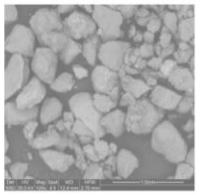
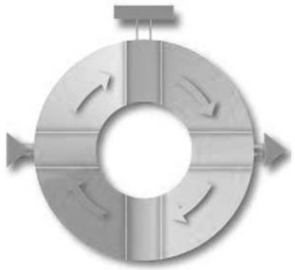
CLIMATIZZAZIONE, FER E MATERIALI A CAMBIO DI FASE

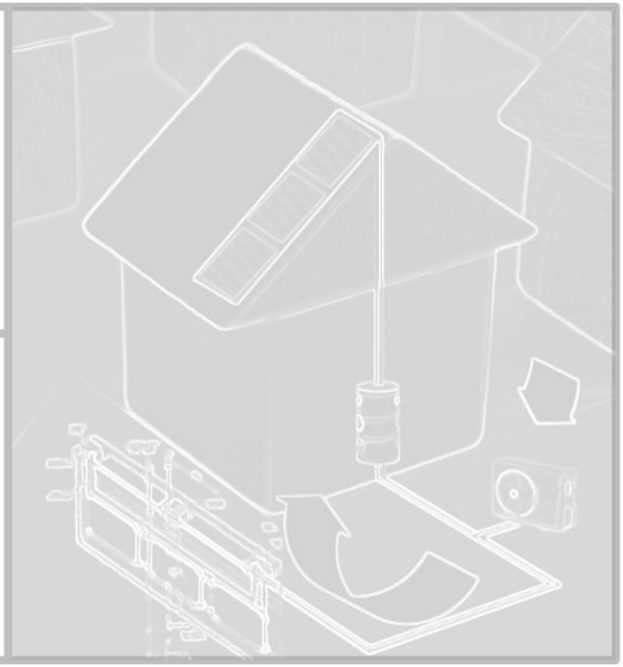
14 dicembre 2021

Geotermia e PCM

- motivazioni dell'accoppiamento
- impianto sperimentale
- risultanze sperimentali







Michele Bottarelli

TekneHub

Università degli Studi di Ferrara

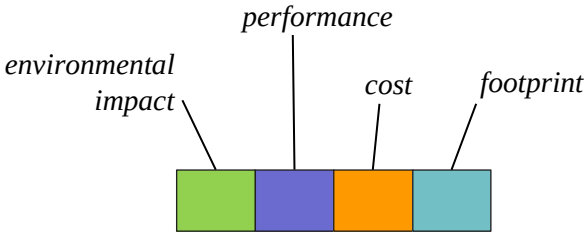
POR FESR EMILIA-ROMAGNA 2014/2020

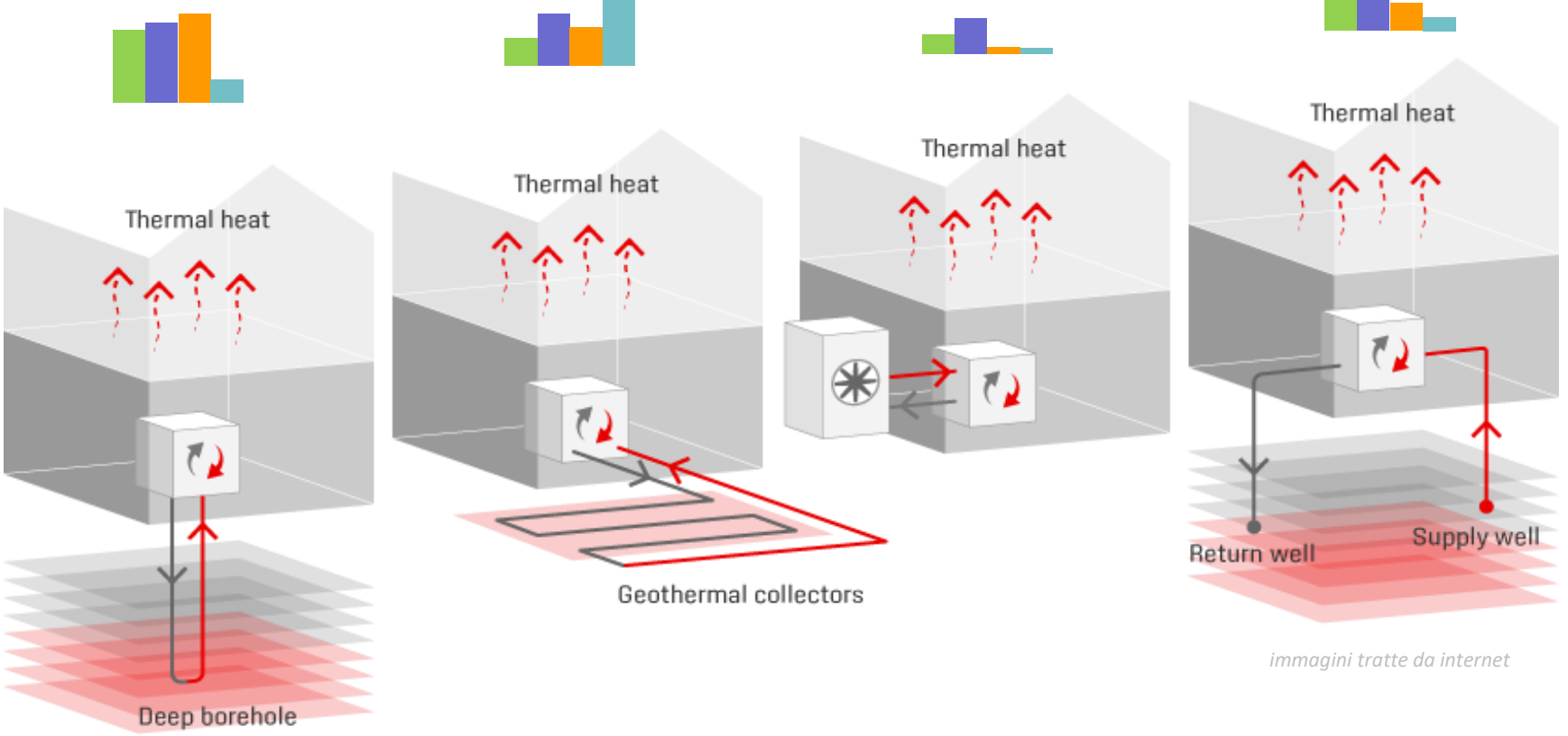
UNIONE EUROPEA

FSC Fondo per lo Sviluppo e la Coesione

RegioneEmilia-Romagna

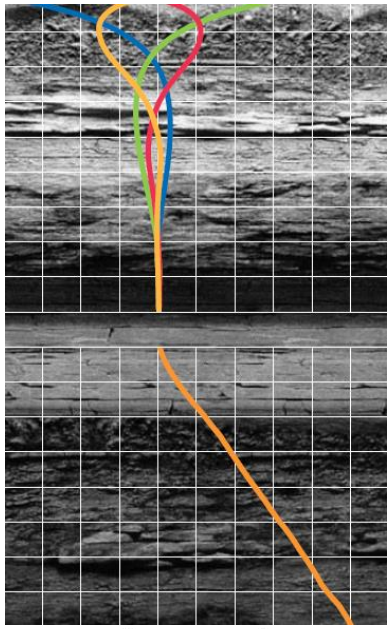
Air, ground or water?



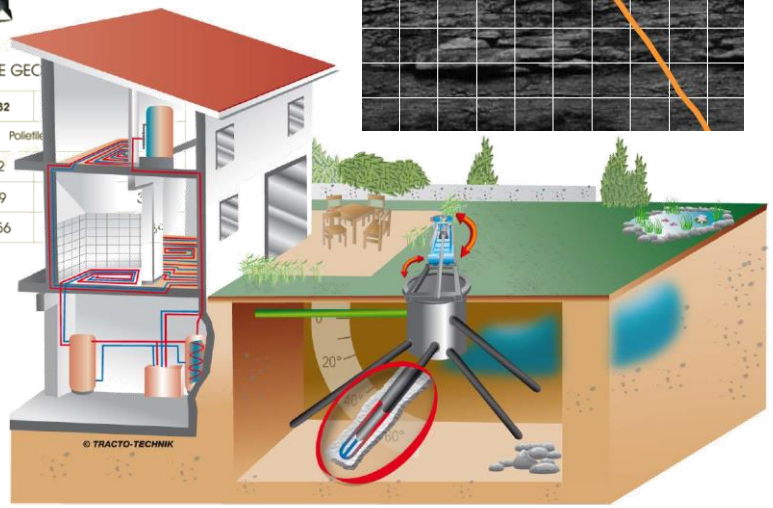


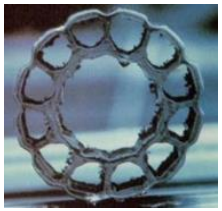
immagini tratte da internet

Scambiatori geotermici verticali (VGHE)



10 m



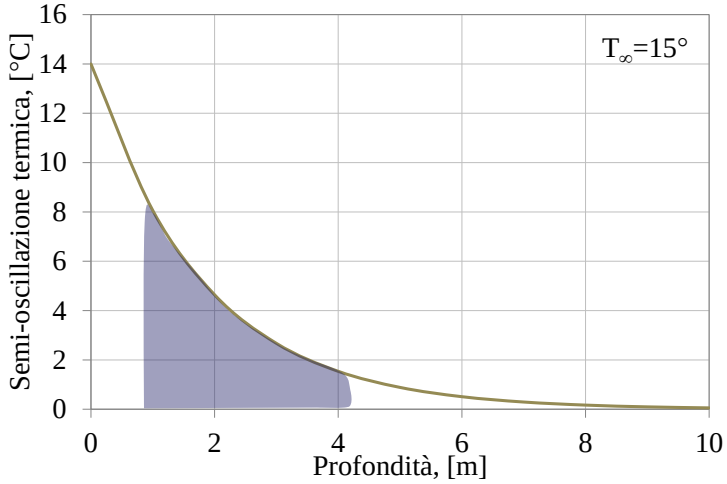


immagini tratte da internet

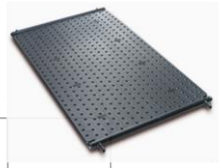
Scambiatori geotermici orizzontali (HGHE)

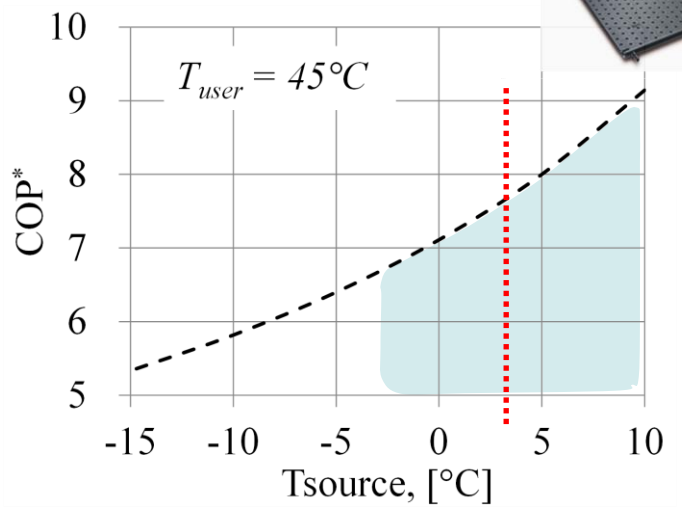
immagini tratte da internet

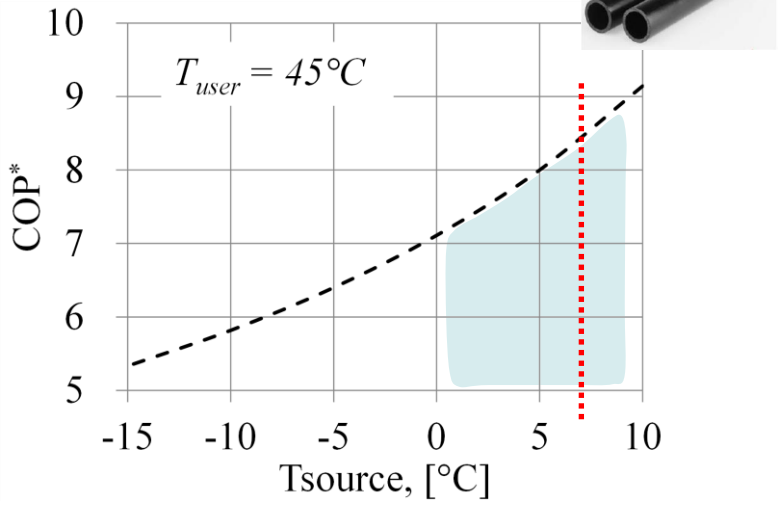
Brevetto Italiano n.0001401414
European Patent EP 2 418 439 A2



HGHE vs. VGHE







$$COP^* = \frac{T_{user}}{T_{user} - T_{source}}$$

	HGHE	VGHE
Energy performance	😐	☺
Building cost	☺	😐
Equipment	☺	😐
Maintenance	😐	☹
Permission	☺	😐
Soil use restriction	😐	☺
GW contaminant risk	☺	😐
Thermal drift	☺	😐
Design	😐	😐

UNI 11466

NORMA ITALIANA

Sistemi geotermici a pompa di calore
Requisiti per il dimensionamento e la progettazione

UNI 11466

NOVEMBRE 2012

Heat pump geothermal systems
Design and sizing requirements

La norma definisce i criteri di progettazione e le procedure di calcolo per la determinazione delle prestazioni di progetto degli impianti a pompa di calore geotermica. La norma inoltre permette di determinare le temperature medie mensili del fluido termovettore lato terreno che servono per determinare le prestazioni energetiche delle pompe di calore ai fini della certificazione energetica degli edifici.
La norma si applica agli impianti geotermici a pompa di calore con fluido secondario utilizzati per la climatizzazione invernale ed estiva e per la produzione di acqua calda sanitaria mediante scambio di calore con il terreno.

Il metodo ripropone l'approccio ASHRAE con alcune variazioni.

