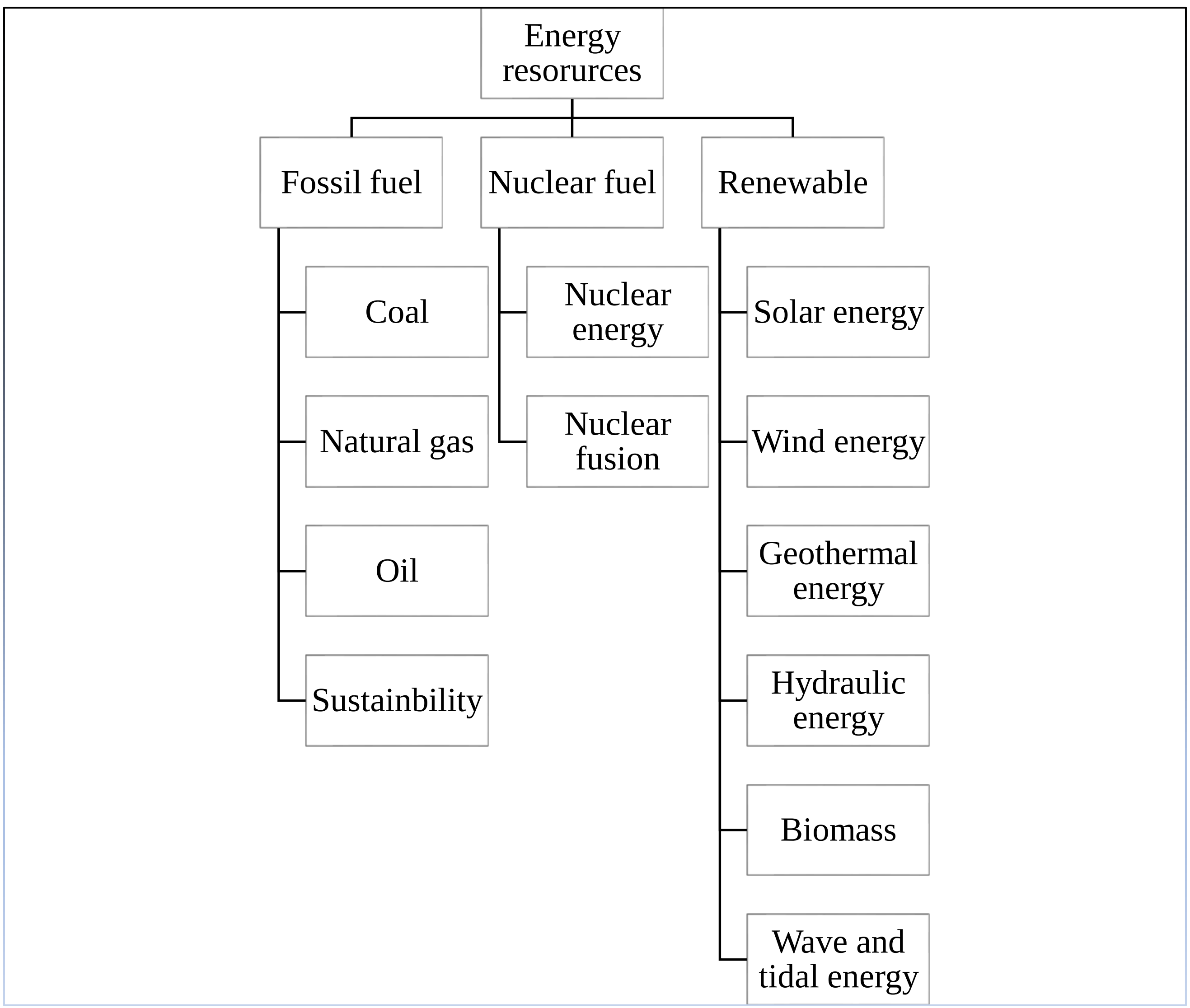
First weak:

Energy resources:

World energy resources are the estimated maximum capacity for energy production given all available resources on Earth. They can be divided by type into **fossil fuel**, **nuclear fuel** and **renewable** resources.



The Energy

We are aware about several activities tacking place in nature. These "activities" have some form of "motion" of particles or objects. Energy is the cause behind motion of particles or objects. Energy is the capability to produce motion, force, work; change in shape, change in form, etc. We notice that energy exists in many forms such as chemical energy, nuclear energy, solar energy, mechanical energy, electrical energy, internal energy in body, bioenergy in vegetables and animal bodies, thermal energy, etc. We also observe the various activities around us are "energy transformations". Green plants capture solar energy and convert it in food and fuel which contain chemical energy. We also observe energy chains comprising of several energy links. Each link represents an energy transformation and the energy chain has several energy links between raw energy and usable energy. For example coal is extracted from nature. Coal energy chain by thermal power plant route is: Energy chain – coal to electric energy Energy exists in several forms. Energy transformations are responsible for various activities. The concept of energy has been derived from classical physical while explaining "Work" Work is performed when a particle or an object moves work is energy in transit. Energy is cause of work. Energy is necessary for performing "work". Energy is capability to perform "work". The world energy has been adopted from Greek language. In Greek, "en" means "in" and "ergon" means "work". "en-ergon" means "in-work" or "work content". En-ergon was simplified to the word Energy. Chemical Energy in Coal Thermal Energy of Steam Mechanical

What is renewable energy and are there other names for it?

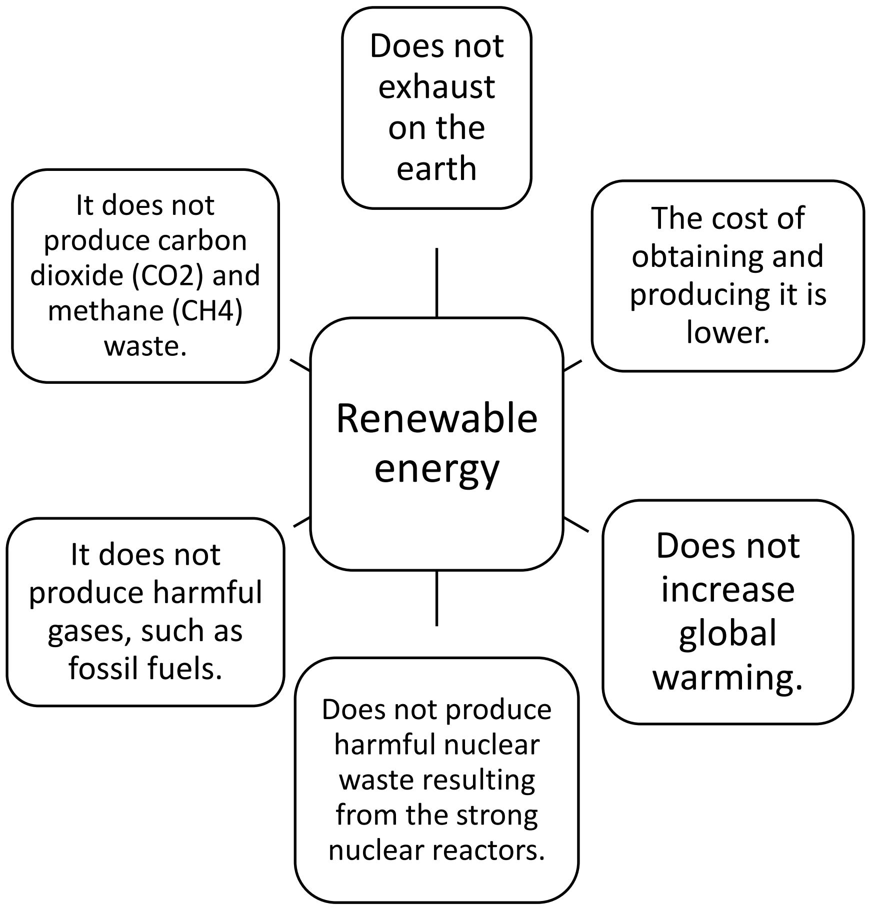
- Renewable energy is energy that is derived from natural resources, which are constantly renewed and that is not exhausted.
- It is also called sustainable energy, as it is a permanent source of life on the planet and its sources do not need an extraction, mining or mechanized processes, they are 100% natural.

Sometimes it is called alternative energy (here it should be noted that this designation is more general, as it includes sources that are used instead of fossil energy sources or produce fuel like the fuel produced by fossil energy). But not all alternative energy sources are renewable. For example, nuclear energy is considered an alternative energy for fossil fuels, but it is considered exhausted

Why focus on renewable energy?

- Increasing the percentage of carbon dioxide in the atmosphere leads to an increase in the temperatures while increasing methane emissions increase the acid rain.
- Radiation and nuclear waste, which is produced by nuclear reactors that produce energy. Although nuclear energy formed a few decades ago, an ideal solution and an important source of energy, the accumulation of its products from dangerous waste on the life of creatures made it undesirable. The resulting waste is more harmful and more expensive to dispose of.

<u>Second week :</u>



Renewable Energy and the Environmental Problems:

A few years ago, most environmental analysis and legal control instruments concentrated on conventional pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulates, and carbon monoxide (CO). Recently, however, environmental concern has extended to the control of hazardous air pollutants, which are usually toxic chemical substances harmful even in small doses, as well as to other globally significant pollutants such as carbon dioxide (CO_2). Additionally, developments in industrial processes and structures have led to new environmental problems. Carbon dioxide as a greenhouse gas plays a vital role in global warming. Studies show that it is responsible for about two thirds of the enhanced greenhouse effect. A significant contribution to the CO2 emitted to the atmosphere is attributed to fossil fuel combustion. (See Fig. 1.4). Table 1.4. shows the annual marginal average emissions rates for 2002.

Nuclear Energy Hazards Nuclear energy:

although non-polluting, presents a number of potential hazards both during the production stage and mainly for the disposal of radioactive waste. Nuclear power environmental effects include the effects on air, water, ground, and the biosphere (people, plants, and animals). Nowadays, in many countries, laws govern any radioactive releases from nuclear power plants. In this section some of the most serious environmental problems associated with electricity produced from nuclear energy are described. These include only effects related to nuclear energy and not emissions of other substances due to the normal thermodynamic cycle

Third week :

Solar Energy:

The Sun:

Solar energy is one of the energies derived from natural and non-depleting sources available in nature. This energy is considered one of the most important sources of renewable energy, as it comes from light and heat emitted from the sun. The sun is a sphere of intensely hot gaseous matter with a diameter of (1.39×10^9) m . thermal radiation travels with the speed of light in a vacuum (300,000 km/s), after leaving the sun solar energy reaches our planet in 8 min and 20 s. As observed from the earth, the sun disk forms .The solar constant is defined as the amount of energy incident per unit of time on a unit area perpendicular to the solar ray solar constant was estimated at (1353 W / m^2).

