Ειδικά κεφάλαια παραγωγής ενέργειας

Ενότητα 3 (α): Solar Power Overview

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Τμήμα Μηχανολόγων Μηχανικών

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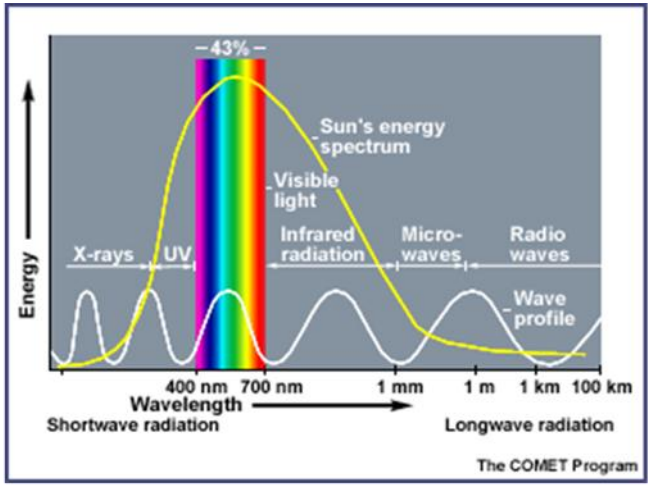
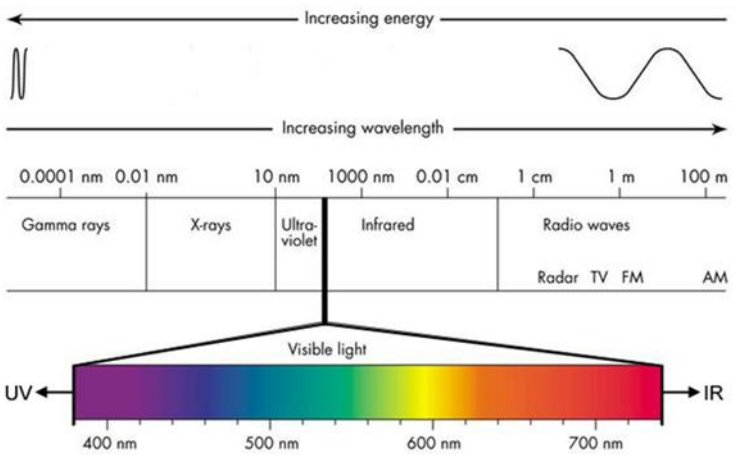
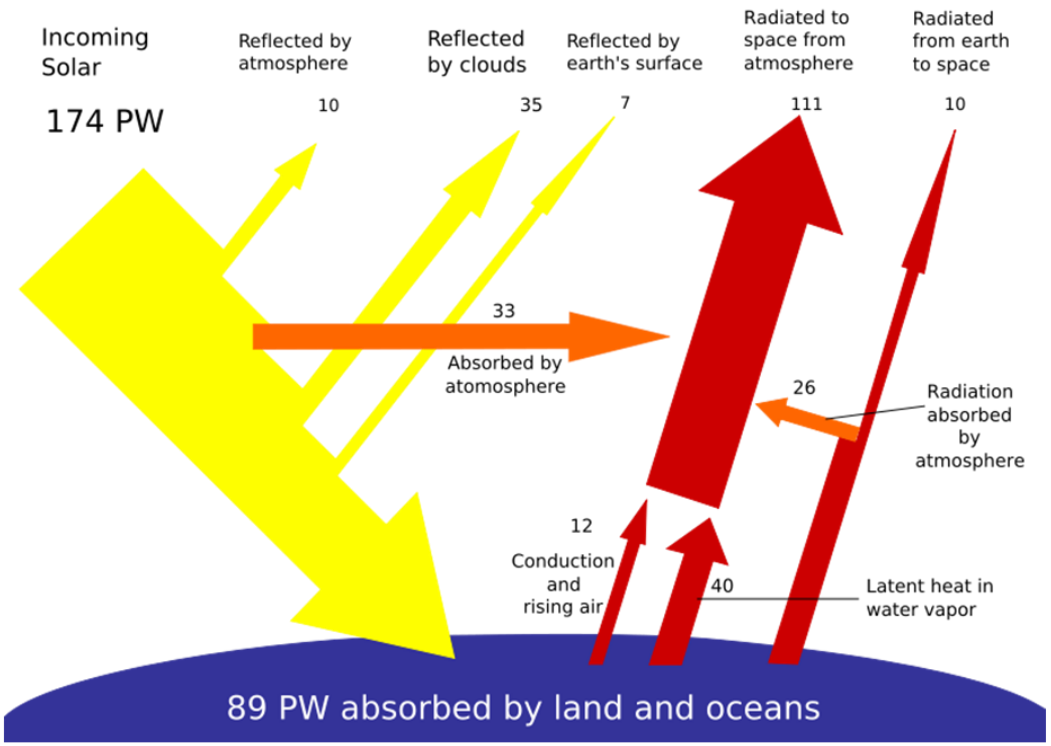
What is Solar Energy?

