CHAPTER - I

INTRODUCTION

Energy is the single largest input contributing to the growth and development of human race. Prosperity and well being of any country is evaluated world over depending on its energy supply and consumption. The demand for energy has been increasing day by day due to the application of the ever-growing population. Hence, the increased level of energy demand requires the equivalent level of supply to meet this challenge. As a result, the energy sources are subjected to over exploitation to sustain and to continue the present growth pattern. Among the various forms of energy utilized for the present economic activity today, coal and oil are the major contributors. In fact, no energy source is found to have direct demand for it, but their convertibility into the kind of energy that provides sources to the society. Hence, though coal and oil are not directly linked to the food chain for the survival of human being, the kind of services these sources offering on combination have finally resulted in mass extraction, transportation and conversion as a major economic activity of any given country. Each phase of this whole process involves very huge investment in terms of land, finance and expertise. This complex social fabric not only enlarged the scope of various innovations but also made available a range of products for the development of the society.

Energy is the cause behind the motion of particles or objects. Energy has the capability to produce motion, force, work change in shape and change in form. Energy exists in many forms such as chemical energy (ECL), nuclear energy (ENU), solar energy (ECC) internal energy in a body (EIN), bio-energy in vegetables and animals bodies
(EBI), thermal energy (ETH) etc. The present day civilization can be termed as a civilization whose life style is so grained in unprecedented use of varied forms of energy, unknown in the annals of human history. Use of wood, charcoal, minerals, coal, fossil fuels and now atomic energy even at the risk of radiation and other dangers involved in the case had their way and now one has to come across a peculiar situation when the civilization has reached the dead end of its growth oriented living. During the last decade, elaborate thinking and world wide consciousness questioned the very idea of development and suggested the limits to growth by more pronounced calling for a halt to the indiscriminate exploitation of exhaustible energy resources and annihilation of all living beings on this planet caused by wide spread pollution.

It was only in the last decade that search for energy resources which are clean and can be renewed and even prove inexhaustible to the yearning appetite of the modern man started in developing and developed countries alike and it was not all in vain. The human in genuinity and its perceiving imagination seems to have succeeded against all darkness as such sources had not only seen identified but persistent R & D have paved the way for evolving technology to exploit abandoned energy resources like seaves, wind, sun light and biomass which can be fruitfully utilized for day to day human need and a variety of other uses of the human race, at least as a supplement energy source.

The subject of renewable energy is one of the most important talks of the day for all scientists, engineers, social scientists and environmentalists for the simple reason that the exhaustible sources of energy reserves are fast giving signals of their depleting stocks. In harnessing alternative renewable sources of energy, quality consciousness should be given the vital consideration at all stages in the implementation of renewable energy.
programme and thereby the efficiency in harnessing renewable energy could be applied to its utmost interest.

The renewable energy supply are very varied including solar heat, solar quantum effects (i.e., photovoltaic solar cells), photo synthesis, hydropower, wind, waves, tides, some geo-thermal sources and unpracticed waste disposal. Within these categories, there are many variations related much to the geographical and social circumstances. Some sources are mechanical (wind and water), some sources are photo physics (solar radiation) and some thermal.

It is stated that the renewable energy available in the environment is about 25MV per person on earth. At four percent capture efficiency, a sunlit or windy ground area of 10x10m could supply on an average of 2 KW per person. Using modern technology, 2 KW per person is considered sufficient in principle for a high standard of living.  

The other side of these scenario in non-renewable front is very much disheartening in so far as reserves of fossil fuels of coal, gas, oil, etc., are concerned. The alarming positions of these resources are very often appearing in newspapers forecasting their life to be for another 30 to 50 years.

There is no question that the new and renewable sources of energy offer a theoretical potential which vastly exceeds our present needs (150 times) and conceivable future energy needs. But to be realistic, the potential for the foreseeable future is not to of the theoretically expected level. It is believed that in the western countries, 5 to 6 percent

the energy is realized through renewable sources by the end of the century as against 2 to 3 percent targeted for our country. But even this attainment would be realized without sustained effort.

In spite of having such a vast theoretical potential of renewable energy resources, the target contemplated to be harnessed is very low. Although there is a good scope for technological progress in developing renewable energy, the technology of exploiting each sector has not been achieved. While the conventional energy sources are economical, high intensity, constant or capable of following demand, the renewable energies are for the most part costly, low intensity, variable and need some form of accumulation of the energy yielded. Capital costs are so high such as to mitigate the attraction of costless primary energy. But one must take credit of the fact that the renewable technology has the potential which is more that can be said for nuclear energy.

