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RAJASTHAN INSTITUTE OF ENGINEERING & TECHNOLOGY

B. Tech. IV Year VII Semester (EE & EEE)

**SUB-** Non-Conventional Energy Sources

I Mid-Term Exam 2018-19

Time: 2:00 hours **SET-A** Max. Marks: 20

**Solution**

All questions are compulsory.

**Q.1 Explain the Global Energy Scenario.**

Ans:

The global primary energy consumption at the end of 2003 was equivalent to 9741 million tons of oil equivalent (MTones). The Figure 1.3 shows in what proportions the sources mentioned above contributed to this global figure.

###### Energy distribution between developed and developing Countries

Although 80 percent of the world's population lies in the developing countries (a four- fold population increase in the past 25 years), their energy consumption amounts to only 40 percent of the world total energy consumption. The high standards of living in the developed countries are attributable to high energy consumption levels.

**Fig. Energy Distribution Between Developed and Developing Countries**

Also the rapid population growth in the developing countries has kept the per capita energy consumption low compared with that of highly industrialized developed countries. The world average energy consumption per person is equivalent to 2.2 tones of coal. In industrialized countries, people use four to five times more than the world average and nine times more than the average for the developing countries. An American uses 32 times more commercial energy than an Indian.

## Indian Energy Scenario

Coal dominates the energy mix in India, contributing to 55% of the total primary energy pro- duction. Over the years, there has been a marked increase in the share of natural gas in prima- ry energy production from 10% in 1994 to 13% in 1999. There has been a decline in the share of oil in primary energy production from 20% to 17% during the same period.

###### Energy Supply Coal Supply

India has huge coal reserves, at least 84,396 million tones of proven recoverable reserves (at the end of 2003). These amounts to almost 8.6% of the world reserves and it may last for about 230 years at the current Reserve to Production (R/P) ratio. In contrast, the world's proven coal reserves are expected to last only for 192 years at the current R/P ratio.

**Reserves/Production (R/P) ratio**- If the reserves remaining at the end of the year are divided by the production in that year, the result is the length of time that the remaining reserves would last if production were to continue at that level.

India is the fourth largest producer of coal and lignite in the world. Coal production is concentrated in these states (Andhra Pradesh, Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Orissa, Jharkhand, and West Bengal).

###### Oil Supply

Oil accounts for about 36 % of India’s total energy consumption. India today is one of the top ten oil-guzzling nations in the world and will soon overtake Korea as the third largest consumer of oil in Asia after China and Japan. The country's annual crude oil production is peaked at about 32 million tonne as against the current oil consumption by end of 2007 is expected to reach 136 million tonne(MT), of which domestic production will be only 34 MT. India will have to pay an oil bill of roughly $50 billion, assuming a weighted average price of $50 per barrel of crude. In 2003-04, against total export of $64 billion, oil imports accounted for $21 billion. India imports 70% of its crude needs mainly from gulf nations. The majority of India's roughly 5.4 billion barrels in oil reserves are located in the Bombay High, upper Assam, Cambay, Krishna-Godavari. In terms of sector wise petroleum product consumption, transport accounts for 42% followed by domestic and industry with 24% and 24% respectively. India spent more than Rs.1,10,000 crore on oil imports at the end of 2004.

###### Natural Gas Supply

Natural gas accounts for about 8.9 per cent of energy consumption in the country. The current demand for natural gas is about 96 million cubic metres per day (mcmd) as against availability of 67 mcmd. By 2007, the demand is expected to be around 200 mcmd. Natural gas reserves are estimated at 660 billion cubic meters.

###### Electrical Energy Supply

The all India installed capacity of electric power generating stations under utilities was 1,12,581 MW as on 31st May 2004, consisting of 28,860 MW- hydro, 77,931 MW- thermal and 2,720 MW- nuclear and 1,869 MW- wind (Ministry of Power).

###### Nuclear Power Supply

Nuclear Power contributes to about 2.4 per cent of electricity generated in India. India has ten nuclear power reactors at five nuclear power stations producing electricity. More nuclear reactors have also been approved for construction.

###### Hydro Power Supply

India is endowed with a vast and viable hydro potential for power generation of which only

15% has been harnessed so far. The share of hydropower in the country's total generated units has steadily decreased and it presently stands at 25% as on 31st May 2004. It is assessed that exploitable potential at 60% load factor is 84,000 MW.

###### Final Energy Consumption

Final energy consumption is the actual energy demand at the user end. This is the difference between primary energy consumption and the losses that takes place in transport, transmission & distribution and refinement. The actual final energy consumption (past and projected) is given in Table1.2.

