Performance Enhancement of Solar Photovoltaic System

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Outline

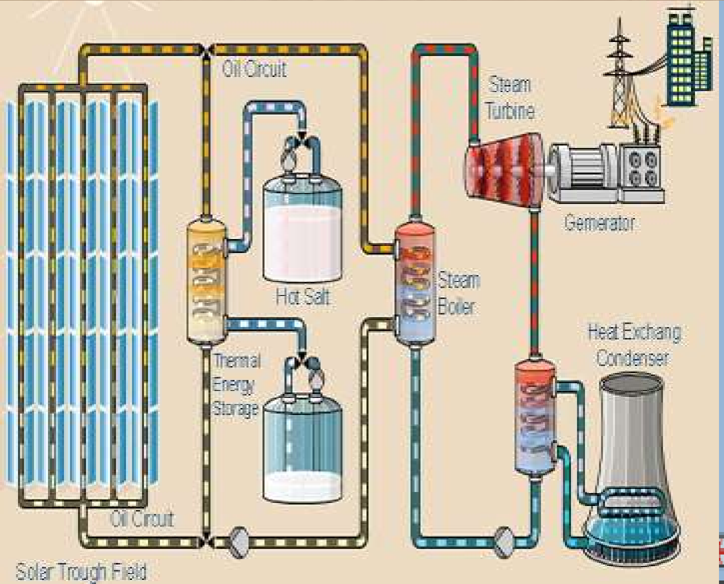
- Solar Thermal
- Solar Photovoltaic
- Performance Enhancement of Solar Photovoltaic
- Case Study

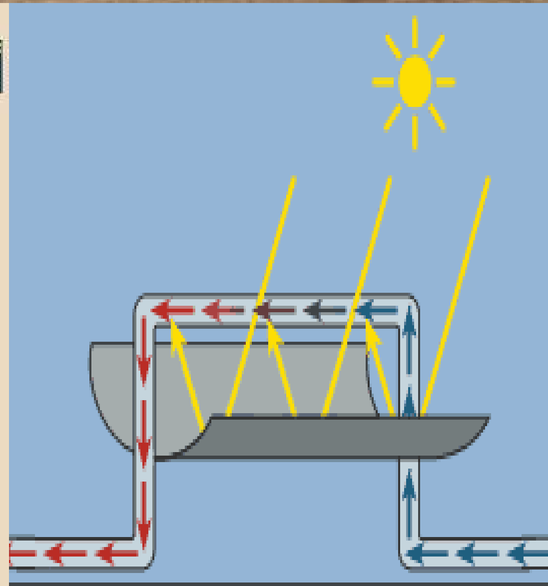
Sun rays to Electricity

- There are mainly two ways to convert sunrays into electricity
  - Solar Thermal
  - Solar Photovoltaic

Solar Thermal: Parabolic Trough

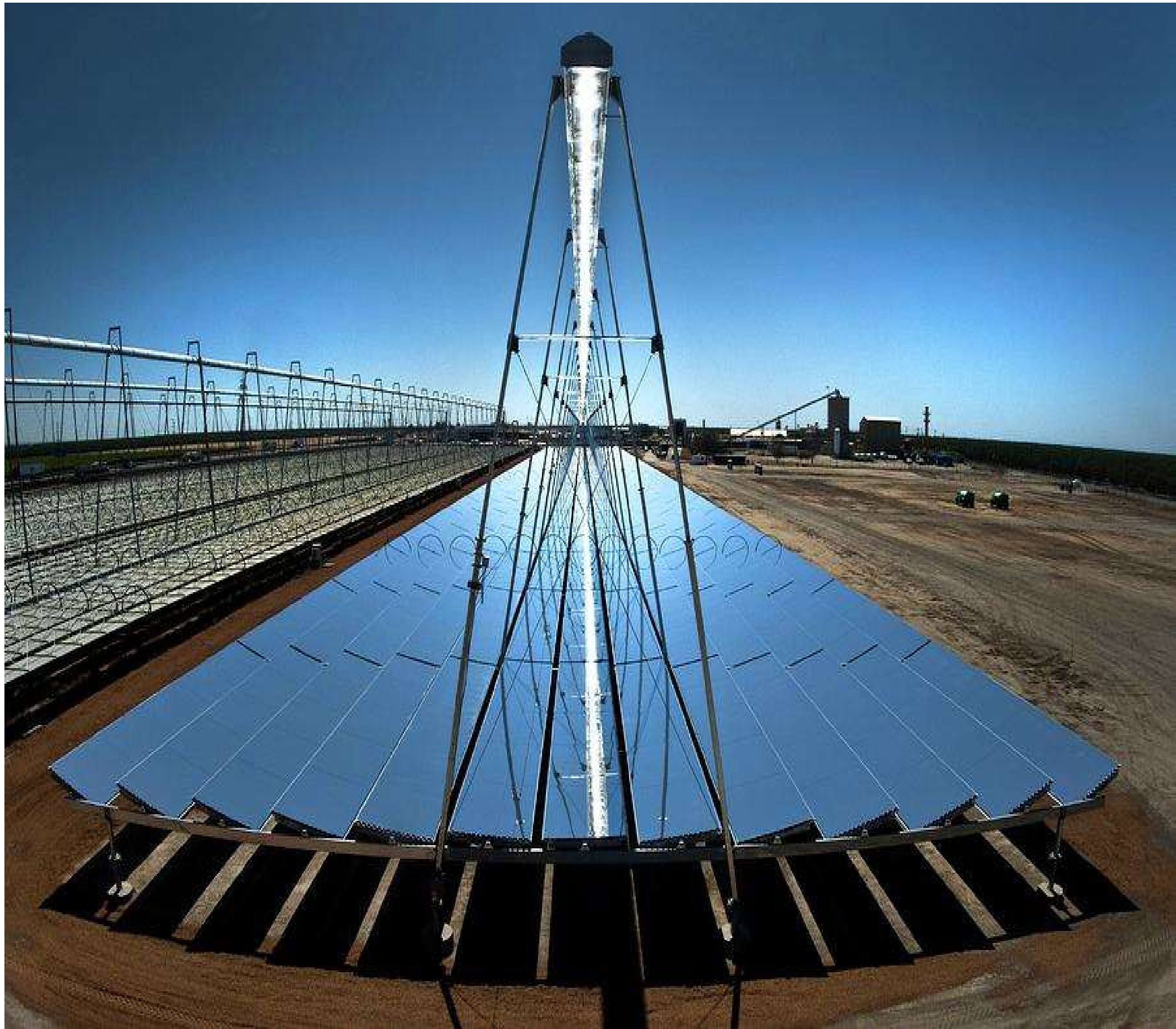
- It consists of parabolic shape mirrors
- Mirrors reflect sun rays onto focus line
- A tube is installed at focus line
- The tube gets heated up by concentrated sun rays
- Fluid passes through tube to collect heat
- Steam Turbine is run to generate electricity
- In this way, system produces electricity
- The mirrors structure needs 1-axis tracking
- Due to massive structure, there is significant wind load





Solar Thermal: Linear Fresnel Reflectors

- To reduce the wind load, a different structure can be adopted
- Instead of parabolic mirror, it consists of several flat linear mirrors
- Each mirror needs 1-axis tracking
- All mirrors reflect sun rays onto common focus line
- Tube is installed at certain height
- Fluid passes through tube to collect heat
- Steam Turbine is run to generate electricity



Solar Thermal: Paraboloid Dish

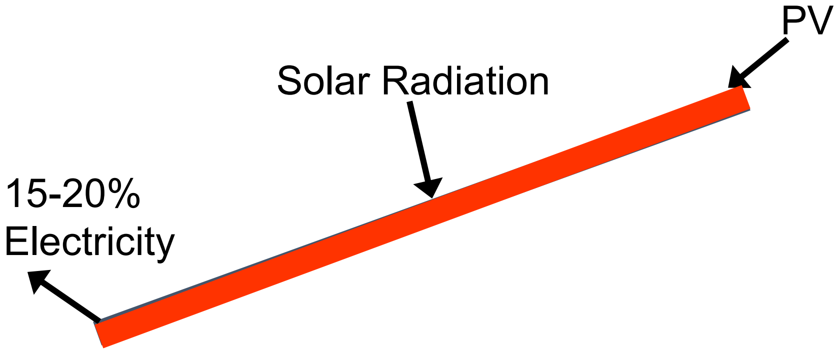
- It consists of Paraboloid shape mirror structure
- Focus is a point instead of line
- Stirling Engine is installed at focus to generate electricity
- It needs 2-axis tracking

Solar Thermal: Solar Tower

- It consists of flat mirrors
- All mirrors reflect sun rays onto tower
- Fluid is pumped up the tower to collect heat
- And electricity is generated
- Each mirror needs separate 2-axis tracking
- In this way, there are various types of mirrors structure to focus sun rays and generate electricity

