# A cold storage PCM heat exchanger for daily summer free cooling with cold night air

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Hes·so
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ENERGY
Institute of Applied Research in Energy Systems

# Introduction

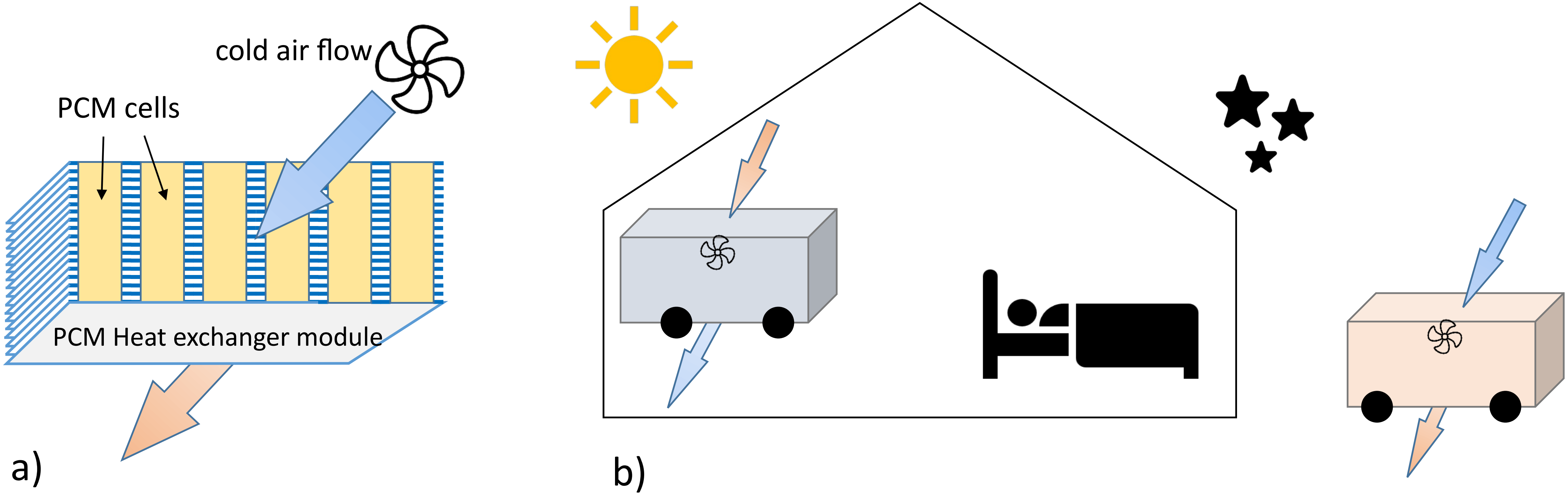
- If renewable energy can be a solution for global transport, this is not the case for global warming and building cooling


- A sea of convector fans
- Reversible heat pumps
increasing hot islands in cities