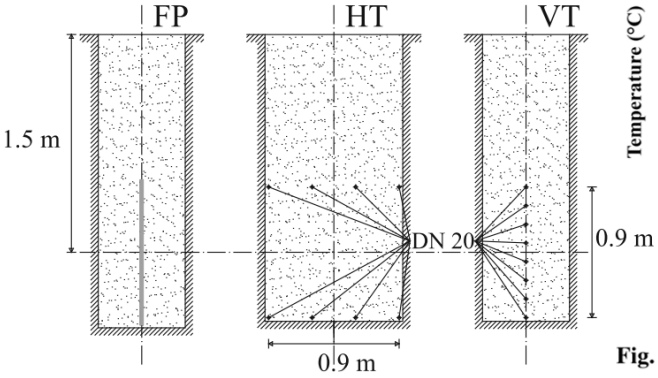
$$L_h = \frac{\dot{Q}_a \times R_{ga} + \dot{Q}_{g,h_D} \times [R_b + (PLF_{m,h_D} \times R_{gm}) + (R_{gd} \times F_{sc})]}{\theta_g - \left(\frac{\theta_{wi} + \theta_{wo}}{2}\right)_{h_D} - \theta_p}$$

$$L_{h,p} = \frac{\dot{Q}_{g,h_D} \times (R_p + R_g \times P_m \times S_m \times F_h)}{\theta_{g,L} - \left(\frac{\theta_{wi} + \theta_{wo}}{2}\right)_{h_D}}$$

Ingersoll L.R., Zobel O.J., Ingersoll A.C. 1954. Heat conduction: with engineering and geological applications. McGraw-Hill Book Co, New York.
Kavanaugh S.P., Rafferty K. 1997. Ground source heat pumps-Design of geothermal systems for commercial and institutional buildings. ASHRAE. Applications Handbook.

EED
Geotermus
GHP Design 3D
EC714
GS2000
TRNSYS
COMSOL

Flat-Panel design



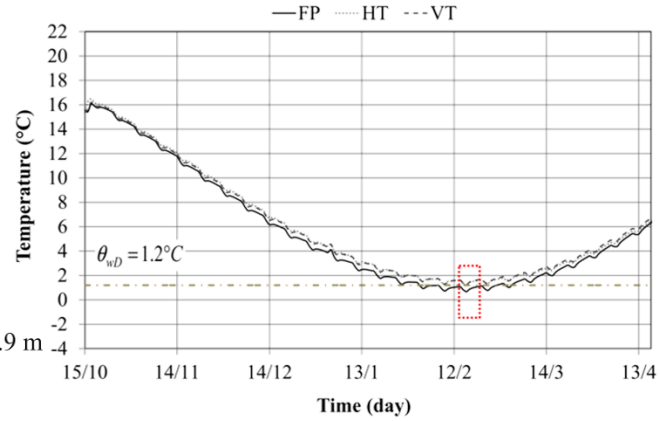


Fig. 6 Daily average temperature at the HGHE surface: 2,500 DD

Int J Energy Environ Eng (2015) 6:55–63
DOI 10.1007/s40095-014-0150-0

ORIGINAL RESEARCH

On the sizing of a flat-panel ground heat exchanger

Marco Bortoloni · Michele Bottarelli

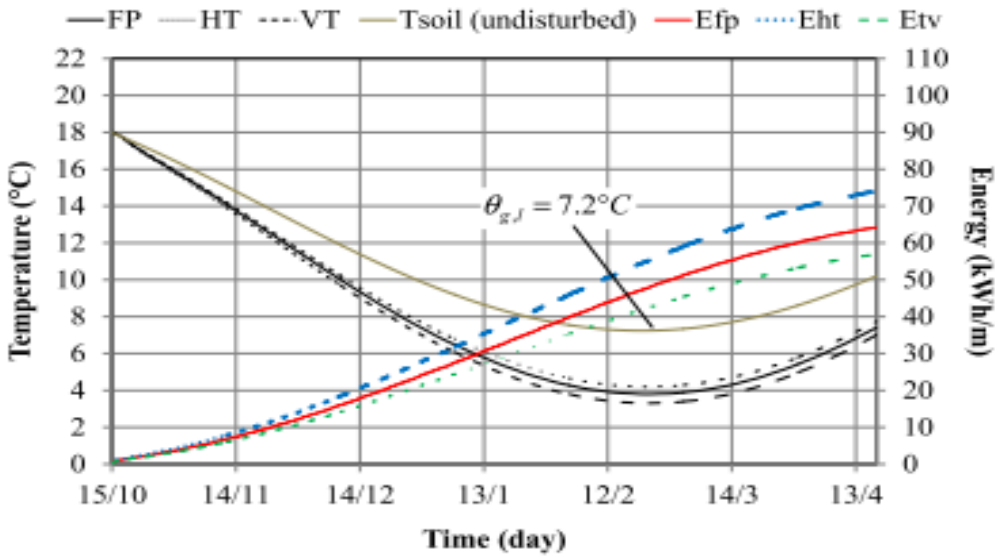
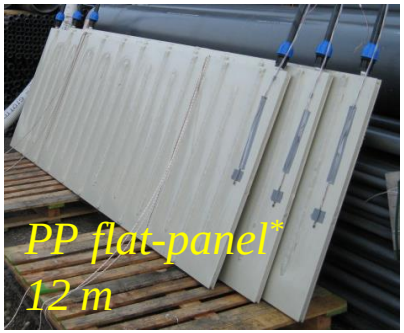


Fig. 12 Temperature of the ground (0; −1.5 m) and energy extracted by HGHEs at 2,500 DD

Comparison



Brevetto Italiano n.0001401414
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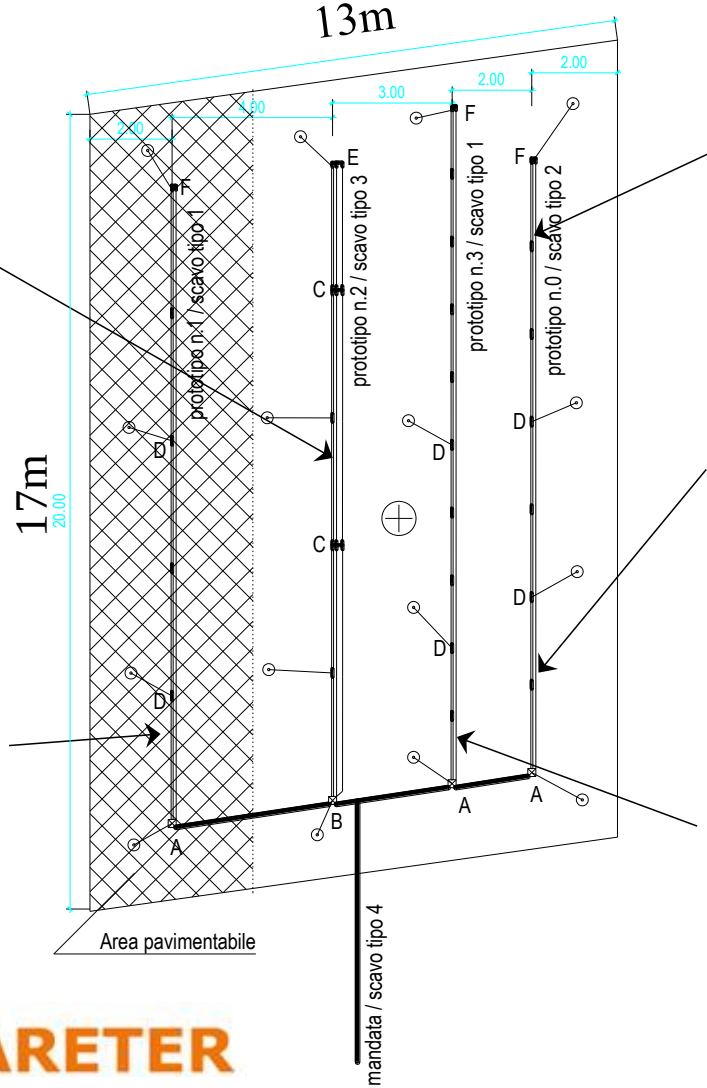
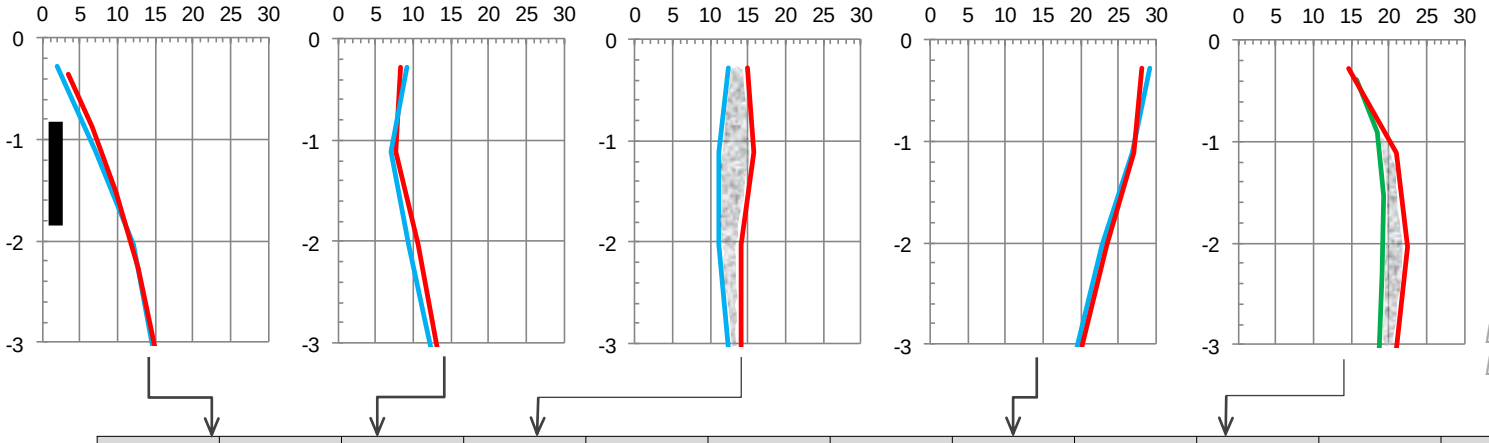
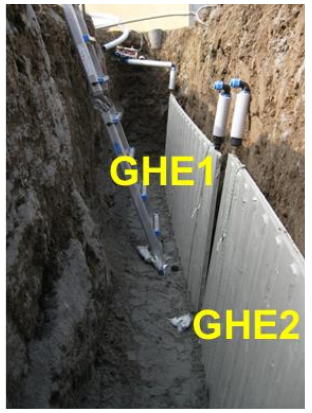


* Patent pending

Research funded by LARETER

Thermal drift



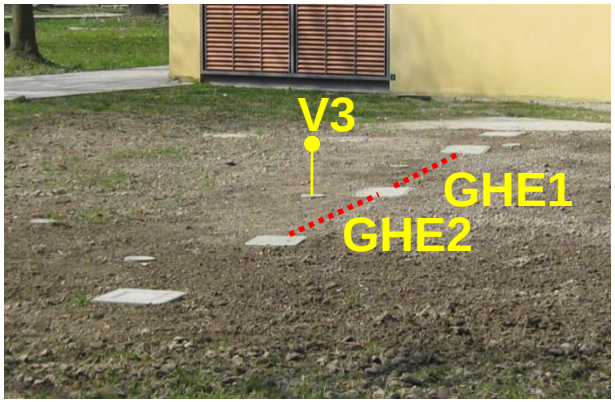


Brevetto Italiano n.0001401414
European Patent EP 2 418 439 A2

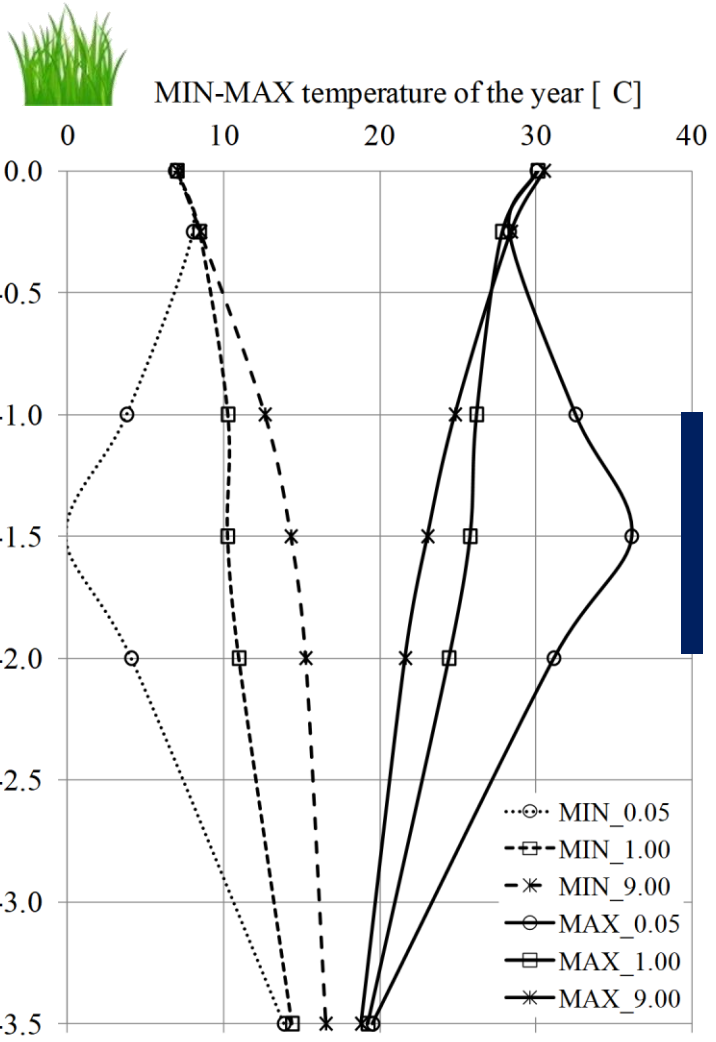
	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sept.	Oct.	Nov.	Dec.	
2010										X	X	X	
2011	X	X	X	X	X	X	X	X	X	X	X	X	+ 700 kWh
2012	X	X	X	X	X	X	X	X					- 300 / + 100 kWh

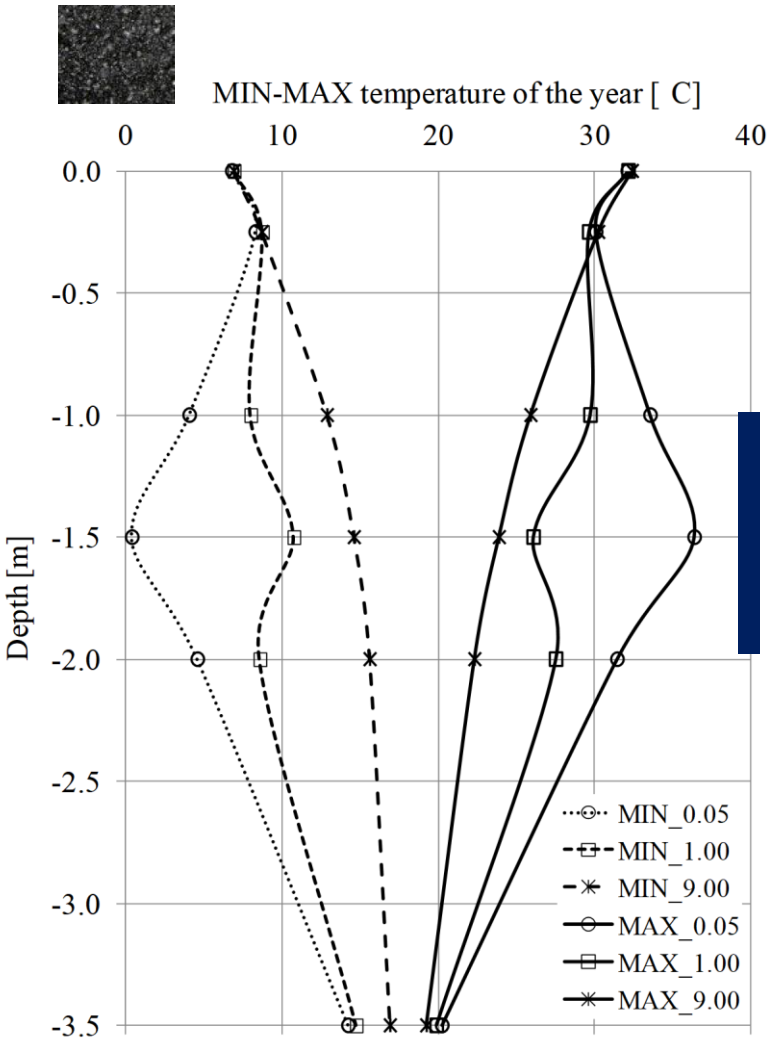
Unlike with the vertical systems, long-term subsurface thermal energy build-up or depletion do not happen with shallow GHEs.

