Renewable Energy In India

India was the first country in the world to set up a ministry of non-conventional energy resources, in early 1980s. Renewable energy in India comes under the purview of the Ministry of New and Renewable Energy (MNRE). Newer renewable electricity sources are targeted to grow massively by 2022, including a more than doubling of India's large wind power capacity and an almost 15 fold increase in solar power from April 2016 levels. Such ambitious targets would place India amongst the world leaders in renewable energy use and place India at the center of its International Solar Alliance project promoting the growth and development of solar power internationally to over 120 countries.

As of 30th April 2016 India's cumulative grid interactive or grid tied renewable energy capacity (excluding large hydro) reached about 42.85 GW, surpassing the installed capacity of large scale hydroelectric power in India for the first time in Indian history. 63% of the renewable power came from wind, while solar contributed nearly 16%. Large hydro installed capacity was 42.78 GW as of 30 April 2016 and is administered separately by the Ministry of Power and not included in MNRE targets.

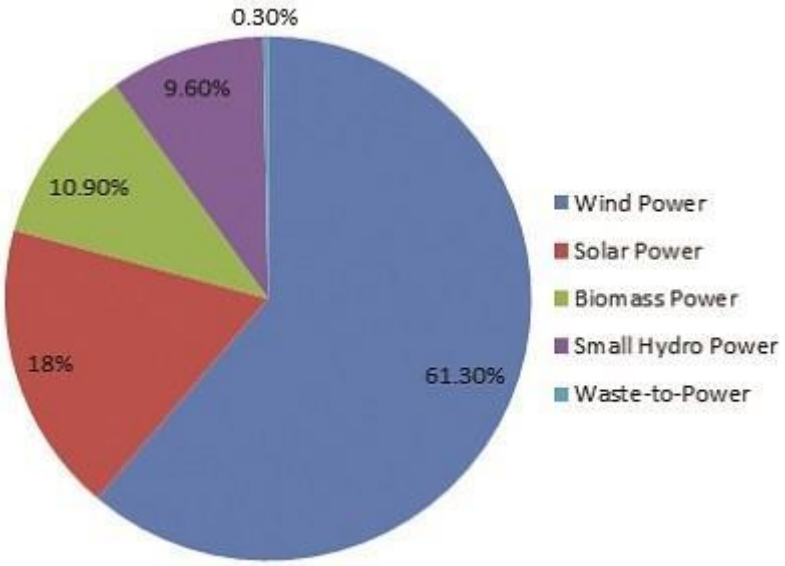
From 2015 onwards, the MNRE began laying down actionable plans for the renewable energy sector under its ambit to make a quantum jump, building on strong foundations already established in the country. MNRE renewable electrictricity targets have been upscaled to grow from just under 43 GW in April 2016 to 175 GW by the year 2022, including 100 GW from solar power, 60 GW from wind power, 10 GW from bio power and 5 GW from small hydro power. The ambitious targets would see India quickly becoming one of the leading green energy producers in the world and surpassing numerous developed countries. The government intends to achieve 40% cumulative electric power capacity from non-fossil fuel sources by 2030.

Table 1: Installed Grid Interactive Renewable Power Capacity in India as of July 31, 2016 (RES MNRE)

Source	Total Installed Capacity (MW)	2022 target (MW)
Wind Power	27,441.15	60,000.00
Solar Power	8,062.00	100,000.00
Biomass Power (Biomass & Gasification and Bagasse Cogeneration)	4,860.83	*10,000.00
Waste-to-Power	115.08	
Small Hydro Power	4,304.27	5,000.00
Total	44,783.33	175,000.00

Renewable Energy Overview And Targets

Installed Grid Interactive Renewable Power Capacity in India as of July 31, 2016 (RES MNRE)



- Wind Power: 27,441.15 MW (61.3%)
  - Solar Power: 8,062 MW (18.0%)
  - Biomass Power: 4,860.83 MW (10.9%)
  - Small Hydro Power: 4,304.27 MW (9.6%)
  - Waste-to-Power: 115.08 MW (0.3%)

