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# Thermal energy storage system adapted to greenhouse cultivation in isolated northern communities: Performances & Lessons learned



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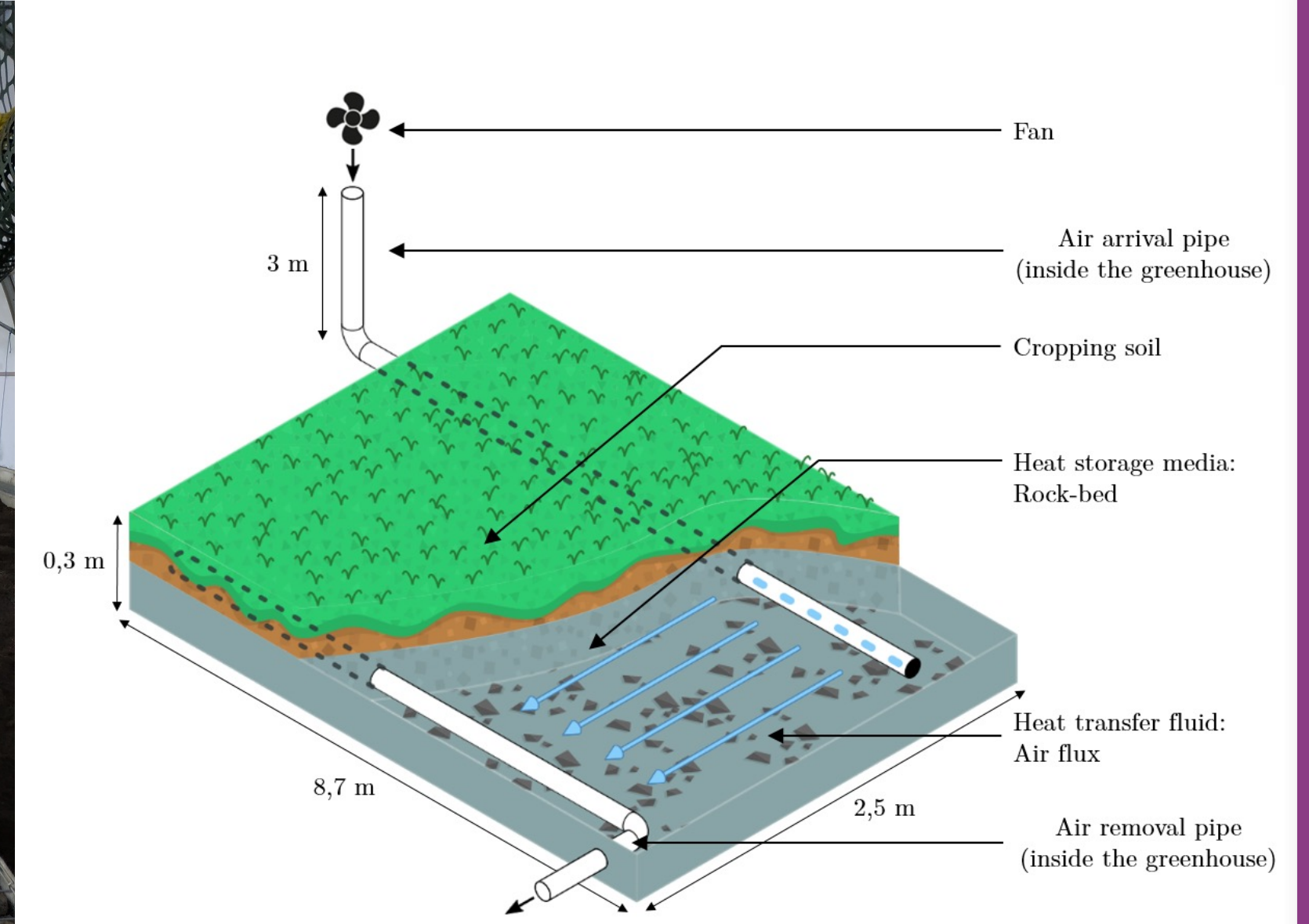
Greenhouse

- Located in Kuujuaq (Quebec, 58°N latitude)
- Surface area of 140 m<sup>2</sup> / Polycarbonate envelope
- In 2016, about one ton of vegetables were harvested



Main problems: (1) The day-night temperature variation is unfavorable to plant growth and (2) the growing season is short.

