Thermal storage and heat discharge efficiency of an air-PCM-water heat exchanger

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Hes·so Haute Ecole Spécialisée de Suisse occidentale Fachhochschule Westschweiz
ENERGY Institute of Applied Research in Energy Systems

aeby + mouthon architectes sa
SOTTAS BULLE building
AMSTEIN + WALTHERT
Wärmeaustausch Technologien AG Technologies d'échangeurs SA WT

Introduction

- In Switzerland, buildings temperature control and hot water = 40% of the energy consumption
- Renewable energy in particular photovoltaic is growing fast, but with production peaks at periods of low heating requirements.

Time mismatch can be solved by thermal storage and
PCM is a solution

Thermal storage concept for winter

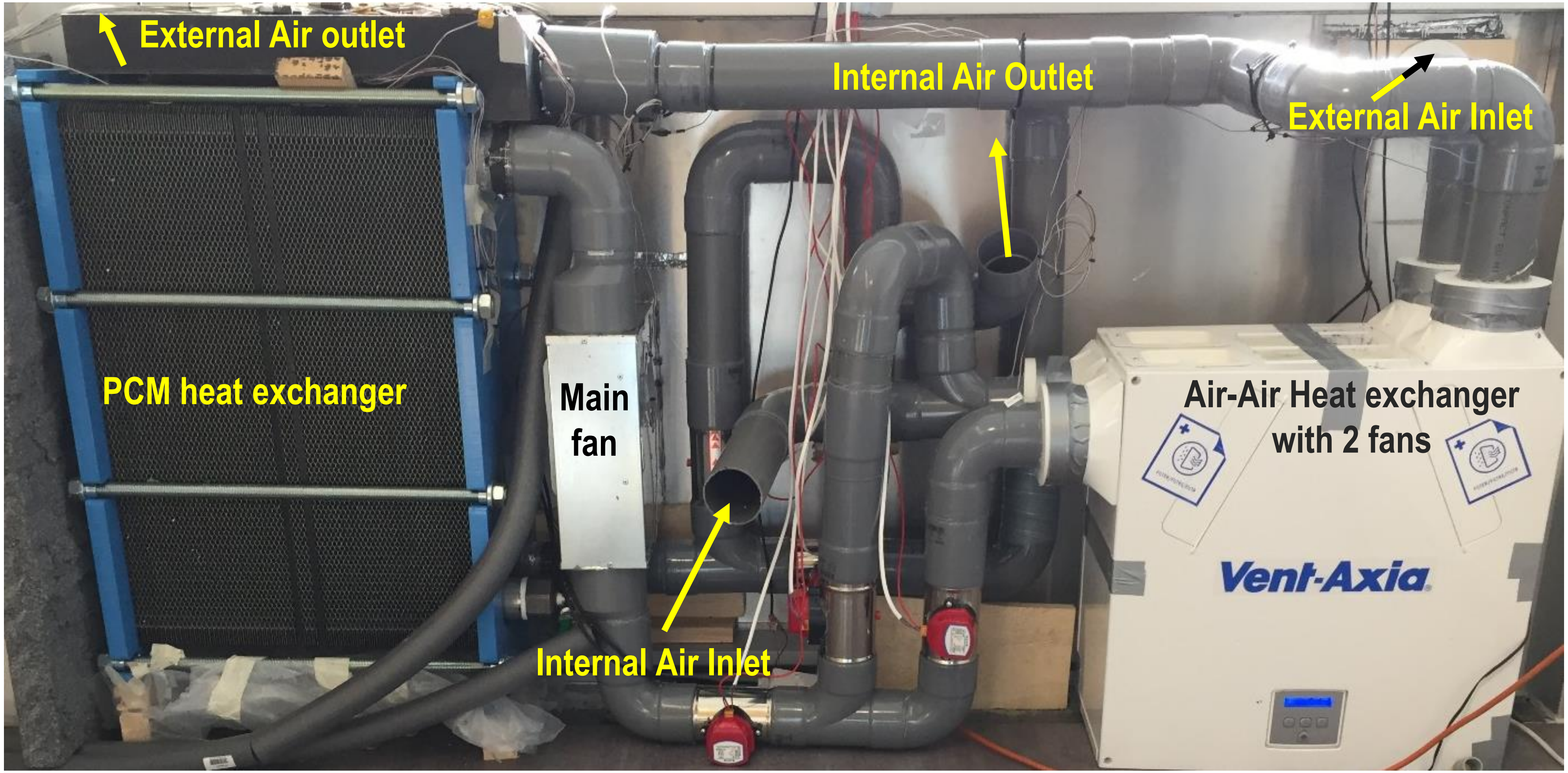
Thermal Battery Mode	Winter
Charge	During the day with PV energy: **hot water → PCM**
Storage	T_{int} >= $T_{comfort}$
Discharge	T_{int} < $T_{comfort}$

Thermal storage concept for winter and summer

Thermal Battery Mode	Winter	Summer
Charge	During the day with PV energy: **hot water → PCM**	During the night **external cold air → PCM**
Storage	T_{int} >= $T_{comfort}$	T_{int} <= $T_{comfort}$
Discharge	T_{int} < $T_{comfort}$	T_{int} > $T_{comfort}$

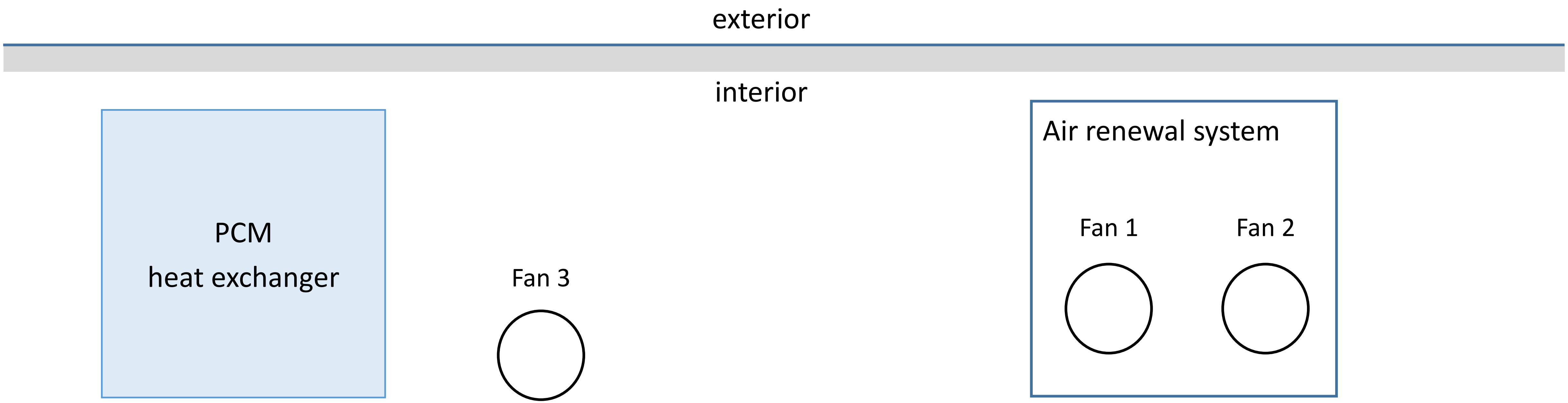
performed by a
single PCM Heat Exchanger
with T_{fusion} = 23°C

