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

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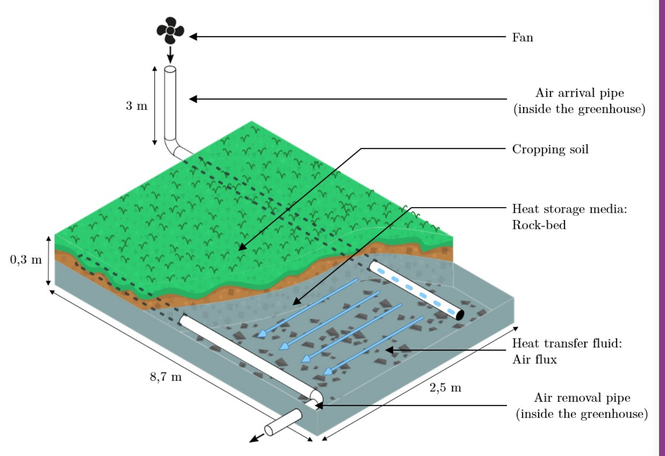
Greenhouse

- Located in Kuujjuaq (Quebec, 58°N latitude)
- Surface area of 140 m² / 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^c_{StoAir} = Energy taken from the air and stored in the rock bed (charging phase)

Q^d_{StoAir} = Energy released by the rock bed to the air (discharge phase)

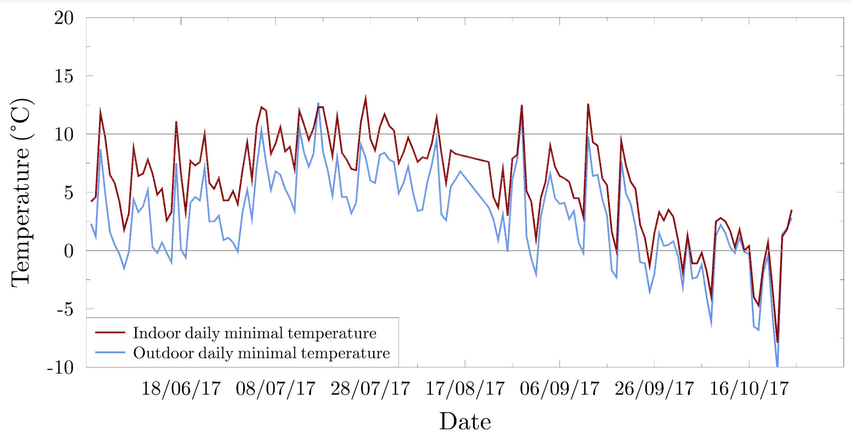
$\eta_r = \frac{Q^d_{StoAir}}{-Q^c_{StoAir}}$ Recovery Factor

$COP = \frac{Q^d_{StoAir}}{Q^c_{elec}+Q^d_{elec}} = \frac{Useful\ energy}{Energy\ paid}$ Coefficient of Performance

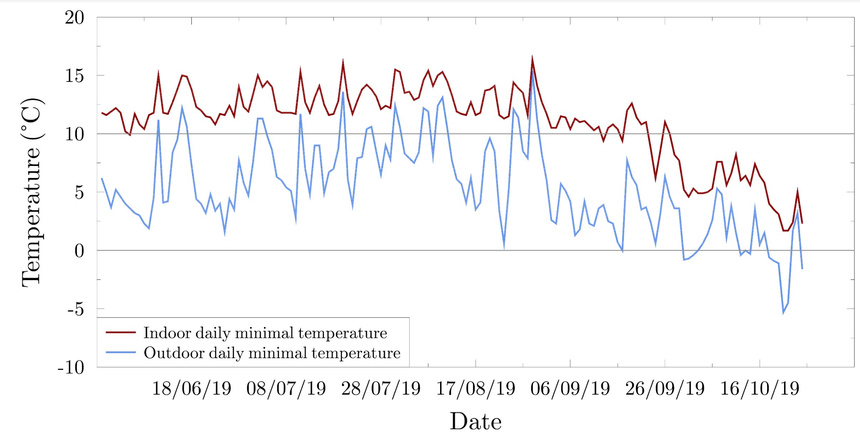
Dates	Q^c_{StoAir} (kWh)	Q^d_{StoAir} (kWh)	η_r (%)	COP
June 07 → June 13	-260	173	67	2,1
July 26 → August 1st	-84	0	0	0
September 06 → September 12	-191	446	234	3,6

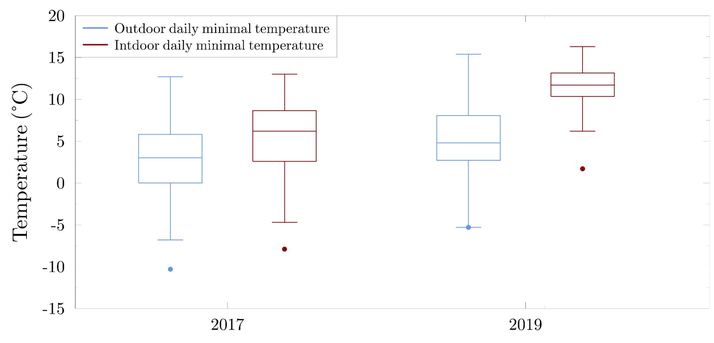
Impact on greenhouse air temperature

Without storage (2017)



With storage (2019)





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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