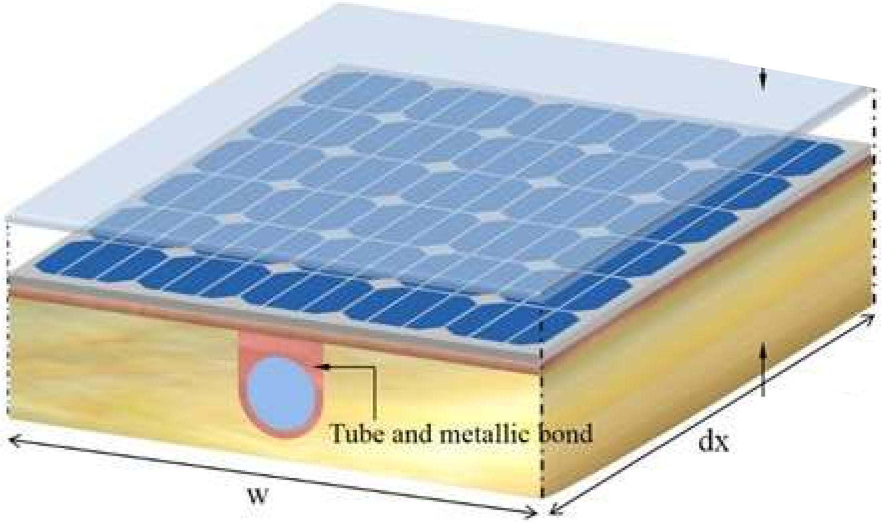
Solar Photovoltaics

- The other way of converting sun rays to electricity is by Solar Cells
- They convert sunlight directly into electricity
- It does not require any tracking to generate electricity
- However, tracking can increase the efficiency
- Only 15-20% sunlight is converted into electricity
- Rest becomes heat
- It rises solar cell temperature
- It decreases power output



Photovoltaic-Thermal Collectors

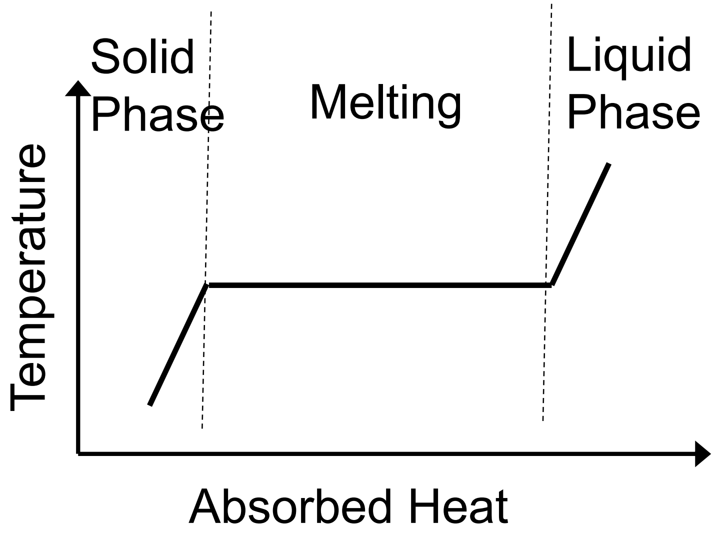
- Pipes are attached at the back of PV
- Water is pumped through pipes
- It cools down the solar cells and increases the electrical efficiency
- It also collects the waste heat
- Hot water can be stored and used when required



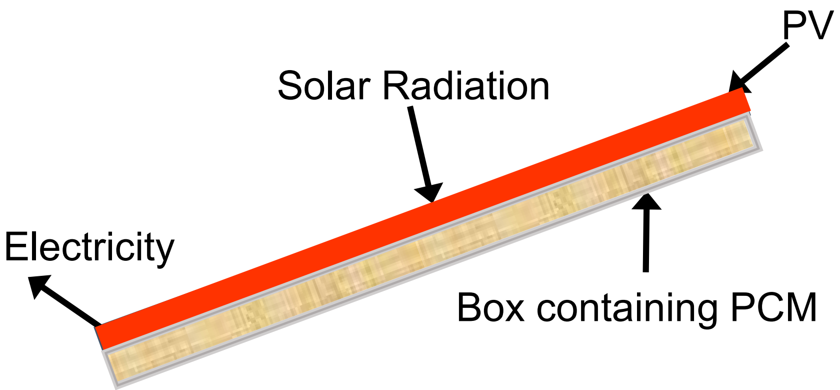
Photovoltaic with Phase Change Material

- During melting, PCM absorbs heat without rise in temperature
- PCM container is attached at back of PV
- It can maintain PV at low temperature
- The system is modelled using software
- Effect of operating conditions are analysed

