

Bio-Nano-Solar Power

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Common Terms

- ❖ **Energy:** Thermal, Mechanical, Electrical, Renewable Energy
- ❖ **What is Electricity?**
- ❖ **Current (Flow):** Ampere (A) = One coulomb of electrical charge (6.24×10^{18} electrons) per second (C/s)
- ❖ **Voltage (Population):** Volts (V) = the difference of potential that would carry one ampere of current against one ohm resistance.
- ❖ **Power (Rating):** Watt (W) = $V \times A = V \times C/s = \text{Joules/s}$
- ❖ kW, MW, kWh, MWh (Capacity of Plant MW or MWh?)
- ❖ PLF, kCal, Downtime, CUF, Outage
- ❖ Why W, J, V, A, M are capital?

Solar Radiation

Useful Solar Radiation

- ❖ **Light as Energy?**
- ❖ **Sunlight as energy? IR, Visible, UV**
- ❖ **100--UV--400--Vis--800--IR--2500 (nm)**
- ❖ **Wavelength vs Energy**
- ❖ **Electromagnetic radiation emitted by the sun as Heat, Light & Disinfectant**
- ❖ **1367.7 W/m² outer space, 1000 W/m² on earth surface**
- ❖ **Direct radiation**
- ❖ **Diffuse radiation**
- ❖ **Two together referred as global radiation**

Solar Radiation Measurements

- ❖ **Global horizontal irradiance (GHI): Pyranometer**
- ❖ **Total: Direct + Diffuse**
- ❖ **Useful for PV**



Solar Radiation Measurements

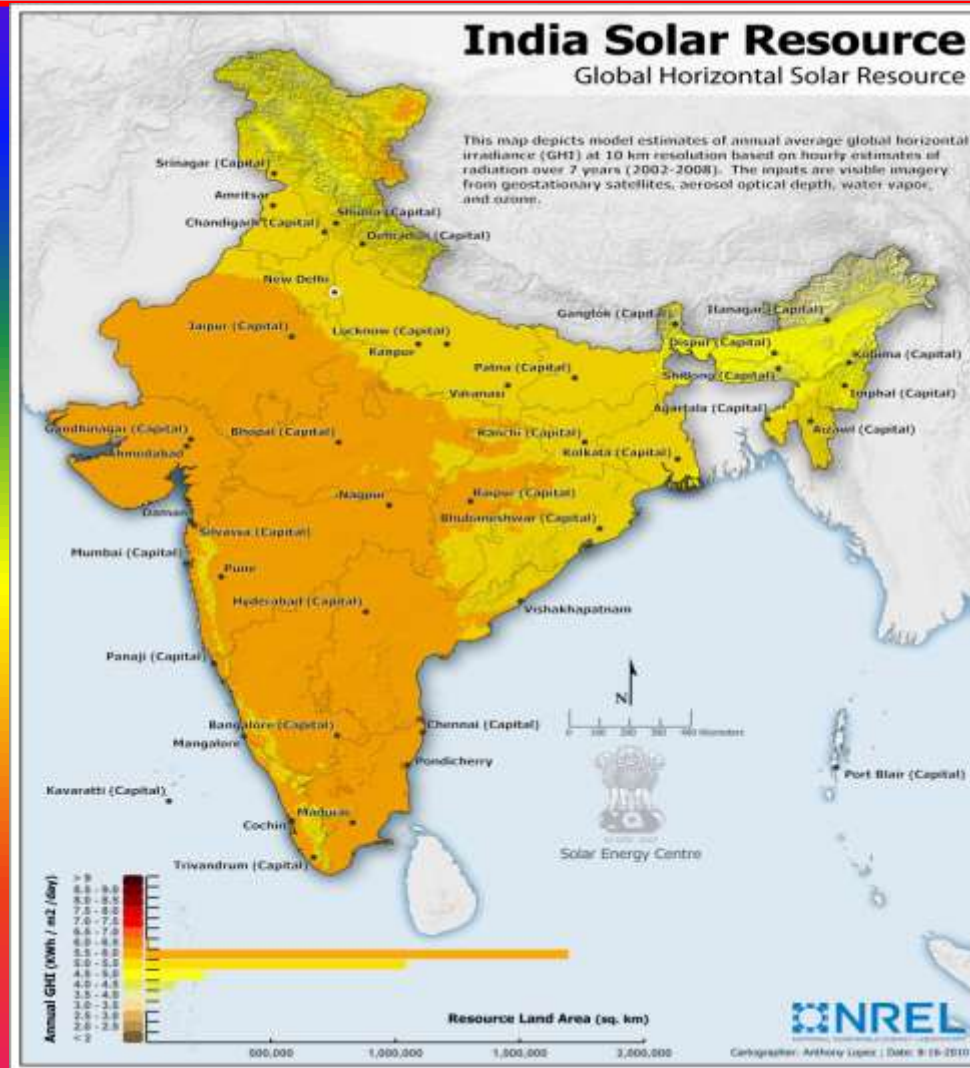
- ❖ **Direct Normal Irradiance (DNI): Pyrheliometer**
- ❖ **Direct on perpendicular surface**
- ❖ **Useful for Reflectors, CSP**



