Center of Excellence for Water

Renewable Energies

Dr Dina Elgayar
Alexandria University

12-8-2023

Exchange, Training, and Scholarships Pillar activities are implemented in cooperation with:

RENEWABLE ENERGY

Outlines

1. Basic concepts of renewable energies.
2. Importance of renewable energies today.
3. Renewable energy resources.
4. Solar energy applications.
5. Potential for the use of solar energy and PV panels in water treatment / desalination.
6. Basics of renewable energy design principles.
7. Renewable energy applications in WWT.

1. Basic concepts of Renewable Energies

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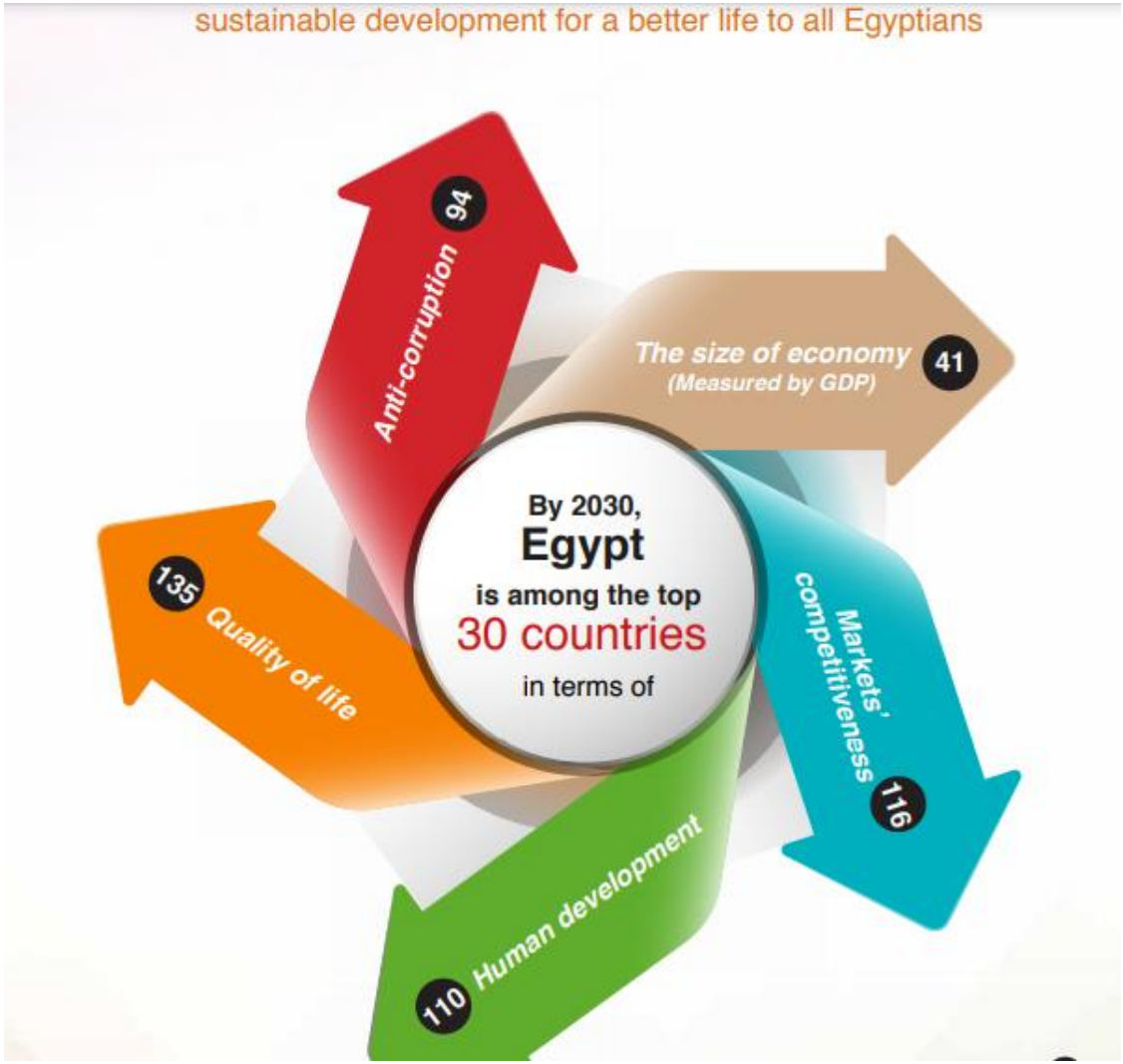
The Global sustainable development Goals

(Source: http://www.globalgoals.org/)


sustainable development for a better life to all Egyptians
Anti-corruption
94
The size of economy
(Measured by GDP)
41
By 2030,
Egypt
is among the top
30 countries
in terms of
Markets' competitiveness
116
Human development
110
135
Quality of life

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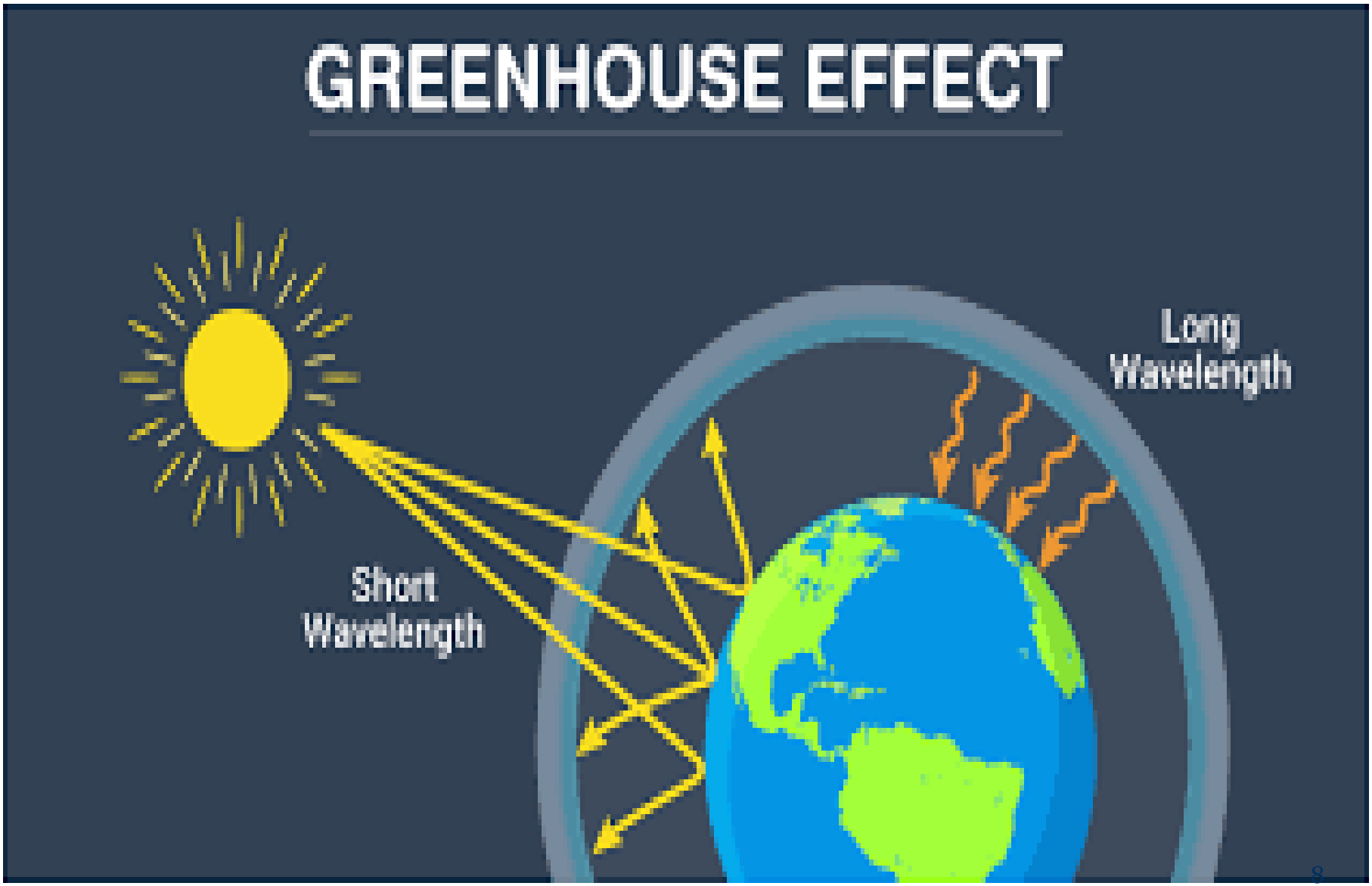
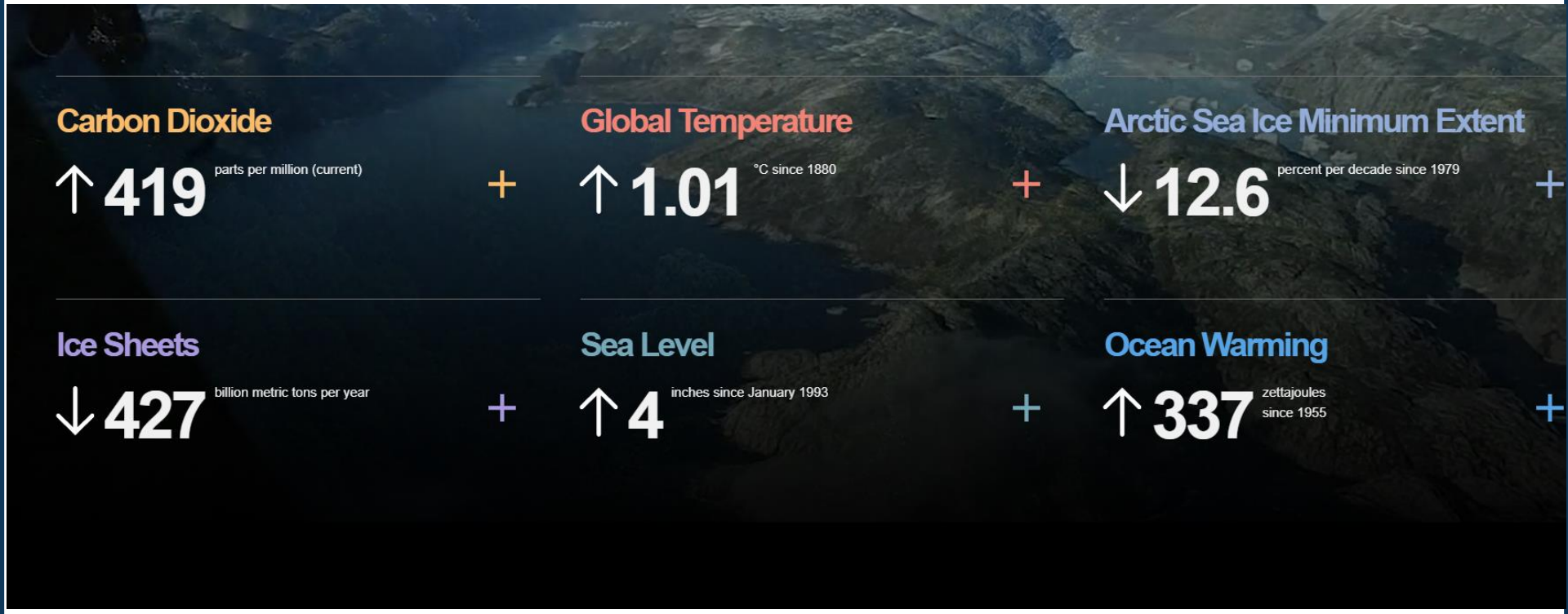
Second pillar: Energy

An energy sector meeting national sustainable development requirements and maximizing the efficient use of various traditional and renewable resources contributing to economic growth, competitiveness, achieving social justice, and preserving the environment. A renewable energy and efficient resource management leader, and an innovative sector capable of forecasting and adapting to local, regional and international developments and complying with SDGs.

