Article

A Perspective of Indian Energy Sources, Depletion of Ozone Layer, and Threat to Life: An Overview

Mrinal K Ghose, PhD, DSc
Emeritus Professor, Department of Biotechnology, West Bengal University of Technology
BF 142 Salt Lake City, Kolkata -700064, India
E-mail: ghosemrinal@lycos.com

ABSTRACT

There has been a very high and positive growth in the consumption of all kinds of primary energy sources. This article focuses on the consumption of different primary energy sources and identifies that coal will continue to remain as the prime energy source in foreseeable future. It examines the energy demand and supply gap in India. Economic development and poverty alleviation depend on securing affordable energy sources. It discusses the strategies to be adopted for growth and meeting the country's energy demand. But such energy is very much concerned with environmental degradation and they must be driven by contemporary managerial acumen addressing environmental and social challenges effectively. Depletion of ozone layer and detection of ozone hole at the South Pole of earth is a very good example of human interference with the natural environment. Without this ozone layer, life on earth would not have evolved in the way it has. This article discusses the causes of ozone depletion, chemicals responsible, and the international agreements and other legislations, which have gone a long way to safeguard this life-supporting shield.

Keywords: Exponential, Consumption, Oil equivalent, Utility, Power, Greenhouse

INTRODUCTION

The requirement of primary energy sources is growing exponentially all over the world [1, 2]. The global primary energy requirement has grown from 6,700 million tonnes of oil equivalent (Mtoe) to 10,200 Mtoe over the last 25 years. There has been a very high positive growth in consumption of all kinds of primary energy sources, e.g., oil, natural gas, nuclear energy, hydroelectricity, and coal [3]. If we look at the regional pattern of consumption of primary energy sources, we find that oil remains the largest single source of primary energy in most parts of the world. However, gas dominates as the prime source in some parts of the world such as former Soviet Union and the Middle East. Coal enjoys the main primary energy source status in Asia Pacific, which comprises the largest population, and an economy that outperforms the rest of the world in growth [4]. The reserve-to-production (R/P) ratio in respect of the major regions of the globe describes the life of different fossil fuels on earth on the basis of current levels of production [5]. The fact remains that oil and gas have limited reserves to last for the next 41 and 67 years, respectively, at the current production level. In contrast, the world has a coal reserve to last for the next 190 years at the current production level.

The energy sector plays a crucial role in the overall development of the economy. Of the total energy consumption of approximately 360 Mtoe in India, an estimated 35 per cent is obtained from traditional sources such as fuelwood, agricultural waste, animal dung, etc., and the other 65 per cent, termed as commercial energy, is obtained from coal, oil, gas, hydel, nuclear and renewable sources [6]. The share of various energy sources in the primary commercial energy consumption of the country is coal and lignite. These are mostly used in power stations (75 per cent), steel plants (6.2 per cent), cement plants (3.6 per cent), other industries, and brick making plants (15.2 per cent). Petroleum and natural gas are mostly used for the transportation sector although significant amounts are used in oil, and gas, fired power stations, fertilizer plants, other industries and in the domestic sector for cooking and lighting. There is a great demand and supply gap of energy in the country, which is widening every year [7,8]. Energy security, which means ensuring that our country can supply lifeline energy to all its citizens, at affordable costs at all times, is a very important and significant need and is an essential step forward. Moreover, burning of fossil fuel is causing environmental degradation. The objective of this article is to highlight the Indian energy perspective to evaluate impact of the usage of these primary energy sources on the depletion of ozone layer, to focus on the threat to life, and measures taken for protection of ozone layer.

MATERIAL STUDIED

Indian energy perspective

More than 60 per cent of Indian households depend on the traditional sources of energy like fuelwood, dung, and crop residues for meeting their cooking and heating needs. Out of the total rural energy consumption, about 65 per cent is met from fuelwood. Fuelwood consumption during 2001–02 is estimated at 223 Mt, of which 180 Mt is for household consumption and the balance for cottage industry, big hotels, etc. The consumption of animal dung and agro-waste is estimated at 130Mt, which does not include the wet dung used for biogas plants. The projected requirement of commercial energy is estimated at about 412 Mtoe and 554 Mtoe in 2007 and 2012, respectively [9].

