Nadar Saraswathi College of Engineering & Technology

NSCET E-LEARNING PRESENTATION

LISTEN … LEARN… LEAD…

ELECTRICAL AND ELCTRONICS ENGINEERING

IVth YEAR / VIIIth SEMESTER

EE6009 – POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

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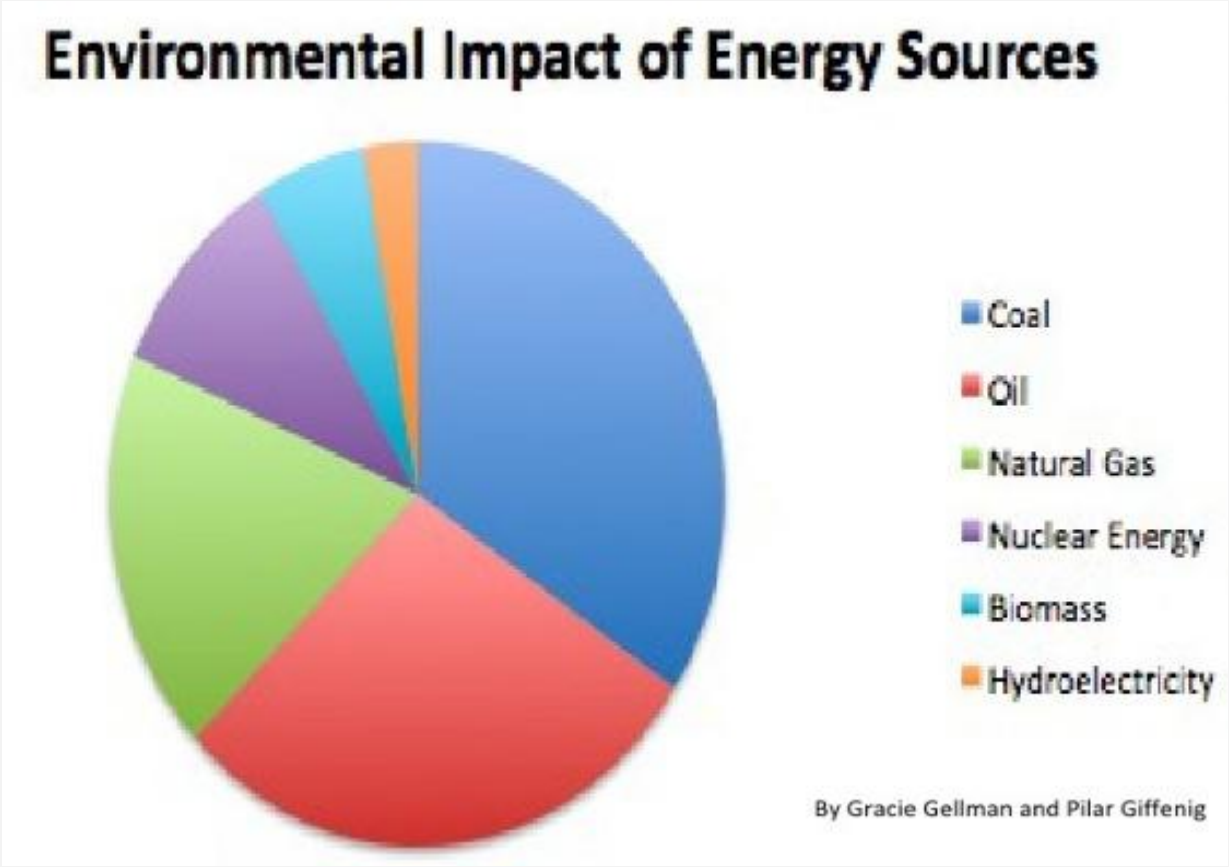
UNIT 01 - Introduction

Learning is the only thing the mind never exhaust, never fears, and never regret.

—Leonardo Da Vinci

UNIT-1

- *Environmental aspects of electric energy conversion*
- *Impacts of renewable energy generation*
- Qualitative study of renewable energy sources
  - ✓ Ocean
  - ✓ Biomass
  - ✓ Hydrogen energy systems
- *operating principles and characteristics*
  - ✓ *Solar PV*
  - ✓ *Fuel cells*
  - ✓ *Wind Electrical systems*


Environmental Impact of Energy Sources
Coal
Oil
Natural Gas
Nuclear Energy
Biomass
Hydroelectricity
By Gracie Gellman and Pilar Giffenig

