CHAPTER-1

1.1 INTRODUCTION

In a country the electrical energy consumption is an important parameter which represents the economic growth of the country. At present, India’s electrical energy requirement is much more than the electrical energy being produced. An effective management of the available resources would be necessary to meet the energy requirement of the country. The conventional fuel resources have been found to be depleting very fast, a need has been felt of some renewable form of energy which could add to the energy mix of India. The energy being derived from the renewable sources has been found to vary depending upon the climatic conditions, geographical landscape and the natural resources available in a particular region. A need has therefore been felt to determine which renewable energy resources should be given priority so that a strategic decision could be taken which will help the policy makers and private entrepreneurs to finance such projects. Thus it would be possible to derive the maximum benefit out of the available renewable resources in shortest period of time.

Power sector is the driver of growth of the country. India has an inadequately developed infrastructure in respect of electrical energy. About two billion population of the world is reported to have no access to enjoy the benefits of electrical energy. In India, about 360 million people are still deprived of enjoying direct benefits of electrical power.

The overall power shortage in the country is 7.2 percent and the peak load power shortage is about 11.2 percent (MoP website, 2010). This is likely to have a worsening trend because the ever increasing demand is
more than what we are able to add to the power generation capacity. The quest for safe, secure and sustainable energy poses one of the most critical challenges of our age due to grave concern for climate change and this can be achieved through new and renewable sources of energy plus large and small hydro power plants. This is also partly achievable, to some extent, through adopting various energy efficiency measures including energy management and energy audit.

According to the sources of Bureau of Energy Efficiency (BEE), power saving through various efficiency schemes has been up to an extent of 814.4 MW during 2007-08 and 1505 MW during 2008-09 respectively (BEE report, 2007-08, 2008-09). The trend is on the increase for the current financial year. According to Ajay Mathur, Director General (BEE), improvements in the energy efficiency will save India an estimated 1200 million dollars a year (BEE report, 2008-09).

Cost of generating new energy is three times the cost of various measures of saving energy. According to a World Bank study, India can reduce its annual electricity usage by 183.5billion kWh by investing 10 billion dollars in energy efficiency improvement measures. The installed capacity of India is about 150 GW and the actual need is about 167 GW. Thus there is a deficit of about 17 GW at present. The power which is extracted from the renewable resources is about 15,695MW (MNRE report, 2009-10). We therefore, see that the total requirement of energy can’t be met by the renewable energy sources alone. The renewable sources of energy can be used to meet part of the peak energy demand but it cannot meet the total demand.

The electrical energy consumption by the consumers is directly dependent on the GDP of the country, average temperature of the country,
cost of the energy etc. The green house gases (GHG) emissions which are produced as a result of power plants, transport sector, industries etc. lead to increase of the global temperature over the last few decades. This is causing much concern to a few countries like Maldives, Fiji and Bangladesh which is likely to face grave consequences as a result of the global temperature rise as per the report of IPCC. The GHG emissions reduction has, therefore, become very important.

The GHG emissions are mostly contributed by the transport sector and then comes the power sector. In India, the major part of electricity generation is based on coal which comprises about 66% of the total installed capacity (IEA, 2006). Thus, the coal contributes a major portion of the GHG emissions. Up to 2012, the trend of coal consumption is likely to increase due to the growing demand of power with the growth of the country. The current policy of the country permits the use of coal in the country. Thus by 2012, the coal consumption will be 1.46 times the coal consumed in 2008. As the GHG emission is directly proportional to the coal consumption, the GHG emission will also increase by 2012 at an alarming rate. At present India is fifth in terms of GHG emission producing countries in the world (EIA, 2007). But with the present rate of rise of GHG emission the contribution of India will be third by 2012. The global GHG emission has been increasing since 2000 at an alarming rate which has been causing global warming, resulting in many disasters such as- floods, melting of glaciers, drought, and ecological changes as seen in different parts of the world.

According to the Kyoto Protocol (KP) an agreement has been made in which emission reduction is imposed on the developed countries up to 2012 (CDM, 2007). Some of the developed countries had reduced the GHG
emission while other countries like USA is still not ready to agree with the conditions imposed by Kyoto Protocol. This is thus delaying the mission of global emission reduction. The powerful nations having more than 33% of the total global power consumption are not agreeing to decrease their country’s economic growth at the cost of global GHG emission reduction. The developing nations having fast growth of economy such as China, India, Brazil etc. will come under this agreement by 2012 A.D. As the GHG reduction policies are implemented in these countries, alternative sources of energy such as renewable energy sources (RES), fuel cells (FC) etc. need to be implemented in both domestic and commercial sector. According to the Bali convention held in December 2008 in Indonesia in which about 190 countries participated and there it was decided that by 2013 A.D. the countries who are producing GHG emissions higher than the 1990 emission level will have to sign the agreement to meet the cause of global concern i.e., global warming.