PCM Characteristics

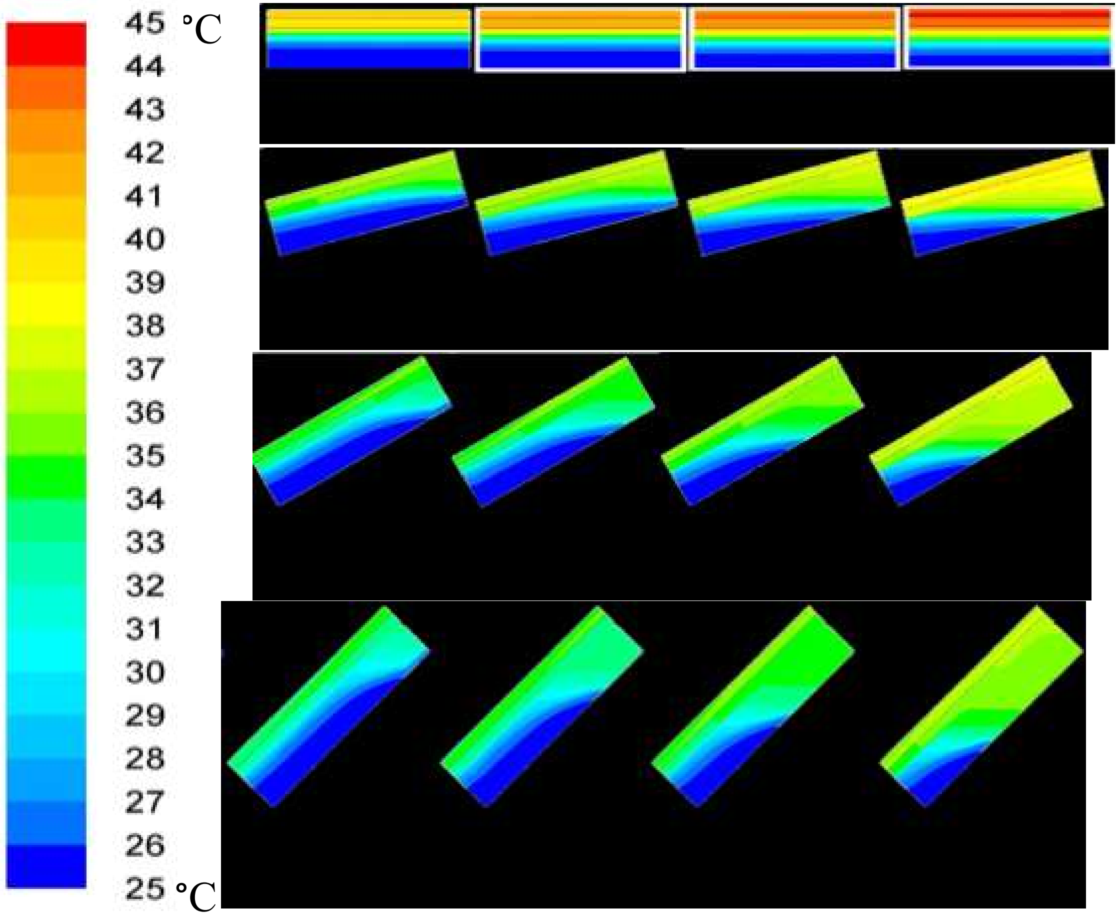


Solar PV



Effect of Operating Conditions

Effect of Tilt Angle

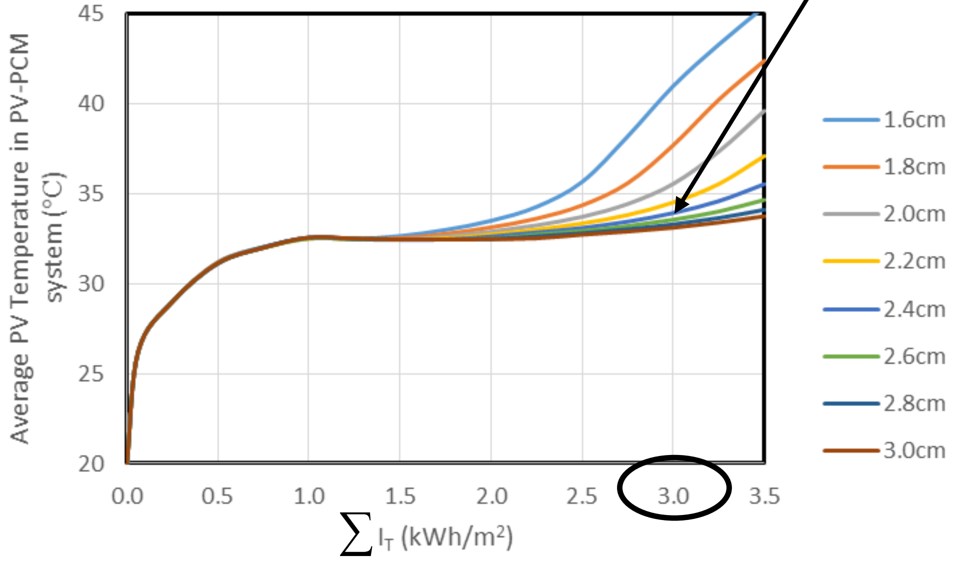


As tilt angle increases, melting speed increases

As tilt angle increases, temperature decreases

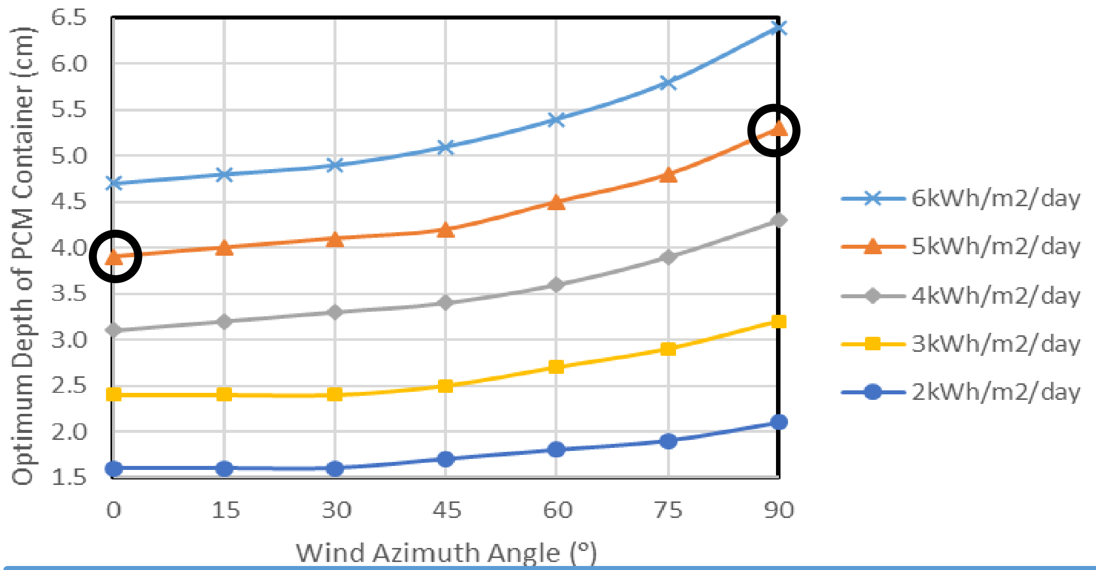
Effect of Depth of PCM Container

2.4cm is optimum depth for $\sum I_T$ = 3kWh/m²/day

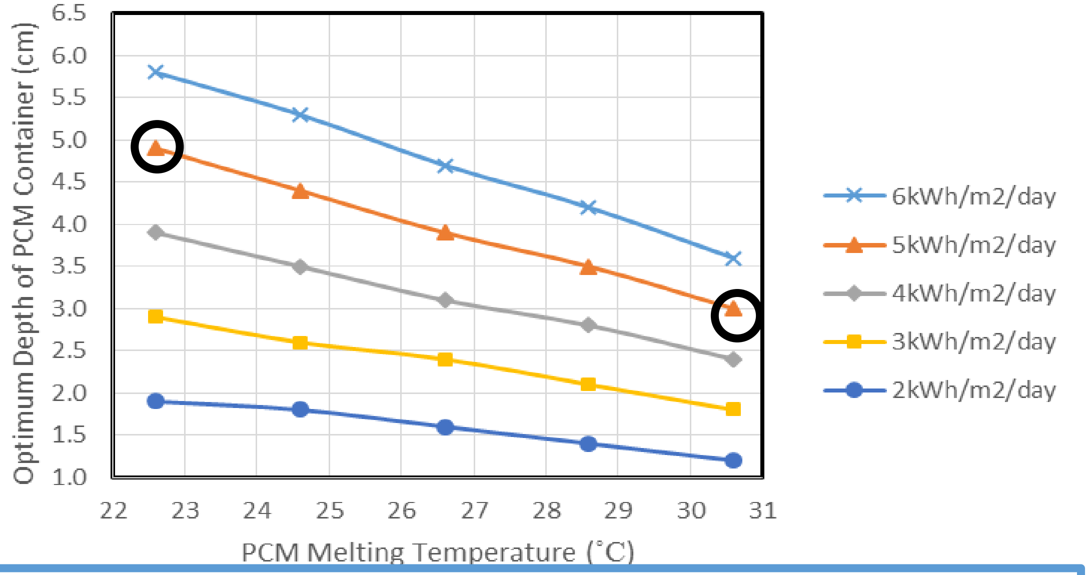


As depth of container increases, cooling duration increases

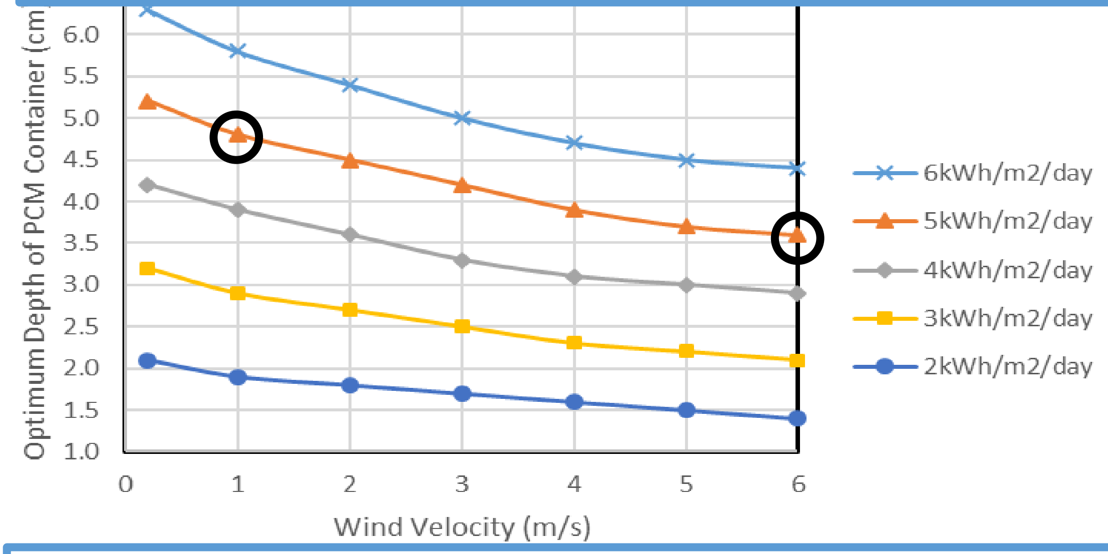
Optimization of PCM Quantity



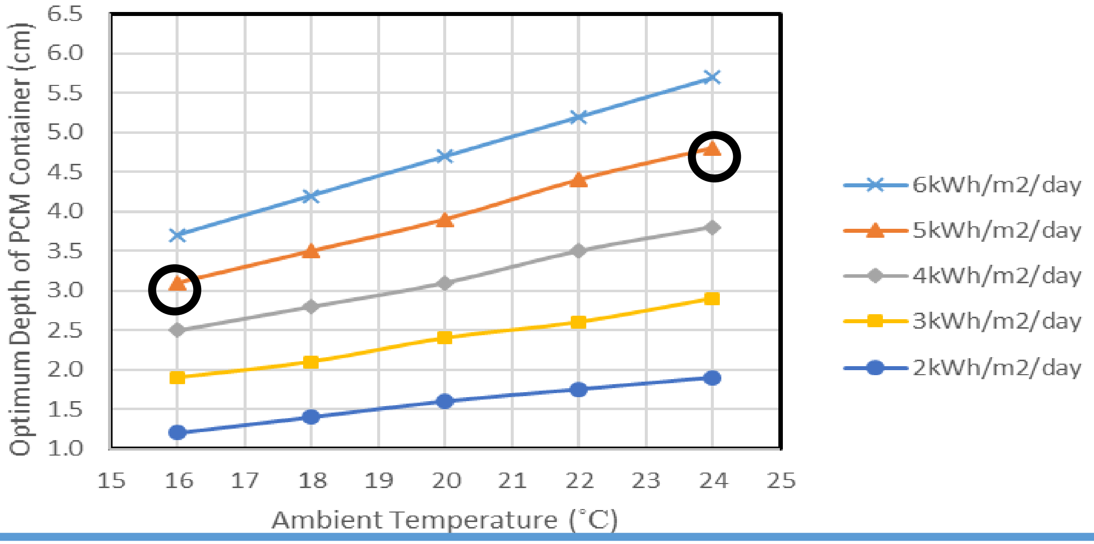
For larger wind azimuth, larger PCM quantity required to cool PV