Solar Radiation Measurements

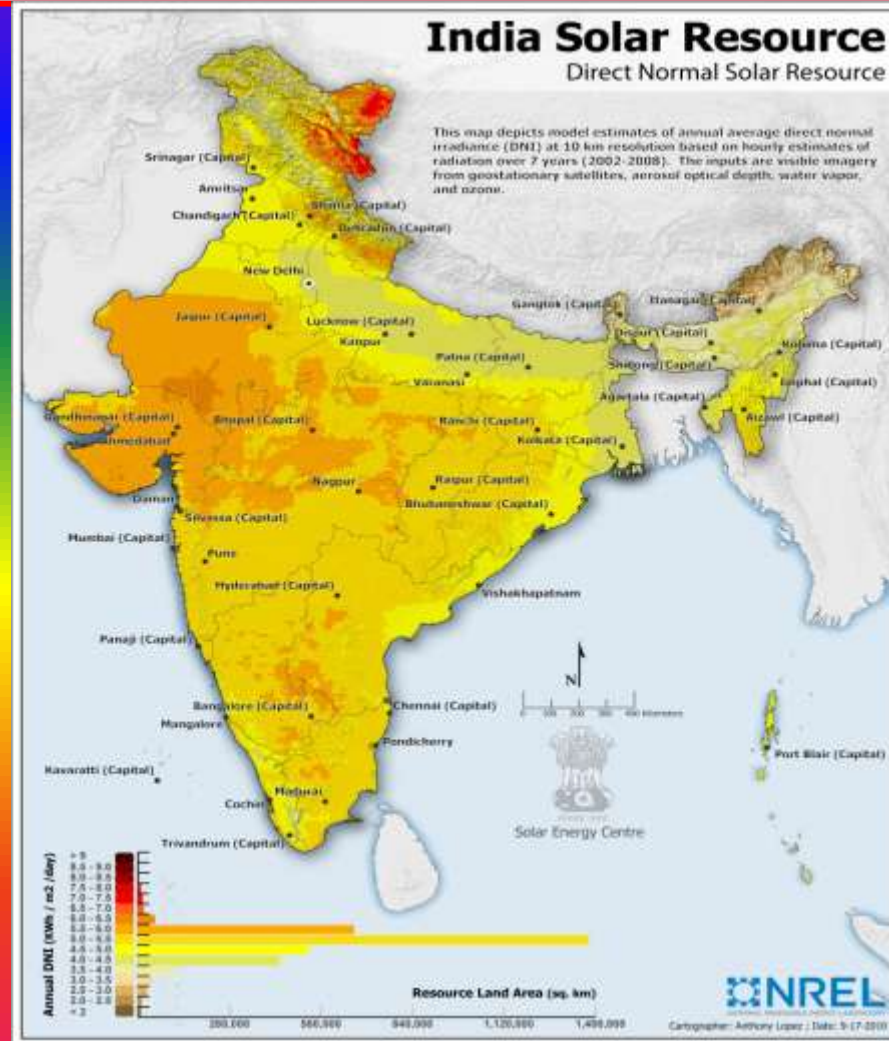
- ❖ **Solar radiation Unit - kWh/m²/day**
- ❖ **Power project :**
 - ❖ **CSP min. DNI-1800 kWh/m²/yr (Reported)**
 - ❖ **SPV min. GHI-1500 kWh/m²/yr (Suggested)**
- ❖ **Small solar power: No standard**
- ❖ **Radiation of site needed for designing**
- ❖ **Actual ground data: Not always available**
- ❖ **Derived data: NASA, METONORM, GeoModel**