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| --- |
| TABLE 1.2 DEMAND FOR COMMERCIAL ENERGY FORFINAL CONSUMPTION (BAU SCENARIO) |
| **Source** | **Units** | **1994-95** | **2001-02** | **2006-07** | **2011-12** |
| Electricity | Billion Units | 289.36 | 480.08 | 712.67 | 1067.88 |
| Coal | Million Tonnes | 76.67 | 109.01 | 134.99 | 173.47 |
| Lignite | Million Tonnes | 4.85 | 11.69 | 16.02 | 19.70 |
| Natural Gas | Million Cubic | 9880 | 15730 | 18291 | 20853 |
| Oil | Million Tonnes | 63.55 | 99.89 | 139.95 | 196.47 |
| Source: Planning Commission *BAU:\_Business As Usual* |

###### Sector Wise Energy Consumption in India

The major commercial energy consuming sectors in the country are classified as shown in the Figure 1.5. As seen from the figure, industry remains the biggest consumer of commercial energy and its share in the overall consumption is 49%. (Reference year: 1999/2000)

**OR**

**Q.1 what is difference between Conventional and Non-Conventional Source of Energy? Explain**

Ans:

Any physical activity in this world, whether carried out by human beings or by nature, is cause due to flow of energy in one form or the other. The word ‘energy’ itself is derived from the Greek word ‘en-ergon’, which means ‘in-work’ or ‘work content’. The work output depends on the energy input.

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever- increasing energy needs requiring huge investments to meet them.

Energy can be classified into several types based on the following criteria:

1. Primary and Secondary energy
2. Commercial and Non commercial energy
3. Renewable and Non-Renewable energy
4. Conventional and Non-conventional energy

## Conventional and Non-conventional energy resources:

###### Conventional Energy

Conventional energy resources which are being traditionally used for many decades and were in common use around oil crisis of 1973 are called conventional energy resources, e.g., fossil fuel, nuclear and hydro resources.

###### Non-conventional energy

Non-conventional energy resources which are considered for large – scale use after oil crisis of 1973, are called non-conventional energy sources, e.g., solar, wind, biomass, etc.

**Q.2 what are the Advantage and Limitation of the Renewable Energy Sources?**

**Ans:**

The definition of renewable energy is that it comes from a resource that will not deplete. When most people think about renewable energy, they think about solar or wind as they tend to be the most popular. Additional renewable energy resources include geothermal energy, hydrogen energy, tidal energy, wave energy, and biomass energy.

Unlike non-renewable energy resources, we cannot store what we collect with renewables over long periods. The United States currently has a stockpile of coal that could last up to 400 years at current consumption levels. With solar or wind energy, a battery is required to store the collected energy and that can provide enough energy for about 24 hours of use, if enough power has been stored.

There are numerous advantages and disadvantages of renewable energy which must be considered. Fossil fuels, by definition, are a finite resource. Exploring options to replace them, should they become in short supply, allows us to continue progressing our society and our lifestyle under modern definitions.

List of the Advantages of Renewable Energy

1. It is a safe form of energy.

The dangers of electricity and other high-power loads apply to all forms of energy. What we do know about renewable energy is that the collection and use process is typically safer than non-renewable energy methods. If you’re using wind or solar energy, for example, then you don’t have to worry about the threat of a nuclear meltdown or particulate contamination from a coal-fired plant.

2. It is an abundant form of energy.

There is enough sunlight that falls on our planet every day that it could meet our energy needs for an entire year. One day of sunlight equals one year of energy. We just do not have the resources at the moment to collect that energy. Wind provides us with constant energy resources as well. The tides are always moving because of the moon. Waves happen because of the tidal energy and the wind. The internal mechanisms of our planet provide us with heat that can be turned into energy.

3. It is a clean form of energy to use.

Although renewable energy is built on an infrastructure that uses fossil fuels, the emissions cost-savings of renewables occurs quite rapidly. Depending upon the type of renewable energy being used, positive gains can be expected between 5-25 years with most options. Depending on the levels of energy collected, it may be sooner or later than that generic timeframe. That means a 5-year investment can begin improving how we collect energy for a lifetime.

4. It can be collected in multiple locations simultaneously.

We use many different forms of renewable energy today, even without realizing it. One of the most common forms of renewable energy in the United States comes from hydropower. Dams are built on rivers and the moving water runs turbines that are able to generate electricity. In 2015, hydropower accounted for over 6% of the electricity used and 35% of renewable energy production. Stations exist in over 30 states, but 44% of the US hydropower comes from the Columbia River basin.

5. It is offered in multiple formats.

Energy diversity is possible through renewable energy. Since the 1970s, an interest in developing new technologies in this field has led to 8 major types of energy collection. New technologies, such as road-based solar panels, could even allow for energy collection within current infrastructure layouts. From small stations to large facilities like Hoover Dam, the levels of diversity are much greater for renewables than non-renewables. That means a greater potential for power generation now and into the future.

