HARNESSING RENEWABLE SOURCES OF ENERGY IN SOUTH ASIA: CASE STUDY OF INDIA

Dissertation submitted to the Jawaharlal Nehru University in partial fulfillment of the requirements for the award of the degree of

MASTER OF PHILOSOPHY

SUBRATA KUMAR BEHERA

SOUTH ASIAN STUDIES DIVISION
CENTRE FOR SOUTH, CENTRAL, SOUTH EAST ASIAN AND SOUTH WEST PACIFIC STUDIES
SCHOOL OF INTERNATIONAL STUDIES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI – 110067
INDIA

2003

Dedicated to
My
Parents

जवाहरलाल नेहरू विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI-110067

SOUTH ASIAN STUDIES DIVISIONCENTRE FOR
SOUTH, CENTRAL, SOUTH EAST ASIAN AND
SOUTH WEST PACIFIC STUDIES,
SCHOOL OF INTERNATIONAL STUDIES.

CERTIFICATE

Certified that the dissertation entitled **"HARNESSING RENEWABLE SOURCES OF ENERGY IN SOUTH ASIA: CASE STUDY OF INDIA"** submitted by **SUBRATA KUMAR BEHERA** in partial fulfillment of the requirements for the award of the degree of **MASTER OF PILOSOPHY** of this university is his own work and has not been submitted for any other degree to this university or any other university.

We recommend that this dissertation may be placed before the examiners for evaluation.

PROF. UMA SINGH
(Chairperson)
Centre for South East and
South West Pacific Studies
School of International Studies
Jawaharlal Nehru University
New Delhi-110067

PROF. I.N. MUKHERJI
(Supervisor)
Centre for South, Central South East
and South West Pacific Studies
School of International Studies
Jawaharlal Nehru University
New Delhi-110067

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abbreviations

ADB	:	Asian Development Bank
BAU	:	Bangladesh Agricultural University
BCSIR	:	Bangladesh Council of Science and Industrial Research
BDTCs	:	Biogas Development and Training Centers
BFRI	:	Bangladesh Forest Research Institute
BPDB	:	Bangladesh Power Development Board
BRAC	:	Bangladesh Rural Advanced Committee
BUET	:	Bangladesh University of Energy and Technology
CARD	:	Centre for Research and Development
CASE	:	Commission for Additional Sources of Energy
CBP	:	Community and Institutional Biogas Plant Programme
CDM	:	Clean Development Mechanism
CEB	:	Central Electricity Board
CEB	:	Ceylon Electric Board
CES	:	Centre for Energy Studies
CII	:	Confederation of Indian Industry
CMES	:	Centre for Mass Education in Science
CMIE	:	Centre for Monitoring Indian Economics
CSE	:	Centre for Science and Environment
C-WET	:	Centre for Wind Energy Technology
DANIDA:		Danish International Development Agency
DGNRER:		Director General office of New and Renewable Energy Resources
DME	:	Department of Mechanical Engineering
DNES	:	Department of Non- conventional Energy Sources
ERM	:	Environment Resource Management
FAO	:	Food and Agricultural Organisation
FYP	:	Five Year Plan
GEF	:	Global Environmental Forum
GNI	:	Gross National Income
GoB	:	Government of Bangladesh
GoI	:	Government of India
HMG	:	His Majesty's Government

IBP	:	Institutional Biogas Plant
IDA	:	International Development Agency
IEA	:	International Energy Agency
IFRD	:	Institute of Fuel Research and Development
IIS	:	Indian Institute of science
IITs	:	Indian Institute of Technologies
IREDA	:	Indian Renewable Energy Development Agency
IREP	:	Integrated Rural Energy Programme
ISCC	:	Integrated Solar Combined Cycle
JICA	:	Japan's International Cooperation Agency
KW	:	Killo Watt
LGED	:	Local Government Engineering Department in Development of Sustainable Technology, Bangladesh
MAT	:	Minimum Alternate Tax
MEMR	:	Ministry of Energy and Mineral Resources, Bangladesh
MNES	:	Ministry of Non-conventional Energy Sources
MW	:	Mega Watt
NABARD:		National Bank of Agriculture and Rural Development
NBGP	:	National Biomass Gasifier Programme
NCAER:		National Council for Applied Economic Research
NEP	:	National Energy Policy
NERD	:	National Engineering Research and Development
NGOs	:	Non-Governmental Organisations
NIST	:	National Institute of Silicon Technology
NPBD	:	National Project on Biogas Development
NPBP/C:		National Programme on Biomass Power/Co- generation
NPIC	:	National Programme on Improved Chulhas
NRDC	:	New and Renewable Energy Development Centre
PCAT	:	Pakistan Council of Appropriate Technology
PCSIR	:	Pakistan Council of Science and Industrial Research
R&D	:	Research and development
RBI	:	Reserve Bank of India
REB	:	Rural Electrification Board
RECAST:		Research Centre for Applied Science and Technology