World over, the fuel on which the global installed electricity generation depends is oil which is nearly 40% of the total fuel consumption (EIA, 2007). The oil is preferred as it is a clean fuel. Next to it is coal which is less than 30% of the total fuel consumption which is increasing at the rate of 2.5% annually (IEA, 2006).

In the third chapter, the clean development mechanism has been discussed. The clean development mechanism (CDM) can be considered as one of the measures that can be used for GHG emission reduction in the developing countries like India (IPCC, 2005). India has bagged about 123 projects out of 824 CDM projects. Whereas China has attracted CDM projects three times more than that of India (IPCC, 2008). The CDM projects are likely to produce sustainable economic development in the country in the long run and also it will help in emission reduction (CDM,
An effort has been made in this thesis to determine the CDM potential of wind, biomass, small hydro and bagasse based cogeneration in India using technology diffusion models.

During the literature survey it has been found that in India renewable energy based grid-connected power plants are limited and there is a pressing and urgent need for research and development in this field. Feasibility study of grid connected power plants based on wind, small hydro, bagasse based cogeneration, bio mass based gasifiers has been carried out in this investigation and the results have been found to be satisfactory over a period of projected ten years using statistical analysis. There are two types of grid connected (GC) systems. In the first type, the grid connected system’s main priority is to cater the local needs for electricity and the surplus generation will be fed into the grid and when there is shortage of electricity it is drawn from the grid. The other option is utility scale, wherein decentralized stations are managed by the utilities in the same way as large electric power plants. Any output of the GC system is fed into the central utility grid without paying heed to the local needs (Kaundinya, 2009). The connectivity to grid enables setting up relatively large scale systems and hence they can operate at high plant load factors improving the economic viability of the operation. In a GC system the power system itself takes care of seasonal load variations, as a result of which the overall efficiency of a GC system is found to improve over the stand-alone (SA) system.

For systems operating on renewable sources like biomass, wind and solar photo voltaic (SPV) there will be a high pressure on these renewable sources as the system usually operates on large scales and would need more biomass for its operation (MNRE draft report, 2002-07).
The SA systems produce power independently and are not connected to the utility grid hence they are called stand alone plants. These are more suitable for remotest locations where it is difficult to access the grid and there is no other source of energy. Stand alone systems comprise mainly of photo voltaic installations in remote regions of the world, as they are often the cost effective choice for locations situated far from the utility grid. The SA system suffers from innate disadvantages like low capacity factor, excess battery costs and finite capacity to store electricity forcing to throw away the extra energy generated (Kaundinya, 2009). In the SA system the operational capacity is matched to the demand. The SA systems are ideal for locations where the system is required to operate at low plant load factor.

According to the 2001 census of India (Census India website, 2001) there are still 78,245 villages out of 5, 87,258 villages in India that do not have electricity. By the end of the tenth five-year plan, 60,245 villages will be electrified using conventional means by connecting the villages to the power grid. For the remaining 18,000 villages, which are remote and hence cannot be connected to the grid, the sole options are the non conventional sources of energy (Kaundinya, 2009).

In the tenth five year plan the MNRE (Khan, 2005) proposes to electrify 5,750 such remote villages through SPV power, biomass-generated power and small hydro power.

India is a tropical country with a vast geographical area which is richly endowed with renewable energy (RE) sources such as solar, wind, biomass, small hydro, energy from waste etc. It can play a crucial role in meeting end use energy needs in a decentralized manner. It is known that the energy requirement in India is steadily increasing and this requirement is being met by both conventional and RE sources. India today has a total
installed capacity of about 15,695 Mega Watts of power from renewable resources (MNRE report, 2009-10). The share of renewables is around 10% of the total installed capacity in India. Contribution in electricity generation during 1999-2000 was 4, 99,450 GWh from commercial sources and 1,699 MW from RE sources (Khan, 2005). We have achieved about 64.7% increase of renewable power generation during the past ten years.