The heat transfer over the soil surface seems to delete the memory of the energy exploitation carried out by FPs.



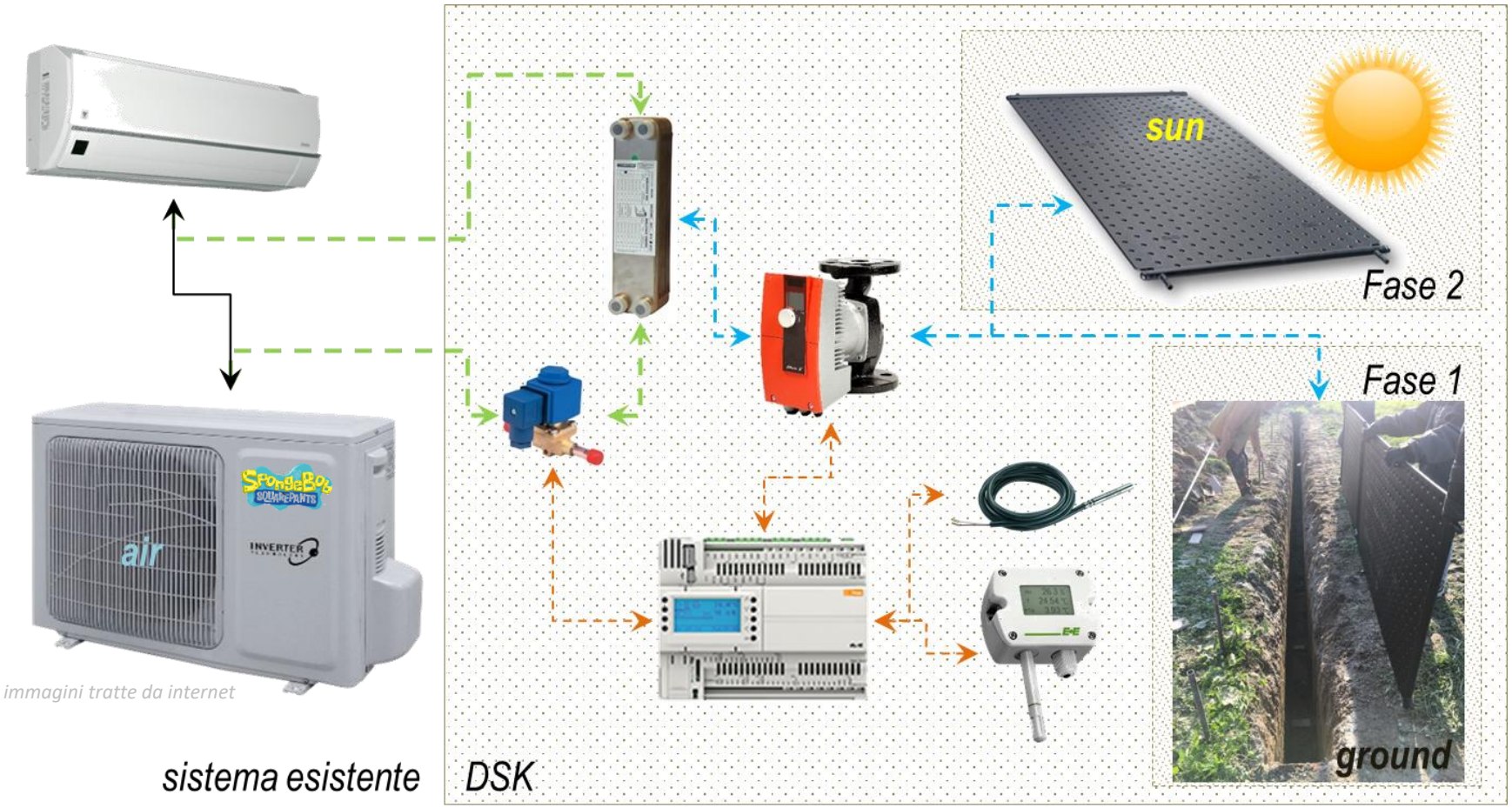
Soil finishing





DSK dual-source kit

http://www.hegos.cnainnovazione.net/



Control rule

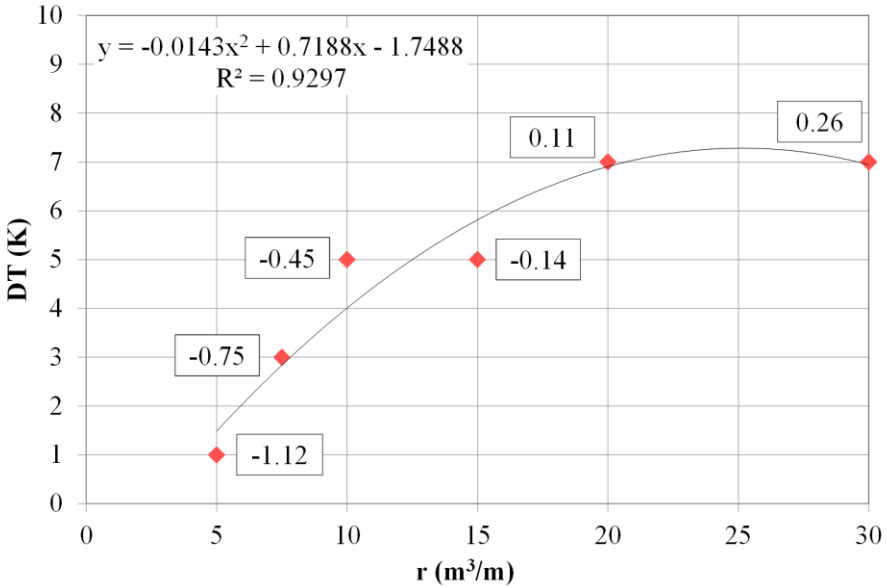
r (m^3/m)	L_{ratio} (-)	DT (K)						
		0	*1*	*2*	*3*	*5*	*7*	*10*
5	*1*	-1.12	**-1.12**	-1.12	-1.12	-1.08	-0.94	-0.59
7.5	*0.67*	-0.64	-0.67	-0.71	**-0.75**	-0.72	-0.63	-0.32
10	*0.5*	-0.27	-0.34	-0.40	-0.44	**-0.45**	-0.39	-0.15
15	*0.33*	0.17	0.06	-0.03	-0.07	**-0.14**	-0.10	0.14
20	*0.25*	0.41	0.29	0.21	0.15	0.12	**0.11**	0.23
30	*0.13*	0.65	0.53	0.43	0.37	0.30	**0.26**	0.29

*kWh_e / m*season*

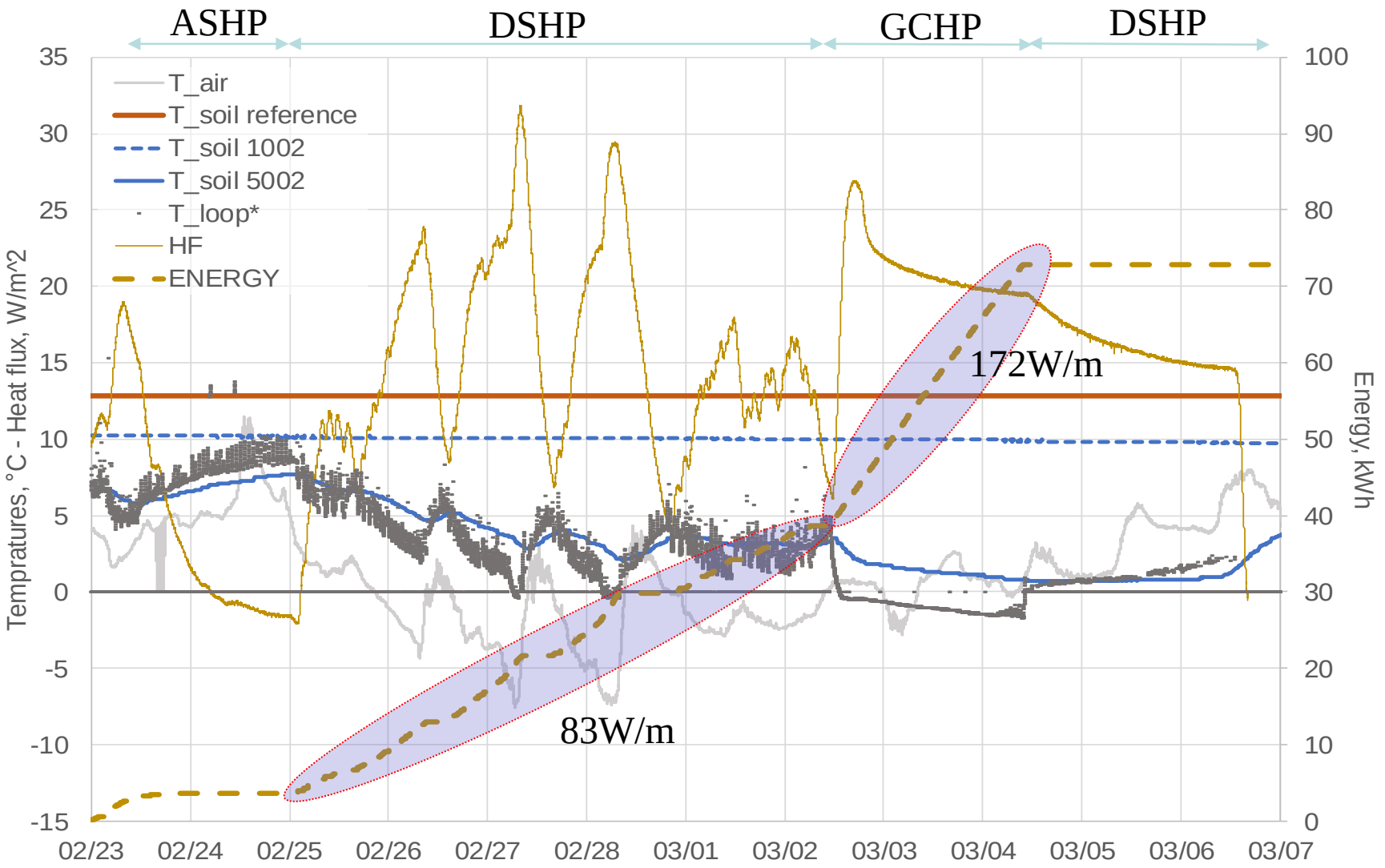
DSHP can be more profitable than GCHP for given *r* & *DT*

Unlike the unpretentious energy saving, DSHP can shorten drastically the length of the GHE.

The shorter the GHE length, the higher must be DT



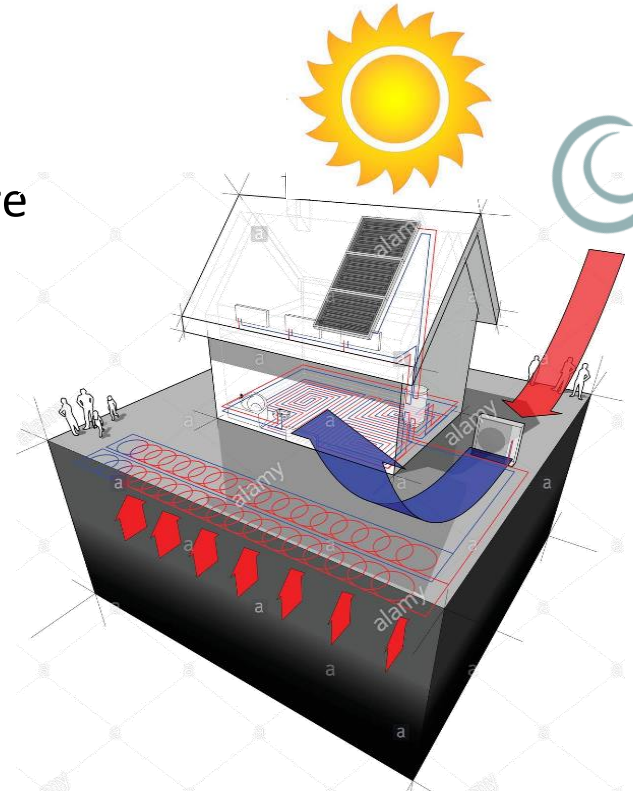
Phase change



Presupposti

L’accumulo termico consente:

- riduzione della potenza di picco del generatore
- migliori prestazioni
- risparmio energetico
- aumento della quota rinnovabile