➔ Thermal Energy Storage!



Thermal Energy Storage

Energy Indicators

$Q_{StoAir}^c$  = Energy taken from the air and stored in the rock bed (charging phase)

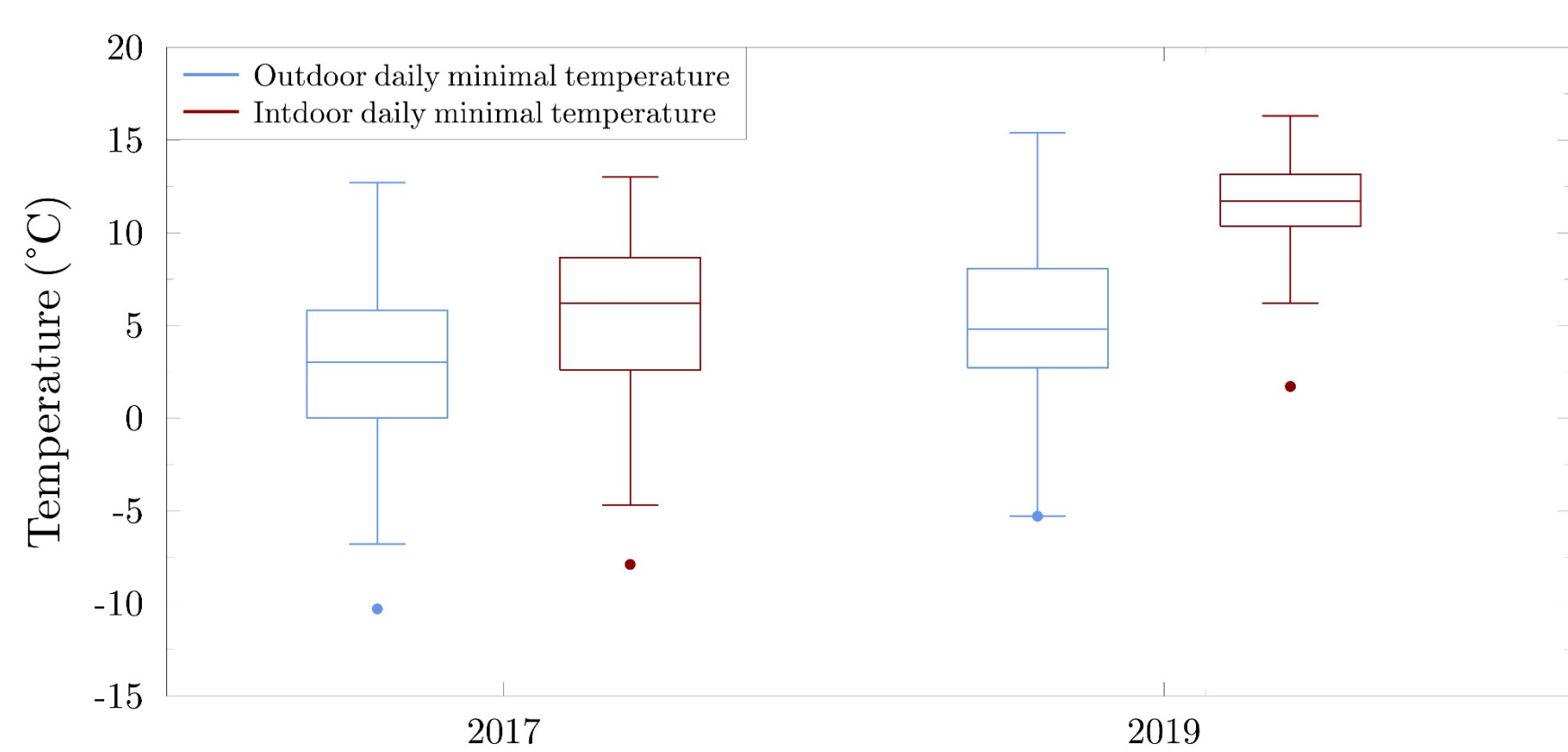