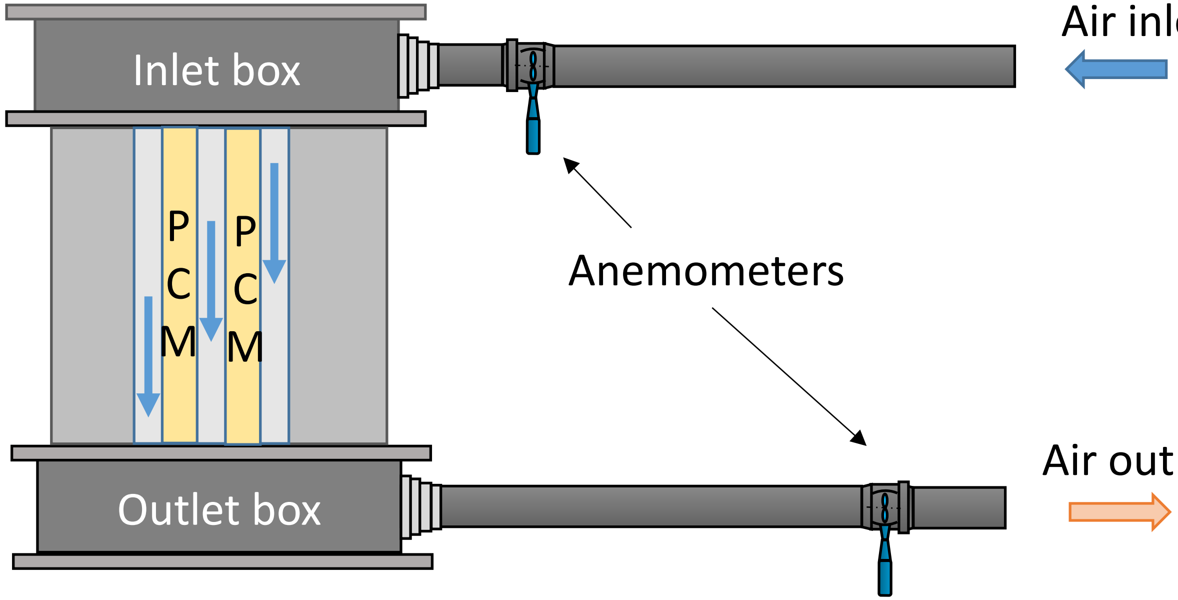
} not a solution

Storing the night cold in
**PCM could be a solution**

# Basic concept



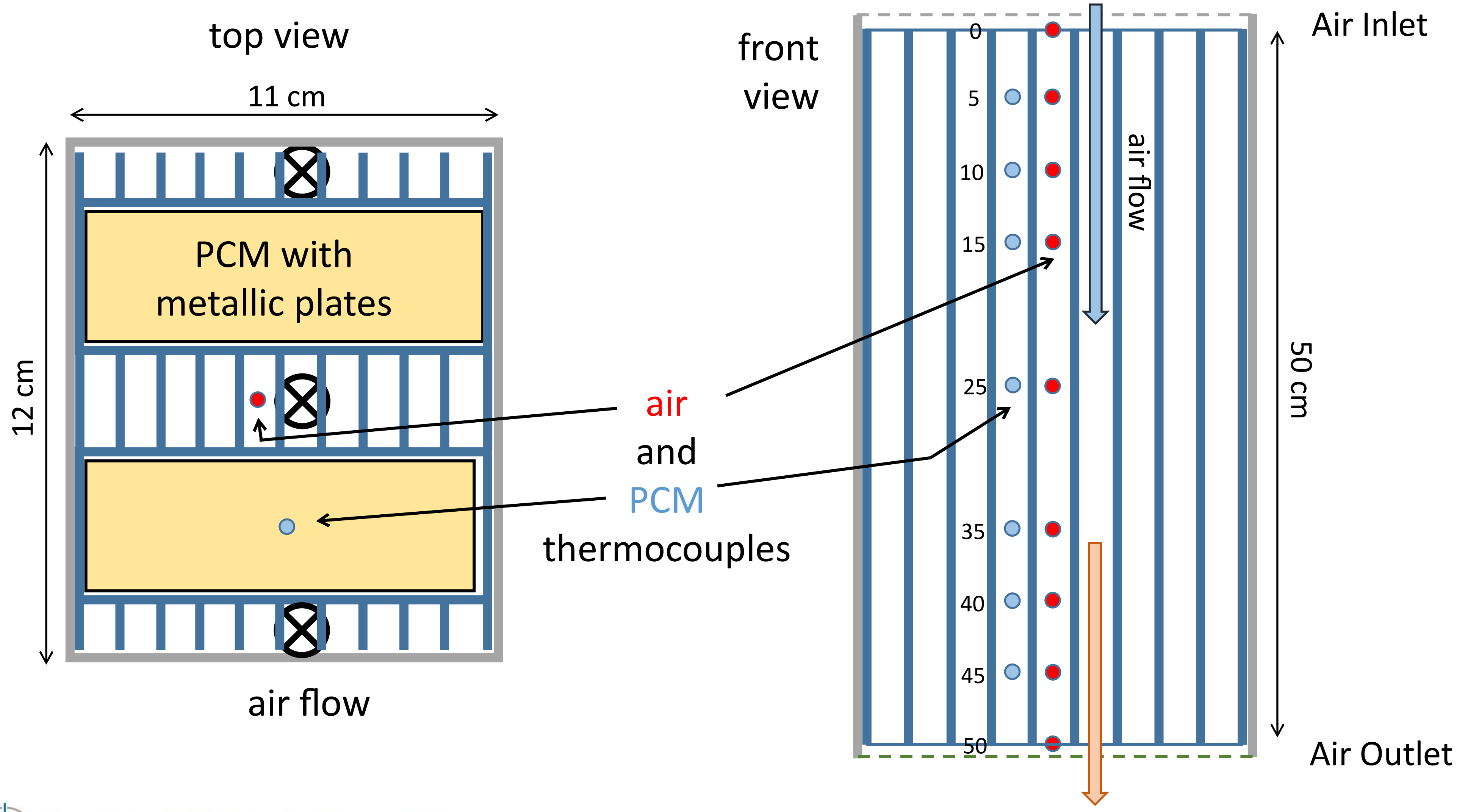
# Testbed (a)


Inlet box
P
C
M
P
C
M
Outlet box
Air inlet
Anemometers
Air outlet

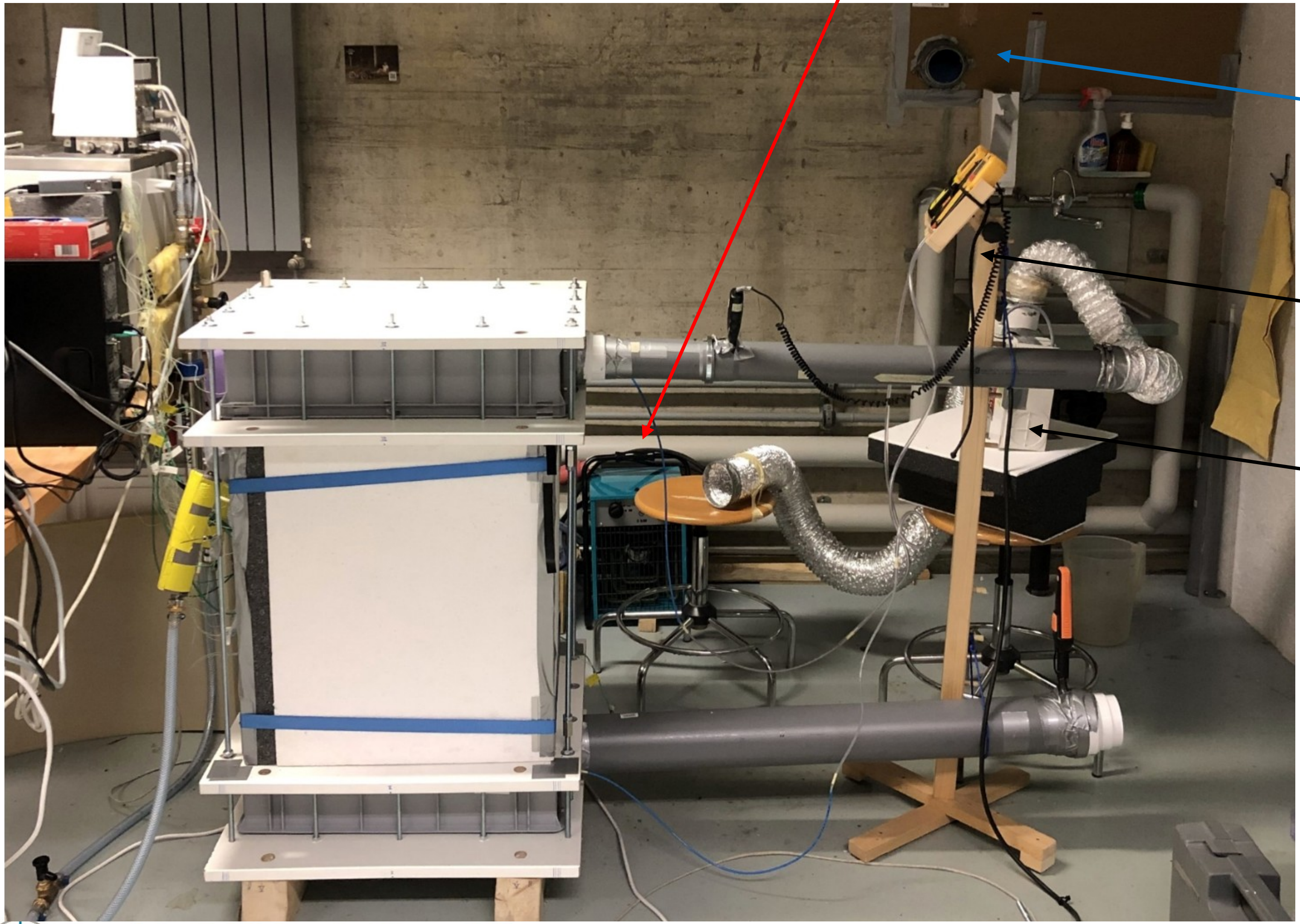
# Testbed (c)

PCM = Crodatherm21 ($T_{melting}$ = 20.5°C)