Thermal battery setup

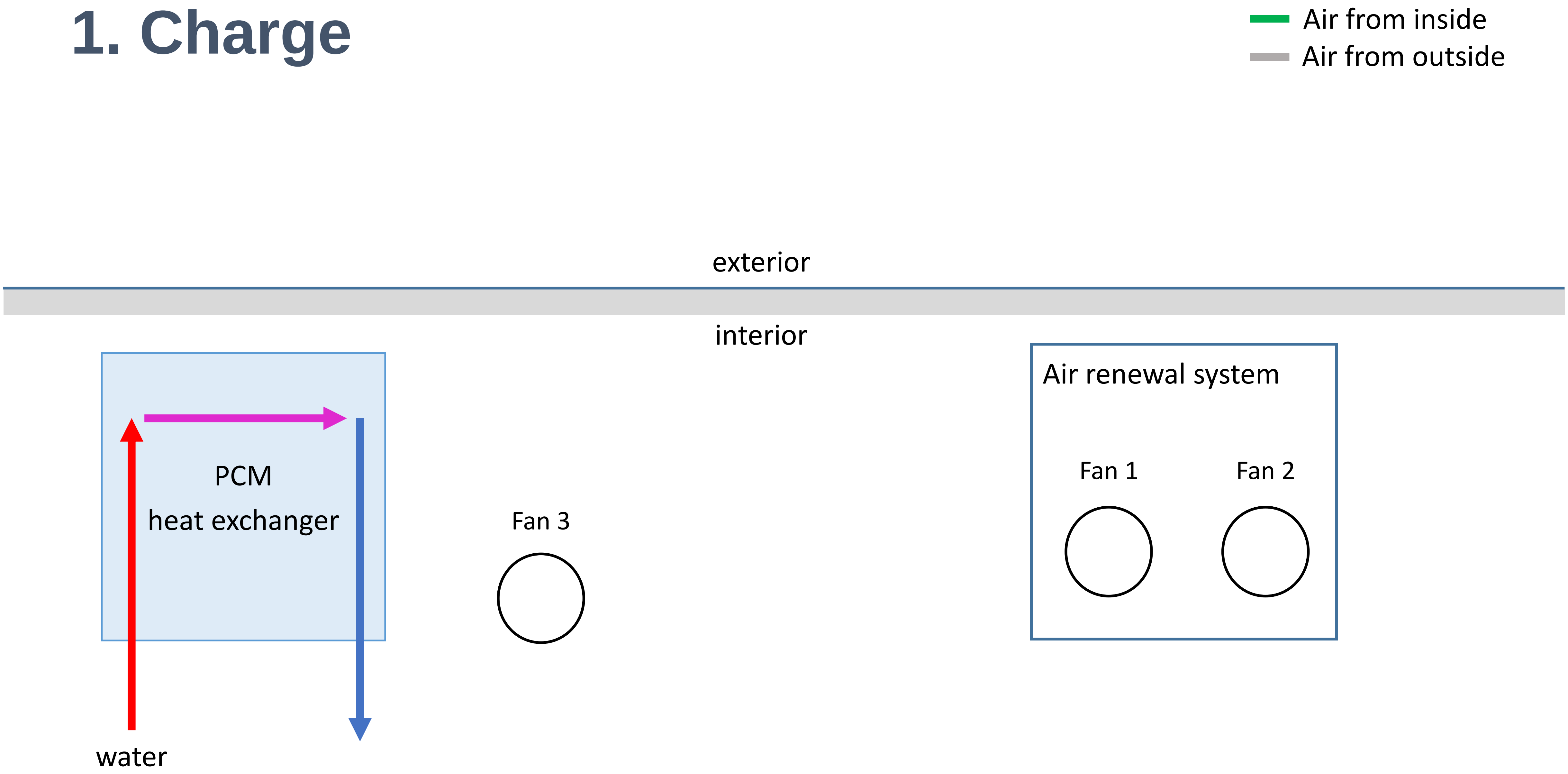


Thermal battery modes

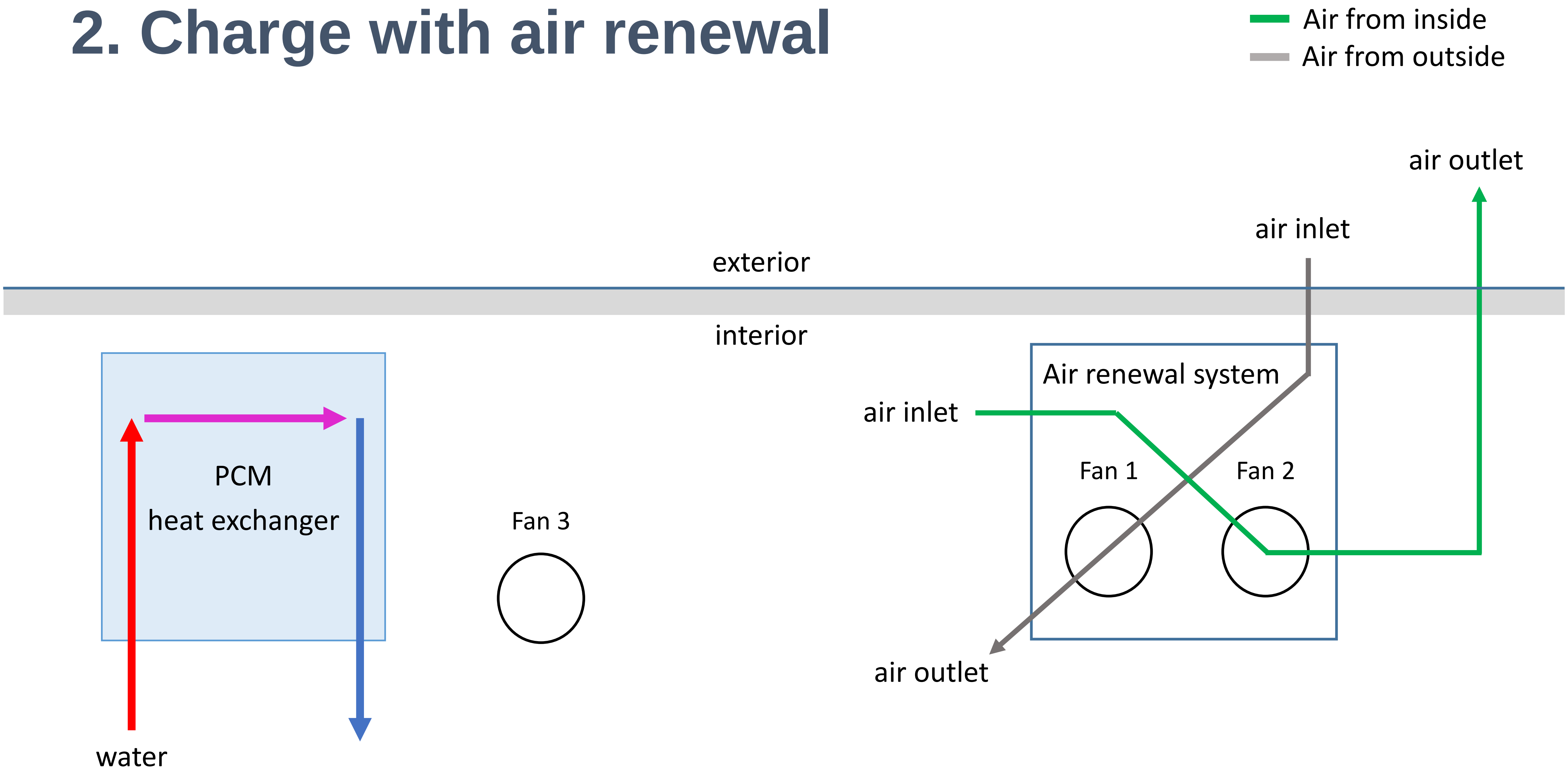
Air from inside
Air from outside



1. Charge

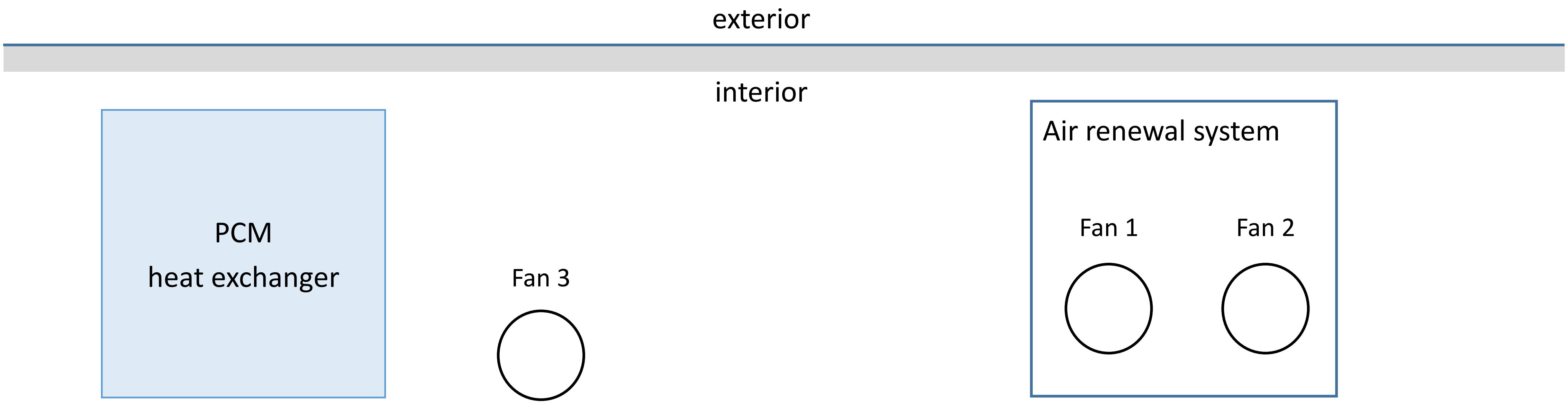

Air from inside
Air from outside
exterior
interior
PCM
heat exchanger
water
Fan 3
Air renewal system
Fan 1
Fan 2