Solar Radiation Map 1/2



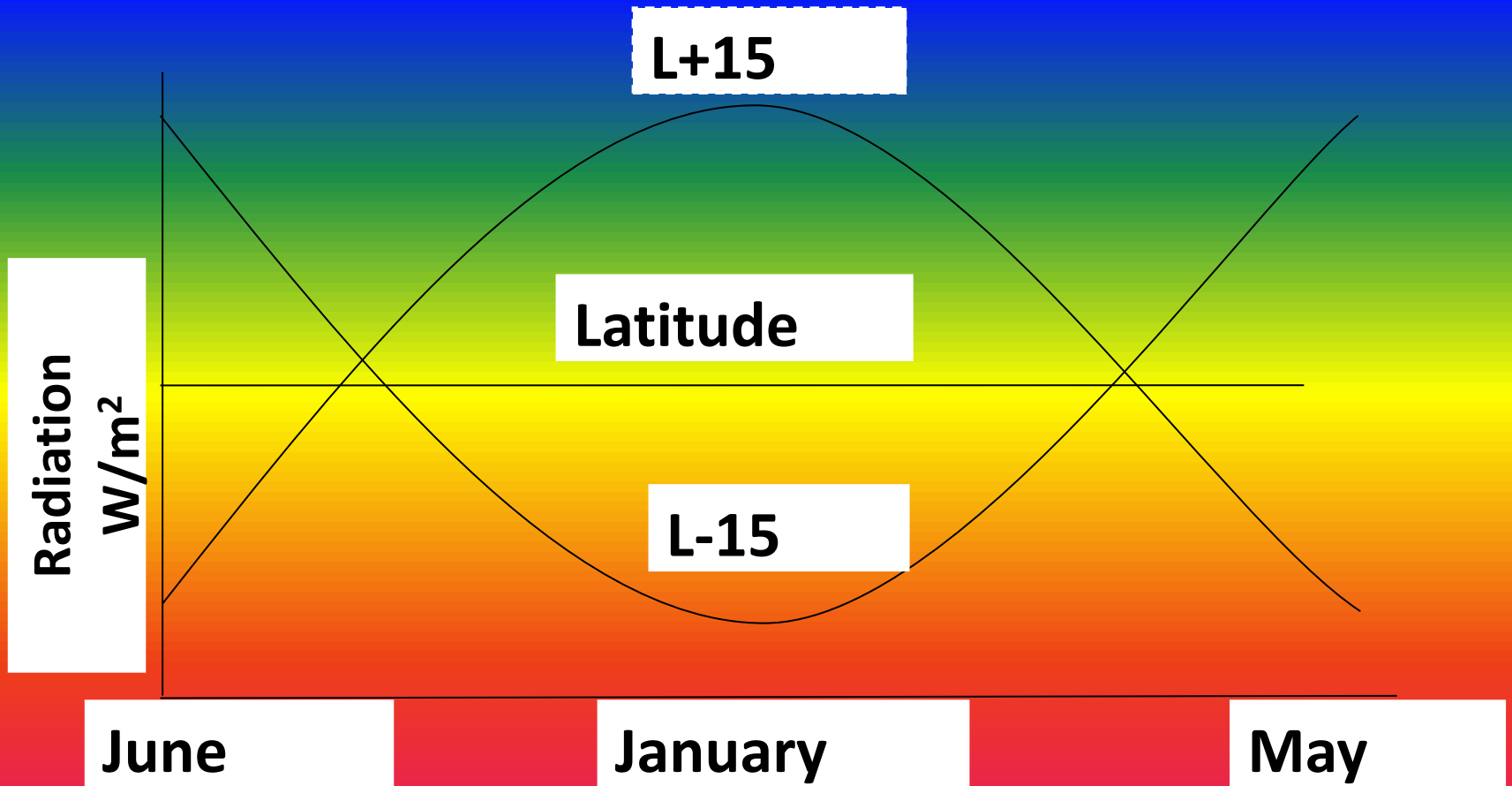
Ideal: > 1500 kWh/m²/yr, Maharashtra: > 2000 kWh/m²/yr (Good)

Solar Radiation Map 2/2



Ideal: > 1800 kWh/m²/yr, Maharashtra: > 1900 kWh/m²/yr (Avg.)