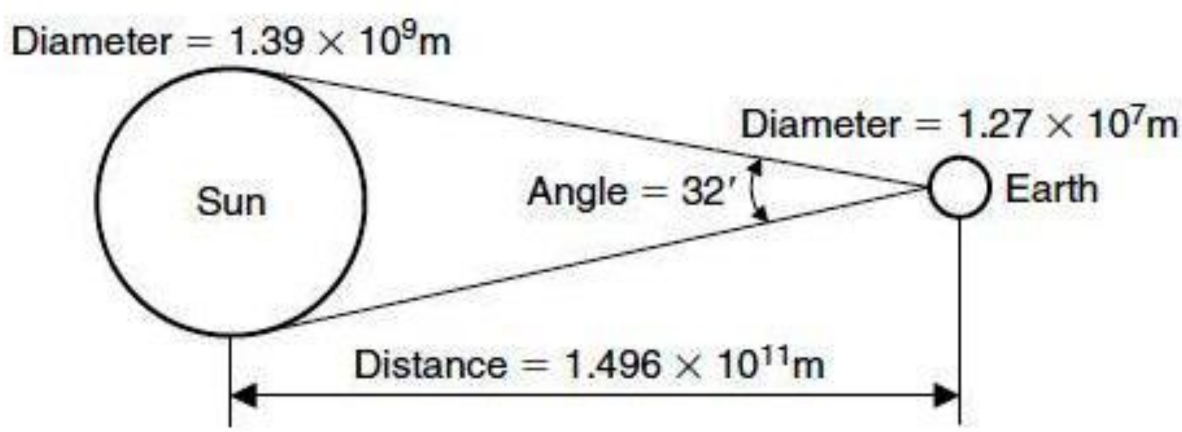


Fig. 1.1 Sun-earth relationship.

Advantage of Solar Energy:

A- Solar energy is continuous and inexhaustible energy.

B - The absence of solar energy from environmental pollutants.

C- Solar energy is free energy that exists in most parts of the earth directly reaching the consumer.

D - East Iraq enjoys its geographical location, as it is located within the hot regions and solar energy is available in large quantities throughout the seasons of the year.

E- Reducing dependence on fossil energy due to the possibility of its depletion in the near future

Solar Radiation:

The Earth obtains solar energy through solar radiation, and this radiant energy comes to us by means of tiny, weightless particles called photons, and photons behave like (electromagnetic) waves.

1. Direct Radiation: radiation from the sun that reaches the earth without scattering
2. Diffuse Radiation: Diffuse Radiation that is scattered by the atmosphere and clouds

Solar angles:

The earth completes a complete cycle around its axis every 24 hours, and it also completes the same cycle around the sun in a period that takes about 365days. This last rotational movement is not circular but takes an oval shape, and the use of solar energy effectively requires detailed knowledge of the angles formed by the fall of the sun on the surface of the globe.

latitude angle (ϕ): of a point on the surface of the earth is its angular distance north or south of the equator measured from the center of the earth. It is the angle between the line OP and the projection of OP on the equatorial plane. Point O represents the center of the earth see in figure (1.2).

hour angle (ω):. It is the angle measured in the earth's equatorial plane between the projection of OP and the projection of a line from the center of the sun to the center of the earth see in figure (1.2) .

$$\omega = (12 - \text{Solar time}) * 15$$

$$Solar\ time = standard\ time + E \mp 4(la - lc)$$

حيث تمثل :

La ؛ خط الطول الفعلي لمدينة كركوك وتساوي 44.35°

Lc :خط الطول للعراق وتساوي 45°.

(E) تمثل معادلة الوقت وتحسب من تطبيق المعادلة الآتية

$$E = 98.7 * sin(2 * B) - 7.53 * cos(B) - 1.5 * sin(B)$$

$$B = \frac{360(ND - 81)}{364}$$

ND = عدد الايام

Declination angle (δ): is the angular distance of the sun's rays north (or south) of the equator. It is the angle between a line extending from the center of the sun to the center of the earth, and the projection of this line upon the earth's equatorial plane. This is the direct consequence of the tilt and it would vary between 23.45° on June 21, to - 23.45° on December 21. see in figure (1.2) .

$$\boldsymbol{\delta} = 23.45 * \sin[\frac{360}{370}(ND - 80)]$$

ND = عدد الايام

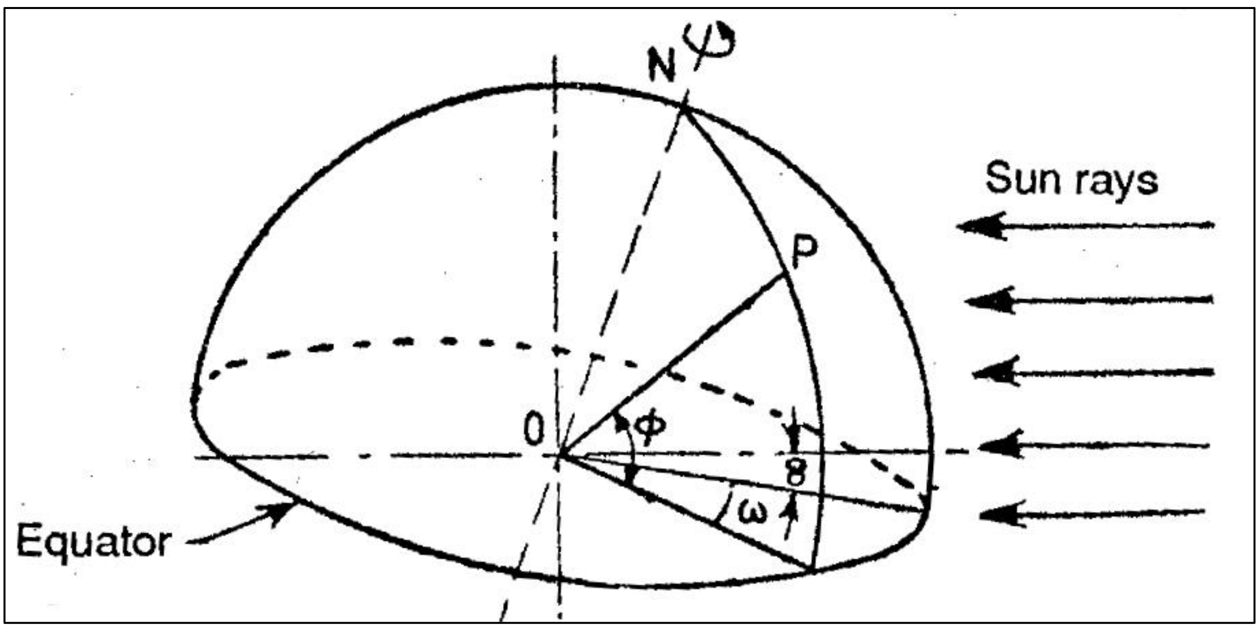


Fig. 1.2 Latitude, hour angle and sun's declination

<u>fourth weak :</u>

Altitude angle α: It is defined as the angle in the vertical plane between the sun's rays and the projection of that rays on the earth's surface

$$\alpha = \text{Sin}^{-1} [\text{Cos}(\delta) * \text{Cos}(\phi) * \text{Cos}(\omega) + \text{Sin}(\delta) * \text{Sin}(\phi)]$$

azimuth angle Ø:

The angle of the azimuth is measured in the horizontal plane between the south and the projection of the line connecting the center .The sun and a certain point on the earth (point P) on the horizontal plane as see in figure (1.3)

$$\text{Ø} = \tan^{-1} \frac{\sin(\omega)}{\sin(\phi)\cos(\omega) - \cos(\phi)\tan(\delta)}$$

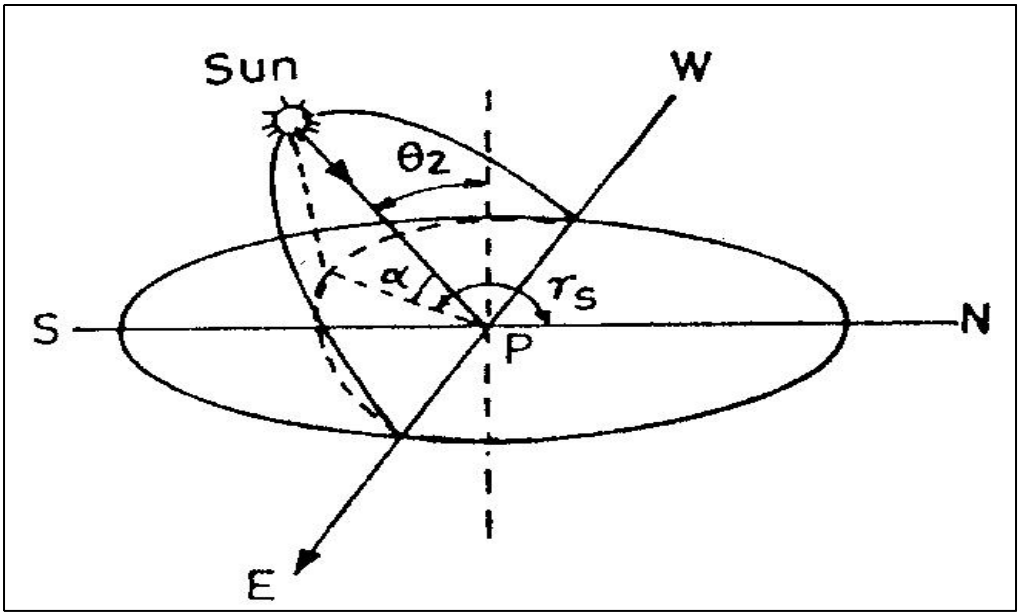


Fig. 1.3 A Latitude, azimuth angle

الاشعة الشمسية المباشرة والمنتشرة :

يتبعثر جزء كبير من الاشعاع الشمسي عند دخوله الغلاف الغازي للارض نتيجة لعمليات بعض مكونات الغلاف الغازي يعكسه الغلاف الانكسار والانعكاس والامتصاص من قبل الجوي وتبلغ ما يتشتت وينعكس ويمتص خلال مروره بالجو35 %منها 6% في غلاف الجوي و2% تعكسهه سطح الارض و27% تعكسه وتتبعثرة الغيوم الى الفضاء

.هذه النسبة تمثل المفقود لا تساهم في تسخين سطح الارض و لا الغلاف الغازي .اما الاشعاع الشمسي الذي يساهم في تسخين الهواء فهو 65%منه 51% يمتص سطح الارض اما الباقي الغلاف الجوي.

