitted

- **Milestones:**

	Title	Resp.	Due date	Status
MS5	Selection of the Heating and Cooling renovation approach in the four pilot sites	Polimi	M24	Done

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Task 4.3: Post-retrofit assessments and guidelines of the integrated Heating&Cooling equipment, RES solutions and wastewater heat recovery systems (M37-M54)

- **Deliverables:**

	Title	Resp.	Type	Due date	Status
D4.6	Post-retrofit assessments and guidelines of the integrated Heating&Cooling equipments, RES solutions and wastewater heat recovery systems	Polimi	Rep	M54	Submitted

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T4.1 + T4.2 (1 of 2)

1. Sofia (BG)

PV + EHP + PCM

3 floors
4 apartments
350 m^2

PV 12 kWp
EHP 10 kWt
PCM 36 kWh

2. Valencia (ES)

ST + TDC + EHP

4 floors
12 apartments
588 m^2

ST 50 m^2
TDC 15 kWc
EHP 45 kWc

3. Chorzow (PL)

PV + EHP + PCM

4 floors
12 apartments
1 330 m^2

PV 15 kWp
EHP 30 kWt
PCM 96 kWh

4. Budapest (HU)

WW + EHP

3 Buildings
1 330 m^2, 1 900 m^2, 8 000 m^2

WW & HP 1 MWt

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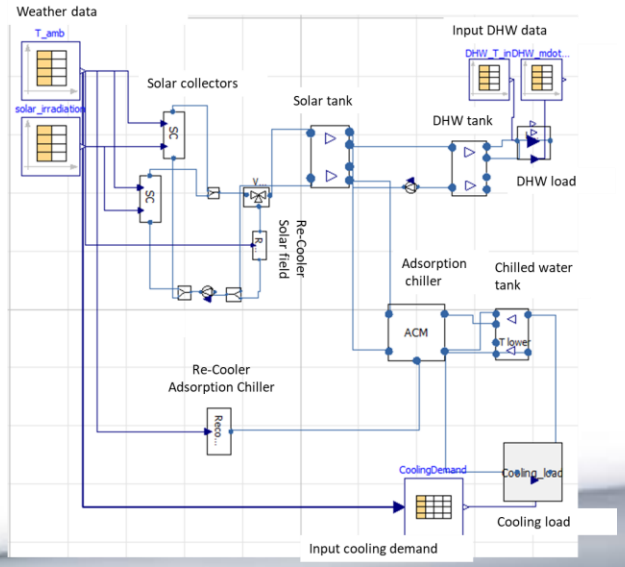
T4.1 + T4.2 (2 of 2)

5. Toledo (ES) – senior residence



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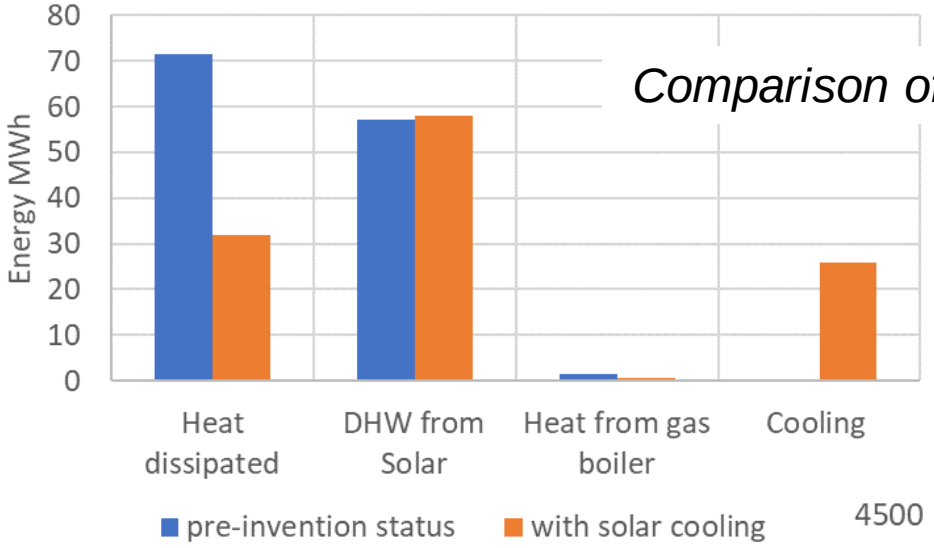
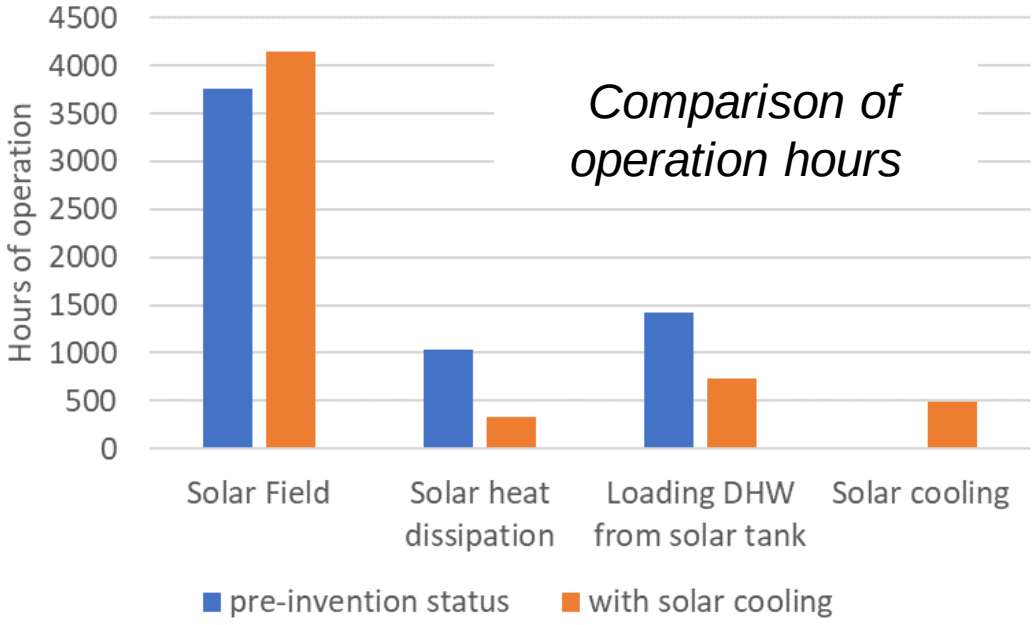
WP4 – D4.7 - Simulation of Toledo system





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WP4 – D4.7 - Simulation of Toledo system

	Pre-retrofit HVAC status
Solar heat	128.4 MWh
Heat dissipated (waste)	71.5 MWh
Solar heat used for DHW	57.1 MWh
Heat from the back-up gas boiler	1.4 MWh

	Solar cooling
Solar heat	123.9 MWh
Solar heat used for cooling	25.8 MWh
Heat dissipated (waste)	32 MWh
Solar heat used for DHW	57.9 MWh
Heat from the back-up gas boiler	0.5 MWh

	Description	Value
SOLAR COOLING	Annual energy consumption	2'316 kWh
	SEER	11.1
	CO_2 emission	703 kg_{CO2}/year
	Electrical energy cost	288 €/year
	Specific cooling cost	0.01 €/$kWh_{cooling}$
V-COMP. COOLING	Annual energy consumption	7'250 kWh
	SEER	3.56
	CO_2 emission	2'200 kg_{CO2}/year
	Electrical energy cost	870 €/year
	Specific cooling cost	0.03 €/$kWh_{cooling}$