Winter or Summer Optimization



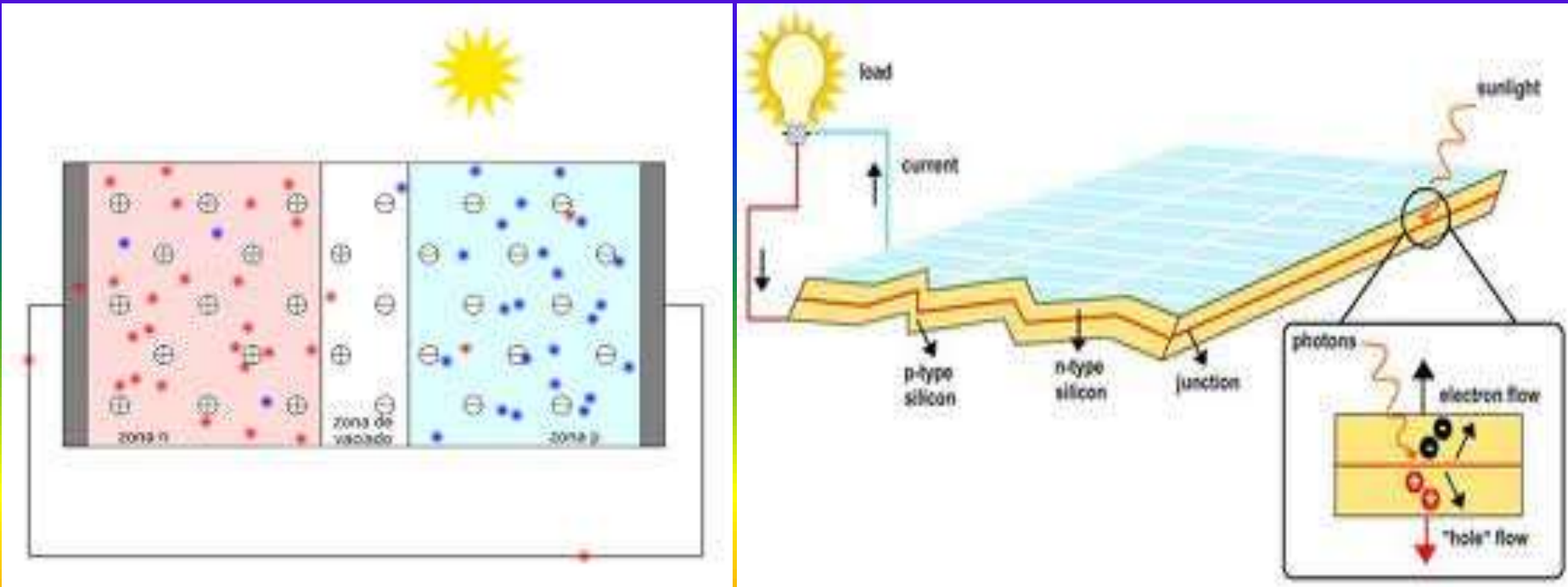
Solar Photovoltaic Power

Photovoltaic cell



- ❖ Silicon n-type film on p-type chip (0.3 mm)
- ❖ Top metal grid + bus bar (photolithography)
- ❖ Bottom full metal cover e.g. Silver
- ❖ Positive (bottom) & Negative (top) connections

Photovoltaic Effect



- ❖ Light energy strikes junction
- ❖ Electrons flow: inside from p- to n-
- ❖ Outer circuit: from n- to p-
- ❖ Suitable load attached for use

Types of PV Cells



Mono



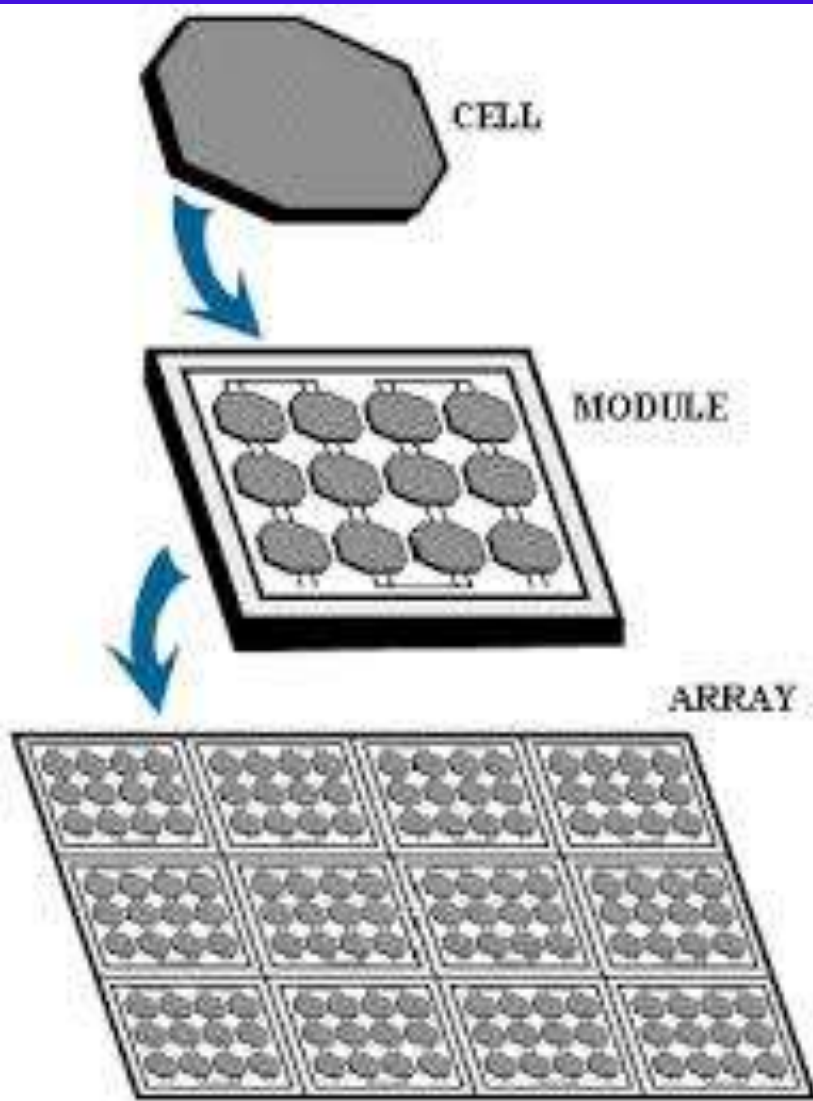
Poly



Thin Film

- ❖ **Crystalline**
 - ❖ **Mono-crystalline silicon solar cells**
 - ❖ **Polycrystalline silicon solar cells**
- ❖ **Thin film**
 - ❖ **Amorphous silicon**
 - ❖ **Cadmium telluride**
 - ❖ **Copper indium di-selenide**