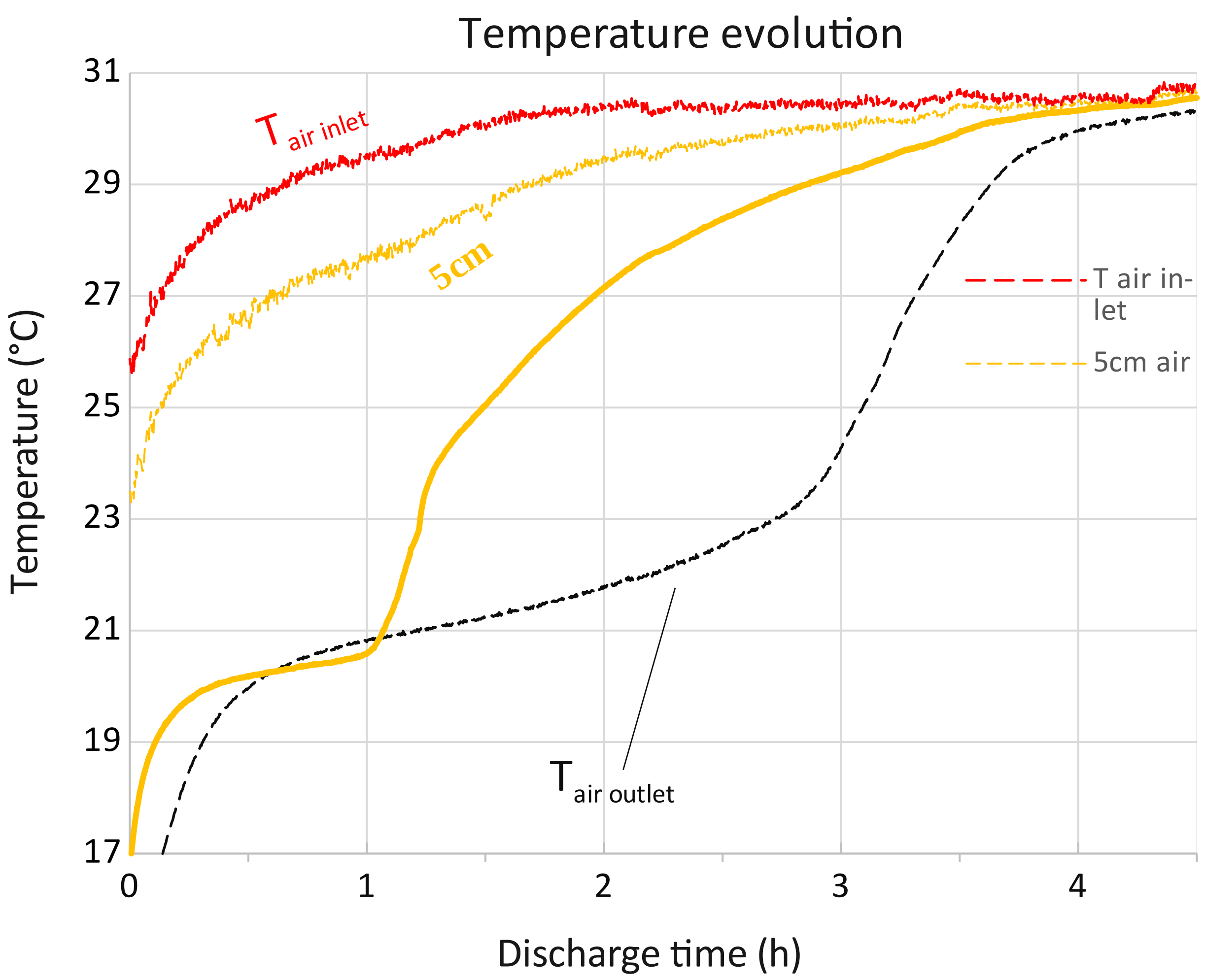
24m³/h air flow at 14°C → full solidification in 3h