REDA	:	Renewable Energy Development Agency
REI	:	Renewable Energy Institute
RERC	:	Renewable Energy Research Centre
RET	:	Renewable Energy Technology
RIS	:	Research Information System
RONAST	:	Royal Nepal Academy for Science and Technology
SAARC	:	South Asian Association for Regional Cooperation
SACs	:	South Asian Countries
SDA	:	Sustainable Development Agreement
SEC	:	Solar Energy Cent re
SELF	:	Solar Electric Light Fund
SERC	:	Solar Energy Research Centre
SHP	:	Small Hydro-Power Programme
SHYDO	:	Small Hydropower Development Organisation
SNAs	:	State Nodal Agencies
SPVS	:	Solar Photo Voltic System
SSS-NIRE	:	Sardar Swaran Singh National Institute of Renewable Energy
STS	:	Solar Thermal System
TERI	:	Tata Energy Research Institute
UNDP	:	United Nations Development Programme
UNFCCC	:	United Nations Framework Convention on Climate Change
USAID	:	United States Aid for International Development
VAT	:	Value Added Tax
WAPDA	:	Water and Power Development Authority
WEC	:	World Energy Council
WECS	:	Water and Energy Commission Secretariat
WII	:	Winrock International India

ACKNOWLEDGEMENTS

I am grateful to the persons and institutions who have contributed for this work. First of all, I express my deep gratitude to my respected supervisor Professor I.N. Mukherji, whose guidance, suggestions and constructive comments helped me in producing this work. I am also thankful to the faculty members of South Asian Studies Division for their cooperation.

I am indebted to my parents for their every kind of support and blessings. My heartfelt thanks goes to my loving younger brothers Tulu and Dilu for their emotional support and encouragements.

I express thanks to the library staff of the Jawaharlal Nehru University, Centre for Science and Environment (CSE), Tata Energy Research Institute (TERI), SAARC Documentation Centre, South Asia Foundation Information and Documentation Centre, Institute for Defence and Strategic Analyses, Asia Pacific Centre for Transfer of Technology, The world Bank (New Delhi), Ministry of Nonconventional Energy Sources and Ministry of Environment and Forests of the Government of India for providing necessary facilities for this work.

My thankful words go to my seniors Vivek, Deepender, Pabitra, Prasanta, Aakash and Devendra for their help moral support. I am also thankful to my roommate Anindya brother like seniors Chitta Bhai, Nihar Bhai, Sumanta Bhai, Gyana Bhai and Srikanta Bhai for their suggestions and help.

I am greatly indebted to Baboo Bhai, Kuni Bhauja and Kaka (G.R. Majhi) who stood beside me holding my hands in the most crucial moments.

I am very much thankful to my friends Sarita, Jyoti and Jayanta for their help and constant emotional support.

It is very difficult to find words to acknowledge the contribution of my senior-brother Partha Bhai, without whose help it was difficult to finish this work in time.

Finally I acknowledge that, I shall be responsible for all sorts of omissions and commissions in this work.

21st July 2003 **SUBRATA KUMAR BEHERA**

New Delhi

Chapter – I

I

INTRODUCTION

Energy is one of the most crucial inputs for human's development. From the very inception of mankind, energy has been used for his/her day-to-day needs. Wood is perhaps the first source of energy known to mankind. From the ancient period upto now, wood has been utilised primarily for cooking, heating and lighting purposes. Although diversified sources of energy have become available now a days, yet wood constitutes a considerable share of energy sources. After the use of coal, industrial revolution occurred in Europe. And this revolutionised the state of affairs of the whole world. Now, diversified sources like coal, petroleum, electricity, natural gas and other non-conventional energies like solar, wind etc. are in use. However, a major share of world's commercial energy need is fulfilled by fossil fuel and it will remain so for next few decades. According to International Energy Agency (IEA), fossil fuel will account over 90% of the world primary energy demand to 2030.[1]