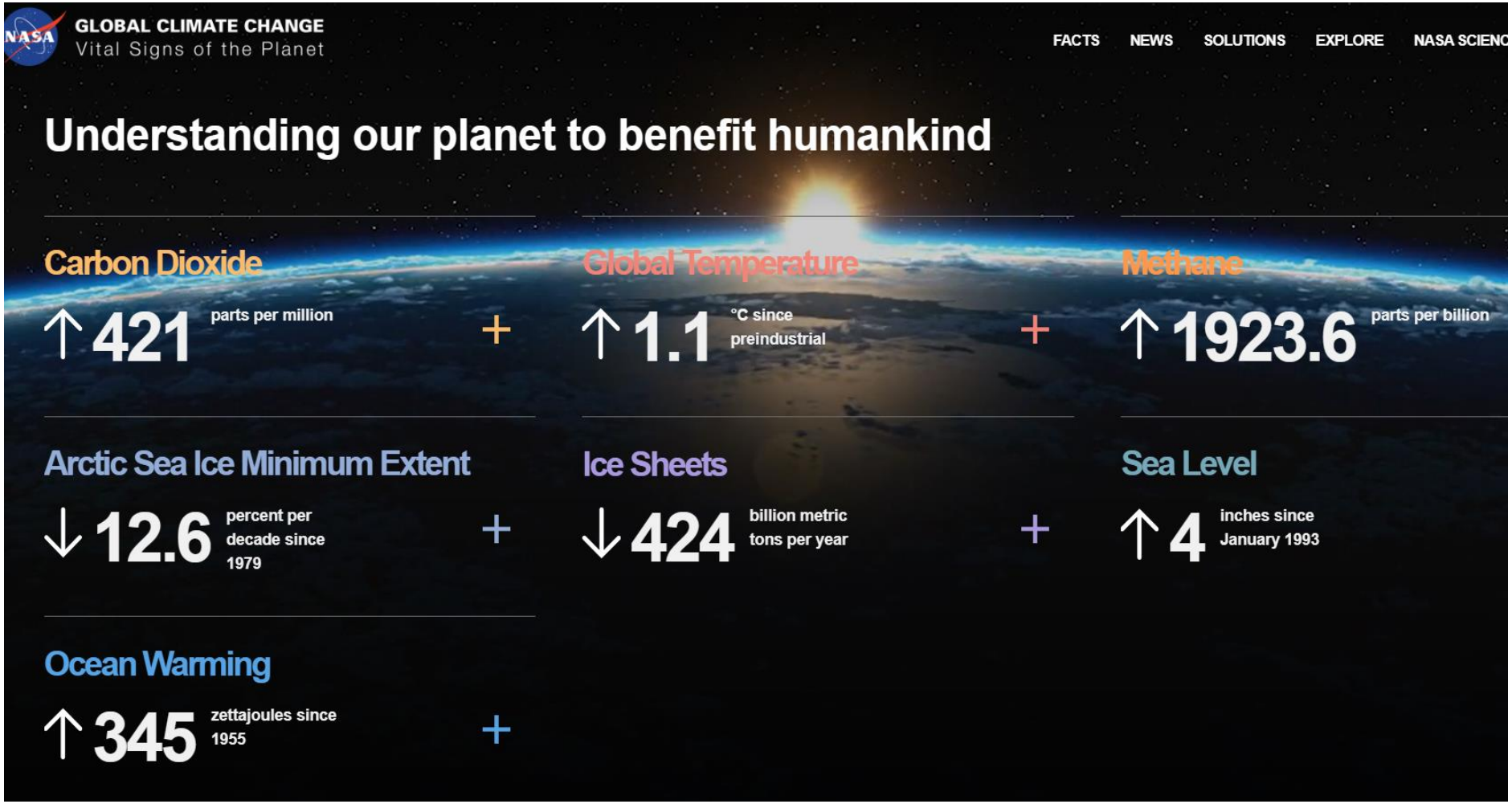

GREENHOUSE EFFECT
Long Wavelength
Short Wavelength

[WMO Climate Risks, extreme events and related impacts | UNFCCC]

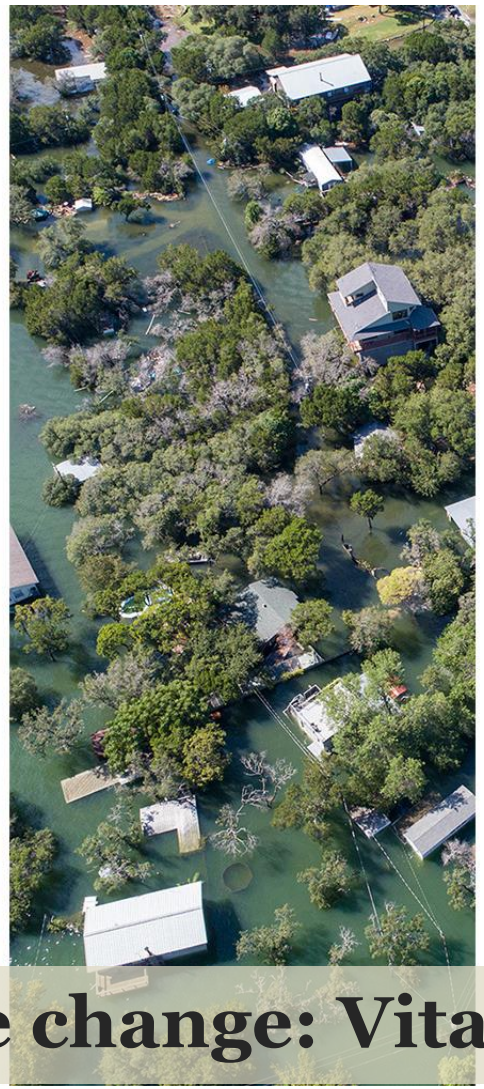
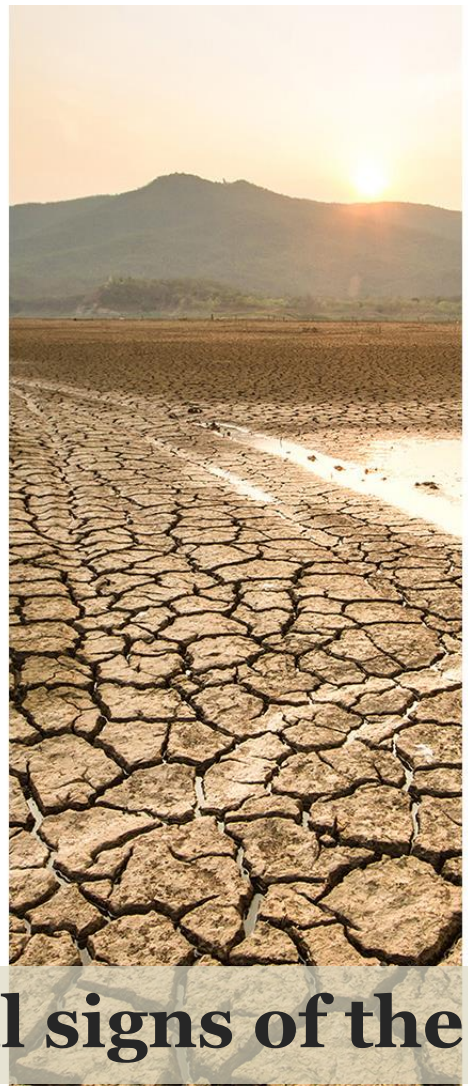
Home – Climate Change: Vital Signs of the Planet (nasa.gov)



NOVEMBER-2022


GLOBAL CLIMATE CHANGE
Vital Signs of the Planet
FACTS
NEWS
SOLUTIONS
EXPLORE
NASA SCIENC
Understanding our planet to benefit humankind
Carbon Dioxide
↑ 421 parts per million
Global Temperature
↑ 1.1 °C since preindustrial
Methane
↑ 1923.6 parts per billion
Arctic Sea Ice Minimum Extent
↓ 12.6 percent per decade since 1979
Ice Sheets
↓ 424 billion metric tons per year
Sea Level
↑ 4 inches since January 1993
Ocean Warming
↑ 345 zettajoules since 1955

AUGUST-2023


Climate change: Vital signs of the Planet

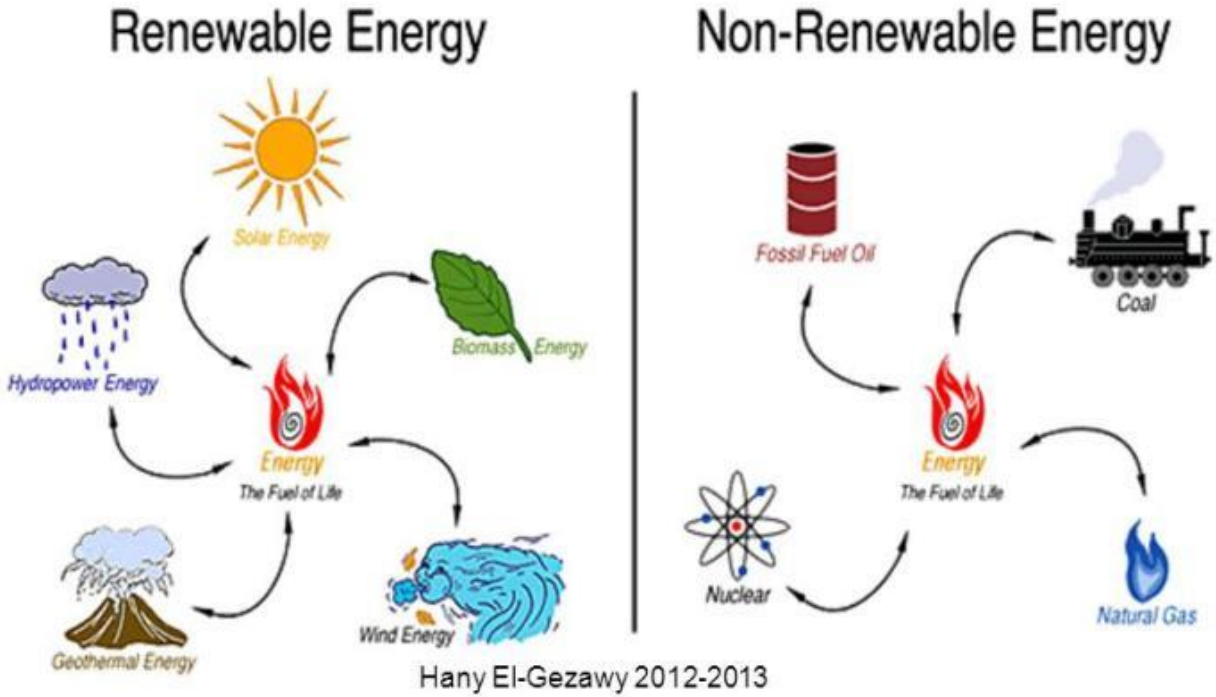
Loire river in France –August 2022

Forms of Energies

Needs for energy in our lives

"Energy is converted from form to another"

Renewable and non-renewable energy sources




THE FOSSIL FUELS
oil
natural gas
coal
©Study.com

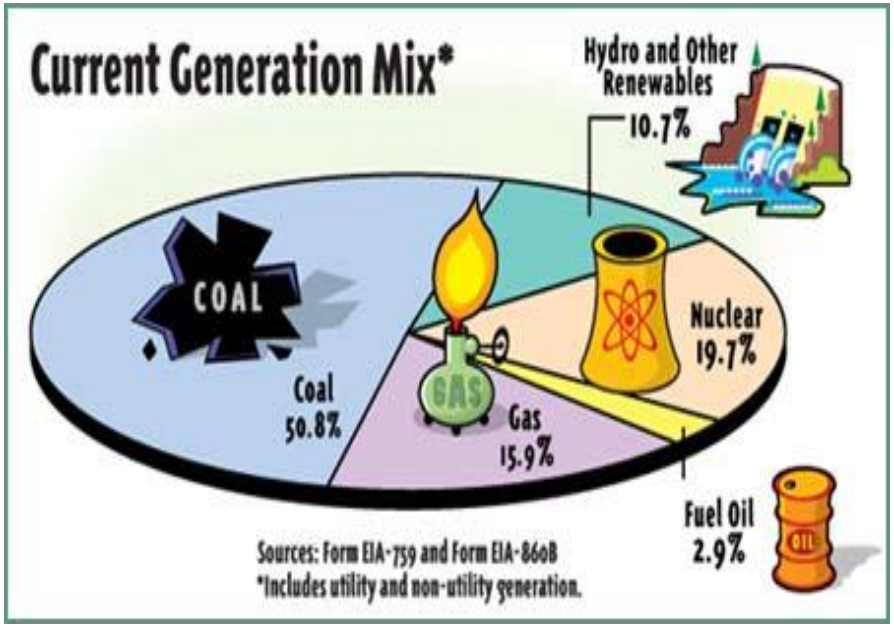
Non Renewable energy sources such as:

Coal, Oil, Natural Gas

AND

Radioactive elements

Once they are gone and can not be replaced in the human time scale



Renewable energy resources

1. Sunlight ➡ Solar Energy
2. Wind ➡ Wind Energy
3. Water ➡ Hydropower
4. Biomass ➡ Biomass Energy
5. Hydrogen Power ➡ Hydrogen Gas
6. Heat from the earth core ➡ Geothermal