India ranks sixth in the world in terms of energy demand accounting for 3.5 per cent of the world's commercial energy demand [10]. With a gross domestic product (GDP) growth of 8 per cent set for the 10th Five-Year Plan (2002–07), the energy demand is expected to grow at 5.2 per cent. Although, the commercial energy consumption has grown rapidly over the last two decades, yet a large part of India's population does not have access to it [2]. At 479 kg of oil equivalent (kgoe), the per capita energy consumption is also low when compared to some of the other developing countries, such as Thailand (1,319 kgoe), Brazil (1,051 kgoe), and China (907 kgoe). Primary commercial energy demand grew almost three-fold at an annual rate of 6 per cent between 1981 and 2001, to reach 314.7 Mtoe. India's incremental energy demand for the next decade is projected to be the highest in the world, spurred by sustained economic growth, rise in income levels, and increased availability of goods and services. India's commercial energy demand is expected to grow even more rapidly than in the past as it goes down the reform path in order to raise standards of living [11].

Energy security must be considered as a transition strategy, to enable us to achieve our real goal, i.e., energy independence or an economy, which will function well with total freedom from oil, gas or coal imports. Energy security rests on two principles: (i) To use the least amount of energy to provide services and cut down energy losses; and(ii) To secure access to all sources of energy including coal, oil, and gas supplies worldwide, till the end of the fossil fuel era, which is fast approaching. Simultaneously, we should access technologies to provide a diverse supply of reliable, affordable, and environmentally sustainable energy. Hence, energy independence has to be our first and highest priority. We have to critically look at the need for energy independence in different ways in its two major sectors, i.e., electric power generation and transportation. We also depend on oil to the extent of 114 million tonnes every year,75 per cent of which is imported, and used almost entirely in the transportation sector. Forecasts of the energy requirements by 2030, when the population may touch 1.4 billion, indicate that demand from power sector will increase from the existing 120,000 MW to about 400,000 MW. This assumes an energy growth rate of 5 per cent per annum.

The all-India installed capacity of electric power generation under utilities was 112,058.42 MW as on March 31, 2004, consisting of 77,968.53 MW of thermal, 29,500.23 MW of hydro, 2,720.00 MW of nuclear, and 1,869.66 MW of wind power which increased to 115,544.81 MW as on January 31, 2005 consisting of 80,201.45 MW of thermal, 30,135.23 MW of hydro, 2,720 MW of nuclear, and 2,488.13 of wind power. A capacity addition of 41,110 MW has been targeted for the tenth plan [12,13]. The commercial energy demand is estimated to grow at an average rate of 5.6 per cent and 6.1 per cent, respectively, during the period 2002–07 and 2007–12 [14]. However, the demand may be less by 5 per cent and 10 per cent during 2006–07 and 2011–12, respectively, due to increasing use of Information Technology (IT) and prevalence of e-Commerce, which will mainly affect the demand of energy in the transport sector. Coal's share of total energy demand remains highest at 46 per cent from now till at least 2011–12 [15]. Burning of all these fossil fuels is not environmentally sustainable and causes greenhouse effect to the atmosphere [16,17].

Formation of ozone layer and its significance to life

Ozone is a form of oxygen, which consists of three atoms of oxygen bound together (O_3). Most of the atmosphere's ozone occurs in the region known as the stratosphere. It is colourless and has a very harsh odour. Out of each 10 million air molecules, about 2 million are normal oxygen, but only 3 are ozone. Most ozone molecules are produced naturally in the upper atmosphere or stratosphere. While ozone can be found through the entire atmosphere, the greatest concentration occurs at altitudes between 19 and 30 km above the earth's surface. This band of ozone-rich air is known as the 'ozone layer'. It is produced at ground level through a reaction between sunlight and Volatile Organic Compounds (VOCs) and Nitrogen Oxides (NOx), some of which are produced by burning of fossil fuels. Ground-level ozone is a component of urban smog and can be harmful to human health.

Ozone is both beneficial and harmful to us. Near the ground, ozone forming as a result of chemical reactions involving traffic pollution and sunlight may cause a number of respiratory problems, particularly for young children. However, at a higher level in the atmosphere, in a region known as the stratospheric layer, ozone filters out incoming radiation from the sun in the cell-damaging Ultraviolet(UV) part of the spectrum. Without this ozone layer, life on earth would not have evolved in the way it has. Concentrations of ozone in the stratosphere fluctuate naturally in response to variations in weather conditions and amounts of energy being released from the sun, and to major volcanic eruptions. Nevertheless, during the 1970s it was realized that man-made emissions of Chlorofluorocarbons (CFCs) and other chemicals used in refrigeration, aerosols, and cleansing agents may cause a significant destruction of ozone in the stratosphere, thereby, letting through more of the harmful UV radiation. Then in 1985 evidence of a large 'ozone hole' was discovered above the continent of Antarctica during the spring season. This has reappeared annually, generally growing larger and deeper each year. More recently, fears have emerged about significant ozone depletion over the Arctic, closer to the more populous regions of the Northern Hemisphere.