Cell, Module, Array

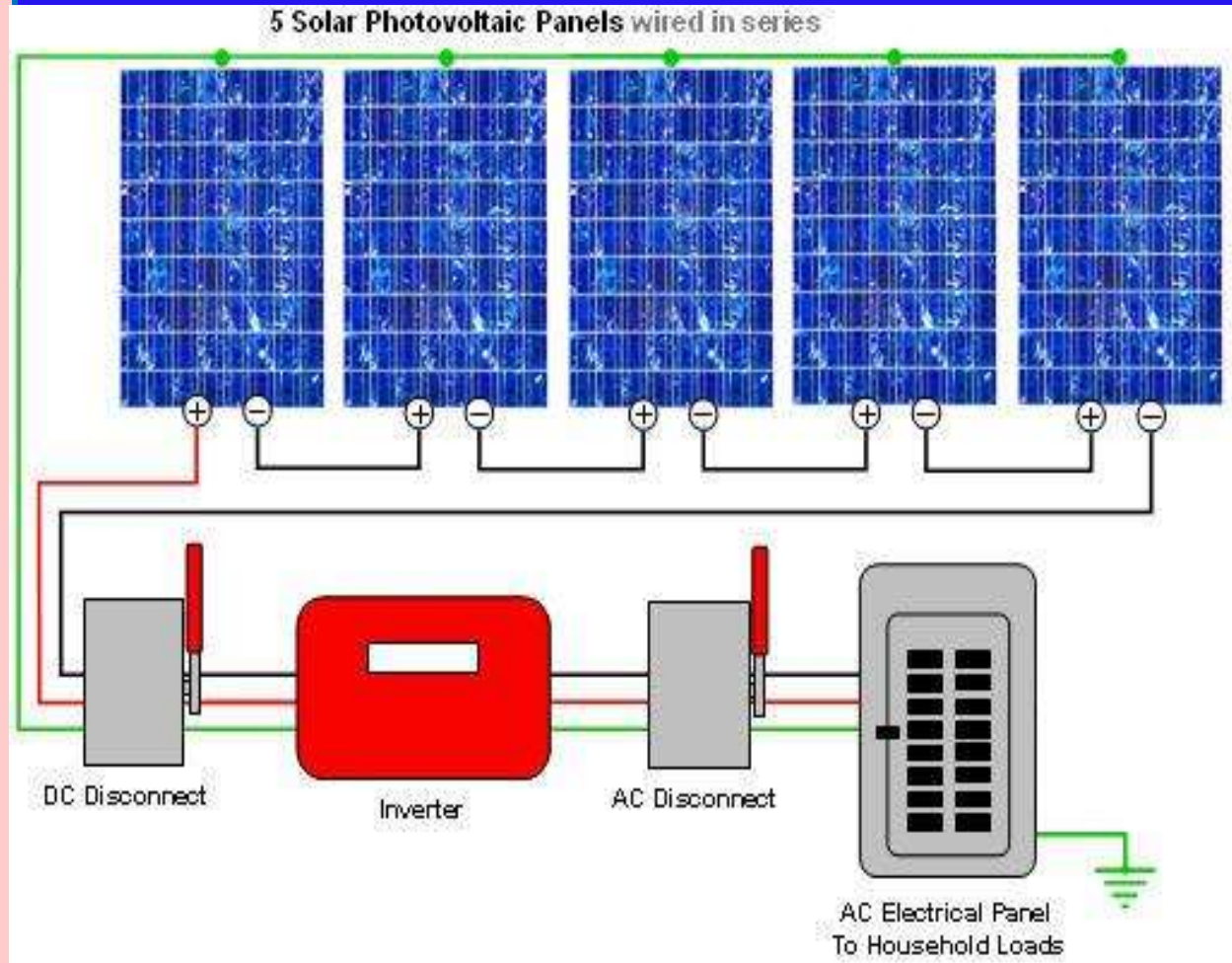


- ❖ **Cells connected in series: Voltage added**
- ❖ **Cells connected parallel: Current added**
- ❖ **Parallel-series combination decides wattage, voltage**
- ❖ **Same logic with modules to form array**
- ❖ **Same logic with arrays to form solar field**