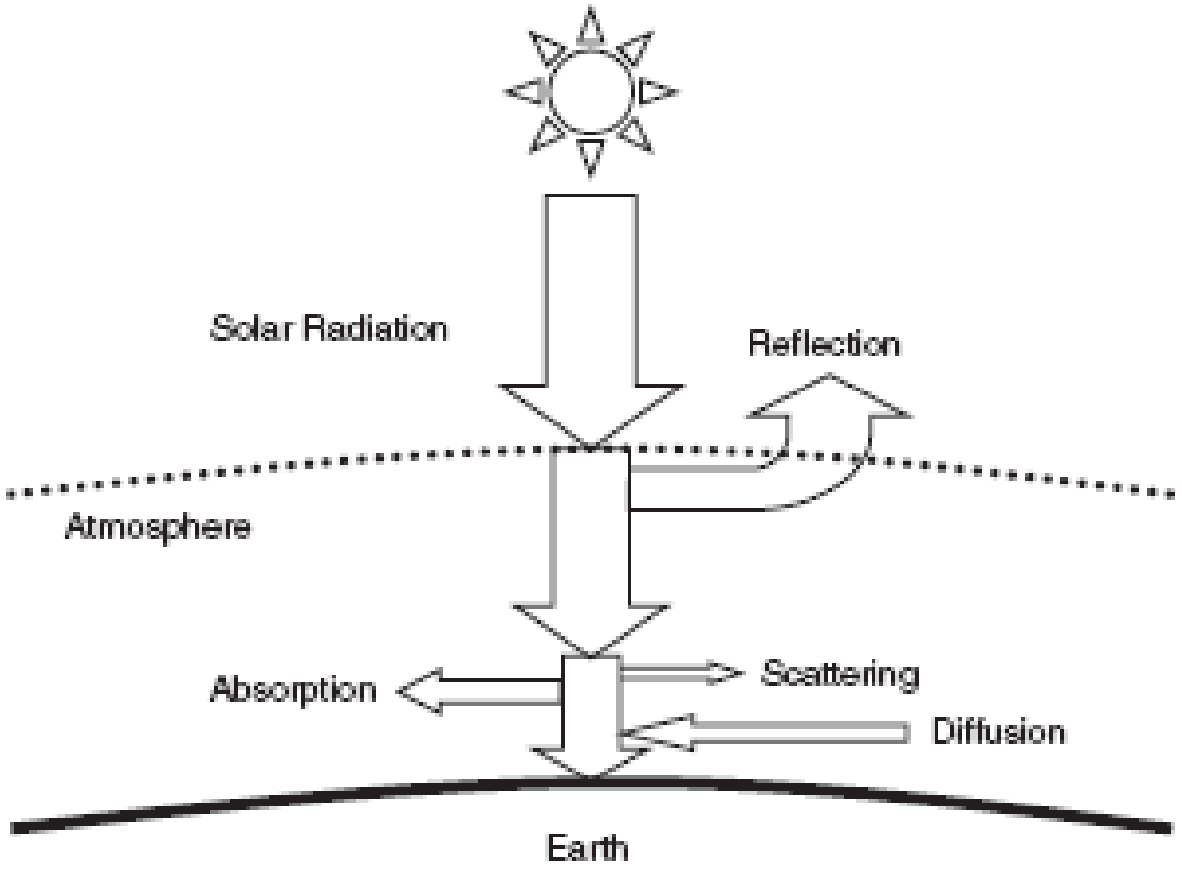
2. Importance of Renewable Energies Today

Why is Renewable Energy Important Today?

1. Energy price stability
2. Clean Air
3. Protecting Global climates
4. Protecting Landscapes and watersheds
5. Unlimited supplies
6. Jobs and economy

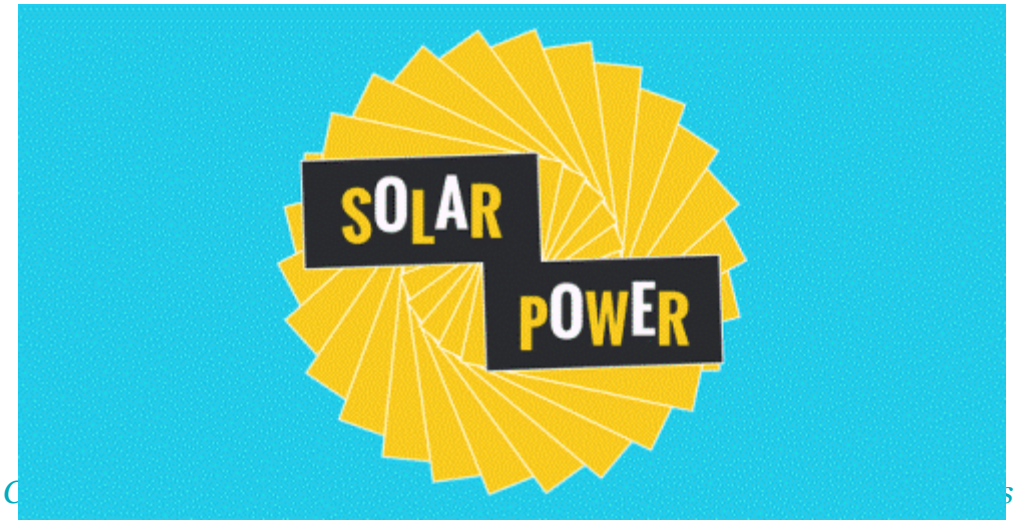
3. Renewable energy resources

Solar Energy



$$E_{inc}\left(t,\theta_{lat},\theta_{long}\right)=S(t)\cos\theta\left(t,\theta_{lat},\theta_{long}\right)$$

where the angle $\theta(t, \theta_{lat}, \theta_{long})$ is the angle between the incident solar flux at time t and the normal to the surface at latitude θ_{lat} and longitude θ_{long}.



Advantages :

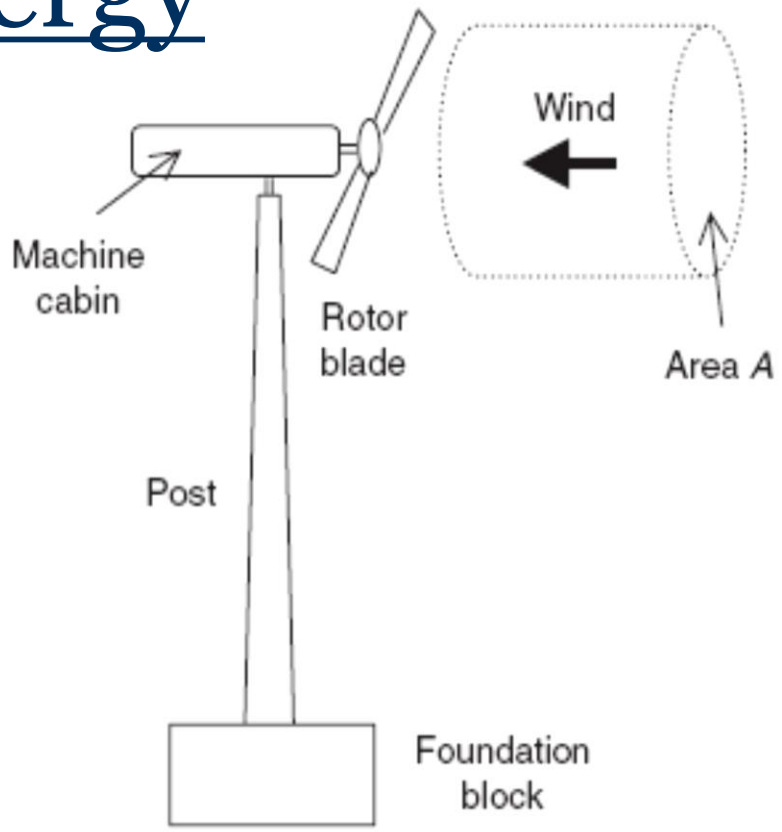
1. It cannot be cut off by blockade or embargo
2. Nor does it involve the burning of any scarce fuels or the generation of any pollution
3. It is freely available to all
4. It cannot be exhausted for it will last as long as the sun shines.

Disadvantages:

1. To be useful, it must be collected and concentrated
2. lots of space is needed for mirrors or collectors
3. Solar energy is also subject to interruption
4. Captured energy must be stored in some way or supplemented with a back-up system

Wind Energy

- ✓ Wind energy is the utilization of the energy that moves the air.
- ✓ The use of wind as a source of energy for generating electrical power depends on estimating the power output of a wind turbine.
- ✓ The wind power depends on 2 effect named: lift and drag effects.

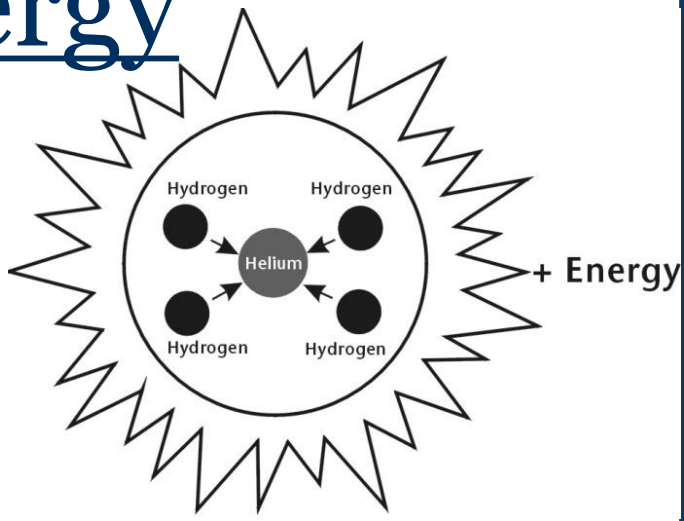


Wind Energy

$$P_{out} = \eta_{wind} P_{wind} = \eta_{wind} \rho_{air} R^2 v^3$$

Betz' limit says that approximately 59.3% of the power in the wind is the maximum percentage of wind power that can be extracted. It is obtained when the downwind velocity **is one third** of the upwind velocity