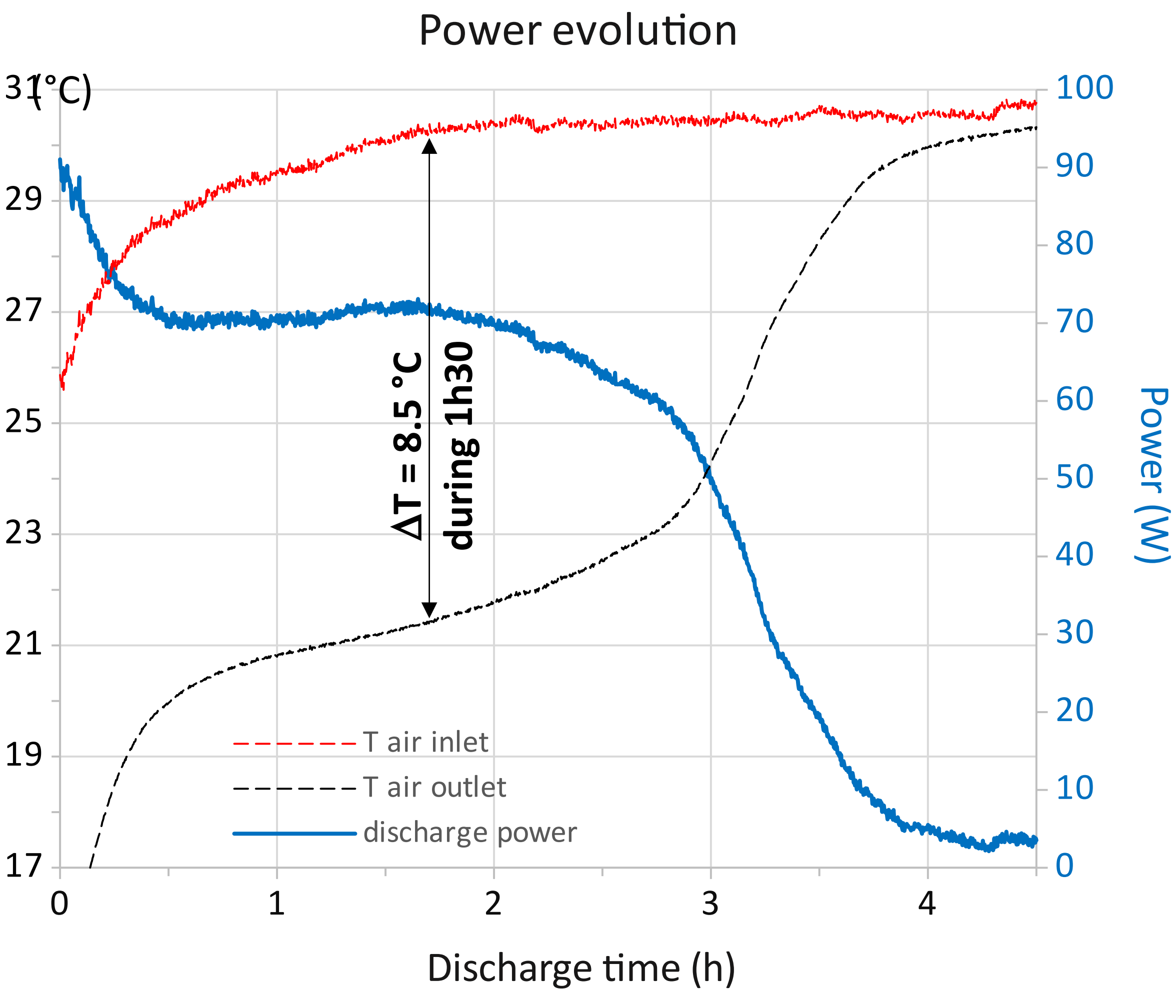


# Testbed (b)

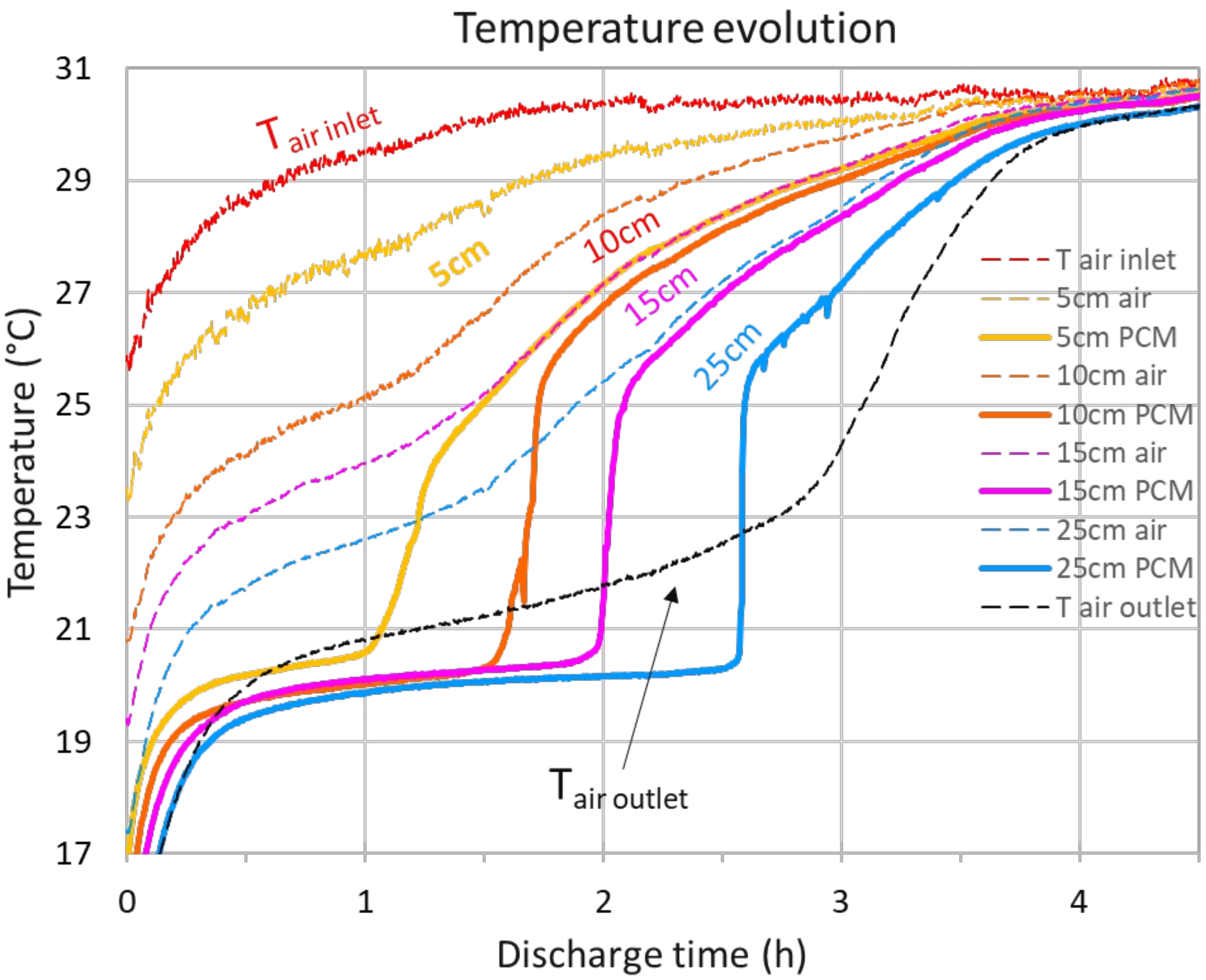


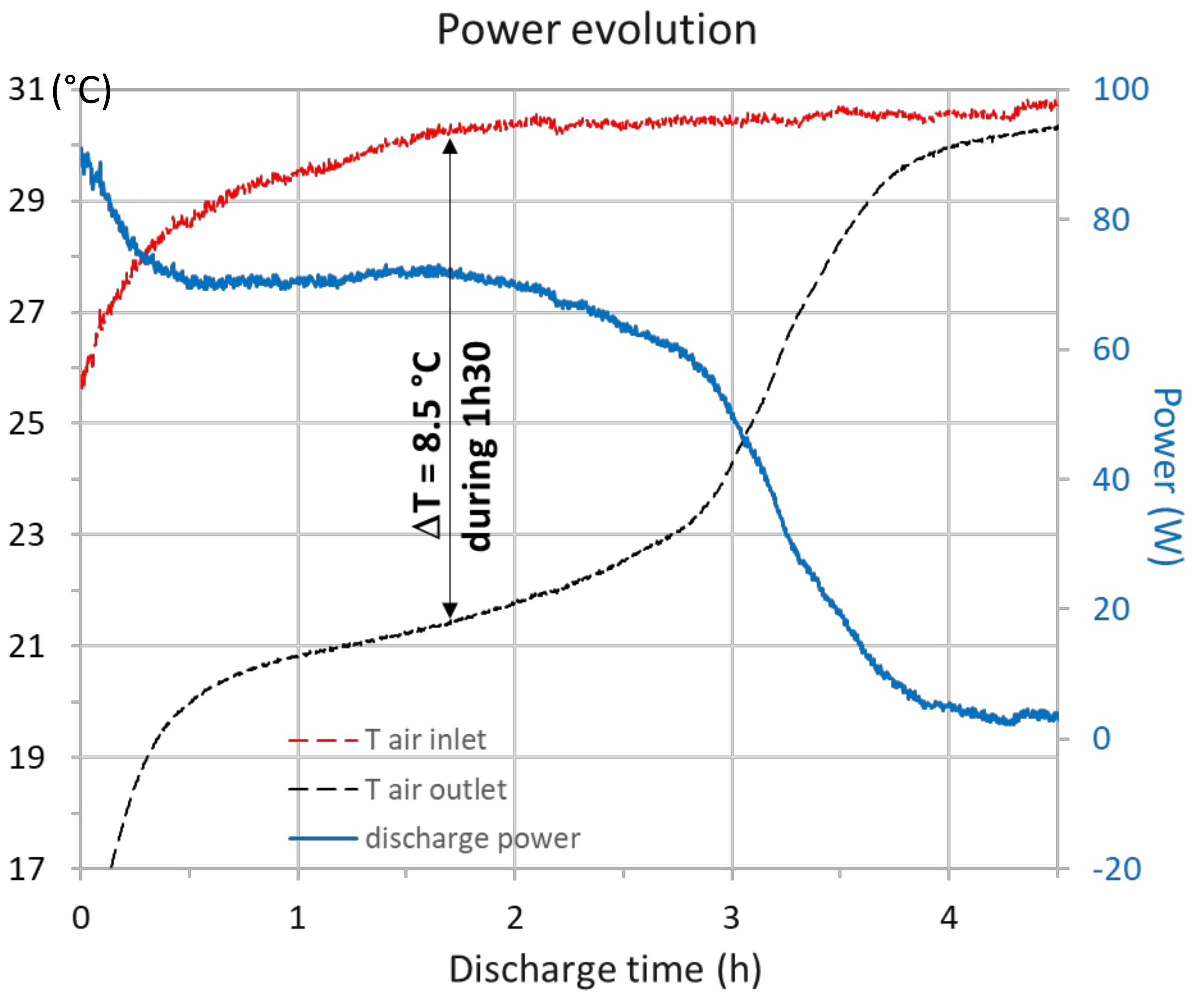
# Cold discharge with a flow