For higher Melting Point, lesser PCM quantity required

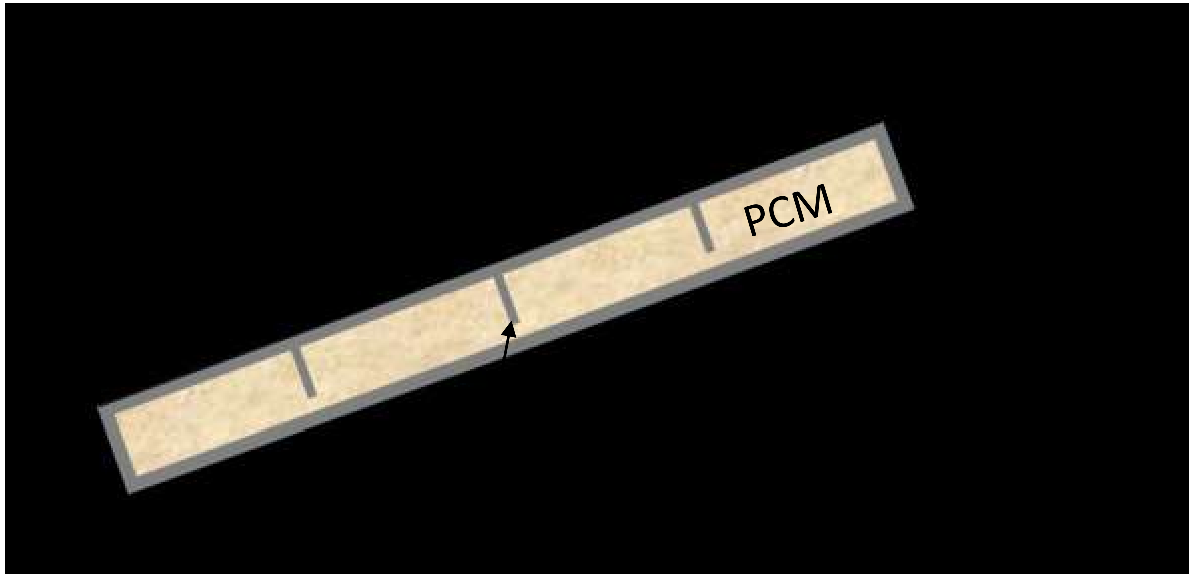


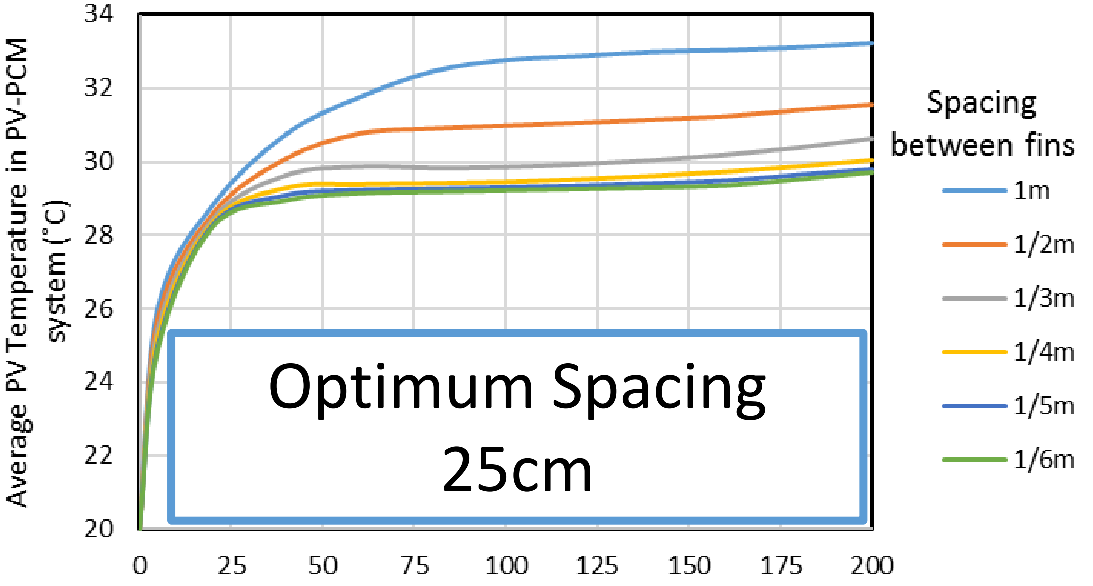
For higher wind velocity, lesser PCM quantity required to cool PV

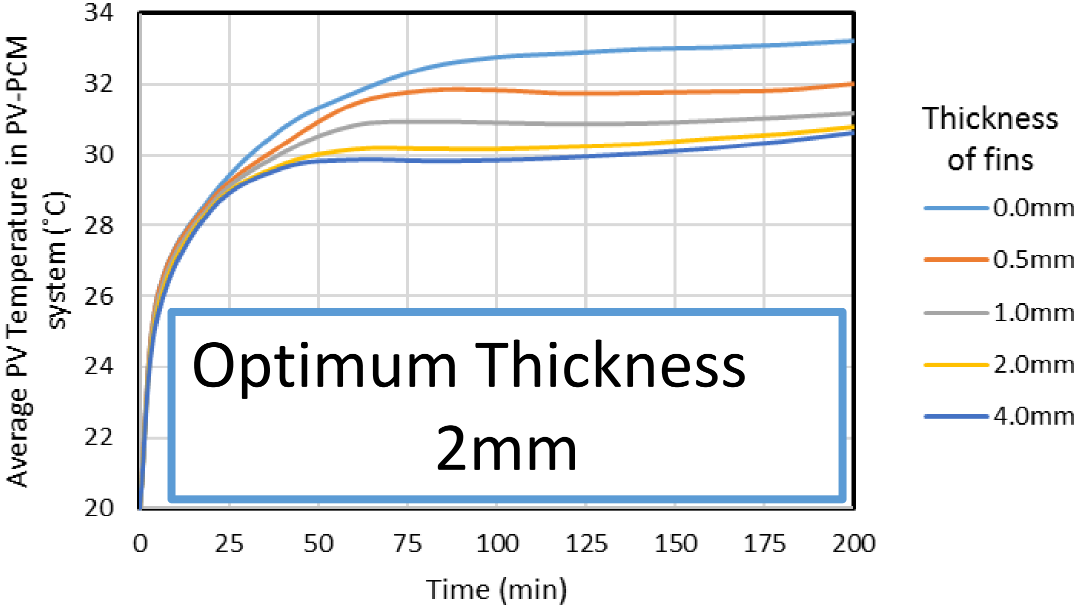


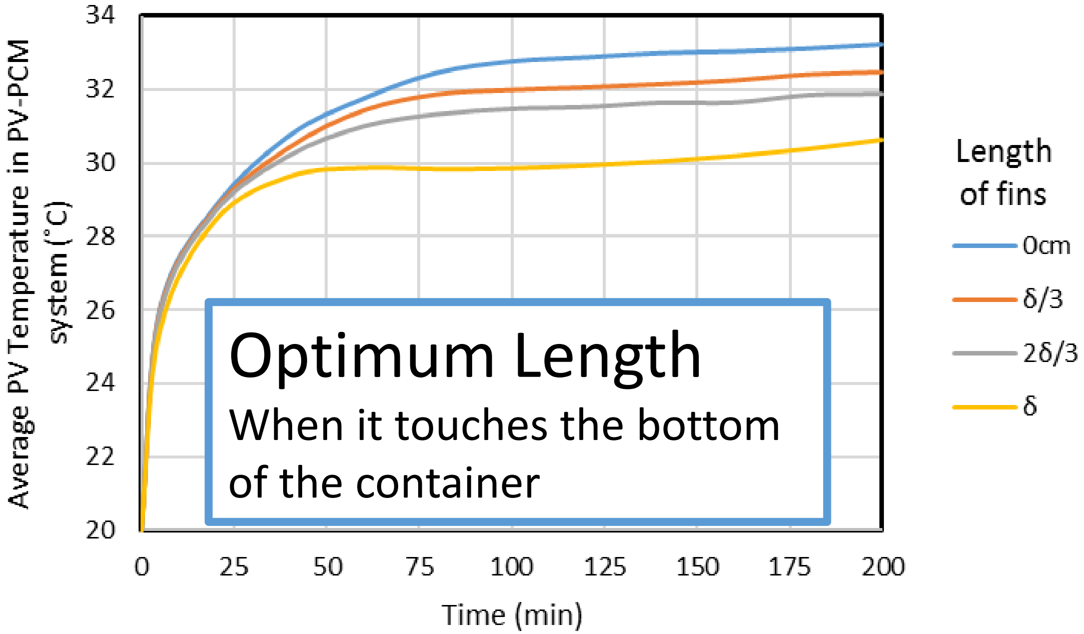
For higher Ambient Temperature, larger PCM quantity required