The second chapter presents the energy scenario the world over in general and in India in particular. The growth of energy usage and its projections has also been discussed. The comparative study of conventional and non-conventional energy sources is carried out on the basis of the data available from the Ministry of New and Renewable Energy and Energy Information Administration report respectively (IEA 2006; MNRE report, 2009-10). The projected energy usage by 2020 A.D. using the technology diffusion models which can be used for projecting up to 2100 A.D. or further has also been presented in second chapter. The increase in the conventional fuel usage in the next few years is expected to maintain the present economic growth rate of the country. But the limited supply of conventional resources such as coal, oil, gas etc. has been responsible for the increase in the cost of these fuels on one hand and faster extinction of these fuels (from earth) on the other. This is a growing concern for both developed and developing countries. There is, therefore, a search for alternative forms of energy which are not exhaustible in the long run. The various options which are feasible are considered such as renewable sources, fuel cells, solar photovoltaic sources etc. The contribution of different sectors (such as central, state and private) has been studied and their effect on the type of the fuel used for energy production has been found. The nature of the past energy consumption
pattern has been studied and the nature of the energy consumption for the future has been predicted. The GDP growth rate has also been studied and a methodology of energy adoption has been suggested without affecting the economic growth of the country. It has been found that the calorie consumption per person of developing countries does not have a direct correlation with the total energy production as has been observed in the neighboring countries. There is a large difference in the energy consumption per person in the developing and developed nations respectively. A joint effort should be made globally to reduce the gap between these two types of nations. The green house gases producing fuels mainly the coal consumption has been analyzed in this chapter for the last three decades and the forecasting for next decade i.e., up to 2020 A.D. has been presented and compared with 2005 emissions and important conclusions have been drawn. On the basis of these conclusions the country policy on coal consumption could be made for the next five year plan (2012-2017) so as to maintain the growth of the country and still reduce the GHG emissions. The other sector which is also a major contributor to the GHG gases is the transport sector. The transport sector mainly uses the fossil fuels. The cost of which has been continuously increasing in the last few decades and a further increase in the cost in the next decade has been expected. In order to maintain the growth of the country and without affecting this sector new alternative method need to be developed to replace this fuel. In this chapter, the fuel cell technology and battery operated vehicles (BOV) have been discussed and in the subsequent chapter the analysis of dissemination of the BOV in the rural and the urban places has been presented. The reduction of GHG emissions in the atmosphere by the use of BOV is possible. A need has been felt to improve the battery technology and thereby increase its life. There has also
been a need of decreasing the charging time of the battery for increasing the use of BOV in the society. The cost of the BOV will decrease if it is adopted by a large number of people which has not been observed in Lucknow since 2008 and it seems that it might not be adopted in the near future, unless the battery technology gets matured and the relaxation of excise duty by the government is given on such vehicles.

The third chapter deals with the clean development mechanism (CDM) and its effect on the country’s economy and environment. The pros and cons of the implementation of the CDM based renewable energy technology has been discussed. The GHG emissions, their causes and the means of reducing it have also been discussed. The GHG reduction could be achieved by incorporating the CDM projects. By estimating of GHG reduction potential we could directly determine the CDM potential in India. The climate change has been man-made due to human deeds such as deforestation, industrialization, pollution etc. which has been affecting the whole world in some way or the other. There has been a need for collective effort to protect the world and its inhabitants. Many target oriented agreements have been held in Kyoto, Bali and Copenhagen respectively.

In the fourth chapter, the different technology diffusion models have been discussed. The forecasting methods and their empirical relations have also been explained. The forecasting accuracy and the testing of technology diffusion models have also been discussed.

The fifth chapter also deals with case studies carried out in villages of Barabanki and Lucknow. The techno economic analysis of the battery operated scooter and motor cycle has been analyzed and prediction have been made. The study of solar home lighting system has been made for the
rural areas and important conclusions have been drawn using technology diffusion model.

In the sixth chapter, diffusion models and their implementation for evaluating the growth rate of energy generation based on renewable energy sources has been presented. Different growth rates corresponding to different RE sources have been observed. The growth of energy usage has been determined. Using MATLAB programming the growth rate of energy usage has been obtained, analyzed and compared with the practically obtained values. The feasibility study of technology diffusion models has been performed using correlation formula and satisfactory results have been found. The GHG reduction potential in India using renewables has been determined in the year 2020 A.D. Using technology diffusion models the prediction of the power generation from the renewable energy sources namely: wind, small hydro, biomass and bagasse based cogeneration up to 2020 A.D. and for long term up to 2050 A.D. has been made. On the basis of it suitable policy formulation could be made to promote a particular technology. The results of different models have been compared and it has been found that the renewable power is likely to increase in the next ten years. The models used have shown a high positive correlation with respect to the actual values over a period of time. It has been observed that as the period of prediction is increased the correlation between the predicted and the actual values are also increased. This shows that the models are highly reliable for prediction purposes and can be used for forecasting of the renewable power generation. Out of the three models used in the present work the logistic model has been found to be the best for prediction purposes.

The seventh chapter concludes the results obtained from the different models. The forecasted result reliability and its applications are
also discussed. The pollution mitigation using renewable sources up to 2020 has been predicted. The results obtained from the different models are determined over a span of 20 years up to 2020. The future scope of the research work has also been discussed in last chapter.