2. Charge with air renewal

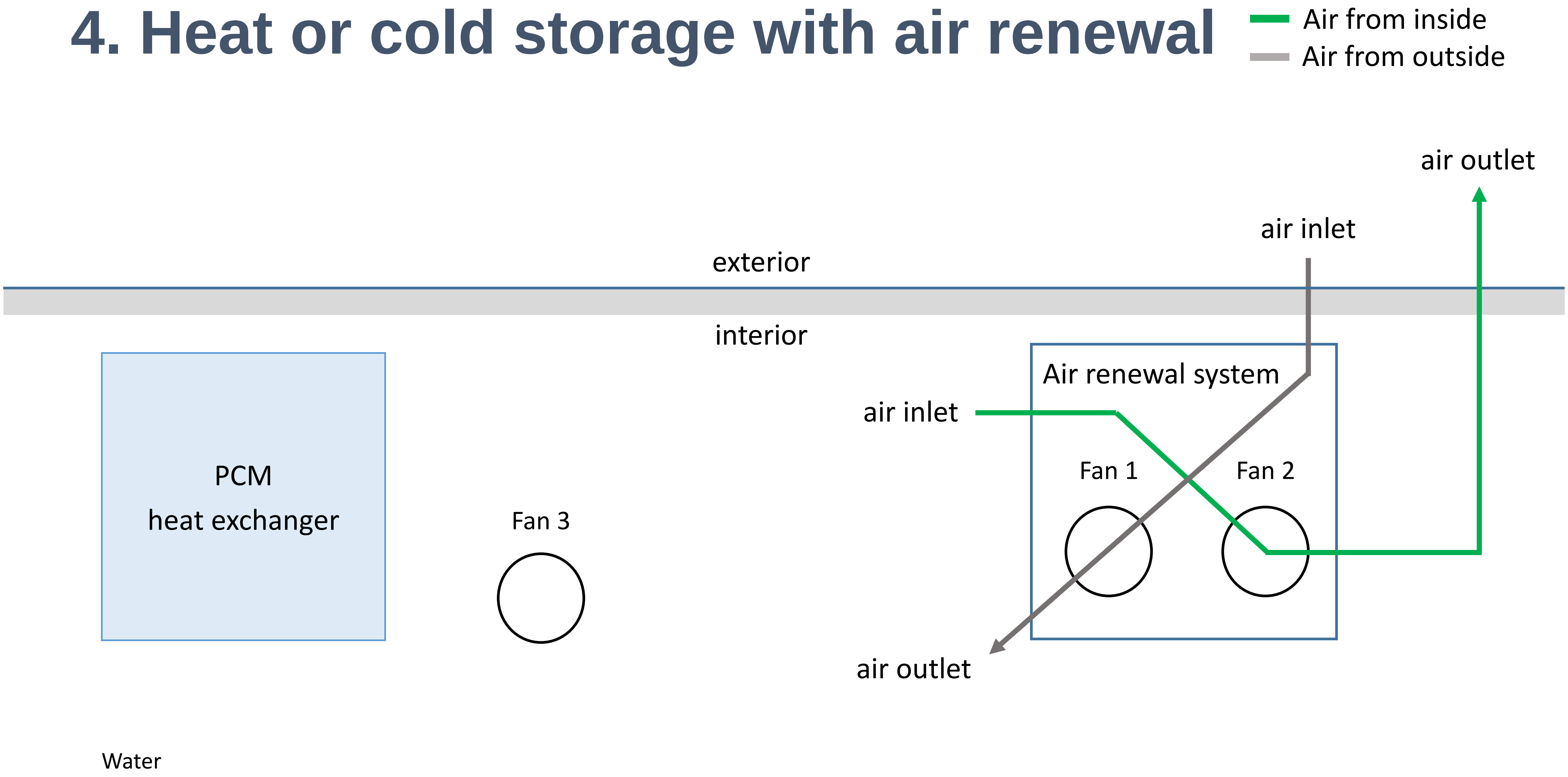


3. Heat or cold storage

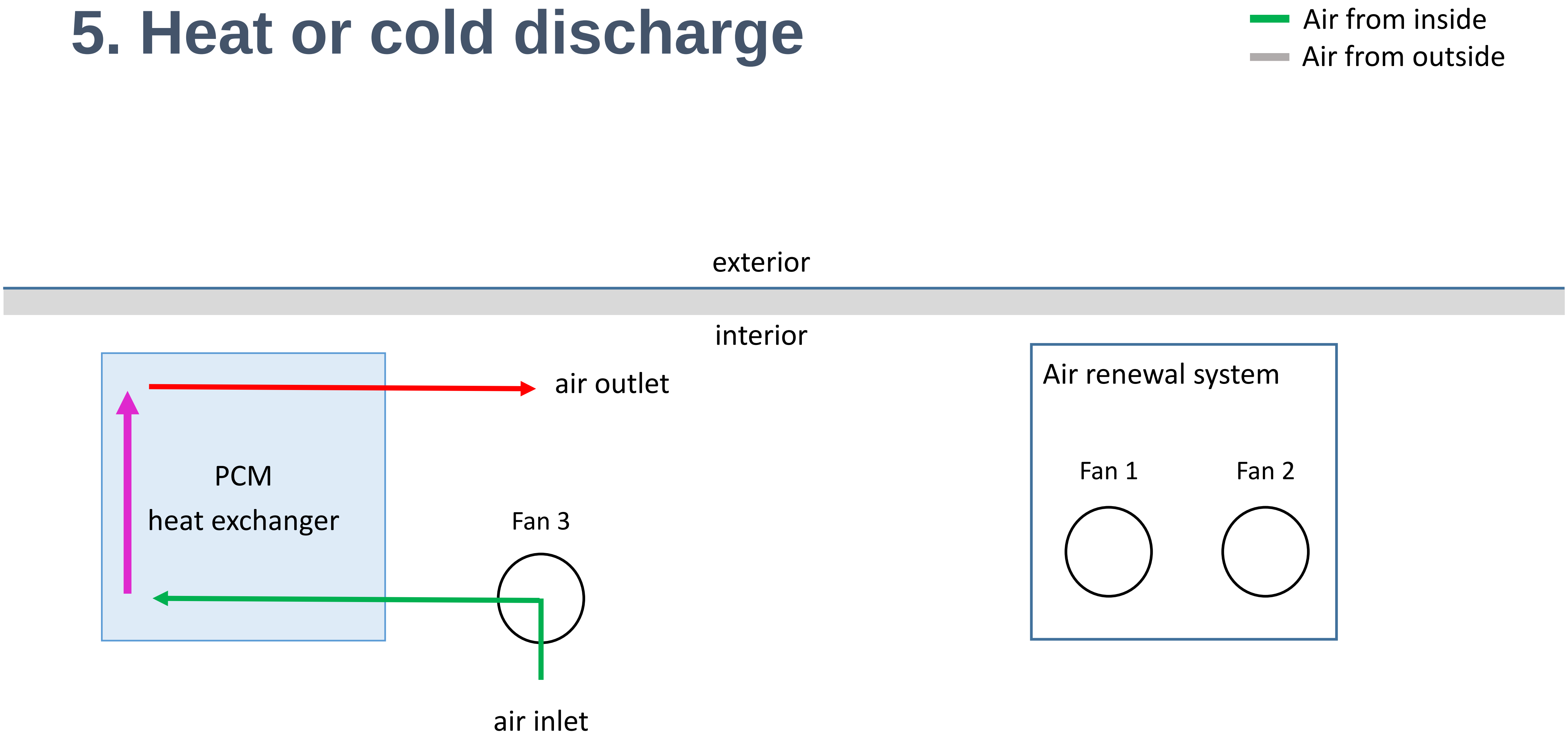
Air from inside
Air from outside



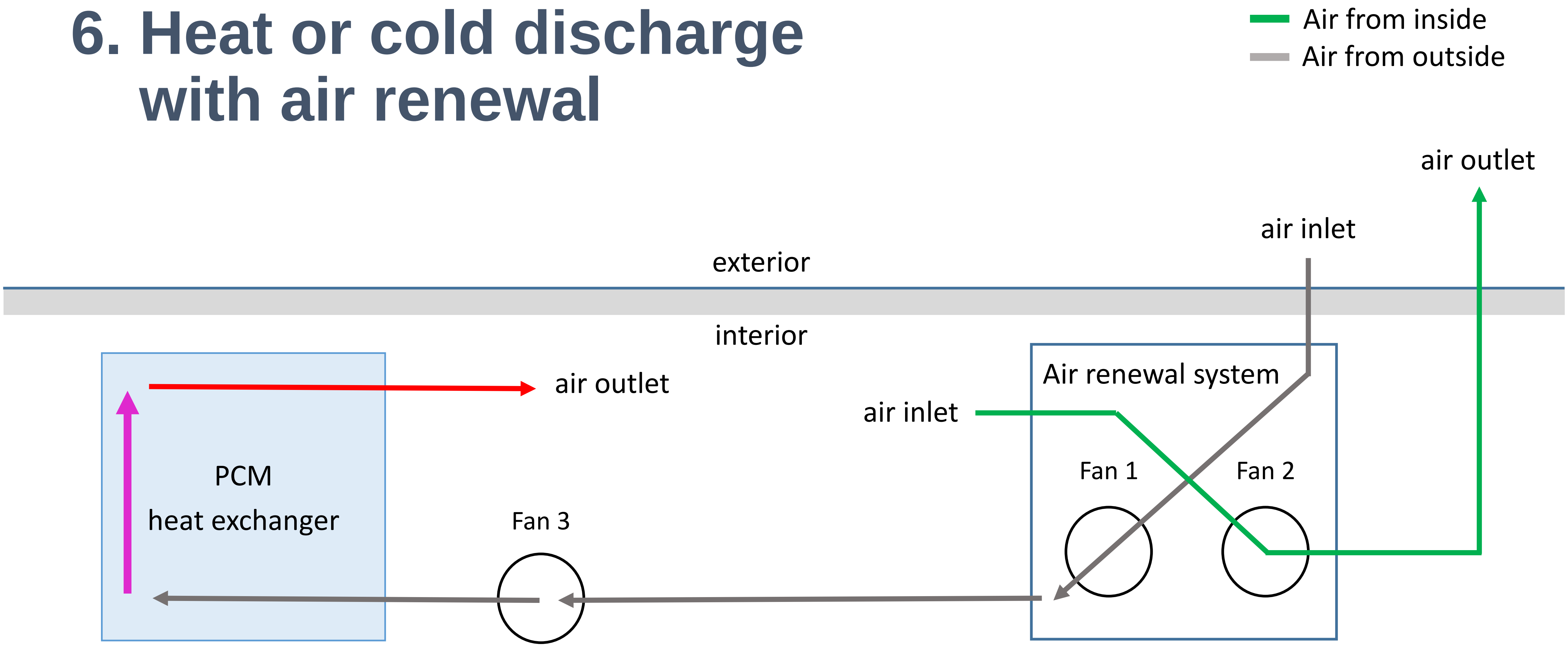
4. Heat or cold storage with air renewal