- Originates with the thermonuclear fusion reactions occurring in the sun.
- Represents the entire range of radiation (visible light, infrared, ultraviolet, x-rays, radio waves).
- Different colors of light have different wavelengths and different energies.



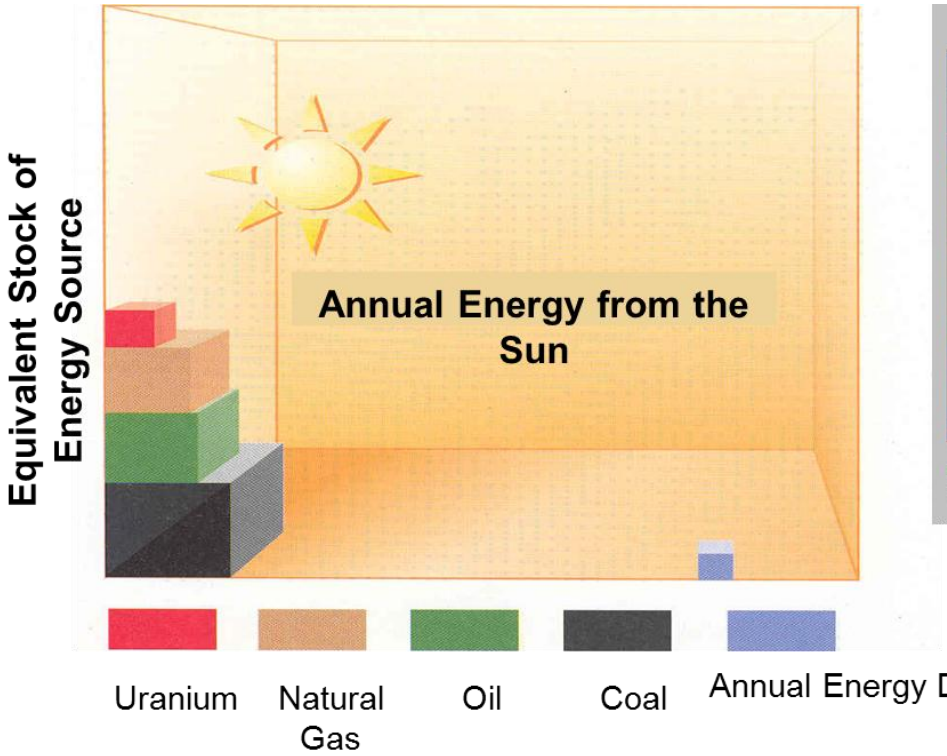


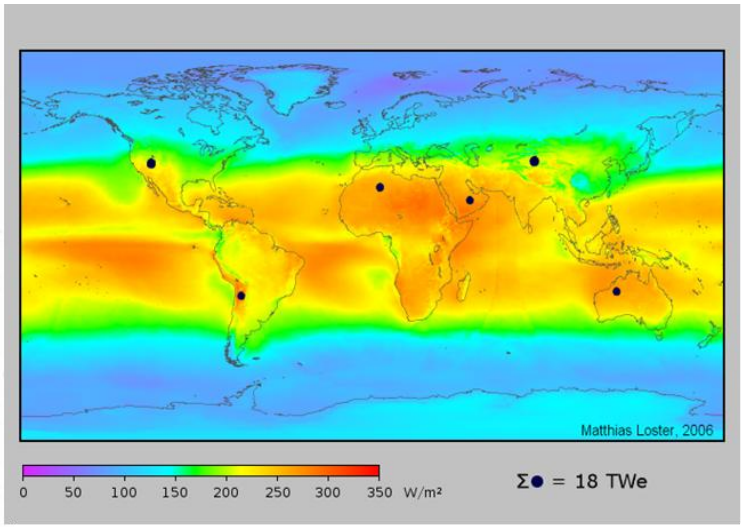
How much solar energy?