Solar radiation in space:

ان الشعاع الشمسي الساقط خارج الغلاف الجوي تتغير المسافة بين الارض والشمس خلال السنة مما يودي الى تغير كمية الاشعاع الشمسي الواصل الى الارض تبعا لدلك . يمكن حساب كمية الاشعاع الشمسي الساقط على السطح الافقي خارج الغلاف الجوي الارضي .

من نموذج أشري حيث تحسب كمية الاشعاع المباشر الساقط على السطح عمودي على مساوه حسب النموذج من المعادلة التالية

$$I_{DN} = A_1 * \exp\left(\frac{-P_L}{P_O} * \frac{B}{\sin(\alpha)}\right)$$

: A_1

هي معامل شدة الاشعاع الشمسي الساقط وتحسب من المعادلة الاتية :

$$A_1 = 1158[\,1+0.066 *\cos\left(\frac{360}{370} *ND\right)]$$

B هو معامل الاضمحلال الجوي بحسب المعادلة التالية :

$$. B= 0.175 *[1 -0.2 *\cos (0.93*ND)- 0.0045* [1 -\cos (1.86 *ND)$$

$\frac{P_L}{P_O}=$

فهو النسبة بين الضغط الجوي عند الموقع المطلوب حساب شدة الاشعاع الشمسي فية الى الضغط عند مستوى سطح البحر وتحسب من المعادلة التالية :

$$\frac{P_L}{P_O}= \exp (-0.0001148 * H_{air}) \quad =$$

H_{air} مقدار الارتفاع عن سطح البحر بالامتار

1. ان مقدار الاشعة المباشرة الساقطة على السطح مائل بزاوية I_D
عن الافق (o).

$$I_D = I_{DN} * \cos(\theta)$$

Cos(θ) هي الزاوية السقوط وتحسب من المعادلة التالية :

Cos(θ) = Sin (**α**) *Cos(O) + Cos(**α**)* Cos(Ø)* Sin(O)

* اما مقدار الاشعة المنتشرة الساقطة على سطح مائل بزاوية(O)مقدار عن الافق تحسب من المعادلة التالية .

$I_{diffuse} = I_{DN}$ [c* (1+cos(O)/2 + s *(c +sin **α**)* 1-cos(O)/2]

:(S)

مقدار الانعكاسية التي تعرف وتتراوح قيمتها بين 0.2 للحالة العادية و0.7 عند الثلوج

(C)

:معامل الاشعة المنتشرة ويعرف انه المعدل الشهري بين الاشعة الشمسية المنتشرة الى شدة الاشعة العمودية المباشرة ولسماء صافية

c= 0.0965 [1-0.42 cos 360/370 *ND]-0.0075 * [1-cos1.95*ND]

اما الاشعة الكلية الساقطة على السطح المجمع الشمسي فتحسب من المعادلة التالية :

. $I_{D_t} = I_d + I_D$

or

I_{D_t} = I_{DN} *[cos (θ) +c * (1+cos(O)/2 +s* (c+ sin **α**)* (1-cos(O) /2]

fifth week :

Example 1:

Determine the local solar time corresponding to 10:00 a.m. on February 8 for a location city at 95° west and home land 90° west

Solution:

$$Solar\ time \quad = standard\ time + \ E \pm 4(la - lc)$$

ياخد اشارة سالبة لان غربا

$$E = 98.7 * sin(\ 2 * B) - 7.53 * \ cos\ (B) - 1.5 * \ sin(\ B)$$

$$B \ = \frac{360(ND - 81)}{364}$$

$B \ = \frac{360(39-81)}{364}$= - 41.5 where ND= 31+8 =39

$$E = 98.7 * sin(\ 2 * -41.5) - 7.53 * \ cos\ (-41.5) - 1.5 * \ \sin\ (-41.5)$$

= -14.207

min. part 0. 207 *60= 13sec

= -0 : 14 :13

= hr . min . sec

= $4(la - lc)$

= $4(95° - 90°)$ = 4(5°)

=4(5*60)

4(300)

1200 sec / 60= 0:20 :0 min

$Solar\ time \quad = 10 + (-0:14:13) - 0:20:0$

$Solar\ time \quad = 9:59:60 + (-0:14:13) - 0:20:0$

= 9:25:47 A.M

Example 2:

Determined the result obtained from Ashry to estimate the amount of direct radiation falling on a horizontal surface in the city of Basra at ten in the morning local time on August 27 , 2004 at Latiled 30° north . if we the Altitude angle is 57.355° and the Azimuth angle is 57.176 °.

حسب نموذج اشري كمية الاشعاع الساقط على سطح عمودي .

$I_{DN} = A_1 * \exp\left(\frac{-P_L}{P_O} * \frac{B}{\sin(\alpha)}\right)$

$A_1 = 1158[\,1+0.066 * \cos\left(\frac{360}{370} * ND\right)]$

سنة 2004 سنة كبيسة ياخذ بنظر الاعتبار ان شهر شباط هو 29

ND = 31+29 +31+30+31 +30+31+27 = 240

A_1= 1158[1+0.066 *cos ($\frac{360}{370}$ *ND) = 1112.55 w /m^2

B= 0.175 *[1 -0.2 *cos (0.93*ND)- 0.0045* [1 -cos (1.86 *ND) = 0.9158

$\frac{P_L}{P_O}$= exp (-0.0001148 * $H_{air)}$ = 1

$\frac{P_L}{P_O}$= exp (-0.0001148 * 0) = 1

0 = بعد عن سطح البحر

I_{DN} = A_1 * exp ($\frac{-P_L}{P_O}$ *$\frac{B}{sin\,(\alpha)}$)

I_{DN} = A_1 * exp (-1 *$\frac{0.9158}{sin\,(57.176}$) = 881.312 w/$m^2$

Example 3:

Calculate the intensity of the total solar rays on the solar complex in the city of Basra, tilted at an angle with 20° at the end of August 2004 for the 27 th horizon and facing the south at ten in the morning local time at 30° latitude. North Degree

Solution:

ND= 31+29+31+30+31+30+31+27=240

To find Declination angle (δ)

$\boldsymbol{\delta} = 23.45 * \sin[\frac{360}{370}(ND - 80)]$

$= 23.45 * \sin[\frac{360}{370}(240 - 80)] =$ 9.659°

To find solar time

$Solar\ time \quad = standard\ time\ +\ E + 4(la - lc)$

$E = 98.7 * sin(\ 2 * B) - 7.53 *\ cos\ (B) - 1.5 *\ sin(\ B)$

$B \quad = \frac{360(ND-81)}{364} = \frac{360(240-81)}{364}$

B = 157.25

E $= 98.7 * sin(\ 2 * 157.25) - 7.53 *\ cos\ (157.25) - 1.5 *\ sin(\ 157.25)$

= -0.675≈ -41 == 0.675 * 60 = 40.5 = -41 sec

$Solar\ time \quad = standard\ time\ +\ E + 4(la - lc)$

$Solar\ time \quad = 10{:}00{:}00 - 00{:}00{:}41\ + 4(47.78 - 45)$

= 09 :59 :19 +00:11:08

=10:10:27

10.175° كيفية تحويل الثانية والدقيقة الى درجة

10 min = 10* 100/60 = 16.666

27 sec = 27 *100/ 3600 = 0.75

$16.666 \quad + 0.75 \quad = 17.416$

$17.416 * 10 = 175°$

To determined hour angle:

$\boldsymbol{\omega} = 15[12 – \text{solar time}]$

$= -27.375°$

وتاخذ زوايا الوقت الشمسي سالبة قبل الظهر .

To determined Altitude angle**:**

$\boldsymbol{\alpha} = \text{Sin}^{-1} [\text{Cos} (\delta)) *\text{Cos} (\phi)* \text{Cos} (\omega) +\text{Sin} (\delta) *\text{Sin} (\phi)]$

$= \text{Sin}^{-1} [\text{Cos} (9.659)) *\text{Cos} (30)* \text{Cos} (-27.375) +\text{Sin} (9.659) *\text{Sin} (30)]$

$= 57 .355°$

azimuth angle ($\varnothing_z$**)** :

$$\varnothing_z = tan^{-1} \frac{\sin(\boldsymbol{\omega})}{\sin(\boldsymbol{\phi}) \cos(\boldsymbol{\omega}) - \cos(\boldsymbol{\phi}) \tan(\boldsymbol{\delta})}$$

$$\varnothing_z = tan^{-1} \frac{\sin(\mathbf{-27.375})}{\sin(\mathbf{30}) \cos(\mathbf{-27.375}) - \cos(\mathbf{30}) \tan(\mathbf{9.659})}$$

$= -57.176°$

$$I_{DN} = A_1 * \exp\left(\frac{-P_L}{P_O} * \frac{B}{sin(\alpha)}\right)$$

$$A_1 = 1158[1+0.066 *\cos (\frac{360}{370} *ND)$$

$$A_1 = 1158[1+0.066 * \cos (\frac{360}{370} *240)] = 1112.55 \text{ w/ m}^2$$

B= 0.175 *[1 -0.2 *cos (0.93*ND)- 0.0045* [1 -cos (1.86 *ND)

= 0.195

معامل الاضمحلال الجوي وتحسب من المعادلة التالية B

$\frac{P_L}{P_O}$= exp (-0.0001148 * H_{air}) = مقدار الارتفاع عن سطح البحر بالامتار

$\frac{P_L}{P_O}$= exp (-0.0001148 *0) = 1

$I_{DN} = A_1 * \exp\left(\frac{-P_L}{P_O} * \frac{B}{\sin(\alpha)}\right)$

$I_{DN} = 1112.553 * \exp\left(-1 * \frac{0.1958}{\sin(-57.176)}\right) = 881.312$ w /m^2

. المجمع الشمسي مقدار الاشعة الساقطة على السطح I_{DN}

$I_D = I_{DN} * \cos(\theta)$

Cos(θ) = Sin (**α**) *Cos(O) + Cos(**α**)* Cos($\emptyset_z$)* Sin(O)

Cos(θ) = Sin (57.355) *Cos(20) + Cos(57.355)* Cos(57.176)* Sin(20)

= 0.891

(θ) : زاوية سقوط الإشعاع الشمسي على سطح المجمع الشمسي وتحسب من تطبيق المعادلة

فتمثل زاوية ميلان المجمع الشمسي عن الافق وتساوي (O)

I_D= 881.312 *0.891 = 785.256 w /m^2

(O) مقدار الاشعة الساقطة على المجمع الشمسي مائل بزواية عن الافق .