5. Heat or cold discharge

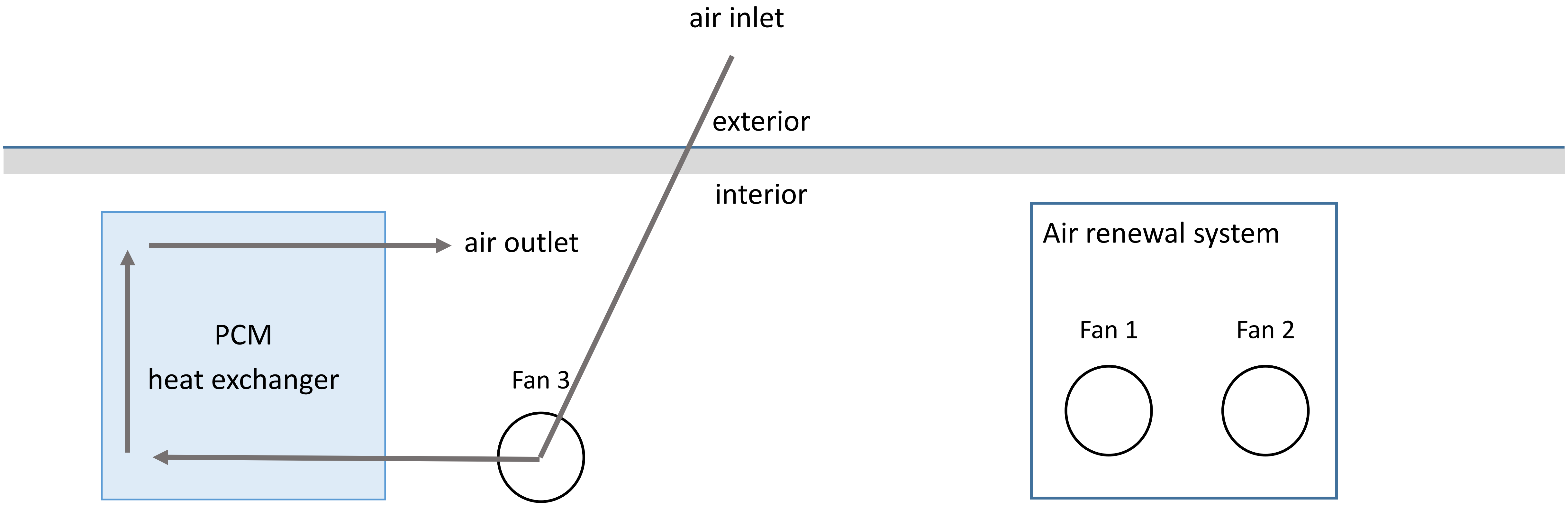


6. Heat or cold discharge with air renewal

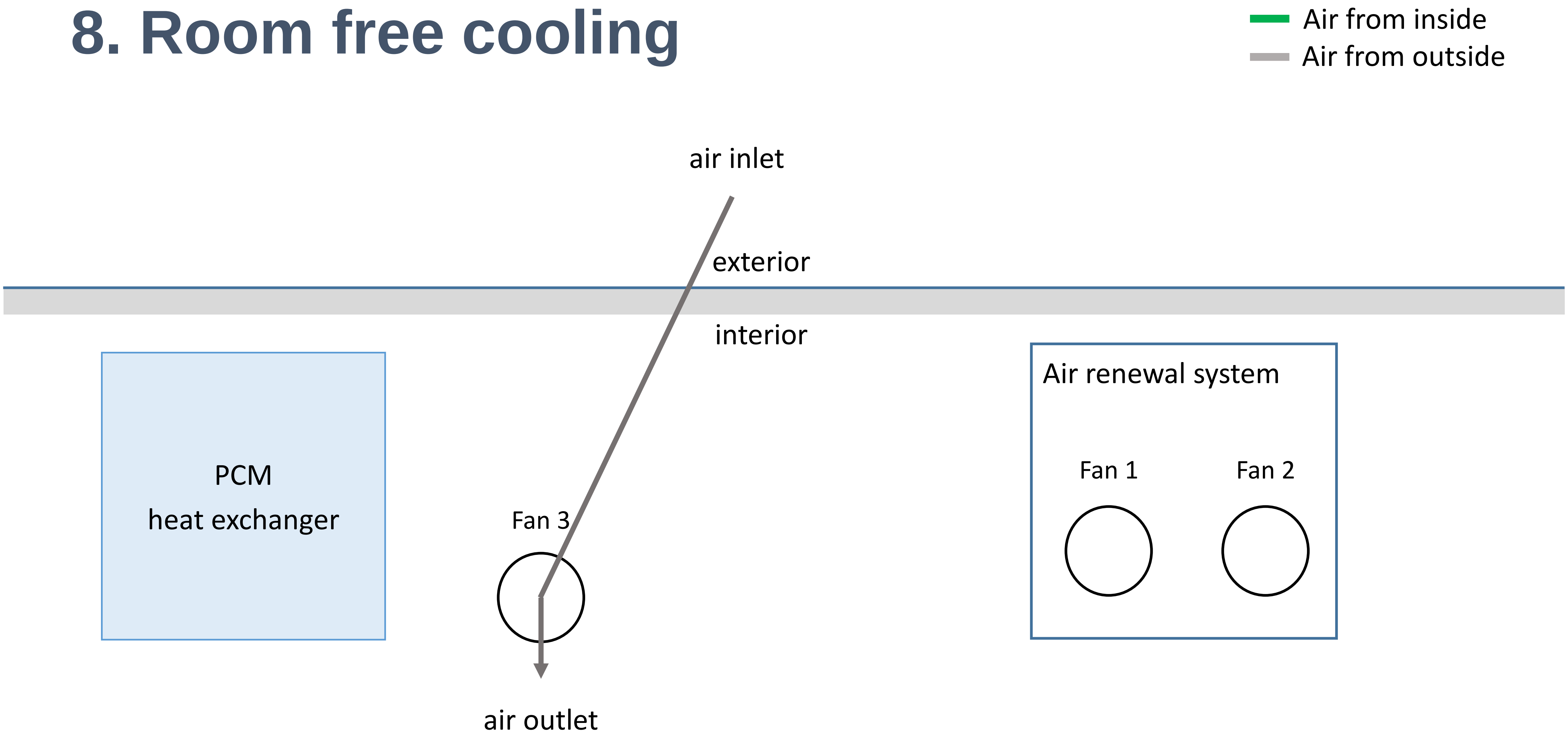


7. PCM free cooling

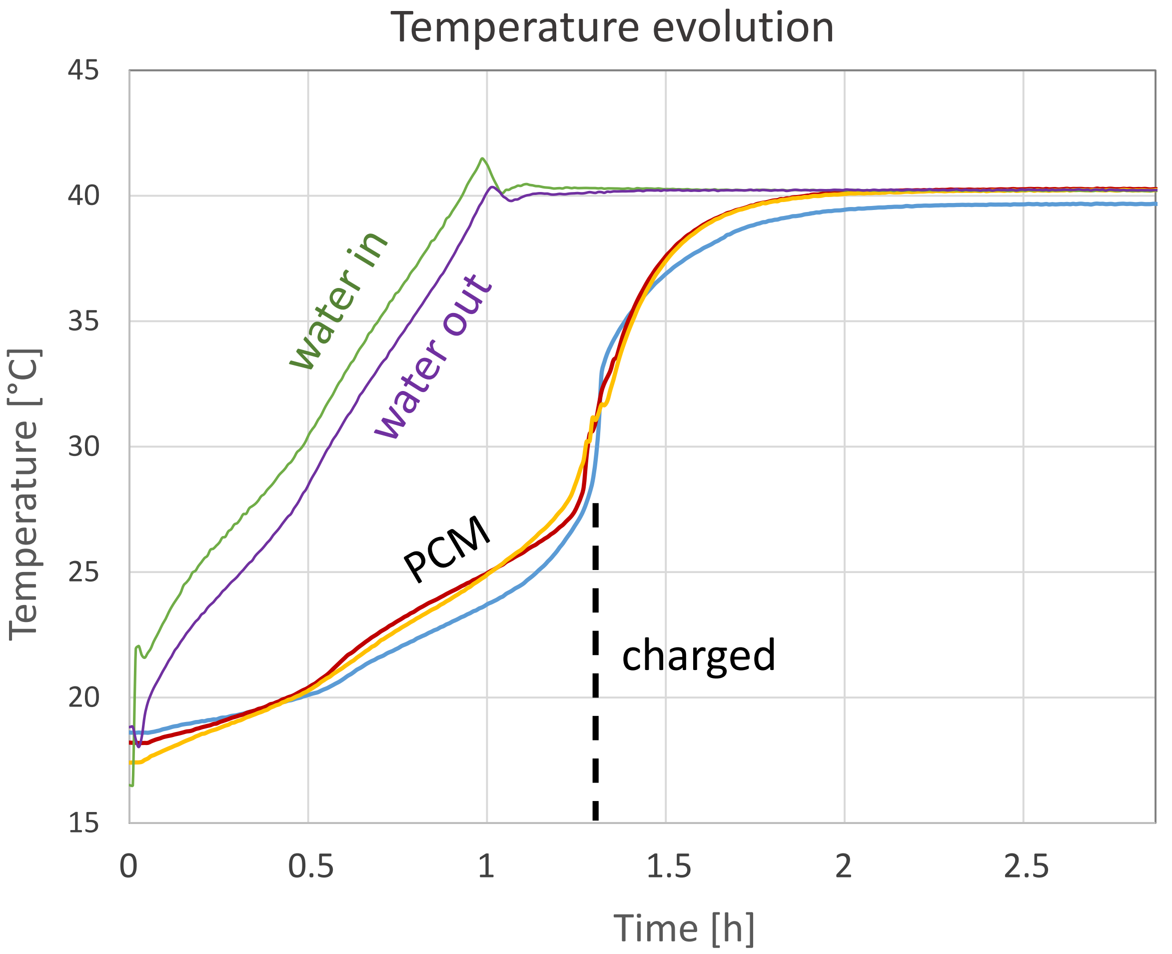
Air from inside
Air from outside

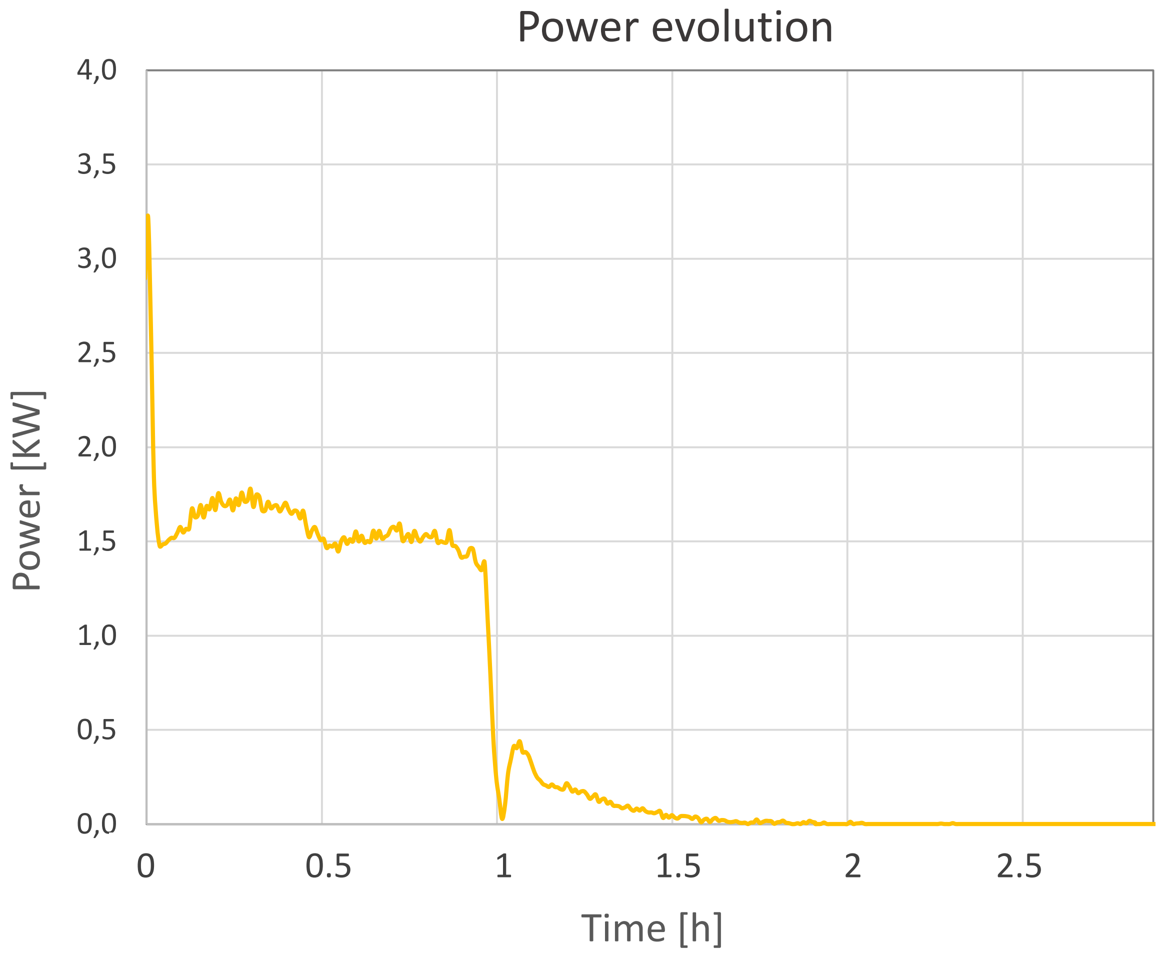


8. Room free cooling



