Solar energy: solar arrays, DC-DC conversion, DC-AC conversion and phase synchronization

The light from the sun is the origin of almost all (except nuclear) forms of energy that we rely upon in our civilization. The energy flux reaching the Earth in its orbit around the sun is ~10 kW/m², mostly in the ultraviolet. The atmosphere absorbs most of the UV (thank goodness!) and ~1 kW/m² of visible light (normal incidence) reaches the surface of the Earth on a clear day.

A silicon diode can be structured so that a photon of visible light boosts an electron-hole pair across the p-n junction, directly transforming part of the photon’s energy into electrical energy. The practical challenges to make this useful include:

- to develop photovoltaic surfaces with high conversion efficiency (Si photocells have efficiencies ~10%, best to date of advanced heterostructures is ~50%);
- to develop manufacturing technologies that reduce the cost of making large-area devices (Si photovoltaics start with a zone-refined boule pulled from molten silicon, very expensive; some heterostructures today can be deposited using chemical vapor deposition onto aluminum foil!);
- to efficiently convert the DC current at low voltage produced by each solar panel into AC current and synchronize it with the AC power on a transmission line so that it can drive distant loads in a distributed electric power grid.

We are providing 6 Si solar panels, each with area 0.2 m², each capable of producing 20 W power at 20V at noon on a clear day. There is a vast literature on solar conversion, DC-DC conversion to adapt the solar array to charge a device requiring a particular DC voltage, and DC-AC conversion using inverter circuits. You should familiarize yourself with this in overview, select a particular problem of interest to you, and then dive into the details of design for that application.