Hydrogen Energy

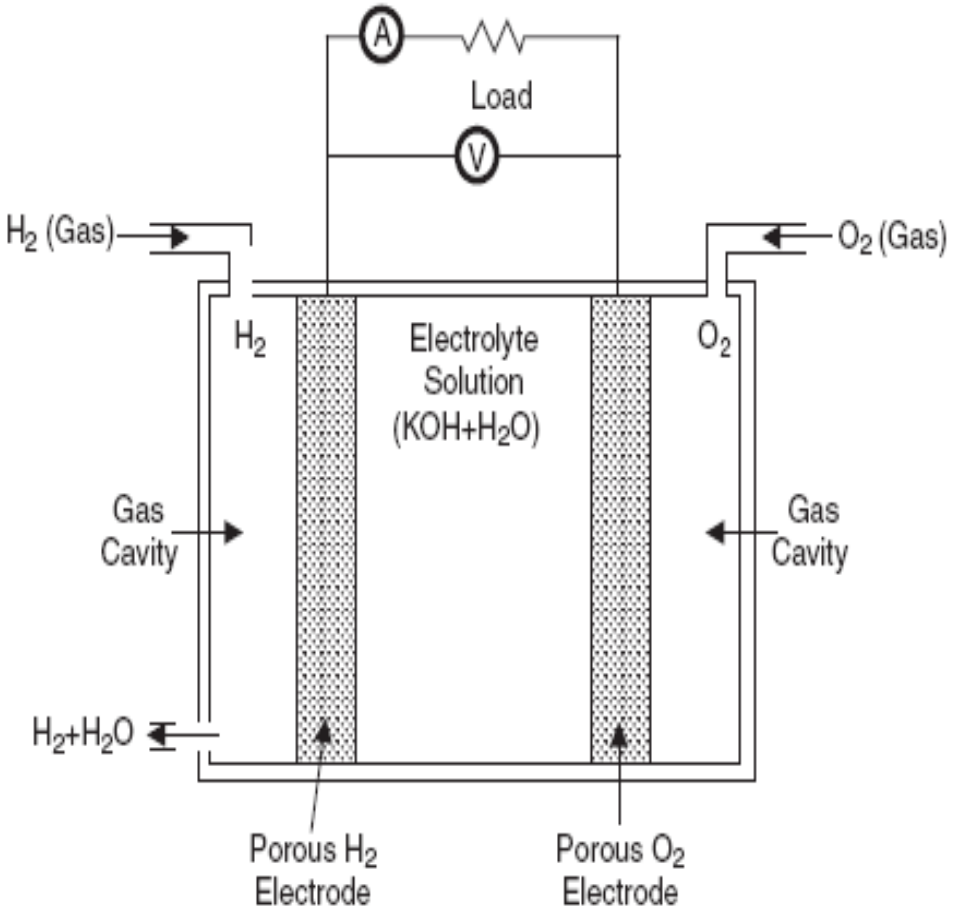


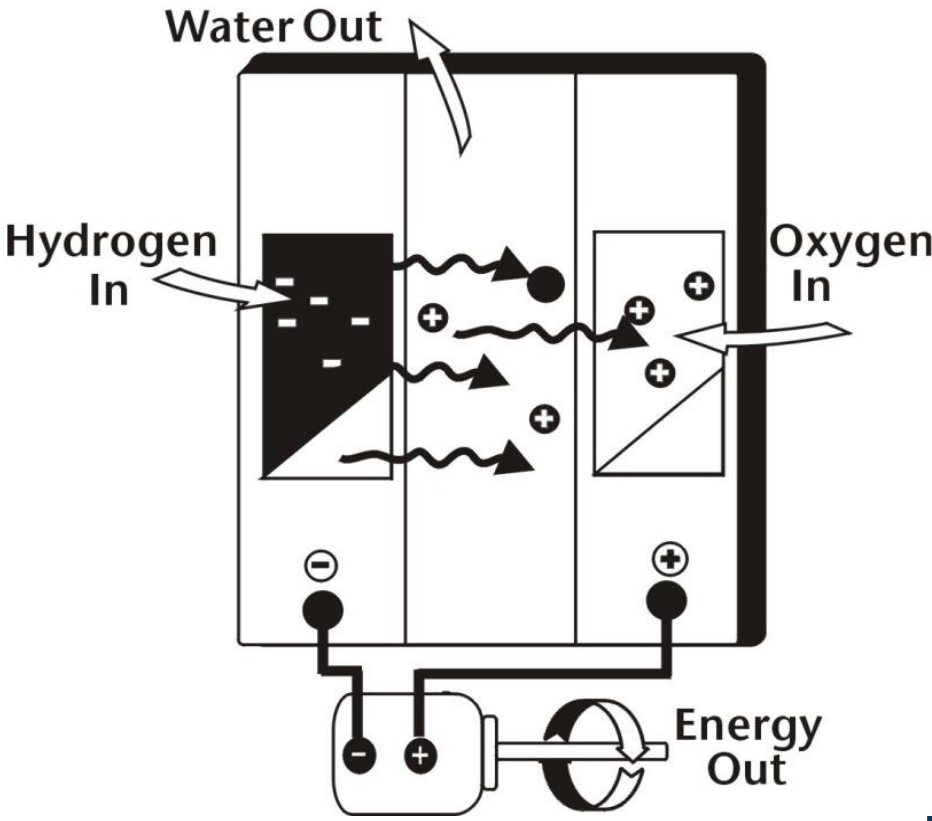
- Our sun's energy comes from hydrogen.
- The sun is a giant ball of hydrogen and helium gases.
- Inside the sun, hydrogen atoms combine to form helium atoms. This process -**called fusion**- gives off radiant energy.
- This radiant energy sustains life on earth. It gives us light and makes plants grow.
- It makes the wind blow and rain fall. It is stored in fossil fuels.
- **Most of the energy we use today came from the sun.**

Property	Hydrogen (gas)	Methane (gas)	Gasoline (liquid)
Molecular weight (g/mol)	2.016	16.04	~ 110
Mass density (kg/m^3)	0.09	0.72	270 – 780
Energy density (MJ/kg)	120	53	46
Volumetric energy density (MJ/m^3)	11	38	35,000
Higher heating value (MJ/kg)	142.0	55.5	47.3
Lower heating value (MJ/kg)	120.0	50.0	44.0

Hydrogen Energy

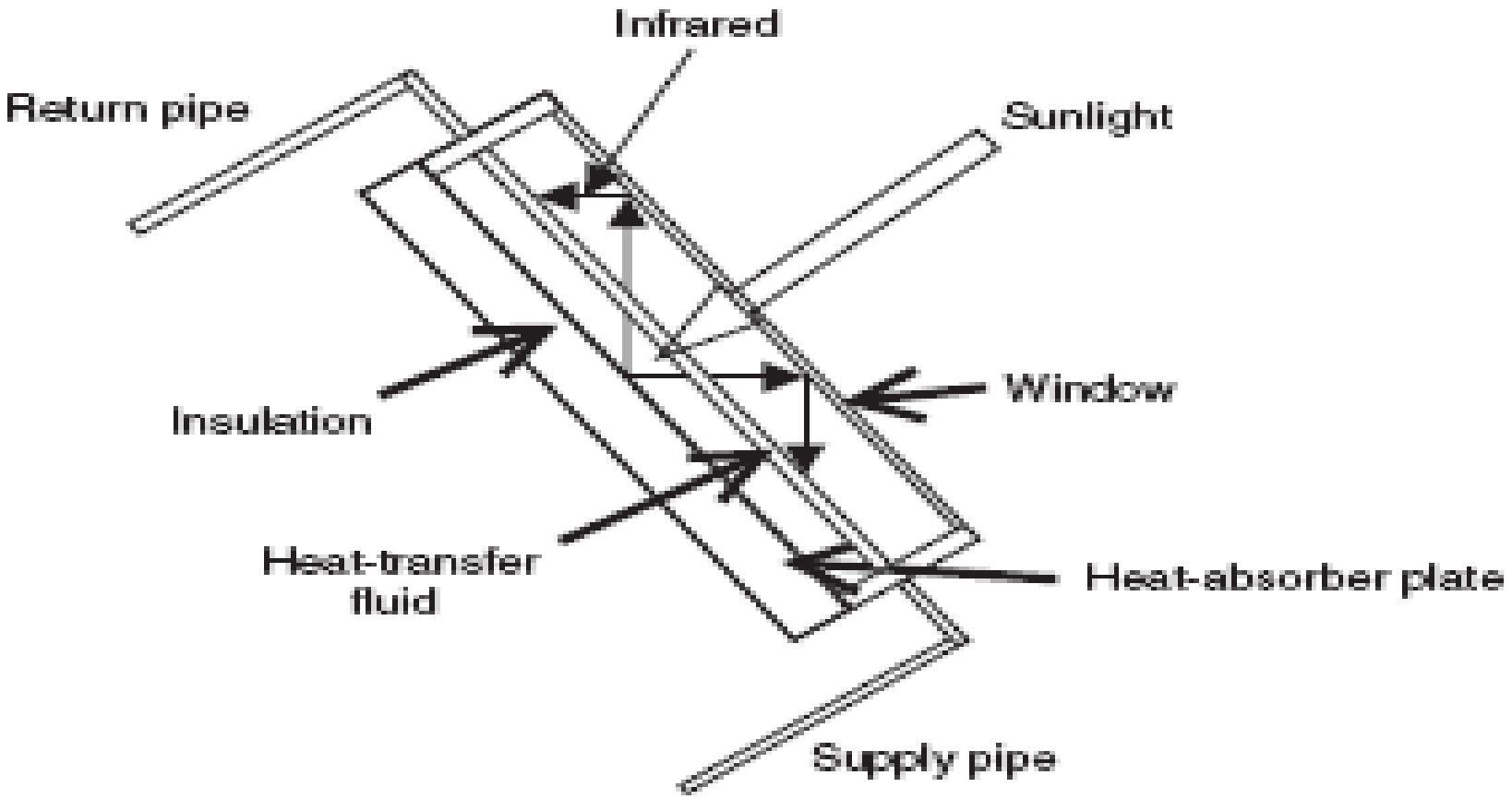
$$2H_2 + O_2 \rightarrow 2H_2O$$





3. Solar Energy Applications

Solar Heater



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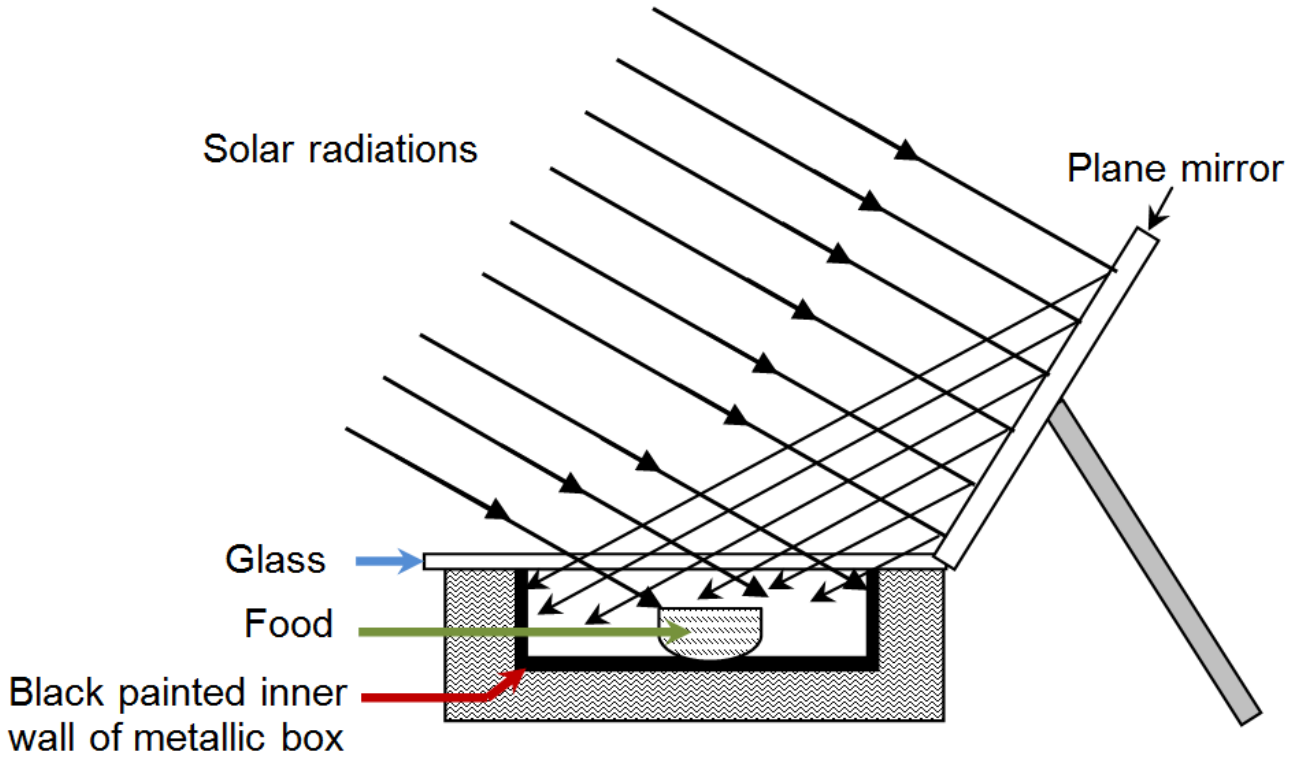
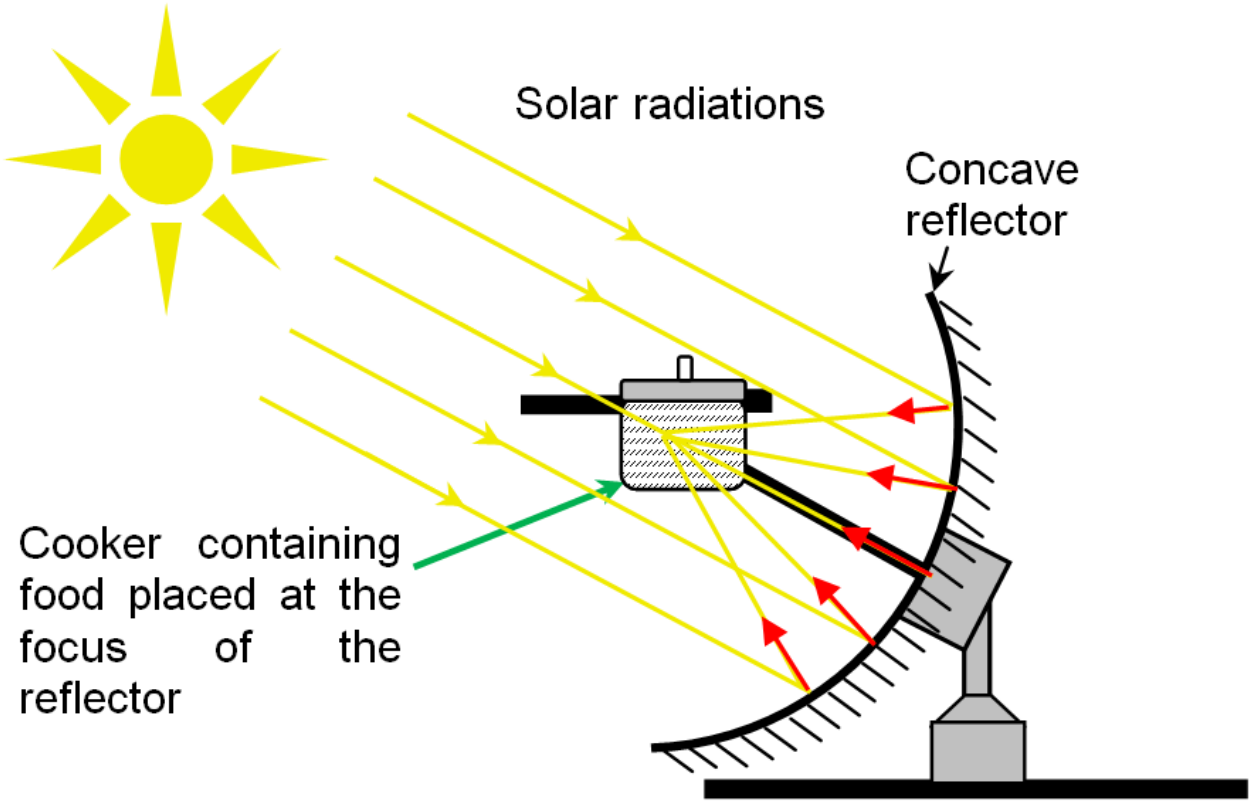
Closed Box solar cooker