Some 30 years ago, nuclear fission was an alternative energy; but today, it is conventional energy, which provides for considerable proportion of the total energy needs. Nuclear fission is now the most economic method of generating electricity, but it was not so 30 years ago. It was only when the first oil shock occurred in 1973, nuclear electricity was ready to play a major role in helping to reduce dependency upon imported oil.

The energy issue cannot be resolved within the sphere of energy per second, demographic factors, rates of industrialization and urbanization, changes in agricultural and transport production systems and above all technical innovation that demand greater or lesser energy input, all contribute as basic building blocks of the energy future.

2. K.N. Roy (1992), Ibid, P.324
Although it is difficult to predict the particular nature of that future, it is worth emphasizing at the outset, that four major environmental issues underline possible energy paths. These four issues are (a) the procurement of household fuels particularly fire wood in the third world. (b) The increasing threat of acidification especially in the temperate ecologies of the northern hemisphere. (c) The serious and plausible threat to economic development created by the climate change associated with fossil fuel usage. (d) The problem of nuclear waste disposal. The feasibility study undertaken on energy projection of the global end use analysis highlights the importance of incorporating more energy efficient technologies and processes in the existing system of industry and transport sectors. A broad analysis would suggest that if such technologies were used, energy consumption would increase by 30 per cent by 2020 in developing countries and decrease by 50 per cent in developed countries. The above position is illustrative of the fact that energy needs of the future are required to be planned right now to overcome the disastrous days ahead.

1.1 ENERGY NEEDS IN DEVELOPING COUNTRIES

Bio fuels like fuel wood, crop residues and animal dung which are also categorized as non-commercial fuels account for 60-70 per cent of energy consumption in rural areas of developing countries and account for 25 to 30 per cent of the total energy consumption in the developing world. Africa is the most dependent on non-commercial fuels followed by Asia and Latin America. In view of fossils fuels not being in abundant supply, dependence on non-commercial fuels is likely to continue undiminished in rural areas.

3. N.K. Roy (1992), Ibid, P.325
areas and with prospects of conventional energy supplies substituting them is not rated very bright. Given this scenario, households are constrained to burn fuel wood or during cakes, which apart from causing deforestation or depriving soil of valuable nutrients also cause eye, throat and lung diseases from the resulting smoke. Biogas provides effective solution to non-availability of fossil fuels and environmentally harmful burning of dung cakes. Biomethanation reduces fuel wood consumption and helps to conserve continuously depleting forest resources which, if not checked, may cause soil-erosion, flash floods, land slides and river inundation in plains. In the context of controlling deforestation, renewable energy sources like biogas assume considerable significance. Within few decades, the fluid hydrocarbon, oil and gas will no longer be available in unlimited amount as energy sources. This anticipation is based on global trends and rapidity expanding global population especially in areas where economic development is seriously hampered following inadequate availability a commercial energy and the increasing dangerous pollution of the atmospheres by human activity.

The number of people on earth increase by almost 90 millions each year. In 1994 the world population was 5.66 billion which has risen to 6 billion in the year 2002 which may further increase to 8.5 billion by 2025 and 10 billion by the year 2050. India’s population which stood at 89.66 crores in 1993-94 is 102 crores in 2000. It will increase to 108.2 crores by 2006 and 139.6 crores by 2025.\(^5\) Needless to emphasize that a slower global population growth will relieve pressure on environment, energy and food needed for human subsistence. This will compel among others fostering sustainable use of energy

and promoting a diverse and vigorous natural environment. Biomethanation, which is a non-conventional energy technology, not only augments energy supplies in energy deficient rural areas but also saves environment degradation.

1.2 ENVIRONMENTAL AND EFFICIENCY IMPLICATIONS

Biotechnology occupies a unique position in applied sciences in its effort to enhance the quality of human life and improve the living conditions through the development of bio-derived products. In recent past, an ample attention has been focused on environmental quality and environmental biotechnology has emerged at a time when deterioration of environmental health has come to an all time high. It attempts to exploit some of the basic biological processes in a cost effective manner towards the amelioration of the degrading health and ecological resources.