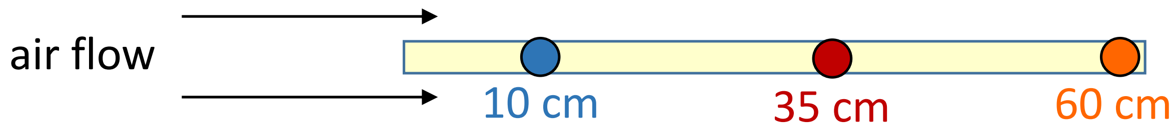
1a. Heat charge 18 → 40°C

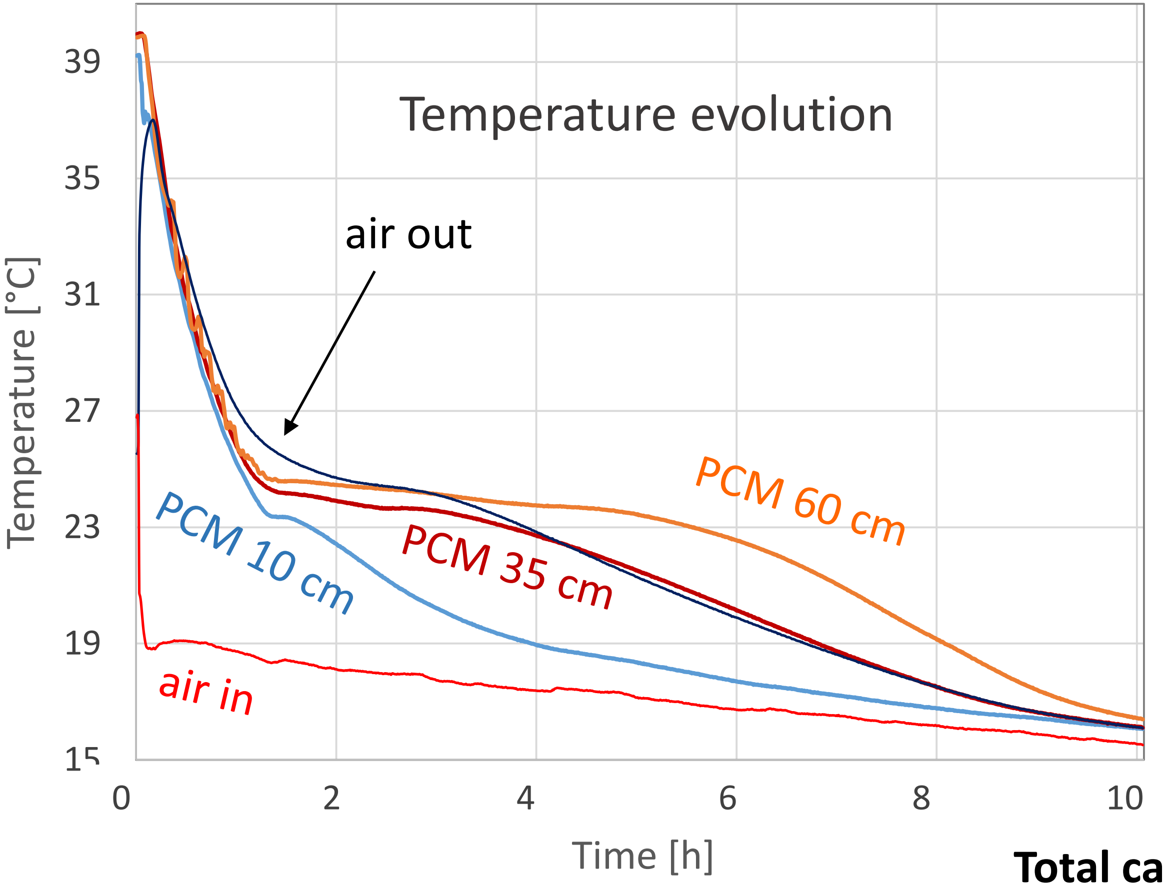


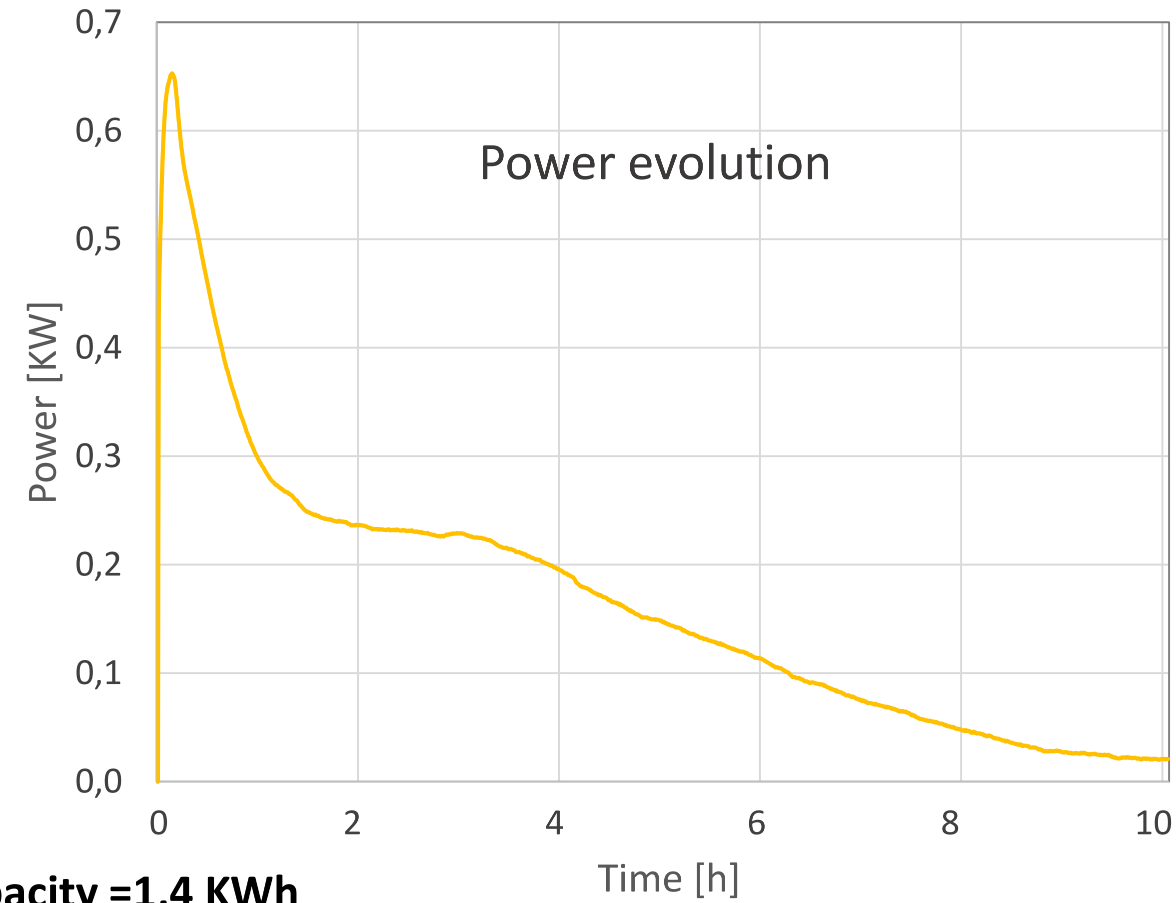


Total capacity = 1,7 KWh

5a. Heat discharge 40°C→16°C



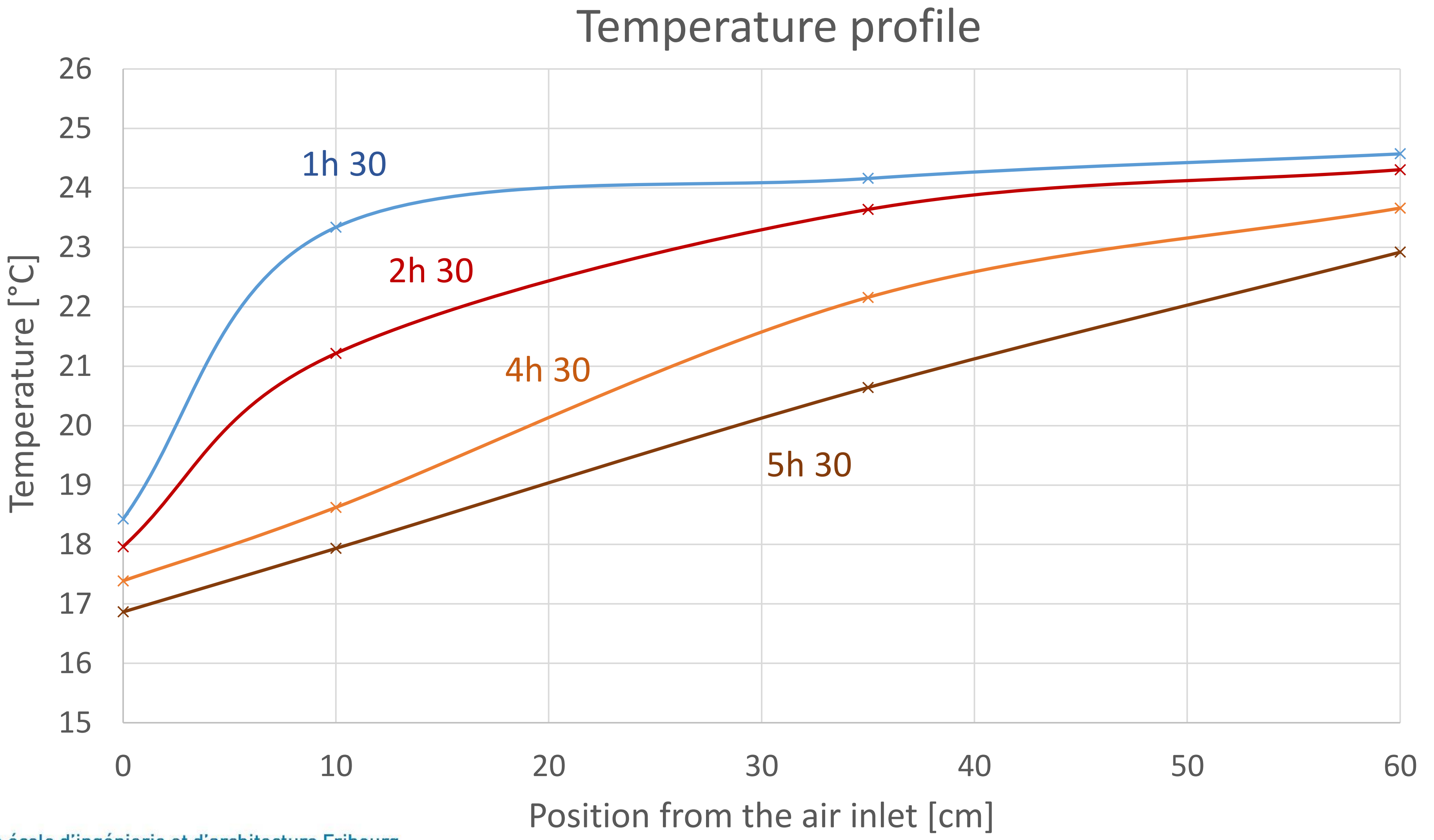




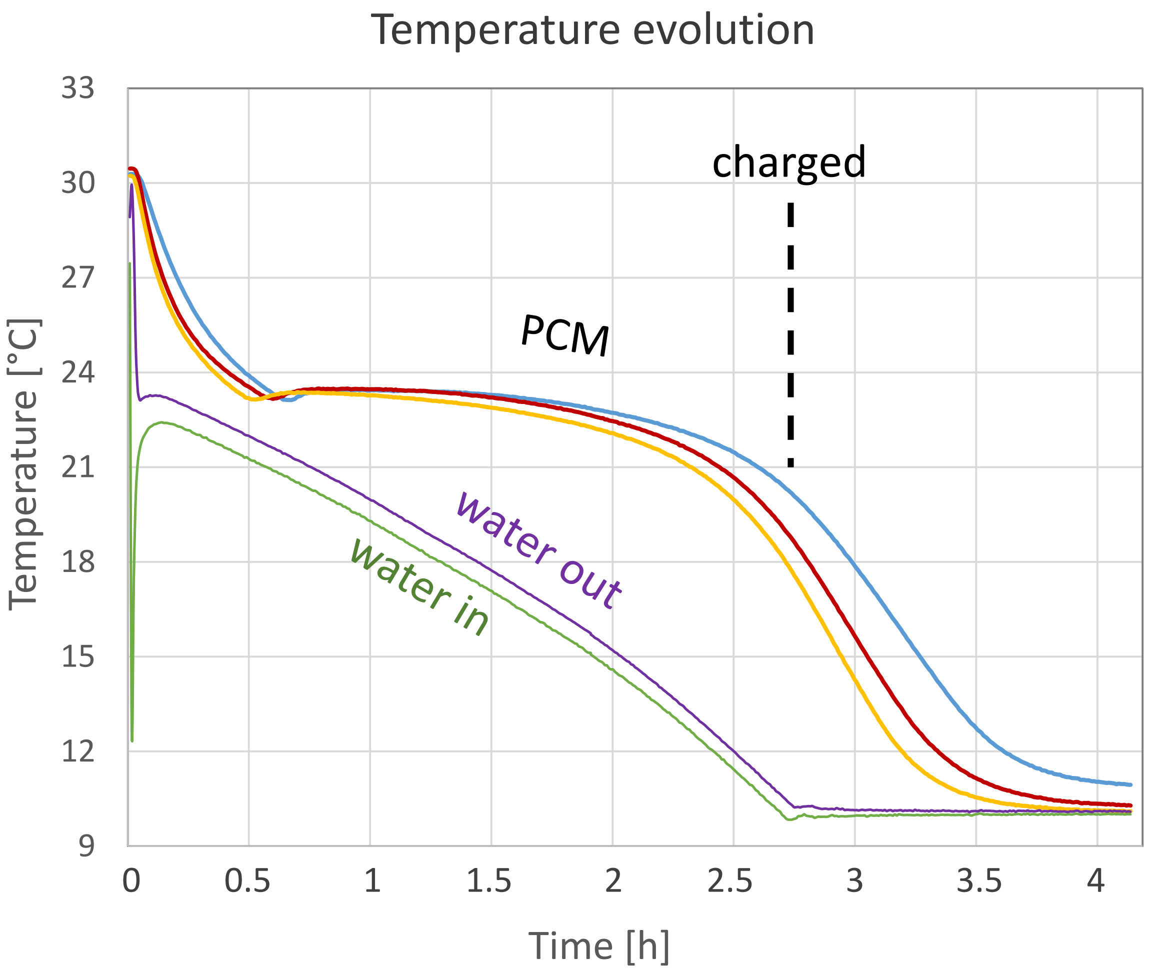