اما حساب الاشعة الشمسية المنتشرة الساقطة على المجمع الشمسي مائل بزاوية عن الافق

$I_{diffuse} = I_{DN}$ [c* (1+cos O)/2 +S *(c +sin α)*(1-cos O)/2]

c= 0.0965 [1-0.42 cos ((360/370) *240)]-0.0075 * [1-cos(1.95*ND)]

c= 0.0965 [1-0.42 cos 360/370 *240]-0.0075 * [1-cos (1.95*240)]=0.11

S= 0.2

$I_{diffuse} =$ 881.312 [0.11* (1+cos 20)/2 +0.2 *(0.11+sin 57.176)* 1-cos 20/2]

$I_{diffuse}$ = 98.47 w

$$I_{D_t} = I_d + I_D$$

= 785.256 +98.97

= 883.726 w

اذا شدة الاشعاع الشمسي الساقط على سطح المجمع الشمسي تساوي مجموع الاشعة الشمسية المباشرة والاشعة الشمسية المنتشرة .

<u>Sixth week :</u>

Solar Energy Collectors:

Solar Energy Collectors are special kinds of heat exchangers that transform solar radiation energy to internal energy of the transport medium. This is a device that absorbs the incoming solar radiation, converts it into heat, and transfers the heat to a fluid (usually air, water, or oil) flowing through the collector.

There are basically two types of solar collectors:

1- non-concentrating collectors

2- concentrating collectors.

A non-concentrating collector has the same area for intercepting and absorbing solar radiation, whereas a sun-tracking concentrating solar collector usually has concave reflecting surfaces to intercept and focus the sun's beam radiation to a smaller receiving area, thereby increasing the radiation flux. Concentrating collectors are suitable for high-temperature applications. Solar collectors can also be distinguished by the type of heat transfer liquid used (water, non-freezing liquid, air, or heat transfer oil). There are basically their types non-concentrating collectors.

1. Flat-plate collectors (FPCs)
2. Stationary compound parabolic collectors (CPCs).
3. Evacuated tube collectors (ETCs).

Flat-Plate Collectors:

A typical flat-plate solar collector is shown in Figure 2.1. When solar radiation passes through a transparent cover and impinges on the blackened absorber surface of high absorptivity, a large portion of this energy is absorbed by the plate and transferred to the transport medium in the fluid tubes, to be carried away for storage or use. The underside of the absorber plate and the two sides are well insulated to reduce conduction losses.

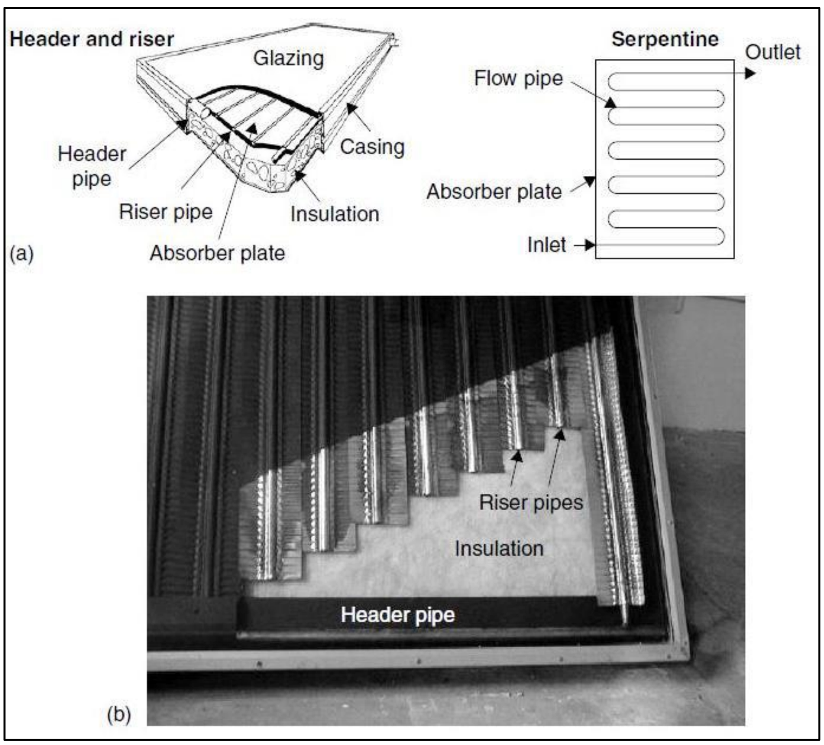


Fig. 2.1flat-plate solar collector

The main components of a flat-plate collector, as shown in Figure 2.2 are the following:

1. Cover: One or more sheets of glass or other radiation-transmitting material.
2. Heat removal fluid passageways: Tubes, fins, or passages that conduct or direct the heat transfer fluid from the inlet to the outlet.
3. Absorber plate: Flat, corrugated, or grooved plates, to which the tubes, fins or passages are attached.
4. Headers or manifolds: Pipes and ducts to admit and discharge the fluid.
5. Insulation: Used to minimize the heat loss from the back and sides of the collector.
6. Container: The casing surrounds the aforementioned components and protects them from dust, moisture, and any other material

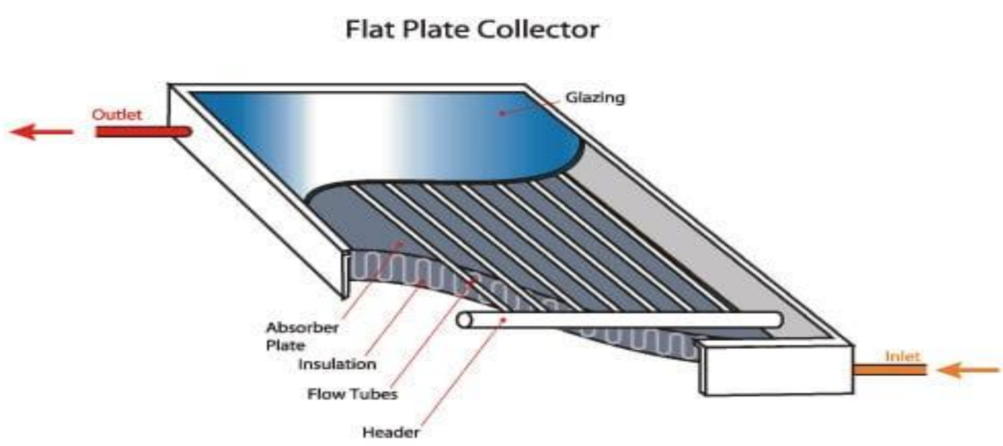


Fig. 2.2 The main components of a flat-plate collector

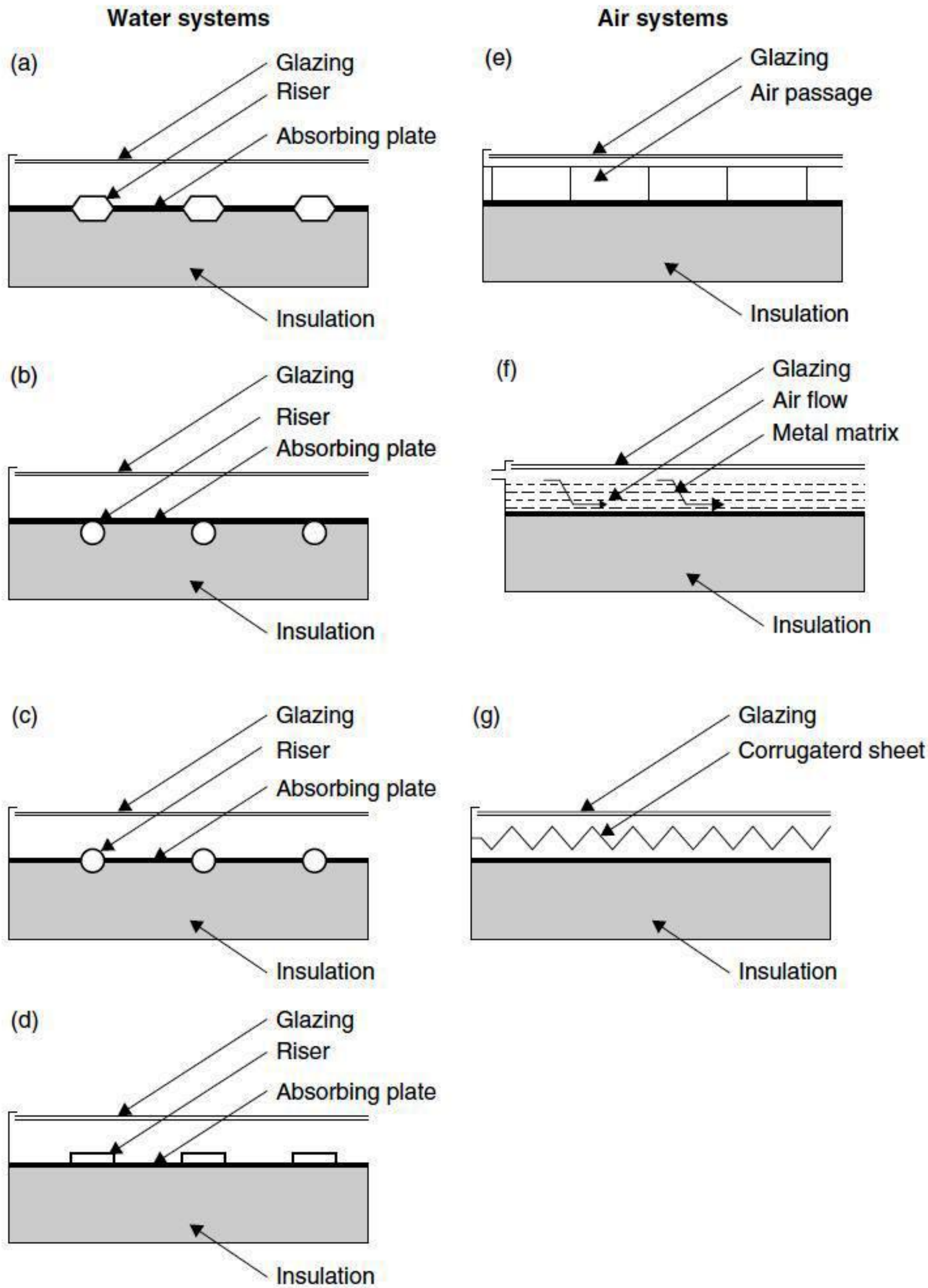


Fig. 2.3 Type components of absorber flat-plate collector configuration for water and air