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Task 4.3

Post-retrofit assessments and guidelines of the integrated H&C equipment, RES solutions and Wastewater HR systems

M37 – 54

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Task 4.3: Post-retrofit assessments and guidelines of the integrated H&C equipment, RES solutions and Wastewater HR systems

- **Responsibilities:**
  - Polimi and Balkanika: Sofia pilot site;
  - Polimi and Iznab: Warsaw pilot site;
  - Polimi and Symelec: Valencia pilot site;
  - Polimi and Thermowatt: Budapest, District 4 pilot site.
- **Inputs:**
  - Expected energy performances from T4.2;
  - Monitoring data from T6.3 (PoliMi managed it).
- **Deliverable:**

	Title	Resp.	Type	Due date
D4.6	Post-retrofit assessments and guidelines of the integrated Heating&Cooling equipments, RES solutions and wastewater heat recovery systems	Polimi	Report	M54

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Task 4.3: Post-retrofit assessments methodology

- The final method used addressed the issues arised linked to:
  - unpredictable buildings occupant behaviour due to Covid-19
  - delay in the retrofit works
  - faults of components
  - control strategy optimization
  - Delta between reference and actual weather conditions
  - non-continuos availability of reliable monitoring data.
- The method used for the post-retrofit assessment can be summarized with the following Steps:
  1. analysis of the technical drawings and specification about the actual retrofit (e.g. water loops, energy generation systems);
  2. creation of a detailed and accurate **model of the as-built retrofitted** heating and cooling system for the energy performance evaluation;
  3. **tune the components** of the aforementioned model with the **monitoring data available**
  4. evaluate the performance of the retrofitted system for a **typical year** and in **reference condition**.

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H4C packages description

Packages	Where
1. Solar **H**eating **C**ooling system **SHC system**	*@ Valencia*
2. Waste **W**ater **H**eat **E**xchanger, **E**lectric **H**eat **P**ump for **D**istrict **H**eating and **C**ooling system **WW-HX + EHP for DHC system**	*@ Budapest*
3. Photo**V**oltaic system, **E**lectric **H**eat **P**ump and **P**hase **C**hange **M**aterial **H**eat **B**atteries **PV, EHP and PCM HB system**	*@ Chorzow and Sofia* *(but it was not possible to perform the post-retrofit assessment for the Sofia pilot site due to lack of monitoring data)*

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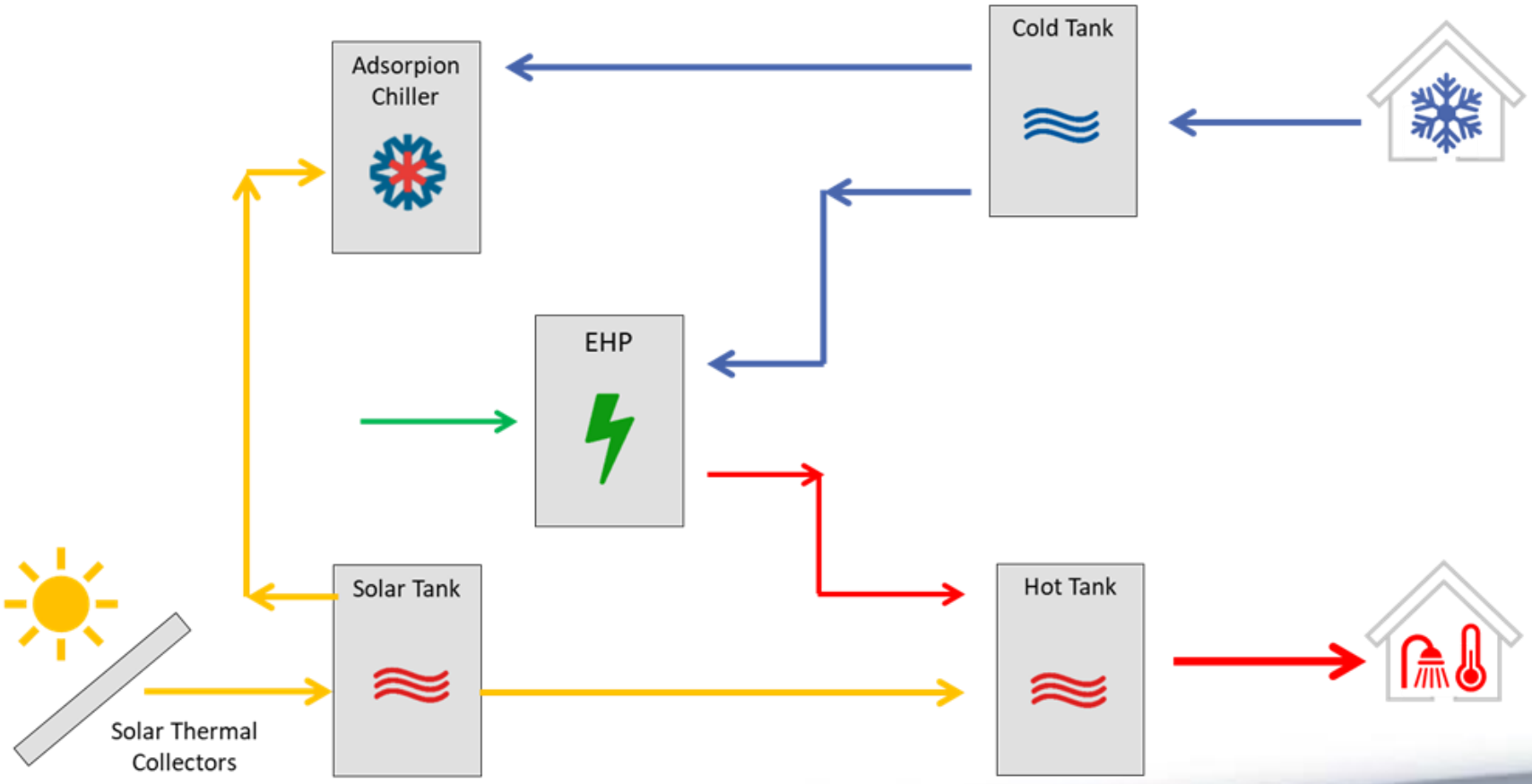
SHC system @Valencia