Total capacity =1,4 KWh

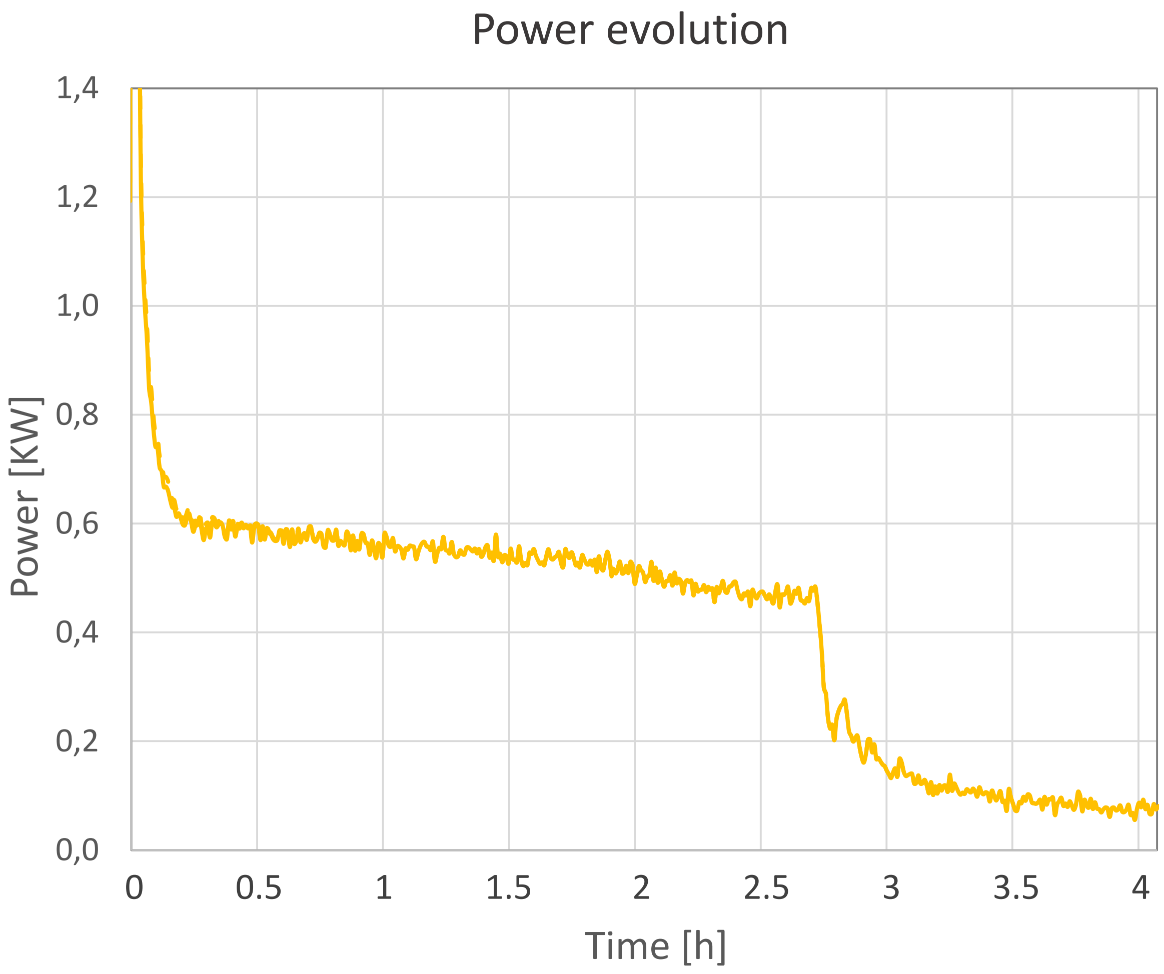
300 W during 4 h

Temperature profile during the heat discharge



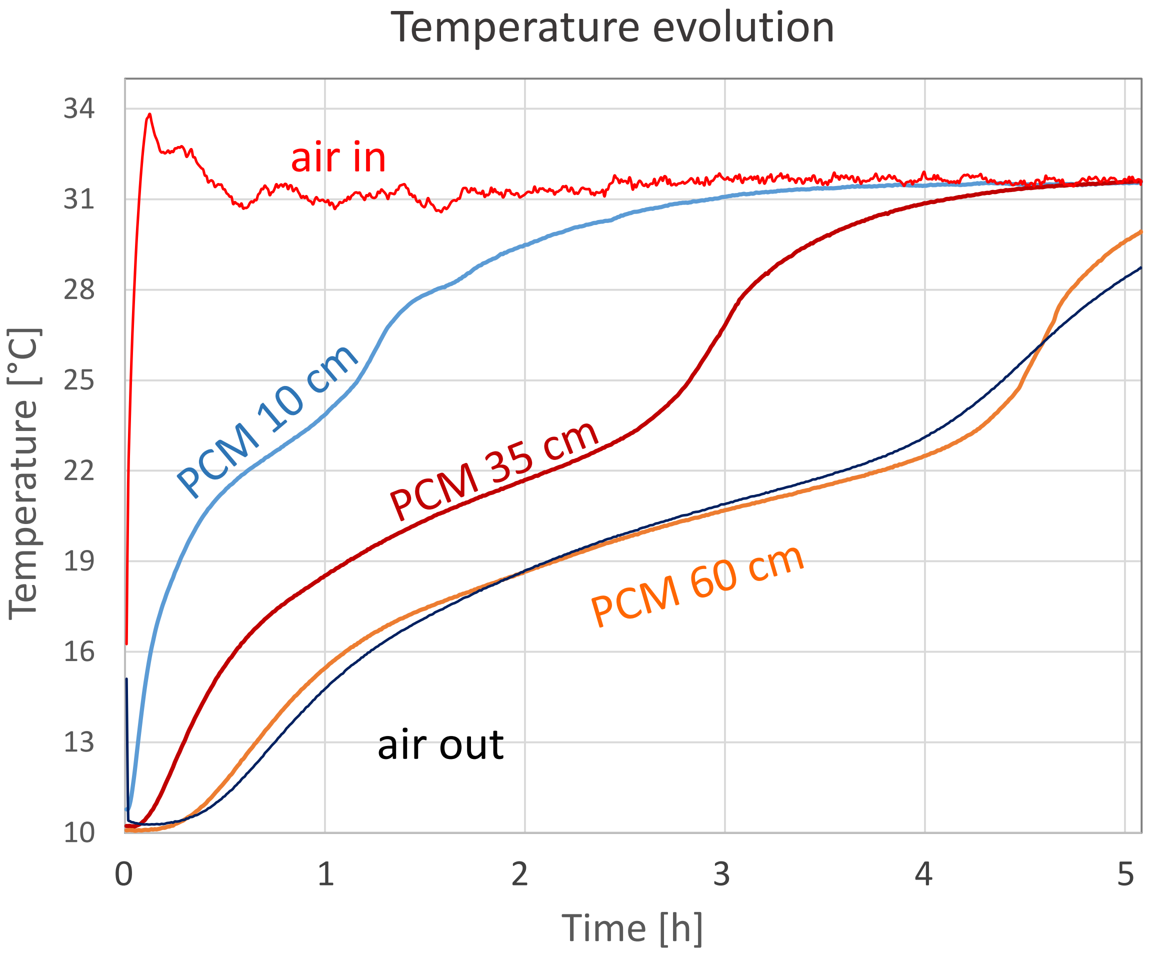
1b. Cold charge 30°C → 10°C

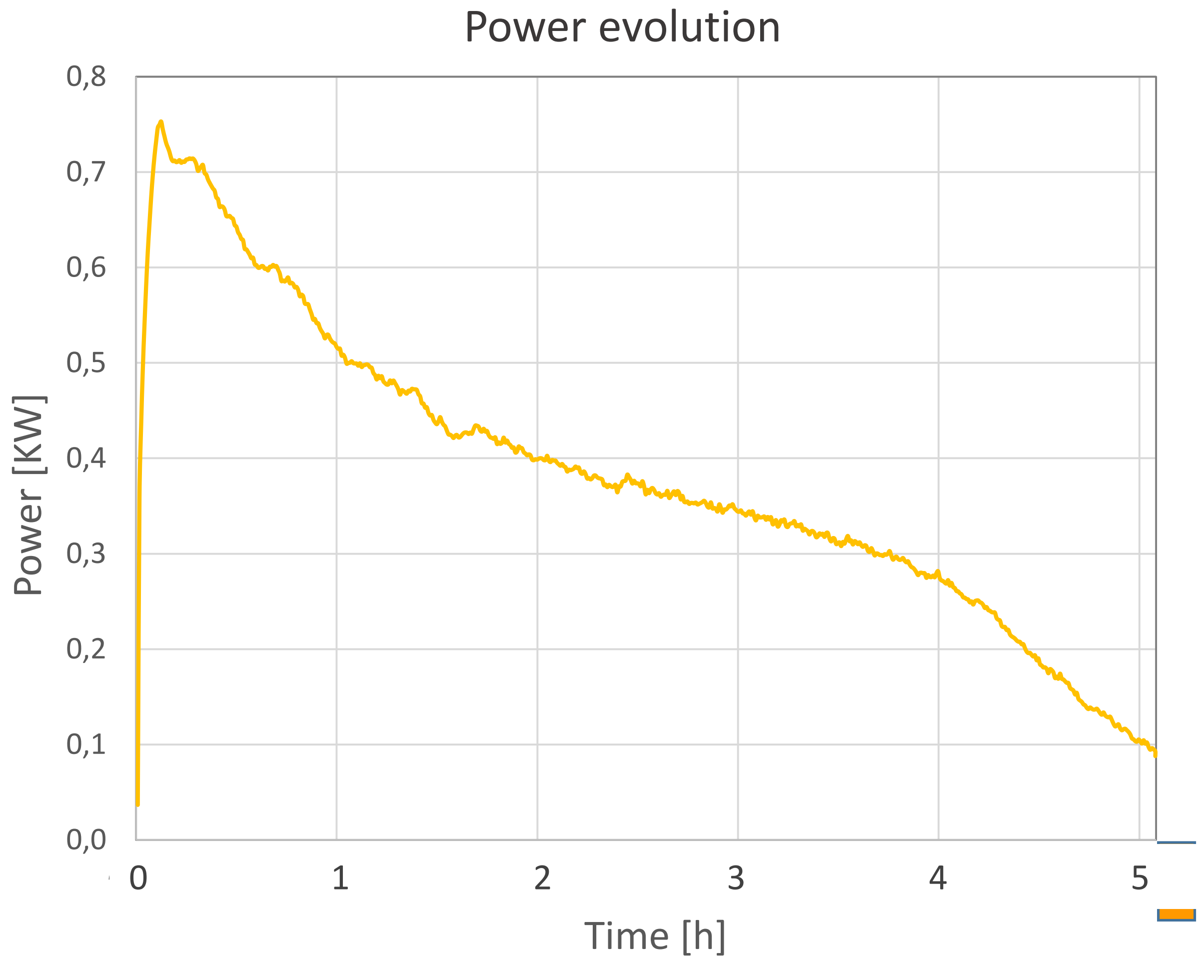




Capacité total=1,9 KWh

5b. Cold discharge 10°C → 30°C