The surface receives about 47% of the total solar energy that reaches the Earth.

Global Energy Situation





The theoretical potential of solar energy reaching the earth is 7500 Gtoe annually, representing the 75000% of the global energy balance. The technical potential of solar energy, is estimated at 40 Gtoe, or 400% of the global energy balance.

Advantages and Disadvantages

- **Advantages:**
  - All chemical and radioactive polluting byproducts of the thermonuclear reactions remain behind on the sun, while only pure radiant energy reaches the Earth.
  - Energy reaching the earth is incredible.

- **Disadvantages:**
  - Sun does not shine consistently.
  - Solar energy is a diffuse source. To harness it, we must concentrate it into an amount and form that we can use, such as heat and electricity.
  - Addressed by approaching the problem through:
    1) collection, 2) conversion, 3) storage.

What can we do with it? (1/2)

- Solar energy can be converted to **thermal (or heat) energy** and used to:
  - Heat water – for use in homes, buildings, etc.
  - Heat spaces – inside greenhouses, homes, and other buildings.

What can we do with it? (2/2)

- Solar energy can be converted to electricity in 2 ways:
  - **Photovoltaic** (PV devices) or “solar cells” – change sunlight directly into electricity. PV systems are often used in remote locations that are not connected to the electric grid. They are also used to power watches, calculators, etc.
  - **Solar Power Plants** - indirectly generate electricity when the heat from solar thermal collectors is used to heat a fluid which produces steam that is used to power generator.

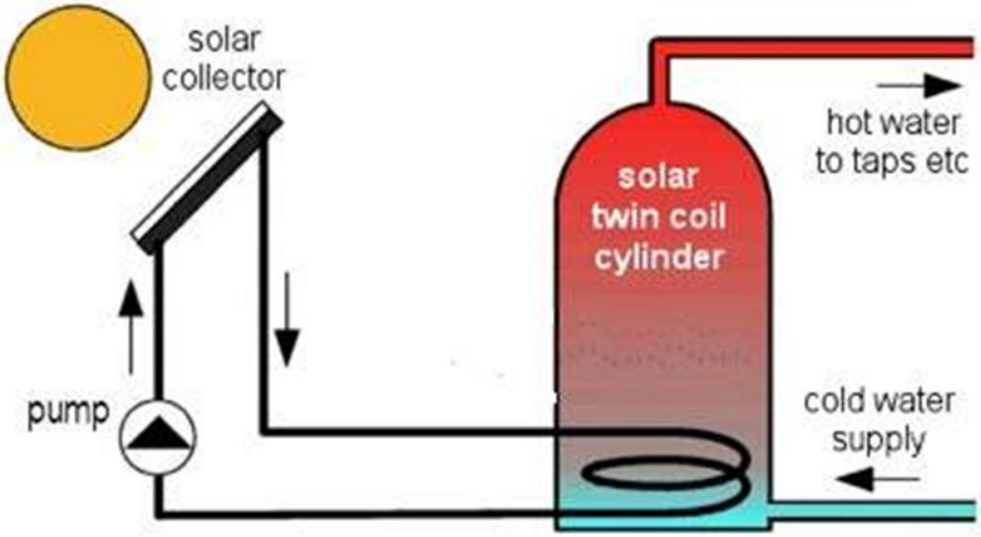
The categories of solar energy!

- Solar space heating systems can be classified as **passive** or **active**.
  - **Passive** heating is what happens to our cars on a hot summer day. In buildings, the air is circulated past a solar heat surface(s) and through the building by convection. No mechanical equipment is needed for passive solar heating.
  - **Active** heating systems require a **collector** to absorb and collect solar radiation. Fans or pumps are used to circulate the heated air or heat absorbing fluid. Active systems often include some type of **energy storage system**.

The types of solar collectors

- Solar collectors can be either **nonconcentrating** or **concentrating**:
  - **Nonconcentrating collectors** – have a collector area (i.e. the area that intercepts the solar radiation) that is the same as the absorber area (i.e., the area absorbing the radiation).
  - **Concentrating collectors** – where the area intercepting the solar radiation is greater, sometimes hundreds of times greater, than the absorber area.