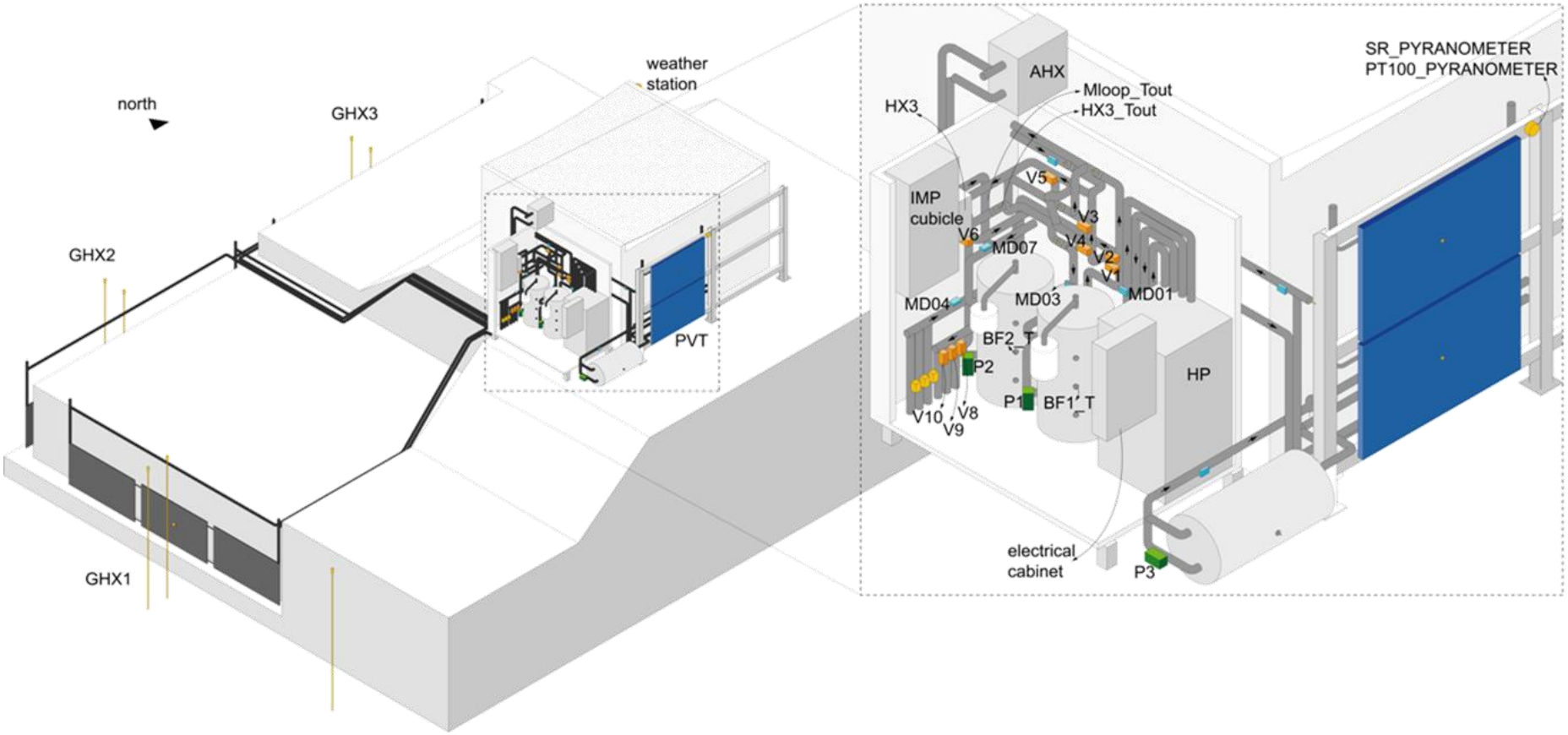


Assumendo il terreno come accumulo, integrare al calore sensibile il calore latente consente, a parità di dimensioni e alle temperature di cambio di fase, una maggiore densità energetica (1:5).

Proposta

Rinfianco di HGHEs tipo Flat-Panel con materiali a cambio di fase per incrementare la capacità di accumulo termico

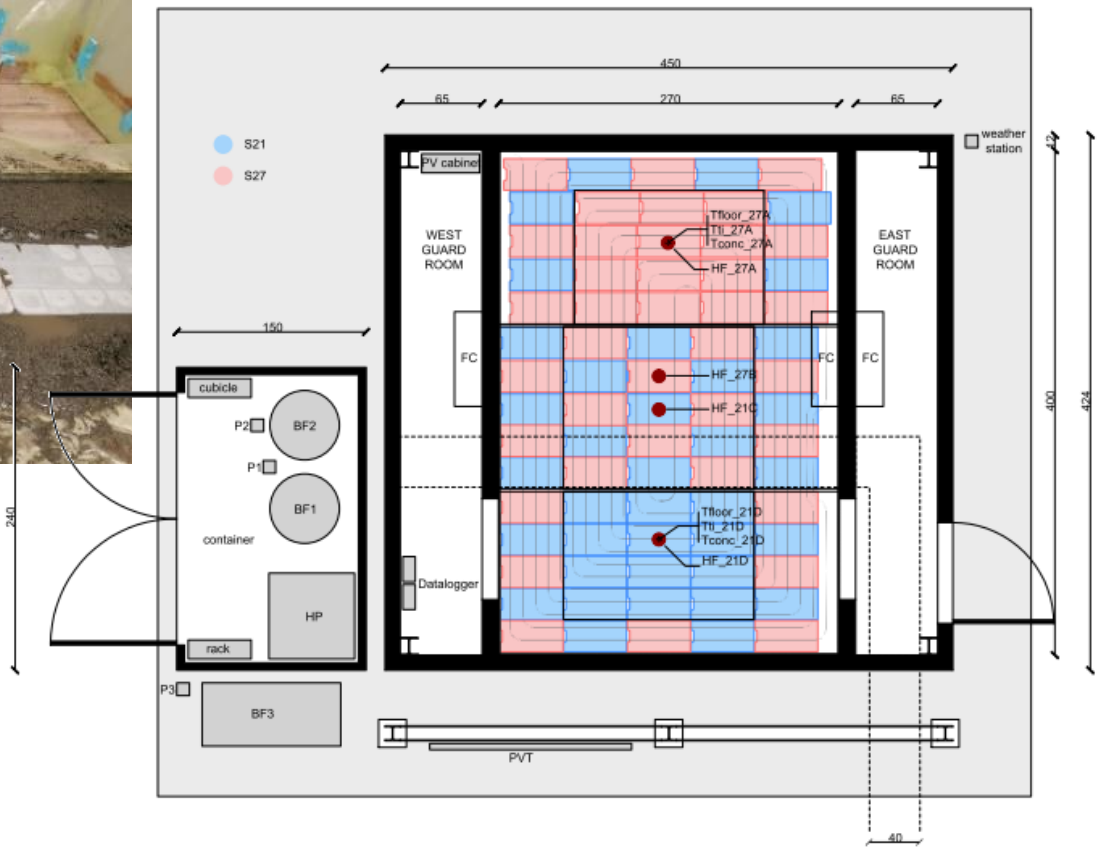
Sistema multisorgente IDEAS



Sistema multisorgente IDEAS

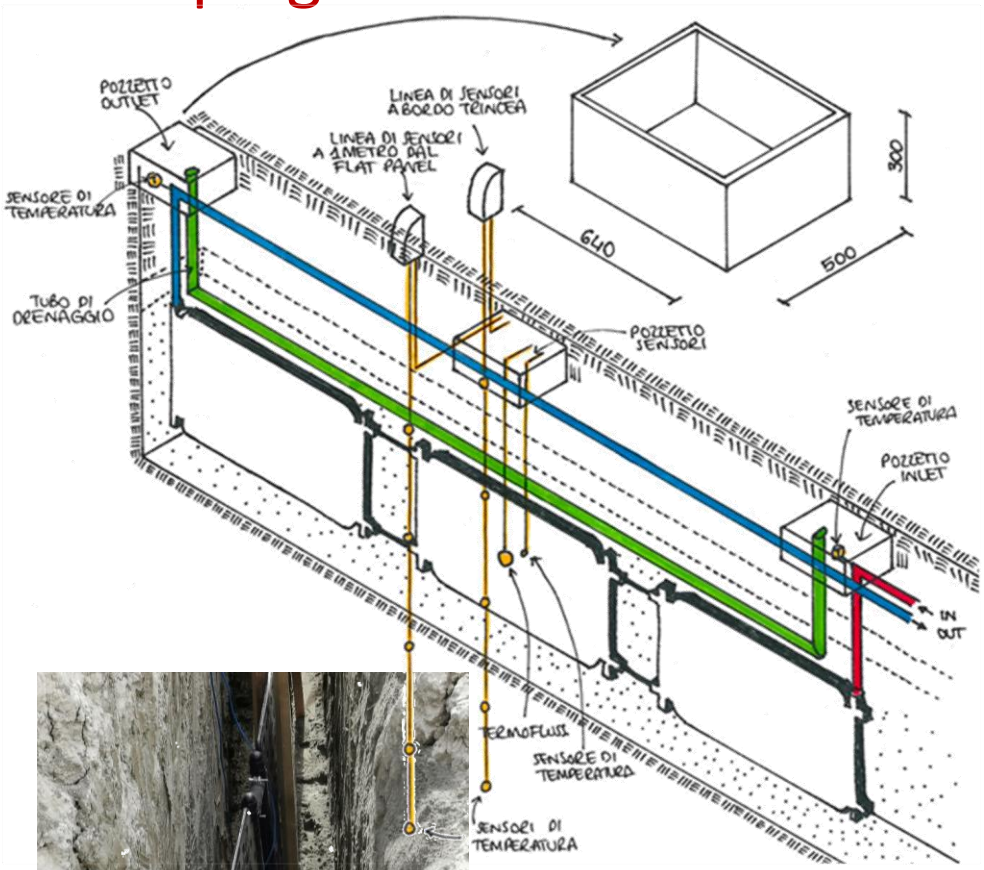
Sistema multisorgente IDEAS

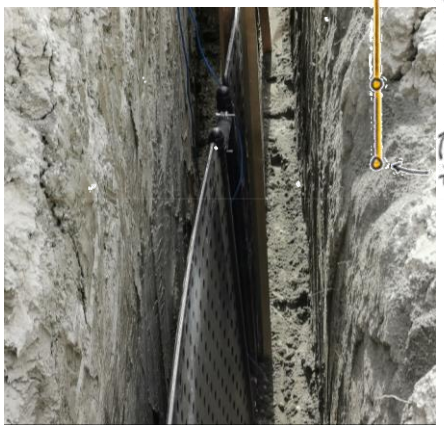
Pavimento radiante

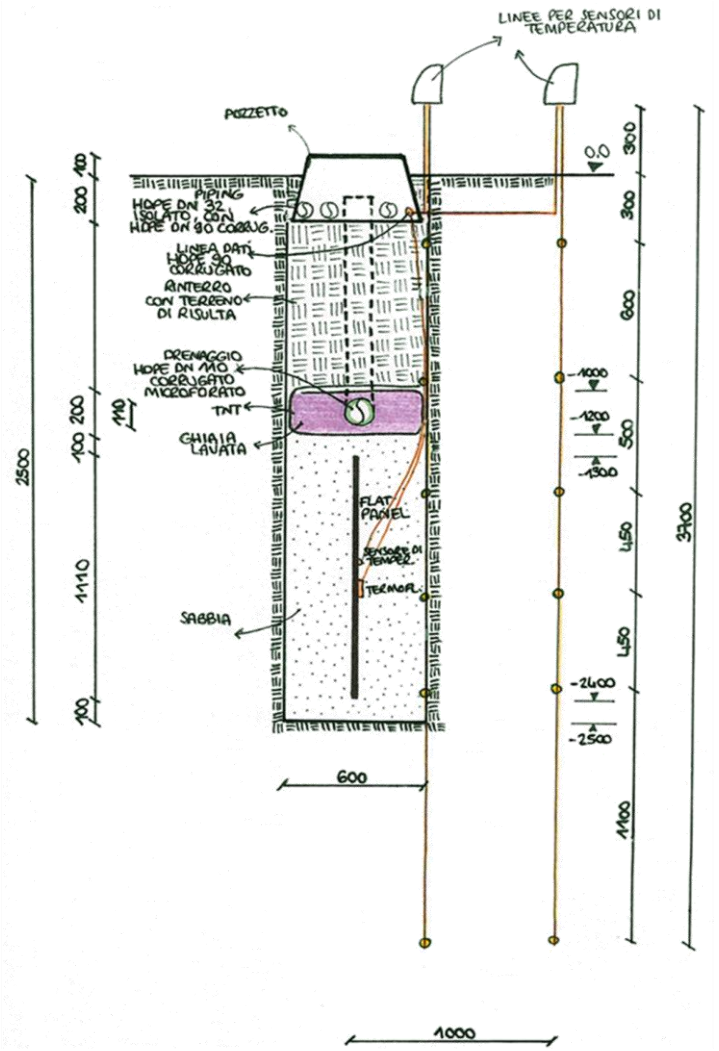


Campo geotermico

Campo geotermico







Rinfianco con sabbia-PCM (paraffine)

SAND:

Volume:	3.8 m^3
Mass:	6.1 t
$UTES_{dry}$ (10K):	61 MJ
$UTES_{wet}$ (10K):	136 MJ

	Heating	*Cooling*
Melting Point	8	27
PCM	A8	A27
Product	granule*	granule*
PCM mass	174 kg	89 kg
Product mass	348 kg	178 kg
UTES	31.3 MJ	22.3 MJ

** granules are supposed having 50% in mass of paraffin (PCM Products Ltd.)*

	summer	*winter*
PCM mass ratio	2.7%	5.7%
PCM UTES ratio	15.2%	21.4%

Rinfianco con container (sali idrati)

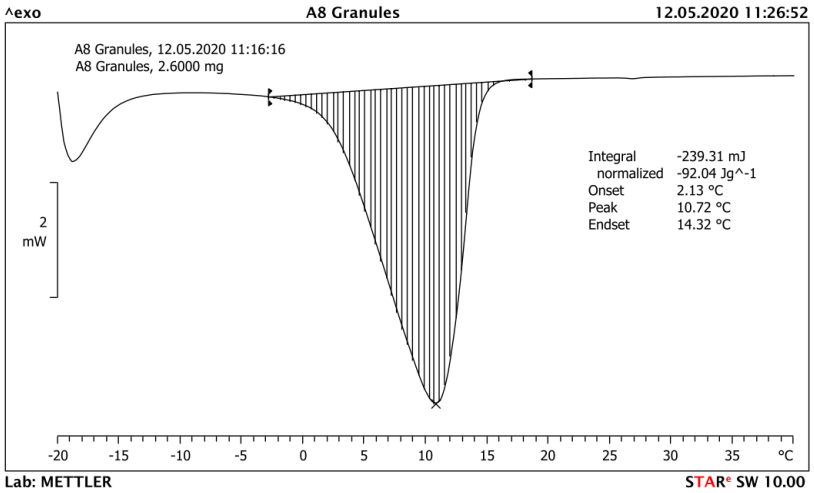
SAND:

Volume:	4.8 m^3
Mass:	7.7 t
$UTES_{dry}$ (10K):	77 MJ
$UTES_{wet}$ (10K):	147 MJ

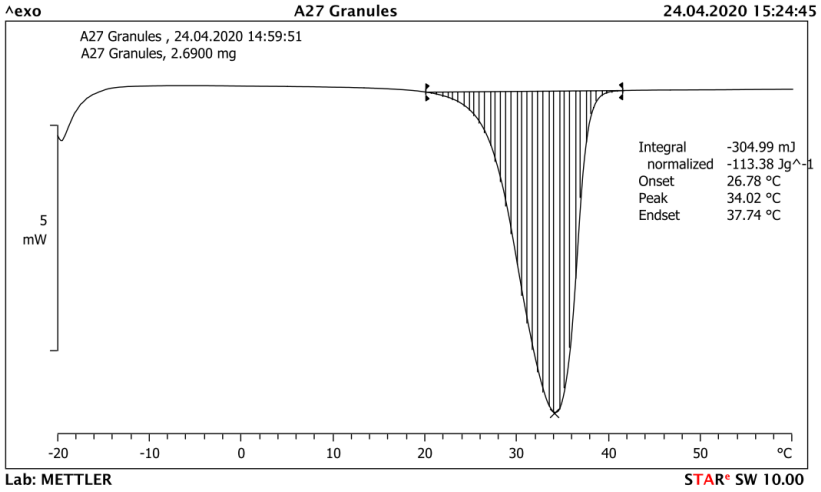
	Heating	*Cooling*
Melting Point	8	27
PCM	S8	S27
Product	TubeICE	TubeICE
Num. of Containers	112	56
PCM mass	241 kg	120 kg
UTES	31.3 MJ	22.3MJ

	summer	*winter*
PCM mass ratio	1.5%	2.9%
PCM UTES ratio	14.5%	20.3%

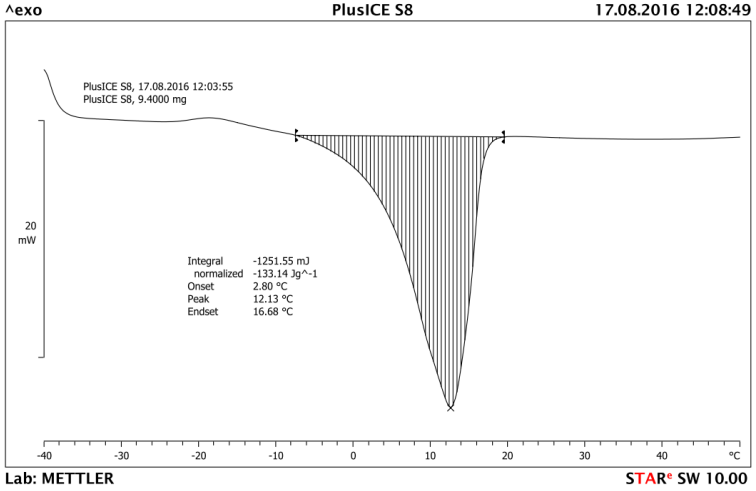
DSC



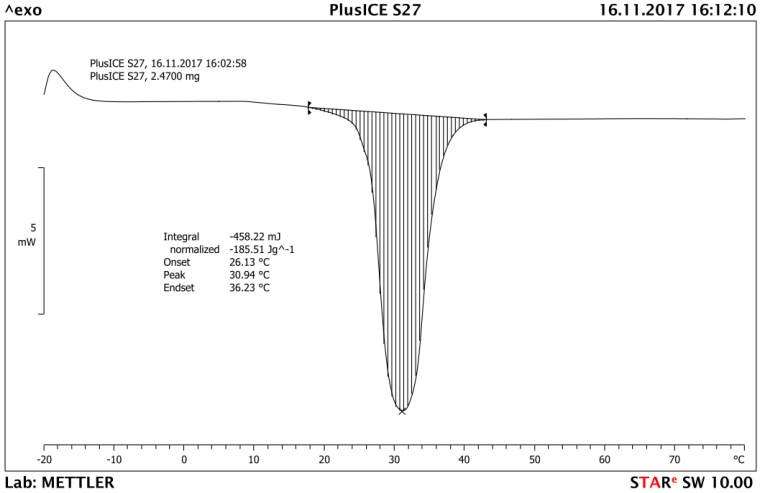
PCM A8 in granules (GHX2)



PCM A27 in granules (GHX2)

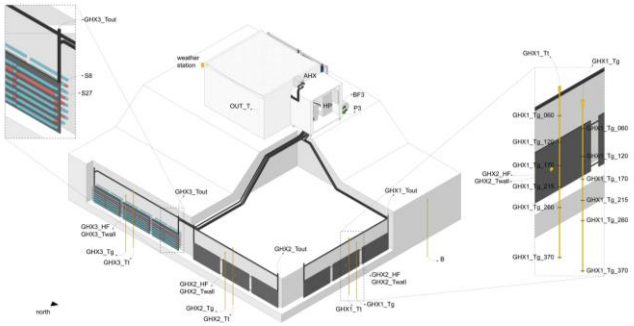


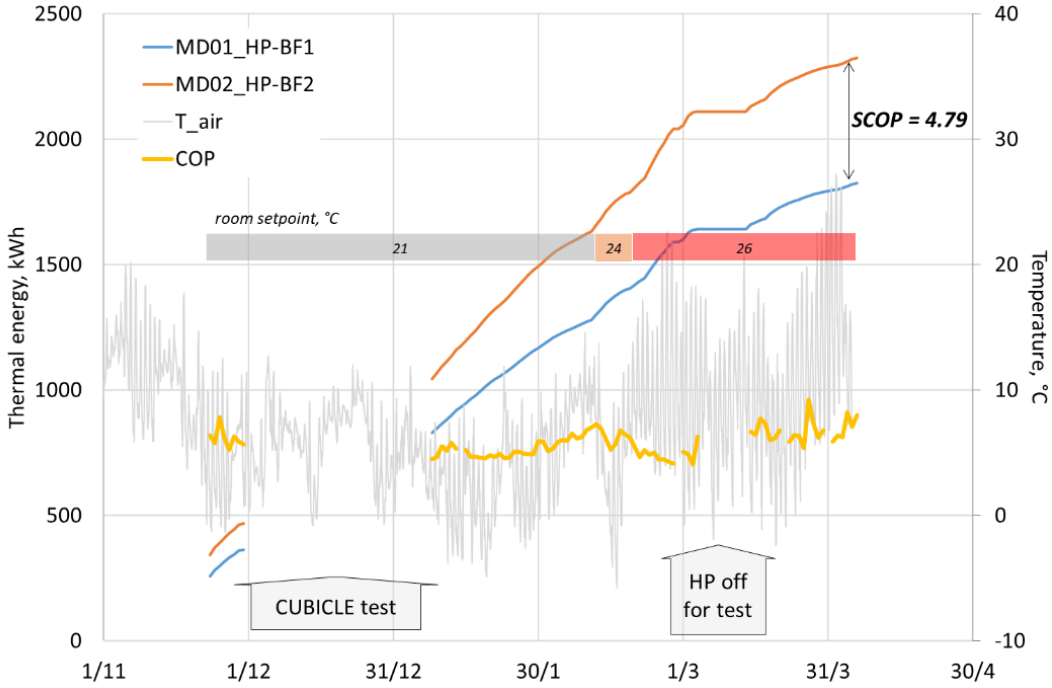
PCM S8 in TubeICE (GHX3)

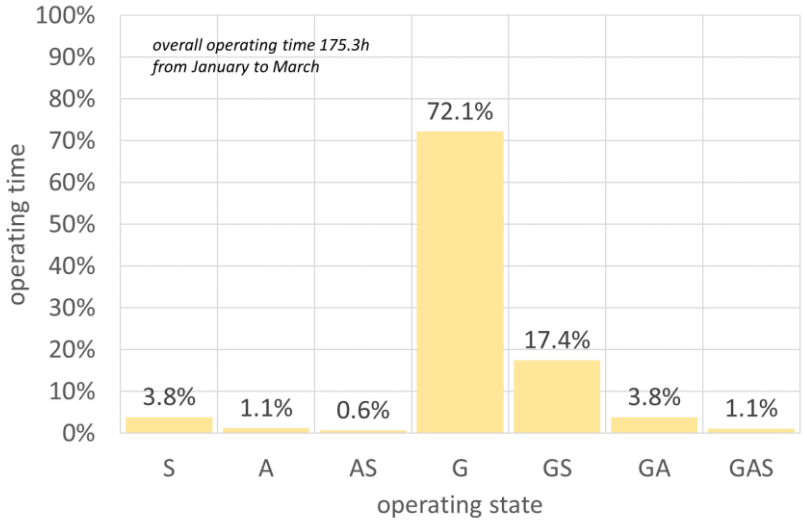


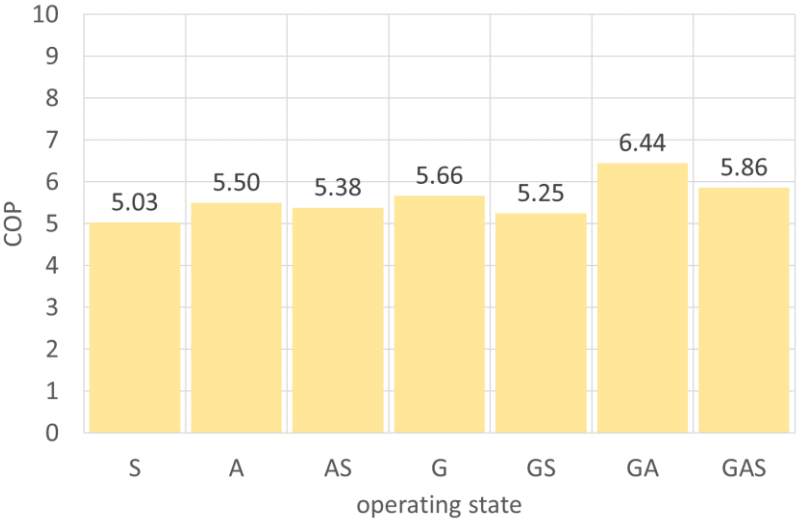
PCM S27 in TubeICE (GHX3)

Prestazioni invernali (1/5)

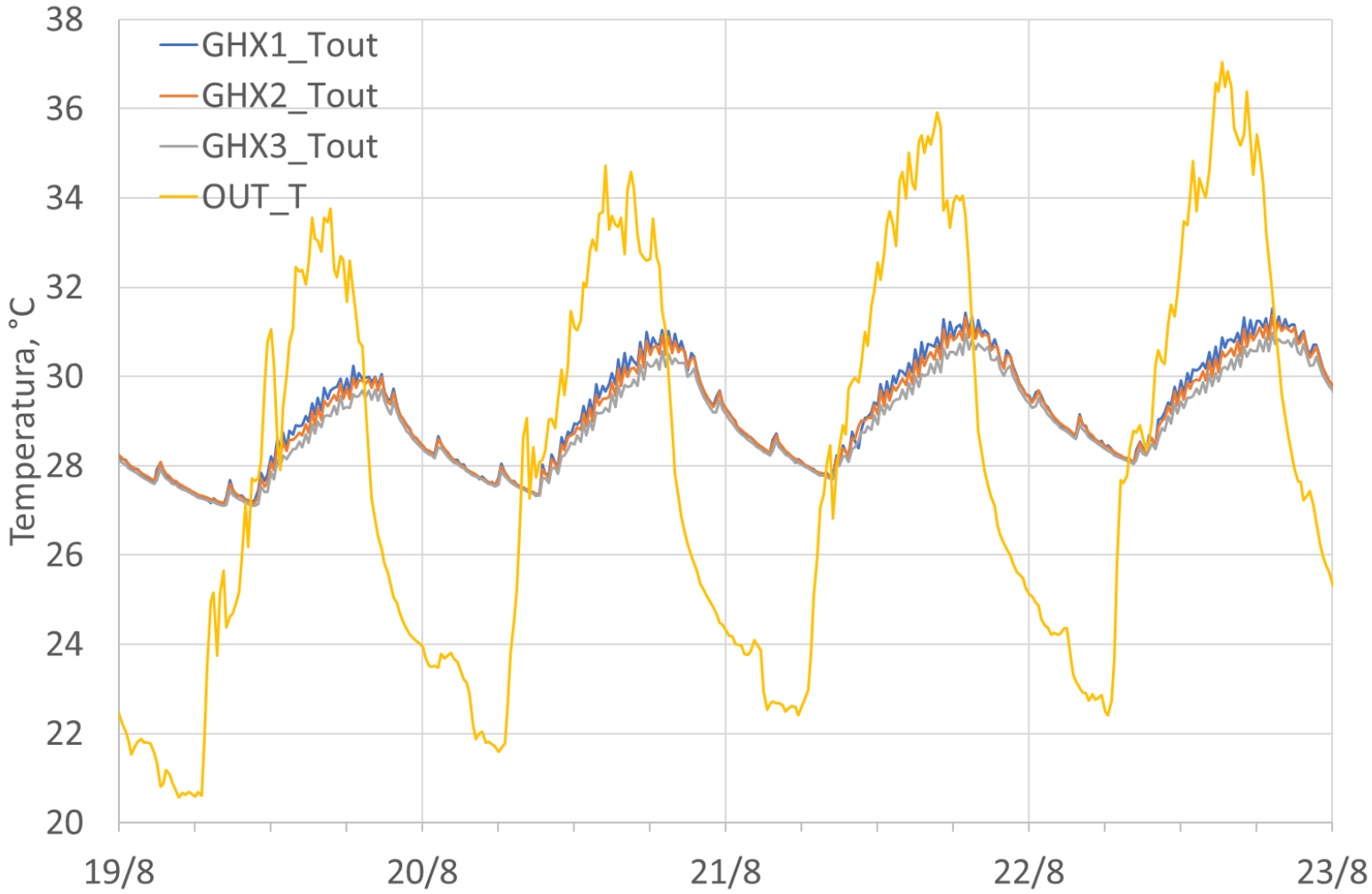




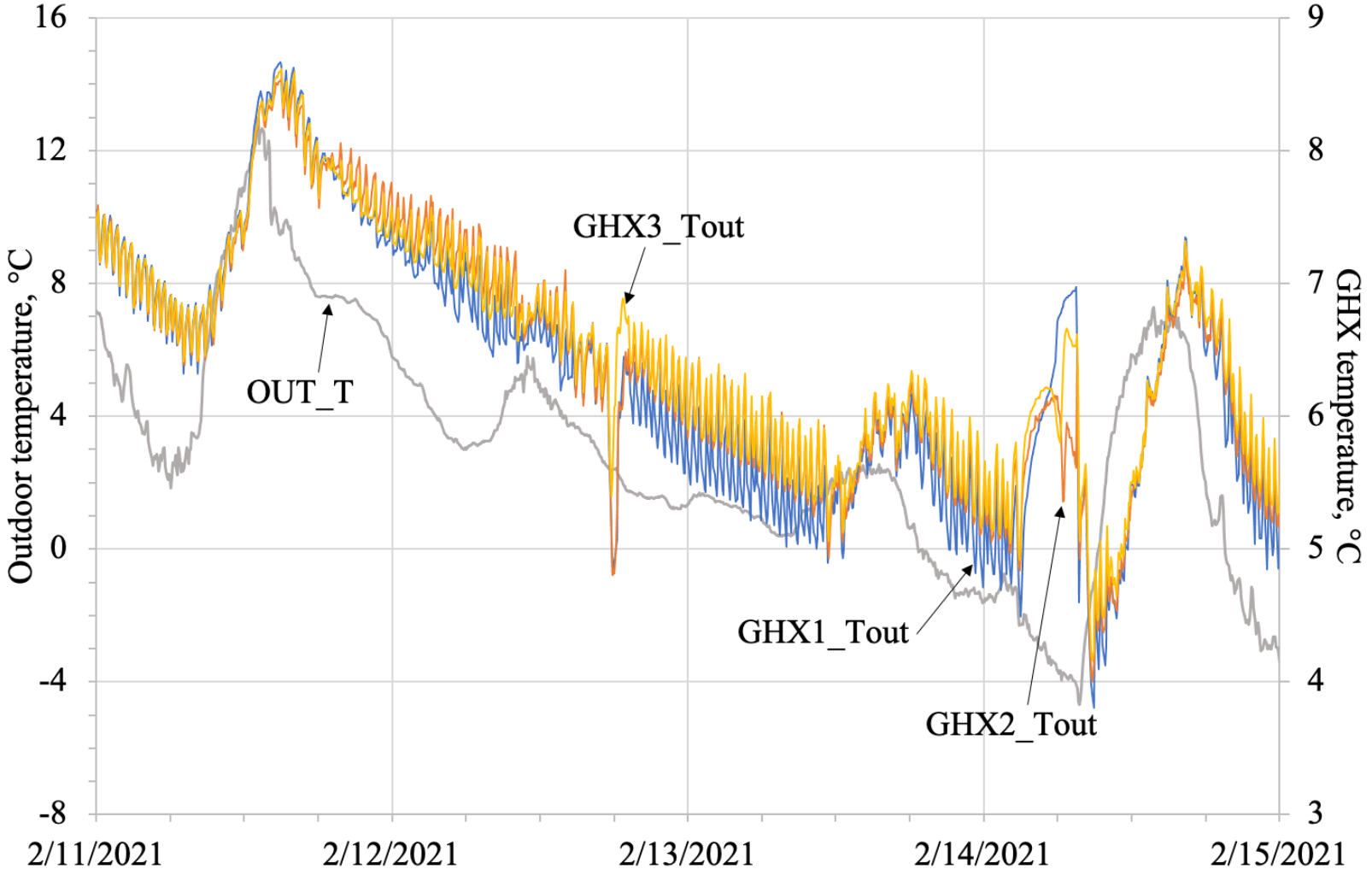




Prestazioni invernali (2/5)