Environmental Impacts of wind power

- Carbon dioxide emissions and pollution NO
- **Ecology**

✓ Impact on wild life
✓ Birds
✓ Bats
✓ Climate change

- **Impacts on people**

✓ Safety
✓ Aesthetics
✓ Noise

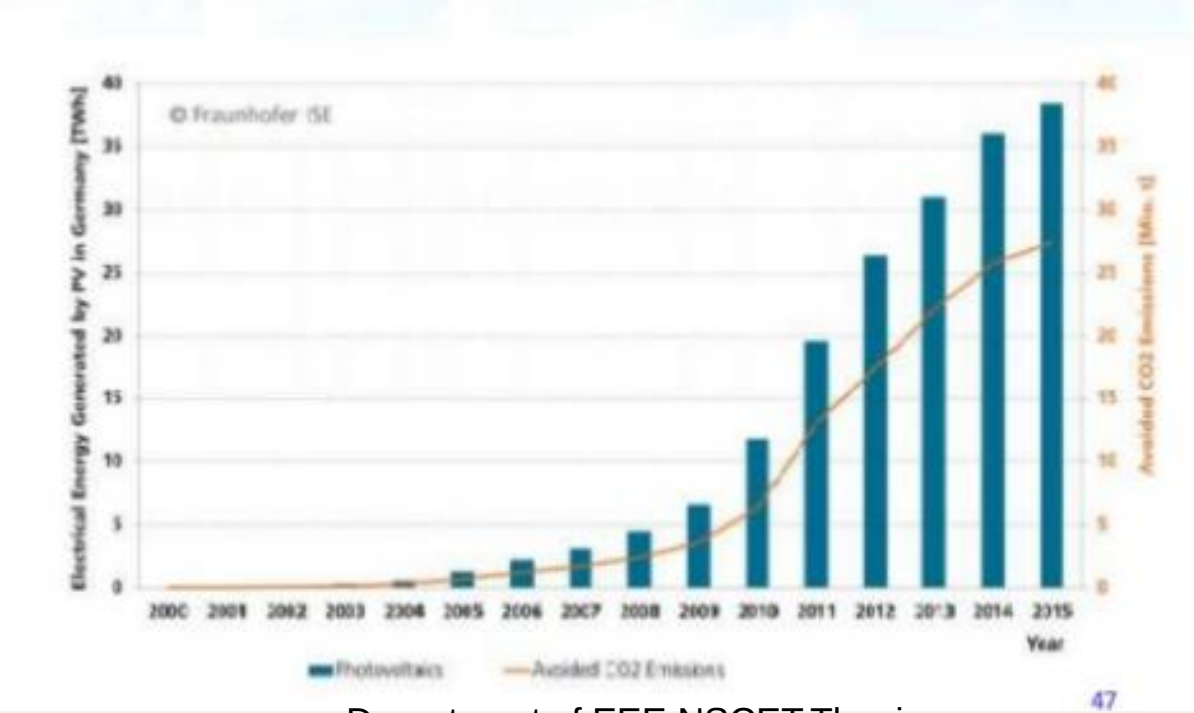
Environmental Impacts of solar power

- Using solar energy may have some indirect negative impacts on environment. For example some toxic materials and chemicals are used to make the photovoltaic(PV).
- Life cycle assessment (LCA) is one method of determining environmental impacts from PV. Most LCA of PV have focused on two categories

✓ Carbon dioxide equivalent per kWh and
✓ Energy Pay-back time (EPBT)

Case study

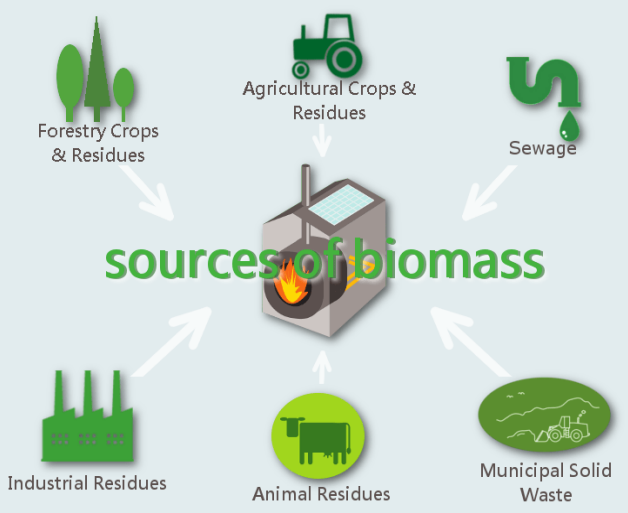
In 2o15, 27.4 CO2 emissions were avoided due to 38.4 TWh PV electricity consumed in Germany.



Environmental Impacts of Geo thermal Energy

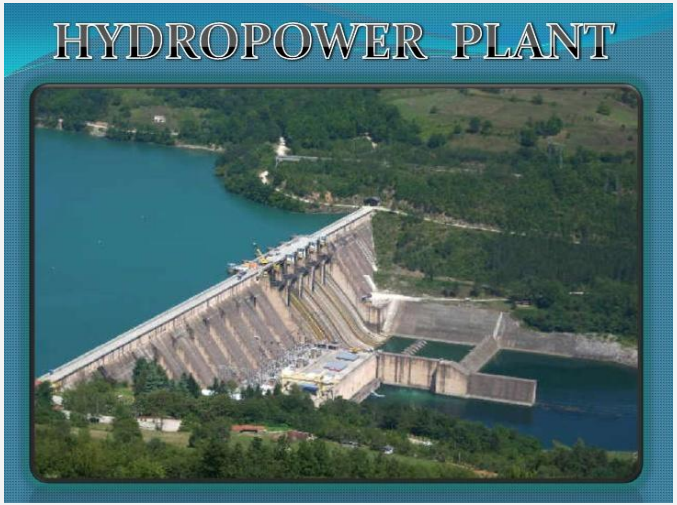
- Gaseous emissions to the atmosphere
- Water pollution
- Solids emissions to the surface and the atmosphere
- Noise pollution
- Land Usage
- Land subsidence
- Induced seismicity
- Induced landslides

Environmental Impacts of Bio mass



- ***Water Use:*** Approximately 75% of existing biomass plants that require cooling uses wet-recirculating technology
- ***Life-cycle Global Warming Emissions:*** Biomass energy 0.04 - 0.2 pounds of CO2 equivalent per kilowatt-hour
- ***Air Emissions:*** Direct Air Emissions from Biomass, Coal and Natural Gas Power Plants, by Boiler Type. Most common pollutants include nitrogen oxides (NOx), sulfur dioxide (SO2), carbon monoxide. Biomass power plants also emit high levels of particulates (soot and ash) and carbon monoxide.