of 24m³/h



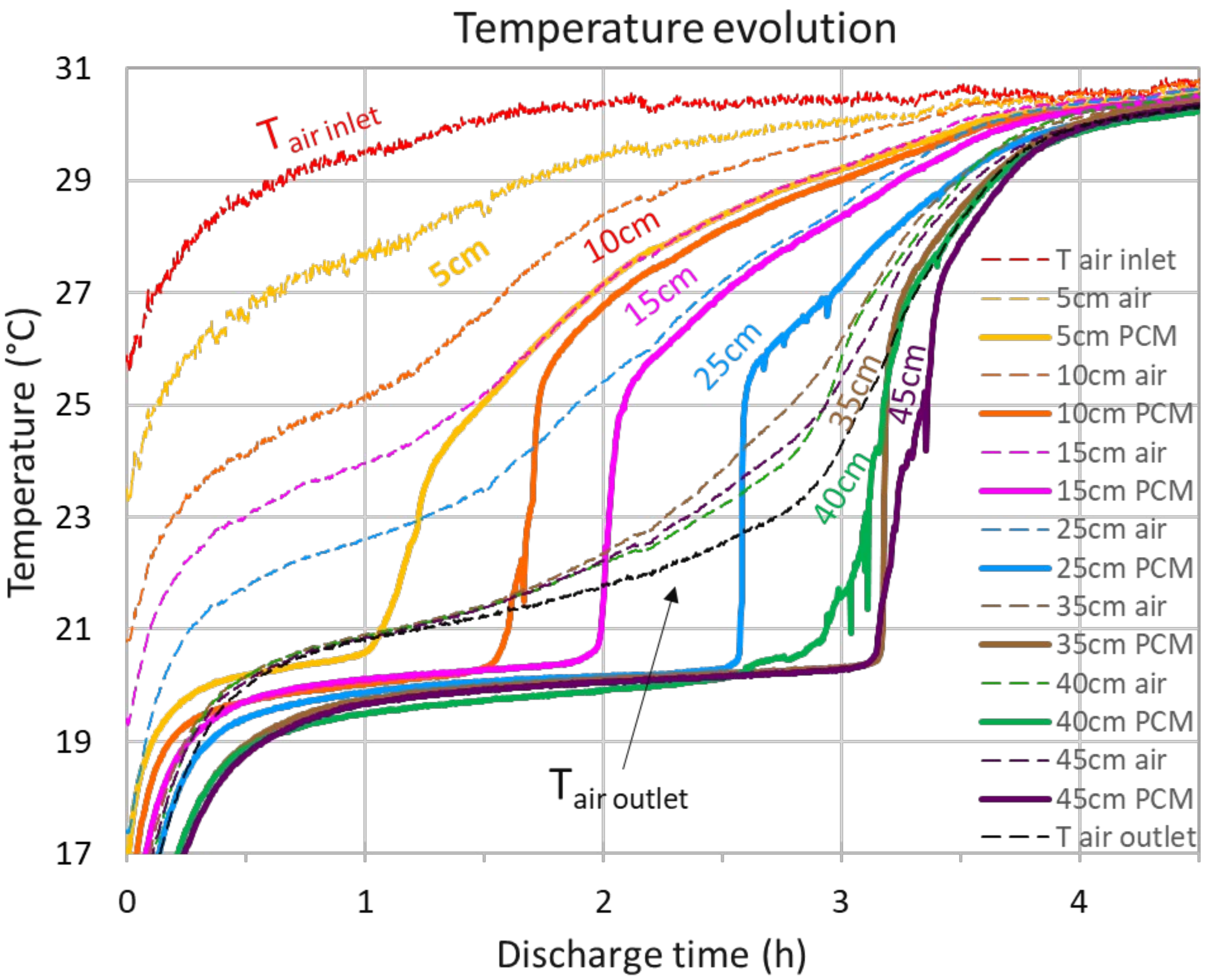



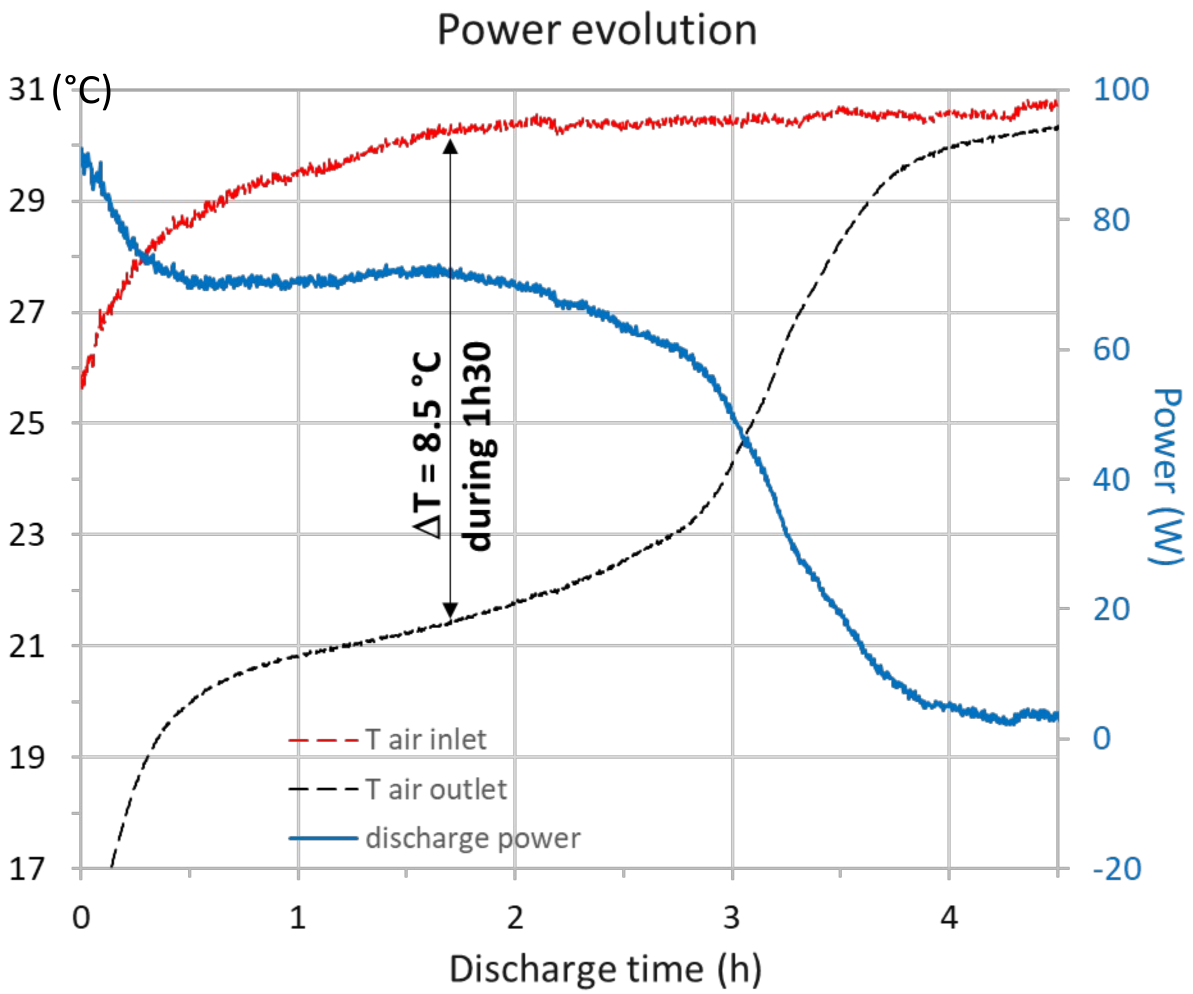
# Cold discharge:
# melting front advances slowly, then accelerates