In response to this and additional fears about more widespread global ozone depletion, the Montreal Protocol on 'substances that deplete the ozone layer' was implemented in 1987. This legally binding international treaty called for participating developed nations to reduce the use of CFCs and other ozone depleting substances. In 1990 and again in 1992, subsequent Amendments to the Protocol brought forward the phase out date for CFCs for developed countries to 1995. Protecting the ozone layer is essential. Ultraviolet radiation from the sun can cause a variety of health problems in humans, including skin cancers, cataract, and a reduction in the body's immunity. Furthermore, UV radiation can be damaging to microscopic life in the surface oceans which forms the basis of the world's marine food chain, certain varieties of crops including rice and soya, and polymers used in paints and clothing. A loss of ozone in the stratosphere may even affect the global climate.

International agreements and other legislation have gone a long way to safeguarding this life-supporting shield. Nevertheless, for there to be real and long-lasting success, everyone must become part of the solution. Individual efforts taken together can be powerful forces for environmental change. There are a number of things that we, as individuals, can do to protect the ozone layer. These include proper disposal of old refrigerators, the use of halon-free fire extinguishers, and the recycling of foam and other non-disposable packaging. Finally, we should all be aware that whilst emissions of ozone depleters are now being controlled, the ozone layer is not likely to fully repair itself for several decades. Consequently, we should take precautions when exposing ourselves to the sun.

Causes of ozone depletion

Ozone depletion occurs when the natural balance between the production and destruction of stratospheric ozone is tipped in favour of destruction. Although natural phenomena can cause temporary ozone loss, chlorine and bromine released from man-made compounds such as CFCs are now accepted as the main cause of this depletion. It was first suggested by Drs M Molina and S Rowland in 1974 that a man-made group of compounds called the CFCs were likely to be the main source of ozone depletion. However, this idea was not taken seriously until the discovery of the ozone holes over Antarctica in 1985 by the British Antarctic survey. Chlorofluorocarbons are not 'washed' back to earth by rain or destroyed in reactions with other chemicals. They simply do not break down in the lower atmosphere and they can remain in the atmosphere from 20 to 120 years or more. As a consequence of their relative stability, CFCs are instead transported into the stratosphere where they are eventually broken down by UV rays from the sun, releasing free chlorine. The chlorine becomes actively involved in the process of destruction of ozone. The net result is that two molecules of ozone are replaced by three of molecular oxygen, leaving the chlorine free to repeat the process. The chemical reaction depicting the process is as follows:

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O \rightarrow Cl + O_2$$

Ozone is converted to oxygen, leaving the chlorine atom free to repeat the process up to 100,000 times, resulting in a reduced level of ozone. Bromine compounds or halons, can also destroy stratospheric ozone. Compounds containing chlorine and bromine from man-made compounds are known as industrial halocarbons. Emissions of CFCs have accounted for roughly 80 per cent of total stratospheric ozone depletion. Thankfully, the developed world has phased out the use of CFCs in response to international agreements to protect the ozone layer. However, because CFCs remain in the atmosphere for so long, the ozone layer will not fully repair itself until at least the middle of the 21st century. Naturally occurring chlorine has the same effect on the ozone layer, but has a shorter life span in the atmosphere.

Chlorofluorocarbons or CFCs (also known as Freon) are non-toxic, non-flammable, and non-carcinogenic. They contain fluorine atoms, carbon atoms, and chlorine atoms. The five main CFCs include: CFC-11 (trichlorofluoromethane—$CFCl_3$), CFC-12 (dichlorodifluoromethane—CF_2Cl_2), CFC-1 3 (trichlorotrifluoroethane—$C_2F_3Cl_3$), CFC-14 (dichlorotetrafluoroethane—$C_2F_4Cl_2$), and CFC-15 (chloropentafluoroethane—C_2F_5Cl). CFCs are widely used as coolants in refrigeration and air conditioners, as solvents in cleaners, particularly for electronic circuit boards, as blowing agents in the production of foam (e.g., fire extinguishers), and as propellants in aerosols. Indeed, much of the modern lifestyle of the second half of the 20th century had been made possible by the use of CFCs. Man-made CFCs, however, are the main cause of stratospheric ozone depletion. CFCs have a lifetime in the atmosphere of about 20–100 years, and consequently one free chlorine atom from a CFC molecule can do a lot of damage, destroying ozone molecules for a long time. Although emissions of CFCs around the developed world have largely ceased due to international control agreement, the damage to the stratospheric ozone layer will continue well into the 21st century.