Environmental Impacts of hydro electric power

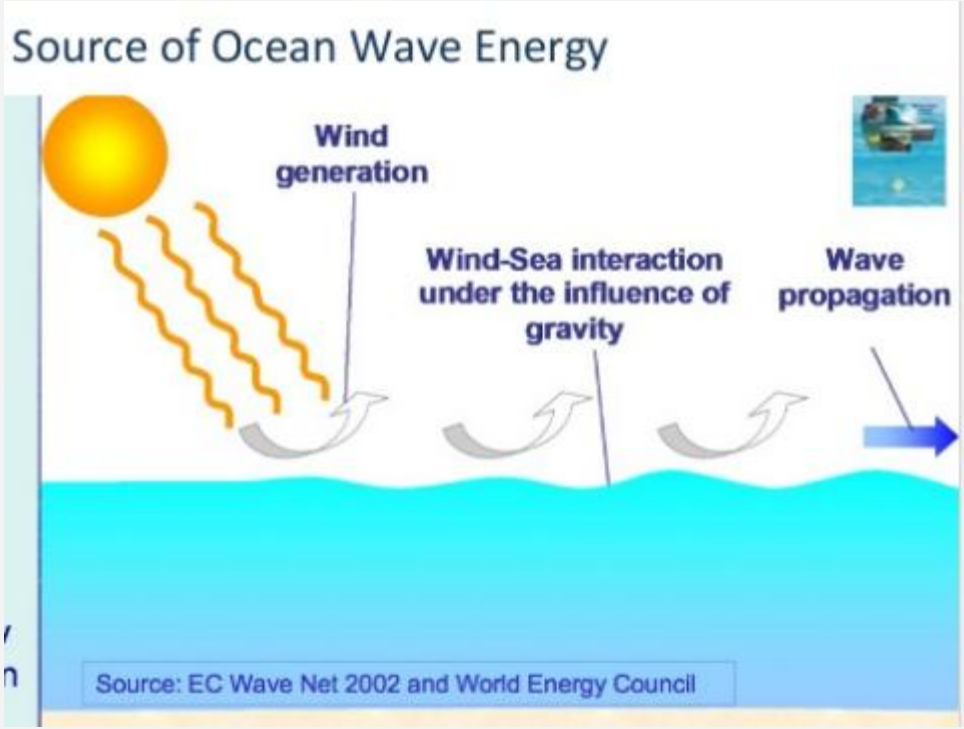


- ***Land Use:*** Hydroelectric plants in flat areas tend to require much more land than those in hilly areas. It destroys forest, wildlife habitat, agricultural land, and scenic lands.
- ***Wildlife Impacts:*** Fish and other organisms can be injured and killed by turbine blades.
- ***Life-cycle Global Warming Emissions:*** Small run-of-the-river plants emit between 0.01 and 0.03 pounds of carbon dioxide, large scale plant emits 0.06 pounds of carbon dioxide equivalent per kilowatt-hour.

Ocean Energy

- The oceans covers 75% of the world surface
- It is the largest renewable energy source available to contribute to the security of energy supply and reduce green house gases emissions
- Generation of electricity from the waves, tides, the currents, the salinity gradient and the thermal gradient.
- Two types of category
- Thermal energy from sun’s heat
- Mechanical energy from the tides and waves

- Potential to develop 20,000 -80,000 TWh Of electricity generated by changes in ocean temperature, salt Content, movements of tides ,waves and Swells.



Different form of Ocean Energy

- Ocean current power
- Osmotic power
- Tidal power
- Ocean thermal energy
- Wave Energy

Global Potential

Global potential

Form	Annual generation
Tidal energy	>300 TWh
Ocean current power	>800 TWh
Osmotic power (Salinity gradient)	2,000 TWh
Ocean thermal energy (Thermal gradient)	10,000 TWh
Wave energy	8,000–80,000 TWh

Source: IEA-OES, Annual Report 2007[3]

Ocean Thermal Energy

- Ocean are the largest solar energy collector.

- The OTEC process uses temperature difference between deep cold water and hot surface water to generate electricity.