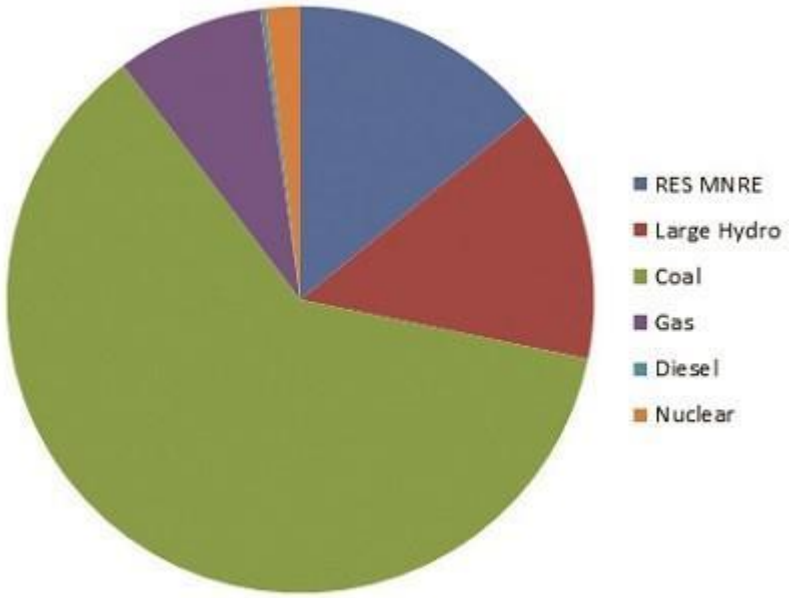
Grid Connected Renewable Electricity

The table 1 refers to newer and fast developing renewable energy sources, and are managed by the Ministry for New and Renewable Energy (MNRE). In addition, as of April 30th 2016, India had 42,783 MW of installed large hydro capacity, which comes under the ambit of Ministry of Power.

In terms of renewable energy sources under the responsibility of the Ministry of New and Renewable Energy by April 2016, wind power was the leading source of renewable power with 26.9 GW installed capacity, almost two thirds of the total renewable power installed capacity. Next came solar power with 6.8 GW installed capacity and biomass power with 4.8 GW accounting for 15.8% and 11.3% of the total renewable power installed capacity. Small hydro power accounted for 4.3 GW and waste-to-power accounted for just over 0.1 GW installed capacity. Total installed renewable power capacity in this category was just under 43 GW by April 2016.

In terms of meeting its ambitious 2022 targets, as of April 30, 2016, wind power was almost half way towards its goal, whilst solar power was below 7% of its highly ambitious target, although expansion is expected to be dramatic in the near future. Bio energy was also at just under half way towards its target whilst small hydro.

Installed Grid Power Capacity All Source In India As Of April 30, 2016



- RES MNRE: 42,849.38 MW (14.1%)
  - Large Hydro: 42,783.42 MW (14.1%)
  - Coal: 185,992.88 MW (61.4%)
  - Gas: 24,508.63 MW (8.1%)
  - Diesel: 918.89 MW (0.3%)
  - Nuclear: 5,780 MW (1.9%)

Power was already 85% of the way to meeting its target. Overall India was 24.5% towards meeting its final 2022 renewable power installed power capacity of 175 GW. The total breakdown of installed grid connected capacity from all sources including large hydro was as follows:

Grid connected installed capacity from all sources as of April 30, 2016

Source	Installed Capacity (MW)
RES MNRE	42,849.38
Large Hydro	42,783.42
Coal	185,992.88
Gas	24,508.63
Diesel	918.89
Nuclear	5,780.00
Total	302,833.20

The first figure at the top of the table refers to the fast growing renewable energy sources under the responsibility of the Ministry for New and Renewable Energy and slightly exceeded the installed capacity of large hydro installations. This figure is targeted to reach 175 GW by 2022. Coal power currently represents the largest share of installed capacity at just under 186 GW. Total installed capacity as of April 30, 2016, for grid connected power in India stood at a little under 303 GW.

India's Renewable Energy Potential Remains Untapped

India has tremendous energy needs and an increasing difficulty in meeting those needs through traditional means of power generation. On July 30th and 31st, 2012 the world's largest blackout. The Great Indian Outage, stretching from New Delhi to Kolkata occurred. This blackout, due to failure of the northern power grid, caused nearly 700 million people – twice the population of the United States – to be without electricity.