OZONE DEPLETING CHEMICALS

The most commonly known ozone depletion chemicals (ODCs) are the CFCs. Over the last 30 years, man-made CFCs have been the main cause of stratospheric ozone depletion. Fortunately, CFCs, once used, for example in refrigeration, air conditioning, and fire extinguishers, have been largely phased out in the aftermath of the Montreal Protocol. CFCs, however, are not the only ozone-depleting chemicals. Other ODCs include the methylhalides, carbon tetrachloride (CCl_4), carbon tetrafluoride(CF_4), and the halons, which contain bromine instead of chlorine. Such compounds are called halocarbons.

Carbon tetrachloride (CCl_4), despite its toxicity, was first used in the early 1900s as a fire extinguishant, and more recently as an industrial solvent, as an agricultural fumigant, and in many other industrial processes including petrochemical refining, and pesticide and pharmaceuticals production. Recently, it has also been used in the production of CFC-11 and CFC-12. It has accounted for less than 8 per cent of total ozone depletion. The use of CCl_4 in developed countries, however, has been prohibited since the beginning of 1996 under the Montreal Protocol.

Methyl chloroform, also known as 1,1,1-trichloroethane is a versatile, all-purpose industrial solvent used primarily to clean metal and electronic parts. It was introduced in the 1950s as a substitute for CCl_4. Methyl chloroform has accounted for roughly 5 per cent of total ozone depletion. The use of methyl chloroform in developed countries has been prohibited since the beginning of 1996 under the Montreal Protocol. Halons, unlike CFCs, contain bromine, which also destroys ozone in the stratosphere. Halons are used primarily in fire extinguishers. Halon-1301 has ozone-depleting potential 10 times that of CFC-11. Although the use of halons in developed countries has been phased out since 1996, the atmospheric concentration of these potent, ozone destroyers is still rising because of their long atmospheric lifetime. To date, halons have accounted for about 5 per cent of global ozone depletion. Methyl bromide, another bromine-containing halocarbon, has been used as a pesticide since the 1960s. Today, scientists estimate that human sources of methyl bromide have been responsible for approximately 5–10 per cent of global ozone depletion.

OZONE LAYER DEPLETION AND ITS IMPACT ON THE LIVING WORLD

Depletion of ozone layer at the South Pole of the earth is a very good example of human interference with the natural environment. Dr Jo Foreman in 1982, a scientist of British Antarctica Survey, first invented the presence of ozone hole. Within 1985, it was established that it is a regular yearly feature and this ozone hole is visible in spring season, in the ozonosphere [18]. It has been estimated that the volume of the hole is so vast that a country like USA may be accommodated within it and it is like the Himalayan Mt Everest peak.

In the second layer, i.e., the stratosphere from 20–50 km height from the earth's surface, ozone layer is present, although the density is very low. Inspite of low-density, ozone layer plays a very important role in our lives. Due to the presence of ozone layer, UV rays from the sun cannot reach the earth directly. Ozone layer absorbs the harmful part of the sunlight (wavelength 320 nm~ to 295 nm~) and protects the life on earth from harmful effects of these rays. It has been revealed from different researches that when the oxides of nitrogen (NO and NO_2) come in contact with ozone (O_3), ozone dissociates into oxygen gas (O_2). It has also been reported that supersonic aeroplanes move through stratosphere and emit huge amounts of NO and NO_2 gases which deplete the ozone layer. Another very important factor is CFCs which have the power to destroy the ozone layer.