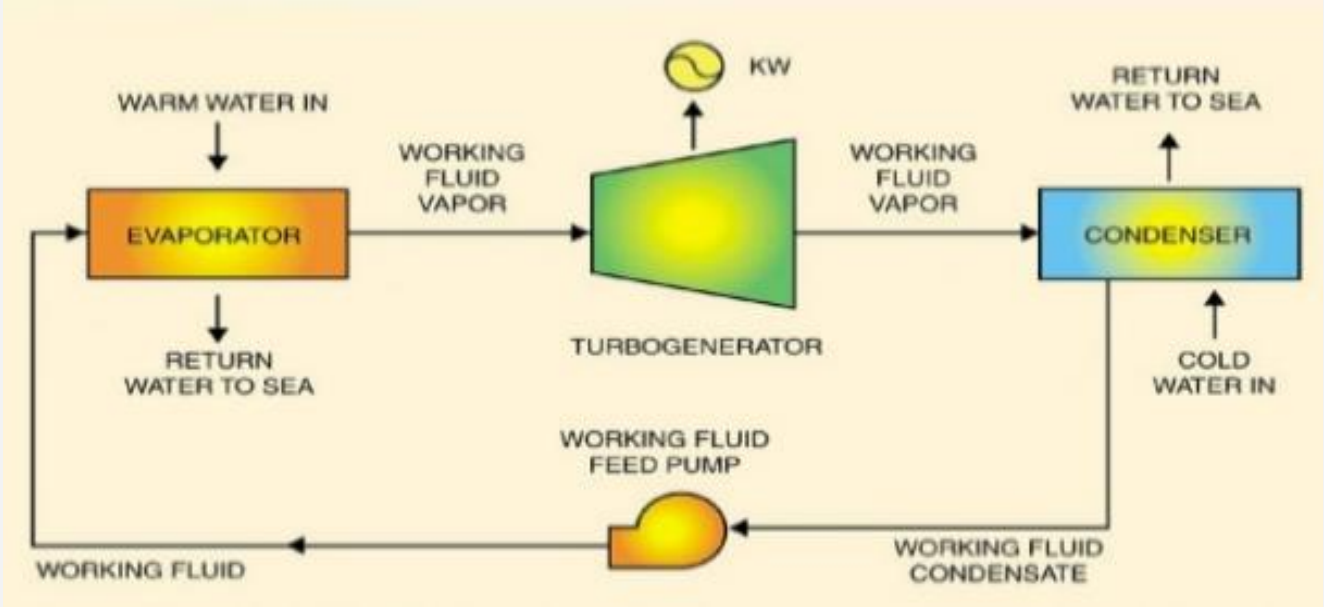
- There are two types of OTEC plant

1. Open Cycle

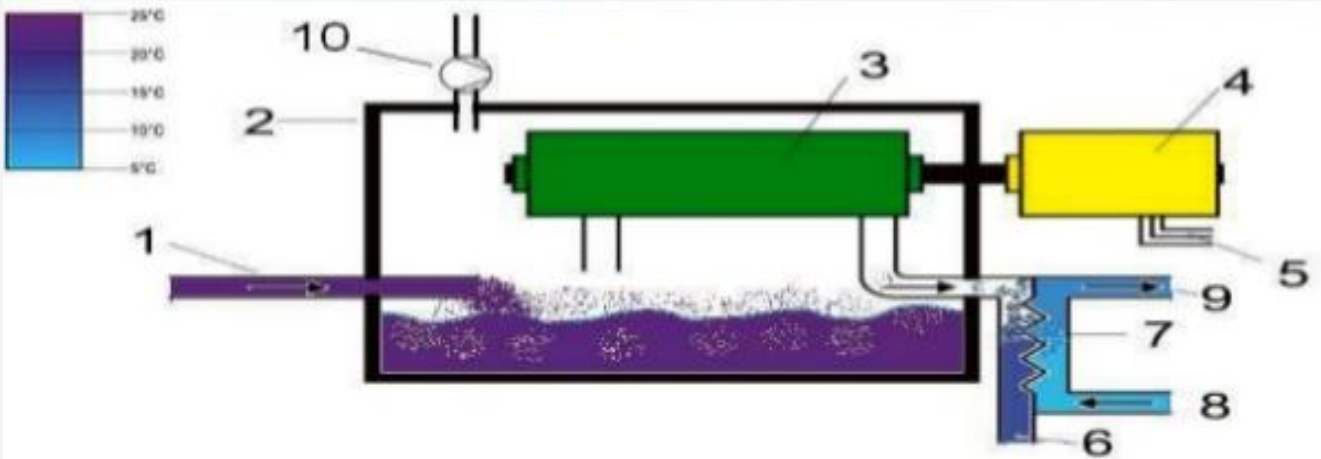
2. Closed Cycle

Closed Loop OTEC

Closed cycle system use fluid with a low boiling point, such as ammonia to power a turbine to generate electricity.



Open loop OTEC



1 Surface water ~ 25°C
2 Vacuum chamber, 3 % to 1 % of atmospheric pressure
3 Turbine
4 Generator
5 Line to the grid

6 Desalinated water ~ 23°C
7 Condenser
8 Deep water ~ 5°C
9 Waste water ~ 7°C
10 Vacuum pump

Advantages

- Does not produce green houses and waste product.
- Does not require any fuel
- Once the technology is built, it does not require extra cost.
- It does not have a big environmental impact.

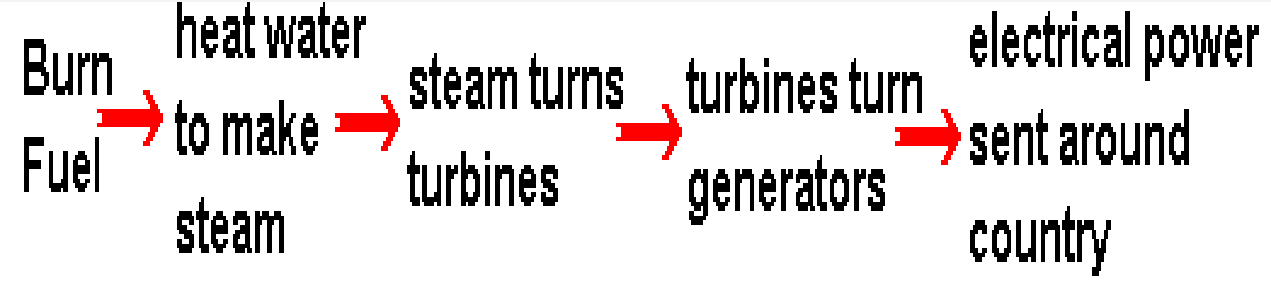
Disadvantages

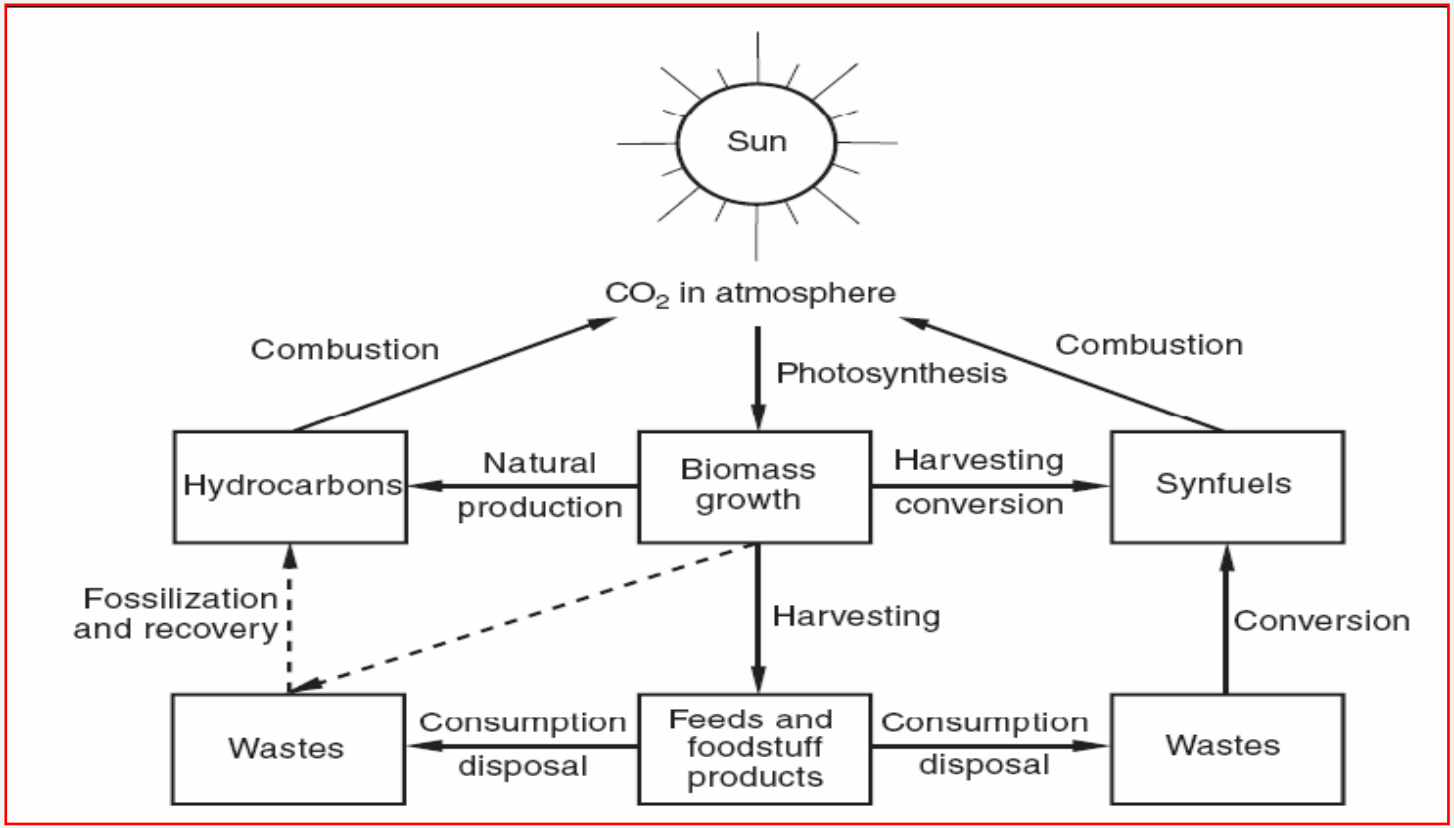
- Electricity generation cost is more
- No energy company will put money because these technologies have been tested for small scales
- Localized marine eco system will be affected
- Frozen ocean areas limit localization for machinery.