Finned-PV-PCM and Optimization

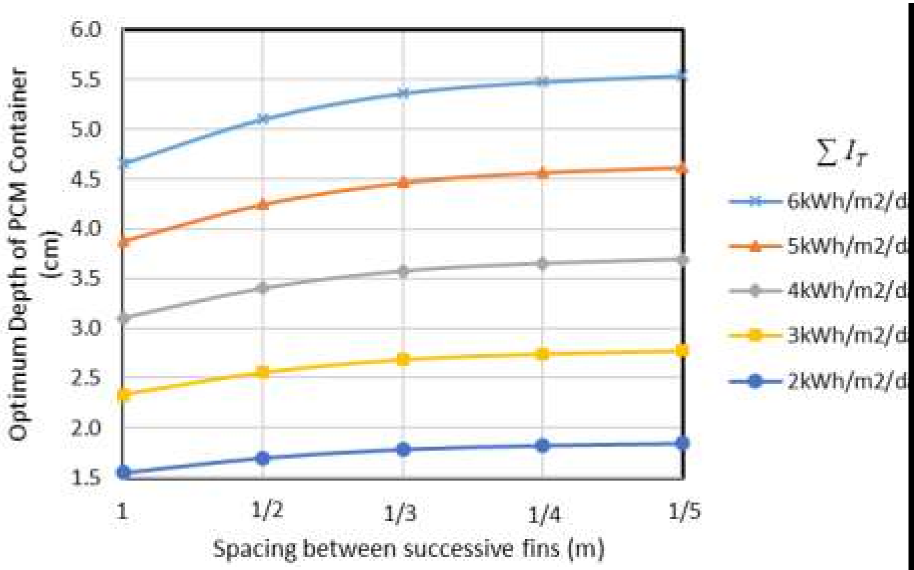


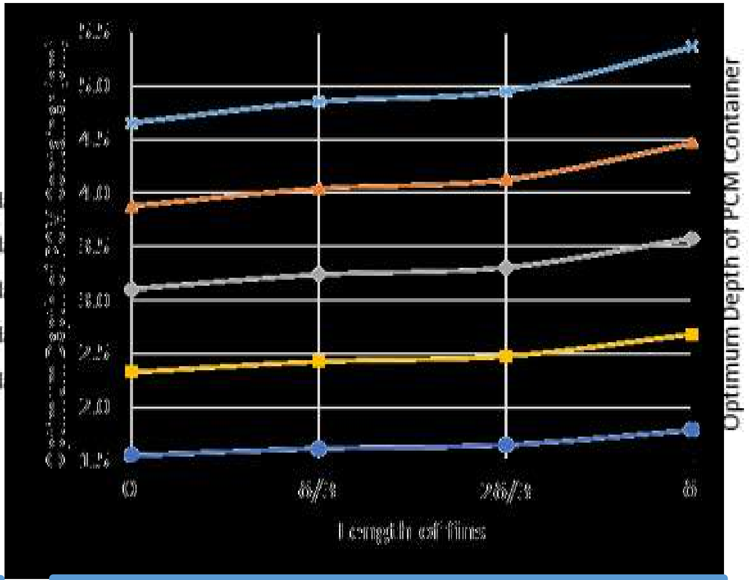


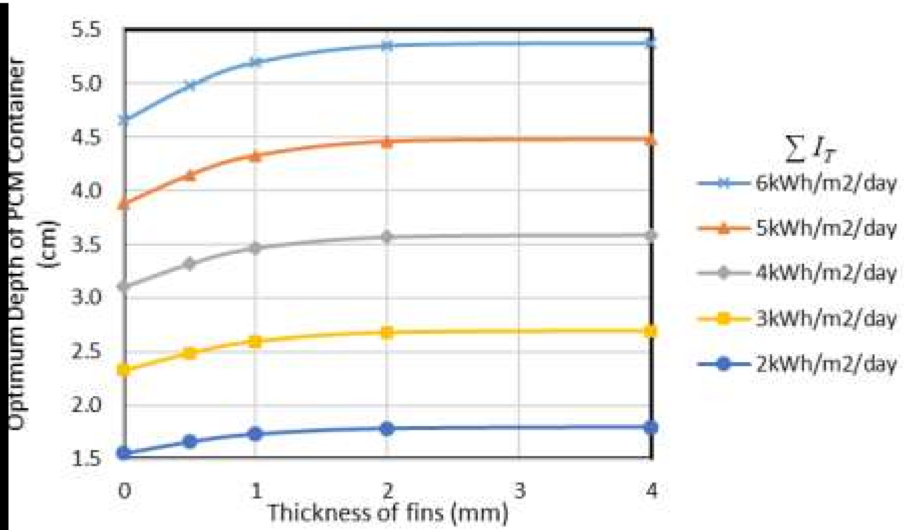




Optimum Depth of Finned-PV-PCM



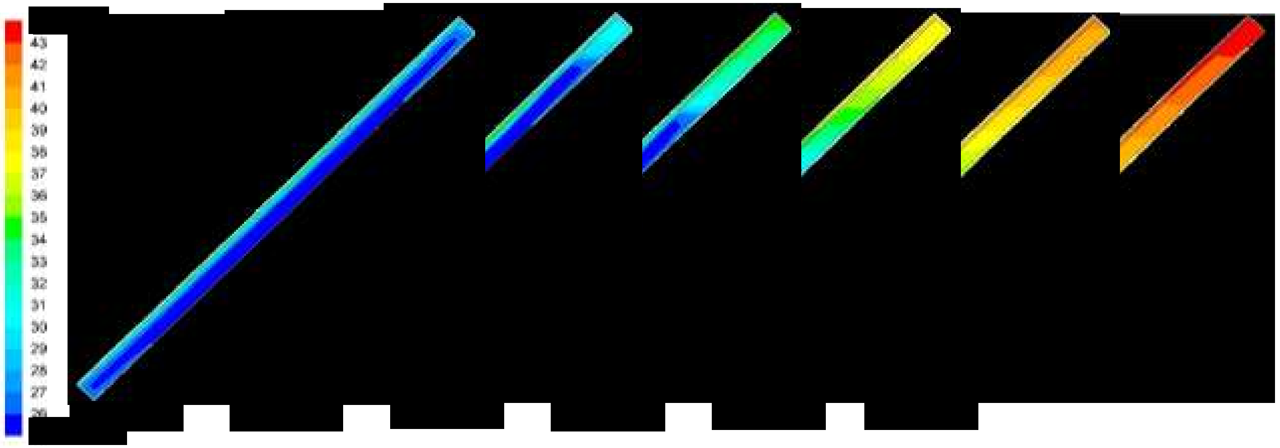


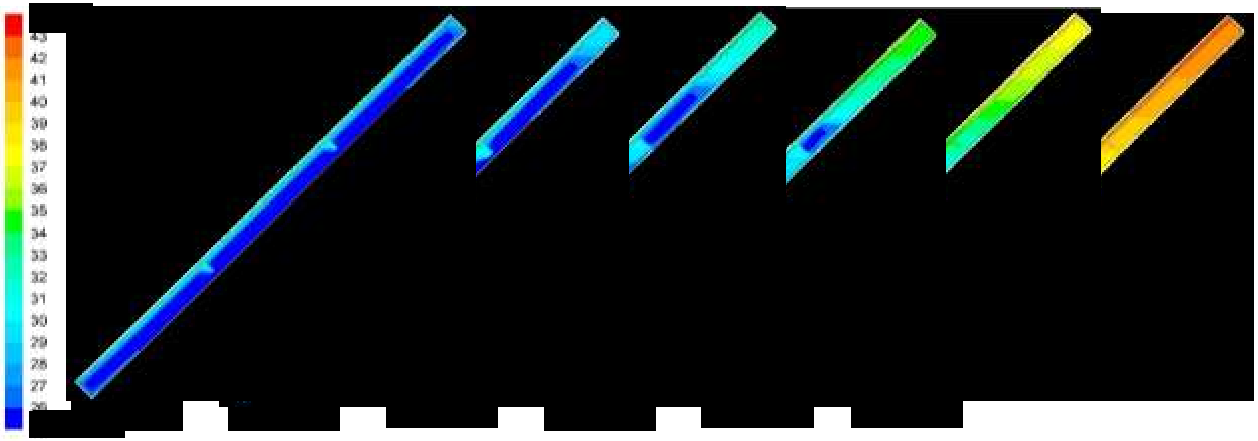


For Smaller spacing, Larger PCM Quantity is required to cool PV

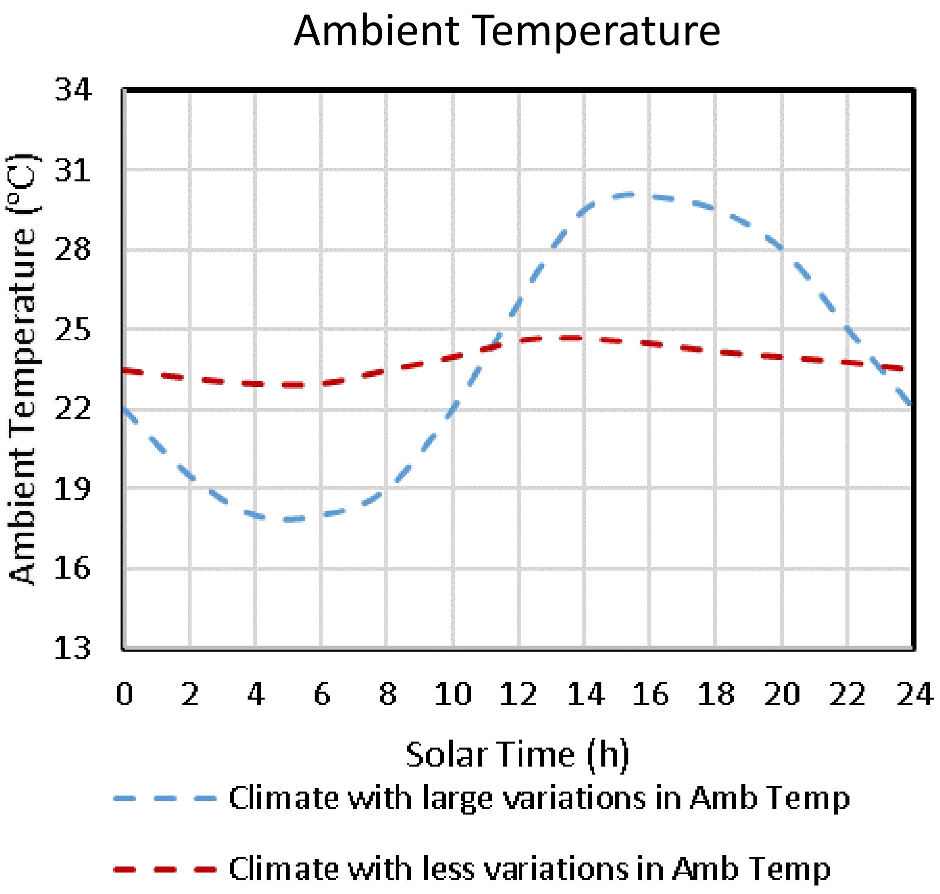
For Smaller Length, Lesser PCM Quantity is required

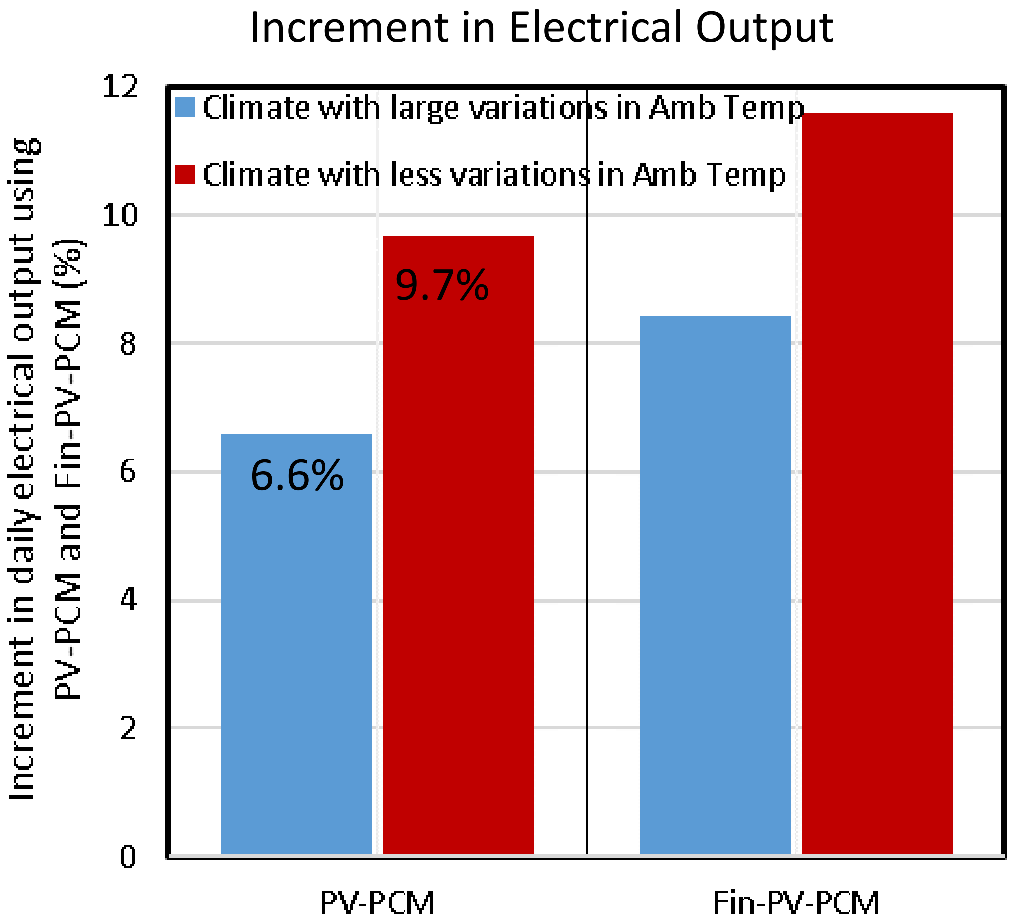
For Thicker Fins, Larger PCM Quantity is required