A grid failure of such magnitude has thrown light onto India's massive demand for electricity, together with its struggle to generate as much power as it needs. India is aiming to expand its power-generation capacity by 44 percent over the next five years but recent problems indicate the scale of the challenge. Even before the blackout, in June of 2012, the country's power generation fell short by 5.8 percent when confronted with a peak-hour demand of 128 GW, according to Government data.

Electricity consumption in India has been increasing at one of the fastest rates in the world due to population growth and economic development. India's economy faces increasing challenges because energy supply is struggling to keep pace with demand, and there are energy shortages (as much as 15 percent daily) almost everywhere in the country. Such chronic lack of energy and unreliable supplies threaten India's economic growth.

For economic as well as environmental reasons India needs to shift to non-polluting renewable sources of energy to meet future demand for electricity. Renewable energy is the most attractive investment because it will provide long-term economic growth for India. Renewable energy also has the advantage of allowing decentralized distribution of energy – particularly for meeting rural energy needs, and thereby empowering people at the grass roots level. Solar electricity could also shift about 90 percent of daily trip mileage from petroleum to electricity by encouraging increased use of plug-in hybrid cars. For drivers in India this means that the cost per mile could be reduced by a quarter in today's prices.

India does not have an overarching energy strategy – instead it has a number of disparate policies. Rather than promoting an overarching energy strategy, to date India has developed a cluster of energy business models and policies that have not been productive. These policies are definitely affecting renewable energy expansion plans. The present business model needs to be changed from a centralized to a decentralized structure that allows all stakeholders including capital investment coming from state-owned investors, pension funds, and foreign countries.

SOLAR GEOMETRY

Solar time (also known as Local Apparent Time) is measured with reference to *solar noon*, which is the time when the sun is crossing observer's meridian. At solar noon the sun is at the highest position in the sky. The sun traverses each degree of longitude in 4 minutes (as the earth takes 24 hours to complete one revolution). The standard time is converted to solar time as follows:

$$\text{Solar time} = \text{Standard time} \pm 4\,(L_{st} - L_{loc}) + E$$

where L_{st} and L_{loc} are the standard longitude used for measuring standard time of the country and the longitude of observer's location respectively. The (+ive) sign is used if the standard meridian of the country lies in the western hemisphere (with reference to prime meridian) and (–ive) if that lies in the eastern hemisphere. E is the correction arising out of the variation in the length of the solar day due to variations in earth's rotation and orbital revolution, and is called *equation of time*.

1. Latitude (angle of latitude), (ϕ)

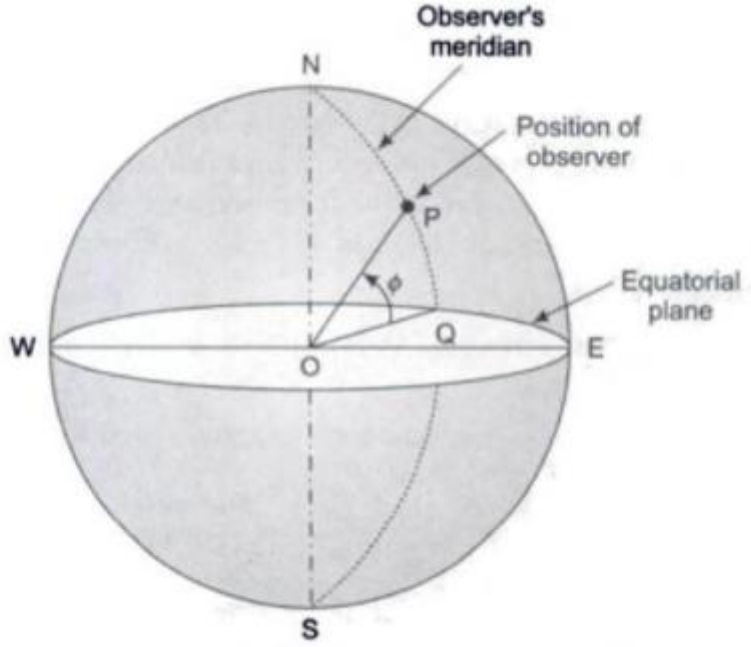
The latitude of a location on earth's surface is the angle made by radial line, joining the given location to the center of the earth, with its projection on the equator plane as shown in Fig. The latitude is (+ive) for northern hemisphere and (–ive) for southern hemisphere.