6. It can provide nations with energy independence.

The average country in our world depends on non-renewable energy for their power resources. Transitioning to renewable energy can lessen the dependence on fuel imports or international aid to meet power demands. An example of this is the Aswan High Dam in Egypt. With just 12 turbines, the dam is able to generate up to 10 billion kilowatt-hours of energy every year. When it first reached peak production, it was provided Egypt with more than 50% of its total energy needs.

7. It is a stable form of energy.

The power produced from all forms of renewable energy is just as stable and useful as any form of non-renewable energy. The power it creates can be used with the current infrastructure, as long as there is a link to the renewable facility that accesses the main network. That makes it suitable for virtually any power need, from computers to automobiles to general heating and cooling.

8. It is an economic force.

In the United States, renewable energy is responsible for about 800,000 jobs. In 2016, the wind turbine industry added 25,000 new manufacturing and installation jobs. Solar added another 73,000 jobs. In fact, 1 out of every 50 new jobs created in the United States in 2016 came from the solar energy industry. If sustainable construction positions are included with these numbers, another 1.4 million people have meaningful employment in the renewables sector. That means renewable energy helps our planet while being an economic force at the same time.

9. It is a technology.

The reason why non-renewable energies tend to be cheaper today is because it is a commodity. Oil, petroleum, gasoline, natural gas – these are products that are bought and sold for the purpose of being consumed. Renewables are different. They are a technology, not a fuel. You don’t burn a wind turbine; you install it. Over time, technology becomes cheaper as production and installation methods are refined. That means non-renewable energies will always be relatively consistent in price, while renewables are on a path that is constantly becoming cheaper.

10. It is relatively easy to maintain renewable energy collectors.

Once a renewable energy product has been installed, the costs of maintaining that technology are relatively low. Many solutions can have a no-maintenance lifestyle for years at a time. At the same time, the costs of manufacturing renewable energy collectors are going down. Over the lifetime of the product, some users may see net profits from personal renewable installations at their home right from the start. In Washington State, for example, the average homeowner, through tax credits and electricity purchases, can see a net gain of about 7 cents per kilowatt hour generated from Day 1.

11. It may be able to improve public health.

There are potential health benefits that a society may see if it transitions to renewable energy use. A study by the U.S. Environmental Protection Agency discovered that almost $1 trillion is spent each year on conditions that could be linked to the consumption of fossil fuels. That includes heart disease, certain cancers, neurological disorders, asthma, and several other health concerns. Reducing our reliance on fossil fuels not only helps us live healthier, but it puts more money back into our pockets from related expenses we don’t even think about.

12. It can be used to recycle our waste products.

This is one specific benefit that biomass energy tends to have more than any other form of renewable. Biomass consumes used organic products to generate energy. That means it can produce power from used vegetable oil, corn and soybean byproducts, or even algae. At the same time, it reduces the amount of waste that goes into landfills while also reducing the amount of overall carbon that goes into the atmosphere.

13. It can be profitable.

How much money can solar panels or other forms of renewable energy save the average homeowner? Over a 20-year period, the savings on electricity costs alone could be more than $30,000 for some homeowners. In California, New York, and Massachusetts, the expected 20-year savings is more than $25,000 with solar panels. Based on the average cost of installation, that can be as much $17,000 more you’ve earned in that same period.

List of the Disadvantages of Renewable Energy

1. It is not as cost-effective as other energy options.

The costs of renewable energy have been going down. Some options are close to being competitive with non-renewable energy resources or have been subsidized to be competitive. From an industry standpoint, however, the lifetime costs of renewable energy are still nearly double that of what has been called conventional energy. The lifetime cost of coal, for example, is just 9.5 cents per kilowatt hour. The cost of offshore wind, one of the cheapest renewable energy resources, is 15.8 cents per kilowatt hour.

2. It isn’t always a commercially-viable option.

Most renewable energy options must be collected at a specific geographical source. Imagine trying to collect high levels of solar energy while living in Seattle or using tidal energy while living in Nebraska. For renewable energy to be effective, it must have a distribution network created to transfer the energy to where it is needed. Those networks require non-renewable energies to be created, which offsets the benefits that the renewable energy generates for years, if not decades, after its installation.3. It still generates pollution.

Renewable energy may be a better option for emission creation than fossil fuels, but that doesn’t mean they are free from pollution. Many forms of renewable energy release particulates into the air. They may release carbon dioxide, or worse – methane. Part of this is due to the fact that the resources needed for renewables are built using fossil fuels, but not every renewable resource is clean. Biomass is a renewable energy and it burns organic matter directly into the atmosphere.

4. It may not be a permanent energy resource.

The environment evolves over time, shifting where renewable resources become available. Some locations, such as offshore wind or tidal energy, are generally quite reliable. Solar energy, however, can be difficult to predict. Geothermal energy may change over time. Billions of dollars can be spent to develop renewable energy resources only to have that money go to waste if that resource stops producing as expected.