In 1974, Dr Mario Molina and Prof. Sareud Ro of California University first expressed their view of probability of ozone depletion in the atmosphere, but industries, scientists and different laboratories seriously opposed this view. They were of the view that ozone, as it depletes, originates simultaneously. But in 1982, Dr Foreman observed ozone hole in the atmosphere from the surface of the earth. It was surprising that Nimbus-7—a satellite of the USA, whose main function was to report detailed composition of the atmosphere, did not report about ozone depletion. Although review Nimbus-7 report indicated 'zero' status of ozone in the South Pole, but that was discarded earlier considering it an error of the instruments. In the following year detailed survey was done to find the status of ozone in the South Pole by the National Aeronautics and Space Administration (NASA) and the presence of 'ozone hole' was proved. The same survey chemicals also proved it like CFCs are mainly responsible for creation of 'ozone hole' size of hole does not remain uniform throughout the year. It starts increasing during winter end and spring, and then starts decreasing. Within a period of 10 years, the maximum has been observed in the year 1989 which spreads up to southern part of South America and Fordland Island leaving behind the polar elliptical region. Recently, it has been reported that not only in the South Pole but also at all the other places, ozone layer is going to be depleted. In the North Pole, which is thickly populated, ozone layer has depleted 4 per cent in winter and 1 per cent in summer season.

All the developed and developing countries are using CFCs-type chemical refrigerants—aerosols, paints, plastics, foam, and thermal insulating materials in spray packaging industries. During the use of such materials, a lot of CFCs get dispersed into atmosphere, where, due to photocell reaction in the presence of sunlight, CFCs get transformed into hydrogen chloride(HCl) gas which ultimately gets dispersed towards the South pole or North pole depending on the direction of the wind. As the South Pole is cooler than the North Pole, ice crystals are found in the former. Gas in the presence of ice crystals breaks into chlorine molecule and after long nights when spring comes, due to bright UV rays of sun, the chlorine molecule dissociates into chlorine atom, which is very reactive. Chlorine atom reacts with ozone (O_3) and dissociates into oxygen (O_2). An interesting fact is that chlorine does not remove—it goes on reacting with ozone molecules, i.e., ozone depletion continues for a long period. It has been found that one chlorine atom destroys at least 10,000 ozone molecules.

The most important question is why does this ozone hole occur in the South Pole? Why not in the North Pole? The probable answer is that the temperature at the South Pole is lower than that of the North Pole and in winter it comes down to –40°C [19]. This temperature forms the ice crystals which ultimately cause the ozone hole. But it is expected that in the near future, the North Pole will also be affected. Recently, in the atmosphere of the North Pole carbon monoxide has been detected which has the power to destroy the ozone layer and there is chance of creation of ozone hole. In the meantime, in the 45° north and 45° south, ozone density has decreased up to 7 per cent.

If there occurs a hole in the ozone layer in stratosphere, then the UV rays of the sun will reach the earth directly without any obstacle or filtration. These UV rays will mainly cause skin cancer and cataract in human beings. It has been reported that the number of skin cancer patients is increasing throughout the world. In the USA alone, skin cancer affects 3 lakh people every year. Ultraviolet rays also reduce the immunity power in other animals and increase susceptibility towards different types of harmful diseases. It has been estimated that the rate at which production of CFCs is increasing, the concentration of ozone would reduce by 20 per cent in the next forty years, due to which about 15 lakh people would get affected by skin cancer and 50 lakh people in the USA alone would suffer from cataract in their eyes [20].

These UV rays give rise to the genetic disorders, which ultimately affects the heredity. Increased concentrations of UV rays disturb ecological balance in marine ecosystem. Ultraviolet rays affect green algae, fish, and other animals on continental shelves. Young cells and larvae of aquatic ecosystem get affected twenty times. Most of the vegetables are very sensitive to the UV rays. Ultraviolet rays can damage the physical and chemical properties of any complex chemical substance. Plastic becomes brittle when it comes in contact with UV rays. As most of the industries use plastic material, so such industries would be affected more. The United Nations Environment Programme's report stated that if the amount of ultraviolet rays goes on increasing, then all living things would disappear in the near future [21].

MONTREAL PROTOCOL FOR THE PROTECTION OF OZONE LAYER

In 1985, the Vienna Convention established mechanisms for international cooperation in research into the ozone layer and the effects of ODCs. The same year (1985) also marked the first discovery of the Antarctic ozone hole. On the basis of the Vienna Convention, *The Montreal Protocol on Substances that Deplete the Ozone Layer* was negotiated and signed by 24 countries and by the European Economic Community in September 1987. The Protocol called for the Parties to phase down the use of CFCs, halons, and other man-made ODCs.