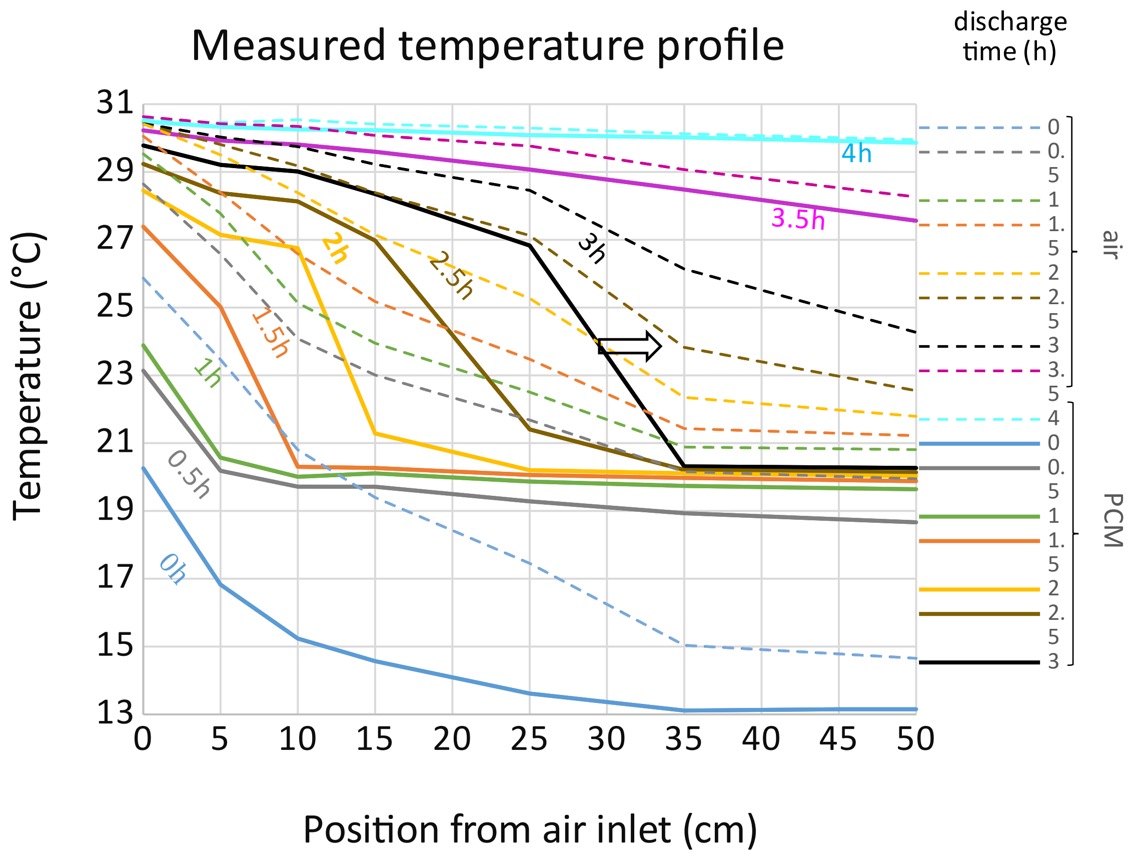



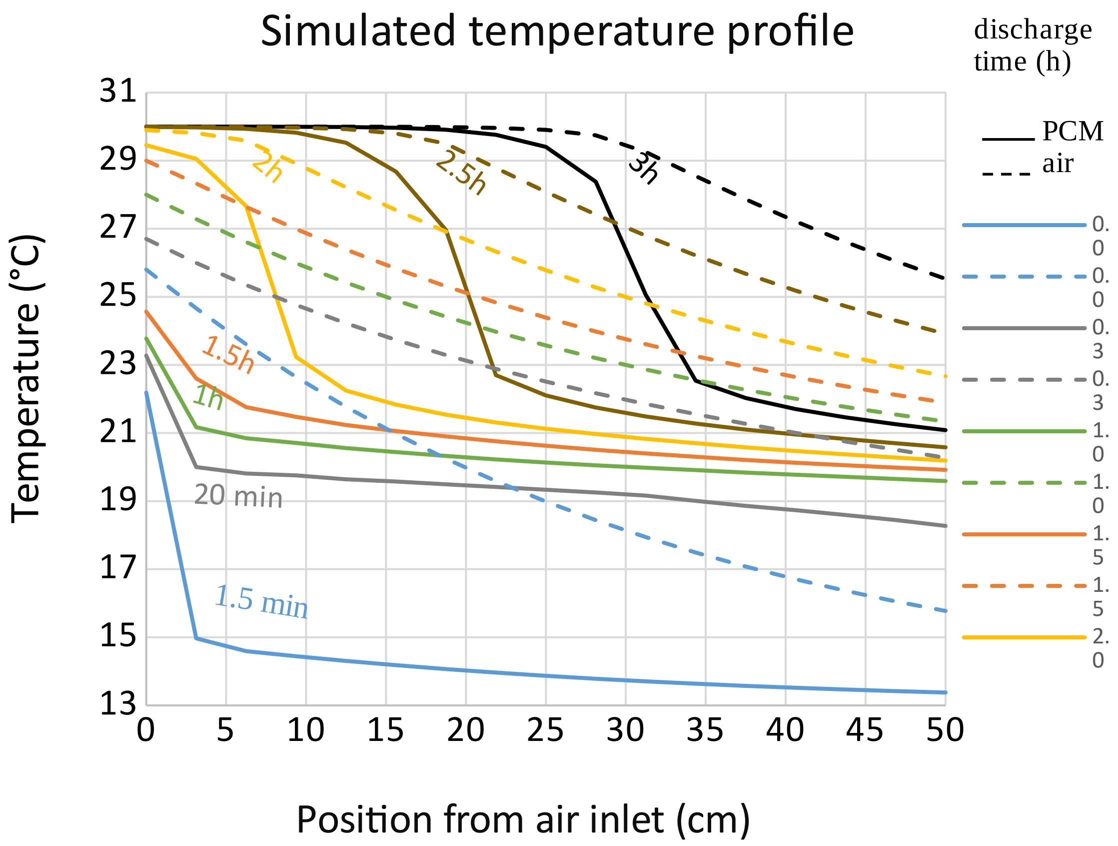
# Cold discharge:
# after 35cm, the melting occurs almost simultaneous