Climatic Suitability of PCM integration

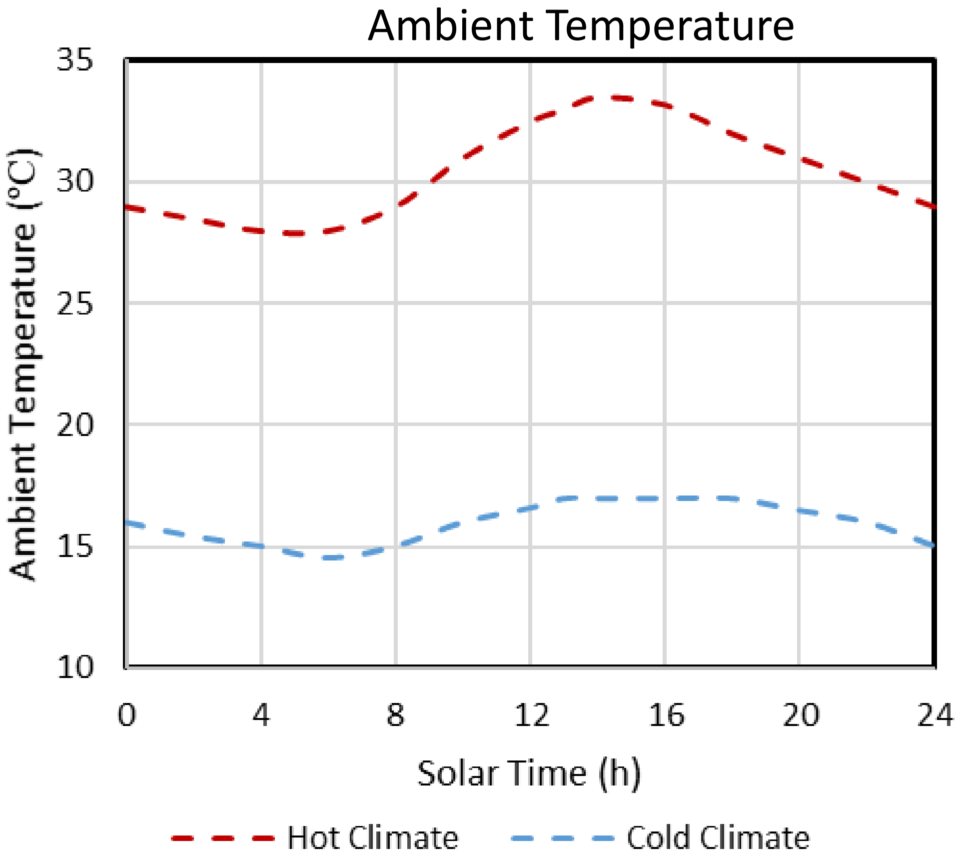


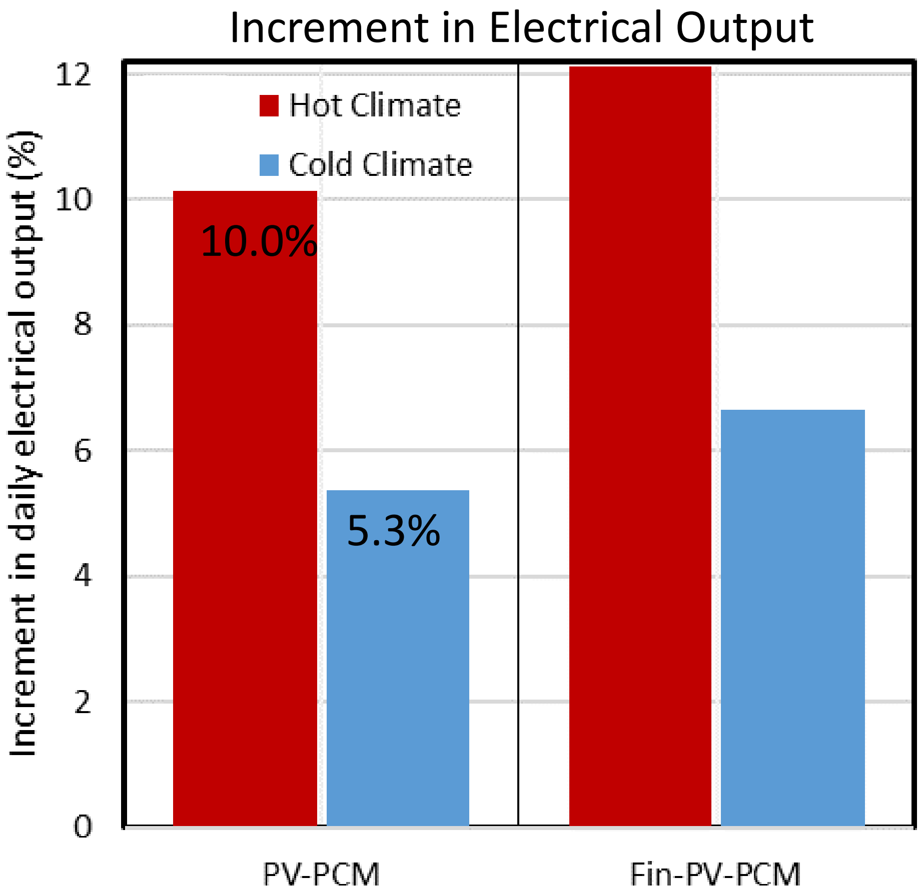


Increment in Electrical Output is 9.7% for climate with less variations

PCM integration is more suitable for climates with less variations in Ambient Temperature