Energy system scheme



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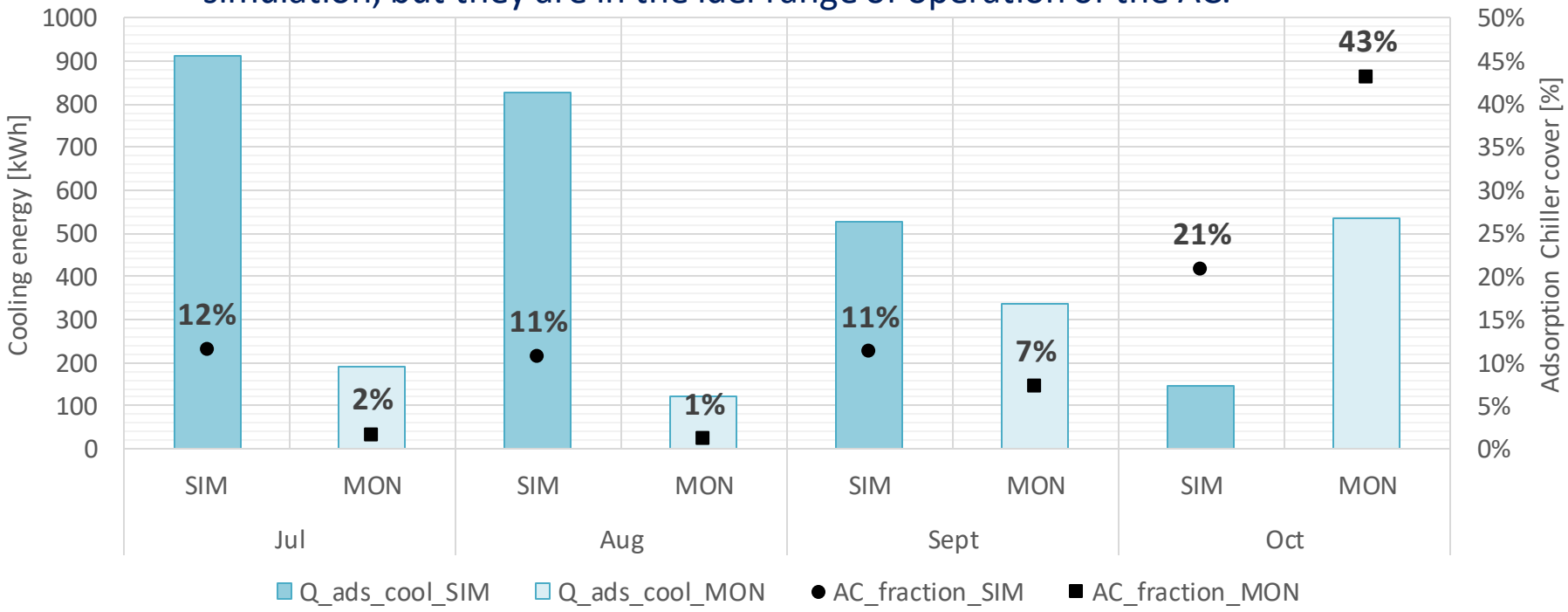
SHC system @Valencia

Adsorption chiller – Operation issues and cooling energy need cover

- July 2020: problem with the energy meter which has been substituted
- August 2020: one of the three electric chiller stopped working thus the adsorption chiller was turned off + very high external temperatures
- September 2020: some issues on a three way valve
- October 2020: the temperatures recorded in this month are higher than the simulation, but they are in the idel range of operation of the AC.



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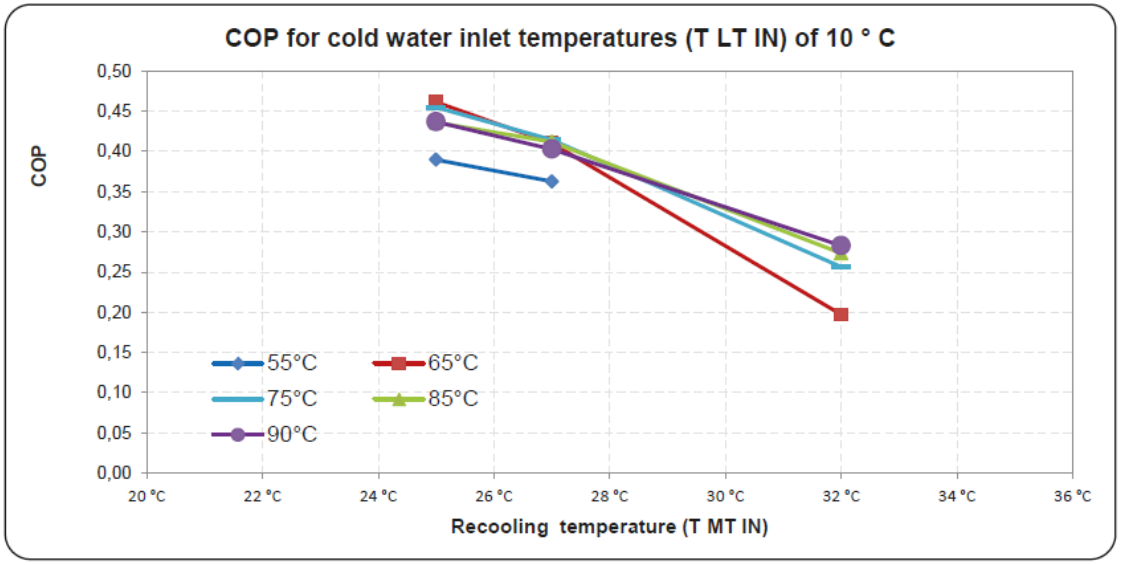
SHC system @Valencia