2. Declination, (δ)

It is defined as the angular displacement of the sun from the plane of earth's equator as shown It is positive when measured above equatorial plane in the northern hemisphere. The declination δ can be approximately determined from the equation:

$$\delta = 23.45 \times \sin\left[\frac{360}{365}(284 + n)\right] \text{ degrees}$$

where n is day of the year counted from 1st January.



(a) Latitude

(b) Declination angle δ

3. Hour angle, (ω)

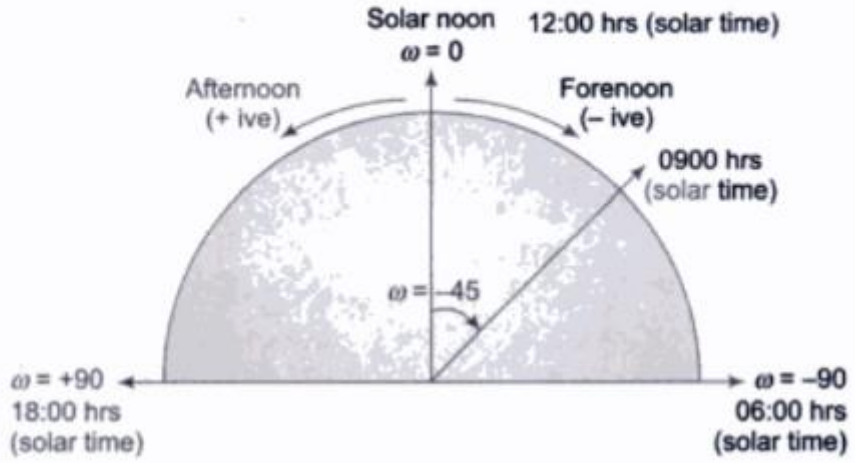
The hour angle at any moment is the angle through which the earth must turn to bring the meridian of the observer directly in line with sun's rays.

In other words, at any moment, it is the angular displacement of the sun towards east or west of local meridian (due to rotation of the earth on its axis). The earth completes one rotation in 24 hours. Therefore, one hour corresponds to 15° of rotation. At solar noon, as sunrays are in line with local meridian, hour angle is zero. It is –ive in the forenoon and +ive in the afternoon.

Thus at 0600 hrs it is –90° and at 1800 hrs it is +90°

It can be calculated as:

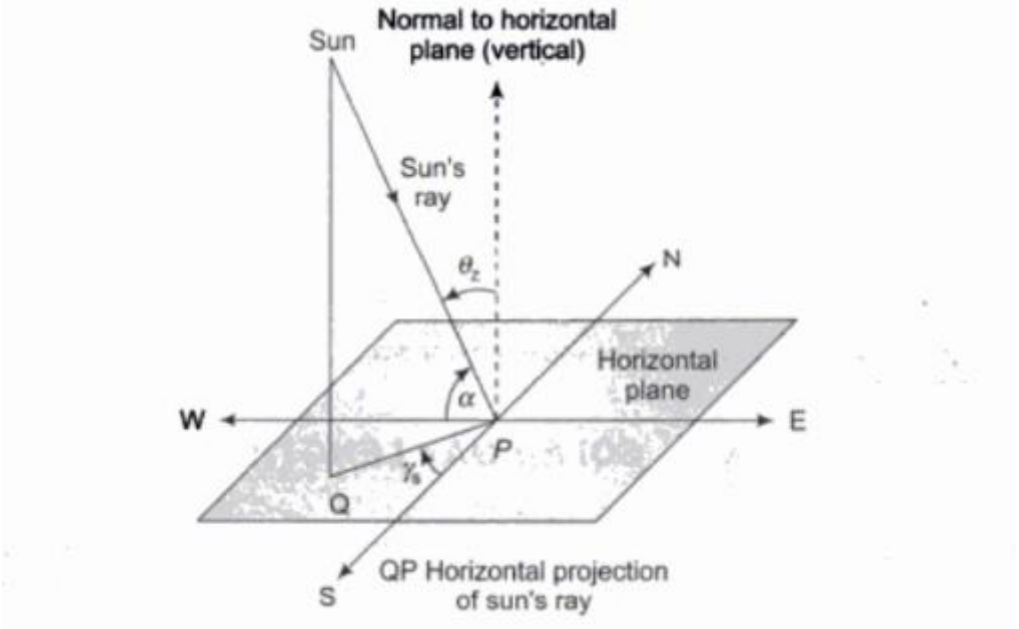
$$\omega = [\text{Solar Time} - 12{:}00] \text{ (in hrs)} \times 15 \text{ degrees}$$



