# Project 2----Thermal Management of Photovoltaic Panel

The photovoltaic (PV) panel is a significant device to directly convert solar energy into electricity, which contributes to the global sustainable development and reduction of carbon dioxide emission. However, during summer seasons at relatively high environmental temperature, the PV panel suffers from an issue of overheating. When the surface temperature of PV panel is increased by 1 ℃ , its photoelectric conversion efficiency decreases by 0.5%. Under these circumstances, an effective thermal management of PV panel is essential for guaranteeing its working efficiency during summer time.

The water liquid cooling with channels under back surface of PV panel is a commonly used method to cool down its temperature. In addition, phase change materials (PCMs) are also usually applied for thermal modulation of renewable energy devices owing to its nearly constant temperature during solid-liquid phase change process. In this project, the water liquid cooling with aluminum channels is required to be used to control the temperature of PV panel coupled with PCM layer for thermal modulation.

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**Known:** The photoelectric energy conversion efficiency of PV panel is 18%, and it is assumed to be independent with the panel surface temperature for simplicity. The intensity of solar irradiation on the PV panel front surface is $q = 1000\ \mathrm{W/m^2}$. The PV panel thickness is about $H = 3$ cm. The environmental temperature $T_f$ is 30 °C with a convective heat transfer coefficient of $h = 10\ \mathrm{W/(m^2 \cdot K)}$. **The front surface area of PV panel is assigned according to the tail ID number for each student in the last page.** The coolant is liquid water, and the aluminum is used for the water channel. The RT35 PCM is used with melting temperature of $T_m = 35$ °C. The initial temperature $T_i$ of whole device is the same as environmental temperature at 30 °C. In the PCM layer region, **the natural convection is driven by the buoyancy force with Boussinesq approximation.** The thermophysical properties of PCM is summarized below, where $\rho$ is the density; $k$ is thermal conductivity; $\mu$ is dynamic viscosity; $C_p$ is specific heat; $\beta$ is thermal expansion coefficient; $\Delta H$ is the latent heat of Paraffin;

| **Material** | ρ($kg/m^3$) | k (w/m·K) | μ (Pa·s) | Cp (J/kg·K) | β (1/K) | ΔH(J/kg) |
|---|---|---|---|---|---|---|
| Paraffin RT35 | 780 | 0.2 | 0.000365 | 2000 | 0.0003085 | 255000 |

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**Find**: Please design the configuration of liquid water cooling channel, the PCM layer, as well as the inlet flow velocity to make sure the maximum temperature of PV panel is less than 40 ℃ with temperature uniformity of $\Delta T \leq 5$ ℃ during 6 hour daytime under the help of thermal modulation using a PCM layer. **Write down the governing equations and boundary conditions; non-dimensionalizing all equations to get dimensionless governing parameters. Post-processing the results such as temperature field, velocity vectors, solid-liquid interface.**

**For the tail number of student ID:0, 5**

The PV panel front surface area A is 10 m× 2 m.

**For the tail number of student ID:1, 6**

The PV panel front surface area A is 8 m × 2 m.

**For the tail number of student ID:2, 7**

The PV panel front surface area A is 6 m × 2 m.

**For the tail number of student ID:3, 8**

The PV panel front surface area A is 5 m × 5 m.

**For the tail number of student ID:4, 9**

The PV panel front surface area A is 4 m × 4 m