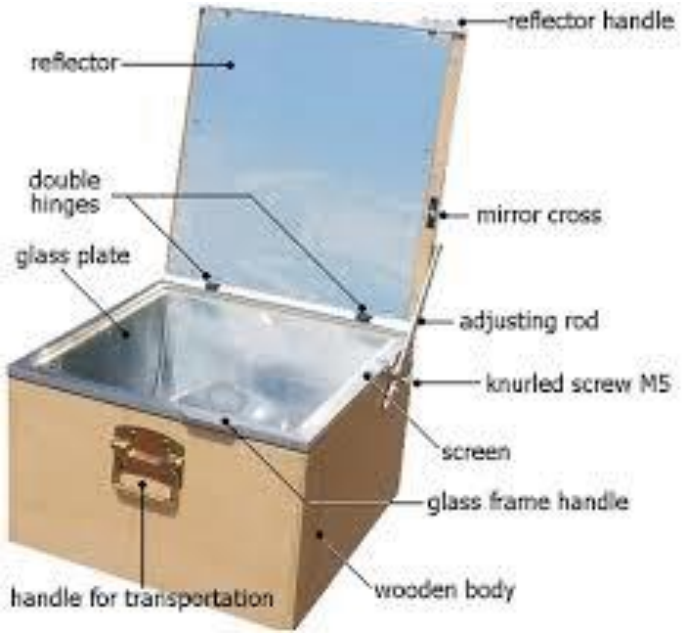


Box type solar cooker

Parabolic Cooker



Spherical reflector type solar cooker


reflector handle
reflector
double hinges
mirror cross
glass plate
adjusting rod
knurled screw M5
screen
glass frame handle
handle for transportation
wooden body

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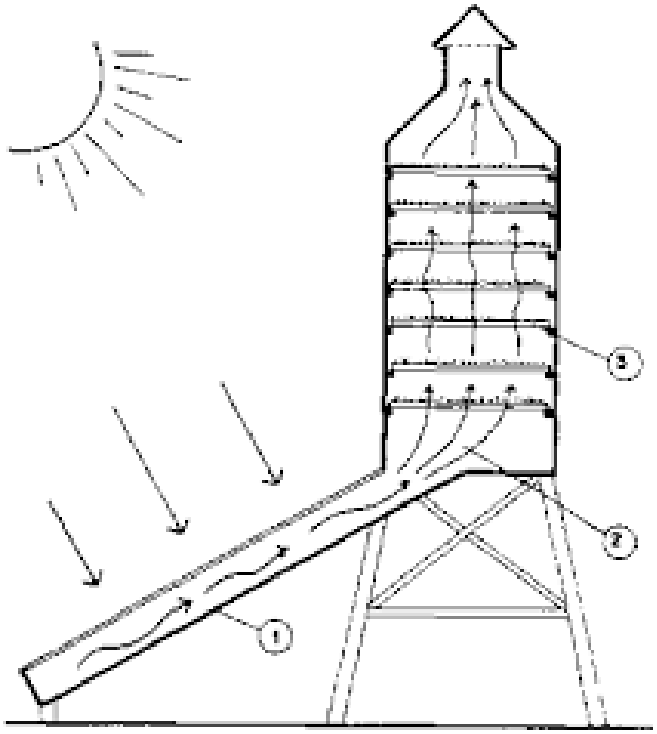
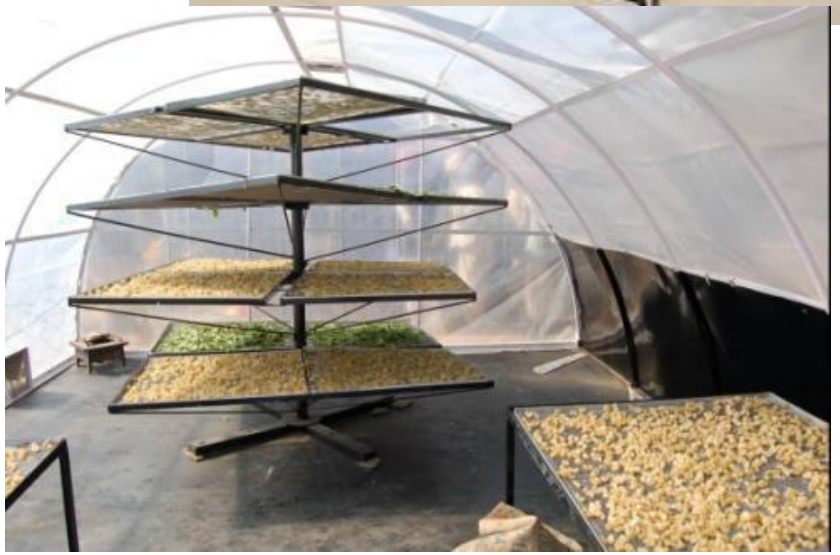
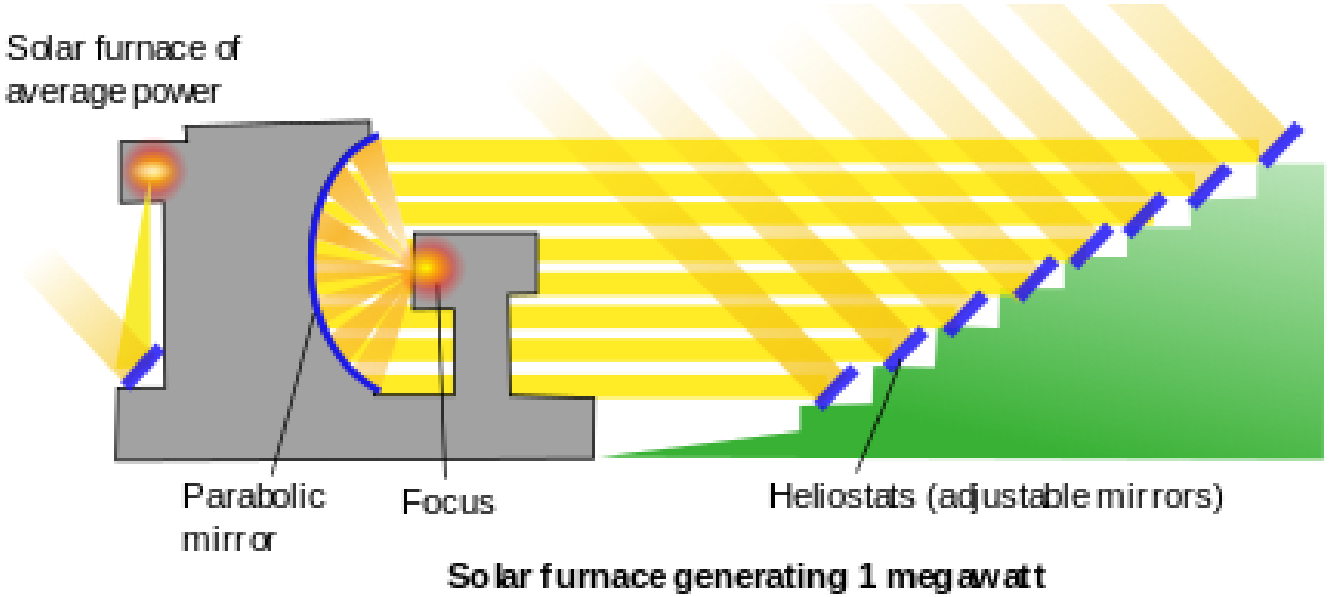
Agricultural and Industrial Drying





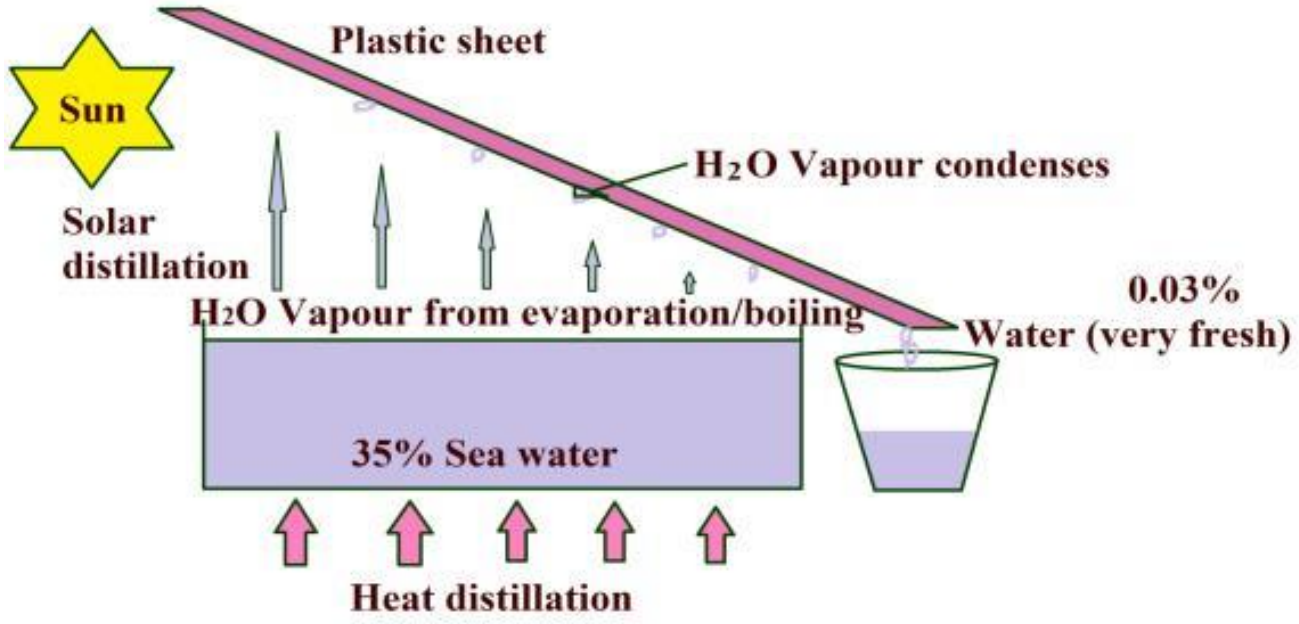
Solar Furnaces

Large parabolic mirrors about 3 m in diameter give temperatures **up to 3500°C in** a small area without contamination from combustion products.