PROBLEM

(1)CALCULATE THE HOUR ANGLE AT NEWDELHI AT 2.30 PM

The term *Irradiance* is defined as the measure of power density of sunlight and is measured in W/m^2. *Irradiation* is the measure of energy density of sunlight and is measured in kWh/m^2. Irradiance and irradiation apply to all components of solar radiation.



SOLAR CONSTANT (I_{SC})

The intensity of solar radiation keeps on attenuating as it propagates away from the surface of the sun, though the wavelengths remain unchanged. Solar radiation incident on the outer atmosphere of the earth is known as *Extraterrestrial Radiation*, I_{ext}. The *Solar Constant*, I_{sc} is defined as the energy received from the sun per unit time, on a unit area of surface perpendicular to the direction of propagation of the radiation, at the top of the atmosphere, at the earth's mean distance from the sun. The World Radiation Center (WRC) has adopted a value of solar constant as 1367 W/m^2

1367W/m² remember this value it will not be given in exam.

The extraterrestrial radiation deviates from solar constant value due to two reasons. The first is the variation in the radiation emitted by the sun itself. The variation due to this reason is less than ±1.5% with different periodicities. The second is the variation of earth-sun distance arising from earth's slightly elliptic path. The variation due to this reason is ± 3% and is given by:

$$I_{ext} = I_{sc} [1.0 + 0.033 \cos (360\, n/365)]\ \mathrm{W/m^2}$$

PROBLEM

CALCULATE THE VALUE OF EXTRATERASTRIAL RADIATION ON JUNE 14 AT MYSORE NOTE THE YEAR IA A LEAP YEAR.

BY DATA ITS LEAP YEAR

PUT

N=31(JAN)+29(FEB)+31(MARCH)+30(APRIL)+31(MAY)+14(JUNE)