Suitable Solar Cell for Solar Power

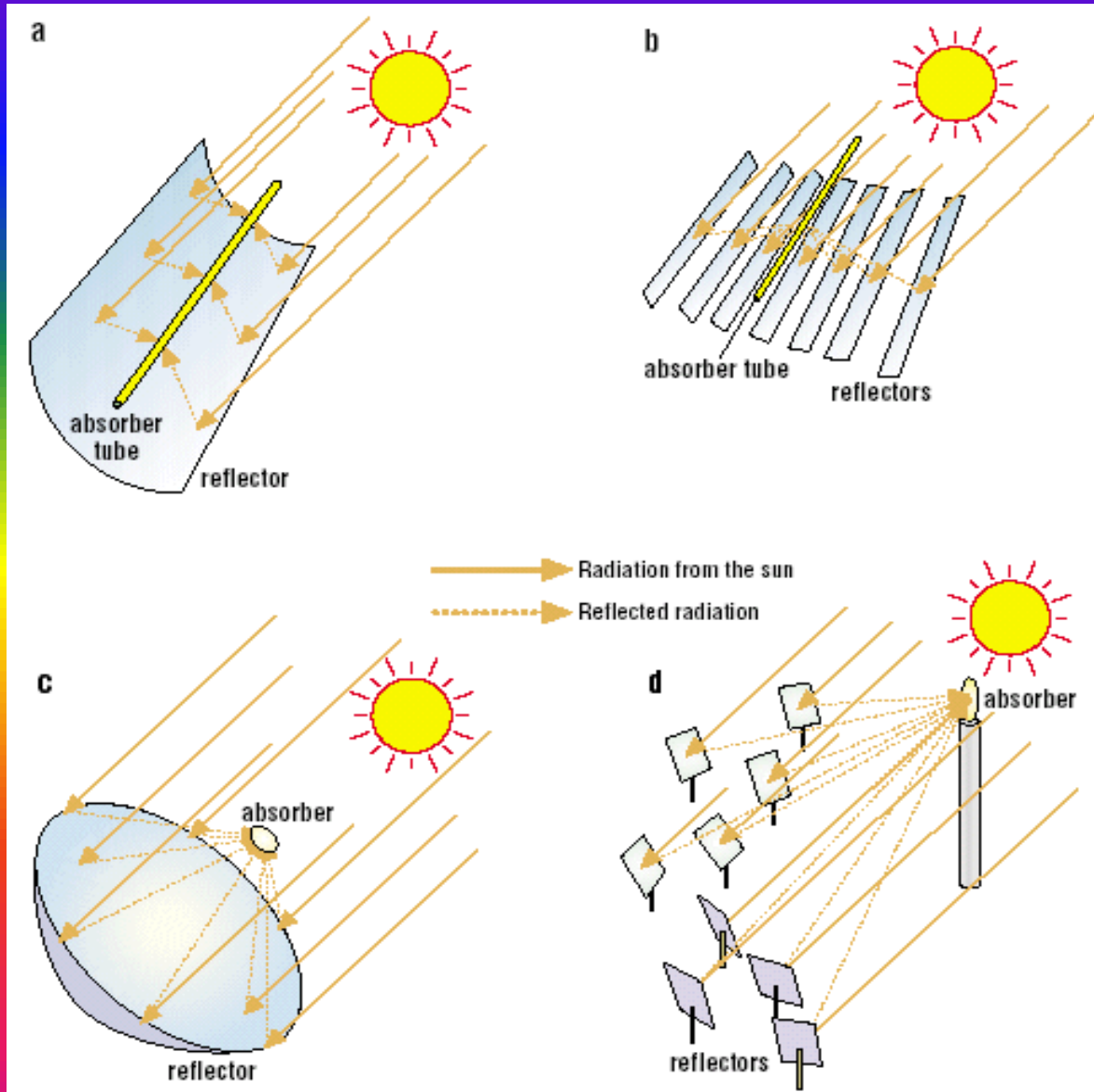
❖ Use the **poly-crystalline modules** solely because:

- ❖ Slight cost advantage,
- ❖ Easier availability with vendors
- ❖ Good efficiency
- ❖ Least degradation
- ❖ Local availability
- ❖ Good life of cell



Solar Thermal Power

Types of Solar Thermal Technologies



- ❖ Parabolic trough solar thermal system
- ❖ Compact linear Fresnel reflector (CLFR) solar thermal system
- ❖ Parabolic dish solar thermal system
- ❖ Power tower solar thermal system

Parabolic Trough Systems: Andasol, Spain



- ❖ **Reflectors:**
Parabolically curved
- ❖ **Placement:** north-south, **track:** east to west
- ❖ **Absorber pipes** contains Heat Transfer Fluid (HTF)
- ❖ **Hot HTF is used to generate steam**
- ❖ **Steam generates power through steam turbine to turn an electric generator to produce electricity**