Prestazioni invernali (3/5)



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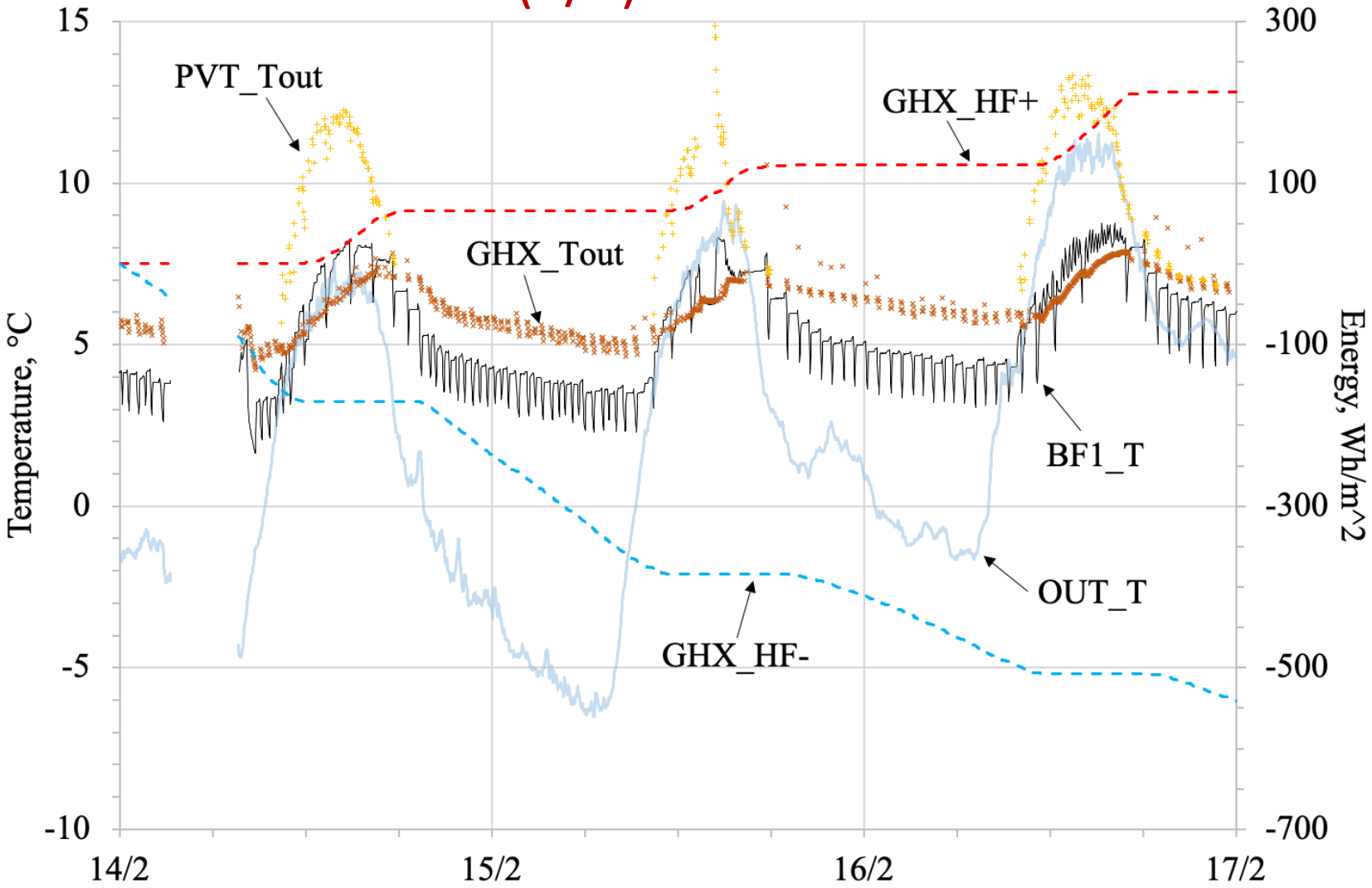

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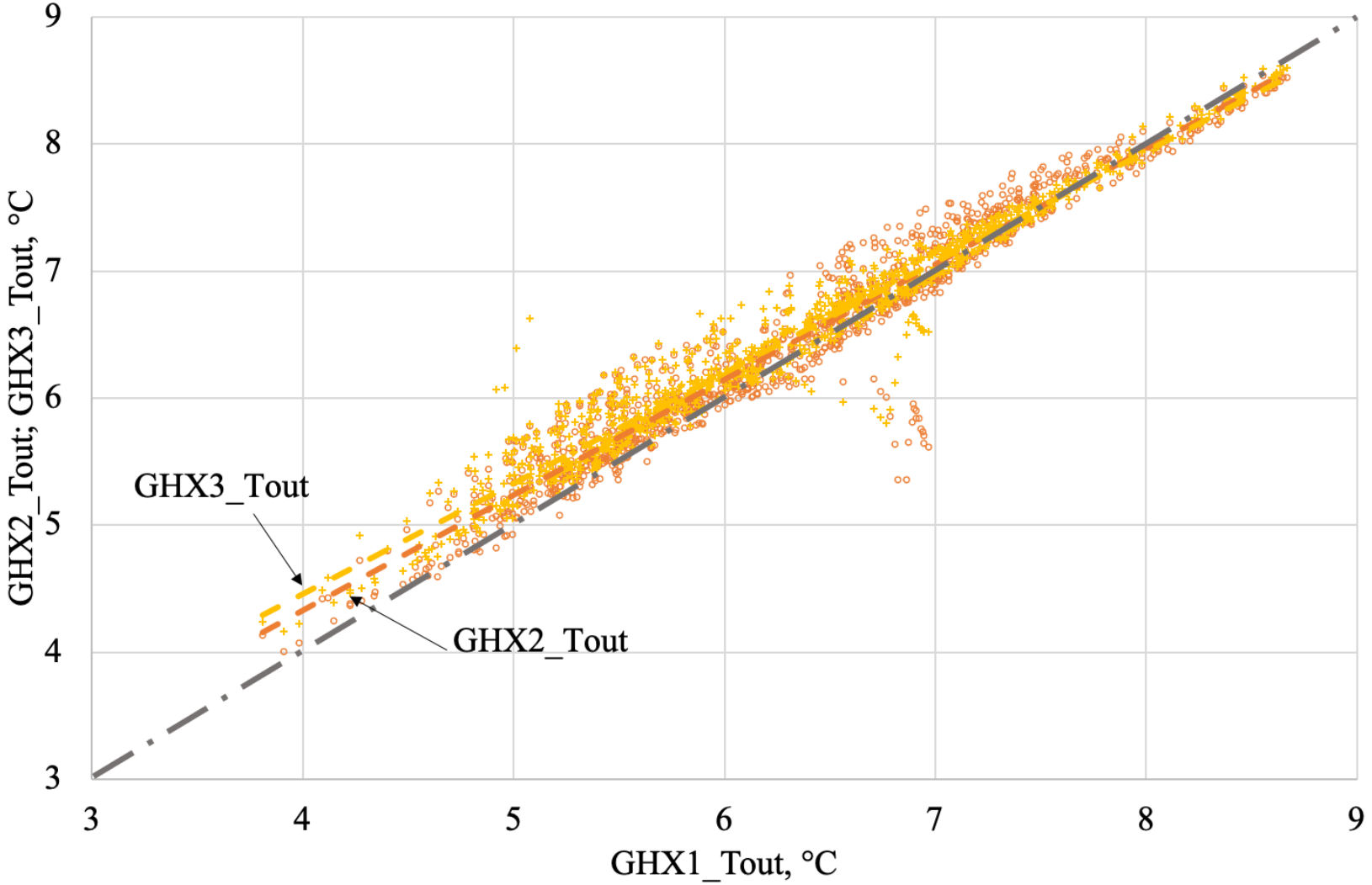
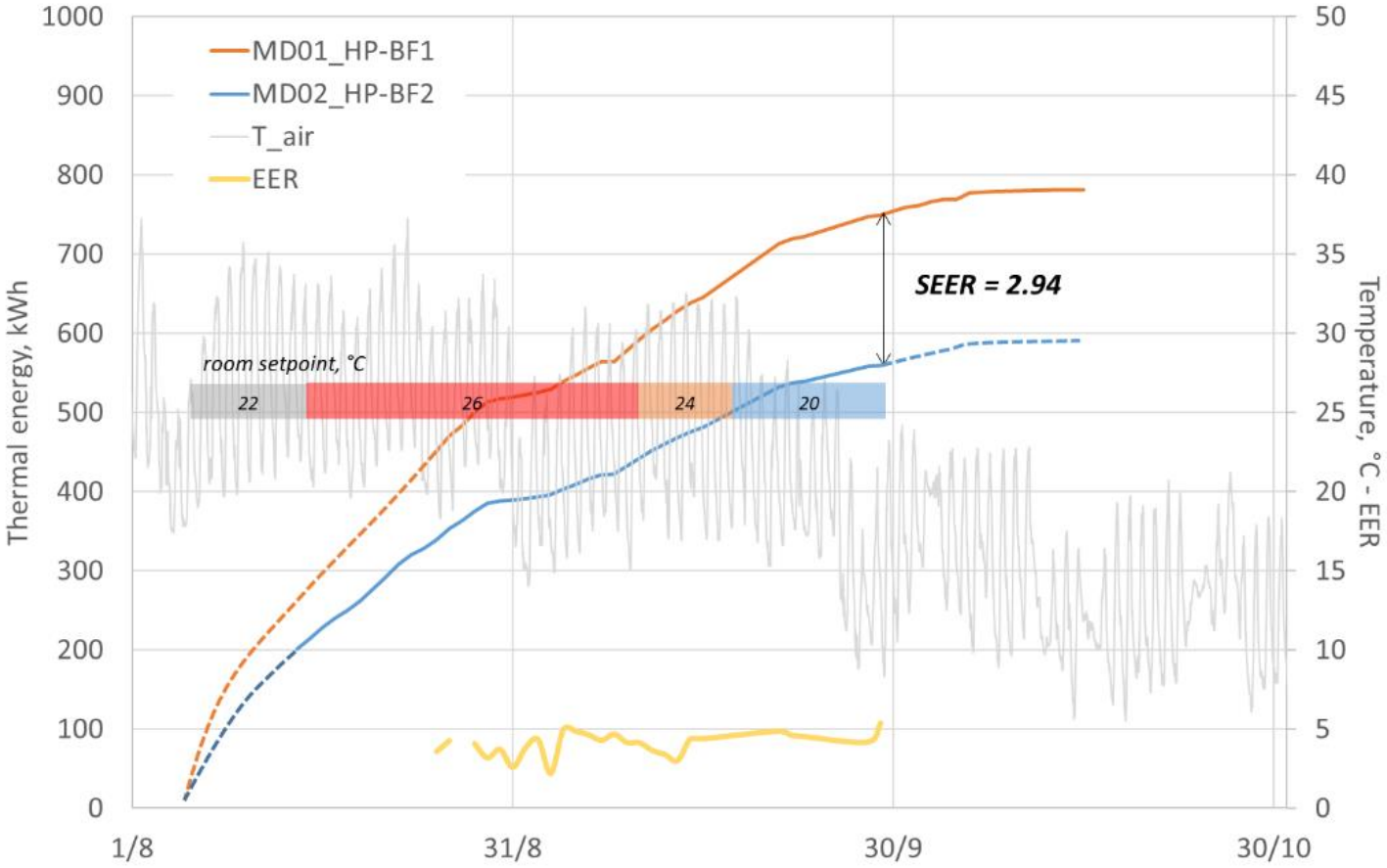
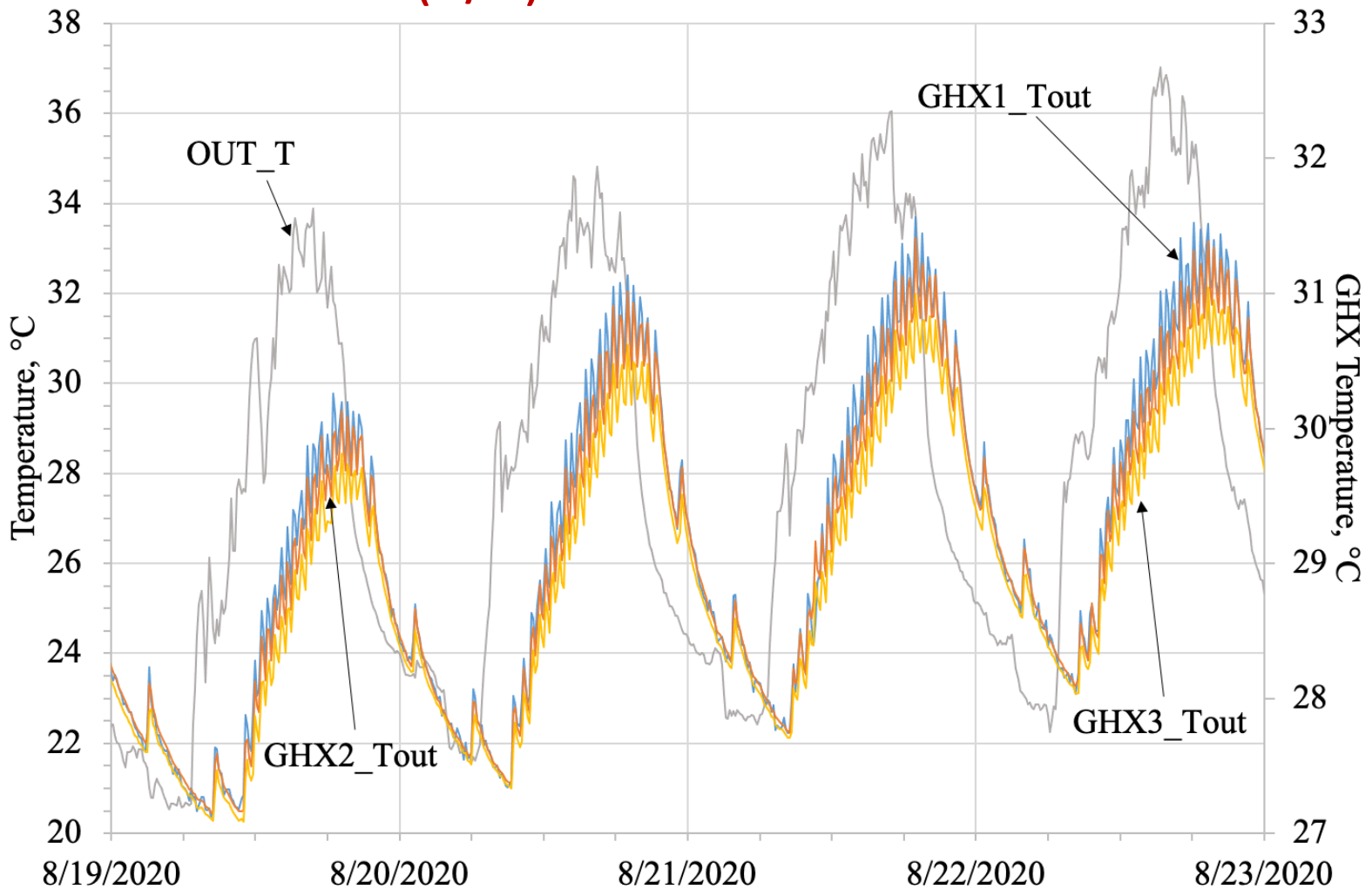