Biomass

Biomass energy

Biomass energy (or) bio-energy, is the energy stored in non-fossil organic materials such as wood, straw, vegetable oils and wastes from the forest, agricultural and industrial sectors.




Sun
CO_2 in atmosphere
Combustion
Photosynthesis
Combustion
Hydrocarbons
Natural
production
Biomass
growth
Harvesting
conversion
Synfuels
Fossilization
and recovery
Harvesting
Conversion
Wastes
Consumption
disposal
Feeds and
foodstuff
products
Consumption
disposal
Wastes

- Biomass Energy conversion Technology

Biomass Energy Technology

Technologies	Conversion Process	Major Biomass Feedstock	Energy (Or) Fuel Produced
Direct Combustion	Thermo-chemical	➲Wood ➲Agricultural waste ➲Municipal solid waste	➲Heat ➲Steam ➲Electricity
Gasification			➲Producer Gas ➲(Low or medium – Btu)
Pyrolysis			➲Synthetic fuel oil (bio-crude) ➲Charcoal
Methanol Production			➲Methanol
Anaerobic (Biogas production)	Biochemical	➲Animal manure, Agricultural waste, Landfills, Waste Water	➲Medium Btu gas (methane)
Aerobic (Ethanol Production)		➲Sugar or starch crops ➲Wood waste ➲Pulp sludge ➲Grass straw	➲Ethanol
Biodiesel Production	Chemical	➲Rapeseed ➲Soy beans ➲Waste vegetable oil ➲Animal fat	➲Bio-diesel

Advantages

- The foresting and agricultural industries that supply feed stocks – provide economic development opportunities in rural areas.
- Pollutant emission is less than fossil fuels.
- Commercial use of biomass may avoid or reduce the problems of waste disposal in other industries.
- Use of biomass plant, apart from supplying clean gas, also leads to improved sanitation, better by generic condition in rural areas.

Disadvantages

- It is dispersal and land – intensive source.
- It is often of low energy density.
- It is also labour intensive.
- Capacity is determined by availability of biomass and not suitable for varying loads.
- Not feasible to set up at all locations.

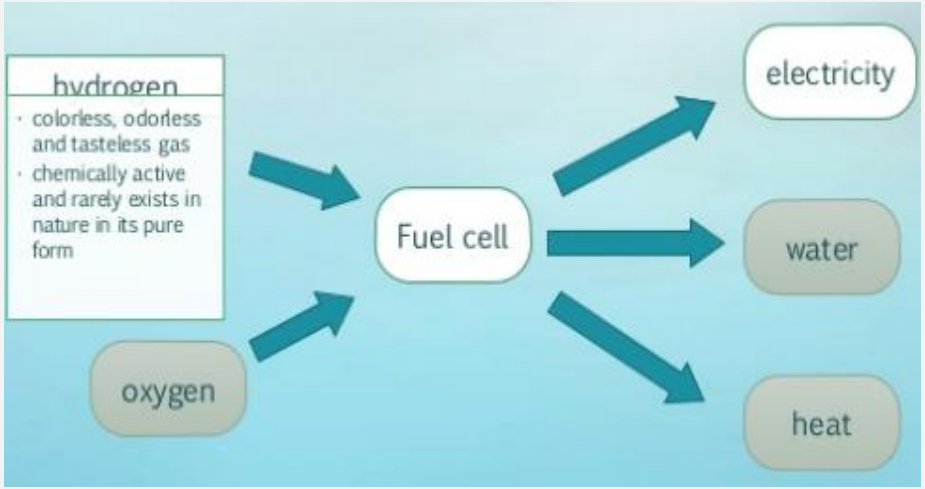
Fuel cell

- A fuel cell is an electrochemical device that converts energy produced from a chemical reaction into electrical energy.

- More specifically it is an electrochemical device that combines hydrogen and oxygen to produce electricity, with water and heat as it's by-product.

- A single fuel cell

Consists of an electrolyte and two catalyst coated Electrodes.