Climatic Suitability of PCM integration

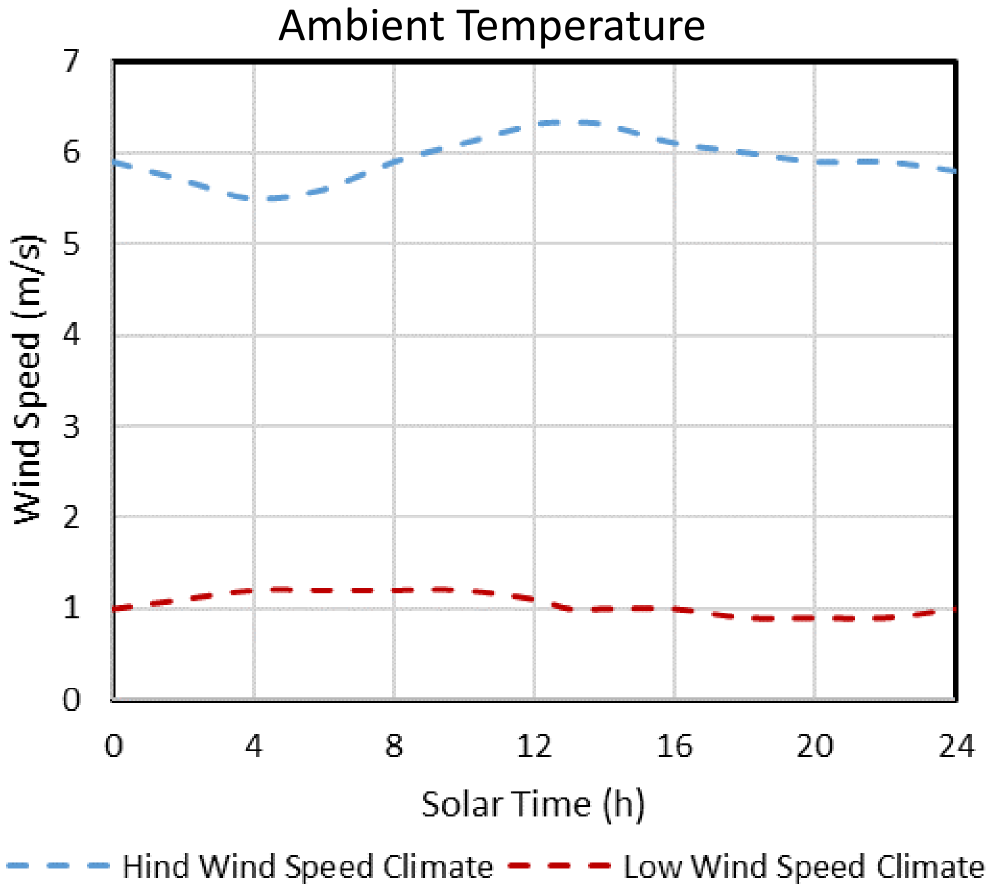


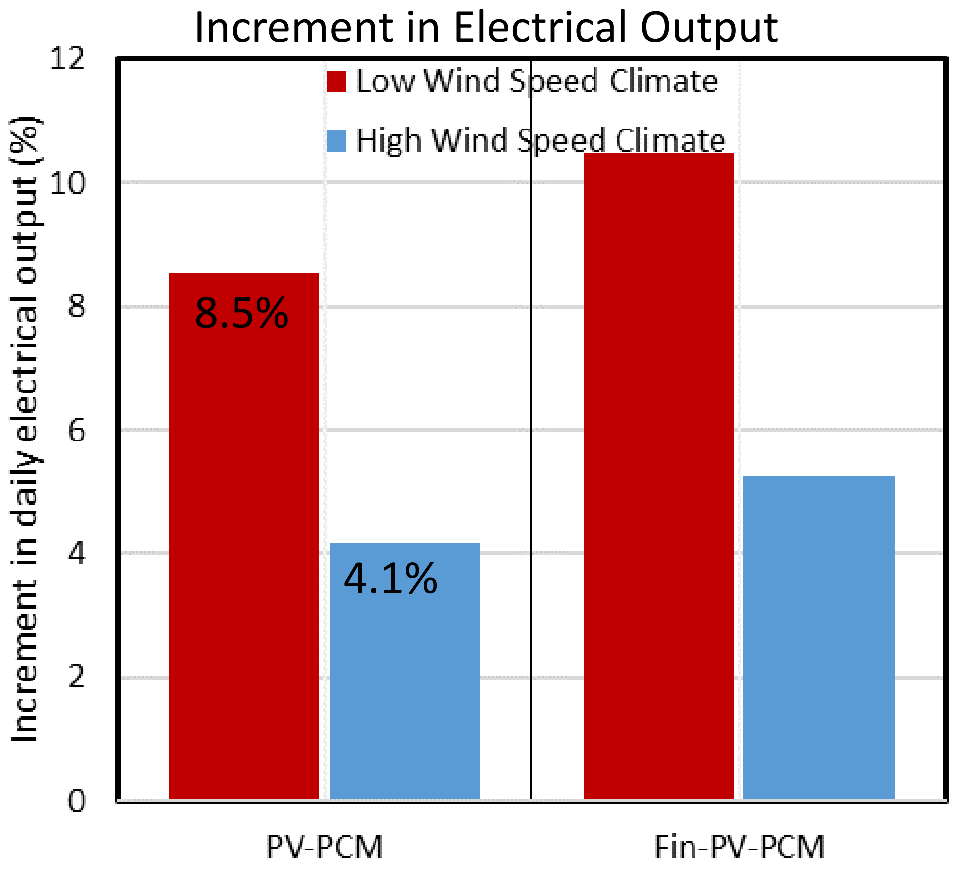


Increment in Electrical Output is 10% for hot climate

PCM integration is more suitable for hot climates

Climatic Suitability of PCM integration

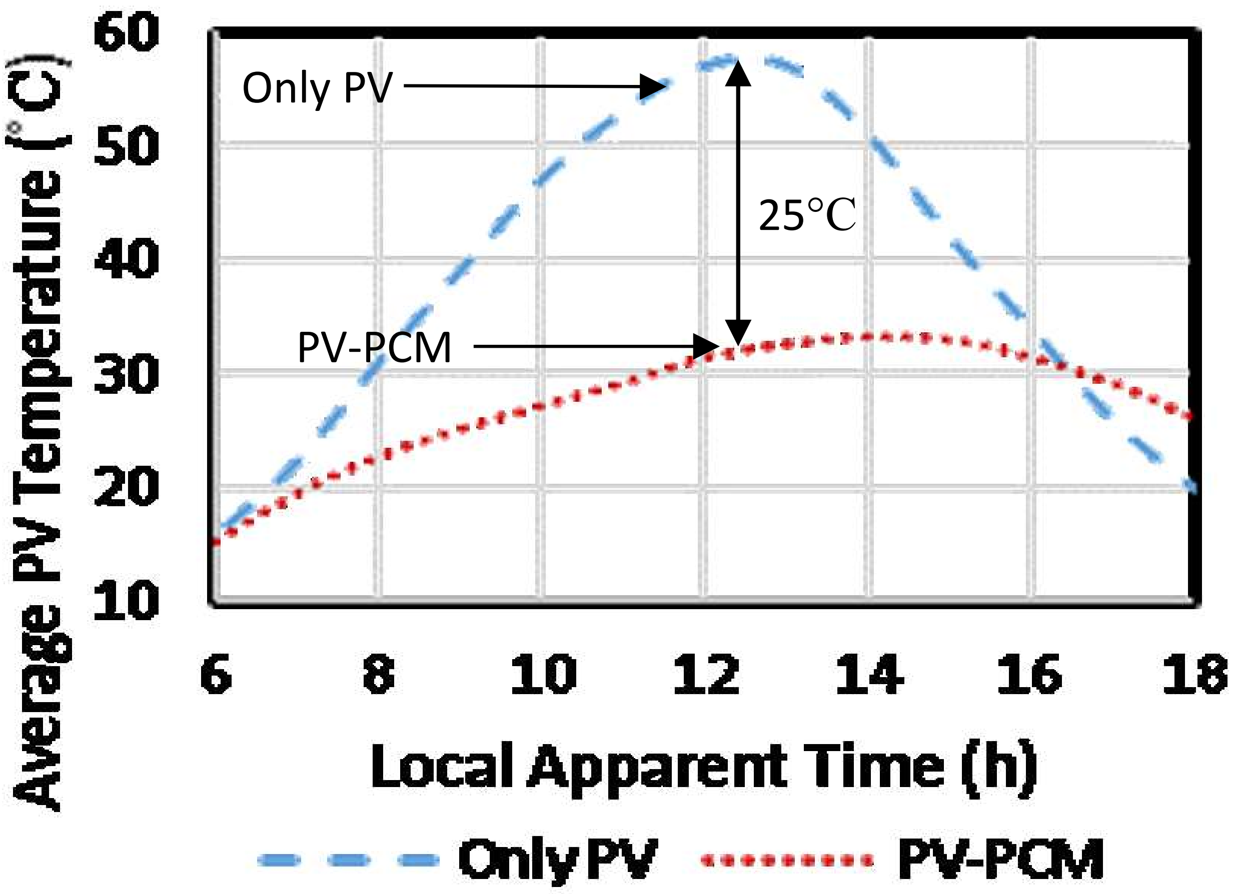




Increment in Electrical Output is 8.5% for climate with low wind speed

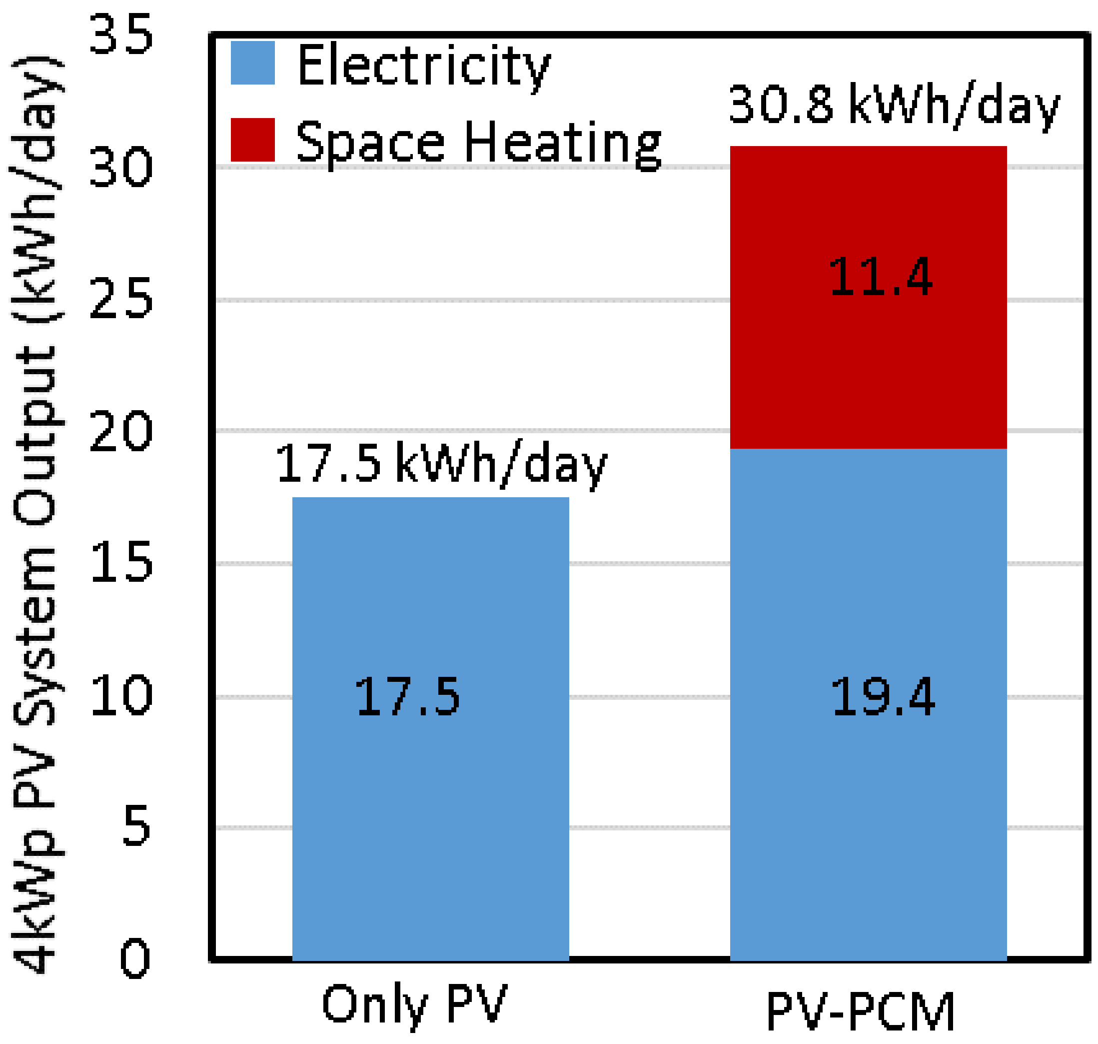