Heating Water: Active System

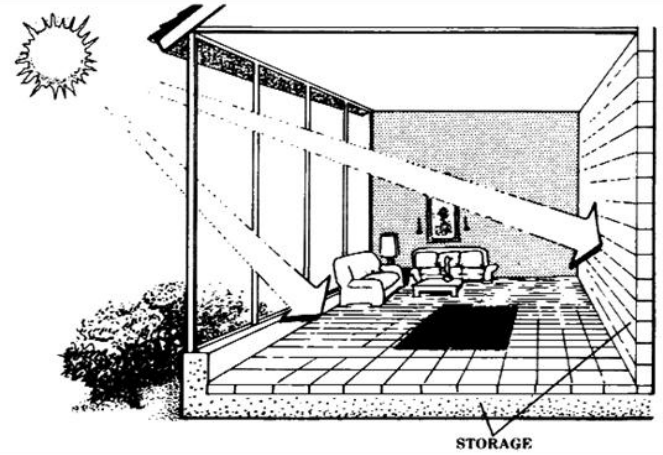


Example system with water heated by solar collector and used to supplement hot water radiator

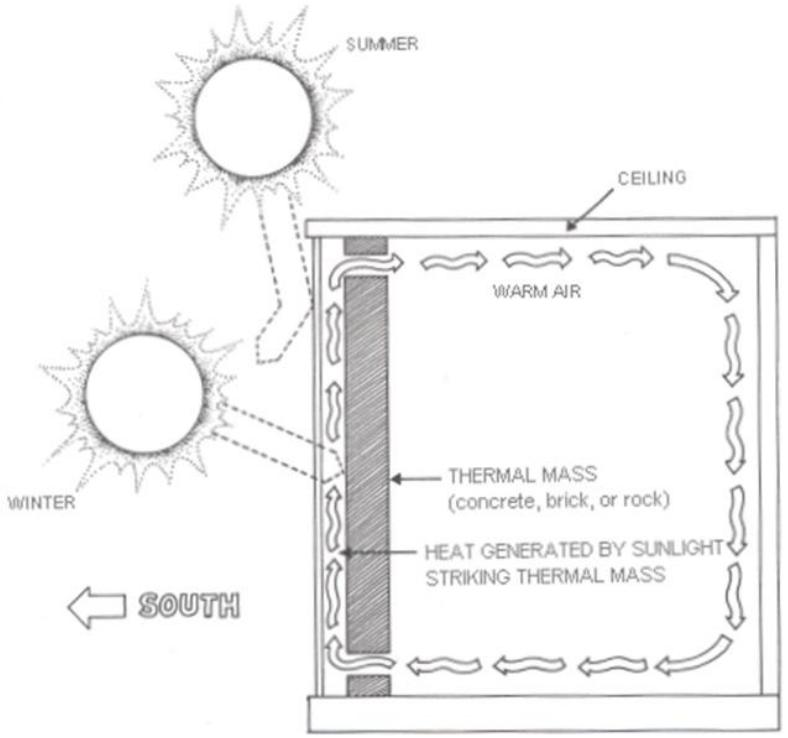
Heating Living Spaces (1/2)

- Best design of a building is for it to act as a solar collector and storage unit. This is achieved through three elements: insulation, collection, and storage.
- Efficient heating starts with proper insulation on external walls, roof, and the floors. The doors, windows, and vents must be designed to minimize heat loss.
- Collection: south-facing windows and appropriate design.

Heating Living Spaces (2/2)



Passively heated home in Colorado



Trombe Wall

Heating Living Spaces

- A passively heated home uses about 60-75% of the solar energy that hits its walls and windows.
- The Center for Renewable Resources estimates that in almost any climate, a well-designed passive solar home can reduce energy bills by 75% with an added construction cost of only 5-10%.
- About 25% of energy is used for water and space heating.
- Major factor discouraging solar heating is low energy prices.

Solar -Thermal Electricity: Power Towers

- Collect the light from many reflectors spread over a large area at one central point to achieve high temperature.

  Example is the 10-MW solar power plant in Barstow, CA.