5. It can often be manipulated by politics.

Although renewable energy is generally accepted as the future of energy production globally, politics can be a negative influence on its development. If renewables are not given a political priority, then the industry tends to falter, and innovation is reduced in favor of non-renewable options. Because politics tends to go in cycles, renewables tend to see 4-8 years of growth, then 4-8 years of stagnation. The stops and starts make it difficult to create a thriving industry.

6. It is an energy resource that is difficult to access for many people.

In the United States over a 30-year period, the government funded more than $100 billion in energy subsidies. Over half of those subsidies were directed toward nuclear power. Just 26% of those subsidies where funneled toward renewable energy technologies and energy efficiency priorities. Even with solar subsidies of up to 88 cents per kilowatt hour being provided, accessing that energy is not cost-effective for many low-income families. That means the priority stays on non-renewables, which further prevents innovation within this sector.

7. It can take a lot of space to install.

Using current solar energy generation technologies, it takes over 40 hectares of panels to generate about 20 megawatts of energy. In comparison, a nuclear power plant of average size generates about 1,000 megawatts of energy on 259 hectares. If given the same amount of space, a solar energy facility would produce less than 200 megawatts. For land-based wind energy, a 2-megawatt turbine requires 1.5 acres of space. If given the same amount of space as a nuclear facility, even it would only generate a maximum of about 850 megawatts.

8. It isn’t a constant energy source.

Then there is the issue with consistency. Nuclear and coal energy can be accessed at any time. Many renewables can only be collected during specific periods of the day. Solar energy, for example, isn’t collected at night. Wind energy cannot be collected unless the wind is blowing. Even then, wind energy is often inefficient as the turbines have a minimum and maximum wind speed during which they operate.

9. It has expensive storage costs.

One of the pricing factors that is often excluded from the conversation on renewable energy is the storage cost. You must store the energy collected or you will lose it, which means having a battery installed. The overall storage cost for the energy is about 9 cents per kilowatt hour, but the cost of the battery is upfront. That means $10,000 to $25,000 upon installation just for the battery. Some types of batteries can wear out very quickly, especially if their full capacity is being used on a regular basis.

10. It has large capital costs.

If a new energy resource needs to be developed for a community right now, the capital cost of the resource will be a primary consideration. At this moment, the capital costs of non-renewable energy resources are lower than the capital costs of renewable energy. This may change in time, but is a primary reason why renewables are not favored in some parts of the world today.

OR

**Q.2 what is the Advantage and Limitations of TIDAL POWER? Explain**

**Ans:**

Tidal Energy: Introduction

Tides are the waves caused due to the gravitational pull of the moon and also sun(though its pull is very low). The rise is called high tide and fall is called low tide. This building up and receding of waves happens twice a day and causes enormous movement of water. It is so powerful that it has caused many mishaps and resulted in sinking of ships. Thus tidal energy forms a large source of energy and can be harnessed in some of the coastal areas of the world. Tidal dams are built near shores for this purpose. During high tide, the water flows into the dam and during low tide, water flows out which result in turning the turbine.

Lets now discuss the advantages and disadvantages of tidal energy.

Advantages of Tidal Energy

1) It is an inexhaustible source of energy.

2) Tidal energy is environment friendly energy and doesn't produce greenhouse gases.

3) As 71% of Earth’s surface is covered by water, there is scope to generate this energy on large scale.

4) We can predict the rise and fall of tides as they follow cyclic fashion.

5) Efficiency of tidal power is far greater as compared to coal, solar or wind energy. Its efficiency is around 80%.

6) Although cost of construction of tidal power is high but maintenance costs are relatively low.

7) Tidal Energy doesn’t require any kind of fuel to run.

8) The life of tidal energy power plant is very long.

9) The energy density of tidal energy is relatively higher than other renewable energy sources.

Disadvantages of Tidal Energy

1) Cost of construction of tidal power plant is high.

2) There are very few ideal locations for construction of plant and they too are localized to coastal regions only.

3) Intensity of sea waves is unpredictable and there can be damage to power generation units.

4) Influences aquatic life adversely and can disrupt migration of fish.

5) The actual generation is for a short period of time. The tides only happen twice a day so electricity can be produced only for that time.

6) Frozen sea, low or weak tides, straight shorelines, low tidal rise or fall are some of the obstructions.

7) This technology is still not cost effective and more technological advancements are required to make it commercially viable.

8) Usually the places where tidal energy is produced are far away from the places where it is consumed. This transmission is expensive and difficult.

Tidal Energy is thus a clean source of energy and doesn’t require much land or other resources as in harnessing energy from other sources. However, the energy generated is not much as high and low tides occur only twice a day and continuous energy production is not possible.