The quality of life on earth is linked inextricably to the overall quality of the environment sustaining it. Pollution is the condition which disturbs this harmony. It is considered as the effects of misplaced resources generating unfavorable conditions that threaten the very fabric of bio-sphere. Although pollution is concomitant with the advancement of human civilization, yet it did not cause such a concern as in the last few decades. We have now entered the new millennium without the necessary ecological wisdom and this may result in jeopardising the quality of life of our future generations. The onslaught on the environment came through increased population pressure leading to over exploitation of land, air and water resources, destruction of bio-wealth and biodiversity (which maintains the ecological balance), and injection of various hazardous xenobiotic
The enormity of the problem has drawn global attention in recent years for finding ways to sustain and manage the environment. It has put forth a challenge to environmentalists, scientists, technologists, politicians and socio-economic reformers as well. The question of sustainable development (a slogan coined by the world commission on environment and development) has emerged which requires judicious use of nature without compromising on its capacity to meet the future needs. This calls for newer approaches towards developmental activities and technologies so that eco-health is preserved along side conservation of invaluable natural resources. Even though nature took thousands of years to create these resources of life-support, it however took a couple of centuries for man to destruct the same.

Scientific endeavour, however has changed its direction and technical approach from time to time for ensuring greater human welfare. The emerging science of biotechnology is certainly an essential tool in this endeavour as it can provide new approach for understanding, managing, preserving and restoring the environmental quality. Biotechnological methodologies can be suitably utilized to assess the well being of ecosystems, transformation of pollutants into benign (harmless) substances, generation of bio-degradable materials from renewable resources and development of eco-friendly manufacturing and disposal processes. All these aspects come under the preview of environment bio-technology.

The first significant change in man’s effect on nature came with his discovery of fire. Pre-historic man built a fire in his cave for cooking, heating and to provide light.
The problem of air pollution came into existence at this time. The problem becomes significant since the industrial revolution in the 19th century. Almost all air pollutants are the result of burning fossil fuels, either in the home, by industry or in internal combustion engine.

There are certain modern ecologist such as Odum (1971), Southwick (1976), Smith (1977) etc., who sought many factors such as human population explosion, unplanned urbanization and deforestation, profit oriented capitalization and technological advancement which may have originated pollution crisis on earth. In fact, in countries where there have been the greatest technological advances, the worst pollution occurs. In these countries, whether capitalist, socialist or communist, there has been an emphasis on growth. Thus in well developed nations, on a per capita basis, citizens consume more food, use more pesticides, fertilizers, fuel, minerals, cars and other manufactured products of all kinds. Most of these products are manufactured in one or other kinds of industries, all of which in their turn add some pollutants in our environment and cause pollution.

Every human society, be it rural, urban, industrial and most technologically advanced society, dispose of certain kinds of by-products and waste products which when are injected into the bio-sphere in quantities so great that they affect the normal functioning of eco-systems and have an adverse effect on plants, animals and man.

1.3 BIOGAS AS A SOURCE OF ENERGY

As a viable eco-friendly alternative technology, biogas can substitute firewood for cooking and kerosene for lighting. The production and use of biogas for cooking and lighting can drastically reduce the depletion of natural resources like forests, which are
otherwise the prominent and traditional source of energy for cooking and lighting. It removes dependence on forest and enhances greeneries leading to improved environment. Additionally, slurry used as farm manure could improve soil condition and enrich it with higher quantities of plant nutrients like nitrogen, phosphorus and potash. This can boost agricultural production and conserve soil from erosion losses, while decreasing the use of chemical fertilizers. This will lead to a sustainable farming system. As biogas burns without odour and smoke, it is non-air pollutant. It improves the hygiene and health conditions of the users and their families. As even night soil can be used as raw material, the sanitation and hygiene conditions of the local areas are improved. There would be less flies and bad odours are reduced or eliminated. The substituting effect of biogas produced from different sized plants decrease the workload due to ease in cooking and quick cleaning of vessels. This is a contributing factor especially to women and children. The principal raw material being animal dung, biogas could be one viable alternative source of energy in rural areas of India where agriculture is dominated by mixed farming systems in which crop and livestock husbandry are combined. As the farming households of the region maintain a number of animals such as cows, oxen, buffalos and goats their daily dung production could be utilized for the production of biogas for cooking and lighting purposes. Biogas is produced during microbial anaerobic digestion of various organics wastes. Two types of bacteria work on the process sequentially in a digester or biogas plant. The first group is the acid forming ones, e.g., Desulphovibrio and others, while the second group is methane forming bacteria or methanogens, who break down acids in to CH4 and CO2, Methanococcus, Methanothrix etc. Biogas is essentially composed of CH4 (60per cent), the other gases like CO2, H2S and NH2 together constitute the rest. CH4 is a combustable gas which can be used for efficient cooking and lighting at home as well as for operating engines to lift the water from wells. The slurry, after digestion, on drying
can provide a good organic fertilizer helping in soil stability. India has a largest livestock population in the world at around 365 million. About one sixth of cattle, half of buffalo and one fifth of goat population in the world are in India. In 1975-76, the consumption of non-commercial energy was met by burning 30 percent of animal dung, 17 percent of agricultural waste and 53 per cent of firewood. Even though there is fall in the consumption of non-commercial energy in recent years, still our major dependence on non-commercial energy continues. With the livestock population of over 360 million, India can set up over 30 million individual biogas plants and 560000 community biogas plants at a simple norm of minimum one in each village of the country. With a modest norm of 10 biogas plants per village, it is feasible to set up some 5.5 million plants in country’s 5.6 lakh villages. If this becomes reality, it would provide at 1981-82 price level fuel equivalent to 5341 million litres of kerosene valued at Rs.5484 million and conserve organic manure to the extent of 89 million tones valued at Rs.4464 million burnt otherwise as dung cake. Effective utilization of organic wastes can yield gas equivalent of 285.5 million tones of coal, almost equal to the volume of energy consumed in the country during 1978-79. In India, it is estimated that over 30 per cent of 980 million tones of cattle dung generated annually on renewable basis is directly burnt as fuel without harnessing its full potential as gas and rich fertilizer following fermentation.