PCM integration is more suitable for Climates with low wind speed

A Case Study of 4kWp System at South East of UK



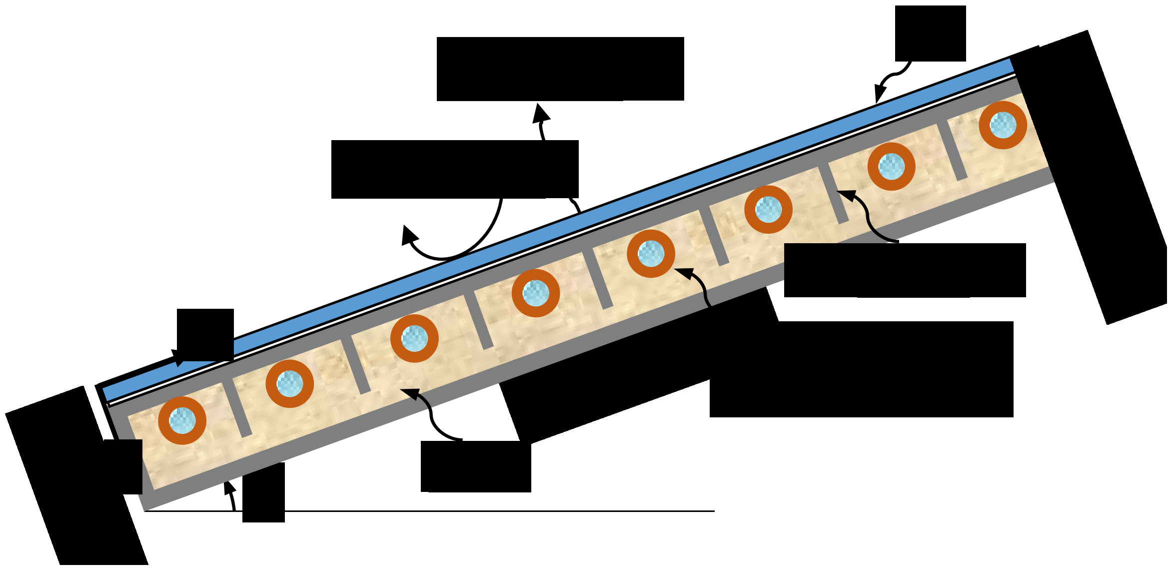
PV temperature can be reduced by 20-25°C by using PCM

Comparison of only PV and PV-PCM systems



Heat Exchanger Integration (Future Work)

- PCM stores heat
- Pipes can be inserted inside PCM
- Water can be heated up when required
- Heat exchanger will be integrated in future work
- Cost analysis will also be carried out



Thanks