Corso di Dottorato di Ricerca in Scienze della Vita e dell'Ambiente - Ciclo XXXV

Thermal energy storage through Phase Change Materials

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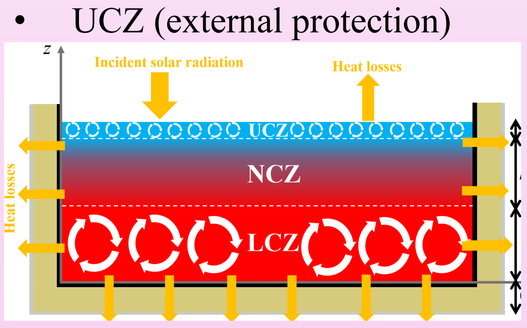
SALINITY GRADIENT SOLAR POND (SGSP) INTEGRATED WITH PCM

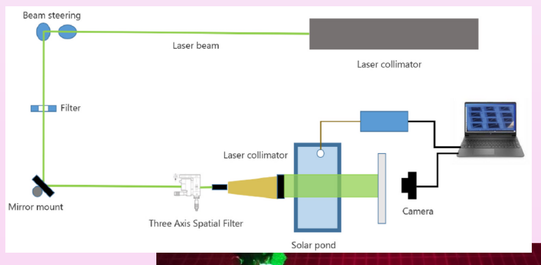
TRADITIONAL SALT GRADIENT SOLAR POND (SGSP)

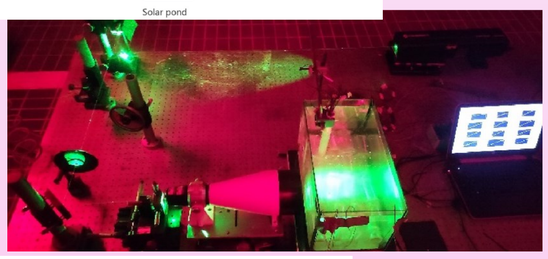
SGSP structure:

- LCZ (storage zone)
- NCZ (thermal insulator)
- UCZ (external protection)

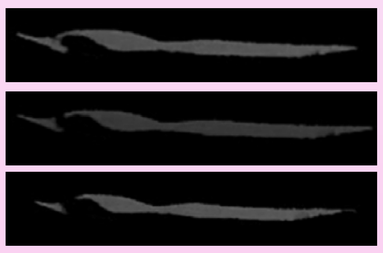


OPTICAL VISUALIZATION OF A SALT GRADIENT SOLAR POND INTEGRATED WITH PCM





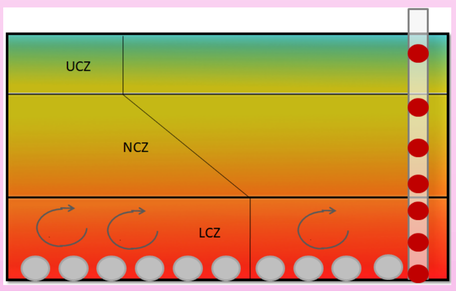
Abstract: This work presents an experimental application of PCMs in the LCZ of a small solar pond. The paraffin wax was enclosed in aluminum cylinders arranged on the bottom. The stability of the pond is analyzed through a laser shadowgraph technique, to visualize the effect of the thermal convection on the interfaces, both with and without PCMs.

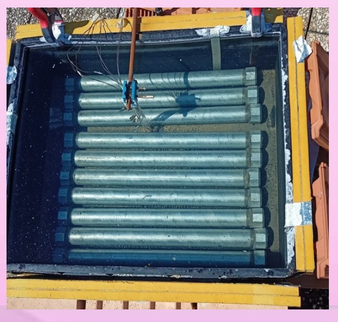


Results:

- The temperature of the LCZ for the case with PCM is **around 3°C lower** than the reference.
- The shadowgraph analysis proves that the solar pond with PCM shows an **improved stability**.

EFFECT OF PCM MELTING TEMPERATURE ON SOLAR PONDS PERFORMANCE





Abstract: In this work, a SGSP with PCM (RT35 HC) and a traditional one were designed, built and tested to evaluate the different performance. Then the effect of different melting temperatures (RT35 HC and RT44 HC) was experimentally investigated.

Results:

- Over ten days, the average temperature in the pond with the **RT35 HC is about 4°C lower** (corresponding to the 5.7%) that the simple SGSP.
- A higher melting temperature (RT 44HC) smooths the peaks of temperature during the daytime, resulting the pond more stable. While a lower melting temperature (RT 35HC) ensures a higher and more stable temperature at night, due to the release of latent heat.