Compact Linear Fresnel Reflector (CLFR): Kogan Creek, Australia



- ❖ Line focusing system
- ❖ Array of nearly flat reflectors
- ❖ Flat segments of rectangular shaped mirrors are arranged horizontally in a north-south
- ❖ Track the sun from east to west

Parabolic Dish : Mojave Desert, USA



- ❖ A parabolic dish shaped point focus concentrator
- ❖ Reflects solar radiation onto a receiver mounted at the focal point
- ❖ Concentrators are mounted on a structure with a **two axis tracking** system
- ❖ Collected heat utilized directly by a heat engine (sterling engine)

Power Tower: Abengoa, Spain



- ❖ Called central receivers
- ❖ Utilizes a **two axis sun-tracking** mirrors called heliostats
- ❖ HTF heated in the receiver
- ❖ Used to generate steam in the steam generator
- ❖ Steam is used to power steam power cycle to turn steam turbine to generate electricity

Power Tower: Abengoa, Spain



Bio-Nano-Solar Power

Plants Bend Towards Light: Phototropism



- ❖ Plants generate food using light energy
- ❖ Takes C, H, O from atmosphere to form $(\text{CH}_2\text{O})_n$ **Biomass**
- ❖ Sensory motor effect
- ❖ Motor, Pump, Cable and Electron Flow all present in plant
- ❖ Can solar energy be used to generate power through plants: **similar to Photovoltaics?**

Photosynthesis Mechanism

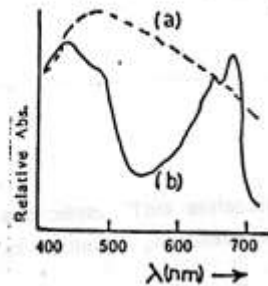


Fig.1. Solar Spectrum (a), Chloroplast action spectrum (b)¹.

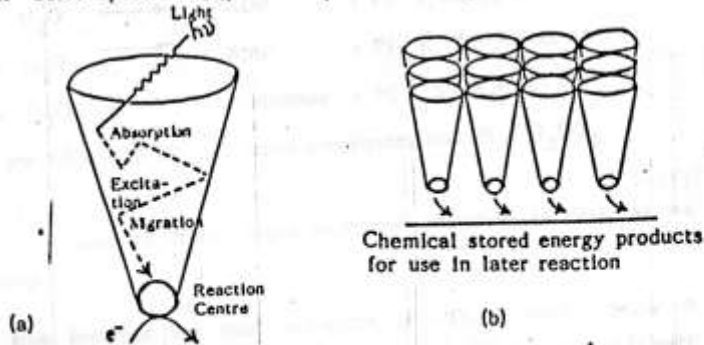
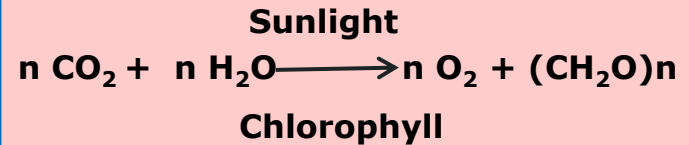


Fig. 2. Photo-antenna systems (a) and their spatial arrangements (b)¹

- ❖ **Micro Structure: Plants leaves have Chlorophyll (antenna like structure)**
- ❖ **Capture solar energy to produce carbohydrate molecules.**



- ❖ **The carbohydrate finally promotes the metabolic and structural functions during the growth of plant.**
- ❖ **Apparently, photosynthesis is the root cause of biomass production.**
- ❖ **Biomass is indirect Solar (We eat solar energy)**

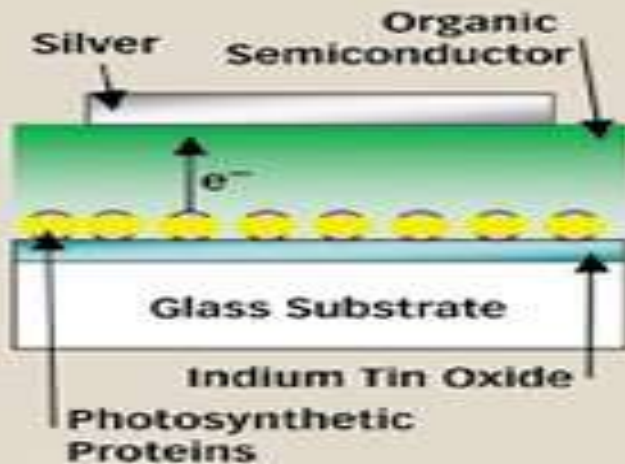
Nano Aspects of Bioenergy

- ❖ **Nanotechnology:** Using nano scale (10^9 meter) particles to achieve technological advancement
- ❖ **Micro-Electronics:** Large floppy-Mini floppy-CD- mini CD-Pendrive-Memory chips **Large memory in small space**
- ❖ **Nanobio**technology: Achieve biological objective using nano technology. Example: nano medicines (localized effect), nano robots (kill ony cancerous cells), Bio chips (Blood test at home) **Cheaper and Faster**
- ❖ **Bio**nanotechnology: Achieve nanotech using Bio-technology. Example: Bio solar Cell, Bio-electrolysis, Biomemory chips, Bio-computers **Simpe to Use**