Adsorption chiller performance



← **Datasheet performance map**

Monitoring data

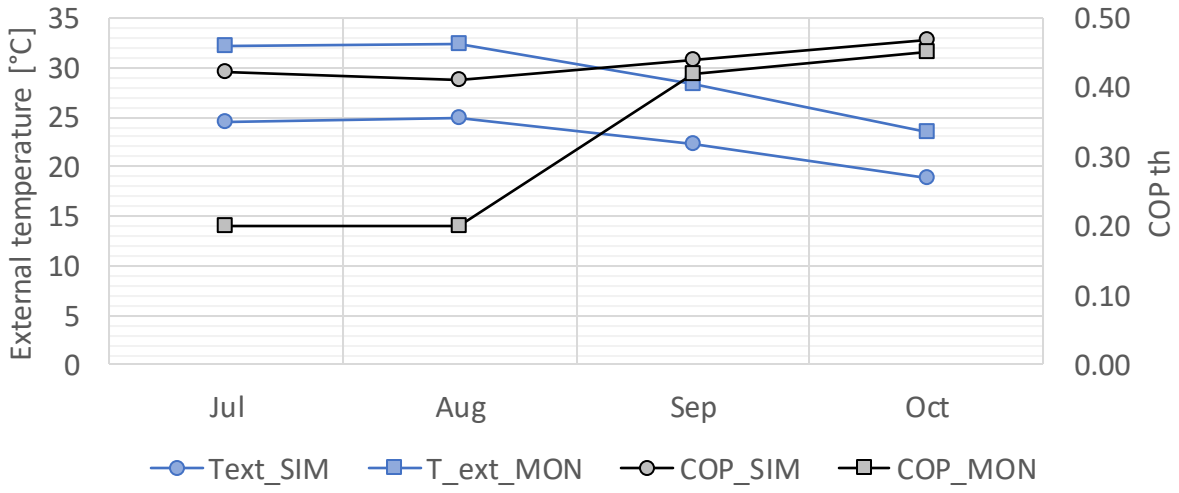
↓

COPth max = 0.45

Text = 23°C

COPth min = 0.20

Text = 32°C



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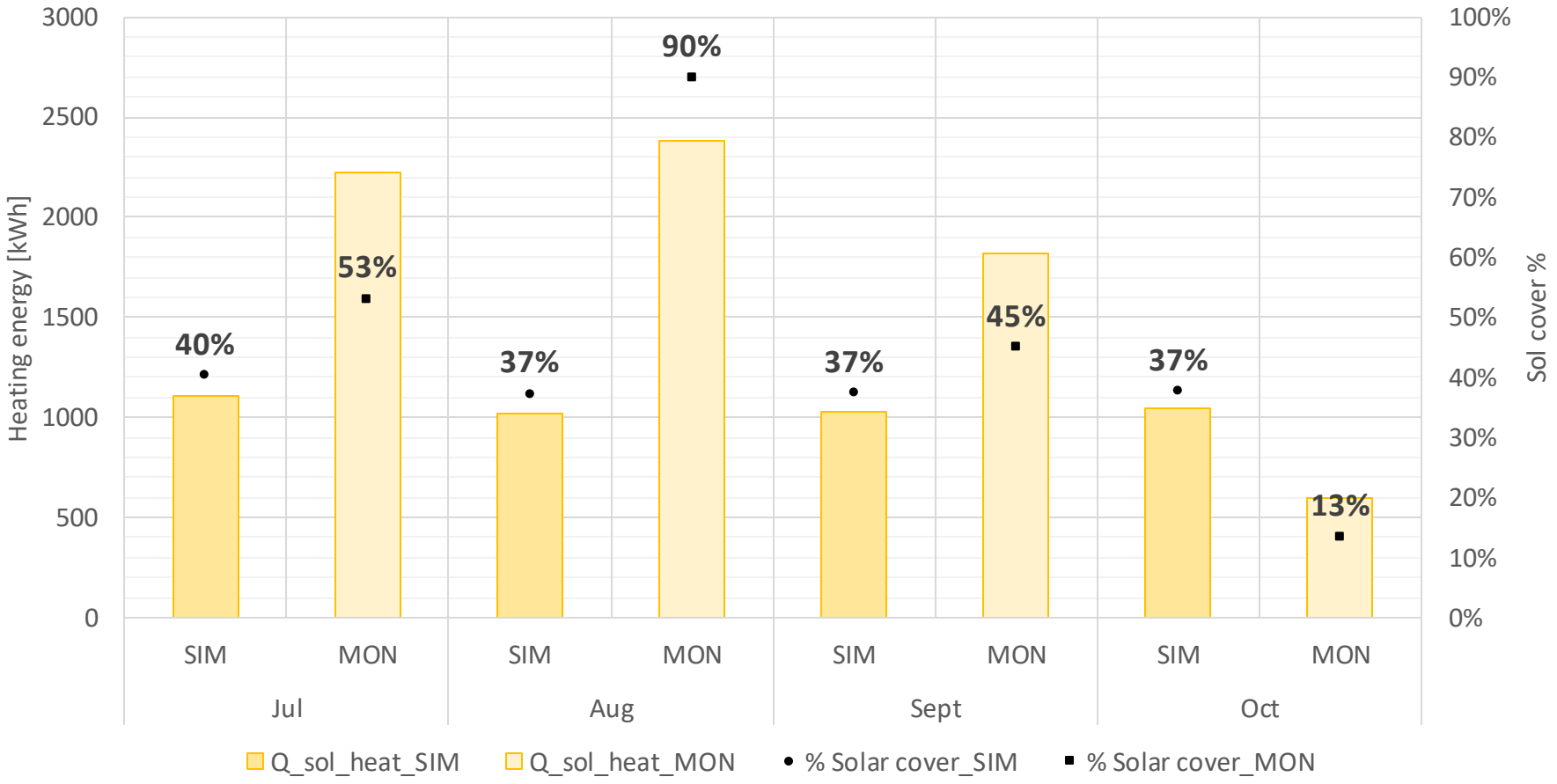
SHC system @Valencia

Solar thermal collectors system – DHW energy need cover



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SHC system @Valencia

Baseline:

Boiler_eff = 0.80

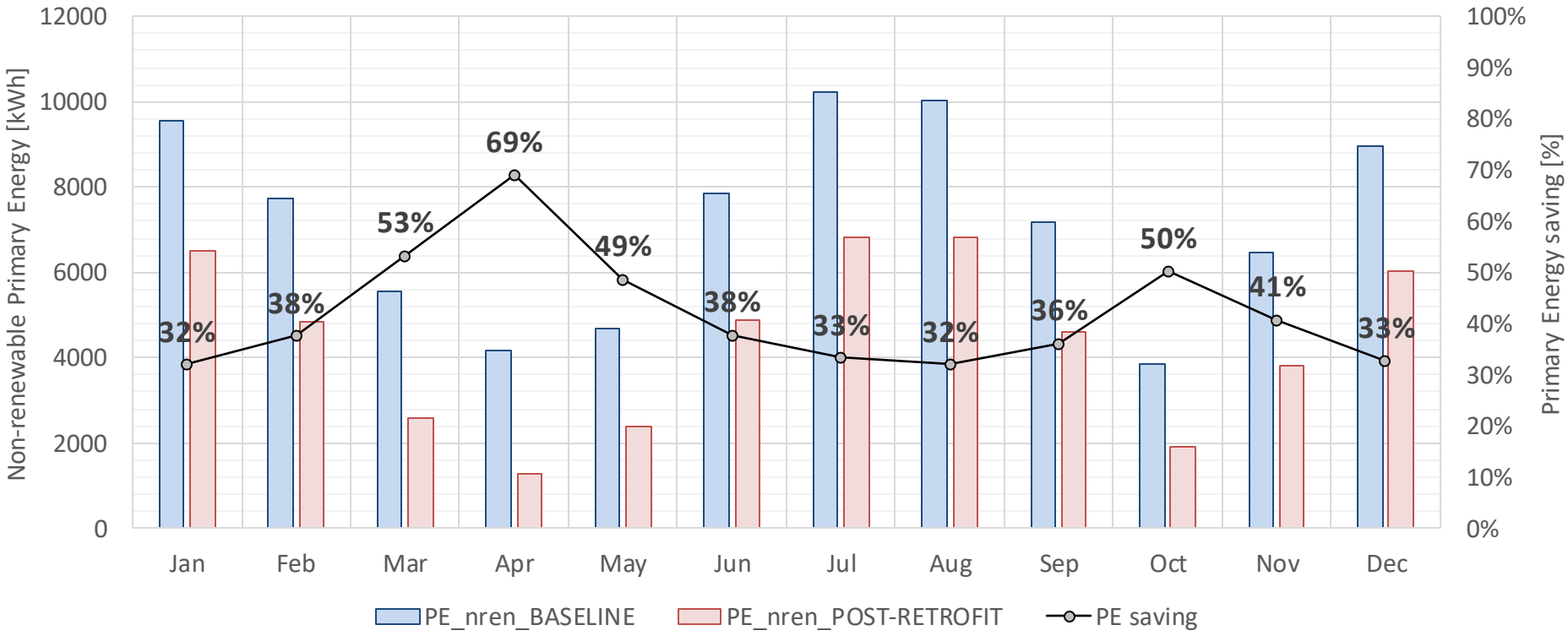
Split_EER = 2.7

Primary Energy factors (EN ISO 52000):