**Q.3 what are the Various Methods of Tidal power generation? Explain**

**Ans:**

Classification of Tidal Power Plants:

Tidal power plants can be classified on the basis of basins used in power generation.

There are two types of basin systems viz.:

1. Single Basin System, and

2. Double Basin System.

1. Single Basin System:

Single basin system can generate power only intermittently. This is the simplest system of generating tidal power. The single basin scheme has only one basin. The basin is separated from the sea by a dam (barrage, Dyke). The sluice way is opened during high tide to fill the basin. The turbine-generator units are mounted within the ducts inside the barrage.

The single basin system can be further classified as:

(i) Single Ebb-Cycle System,

(ii) Single Tide-Cycle System,

(iii) Double Cycle System.

(i) Single Ebb-Cycle System:

In single ebb-cycle system, when the high tides (flood side) are falling, sluices are opened to permit the sea water to enter the basin, while the turbine sets are shut. The level of the basin begins increasing. The energy is stored in the form of tidal range. Tidal range provides water head during low tides. The generation of power takes place, when the water from the basin flows over the turbine into the low level sea water. The turbines are designed for single way operation. The power output from such system is intermittent in nature and highly variable.

(ii) Single Tide-Cycle System:

In single tide cycle system, the generation is affected when the sea is at flood tide. The sea water is admitted into the basin over the turbines. As the flood tide period is over and the sea level begins falling again, the generation is stopped. The basin is drained into the sea through the sluice ways. In this system also the power output is intermittent.

(iii) Double Cycle System:

In double cycle system, the reversible turbines are installed and power is generated during filling and emptying of basin. Filling process occurs when the ocean is at high tide while the water in basin at low tide level, the emptying occurs when the ocean is at low tide and basin at high tide level.

The flow of water in both directions is used to drive the reversible turbines. Each turbine drives the generator. In this system also continuous generation of power is not possible because of short duration. Electric power is generated during two short periods, during each tidal period of 12 hours 25 minutes or once every 6 hours and 12.5 minutes.

2. Double Basin System:

There are two basins at different levels. A dam is provided between two basins. The turbines are located in the dam. The sluice gates are provided in the dam. One basin is called the upper basin; the water level is maintained above that in the other, the low basin. The high level basin gates are called the inlet gates and low level gates as outlet gates. The upper basin is filled with water.

When the water level in upper basin A provides a sufficient difference of head between the two basins, the turbines are started. The water flows from basin A to basin B through the turbines and the power is generated. The power generation thus continues simultaneously along with filling up of water in basin A. When the tide attains its peak value, the water level in basin A is maximum; the inlet sluices are then closed. The water flows from the upper basin to the lower basin through the turbines.

Thus, the water level in the upper basin falls and that in the lower basin rises. When the rising level in lower basin B becomes equal to the level of the falling tide, the outlet sluices are opened. When the tide reaches its lower most level, the outlet gates are closed. After some time the tide rises. When its level becomes equal to low level of the upper basin, the inlet gates are opened. Consequently the level of water in basin A starts rising. Thus, the cycle is repeated.

Two basin schemes have the advantages over normal schemes is that generation time can be adjusted with high flexibility and it is also possible to generate almost continuously. In normal estuarine situations, however, two basin schemes are very expensive to construct due to the cost of extra length of barrage. There are some favourable geographies, however, which are well suited to this type of scheme.

#### Operation of Tidal Power Plants:

**The tidal power scheme may be designed to operate in any one of following modes:**

**1. Ebb Generation:**

The basin is filled through the sluices until high tide. Then, the sluice gates are closed. At this stage, there may be pumping to raise the level further. The turbine gates are closed until the sea level falls to develop sufficient head across the barrage, and then are opened so that the turbines generate power until the head is again low. Then the sluices are opened, turbines disconnected and the basin is filled again. The cycle repeats. Ebb generation, also known as outflow generation, takes its name because generation occurs as the tide changes tidal direction.

**2. Flood Generation:**

The basin is filled through the turbines, which produce at tide flood. This is usually much less efficient than Ebb generation, because the volume contained in the upper half of the basin (which is where Ebb generation operates) is greater than the volume of the lower half (filled first during flood generation).

Thus, the available level difference between the basin side and the sea side of the barrage reduces more quickly than it would in Ebb generation. Rivers flowing into the basin may further reduce the energy potential, instead of increasing it as in case of Ebb generation. Of course, this is not a problem with the “lagoon” model, without river in flow.

**3. Pumping:**

Turbines are operated as pumps by excess energy in the grid to enhance the water level in the basin at high tide (Ebb generation). This energy is more than returned energy during generation, because power output is strongly related to the head. If water is raised 0.61 m by pumping on a high tide of 3 m, this will have been raised by 3.7 m at low tide. The cost of a 0.61 m rise is returned by the benefits of a 3.7 m rise. This is since the correlation between the potential energy is not a linear relationship, rather is related by the square of the tidal high variation.