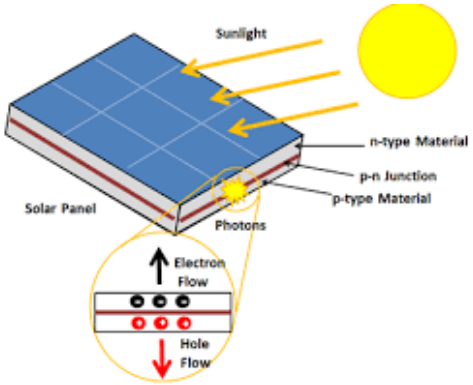
Solar furnace generating 1 megawatt

Solar Distillation



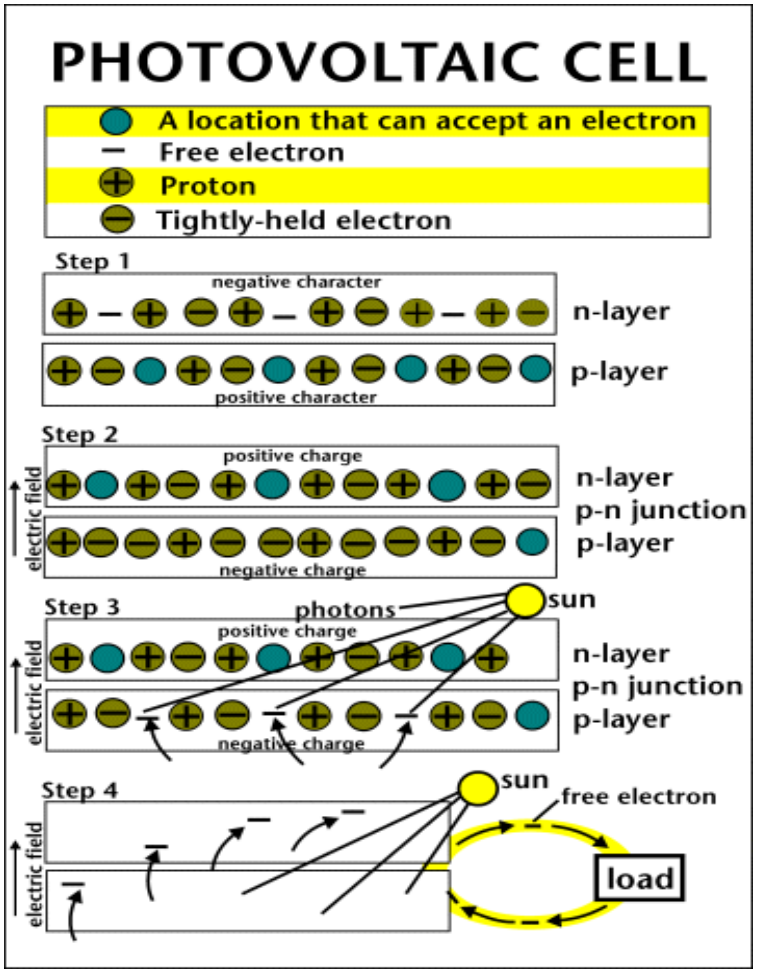
Photovoltaic cell

- Photovoltaic energy is the conversion of sunlight into electricity through a photovoltaic (PVs) cell, commonly called a **solar cell.**
- A photovoltaic cell is a **non mechanical device** usually made from **silicon alloys.**
- Sunlight is composed of photons, or particles of solar energy.



Photovoltaic cell

When photons strike a photovoltaic cell, they may be reflected, pass right through, or be absorbed. Only the **absorbed photons** provide energy to generate electricity.

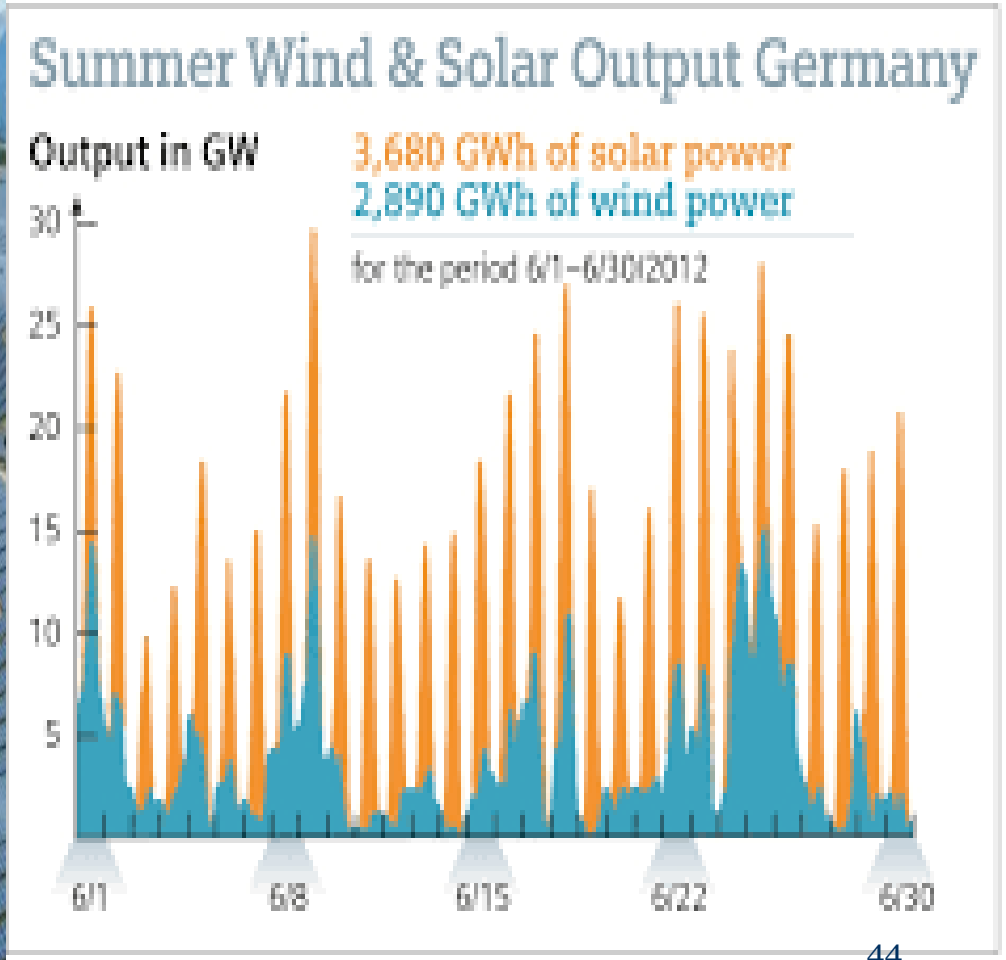


Photovoltaic cell

Photovoltaic conversion is useful for several reasons:

- ✓Conversion from sunlight to electricity is **direct**.
- ✓**Modular** characteristic of photovoltaic
- ✓The **environmental impact is minimal.**

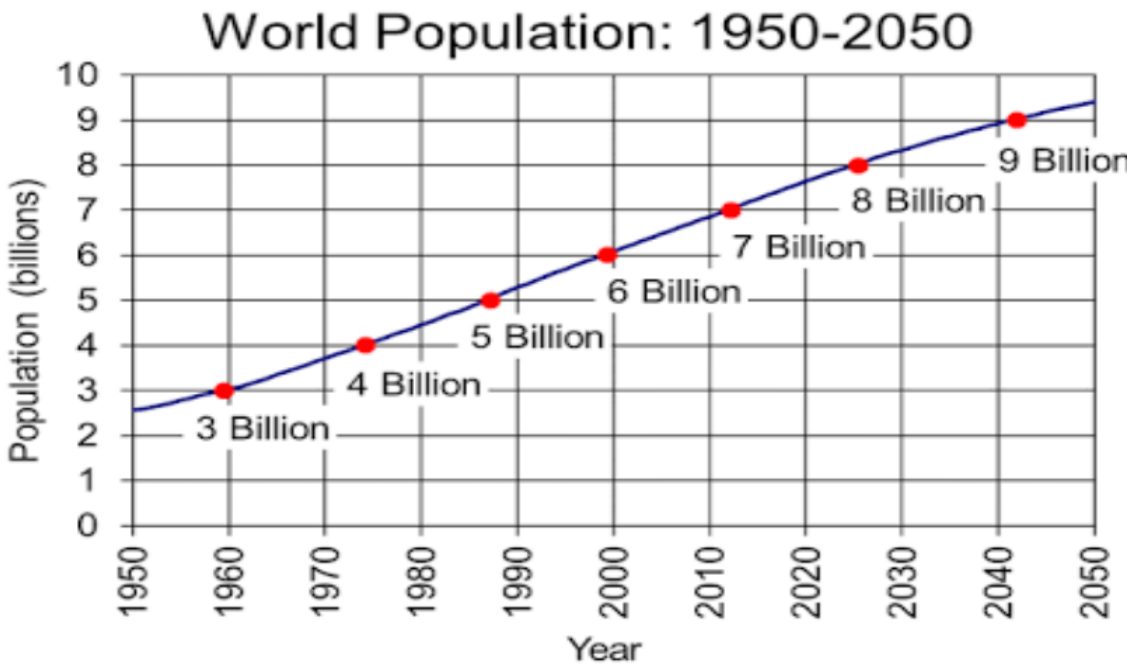
Solar panels in Germany



5. Potential for the Use of Solar Energy

Problem Definition

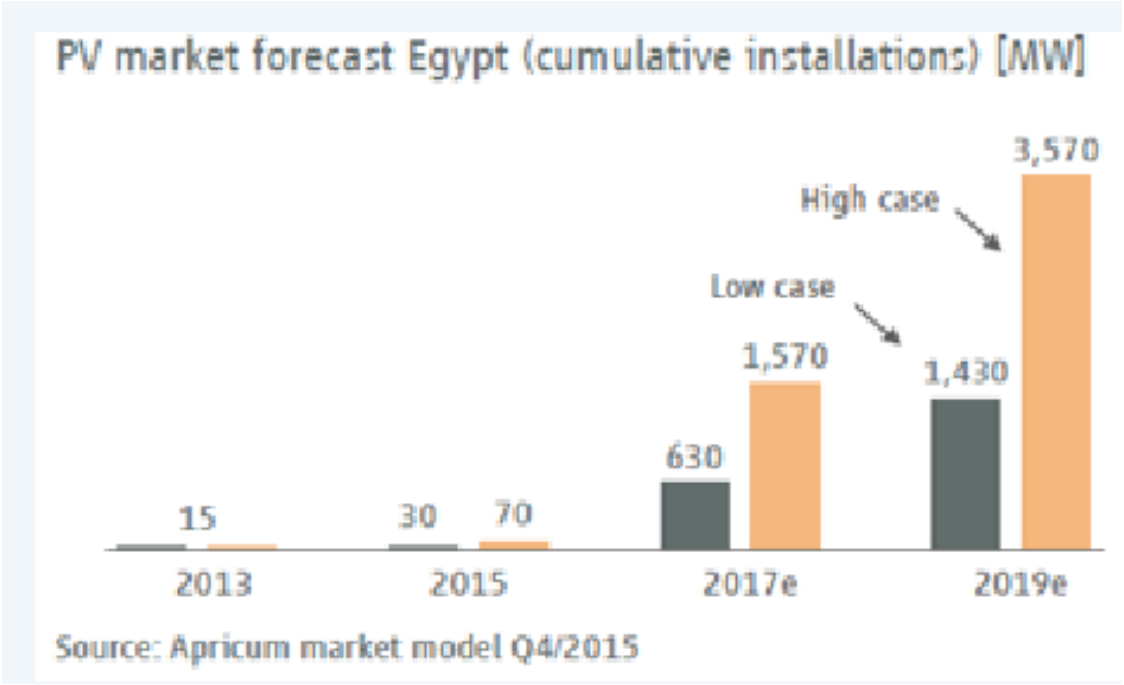
- Rapid Demographic Growth
- Water – Energy – Food insecurity



Source: U.S. Census Bureau, International Data Base, July 2015 Update.