f_PE_ele_nren = 2.30

f_PE_gas_nren = 1.10

Annual Primary Energy saving: 39%



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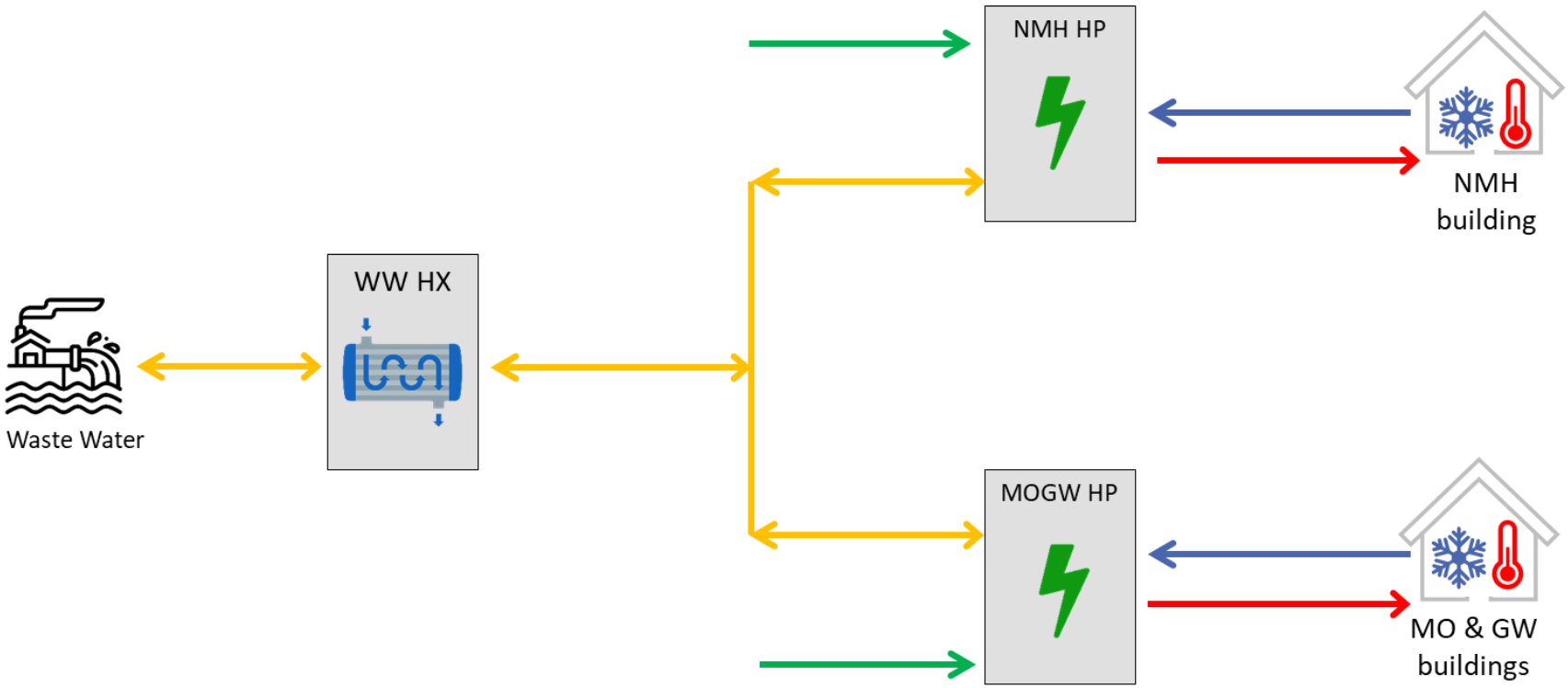
WW-HX, EHP for DHC system @Budapest

Energy system scheme



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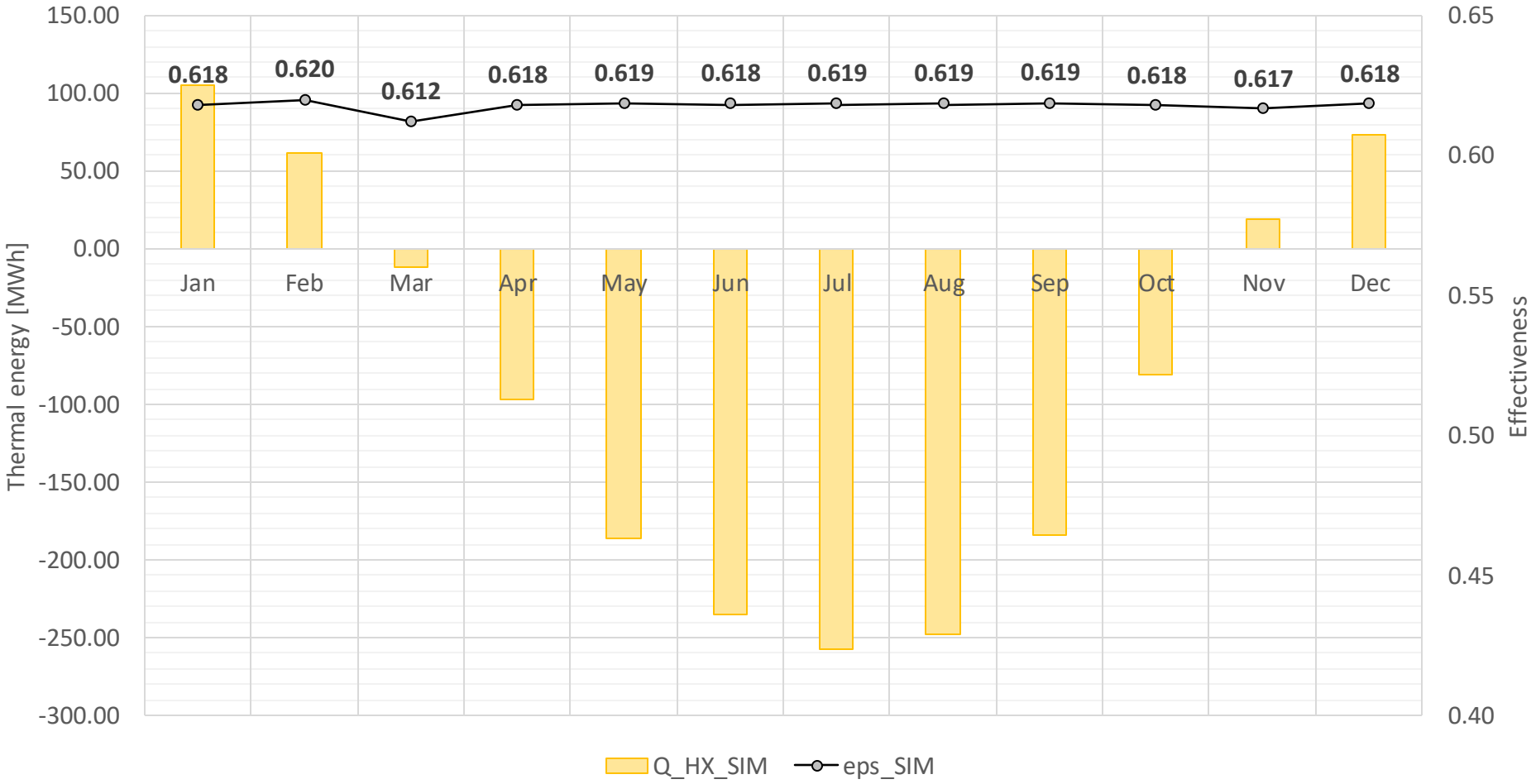
WW-HX, EHP for DHC system @Budapest