Parts of fuel cell

Anode

- Negative post of the fuel cell
- Conducts the electrons that are free from the hydrogen molecule so that they can be used in an external circuit.
- Etched channels disperse hydrogen gas over the surface of catalyst

Cathode

- Positive post of the fuel cell
- Etched channel distribute oxygen to the surface of the catalyst
- Conducts electrons back from the external circuit to the catalyst
- Recombine with the hydrogen ions and oxygen to form water

Electrolyte

- Proton exchange membrane
- Specially treated material, only conducts positively charged ions.
- Membrane blocks electrons

Catalyst

- Special material that facilitates reaction of oxygen and hydrogen
- Usually platinum powder very thinly coated onto carbon paper or cloth
- Rough & porous maximizes surface area exposed to hydrogen or oxygen
- The platinum coated side of the catalyst faces the PEM.

Principle and operation of fuel cell

At anode

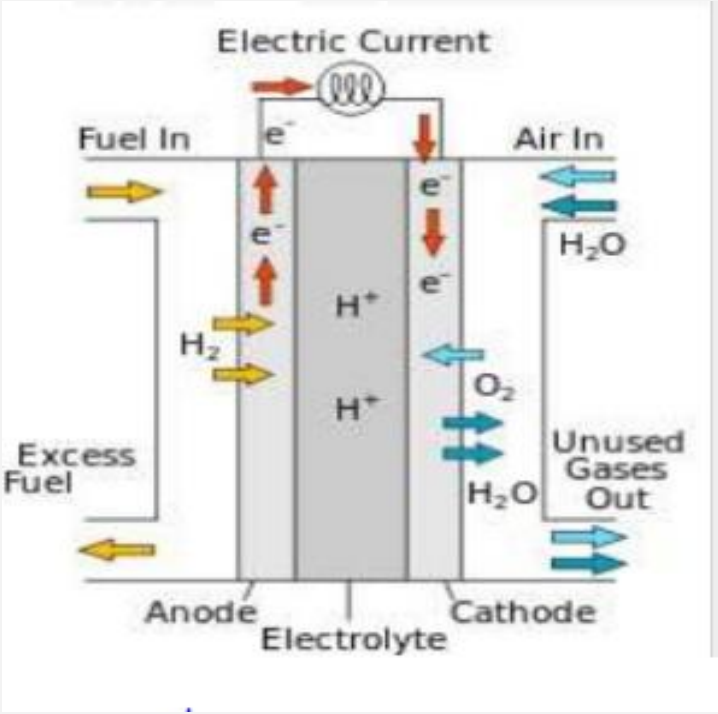
$2H_2=4H+4e$

At cathode

$O_2+4H+4e=2H_2O$

Net reaction

$2H_2+O_2=2H_2O$



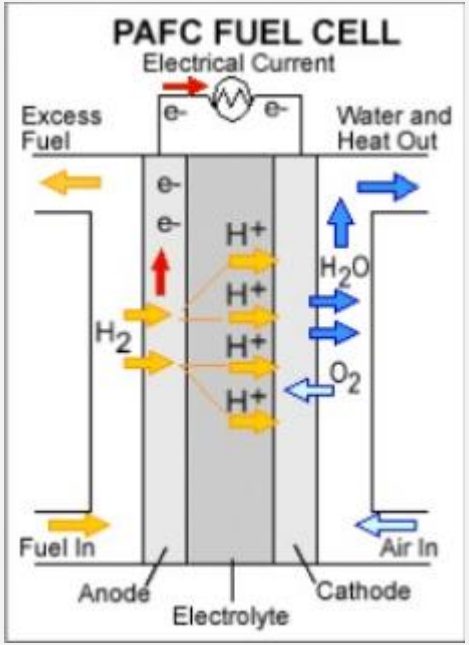
Types of fuel cell

Fuel cells are classified primarily by the kind of electrolyte they employ

- Phosphoric-acid fuel cell(PAFC)
- Alkaline fuel cell(AFC)
- Solid oxide fuel cell(SOFC)
- Molten Carbonate fuel cell(MCFC)
- Polymer electrolyte membrane fuel cell(PEM)
- Direct methanol fuel cell(DMFC)
- Regenerative fuel cell

Phosphoric acid fuel cell(PAFC)

- PAFC were the first fuel cell commercialized
- PAFCs use liquid phosphoric acid as the Electrolyte
- The acid is contained in a Teflon-bonded Silicon carbide matrix.
- It consists of porous carbon electrodes Containing a platinum catalyst.



Anode Reaction:

$2\ H_2 \Rightarrow 4\ H^+ + 4\ e^-$

Cathode Reaction:

$O_2(g) + 4\ H^+ + 4\ e^- \Rightarrow 2\ H_2O$

Overall Cell Reaction:

$2\ H_2 + O_2 \Rightarrow 2\ H_2O$

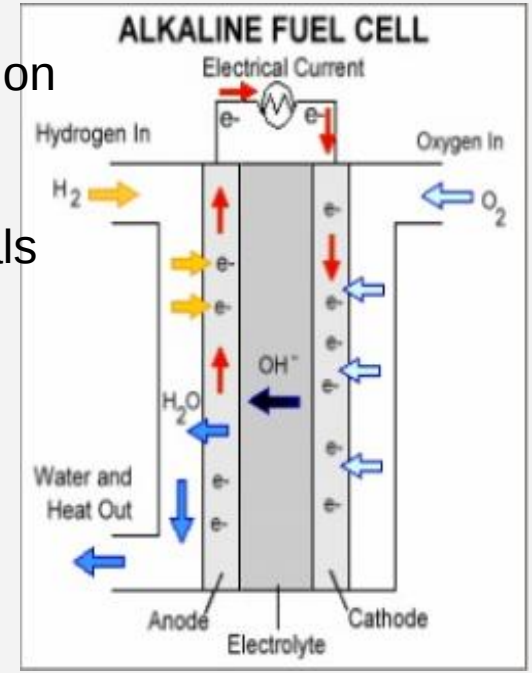
Alkaline fuel cell(AFC)

- The basic construction involves two electrodes

That are separated by a porous matrix that
Is saturated with an aqueous alkaline solution

- This construction is very similar to that

Of batteries as are the metals and chemicals
Used.