- **It clarified that the share of renewable energy reached 31 percent of the total generated energy in 2021.**

  According to the info-graphic, Egypt's targets for the contribution of the installed capacities from renewable energies to hit 20 percent in 2021, and to exceed 42 percent of the total energy generated by 2035. Home-SIS



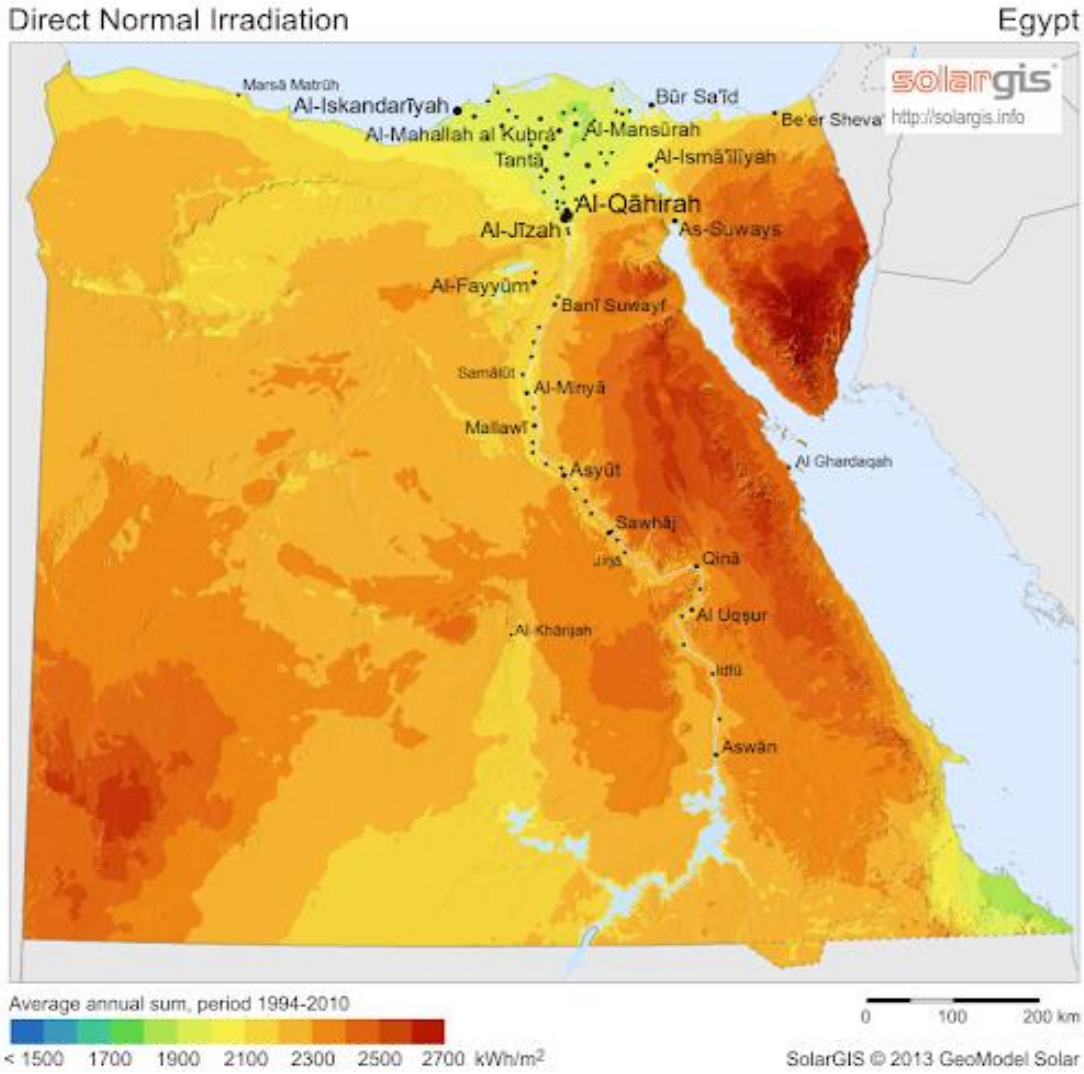
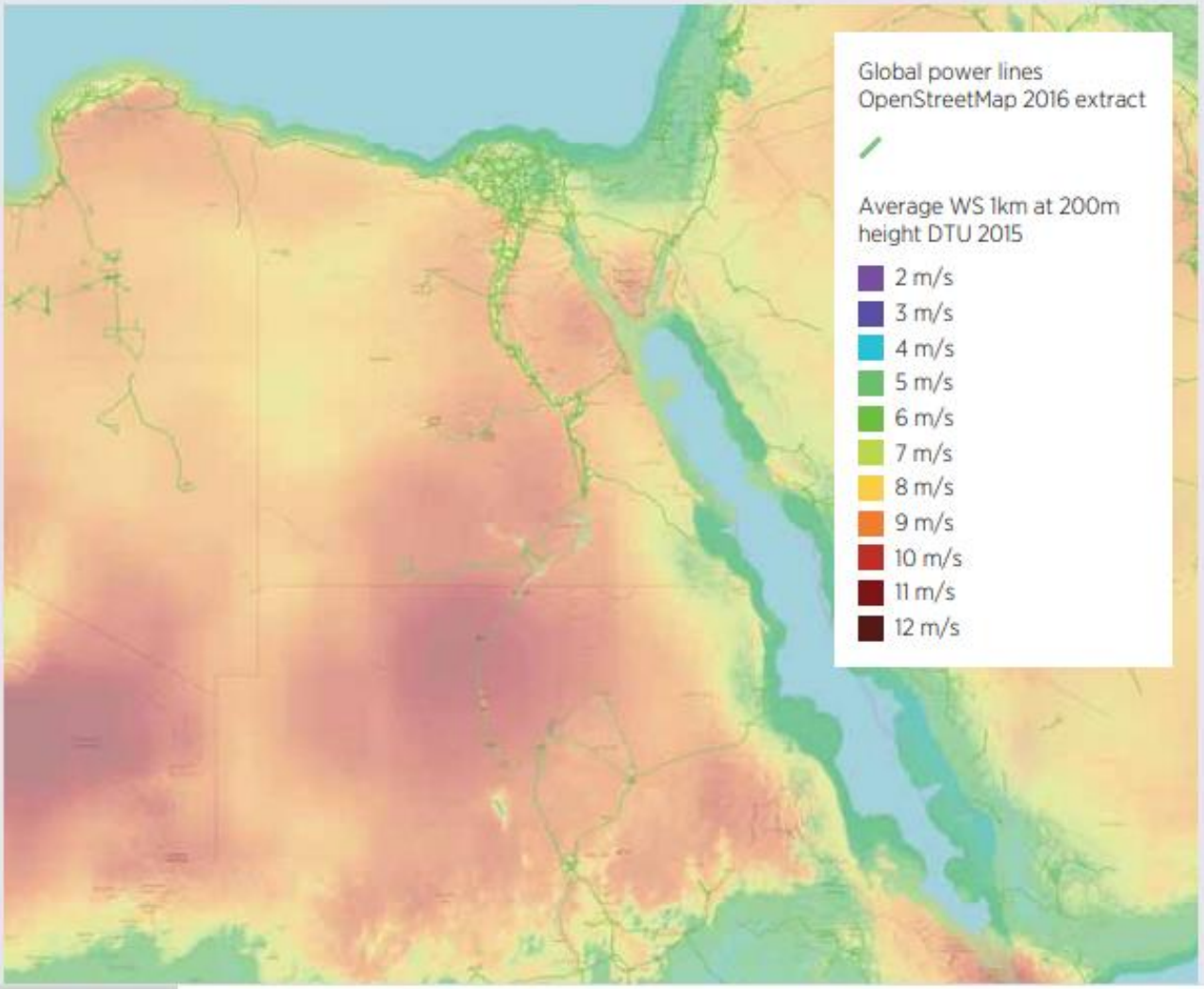

Direct Normal Irradiation
Egypt
solargis
http://solargis.info
Marsá Matrūh
Al-Iskandarīyah
Bür Sa'īd
Be'er Sheva
Al-Mahallah al Kubrá
Al-Mansūrah
Tanta
Al-Ismā'īlīyah
Al-Qāhirah
Al-Jīzah
As-Suways
Al-Fayyūm
Banī Suwayf
Samālūt
Al-Minyā
Mallawī
Al Ghardaqah
Asyūt
Sawhāj
Jirjā
Qinā
Al Uqşur
Al-Kharjah
Idfū
Aswān
Average annual sum, period 1994-2010
< 1500 1700 1900 2100 2300 2500 2700 kWh/m²
0 100 200 km
SolarGIS © 2013 GeoModel Solar

Figure 15. Egypt's wind atlas



Renewable Energy Outlook: Egypt recommends seven key actions

1. **Update** energy and power sector strategies to reflect the growing cost advantages and other benefits of renewables.
2. Reflect the **potential of biomass** in future updates of the energy strategy;
3. Streamline **regulations** and clarify institutional **roles and responsibilities** for wind and solar development;

Renewable Energy Outlook: Egypt recommends seven key actions

4. Reform the current **market framework** to improve project bankability;(ability to make money)
5. **Bundle** renewable energy projects to strengthen risk mitigation and ensure their financial viability;
6. **Conduct** comprehensive measurement campaigns for solar and wind potential;
7. Develop a master plan for **enhancing local manufacturing capabilities** and create a vibrant domestic renewable energy industry.

Egypt's Massive 1.8-Gigawatt Benban Solar Park Nears Completion

Sun-soaked Egypt's first utility-scale PV power plant —one of the world's largest solar installations—is coming online

By **Amy Nordrum**

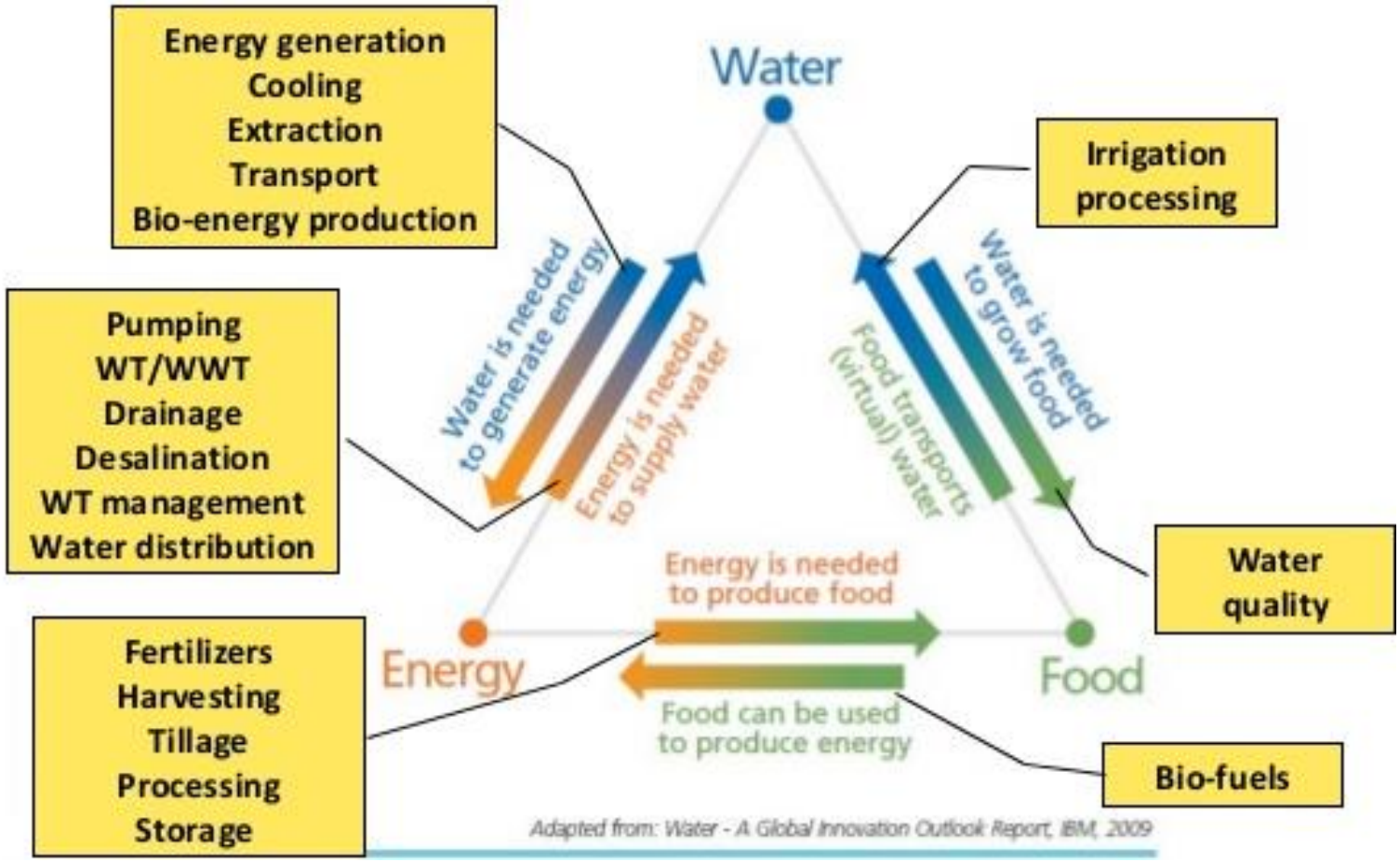
PROGRAMS AND PROJECTS FOR ENERGY UNTIL 2030

1. Developing an integrated energy strategy for medium and long-term.
2. Energy sector restructuring.
3. Reforming the current legislative framework.
4. Improving the efficiency of energy subsidy.
5. Developing the energy sector's infrastructure.
6. Promoting innovation in energy sector.
7. Applying environmental standards and accurate measurements.
8. Improving skills development.
9. Establishing the nuclear station in Dab'aa.