Seventh week :

Compound Parabolic Collectors (CPCs):

Compound parabolic collectors (CPCs) are non-imaging concentrators. They have the capability of reflecting to the absorber all of the incident radiation within wide limits. The necessity of moving the concentrator to accommodate the changing solar orientation can be reduced by using a trough with two sections of a parabola facing each other,

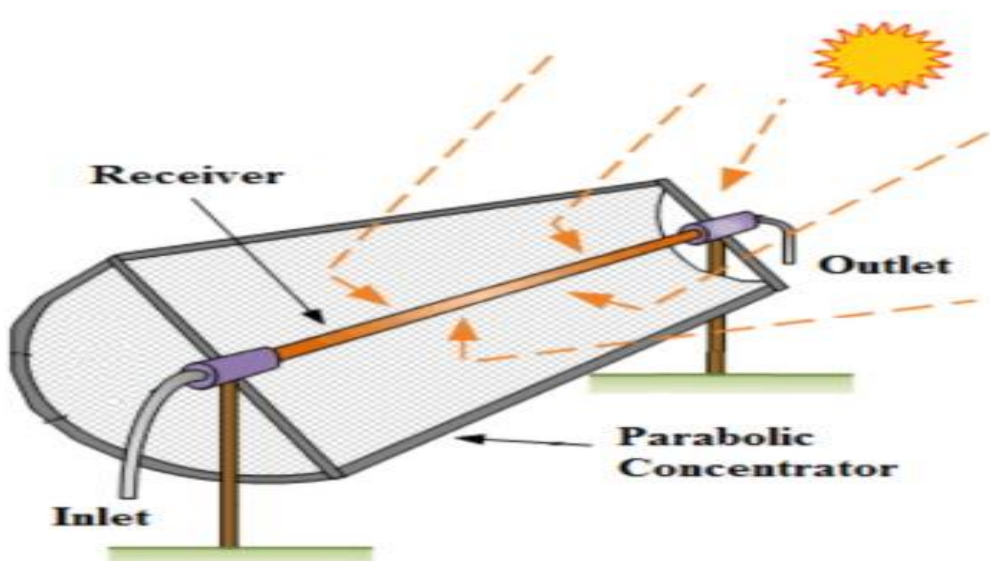


Fig. 2.4 Compound Parabolic Collectors

Evacuated Tube Collectors:

Evacuated heat pipe solar collectors (tubes) operate differently than the other collectors. These solar collectors consist of a heat pipe inside a vacuum-sealed tube, as (ETCs) are relatively expensive. the cost effectiveness of these collectors can be improved by reducing the number of tube and sung reflectors to concentrate the solar radiation on to the tube. the system also presents a 10 % increase in energy collection over a full day because of incidence angles.

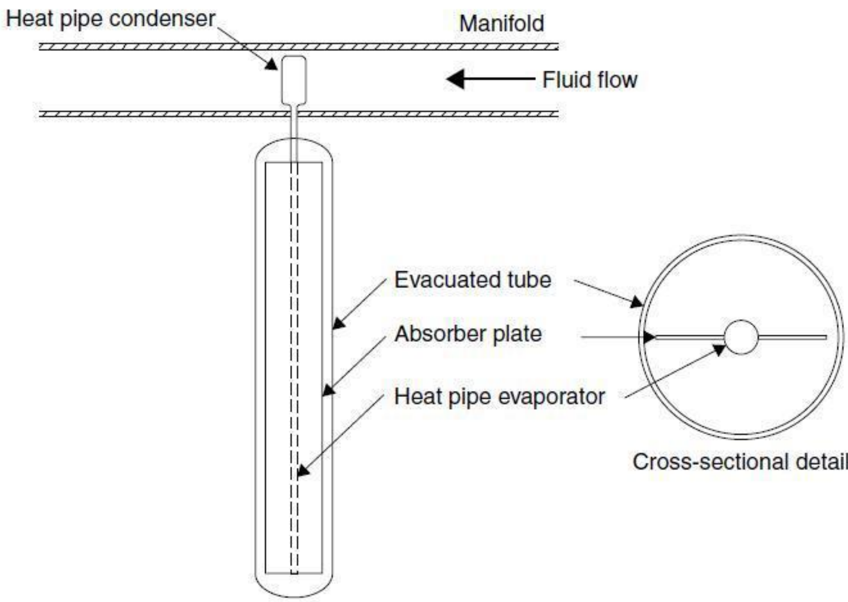
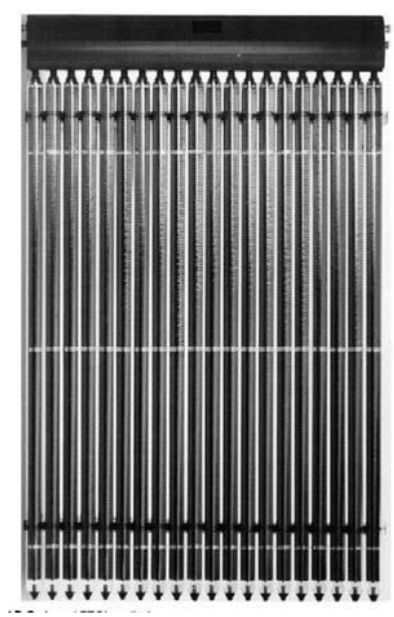


Fig. 2.5 Schematic diagram of an evacuated tube collector.



Concentrating collectors:

The main advantages of concentrating collectors are:

1. The working fluid can achieve higher temperatures in a concentrator system than a flat-plate system of the same solar energy-collecting surface. This means that a higher thermodynamic efficiency can be achieved.

2. It is possible with a concentrator system to achieve a thermodynamic match between temperature level and task. The task may be to operate thermionic, thermodynamic, or other higher-temperature devices.

3. The thermal efficiency is greater because of the small heat loss area relative to the receiver area.

4. Reflecting surfaces require less material and are structurally simpler than flat-plate collectors. For a concentrating collector, the cost per unit area of the solar-collecting surface is therefore less than that of a flat plate collector.

5. Owing to the relatively small area of receiver per unit of collected solar energy, selective surface treatment and vacuum insulation to reduce heat losses and improve the collector efficiency are economically viable

Their disadvantages are:

1. Concentrator systems collect little diffuse radiation, depending on the concentration ratio.

2. Some form of tracking system is required to enable the collector to follow the sun.

3. Solar reflecting surfaces may lose their reflectance with time and may require periodic cleaning and refurbishing.

Parabolic Trough Collectors (PTCs):

To deliver high temperatures with good efficiency a high-performance solar collector is required. Systems with light structures and low-cost technology for process heat applications up to 400°C could be obtained with parabolic trough collectors (PTCs). PTCs can effectively produce heat at temperatures between 50°C and 400°C. Parabolic trough collectors are made by bending a sheet of reflective material into a parabolic shape. A black metal tube, covered with a glass tube to reduce heat losses, is placed along the focal line of the receiver.

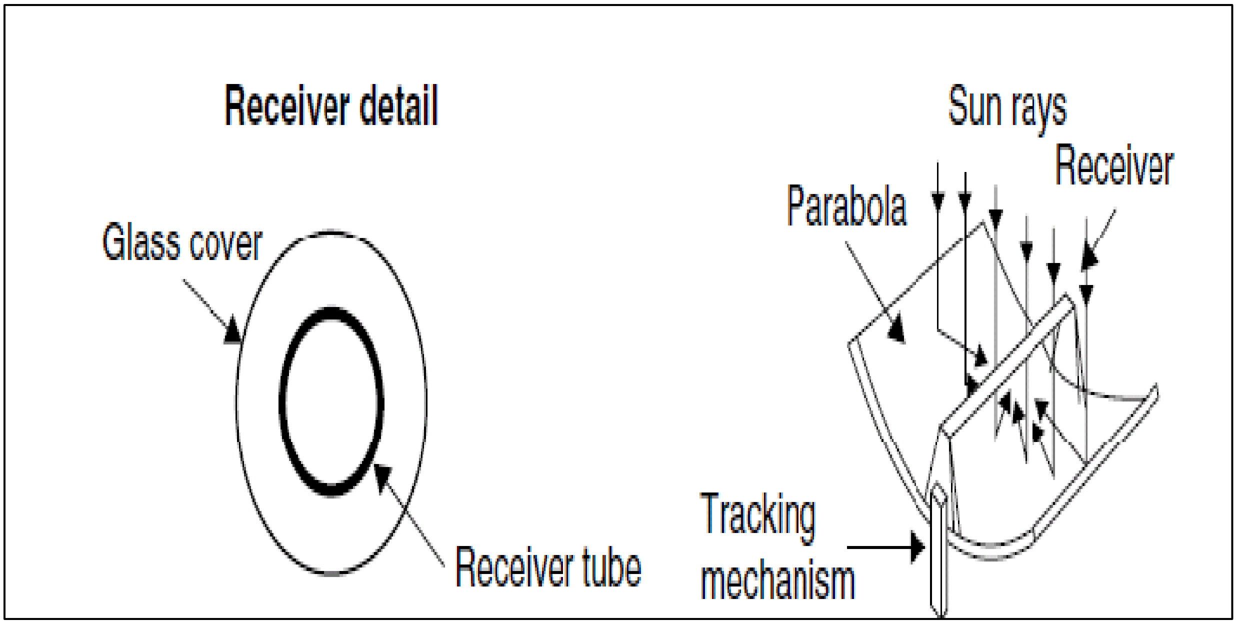


Fig. 2.7 Schematic of Parabolic Trough Collectors

eighth week :

Parabolic Dish Reflectors (PDRs) :

A parabolic dish reflector (PDR), shown schematically in Figure 3.20a, is a point-focus collector that tracks the sun in two axes, concentrating solar energy onto a receiver located at the focal point of the dish. The dish structure must fully track the sun to reflect the beam into the thermal receiver. For this purpose, tracking mechanisms similar to the ones described in the previous section are employed in double, so the collector is tracked in two axes.