Anode Reaction:

$2\ H_2 + 4\ OH^- \Rightarrow 4\ H_2O + 4\ e^-$

Cathode Reaction:

$O_2 + 2\ H_2O + 4\ e^- \Rightarrow 4\ OH^-$

Overall Net Reaction:

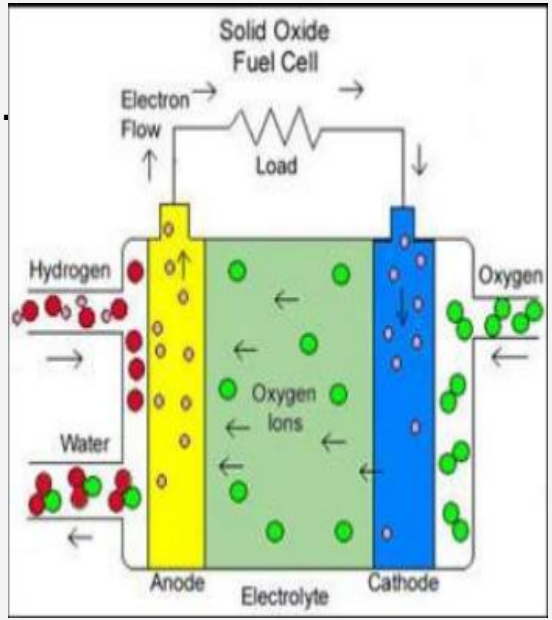
$2\ H_2 + O_2 \Rightarrow 2\ H_2O$

Solid Oxide fuel cell

- Solid Oxide fuel cells (SOFC) use a hard, ceramic compound of metal (like calcium or zirconium) oxides (chemically, O_2) as electrolyte.

- Efficiency is about 60 percent, and operating temperatures are about 1,000 degrees C.

- Cells output is up to 100 kW. At such high temperatures a reformer is not required to extract hydrogen from the fuel, and waste heat can be recycled to make additional electricity.

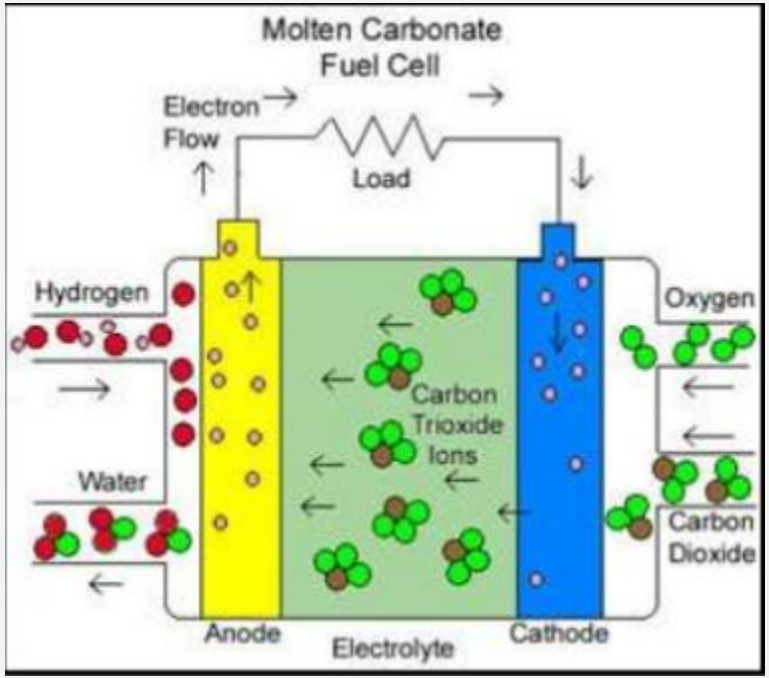


Molten Carbonate fuel cell(MCFC)

- Molten alkaline carbonate like Sodium bicarbonate is used as the Electrolyte.

- They can produce high power Up to 100 Mega Watts. Thus they can be used as high power Generators.

- It has an efficiency of almost 55%



Advantages

- Higher efficiency than conventional engines.
- Zero emission.
- No rotating parts in the main hardware components.
- Negligible noise pollution.
- Excellent part load characteristics.

Disadvantages

- CO_2 discharged with methanol reform.
- Pure hydrogen is difficult to handle
- Technology currently expensive.

Solar Photovoltaic system

Introduction

- Solar energy comes from the light of the sun, which means it is a renewable source of energy. We can use the sun light to create pollution free electricity.

Solar Constant:

It is defined as the total energy that falls on a unit area exposed normally to the rays of the sun at the average sun-earth distance.

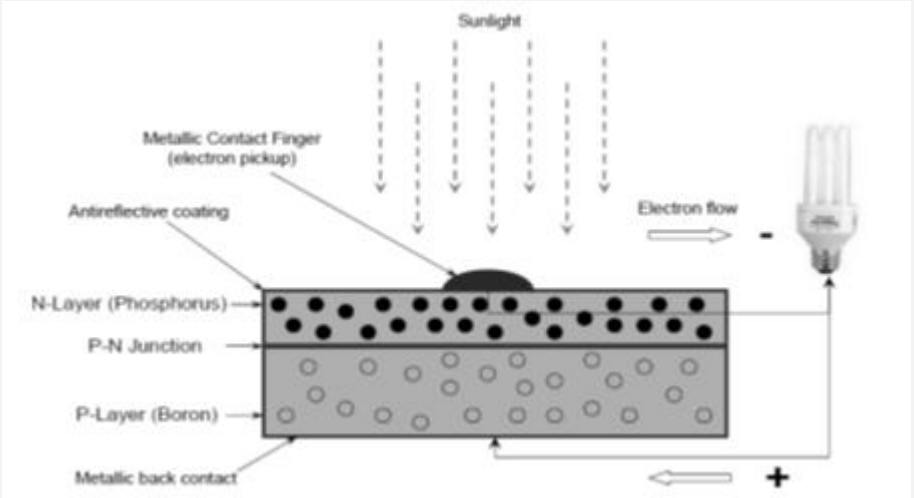
Principle:

The solar cells are based on the principles of photovoltaic effect. The photovoltaic effect is the photo generation of charge carriers in light absorbing materials as a result of absorption of light radiation.

