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PHASE CHANGE MATERIALS FOR THERMAL CONTROL IN BUILDING INTEGRATED PHOTOVOLTAICS

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Table of Contents

1. Purpose of the Short Term Scientific Mission (STSM)

This Scientific Mission was built on an experimental work which took place in the University of Ulster in Belfast. The aim of the STSM was to assess how PCM performed as a thermal regulator of the PV panels. The PCM is contained in a container integrated behind the PV. The PCM used were Calcium Chloride Hexahydrate & Capric Palmitic Acid, which then are compared to data readings of the PV without PCM. The parameters considered are indoor temperature and solar irradiation.
The PV temperature and electrical output with and without PCM will be compared to determine the thermal regulation potential of the PCM and its associated impact on PV electrical power output.
Finally the thermal regulation potential of each PCM and the associated increase in PV electrical power will be compared to find out the best PCM.

2. Description of the Work Carried out During the STSM

To achieve our aims (Examine the temperature, Voc & Isc behaviour) in relation to this indoor experimental work, which took place in the Centre for Sustainable Technology (CST) in the University of Ulster in Belfast, we considered the following steps: "3 (three) PV Panels (One without PCM & Two with PV/PCM) were used for examination. Measurement recorded was at 500, 750 & 1000W/m2. There were installed 13 (thirteen) thermocouples in total, 9 (nine) on the front and 3 (three) on the back of PV panels, and one thermocouple for the ambient temperature, in total 13 thermocouples. All thermocouples were terminated in a data logger which monitors temperature every 10seconds. Also, the Open Circuit Voltage (Voc) & Short Circuit Current (Isc) were measured every 10minutes by a multimeter. To investigate the behaviors of each PV Panel, the experimental work lasted 10 Days in Total. Each PV panel was investigated per each day, with the arrangement:

- Simulator used 4 Hours for PV without PCM.
- Simulator used 6 hours for PV/PCM.

To investigate temperature behaviours, 13 thermocouples, nine on the front, three on the back and one for the ambient temperature were installed at each the above PV panels. The thermocouples were terminated in a data logger which was set to measure temperatures every 10 seconds. Meanwhile, Open Circuit Voltage (Voc) & Short Circuit Current (Isc) were measured every 10minutes by a multimeter.

3. Description of the Main Results Obtained and Graphs

The results for 3 (three) measurement temperatures ($500W/m^2$; $750W/m^2$ and $1000W/m^2$) indicate that the temperature of PV2 (without PCM) reaches ~40°C at $500W/m^2$; ~53°C at $750W/m^2$ and ~60°C at $1000W/m^2$.
PV1/PCM (Capric Palmatic Acid) reaches ~40°C at $500W/m^2$; ~46°C at $750W/m^2$ and ~55°C at $1000W/m^2$.

PV3/PCM (Calcium Chloride Hexahydrate) reaches ~35°C at 500W/m^2; ~43°C at 750W/m^2 and ~45°C at 1000W/m^2.
These results indicate that temperatures of the PV/PCM are maintained much better than temperatures of PV without PCM. The PCM removed the heat from the PV panel, so as result the temperature was maintained better compared to the PV without PCM. This shows the potential of both PCM to regulate PV temperature.

Below are listed the difference of the maintained temperature using PCM:

- At 500W/m^2 insulation the temperature was maintained at ~5°C.
- At 500W/m^2 insulation the temperature was maintained at ~8°C.
- At 500W/m^2 insulation the temperature was maintained at ~15°C.

To demonstrate the results gathered in this STSM, the following graphs are shown to illustrate the simulated time series and results in relation to temperature measurements at 500W/m^2-Fig 1; at 750W/m^2-Fig 2 and at 1000W/m^2-Fig 3.