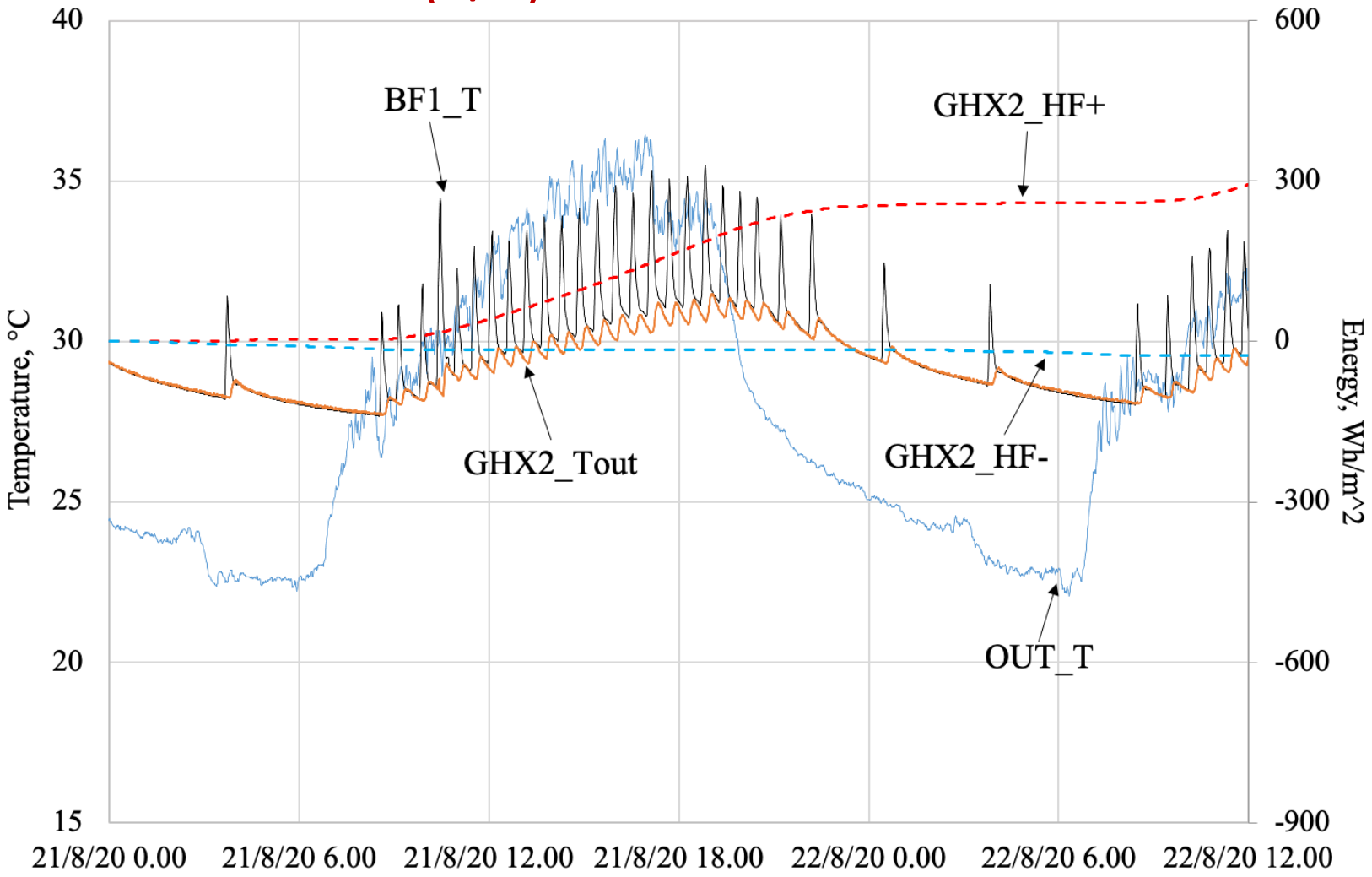
Prestazioni estive (1/5)



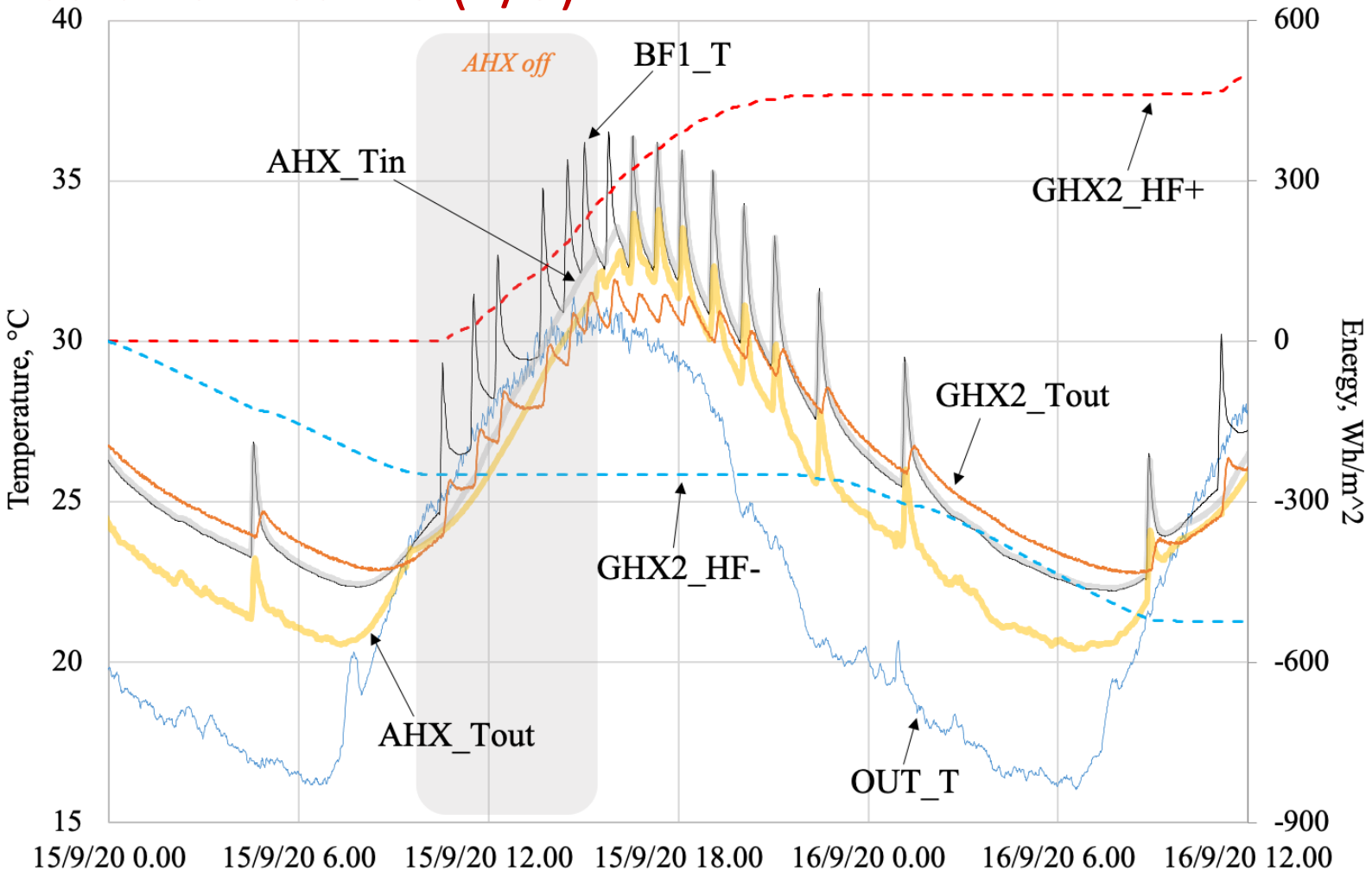
Prestazioni estive (1/5)



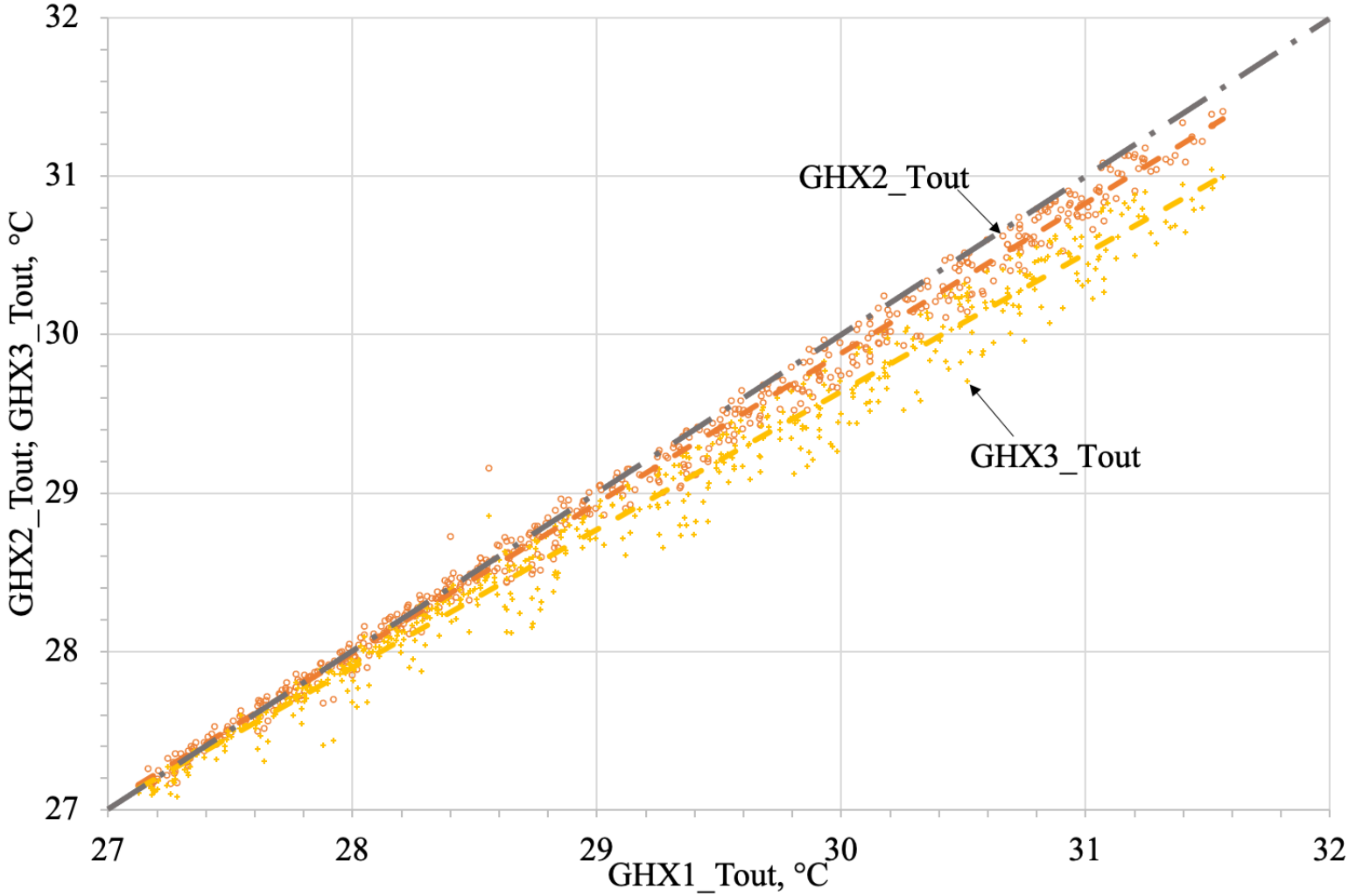
Prestazioni estive (3/5)



Prestazioni estive (4/5)