WW Heat Exchangers – Monthly energy exchanged and HX effectiveness



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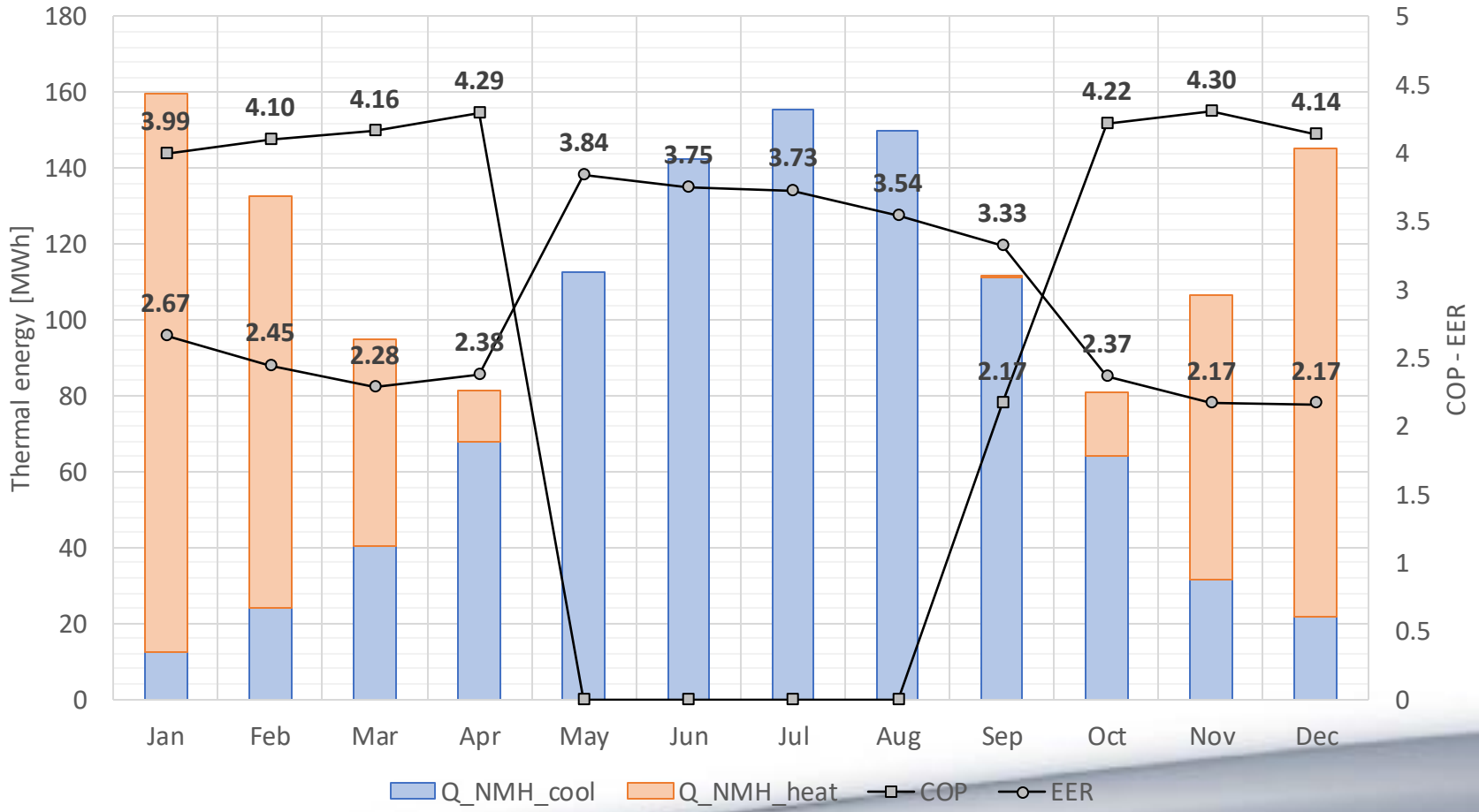
WW-HX, EHP for DHC system @Budapest

NMH Heat Pump – Heating and cooling energy production and efficiency (COP and EER)



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WW-HX, EHP for DHC system @Budapest

Baseline:

Boiler_eff = 0.80

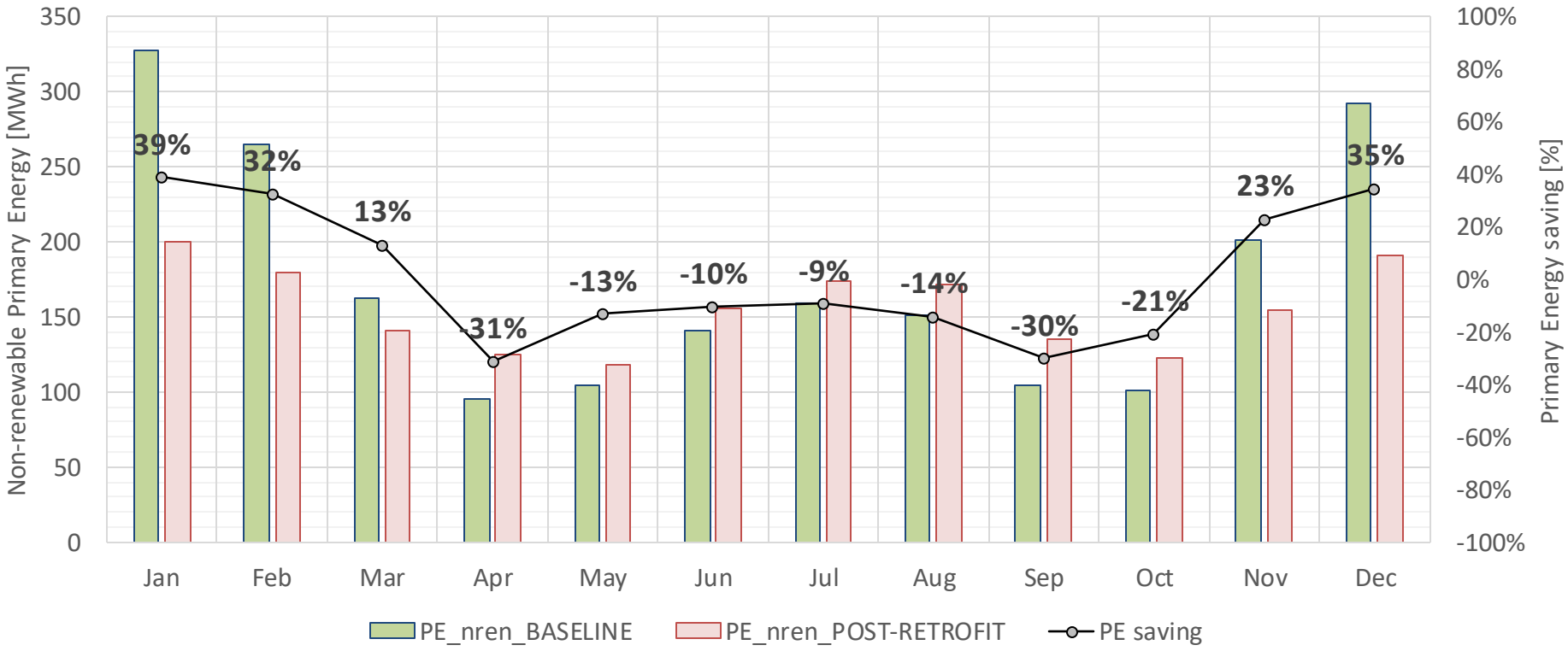
Split_EER = 2.7

Primary Energy factors (EN ISO 52000):