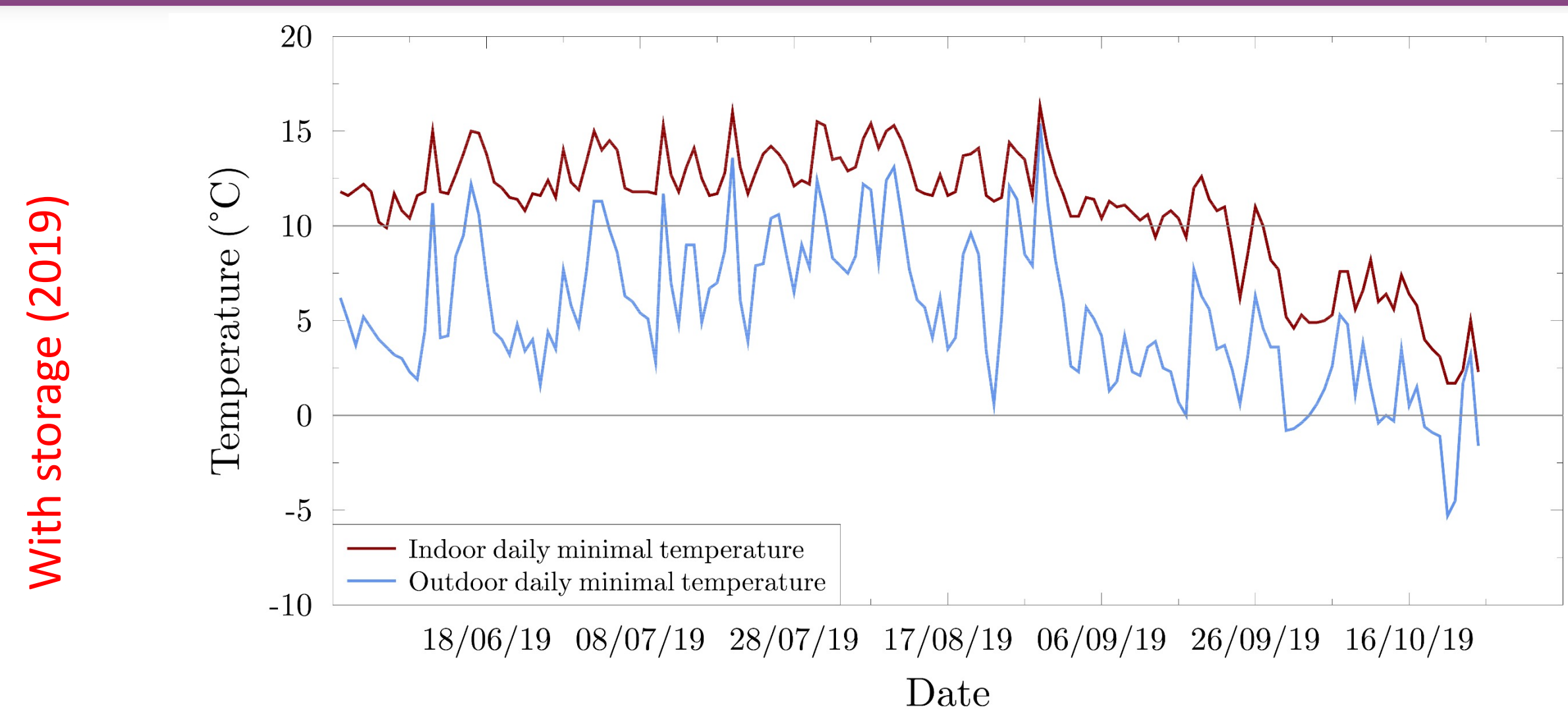
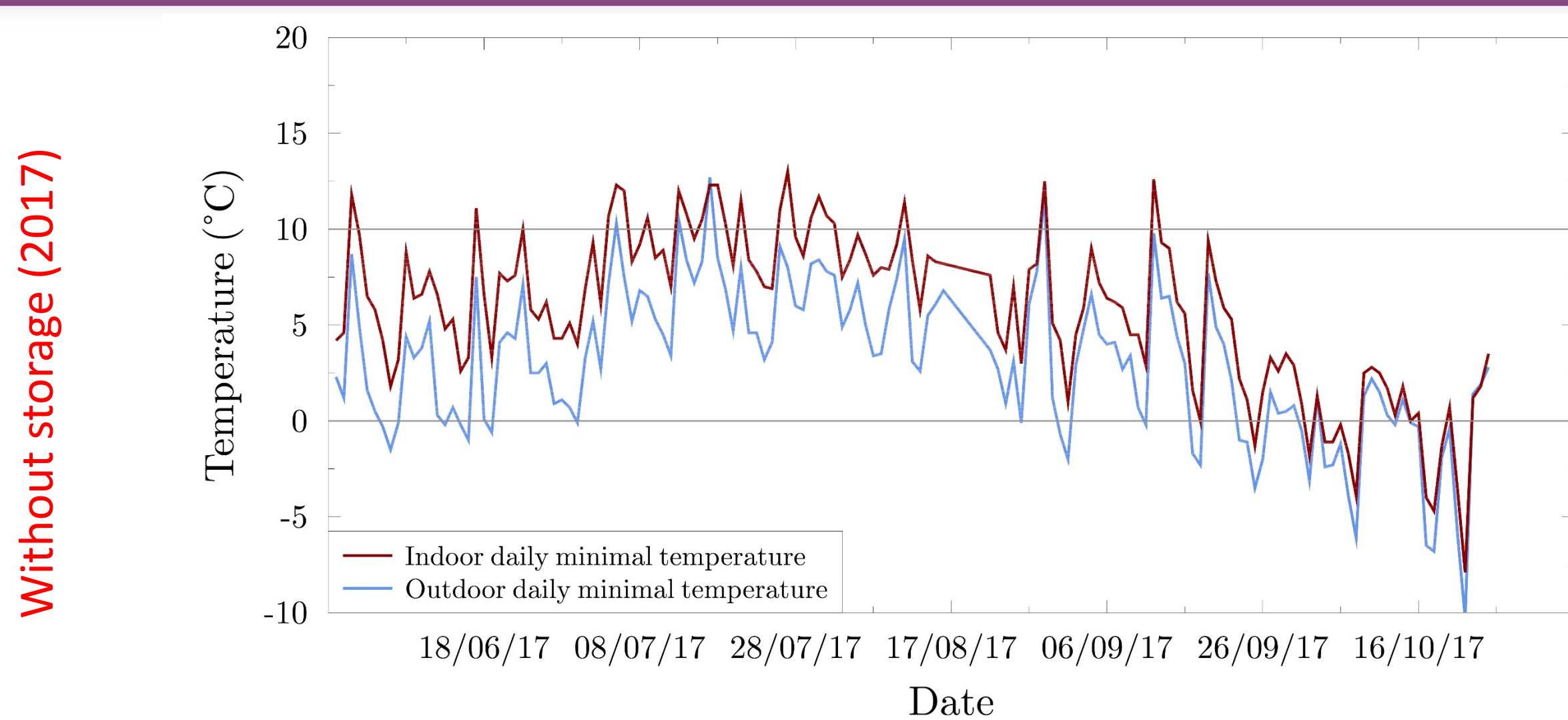
$Q_{StoAir}^d$  = Energy released by the rock bed to the air (discharge phase)