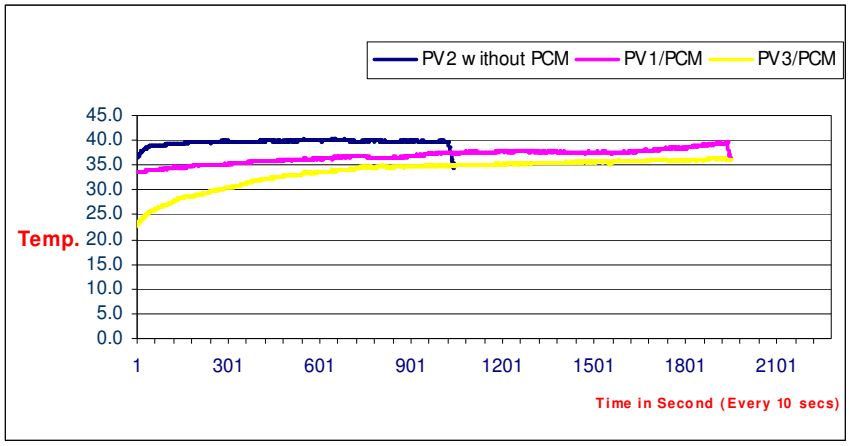

Fig. 1 – Temperature Measurements at 500W/m²

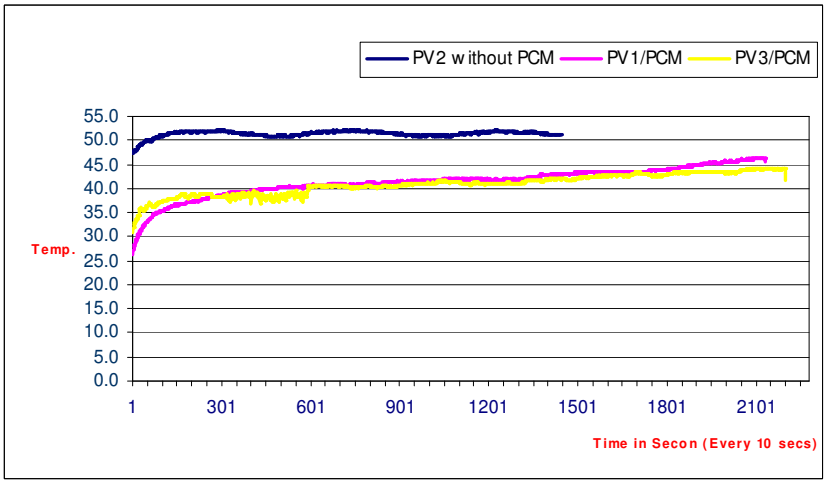

Fig. 2 – Temperature Measurements at 750W/m²

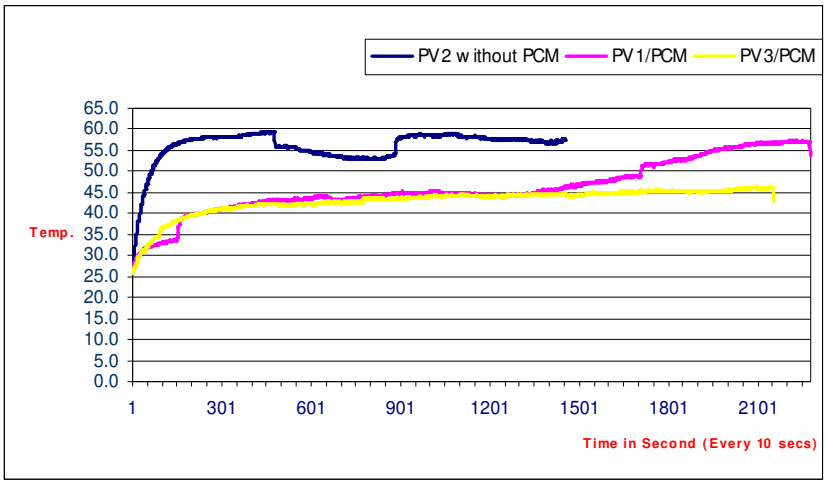

Fig. 3 – Temperature Measurements at 1000W/m²

Open Circuit Voltage (Voc)

In relation to Voc measurement at 500W/m²; 570W/m² and 1000W/m², the results gathered during this STSM indicate a DC voltage improvement as follow:

- At 500W/m², the improvement of Voc is by ~0.8Volt (DC) using PCM.
- At 750W/m², the improvement of Voc is by ~1.1Volt (DC) using PCM.
- At 1000W/m², the improvement of Voc is by ~1.6Volt (DC) using PCM.

To illustrate the above results, the following graphs illustrate the simulated time series and results in relation to Voc measurement at 500W/m²-Fig 4; at 750W/m²-Fig 5 and at 1000W/m²-Fig 6.