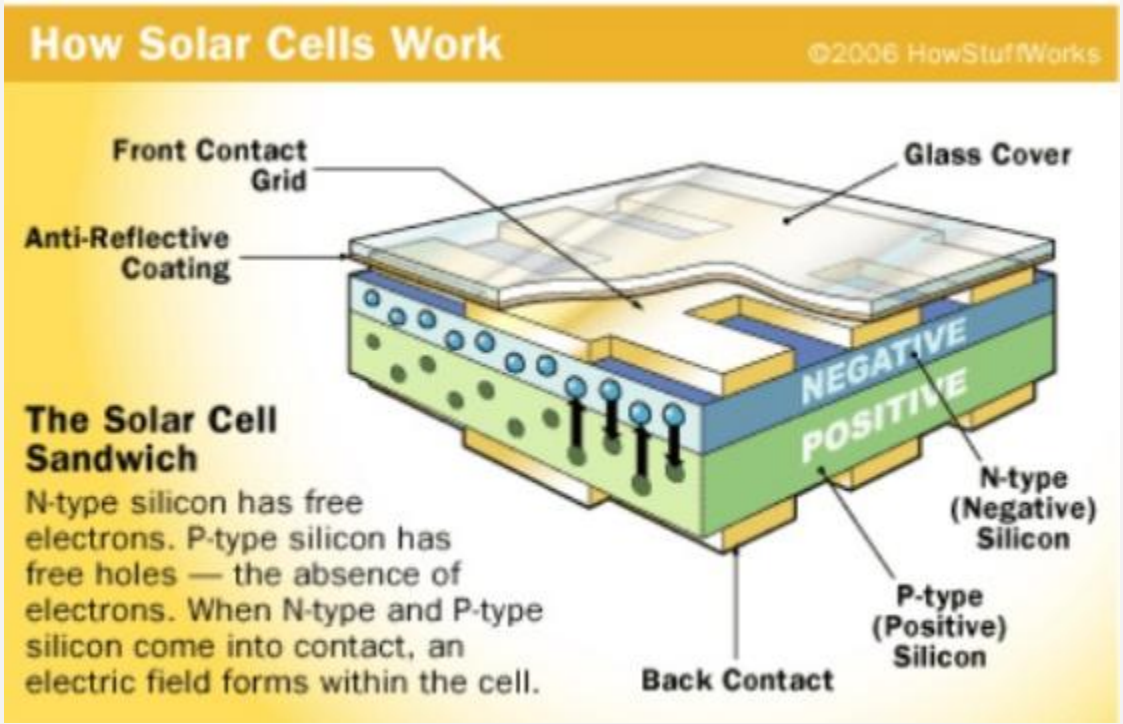
Construction

- Solar cell (crystalline Silicon) consists of a *n-type semiconductor (emitter)* layer and *p-type semiconductor layer (base).* The two layers are sandwiched and hence there is formation of p-n *junction.* The surface is coated with *anti-reflection coating* to avoid the loss of incident light energy due to reflection.

- Proper metal contacts are made on the n-type and p-type side of the semiconductor for Electrical connection.



Working


How Solar Cells Work
©2006 HowStuffWorks
Front Contact Grid
Glass Cover
Anti-Reflective Coating
NEGATIVE
POSITIVE
The Solar Cell Sandwich
N-type silicon has free electrons. P-type silicon has free holes — the absence of electrons. When N-type and P-type silicon come into contact, an electric field forms within the cell.
N-type (Negative) Silicon
P-type (Positive) Silicon
Back Contact

- The most important components of a PV cell are two layers of semiconductor material generally composed of silicon crystals.
- The bottom layer of the PV cell is usually doped with boron, which bonds with the silicon to facilitate a positive charge (P).
- The top layer is doped with phosphorus, which bonds with the silicon to facilitate a negative charge (N).
- The surface between the resulting "p-type" and "n-type" semiconductors is called the P-N junction
- When a solar panel exposed to sunlight, the light energies are absorbed by semi conductor material.
- Due to this absorbed energy the electrons are liberated and produce the external DC current.

Types of solar cell

Base on the types of crystal used, solar cell can be classified as

1. Monocrystalline silicon cells
2. Polycrystalline silicon cells
3. Amorphous silicon cells

Monocrystalline silicon cells

- The Monocrystalline silicon cells is produced from pure silicon (single crystal).
- *Single-crystal cells* are made in long cylinders and sliced into round or hexagonal wafers.
- While this process is energy-intensive and wasteful of materials, it produces the highest-efficiency cells

Polycrystalline silicon cells

- *Polycrystalline cells* are made of molten silicon cast into ingots or drawn into sheets, then sliced into squares.
- While production costs are lower, the efficiency of the cells is lower too—around 15 percent.
- Because the cells are square, they can be packed more closely together.
- Polycrystalline cells make up 62 percent of the global PV market

Amorphous silicon cells

- *Amorphous silicon (a-Si)* is a radically different approach.

- Silicon is essentially sprayed onto a glass or metal surface in thin films, making the whole module in one step.

- This approach is by far the least expensive, but it results in very low efficiencies—only about five percent.

Comparision

Material	Efficiency(%)
Monocrystalline silicon cells	14-17
Polycrystalline silicon cells	13-15
Amorphous silicon cells	5-7

Advantages

- It is clean and non-polluting
- It is a renewable energy
- Solar cells do not produce noise and they are totally silent.
- They require very little maintenance
- They are long lasting sources of energy which can be used almost anywhere
- They have long life time
- There are no fuel costs or fuel supply problems

Disadvantages

- Soar power cannot be obtained in night time
- Solar cells (or) solar panels are very expensive
- Air pollution and whether can affect the production of electricity
- They need large area of land to produce more efficient power supply.

Applications

- Soar pumps are used for water supply.
- Domestic power supply for appliances include refrigeration, washing machine, television and lighting
- Telecommunication systems: radio transceivers on mountain tops or telephone boxes in the country can often be solar powered
- Electric power generation in space: To providing electrical power to satellites in an orbit around the Earth

Thank you