Palak (Spinach) Solar Cells

- ❖ **More than 40 years ago, scientists discovered that one of the proteins involved in photosynthesis (PS1) was able to function even after it was extracted from plants**
- ❖ **PS1 impressively converts sunlight into electrical energy with nearly 100 % efficiency compared to max. 40% of Silicon solar cells**
- ❖ **Palak is very rich with PS1. Hence useful for bio-solar cells**

Palak (Spinach) Solar Cells



- ❖ Massachusetts Institute of Technology, USA extracted PS1 proteins from Palak
- ❖ Placed ~ 2 billion PS1 on a piece of glass in artificial cell membrane
- ❖ Fixed a layer of proteins between layers of semiconductors
- ❖ Exposed to sun light to produce electric current

Bio-Solar Cells: Challenges Ahead

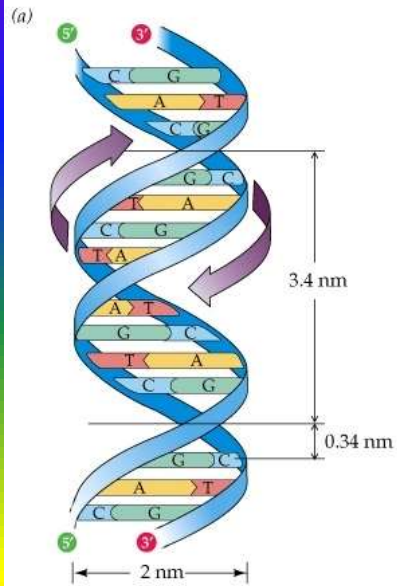
❖ ISSUES:

- ❖ **Less Power - Less current (1 mA/cm²) vs. Silicon (30 mA/cm²)**
- ❖ **Short Lifespan- Few weeks to nine months vs. Silicon (25 yrs)**
- ❖ **Dis-orientation:**
 - ❖ **PS1 proteins in membrane of live plant: Same orientation**
 - ❖ **Extracted PS1 is applied to a surface and dried: Disoriented**
 - ❖ **That's bad for energy production**

❖ RESEARCH REQUIRED:

- ❖ **Make protein-based solar cell self-repairing by swapping out the old copies for new one: to improve life**
- ❖ **Prepare synthetic PS1 protein dominant PALAK: to produce solar electricity**
- ❖ **Synthesize light sensitive PS1 proteins which rearrange in single orientation when photo-exposed: to capture maximum sunlight**
- ❖ **Improve transparency and conductivity of PALAK membrane: to use the leaf directly as semiconductor with well oriented PS1**

The Way Out

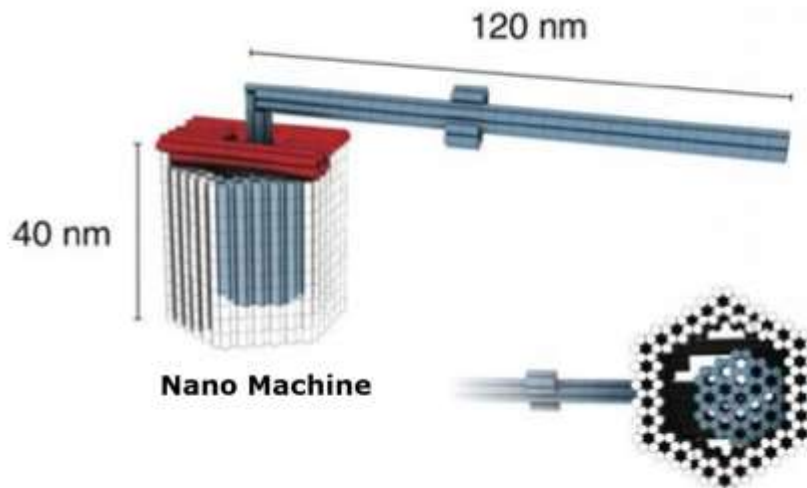


The Mechanism:

- ❖ DNA (Deoxyribonucleic acid) is information Center
- ❖ Enzymes read message and send through messenger RNA (Ribonucleic acid)
- ❖ RNA translates message into "language" of Amino acids
- ❖ Amino acids create proteins

The Solution:

- ❖ Read and write DNA using nano machine
- ❖ Modify it using nano motors and nano robots
- ❖ Synthesize PS1 dominant PALAK
- ❖ Generate light responsive PS1
- ❖ Create transparent and conductive membrane



THANK YOU

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