**OR**

**Q.3 Explain the Mathematical calculation of TIDAL Power Generation.**

**Ans:**

Tidal  energy  is  generated  by  the  relative  motion  of  the  water  which  interact  via  gravity.  Periodic changes of ater levels, and associated tidal  currents, are  due to the  gravitational  attraction  by  the  Sun  and Moon. The  magnitude of  the  tide  at  a location is  the result  of  the  changing  positions  of  the Moon  and  Sun relative to the Earth, the effects of Earth rotation, and the local shape of the sea floor and coastlines. Because  the Earth’s  tides are caused by  the  tidal  forces due  to gravitational  interaction with  the Moon and Sun, and the Earth’s rotation,  tidal power is practically inexhaustible and classified as a  renewable energy source. A tidal generator uses this phenomenon to generate electricity. The stronger the tide, either in water level height or tidal current velocities, the greater the potential for tidal electricity generation. Tidal  movement  causes  a  continual  loss  of  mechanical  energy  in  the  Earth–Moon  system  due  to pumping of water through the natural restrictions around coastlines, and due to viscous dissipation at the seabed and in turbulence. This loss of energy has caused the rotation of the Earth to slow in the 4.5 billion years since formation.  During  the  last  620 million  years  the  period  of  rotation  has  increased  from  21.9 hours  to  the 24 hours we  see now;  in  this period  the Earth  has  lost 17% of  its  rotational energy. While  tidal power may take additional energy  from  the  system,  increasing  the  rate of  slowdown,  the effect would be noticeable over  millions of years only, thus being negligible.  Dynamically speaking, the earth and the Moon are two masses that display centrifugal forces on one another.  First, we must consider a particle of mass m which is located on the earth‘s surface. Given Newton‘s law of gravitational state we introduce the equation:

F = G m1m2 R2

Where F is the force created between mass1 and mass2, G is the universal gravitational constant whose value depends only on the chosen units of mass, length, and force

(Typically 6.67 x 10-11 N m2kg-2). If we then take  the difference between  the  force  towards  the moon and  the  force  necessary  for earth‘s  rotation we generate the tidal producing force.

Tidal Force = 2Gmm1a (1.2) R3

Where m is the mass of the earth, a is the mean radius of the earth and R is the distance between earth and the lunar surface. The net effect of this equation is to displace particle m1 away from the center  of  the earth. Thus, we can conclude that diurnal tides are generated because the maxima and minima  in each daily rotation are unequal in amplitude. (Pugh 64) This is ultimately, in its simplest form, the process behind the half-day cycle which results in a period of 12 hours 25 minutes between successive high waters. Figure 1.3 demonstrates Tidal Force and its tendency to create bulging at  the water‘s surface;  thus making  for the differential sloshing effect.

Spring-neap tides are a second significant tidal pattern type. The fortnightly modulation in semidiurnal   tidal amplitudes is due to the various combinations of lunar and solar semidiurnal tides. The minimum ranges occur  at  the  first  quarter  and  last  quarter. This  is  because  at  times  of  spring  tides  the  lunar  and  solar  forces combine  together, but at  neap  tides  the  lunar and  solar  forces are out of phase and  tend  to cancel.  (Pugh 82) Figure 1.4 illustrates the difference between Neap and Spring ellipses; notice during the Spring Tide, the ellipse is drawn outward toward the Sun, allowing for increases tidal activity in terms of range. During  the Neap Tide, one gets  a  significant decrease  in  tidal  activity  due  to  the  gravitational  strain  at  the  poles  instead  of  at  the Equator.  Unfortunately,  although  predictable,  this  tidal  pattern  makes  for  increased  variation  in  terms  of expected power output; if tidal power produced 25% of a large city‘s power peak load, the city would be forced to  find  another  source  of  power  during  times  of Neap Tide. This has  always  been  a  significant  factor when considering tidal energy schemes as a significant portion of a population‘s energy requirement.

**Q.4 Write the name of the Instruments used to measure Solar Radiation? Explain the Pyrheliometer Instrument using the Diagram.**

**Ans:**

ULTRAVIOLET MEASUREMENTS

For the measurement of sun and sky ultraviolet radiation in the wavelength interval 0.295 to 0.385 µm, which is particularly important in environmental, biological, and pollution studies the Total Ultraviolet Radiometer (Model TUVR) was developed. This instrument utilizes a photoelectric cell protected by a quartz window. A specially designed teflon diffuser not only reduces the radiant flux to acceptable levels but also provides close adherence to the Lambert cosine law. An encapsulated narrow bandpass (interference) filter limits the spectral response of the photocell to the wavelength interval 0.295-.0385 µm.