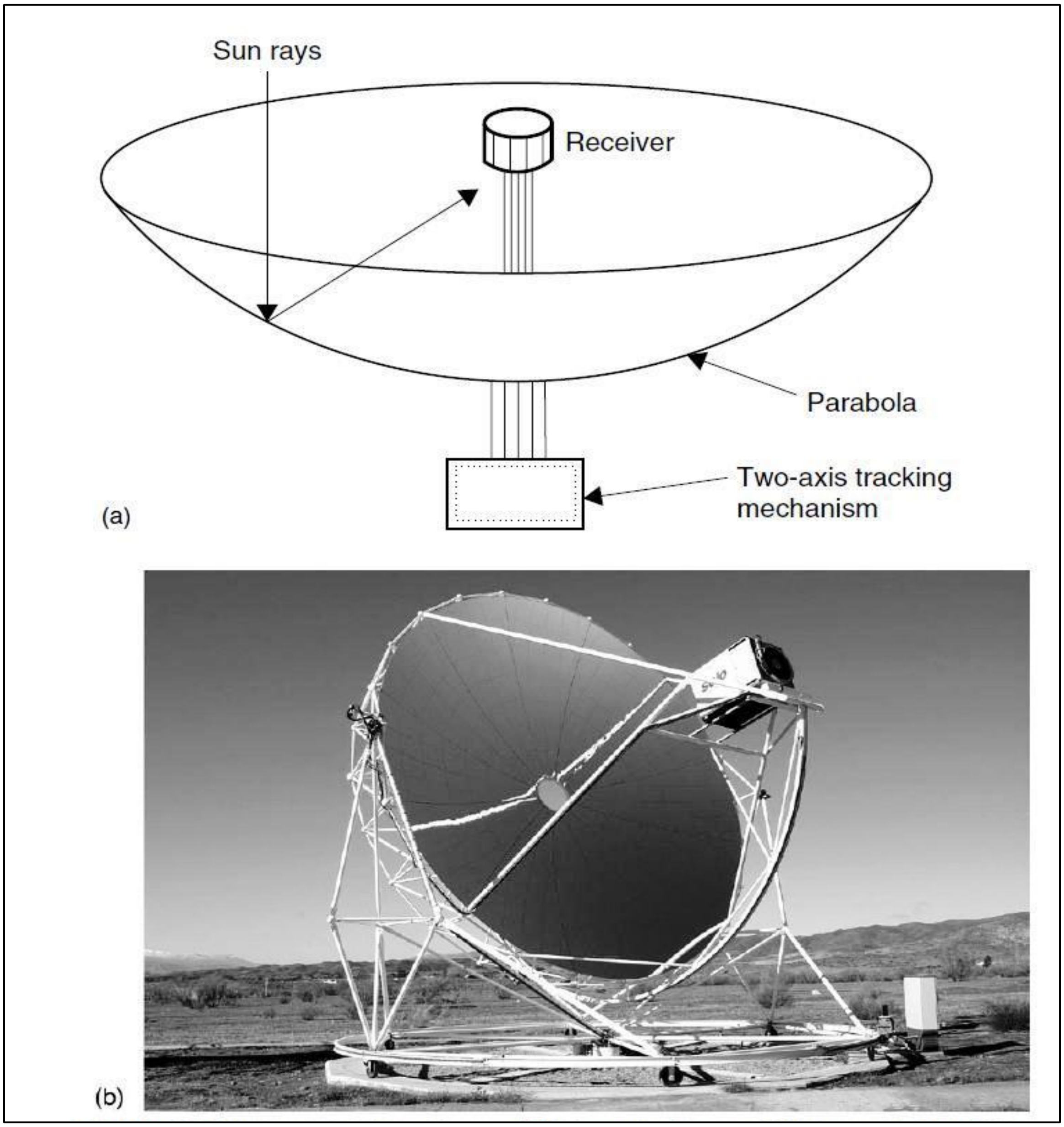


Fig. 2.8 Parabolic dish collector. a) Schematic diagram b) Photo of euro dish collector

Fresnel collectors:

Fresnel collectors have two variations the Fresnel lens collector and linear Fresnel collectors the strips can also be mounted on flat ground and concentrate light on a linear fixed receiver mounted on a tower a representation of an element of an LER collector system is show only one receiver and there is no choice about the direction and orientation of a given reflector. if they are close enough then individual reflectors have the option of directing reflected solar radiation to at least towers.

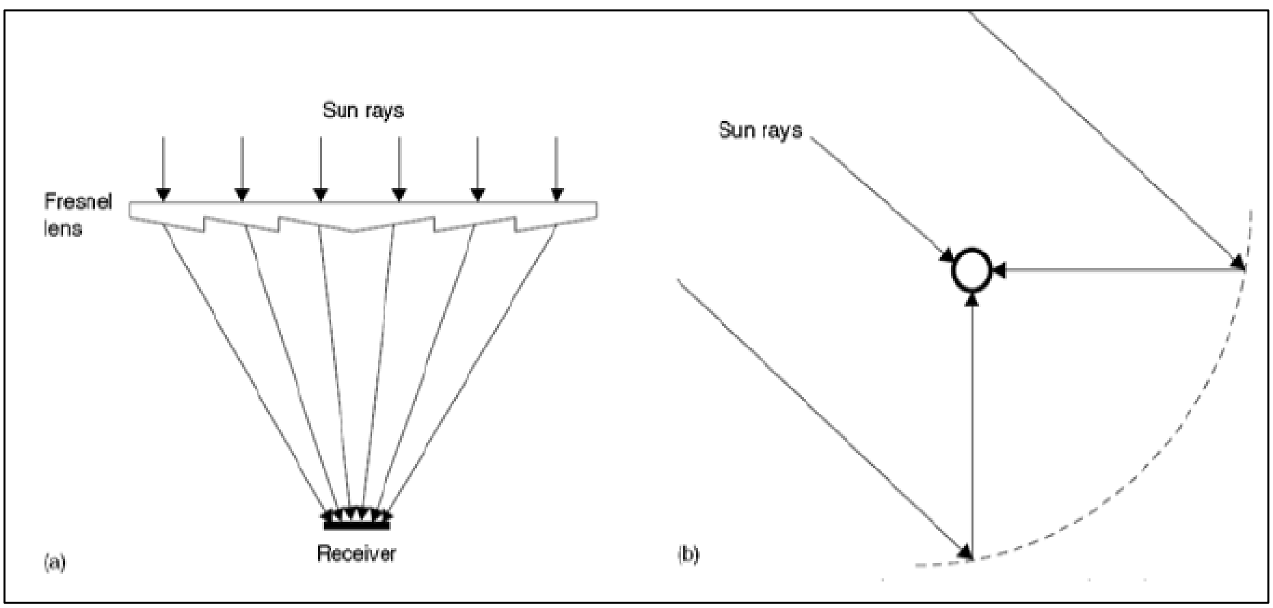


Fig. 2.9 Fresnel collectors

Heliostat Field Collectors (HFCs)

For extremely high inputs of radiant energy, a multiplicity of flat mirrors, or heliostats, using altazimuth mounts can be used to reflect their incident direct solar radiation onto a common target, the power conversion system consists of a steam generator, turbine generator, and support equipment, which convert the thermal energy into electricity and supply it to the utility grid.

Central receivers have several advantages:

1. They collect solar energy optically and transfer it to a single receiver, thus minimizing thermal energy transport requirements.

2. They typically achieve concentration ratios of 300 to 1500 and so are highly efficient, both in collecting energy and in converting it to electricity. The Techniques Engineering of Refrigeration and Air Conditioning Department Technical College - Baghdad Renewable 3. They can conveniently store thermal energy.

4. They are quite large (generally more than 10 MW) and thus benefit from economies of scale. Each heliostat at a central receiver facility has from 50 to 150 m2 of reflective surface, with four mirrors installed on a common pillar for economy, The heliostats collect and concentrate sunlight onto the receiver, which absorbs the concentrated sunlight, transferring its energy to a heat transfer fluid. The heat transport system,

which consists primarily of pipes, pumps, and valves, directs the transfer fluid in a closed loop among the receiver, storage, and power conversion systems. A thermal storage system typically stores the collected energy as sensible heat for later delivery to the power conversion system. The storage system also decouples the collection of solar energy from its conversion to electricity. The power conversion system consists of a steam generator, turbine generator, and support equipment, which convert the thermal energy into electricity and supply it to the utility grid.

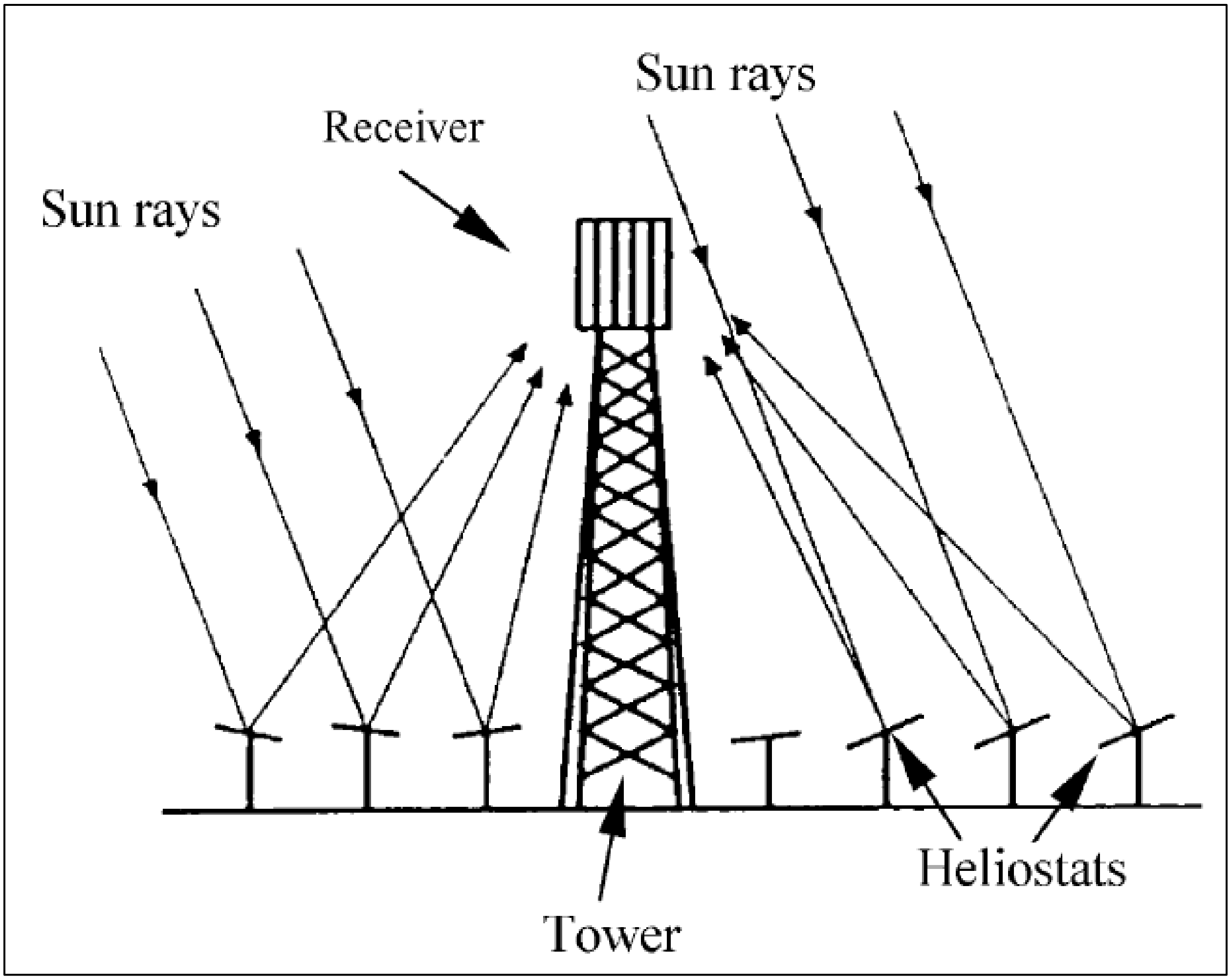


Fig. 2.10 Heliostats collectors

ninth weak :