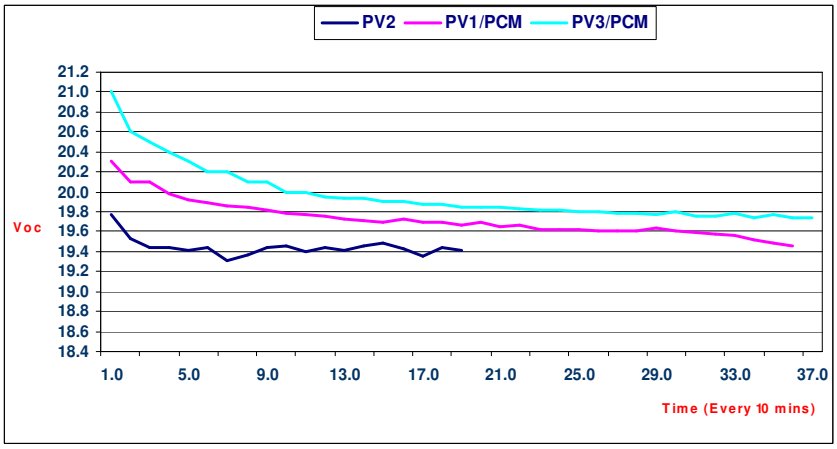

Fig. 4 – Voc Measurements at 500W/m²

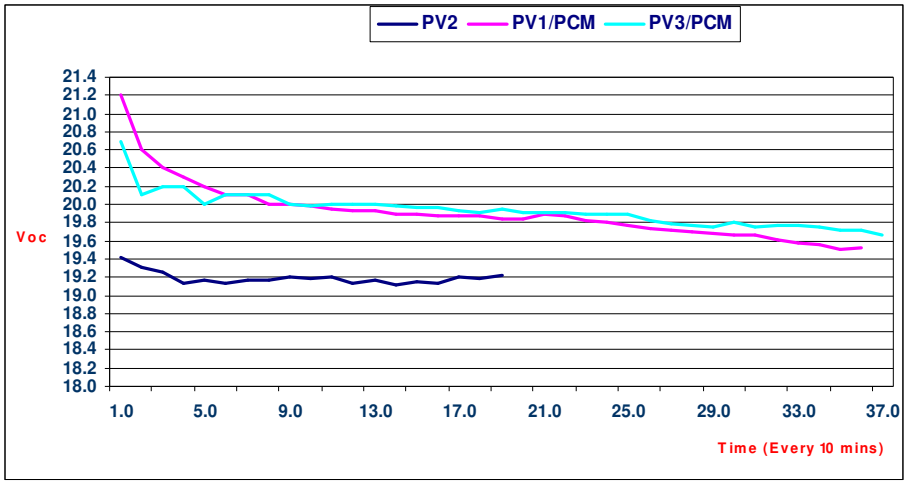

Fig. 5 – Voc Measurements at 750W/m²

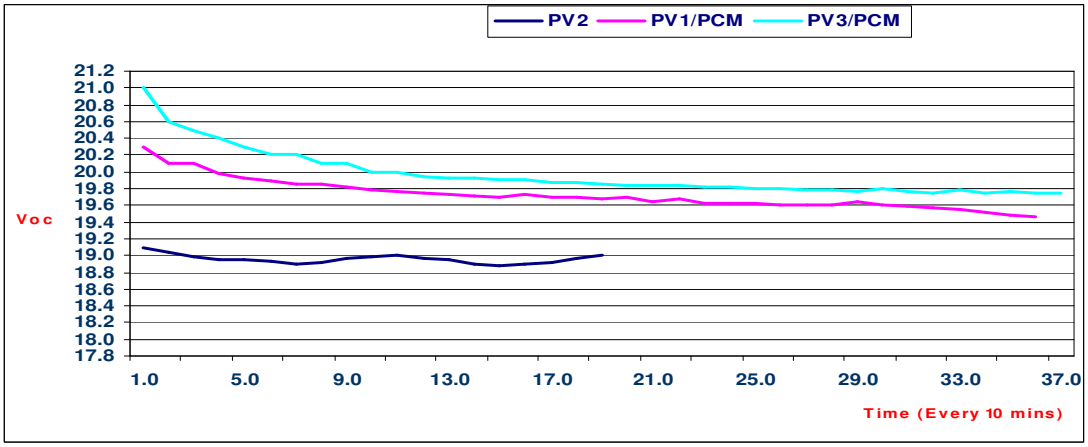

Fig. 6 – Voc Measurements at 1000W/m²

Short Circuit Current (Isc)

Short Circuit Current (Isc) is usually positively effected by temperature, such that the current in this experiment is increased with temperature. This increase is very small compared to the reduction of the voltage with temperature. Current for all PVs (PV2 without PCM; PV1/PCM-Capric Palmatic Acid & PV3/PCM-Calcium Chloride Hexahydrate) reaches ~1.3mA for measurement at 500W/m², and ~2.1mA for measurement at 750W/m² and ~2.8mA for measurement at 1000W/m², for the duration of 4 to 6 hours.

4. Result from the STSM

Result gathered from this Short Term Scientific Mission (10 days in total) has shown us that using phase change materials in the PV system can reduce and maintain temperature, and can improve Open circuit Voltage (Voc) and Short Circuit Current (Isc), demonstrating cost per generated power is maintained better than temperatures of PV without PCM. However, further experimental and analytic investigations are required to identify the effect of using phase change materials to modify and reduce temperature rise on PV. The outcomes demonstrate the value of further development and techniques to be used in future in relation to phase change materials integrated in Photovoltaics. However, it could be suggested that an economic and environmental impact analysis in relation to this novel technology is required to determine the potential benefits which this new technique can bring into current market.

5. Conformation by the host Institution of the Successful Execution of the STSM

At the end of this short term scientific mission, we received from Mr. Philip Griffiths a letter of confirmation, which states that this STSM, which took place in Centre for Sustainable Laboratories, University of Ulster, Newtownabbey, North of Ireland, UK lasted fortnight only, and also, that the aim of this work was to assess how the PCM performed as a thermal regulator of the PV panels. In relation to this, the original host report is going to be included beside this scientific report.

6. Acknowledgements

We wish to acknowledge the assistance from Centre for Sustainable Technology (CST), university of Ulster, in Belfast in development and completion of this short term experiment. Finally, and most important, we are infinitely grateful and to the Cost Office for making possible this research

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