f_PE_ele_nren = 2.30

f_PE_gas_nren = 1.10

Annual Primary Energy saving: 11%



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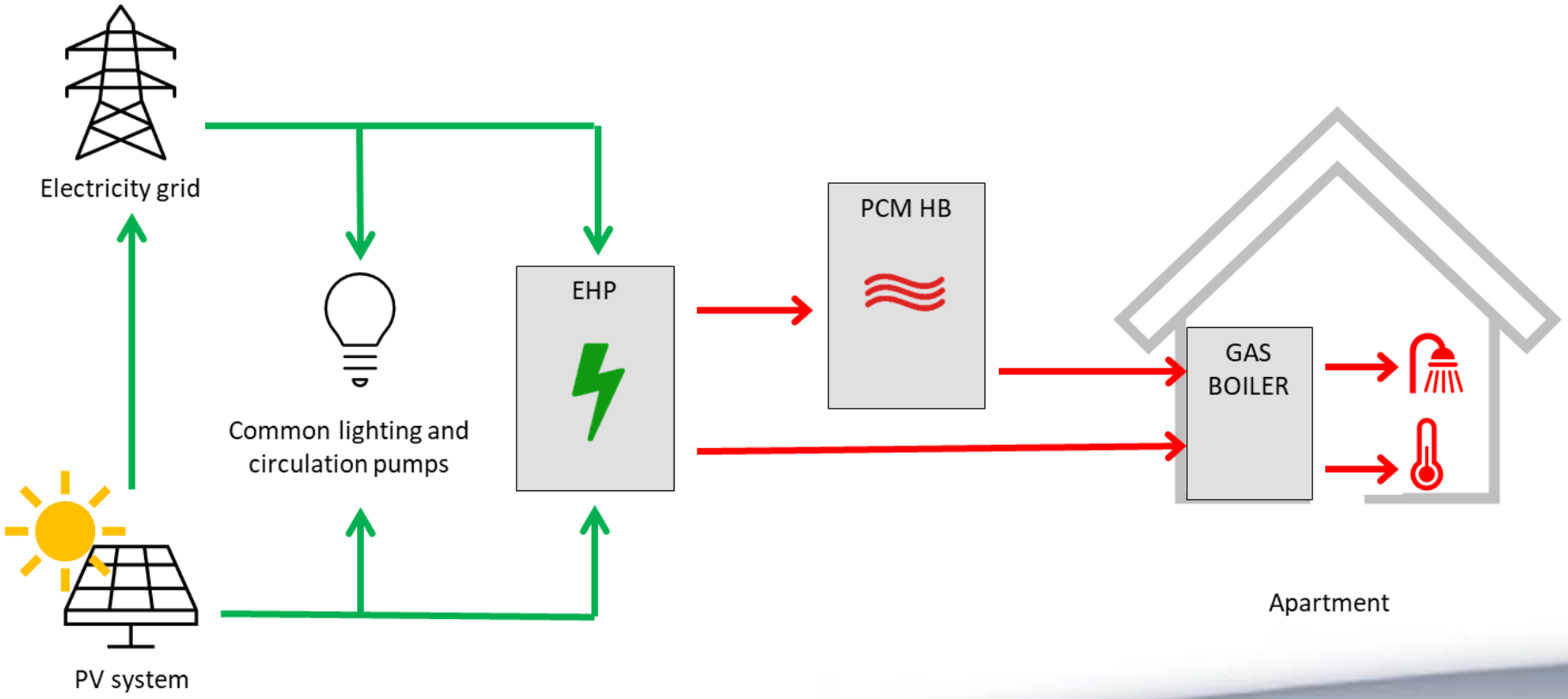
PV, EHP and PCM HB system @Chorzow

Energy system scheme



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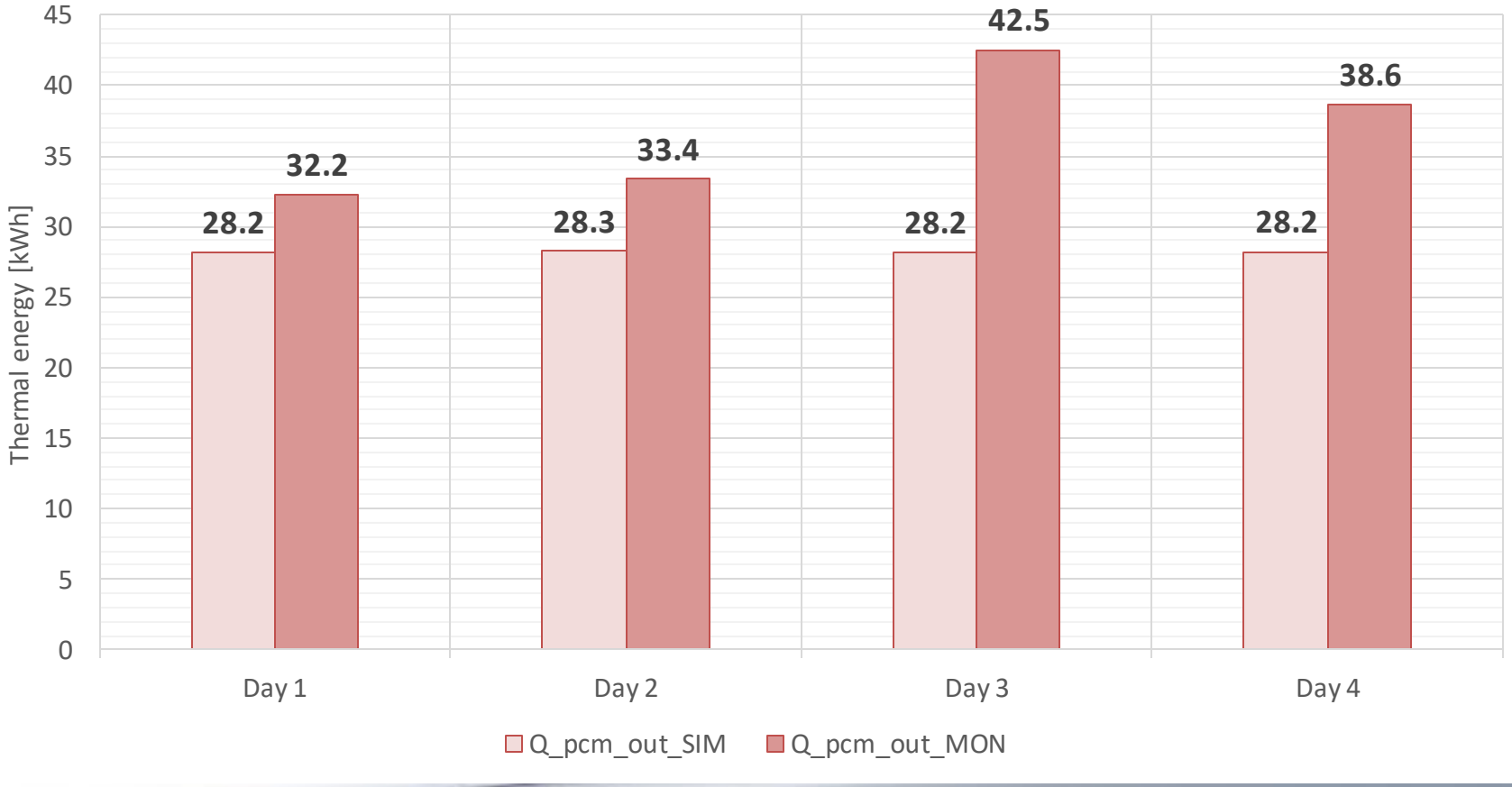
PV, EHP and PCM HB system @Chorzow