$$\eta_r = \frac{Q_{StoAir}^d}{-Q_{StoAir}^c} \quad \text{Recovery Factor}$$

$$COP = \frac{Q_{StoAir}^d}{Q_{elec}^c + Q_{elec}^d} = \frac{\text{Useful energy}}{\text{Energy paid}} \quad \text{Coefficient of Performance}$$

| Dates                       | $Q_{StoAir}^c$ (kWh) | $Q_{StoAir}^d$ (kWh) | $\eta_r$ (%) | COP |
|-----------------------------|----------------------|----------------------|--------------|-----|
| June 07 → June 13           | -260                 | 173                  | 67           | 2,1 |
| July 26 → August 1st        | -84                  | 0                    | 0            | 0   |
| September 06 → September 12 | -191                 | 446                  | 234          | 3,6 |

Impact on greenhouse air temperature



Nights below 10°C : 82% in 2017 ; only 24% in 2019  
Reduction of the day/night variation



Extending the growing season: yes but... it requires a long-term analysis (growing seasons are not the same from one year to an other)

Outlooks

- Improve the operation of the TES by changing the control system (take into account the temperature of the rocks, modify the threshold temperatures of the roof)
- Power the fans with renewable energy (PV panels, wind turbines)
- Install solar thermal air panels to increase the indoor temperature at the beginning of the season and allow water to thaw
- Replicate the TES and instrumentation in other communities



We are still working! And there is still a lot to do!

➔ ETS/LaTEP collaboration + Paul Piché postdoctoral fellowship + SIQINIQ

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