  - *1900 heliostats, each 20 ft by 20 ft.*
  - *a central 295 ft tower.*

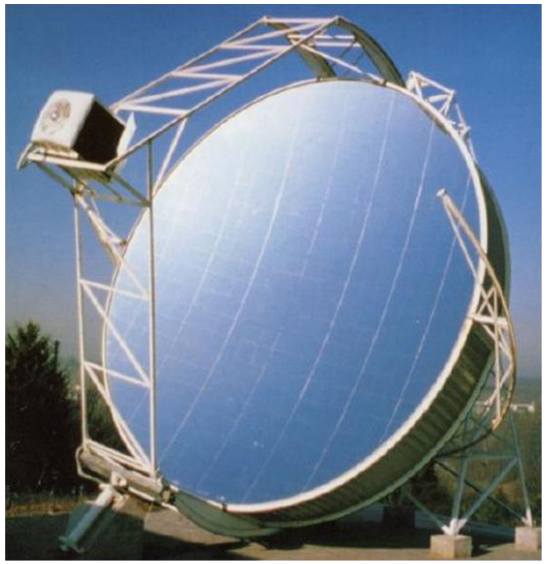
- Capital cost is greater than coal fired power plant, despite the no cost for fuel, ash disposal, and stack emissions.
- Capital costs are expected to decline as more and more power towers are built with technological advances.

Power Towers

Power tower in Barstow, California.

Solar-Thermal Electricity: Parabolic Dishes and troughs

- The more recent facilities converted a remarkable 22% of sunlight into electricity.



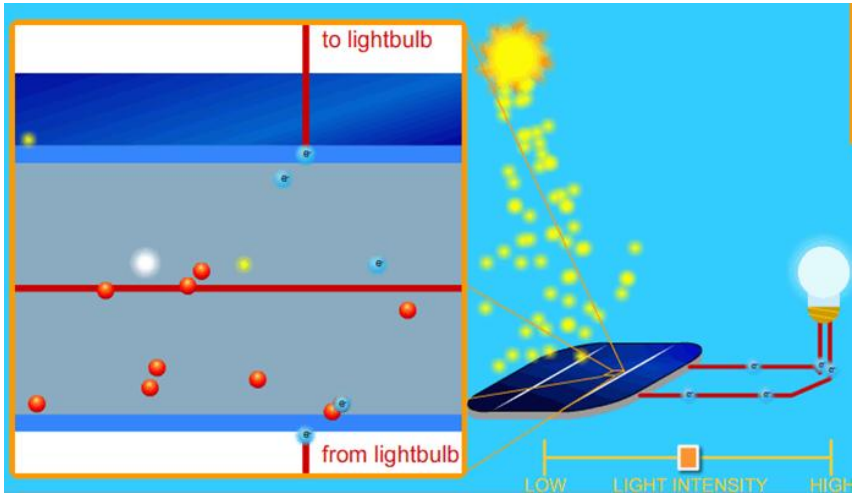
Because they work best under direct sunlight, parabolic dishes and troughs must be steered throughout the day in the direction of the sun.

How Solar Cells Work

1. Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.

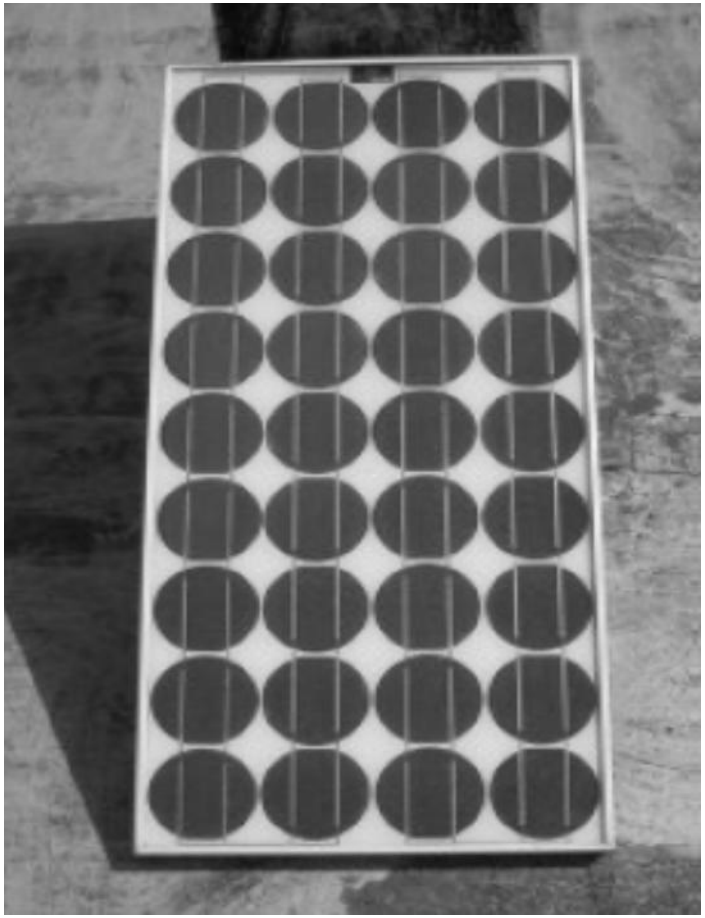
2. Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity.