The Montreal Protocol represented a landmark in the international environmentalist movement. For the first time, all the countries party to the agreement were legally bound to reduce and eventually phase out altogether the use of CFCs and other ODCs. Failure to comply was accompanied by stiff penalties. The original Protocol aimed to decrease the use of chemical compounds destructive to ozone in the stratosphere by 50 per cent by the year 1999. The Protocol was supplemented by agreements made in London in 1990 and in Copenhagen in 1992, where the same countries promised to stop using CFCs and most of the other chemical compounds destructive to ozone by the end of 1995. Fortunately, it has been fairly easy to develop and introduce compounds and methods to replace CFC compounds.

In order to deal with the special difficulties experienced by developing countries it was agreed that they would be given an extended period of grace, so long as their use of CFCs did not grow significantly. China and India, for example, are strongly increasing the use of air conditioning and cooling devices. Using CFC compounds in these devices would be cheaper than using replacement compounds harmless to ozone. An international fund was therefore established to help these countries introduce new and more environmentally friendly technologies and chemicals. The depletion of the ozone layer is a worldwide problem, which does not respect the frontiers between different countries. It can only be affected through determined international cooperation.

As the main factors of ozone depletion are CFCs, so the ozone layer can be protected by the following two ways:

I. International programmes to reduce CFCs production.
II. Alternative technologies to replace CFCs use.

International programmes to reduce CFCs production are as follows:

a. In 1977, a review committee was set up to collect detailed information on ozone depletions under United Nations Environment Programme (UNEP).
b. To adopt any global programme on the issue, UNEP conveyed one convention in Vienna in 1985.
c. USA, Canada, Norway, and Sweden decided to control CFCs production without waiting for any international laws. These countries agreed to fix the production of CFC-11 and CFC-12 and Sweden announced to stop CFC production within 1994.
d. International real success on ozone layer protection was achieved in 1987 through the Montreal Protocol Convention. Forty nations took part in the convention and 30 of these fully agreed on the decisions. Developed countries decided to reduce CFC production step by step.

Some relaxations were granted to developing countries like India and China as use of CFCs in these countries is 0.005 g per capita whereas in developed countries it is more than a kg. It was also agreed that extra cost in using alternative chemicals to CFCs would be borne by the developed countries.

e. To review the Montreal Protocol recommendations, an international convention was conveyed in 1990 and it was realized that the developed countries could reduce CFCs production. It was also decided that within 2000, CFCs production should be reduced to zero level. In the same conference, carbon tetrachloride (CCl_4) and chloroform ($CHCl_3$) were included in band with CFCs. Therefore, a control plan is to be adopted to reduce CFCs. It has been established that if only CFC-11 and CFC-12 and Halone are banned and other CFCs (CFC-22, CFC-113), carbon tetrachloride, methyl chloroform (CH_3CCl_3) continue to be used without control, then 50 per cent of the total ozone layer would be depleted within 2075 AD.

Alternative technologies to replace CFCs uses are as follows:

a. The chemical compounds experimentally used in place of CFC-11 and CFC-12 are HCFC-123a, HCFC-123, and HCFC-141b.
a. CFCs are generally used as a computer cleaning agent. So, under technology CFC-11 can be recycled by which 70 per cent of the CFC-11would be reused.
a. CFCs are generally used for spraying of pesticides, but now spray of pesticides at high pressure has been recommended.

All these efforts to protect the ozone layer are only possible by the mutual understanding and cooperation among different nations. But the governments of the states/nations only try for the same unless and until there would be pressure from the public. But these efforts should be undertaken immediately, because already the CFC molecules, halons, and hydrocarbons, which are in the atmosphere for 25 years, depleted the ozone layer to a considerable extent and it is estimated that it will take around 100 years to rectify it.

CONCLUSION

The global energy demand is on the rise, more so in the case of developing countries like India. Energy security, which means ensuring that our country can supply lifeline energy to all its citizens, at affordable costs at all times, is a very important and significant need and is an essential step forward. Moreover, burning of fossil fuel is causing environmental degradation. Though conventional fossil fuels that provide primary energy have limited resources, coal will maintain its dominance in international energy scenario because of its huge reserves that will last for two centuries. Due to environmental concerns, various other energy options including renewable are being tried globally but they have failed to provide bulk energy at competitive cost. It has been revealed that when the oxides of nitrogen (NO and NO_2) come in contact with ozone (O_3), ozone dissociates into oxygen gas (O_2). Another very important factor is CFCs which have the power to destroy the ozone layer. The Montreal Protocol represented a landmark in the international environmentalist movement, which will go a long way to safeguard this life-supporting shield.

Depletion of the ozone layer is a very good (but unfortunate) example of human interference with the natural environment.

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