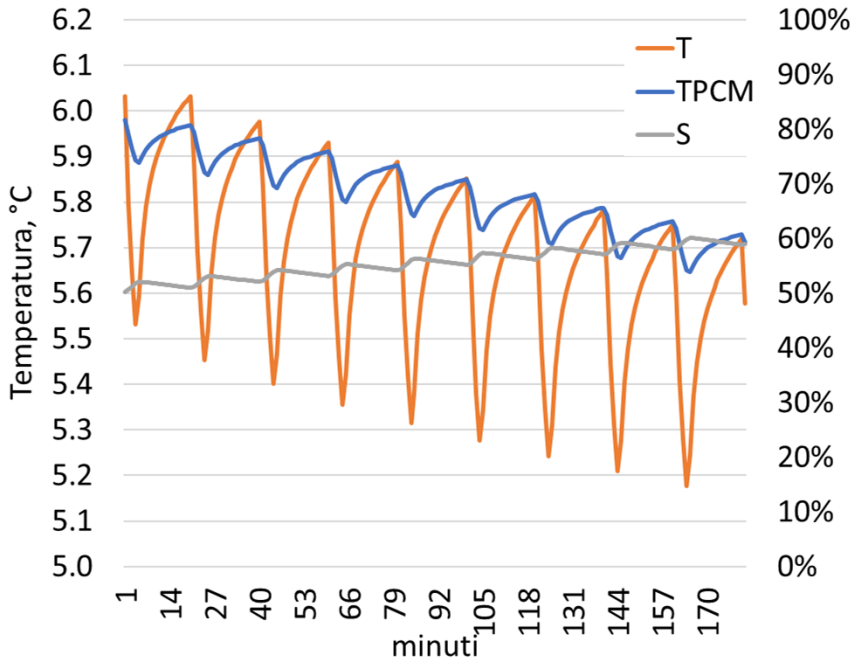


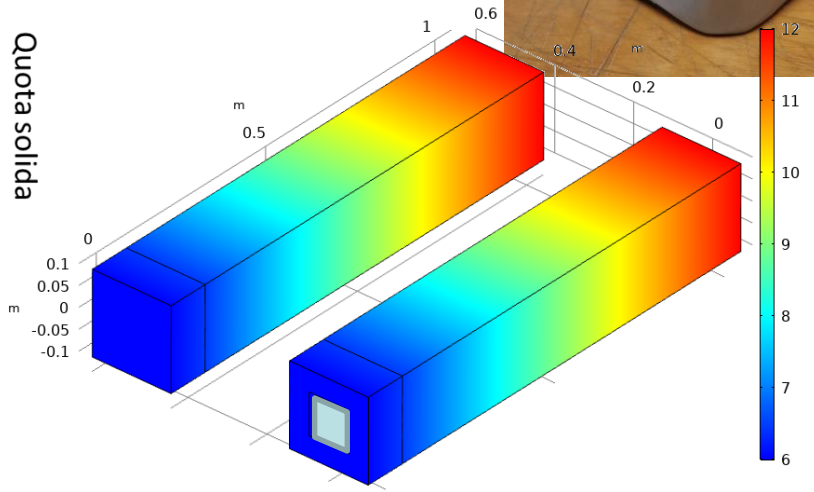
Prestazioni estive (5/5)



Questioni aperte

- segregazione dei sali idrati
- durabilità della miscelazione diretta
- conducibilità termica dei PCM
- accoppiamento (massa, prossimità)



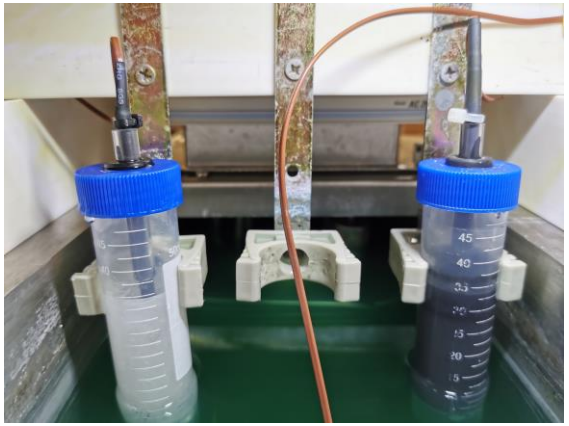


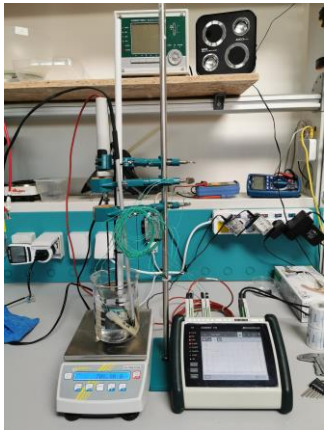
Conducibilità termica

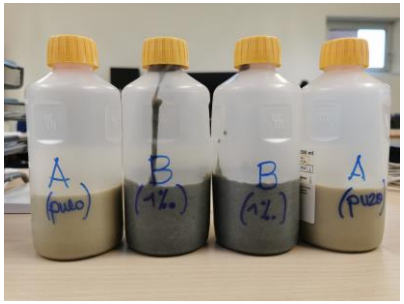
La conducibilità è già stata raddoppiata con l'additivazione di grafene (0.8 W/mK)

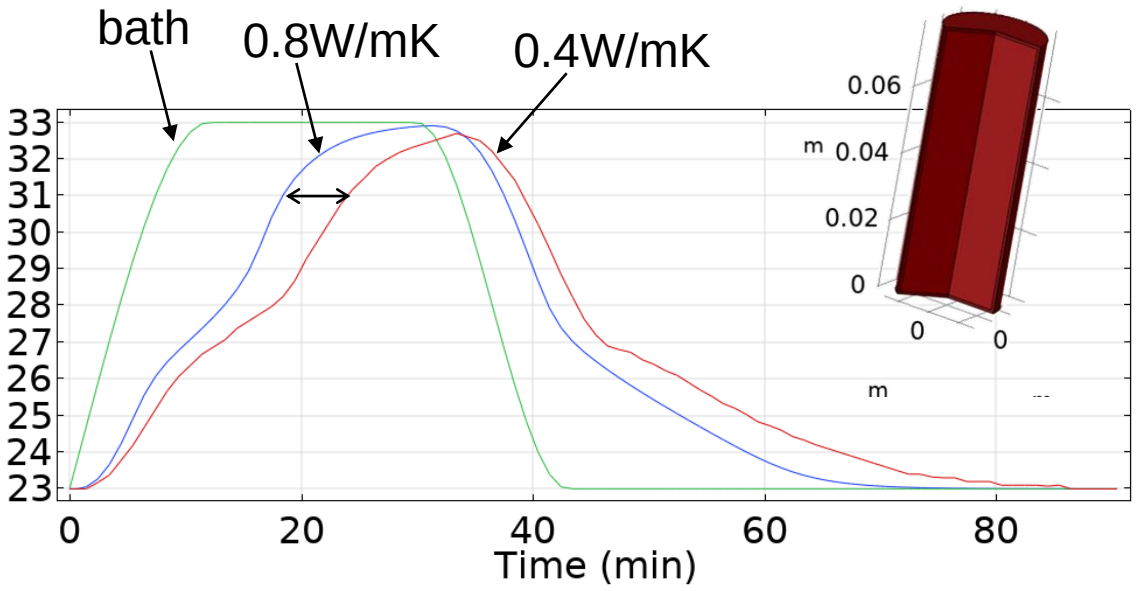
Gli obiettivi sono

- «*trasparenza*» termica rispetto al materiale di rinfianco (sabbia)
- stabilizzazione della miscela PCM-grafene



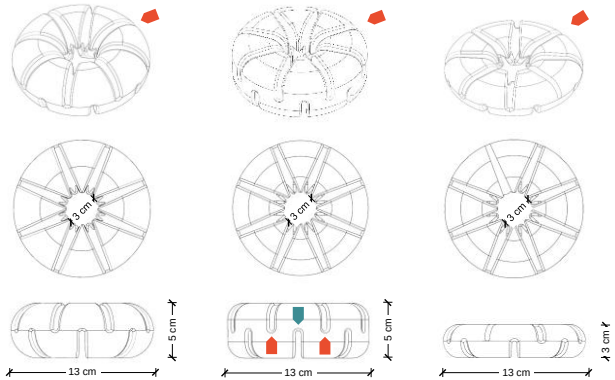


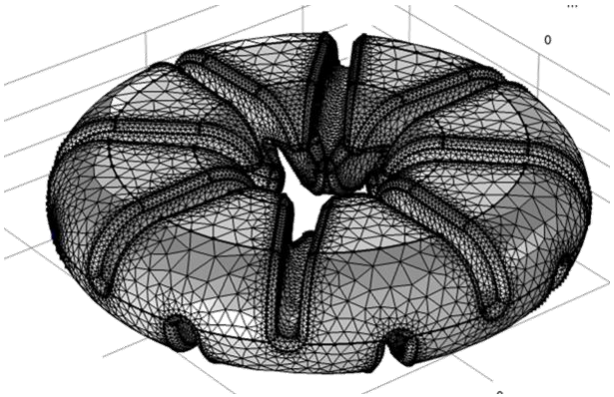




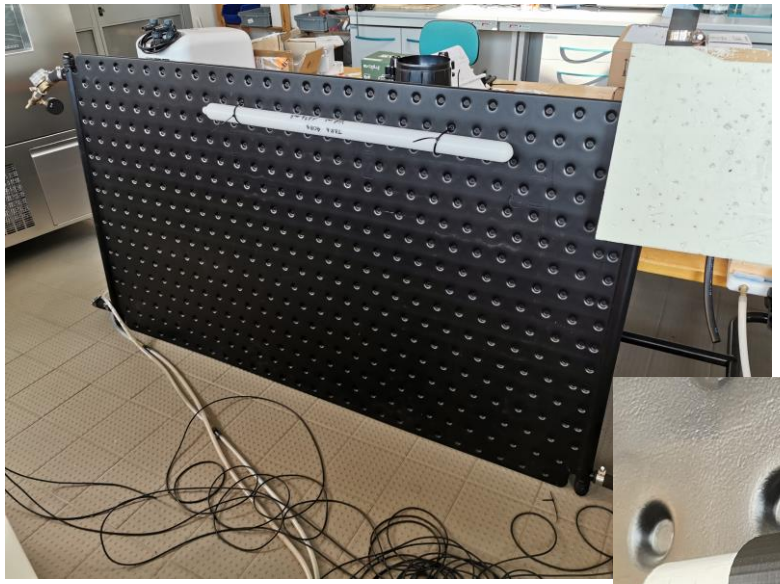
Accoppiamento per massa

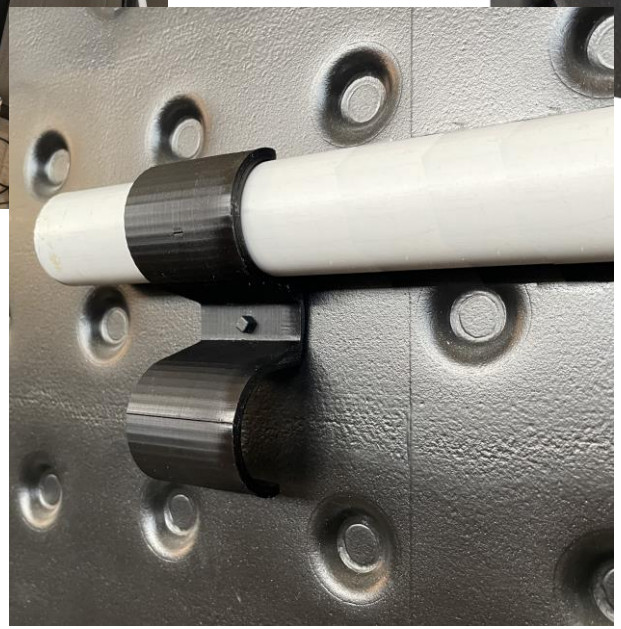
- segregazione dei PCM
- superficie di scambio
- durabilità
- costo

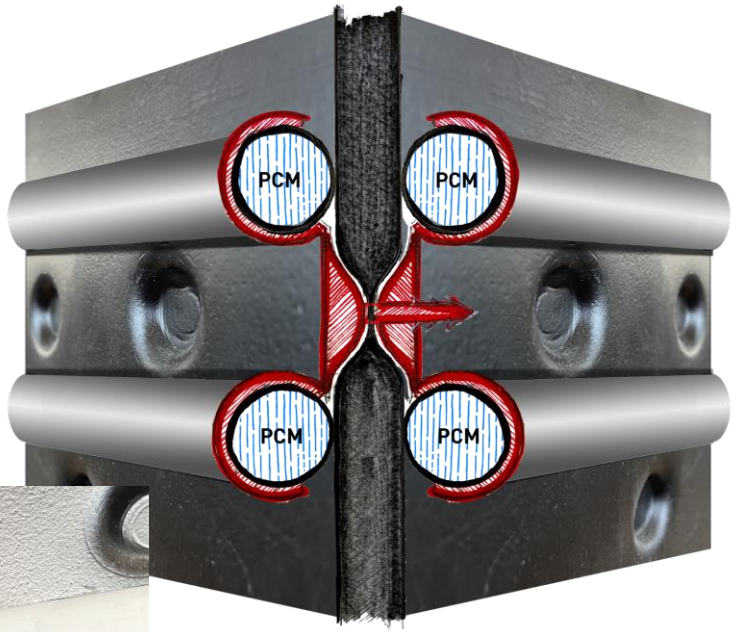




Accoppiamento per prossimità

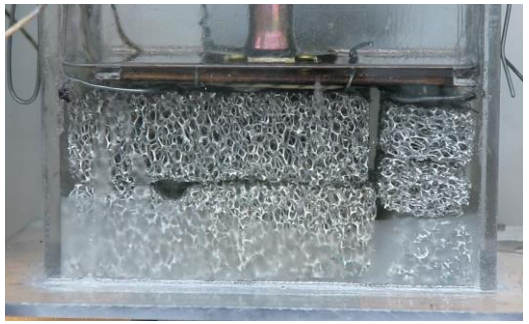






Prospetive

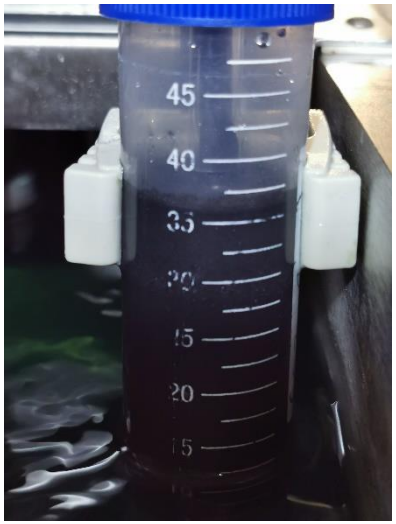
L’innovazione proposta è ancora poco esplorata, sebbene già applicata in altri settori.



L’opportunità rappresenta un vantaggio competitivo di filiera per tipologia d’offerta, prestazioni e know-how.

Le proposte testate a livello prototipale possono già costituire un punto di partenza per l’industrializzazione. Tuttavia, sono ancora da risolvere aspetti legati a:

- conducibilità termica
- segregazione
- affidabilità
- costo
- progettazione



Partenariati

Informazioni sulle ricerche, sulle tecnologie in fase di sviluppo e su iniziative in corso sono disponibili nei siti di progetto

www.cliwax.it

IDEAS

https://www.horizon2020ideas.eu/

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