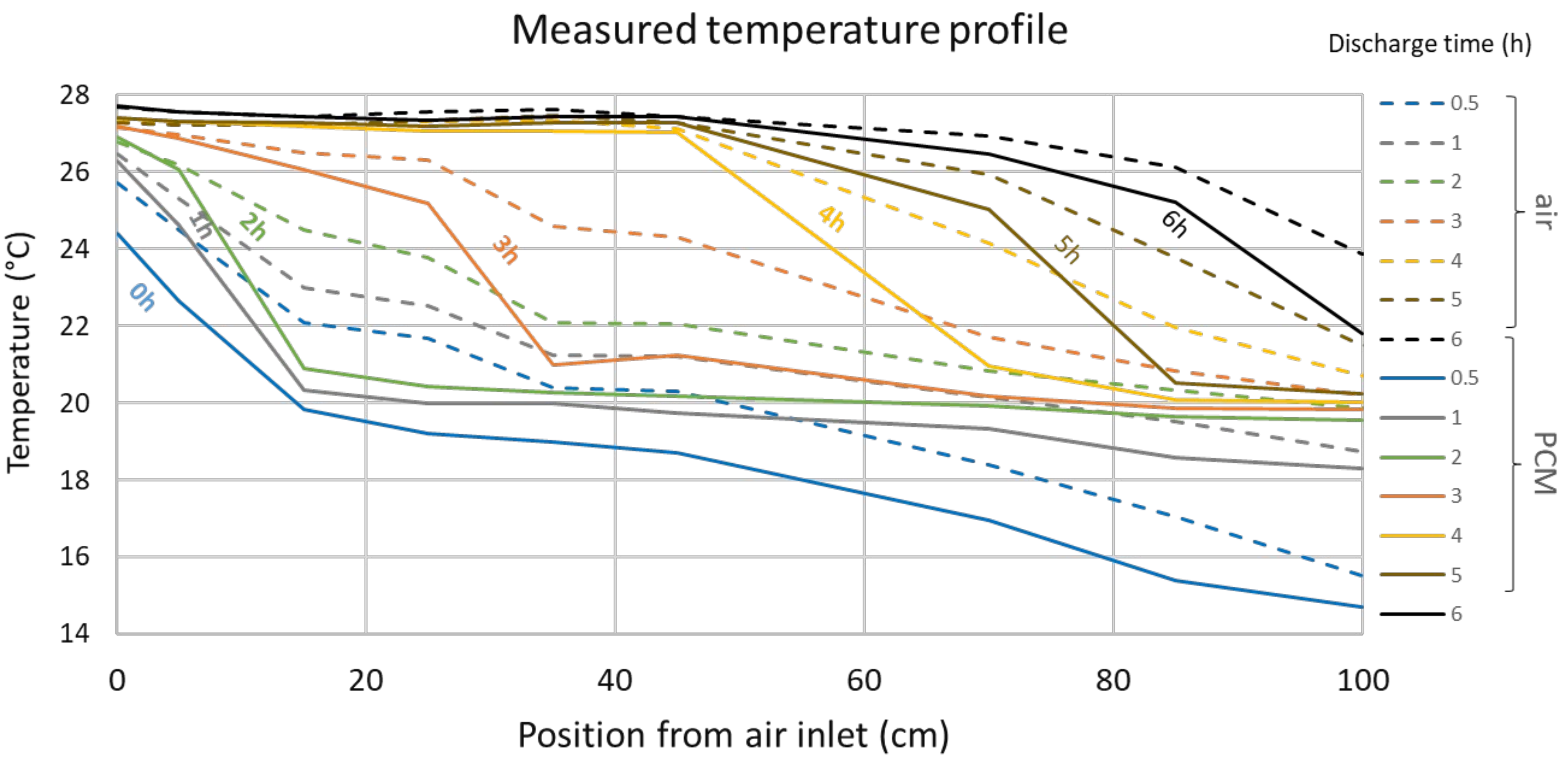



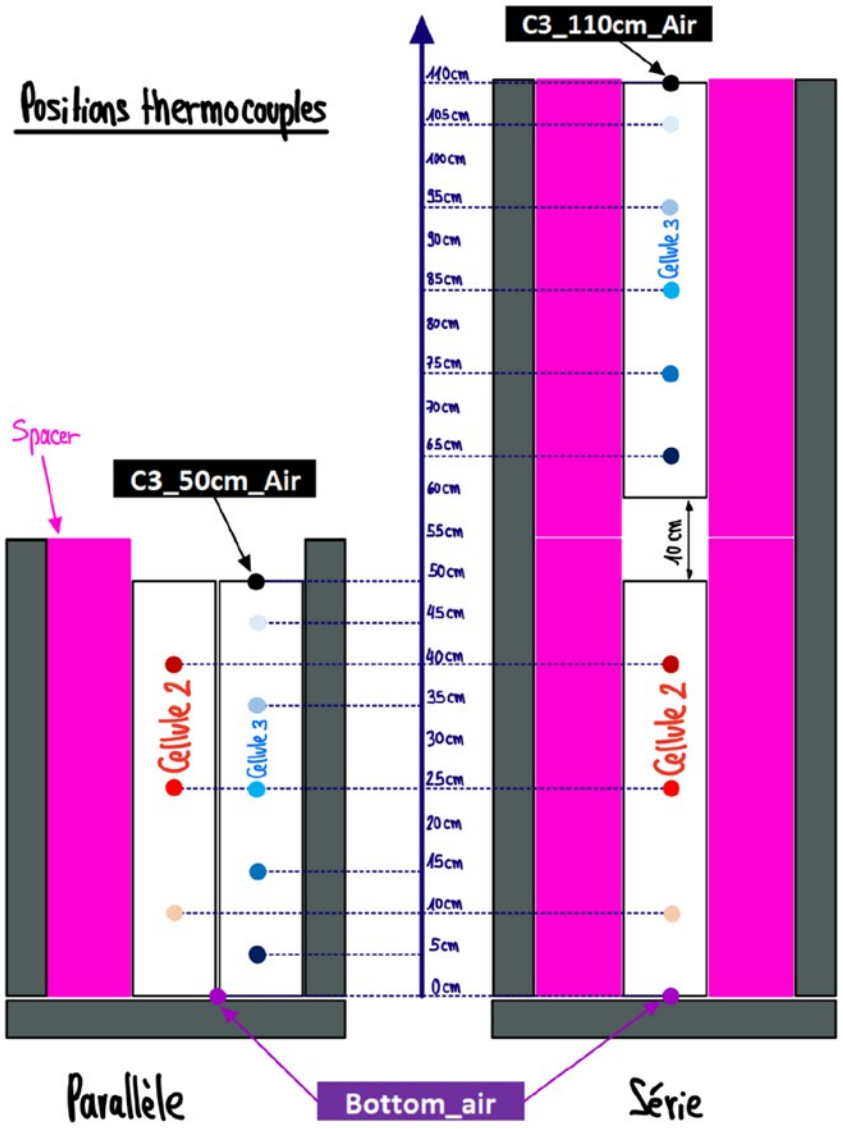
# Cold discharge: measured and simulated temperature profile along the airflow in the PCM cell