Wind energy

Wind energy is the kinetic energy of air in motion, also called wind. Wind power is converted to electrical energy by wind turbines. Several different factors influence the potential wind resource in an area. The three main factors that influence power output are: wind speed, air density, and blade radius. Total wind energy flowing through an imaginary surface with area A is:

$$E_w = 1/2 \rho A v^3$$

where ρ is the density of air Kg/m^3; v is the wind speed m/s; A is the volume of air passing through A m^2 (which is considered perpendicular to the direction of the wind); therefore, the mass m passing through "A". ½ ρv^2 is the kinetic energy of the moving air per unit volume.

Ex: Find the electrical energy generated by an air fan the area of blades is 20m^2 if the air density is 0.1kg/m^3, and the wind speed is 7m/s?

$E_w = 1/2 \rho A v 3$

$1/2 * 0.1 * 20 * 7^3 \approx 343\ Watt$

Wind turbine

Wind turbines operate by transforming the kinetic energy in wind into mechanical power which is used to generate electricity by spinning a generator. These turbines can be on land or can be offshore wind turbines. There are two main types of wind turbines, horizontal and vertical axis. A wind turbine applicable for urban settings was also studied. All types of wind turbines have varying designs, and different advantages and disadvantages.

Horizontal axis

Horizontal axis wind turbines are the most common type used (see figure 1). All the components (blades, shaft, generator) are on top of a tall tower, and the blades face into the wind. The shaft is horizontal to the ground. The wind hits the blades of the turbine that are connected to a shaft causing rotation. The shaft has a gear on the end which turns a generator. The generator produces electricity and sends the electricity into the power grid. The wind turbine also has some key elements that adds to efficiency. Inside the Nacelle (or head) is an anemometer, wind vane, and controller that read the speed and direction of the wind. As the wind changes direction, a motor (yaw motor) turns the nacelle so the blades are always facing the wind. The power source also comes with a safety feature. In case of extreme winds, the turbine has a break that can slow the shaft speed. This is to inhibit any damage to the turbine in extreme conditions.

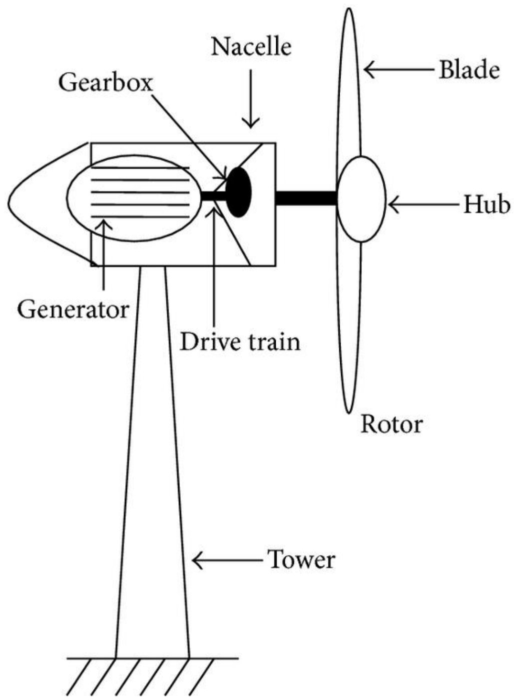


Fig. 3.1 Horizontal axis wind turbine

Tenth week:

Advantages

• Blades are to the side of the turbines center of gravity, helping stability

• Ability to wing warp, which gives the turbine blades the best angle of attack

• Ability to pitch the rotor blades in a storm to minimize damage

• Tall tower allows access to stronger wind in sites with wind shear

• Tall tower allows placement on uneven land or in offshore locations

• Can be sited in forest above tree-line

• Most are self-starting

Disadvantages

• Difficulty operating in near ground winds

• Difficult to transport (20% of equipment costs)

• Difficult to install (require tall cranes and skilled operators)

• Effect radar in proximity

• Local opposition to aesthetics

• Difficult maintenance

Vertical axis

In vertical axis turbines the shaft the blades are connected to is vertical to the ground (see figure 2). All the main components are close to the ground. Also, the wind turbine itself is near the ground, unlike horizontal where everything is on a tower. There are two types of vertical axis wind turbines; lift based and drag based. Lift based designs are generally much more efficient than drag, or ‘paddle’ designs.

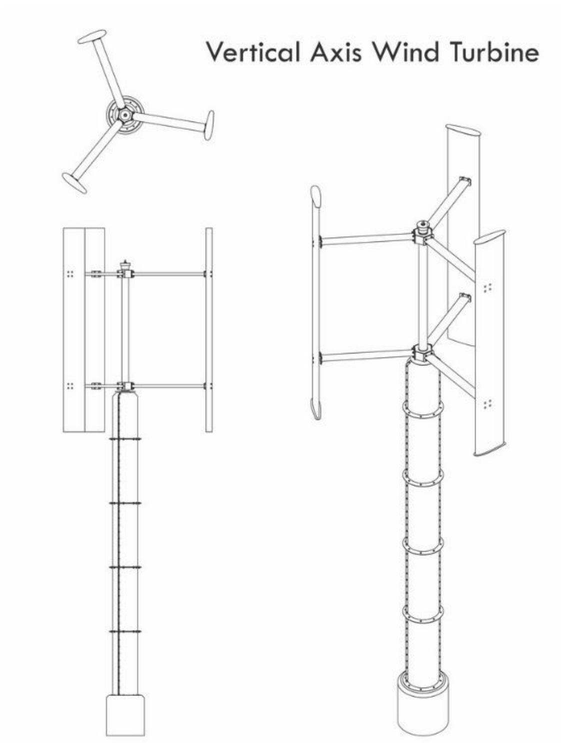


Fig. 3.2 Vertical axis wind turbine (lift type)

Advantages

• Easy to maintain

• Lower construction and transportation costs

• Not directional

• Most effective at mesas, hilltops, ridgelines and passes

Disadvantages

• Blades constantly spinning back into the wind causing drag

• Less efficient

• Operate in lower, more turbulent wind

• Low starting torque and may require energy to start turning

eleventh week :

Wind electric generators Electricity generation is the most important application of wind energy today. The major components of a commercial wind turbine are:

1. Tower
2. Rotor
3. High speed and low speed shafts
4. Gear box
5. Generator
6. Sensors and yaw drive
7. Power regulation and controlling units
8. Safety systems The major components of the turbine

The Techniques Engineering of Refrigeration and Air Conditioning Department Wind farms Wind turbines of various sizes are available commercially. Small machines are often used for stand alone applications like domestic or small scale industrial needs. When we have to generate large quantities of power, several wind turbines are clubbed together and installed in clusters, forming a wind farm or wind park. There are several advantages in clustering wind machines. The installation, operation and maintenance of such plants are easier than managing several scattered units, delivering the same power. Moreover, the power transmission can be more efficient as the electricity may be transformed to a higher voltage.

Types of wind farms

1- On shore wind farm (A land based wind farm)

2- Offshore wind farms

Classification of wind turbines

Since the inception of the wind energy technology, machines of several types and shapes were designed and developed around different parts of the world. Some of these are innovative designs which are not commercially accepted. Although there are several ways to categorize wind turbines, they are broadly classified into horizontal axis machines and vertical axis machines, based on their axis of rotation.

Power curve of the wind turbine

the typical power curve of a pitch controlled wind turbine. The rated power of the turbine is 1 MW. The given curve is a theoretical one and in practice we may observe the velocity power variation in a rather scattered pattern. We can see that the important characteristic speeds of the turbine are its cut-in velocity (VI), rated velocity (VR) and the cut-out velocity (VO). The cut-in velocity of a turbine is the minimum wind velocity at which the system begins to produce power. It should not be confused with the start-up speed at which the rotor starts its rotation. The cut-in velocity varies from turbine to turbine, depending on its design features. However, in general, most of the commercial wind turbines cut-in at velocities between 3 to 5 m/s. Due to technical and economical reasons, the wind turbine is designed to produce constant power - termed as the rated power (PR) - beyond its rated velocity. Thus, the rated velocity of a turbine is the lowest wind velocity corresponding to its rated power. Usually the system efficiency is maximum at VR. From VI, to VR, the power generated by the turbine increases with the wind velocity. Between VR and VO, the turbine is restricted to produce constant power PR corresponding to VR, irrespective of the changes in velocity. This power regulation is for better system control and safety. Hence PR is the theoretical maximum power expected from the turbine. At wind velocities higher than VO, the machine is completely shut down to protect the rotor and drive trains from damage due to excessive loading. Some times VO is also termed as the furling velocity, as in the earlier sail type machines the canvas was rolled upto protect the mill from strong winds.

Twelve week :

Hydraulic energy:

Hydraulic power is based on taking advantage of the water fall from higher to lower land surface to produce electrical energy. In order to convert this potential to applicable electric energy, water flow should be led to and drive a hydraulic turbine, transforming hydroenergy into mechanical energy, connected generator transforming the mechanical energy into electric energy.

Hydro Power station

A hydro power station uses potential energy of water at high level for generating electrical energy.