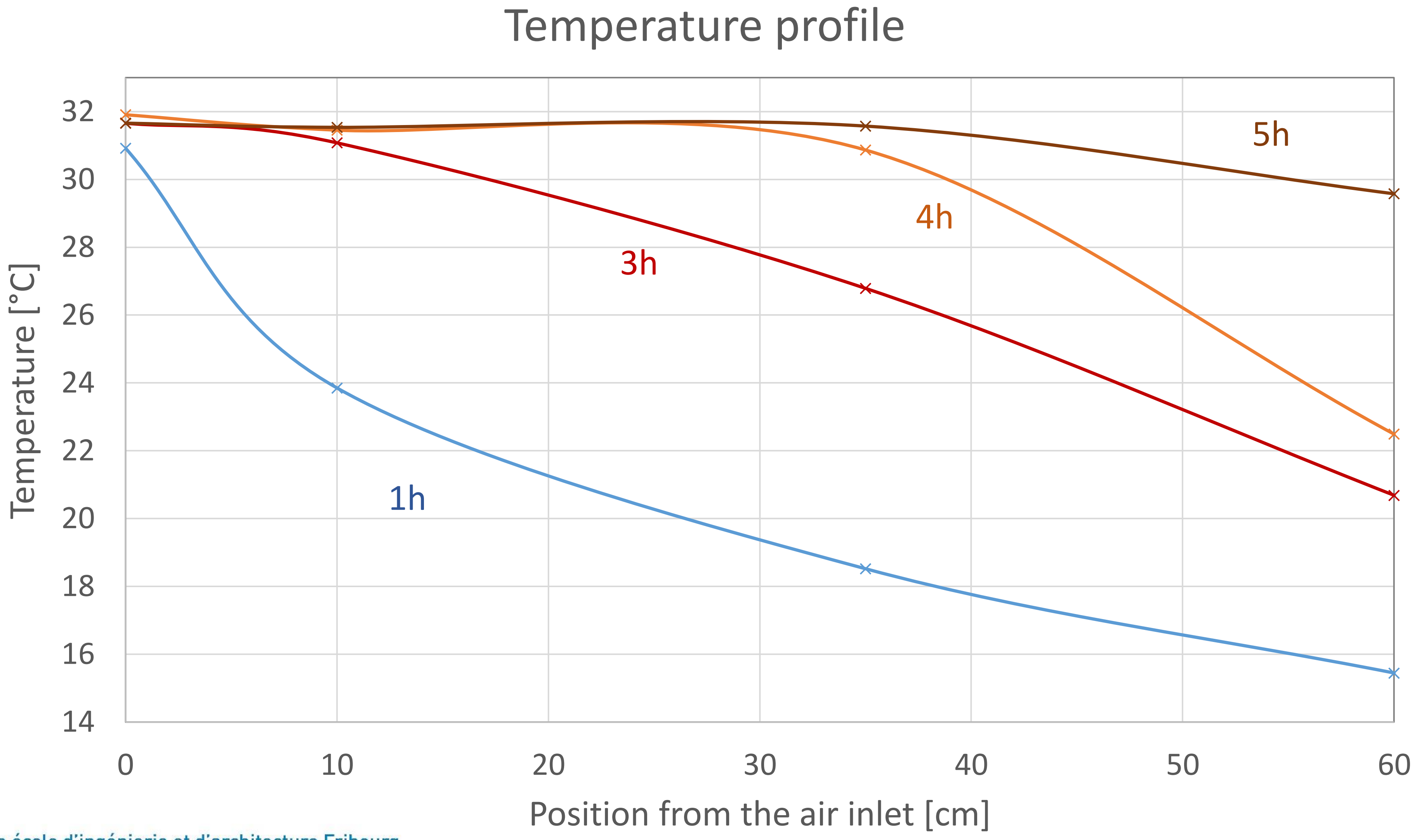




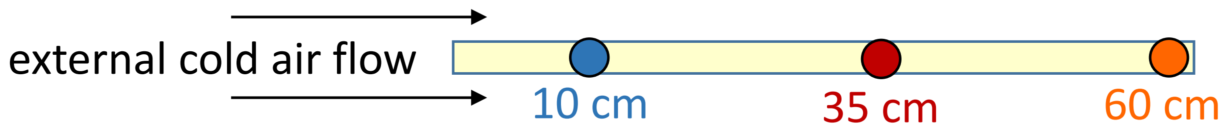
Total capacity = 1,8KWh

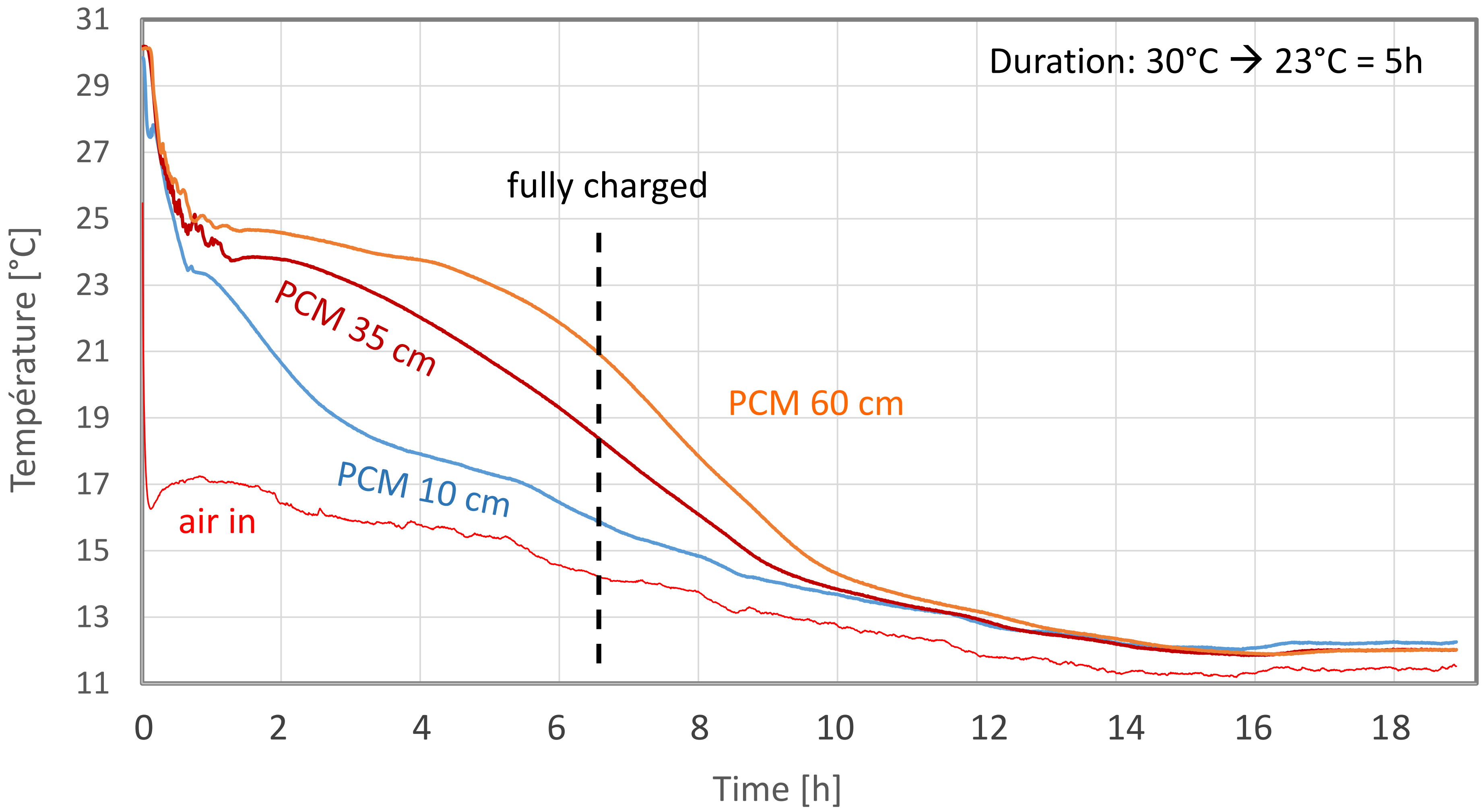
440 W during 4 h

Temperature profile during the cold discharge



PCM free cooling





Conclusions

- **PCM Heat-exchanger** for heating, cooling, storage of heat&cold and air renewal
- **Storage of 1.7 KWh** with 18 litres of PCM
- Discharge power over 4 h:
  - **300 KWh** for heating
  - **440 KWh** for cooling
- **PCM free cooling** with external air of 16°C → full solidification in 6.5h
- Strong potential for future implementation in **new and old buildings**