biogas production could yield energy equivalent to 30 million tones of kerosene per annum.

In developing country like India, biogas holds a good promise as an alternative source of energy, which can be harnessed successfully to meet the existing as well as future needs of rural areas. If the entire quantity of 980 million tones of dung produced in the country annually is put through biogas plants, it is estimated to provide 63750 million cubic meter of gas having 38250 million cubic meter of methane with a net heat value of $312 \times 10^{12}$ kcal$^10$ which can meet the cooking requirement of about 87.45 million families besides producing one million tone of nitrogen, one million tone of phosphate and half million tone of potash to be used as fertilizer.$^11$

It has been estimated that the construction of one million biogas plants in the country would cost Rs.300 crores and result in an annual saving of more than 4million tones of fuelwood, over 22 million litres of kerosene and about 3.42 lakh metric tones of chemical fertilizers. The total benefit to the national economy in terms of 1982 energy prices is estimated to be 176.45 crores annually.$^{12}$ Biogas technology, thus may bring green revolution in the country and help in economic uplift of people.

The importance of increasing use of renewable energy sources in the transition to a sustainable energy base was recognized in India in the early 1970. During the last quarter.

$^{10}$ TERI, Biogas Technology, (Project Sponsored by Ministry of Non-conventional Energy Sources), New Delhi, 1994.


of 19th century, a significant effort has gone into the development, trial and induction of a variety of renewable energy technologies for use in different sectors of the economy and sections of society in India.

With a strong industrial base and successful commercialization of technologies in wind, solar photovoltaics, solar thermal, small hydel, biogas and improved biogas stoves, today, India is in a position to offer state-of-the-art technology to other developing countries and is poised to play a leading role in the global movement towards sustainable energy development.

India has today among the world’s largest programmes for renewable energy. Our activities cover all major renewable energy sources of interest to us, such as biogas, biomass, solar energy, wind energy, small hydropower and the other emerging technologies. In each of these areas, we have programmes of resource assessment, R&D, technology development and demonstration. Several renewable energy systems and products are now not only commercially available but also economically viable in comparison to fossil fuels, particularly when the environmental cost of fossil fuels are taken into account.

The ministry is involved in the implementation of these programmes for development, demonstration and utilization of various renewable energy based technologies, such as solar, thermal, solar photovoltaics, wind power generation and pumping biomass combustion/co-generation, small, mini & micro hydropower, solar power utilization of biomass-gasifiers, briquetting, biogas improved chulha (cook-stove), geo-thermal for heat applications and power generation/energy recovery from urban, municipal and industrial wastes and tidal power generation.
Of the various alternative sources of renewable energy, biomass provides a cheap source of energy and particularly biogas technology with animal dung as input. Realising its importance, the advanced as well as developing countries have adopted more and more of biogas technology to meet their energy needs. Among the 45 countries in the world which are promoting biogas, China and India are the pioneering countries in the development and use of biogas technology.

Biogas technology has a multi-various benefits which cannot be directly calculated as it does not generate direct cash income. However, it involves greater financial investment which the majority of farmers in India with their meager income are not afford to invest. Hence, from the individual angle, it may appear to be an unnecessary burden. However, from social angle it will be a welfare proposition. When the multi-various benefits are estimated and taken into consideration while evaluating the feasibility of gobar gas plants it will be profitable proposition even from the individual's point. Hence, the present study has been undertaken in this direction by taking into account the social costs and social benefits.