ADD AND OBTAIN N=

Problem

Calculate the solar declination angle on October 16 2019

Solution

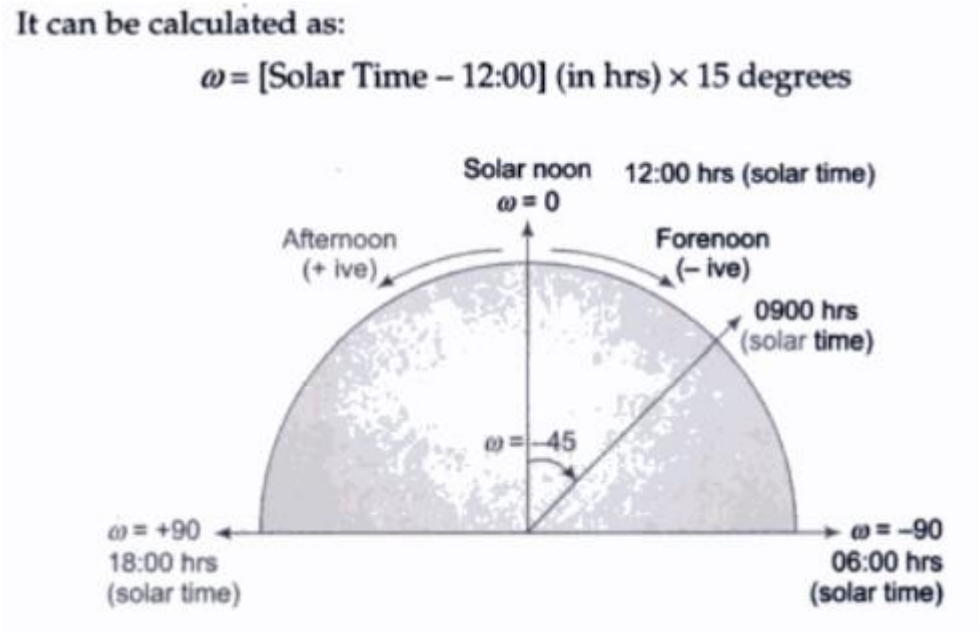
n—october 16

$$\delta = 23.45 \sin\left[\frac{360}{365}(289 + 284)\right]$$

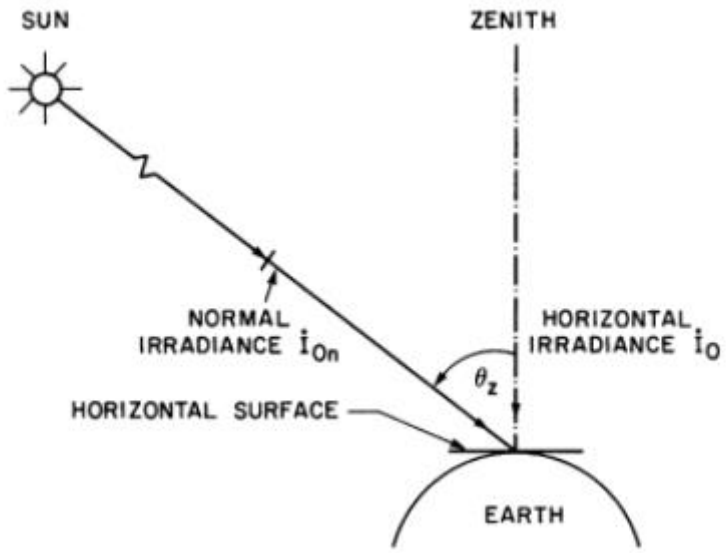
$$= -9.97^{\circ}.$$

Find the hour angle at 10:30 a.m. local apparent time .

Solution :



Solution =(10.30-12.00)*15=-25.5.



Relationship between the direct normal and the horizontal irradiance.

What is the Global Energy Crisis?

- The energy crisis is the concern that the world's demands on the limited natural resources that are used to power industrial society are diminishing as the demand rises. These natural resources are in limited supply. While they do occur naturally, it can take hundreds of thousands of years to replenish the stores.

1. Overconsumption

The energy crisis is a result of many different strains on our natural resources, not just one. There is a strain on fossil fuels such as oil, gas, and coal due to overconsumption – which then, in turn, can put a strain on our water and oxygen resources by causing pollution.

2. Overpopulation

Another cause of the crisis has been a steady increase in the world's population and its demands for fuel and products. No matter what type of food or products you choose to use – from fair trade and organic to those made from petroleum products in a sweatshop – not one of them is made or transported without a significant drain on our energy resources.

3. Poor Infrastructure

Aging infrastructure of power generating equipment is yet another reason for energy shortage. Most of the energy-producing firms keep on using outdated equipment that restricts the production of energy. It is the responsibility of utilities to keep on upgrading the infrastructure and set a high standard of performance.

4. Unexplored Renewable Energy Options

Renewable energy still remains unused in most of the countries. Most of the energy comes from non-renewable sources like coal. It, therefore, remains the top choice to produce energy.

Unless we give renewable energy a serious thought, the problem of energy crisis cannot be solved. Renewable energy sources can reduce our dependence on fossil fuels and also helps to reduce greenhouse gas emissions.

5. Delay in Commissioning of Power Plants

In a few countries, there is a significant delay in the commissioning of new power plants that can fill the gap between demand and supply of energy. The result is that old plants come under huge stress to meet the daily demand for power. When

supply doesn’t match demand, it results in load-shedding and breakdown.

6. Wastage of Energy

In most parts of the world, people do not realize the importance of conserving energy. It is only limited to books, the internet, newspaper ads, lip service, and seminars. Unless we give it a serious thought, things are not going to change anytime sooner.

Simple things like switching off fans and lights when not in use, using maximum daylight, walking instead of driving for short distances, using CFL instead of traditional bulbs, proper insulation for leakage of energy can go a long way in saving energy.

7. Poor Distribution System

Frequent tripping and breakdown are a result of a poor distribution system.

8. Major Accidents and Natural Calamities

Major accidents like pipeline burst and natural calamities like the eruption of volcanoes, floods, earthquakes can also cause interruptions to energy supplies. The huge gap between supply and demand for energy can raise the price of essential items, which can give rise to inflation.