SHORTWAVE MEASUREMENTS: DIRECT, DIFFUSE AND GLOBAL

As solar radiation passes through the earth’s atmosphere, some of it is absorbed or scattered by air molecules, water vapor, aerosols, and clouds. The solar radiation that passes through directly to the earth’s surface is called Direct Normal Irradiance (DNI). The radiation that has been scattered out of the direct beam is called Diffuse Irradiance. The direct component of sunlight and the diffuse component of skylight falling together on a horizontal surface make up Global Irradiance. The three components have a geometrical relationship.

Direct radiation is best measured by use of a pyrheliometer, which measures radiation at normal incidence. The Normal Incidence Pyrheliometer (Model sNIP) consists of a wirewound thermopile at the base of a tube with a viewing angle of approximately 5º which limits the radiation that the thermopile receives to direct solar radiation only.

The pyrheliometer is mounted on a Solar Tracker (Models ST-1 and ST-3) or an Automatic Solar Tracker (Model SMT) for continuous readings.

Diffuse radiation can either be derived from the direct radiation and the global radiation or measured by shading a pyranometer from the direct radiation so that the thermopile is only receiving the diffuse radiation. Eppley has developed Shade Disk Adaption Kit (Model SDK) that mounts on the SMT which allows you to measure the diffuse and direct at the same time. We also manufacture the Shadow Band Stand, (Model SBS) for Diffuse measurements in sites where there is no power available to operate an Automatic Tracker.

Global radiation is measured by a pyranometer. The modern pyranometer manufactured by the Eppley Laboratory, using wirewound plated thermopiles, can be one of three models: the Standard Precision Pyranometer (Model SPP), the Global Precision Pyranometer (Model GPP), and the Black & White Pyranometer (Model 8-48). The SPP has a black sensor protected by two precision ground, polished hemispheres and is the preferred instruments for Global measurements. Based on the SPP, the GPP is specifically designed as a lower cost alternative for the PV/CSP industry. The 8-48 has a black and white sensor that is protected by a single polished hemisphere and is the preferred instrument for Diffuse measurements.

LONGWAVE (INFRARED) MEASUREMENTS

The Precision Infrared Radiometer, (Model PIR) was a development of the PSP Pyranometer (forerunner to the SPP Pyranometer) and continues to be the industry standard for precise measurement of incoming or outgoing longwave radiation. The PIR comprises the same wirewound thermopile detector and temperature compensation circuitry as found in the PSP/SPP. This thermopile detector is used to measure the “net radiation” of the PIR and a case thermistor (YSI 44031) is used to determine the outgoing radiation from the case. A dome thermistor is also included if one wishes to measure the dome temperature as compared to the case temperature to make any “corrections” to the final result.

ALBEDO/REFLECTION MEASUREMENTS

Albedo is the ratio of the incoming shortwave divided by the reflected shortwave. Eppley believes the best way to measure albedo is with two (2) distinct SPPs instead of mounting the two sensors in the same body. This allows for better calibration results and prevents the cold junctions of the two sensors from affecting each other. We have supplied Albedometers as well a Roof Reflectance Kits based on customers wishes.

NET RADIATION MEASUREMENTS

Net radiation is the sum of four individual measurements: Incoming Shortwave, Reflected Shortwave, Incoming Longwave and Outgoing Longwave. Eppley recommends measuring each of the four componants separately using two (2) SPPs and two (2) PIRs.

SUNSHINE DURATION MEASUREMENTS

Sunshine duration is typically defined as the amount of time that the Direct Normal Irradiance (DNI) is greater than 120 Wm-2. This can be determined by using the data collected from the sNIP.

# Pyrheliometer



Typical pyrheliometer, for measurement of direct solar radiation



Pyrheliometer: (3) body, (4) protection cap, (5) window with heater, (2) sight, (1) humidity indicator, (7) cable

A **pyrheliometer** is an instrument for measurement of direct beam [solar irradiance](https://en.wikipedia.org/wiki/Solar_irradiance).[[1]](https://en.wikipedia.org/wiki/Pyrheliometer#cite_note-1) Sunlight enters the instrument through a window and is directed onto a [thermopile](https://en.wikipedia.org/wiki/Thermopile) which converts heat to an electrical signal that can be recorded. The signal voltage is converted via a formula to measure watts per square metre.[[2]](https://en.wikipedia.org/wiki/Pyrheliometer#cite_note-2) It is used with a solar tracking system to keep the instrument aimed at the sun. A pyrheliometer is often used in the same setup with a [pyranometer](https://en.wikipedia.org/wiki/Pyranometer%22%20%5Co%20%22Pyranometer).