3. An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.



From Cells to Modules

- The open circuit voltage of a single solar solar cell is approx 0.5V.
- Much higher voltage is required for practical application.
- Solar cells are connected in series to increase their open circuit voltage.



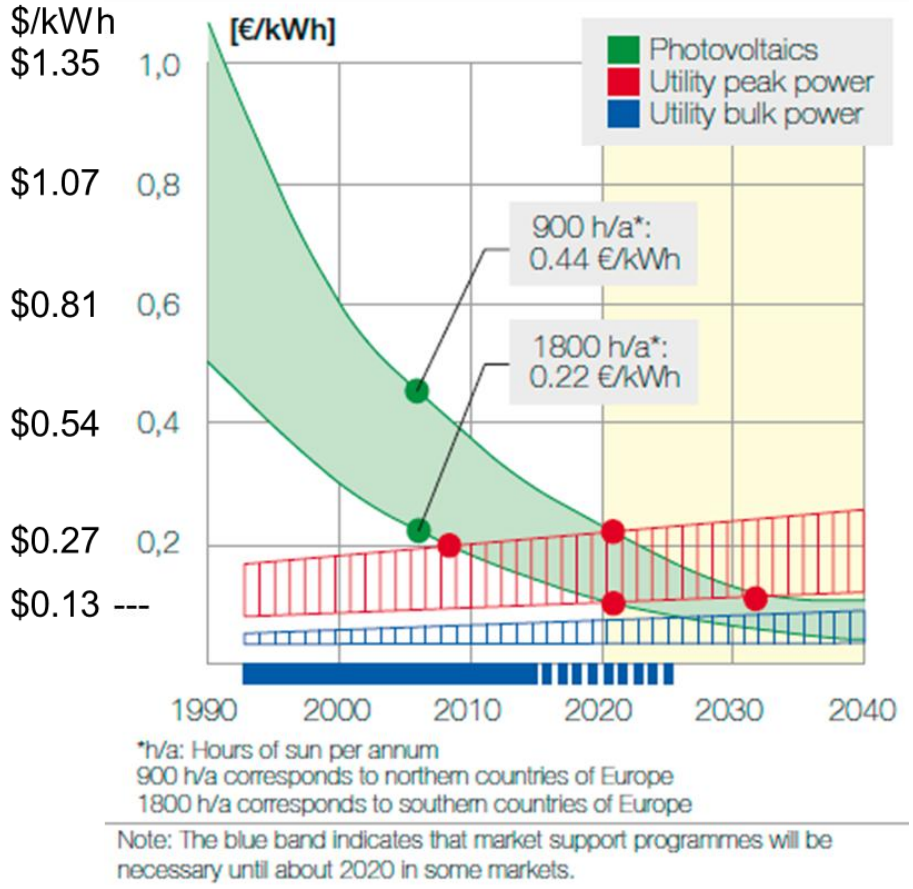
Efficiency and Disadvantages

- Efficiency is far less than the 77% of solar spectrum with usable wavelengths.
- 43% of photon energy is used to warm the crystal.
- Efficiency drops as temperature increases (from 24% at 0°C to 14% at 100°C.)
- Light is reflected off the front face and internal electrical resistance are other factors.
- Overall, the efficiency is about 10-14%.

- Cost of electricity from coal-burning plants is between 8-20 cents/kWh, while PV power generation is anywhere b/w $0.50-1/kWh.
- Underlying problem is weighing efficiency against cost.
  - Crystalline silicon-more efficient, more expensive to manufacture.
  - Amorphous silicon-half as efficient, less expensive to produce.

Cost Projections

"Grid parity' where PV cost are equal to residential electricity costs is expected to be achieved first in southern European countries and then to move north



www.epia.org EPIA Solar Generation V Report Sept 08

Τέλος Ενότητας