THE EFFECT OF THERMOSOLUTAL CONVECTION ON A SGSP: EXPERIMENTAL AND NUMERICAL INVESTIGATIONS

Abstract: The aim of this study is to investigate, numerically and experimentally the effect of the thermosolutal convection on thermal behavior of a SGSP. Two-numerical models are developed. The first one neglects the development of the thermosolutal convection, while the second one is considers it. To validate and compare both numerical models, a laboratory-scale SGSP is designed, built and tested indoor for 82 hours under a solar simulator

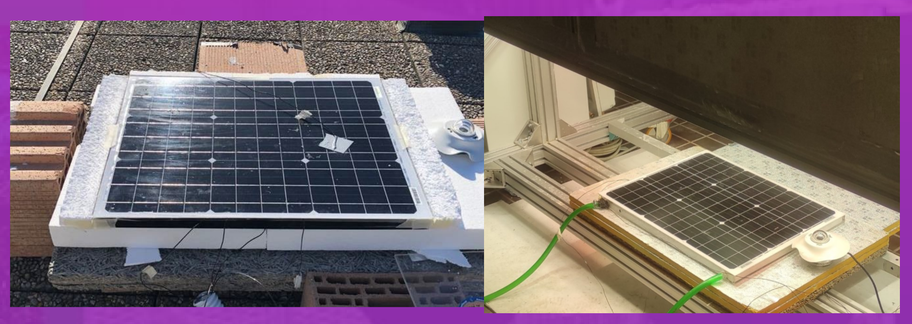
Results:

- Both numerical models return a good accuracy, since the maximum relative error is less than 10%.
- The average relative error between numerical and experimental results is about **9.39% for UCZ and 2.92% for LCZ basing on the first model**.
- This error reduces to around **5.98% for UCZ and 3.74% by using the second model**.
- The model without thermosolutal convection modeling tends to overestimate the thermal energy stored in the LCZ by about 4.3% after 82 hours.

PHOTOVOLTAIC (PV) PANEL INTEGRATED WITH PCM

INDOOR AND OUTDOOR PERFORMANCE OF AN INTEGRATED PV-PCM PANEL

Abstract: The operative temperature of a photovoltaic cell influences the electric conversion yield. This can be enhanced by cooling the panel. This work presents a hybrid graphene/fins/PCM cooling system to maximize efficiency gains and thermal recovery. An indoor test compares the proposed model with a simple PV module under fixed environmental conditions. Outdoor tests compare the two systems under real climatic conditions.

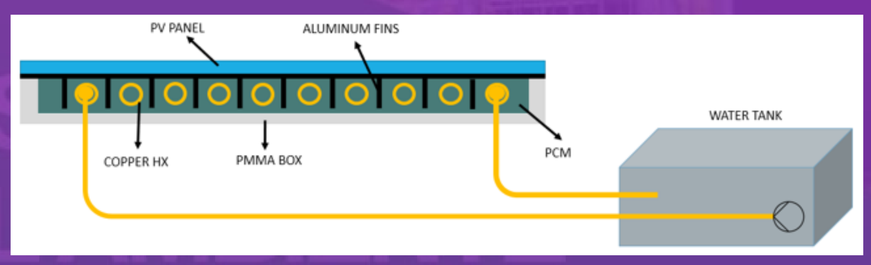


Results:

- Indoor, the front temperature of the integrated module is **averagely 6 °C lower, with a peak of 8 °C**, than the reference case.
- The increase of the electric yield is about 3%.
- Outdoor, the front temperature of the integrated module is averagely 1.12 °C (PCM solid) and 4.87 °C (phase change) lower than the reference case. The thermal efficiency is 30% and 65%, respectively.
- Once the PCM is liquid, the efficiency worsens rapidly.

YEARLY PERFORMANCE OF A PV-PCM AND WATER STORAGE FOR DOMESTIC HOT WATER ENERGY DEMAND

Abstract: This works experimentally investigates the yearly performance of a PV-PCM system, to provide thermal energy for the domestic hot water (DHW) service of a typical residential building. A summer and an intermediate month have been simulated indoor, while a winter month has been tested outdoor. A water circulation system, coupled to a water tank, extracts the heat stored, through a copper heat exchanger.



Results:

- A storage volume of 50 L, 75 L, 100 L and 125 L ensures an **energy saving of 15.3%, 21.2%, 22% and 21.5%** respectively.
- The same percentages are 8.2%, 9.8%, 10% and 9.9% in an intermediate month.
- The PV-PCM system reaches **38% of efficiency** during the summer month and a minimum of 16% during the winter ones.