Standards

Pyrheliometer measurement specifications are subject to International Organization for Standardization (ISO) and World Meteorological Organization (WMO) standards. Comparisons between pyrheliometers for intercalibration are carried out regularly to measure the amount of solar energy received. The aim of the International Pyrheliometer Comparisons,[3] which take place every 5 years at the World Radiation Centre[4] in Davos, is to ensure the world-wide transfer of the World Radiometric Reference. During this event, all participants bring their instruments, solar-tracking and data acquisition systems to Davos to conduct simultaneous solar radiation measurements with the World Standard Group.[5]

Applications

Typical pyrheliometer measurement applications include scientific meteorological and climate observations, material testing research, and assessment of the efficiency of solar collectors and photovoltaic devices.

Usage

Pyrheliometers are typically mounted on a solar tracker. As the pyrheliometer only 'sees' the solar disk, it needs to be placed on a device that follows the path of the sun.

**OR**

**Q.4 Write short note on Latitude and Hour angle.**

**Ans:**

Latitude and longitude are angles that uniquely define points on a sphere. Together, the angles comprise a coordinate scheme that can locate or identify geographic positions on the surfaces of planets such as the earth.

Latitude is defined with respect to an equatorial reference plane. This plane passes through the center C of the sphere, and also contains the great circle representing the equator. The latitude of a point P on the surface is defined as the angle that a straight line, passing through both P and C, subtends with respect to the equatorial plane. If P is above the reference plane, the latitude is positive (or northerly); if P is below the reference plane, the latitude is negative (or southerly). Latitude angles can range up to +90 degrees (or 90 degrees north), and down to -90 degrees (or 90 degrees south). Latitudes of +90 and -90 degrees correspond to the north and south geographic poles on the earth, respectively.

Longitude is defined in terms of meridians, which are half-circles running from pole to pole. A reference meridian, called the prime meridian , is selected, and this forms the reference by which longitudes are defined. On the earth, the prime meridian passes through Greenwich, England; for this reason it is also called the Greenwich meridian. The longitude of a point P on the surface is defined as the angle that the plane containing the meridian passing through P subtends with respect to the plane containing the prime meridian. If P is to the east of the prime meridian, the longitude is positive; if P is to the west of the prime meridian, the longitude is negative. Longitude angles can range up to +180 degrees (180 degrees east), and down to -180 degrees (180 degrees west). The +180 and -180 degree longitude meridians coincide directly opposite the prime meridian.

Latitude and longitude coordinates on the earth are sometimes extended into space to form a set of celestial coordinates.

**Hour Angle**

In astronomy and celestial navigation, the hour angle is one of the coordinates used in the equatorial coordinate system to give the direction of a point on the celestial sphere. The hour angle of a point is the angle between two planes: one containing the Earth's axis and the zenith (the meridian plane), and the other containing the Earth's axis and the given point (the hour circle passing through the point).

As seen from above the Earth's north pole, a star's local hour angle (LHA) for an observer near New York (red dot). Also depicted are the star's right ascension and Greenwich hour angle (GHA), the local mean sidereal time (LMST) and Greenwich mean sidereal time (GMST). The symbol ʏ identifies the vernal equinox direction.

Assuming in this example the day of the year is the March equinox so the sun lies in the direction of the grey arrow then this star will rise about midnight. Just after the observer reaches the green arrow dawn comes and overwhelms with light the visibility of the star about six hours before it sets on the western horizon. The Right Ascension of the star is about 18h

The angle may be expressed as negative east of the meridian plane and positive west of the meridian plane, or as positive westward from 0° to 360°. The angle may be measured in degrees or in time, with 24h = 360° exactly.

In astronomy, hour angle is defined as the angular distance on the celestial sphere measured westward along the celestial equator from the meridian to the hour circle passing through a point. It may be given in degrees, time, or rotations depending on the application. In celestial navigation, the convention is to measure in degrees westward from the prime meridian (Greenwich hour angle, GHA), from the local meridian (local hour angle, LHA) or from the first point of Aries (sidereal hour angle, SHA).

The hour angle is paired with the declination to fully specify the location of a point on the celestial sphere in the equatorial coordinate system.

Solar hour angle

Observing the sun from earth, the solar hour angle is an expression of time, expressed in angular measurement, usually degrees, from solar noon. At solar noon the hour angle is 0.000 degree, with the time before solar noon expressed as negative degrees, and the local time after solar noon expressed as positive degrees. For example, at 10:30 AM local apparent time the hour angle is -22.5° (15° per hour times 1.5 hours before noon).

The cosine of the hour angle (cos(h)) is used to calculate the solar zenith angle. At solar noon, h = 0.000 so cos(h)=1, and before and after solar noon the cos(± h) term = the same value for morning (negative hour angle) or afternoon (positive hour angle), i.e. the sun is at the same altitude in the sky at 11:00AM and 1:00PM solar time, etc.[5]