PCM heat batteries - Charging / discharging energy and efficiency

- Simulation = 80%
- Monitoring = 83%



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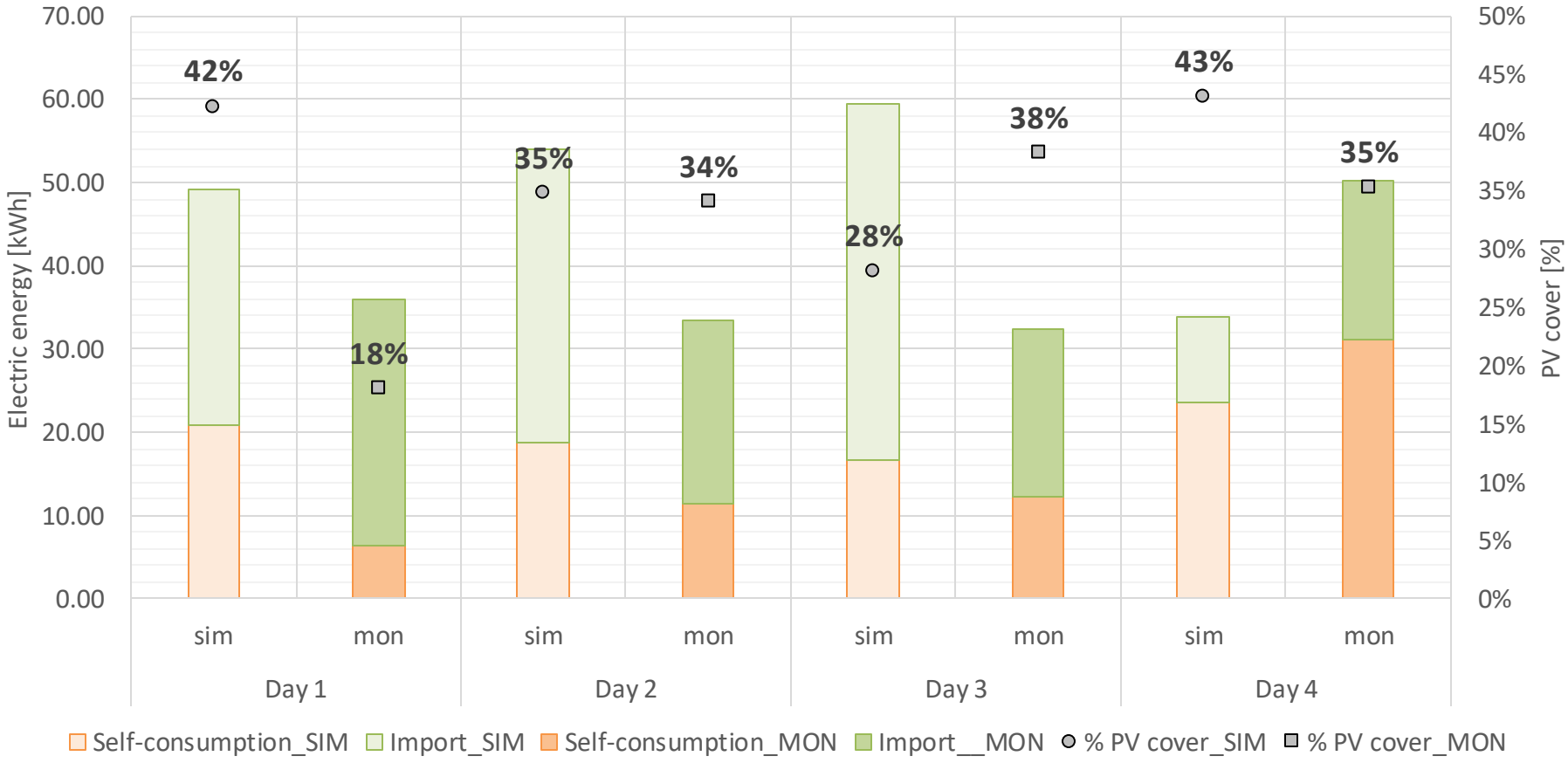
PV, EHP and PCM HB system @Chorzow

PhotoVoltaic system – Self consumption and import electric energy

(monitored data do not includes EHP electricity consumption)



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PV, EHP and PCM HB system @Chorzow

Baseline:

Boiler_eff = 0.80

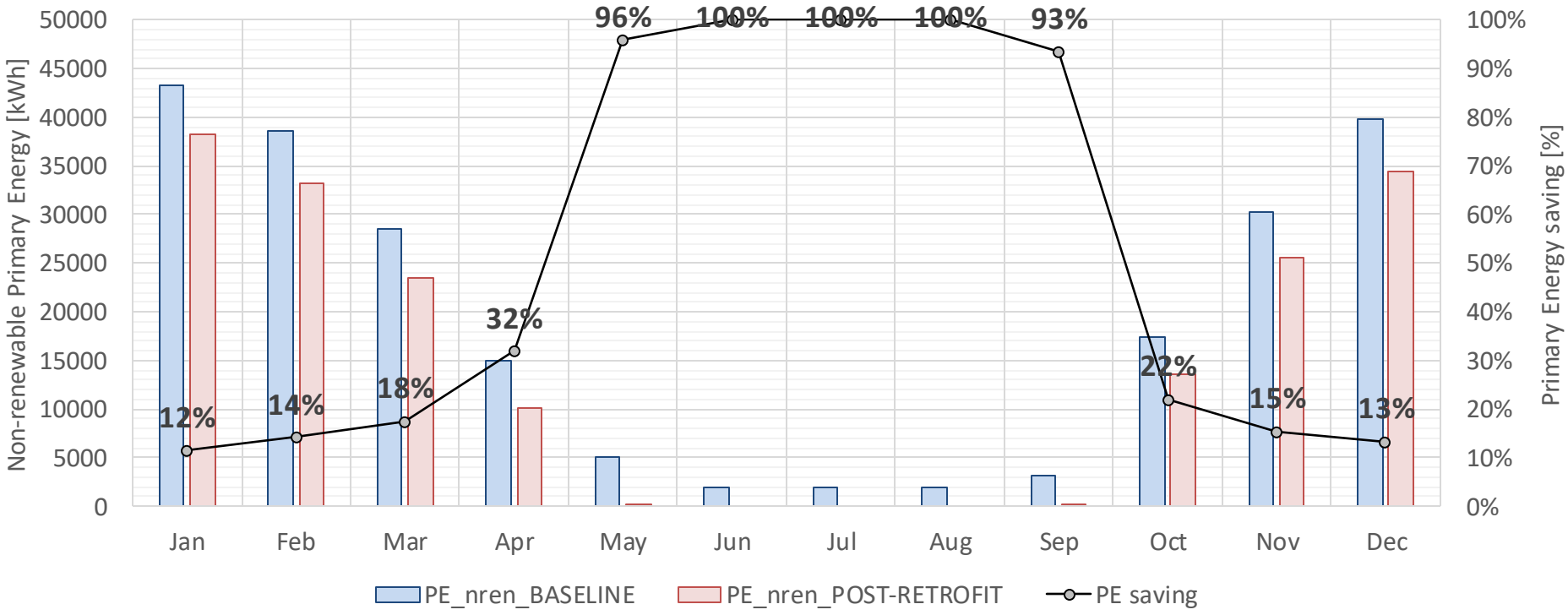
Split_EER = 2.7

Primary Energy factors (EN ISO 52000):

f_PE_ele_nren = 2.30

f_PE_gas_nren = 1.10

Annual Primary Energy saving: 21%



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Conclusions

SHC system – Valencia

- Solar thermal Collectors system: Solar Fraction ≥ 50% during summer months
- Adsorption Chiller: cooling energy cover ≥ 10%
- Annual Primary Energy saving: 39%

WW-HX, EHP for DHC system – Budapest

- Exemplary installation of DHC system in Eastern Europe
- Example of electrification of energy systems in Eastern Europe cities
- Annual Primary Energy saving: 11%

PV, EHP and PCM HB system – Chorzow

- DHW energy supplied by PCM Heat Batteries: 62%
- Electricity demand supplied by PV system: 20%
- Annual Primary Energy saving: 21%

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Thank you

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