This power station is generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained. This kind of power station can be used to produce large amounts of electrical energy. In most countries these power stations are used as peak load power stations. This is because they can be started and stopped easily and fast.

Operation

The water from the dam is lead to the water turbine through the penstock. Here the hydraulic energy of water is converted to rotational mechanical energy by the turbine. The turbine is connected to the generator through the turbine shaft and hence mechanical energy is converted into electrical energy by the generator.

Pros & Cons: what this power station presents

Thirteen week :

Advantages	Disadvantages
Also used for flood control and irrigation	Impacts native watershed ecology
Requires no fuel, thus called *clean power station*	Very high capital cost for dam construction
Simple construction & requires less maintenance	Skilled personel required for construction
Small running charges and no need for specialised manpower	Uncertainty about availability of huge amounts of water
Very robust & has long life	High cost of transmission line as plant is located in hilly areas.

- Future generations will want to depend more on this type of electricity generating power station (and other renewable energy sources), due to a fast-increasing depletion of fuels (Coal).

Hydroelectric power stations boast a simple design and construction method that is very robust and reliable (when done properly). The following sub topic discusses the most important constituents of this kind of power station (as shown in fig.4.1).

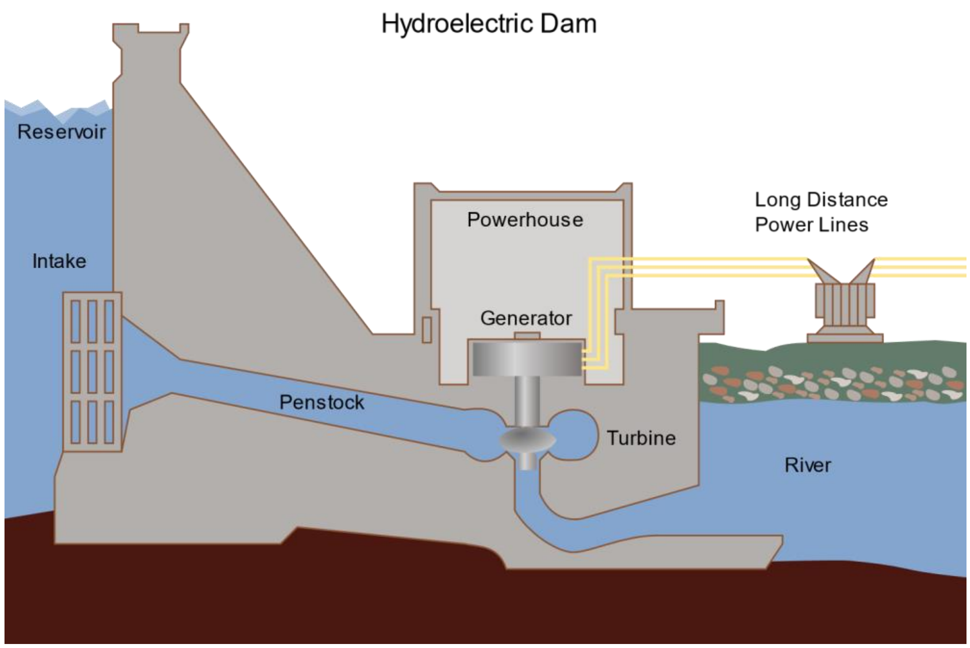


Fig. 4.1 Hydroelectric dam cross-section diagram

Constituents of Hydroelectric power station

- **Reservoir:** This is where water is stored for use as and when needed. The type and arrangement depend on topography of the site.
- **Penstock:** This is a conduit (conduits) that carry water to the turbines. They are made of reinforced concrete or steel. A surge tank is installed next to each penstock for over flow control and protection of penstock from bursting.
- **Water turbine:** Water turbines are used to convert hydraulic energy of flowing water into rotational mechanical energy.
- **Generator:** This machine is used to convert rotational mechanical energy transferred from the turbine through the shaft, into

electrical energy. the produced electrical energy is transmitted to the transformer for long distance transmission.

Location of Hydroelectric power station: influencing factors

- **Availability of water:** Adequate water must be available at good head.
- **Cost and Type of Land:** Land should be available at reasonable price. The bearing capacity of the land should be enough to withstand huge structures and equipment.
- **Storage of water:** A dam must be constructed to store water in order to deal with variations of water availability during the year.
- **Transportation facilities:** The site should be accessible by rail and (or) road for ease in transporting equipment and machinery.

Fourteen week:

Pumped storage schemes

are a convenient way of storing large quantities of energy which can be used during emergency or peaking times. (as shown in fig.4.2).

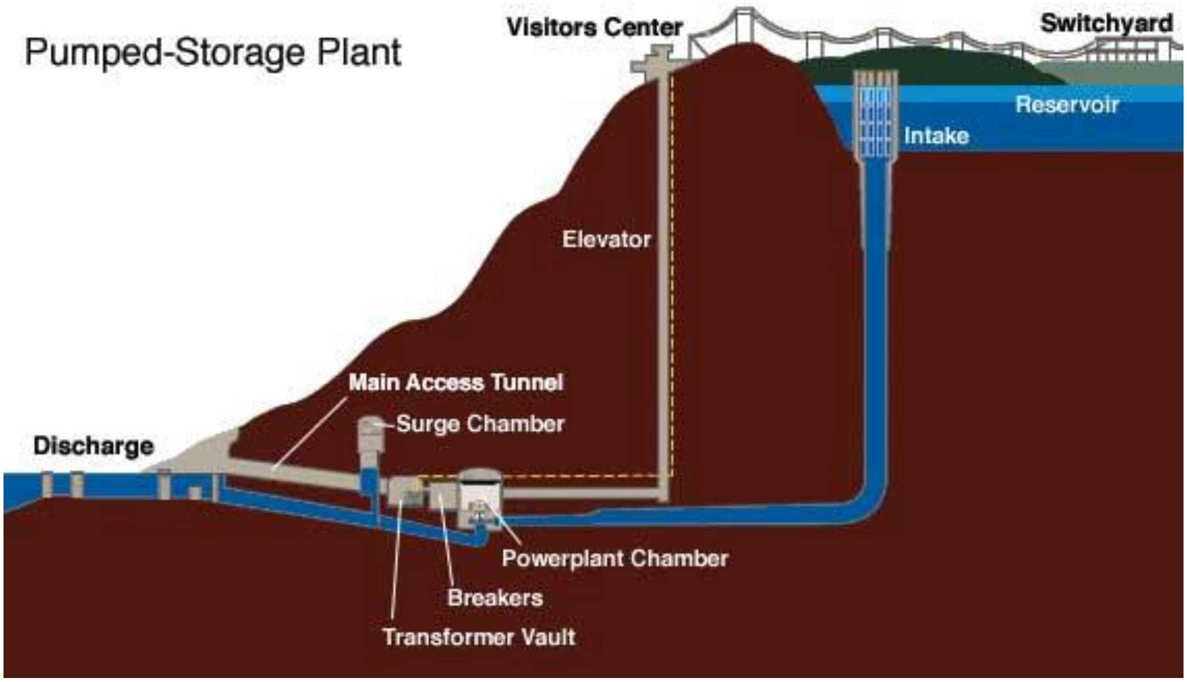


Fig.4.2 Pumped storage scheme power station diagram

Operation:

During off-Peak hours, the plant draws electric energy from the electrical grid & uses that to pump water to the upper reservoir.

When Peak time comes, the water from the upper reservoir is released & electric energy is generated in the lower reservoir. This cycle is repeated daily.

By their nature, pumped storage schemes cannot be used as base load power stations. These are strictly used for peak time supply as they can be brought on-line quickly.

Comparison

Hydro power plant	Pumped storage plant
Once water passes through penstock & turbine, it is released into the river	Water is re-used by pumping and generative action of the scheme.
Can be used for irrigation & flood control	Can be used for pumping water from readily available areas to areas in need of water
Can still be used as base load station	can not be used as base load station as it can only generate for limited hours

- As evident from above table, both power stations are very desirable for use that goes outside of electrical energy generation confines. This schematic diagram must be properly understood. it is the basis upon which pumped-storage scheme power station designs are done. the individual power station complexity may differ slightly to the schematic and yet over and above that will use the same principle.

- **fifteen week :**

Power Estimation

The potential electric power of the water in terms of flow and head can be calculated from the following equation.

$KW = 9.81 \times Q \times H \times \eta$

Where,

kW = electric power in kW

Q = quantity of water flowing through the hydraulic turbine in cubic meters

per second. Discharge (quantity of water) flowing in a stream and available for power generation has daily and seasonal variation. Optimum discharge for power generation is determined on the basis of energy generation cost.

H = Net available head in meters (gross head – losses)

η = overall efficiency of the hydro power plant. For general estimation

purposes, η is normally taken as 0.85

Hydropower Plants The energy that can be exploited from water essentially depends on two parameters: runoff volume and the head of the water. Almost all hydropower plants utilize natural elevation differences using technical equipment The types of hydropower plants are:

1- Run - of - River Power Plants
2- Storage Power Plants
3- Pumped - Storage Power Plants Run - of - River Power Plants The natural course of a river itself concentrates large quantities of water.

A run - of - river power plant can be built anywhere on a river where a sufficient difference in elevation exists. The weir then backs up the water. This creates a difference in elevation in the water's surface above and below the plant. At the top the water flows through a turbine that powers an electric generator. Grating at the turbine intake prevents rubbish and flotsam washed along by the river from blocking up the turbine. A transformer then converts the voltage of the generator into the desired mains voltage. Large hydropower plants are usually constructed so that multiple turbines can run in parallel. If the water flow drops during the dry periods of the year, some of the turbines can be shut down. The remaining turbines then still receive almost the full amount of water they need. This prevents the turbines from working in partial – load mode with poor efficiency. If, on the other hand, there is flooding and a river carries more water the surplus water has to be let out unused over a weir. Storage Power Plants Storage power plants produce high levels of power output. Dams store huge masses of water at geographically optimal locations. This type of dam makes it possible for storage power plants to be built in the mountains A high – pressure pipeline pumps the water into a machine house, where, due to the large head, enormous water pressure of up to 200 bars is created. In the machine house water powers the turbines that produce energy over an electric generator. It is not unusual to find dams over 100 m high. The highest dams on earth are over 300 m high. Reservoirs are often also used to store drinking water and to control flooding. Storage power plants that are designed primarily to generate electricity have very high power output. Power plants that produce several hundred or even thousand megawatts are not unusual