# Cold discharge with 2 PCM cells in series
# → pressure drop **increased by 3.5x**→ airflow = **13.3 m³/h** for the same fan power level



# Performance comparison as function of flow and setup

| Parameter | | Air flow rate Q $(m^3/h)$ | Air flow speed v $(m/s)$ | Pressure drop Δp $(Pa)$ |
| --- | --- | --- | --- | --- |
| Setup | parallel | 24<br>**44** | 1.8<br>**3.2** | **11**<br>**37** |
| | serial | 13.3<br>**30** | 2.0<br>**4.3** | 35<br>**130** |

- **Parallel** setup has better performances than serial one due to **lower pressure drop**

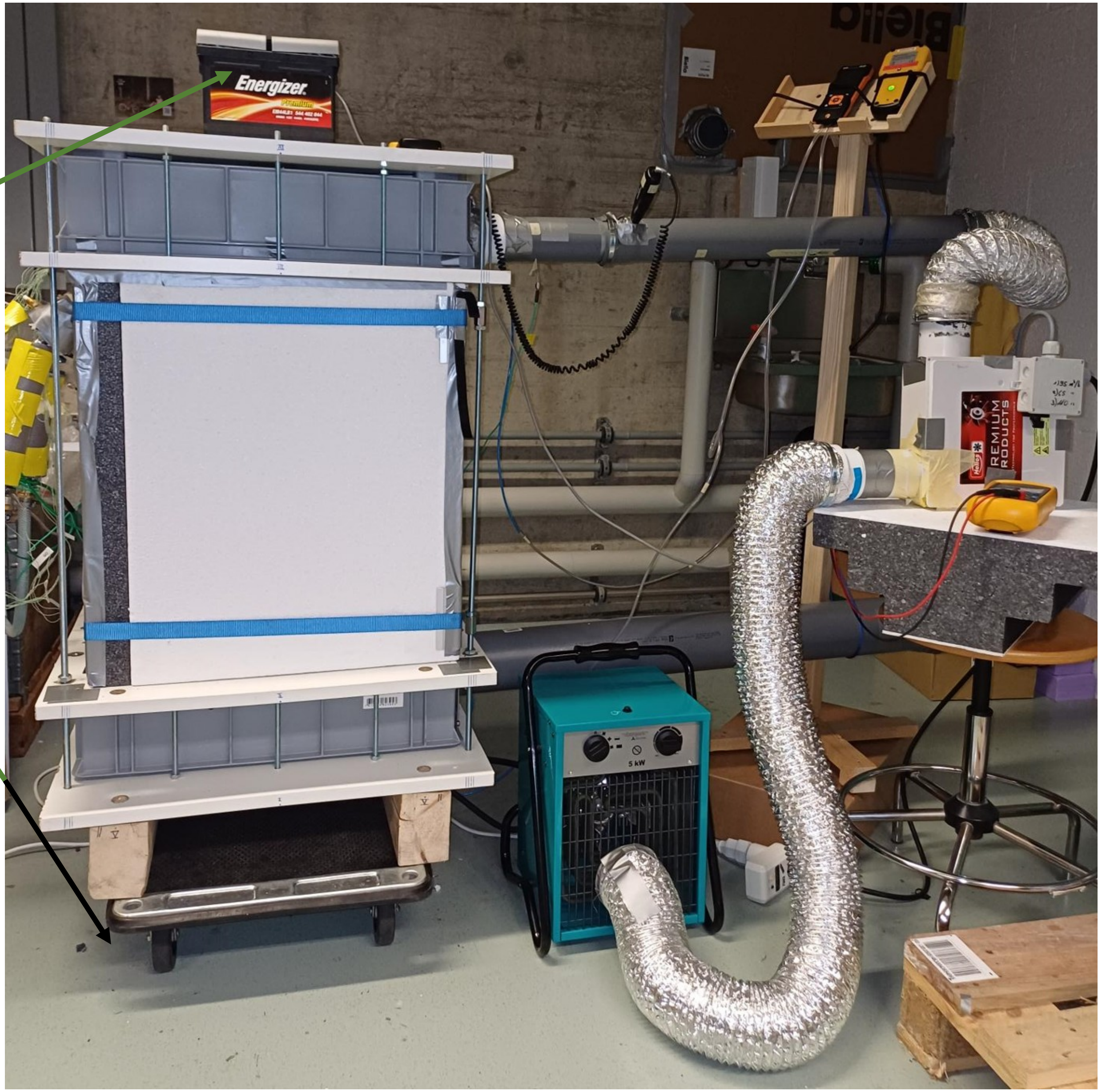
# Performance comparison as function of flow and setup

| Parameter | | Air flow rate Q $(m^3/h)$ | Air flow speed v $(m/s)$ | Pressure drop $\Delta p$ $(Pa)$ | Efficiency η (% $T_{air}$ increase towards $T_m$) | Linear heat transfer $U_l$ $(W\,m^{-1}\,K^{-1})$ | Power P $(W)$ | Power/($T_{air\ in}$-$T_m$) P/ΔT $(W\ K^{-1})$ |
|---|---|---|---|---|---|---|---|---|
| Setup | parallel | 24 | 1.8 | **11** | 94% | 56 | 71 | 7.6 |
| | | **44** | **3.2** | **37** | 83% | **72** | **129** | **12.4** |
| | serial | 13.3 | 2.0 | 35 | **100%** | 38 | 31 | 4.6 |
| | | **30** | **4.3** | **130** | **95%** | **49** | **100** | **10** |

- **Parallel** setup has better performances than serial one due to **lower pressure drop**
- **Serial** setup has the air temperature increase efficiency η which is better but the parameter cannot compensate the **pressure drop drawback**

# Mobile Cooling system with battery charged with renewable energy

Battery and wheels



# Conclusion

- We develop 2 systems (parallel + serial) to store the night cold with PCM and refresh buildings during hot summer days
- Due to **low pressure drop** the **parallel setup is the best**
- By using 20 cells instead of 2, we can **1.75 kWh** of cold storage what is sufficient for **20m²** well insulated rooms.
- Outside temperatures of 14°C allow to charge a cell with 12m³/h airflow in **3 hours**.
- the use of an electric battery makes it possible to refresh buildings with **renewable energy** without using noisy, energy-inefficient fan coils.