The Challenges Renewable Energy Sources Face:

- Availability of Power. One of the biggest concerns in the field of renewable energy is power generation depending on natural **resources** that are uncontrollable by humans.
- Power Quality **Issues.**
- Resource Location.
- Information Barrier.
- **Cost** Issue.

Challenges among the WEF sectors



6. Basics of renewable energy design principles

Solar Water Heater

All solar collectors include an absorbing surface which may be called the **plate**. In Figure 1;

The radiant flux striking the plate = $\tau_{cov}\, A_p\, G$, where

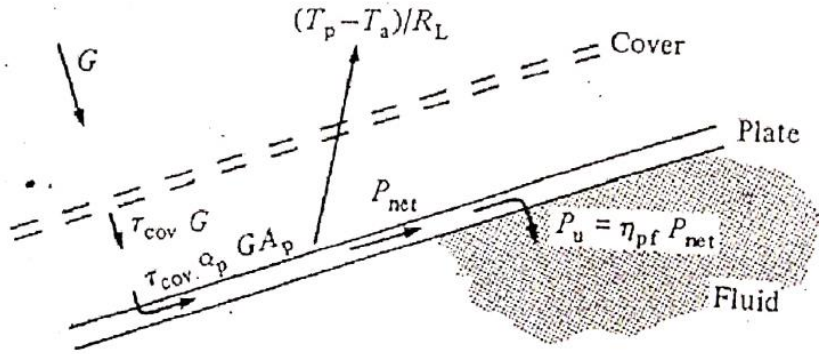
G = the irradiance on the collector,

A_p = the exposed area of the plate and

τ_{cov} = the transmittance of any transparent cover that may be used to protect the plate from the wind.

Only a fraction α_p of this flux is actually absorbed. Since the plate is hotter than its surroundings, it loses heat at a rate $(T_p - T_a)/R_L$, where R_L is the resistance to heat loss from the plate (temperature Tp) to the outside environment (temperature Ta). The net heat flow into the plate is

$$P_{net} = \tau_{cov}\alpha_p A_p G - [(T_p - T_a)/R_L]$$
$$= A_p\left[\tau_{cov}\alpha_p G - U_L(T_p - T_a)\right]$$
$$= \eta_{sp} A_p G$$



Solar Water Heater

the transfer efficiency pf is only slightly less than 1. Thus the useful output power from the collector is

$$
\begin{aligned}
P_u &= \eta_{pf} P_{net} \\
&= mc\,dT_f/dt \text{ if a static mass } m \text{ of fluid is being heated} \\
&= \dot{m}c(T_2 - T_1) \text{ if a mass } \dot{m} \text{ flows through the collector in unit time}
\end{aligned}
$$

In the third case, T_1 is the temperature of the fluid as it enters the collector and T_2 as it leaves the collector.

These equations are most commonly used to determine the output P_u for a given irradiance G. The parameters A_p, α, τ of the collector are usually specified. Although T_p depends on P_u, a reasonable first estimate can be made and then refined later if required.

Solar Water Heater

A collector of area A_p exposed to irradiance G (measured in the plane of the collector) gives a useful output

$$P_u = A_p q_u = \eta_c A_p G$$

$P_u = \eta_{PF} P_{Net} \eta\eta_{sp} A_p G$

Energy collection is in two sequential stages, so the collector efficiency η_c is the product of the capture efficiency η_{sp} and the transfer efficiency η_{pf}

$$\eta_c = \eta_{sp}\eta_{pf}$$

$$\eta_{sp} = \tau_{cov}\alpha_p - U_L(T_p - T_a)/G$$

which shows that as the plate gets hotter, the losses increase until η_{sp} decreases to zero at the 'equilibrium' temperature $T_p^{(m)}$ (also called the stagnation temperature). As the plate temperature T_p in an operating collector is not usually known, it is more convenient to relate the useful energy gain to the mean fluid temperature $\bar{T}_f$, so that:

PV panel

To calculate solar panel output:

1. Solar panels' efficiency.
2. Location (how much sunlight shines on your solar panels).
3. Which direction solar panels are facing.

PV panel

The most common environmental factors that can subdue efficiency are:

- **Shading from nearby trees or other buildings**
- **Excessive cloud coverage**
- **Excessive dirt, dust, and pollution**
- **Thick layers of snow**

7. Renewable energy applications in WWT.

Solar Energy Applications

Renewable energy technologies have long been used **for water-supply applications.**

They can be used to:

a) **pump water** from wells or to **power booster pumps**

b) **water-treatment systems**

c) **power for traditional or conventional water treatment technologies**

d) **new emerging technologies**

(UV disinfection, desalination plants, and distillation, direct heat, or photocatalytic oxidation to destroy pathogens)

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Solar Energy Applications

Renewable energy sources, **such as solar, wind, biomass, and bio-fuel**-related sources are becoming more attractive for water supply and wastewater treatment applications.

Solar Energy

can be used either **directly** or **indirectly** (thermally or electrically) to pump or treat water and wastewater

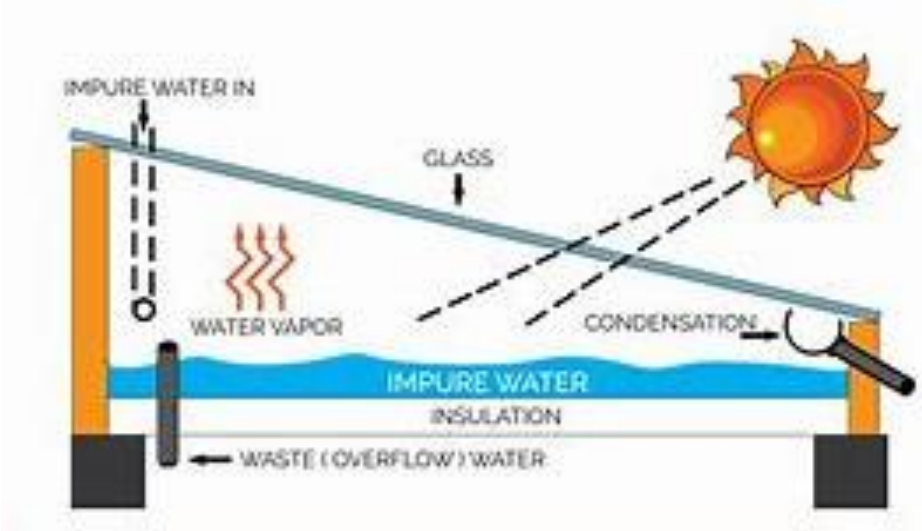
Solar thermal energy can be best utilized for:

i. desalination of salty or brackish water,
ii. various methods of distillation,
iii. indirectly even for water pumping applications.

Solar Energy Applications

A- Solar energy

Direct solar radiation is used for desalination and wastewater treatment.



Reverse Osmosis (RO)

Energy recovery reverse osmosis(ER-RO) systems. Solar energy can be used with RO systems as a prime mover source driving the pumps with the direct production of electricity through the use of photovoltaic panels

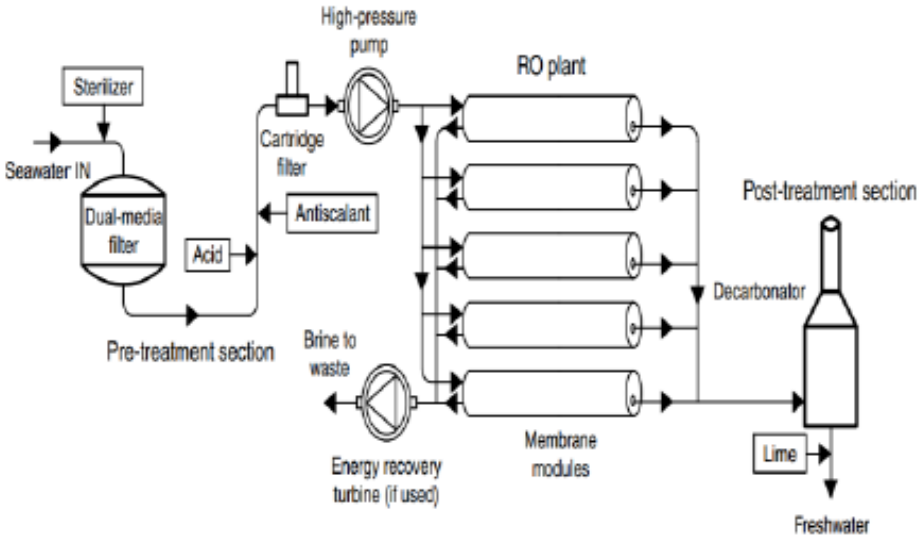


Fig. 5. A complete process of an RO system

Hybrid Systems

Hybrid systems are also becoming more attractive these days, especially for remote standalone applications. A hybrid system can be a combination of PV, a wind turbine with or without a backup generator, and battery storage.

Water treatment in rural villages, one must consider issues like:

a) **system sustainability**
b) **costs**
c) **availability of energy resources**
d) **skilled manpower**
e) **spare parts**

Hybrid Systems

- Using renewable energy technologies for water treatment, especially desalination plants, **can be very expensive.**
- The process demands a lot of energy, which is a high investment cost, especially for rural applications.
- On the other hand, renewable energy sources can be more viable options for certain treatment needs and locations.

Hybrid Systems

- For example, grid power may not be an alternative source for remote locations of many developing countries and islands because of high grid extension.
- In such cases, renewable energy sources might be the only alternative solutions.
- Therefore, every alternative system must be evaluated based on the local conditions and system sustainability issues.

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Wastewater Treatment

Wednesday, 29 September 2021

Bahr El Baqar: Egypt's record-breaking wastewater treatment facility

Center of Excellence for Water - Exchange, Training, and Scholarships

Wastewater Treatment

- Solar energy is particularly important in treating wastewater. Direct solar radiation is used for wastewater treatment.
- The three most common wastewater treatment methods are:

I. stabilization ponds
II. aerated lagoons
III. oxidation ditches

Wastewater Treatment

- Oxidation ditch

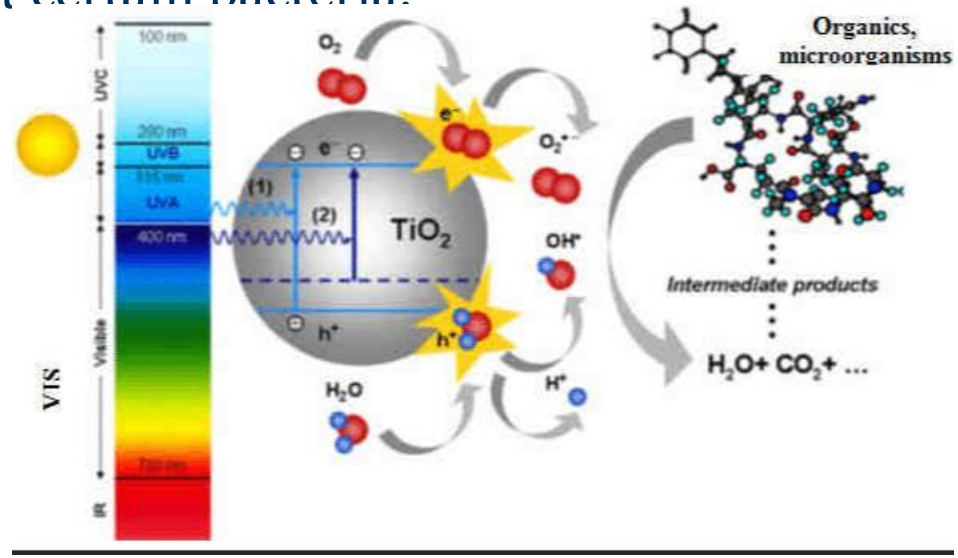
Aerated lagoon

Solar Detoxification

- Solar radiation energy (direct sunlight) has been used for the biological processes in stabilization ponds.
- Now there are new emerging technologies for treating wastewater that use the UV portion of the solar spectrum to activate the semiconductor catalyst that produces hydroxyl radicals.
- The most promising technology for destroying TOCs in wastewater treatment is the UV advanced oxidation processes (AOPs).

Solar Detoxification

- The oxidation chemistry and potency of the photocatalytic process of solar detoxification systems are similar to other chemical oxidation methods that generate hydroxyl radicals.
- Like UV/O_3 and UV/H_2O_2 solar detoxification systems can oxidize organic pollutants into nontoxic materials, such as CO_2 and water and can disinfect certain bacteria.



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