According to the World Bank sources, fossil fuel constitutes 87.6 percent of the world's total commercial energy consumption.[2] While coal is more or less distributed in the world, petroleum is mostly concentrated in the Middle Eastern regions. Therefore, the importance of that region is higher than any other region especially for the most user of petroleum products like USA and Japan. Wars have been fought in this region to get hegemonic access to oil. Middle eastern region has been the most conflictual zone for decades mainly for its fossil fuel reserves. After decolonisation, rapid development process was started in the decolonised countries. This increased the demand

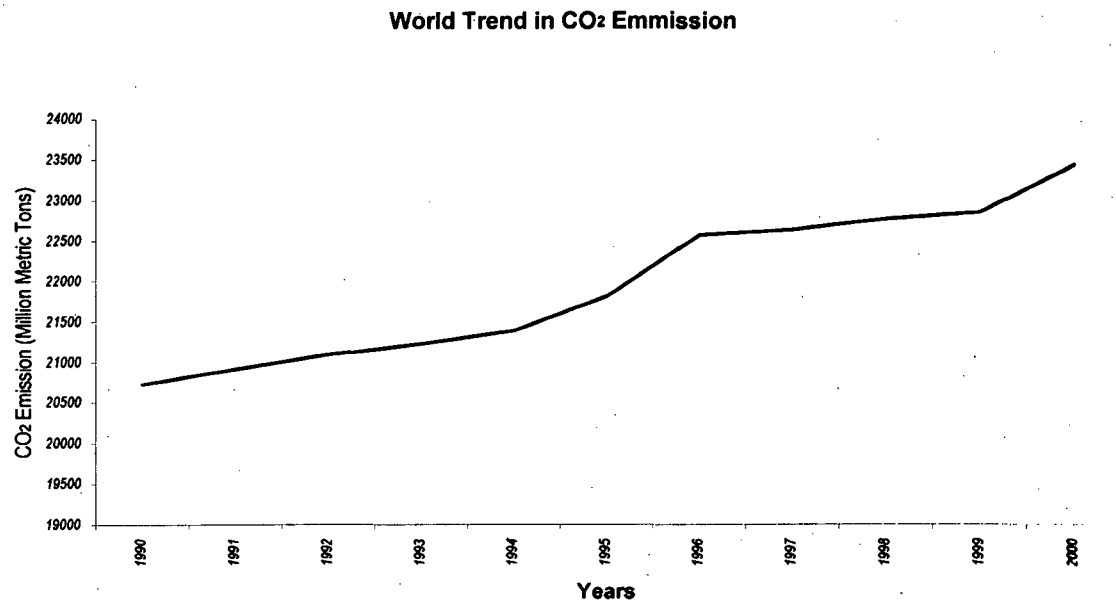
[1] International Energy Agency (IEA), *World Energy Outlook 2002: Highlights* (Paris: IEA, 2002), p. 27.
[2] Calculated from IEA, n.1, p.26.

for the fossil fuel tremendously. As the population rose, so also transport and industry ultimately deepening the demand for more energy.

1.1. Energy and Environment

Large scale use of fossil fuel has hazardous effects on the environment. The use of fossil fuel generates gases like carbon monoxide, carbon dioxide, sulphur dioxide and other such toxic gases. These gases released to the atmosphere cause numerous respiratory diseases and the most hazardous effects of these gases are on the ozone layer. Ozone layer in the upper atmosphere which saves the earth from the ultra violet rays of the sun is being depleted slowly in recent years as a result of large scale emission of these gases which are otherwise known as Green House Gases (GHG). The emission of carbon dioxide, the major constituent of the GHG has risen to 23422.3 million tons in 2000 from 20720.7 million tons in 1990.[3]

Figure 1.1



Source: IEA,CO_2 Emission from Fuel Combustion 1971-2000: Highlights (Paris: IEA, 2002), p.52

[3] IEA, *CO_2 Emission from fuel combustion 1971-2000: Highlights* (Paris: IEA, 2002), p.52.

Seeing the degrading environment, analysts have linked environment with 'security'. It is true that if one's living environment is unsuitable, then how can he/she survive and lead a healthy life? This type of security, known as environmental security, is one form of non-military security. Environmental security as a non-military security was first time officially recognised in the International Conference on the Relationship between Disarmament and Development, convened by UN General Assembly in New York from 24th August to 11th September 1987.[4] Large scale emission gives rise to the problem of climate change. These types of problems can't be solved by any one country. It can only be fought by combined effort from all countries of the world. Although a number of initiatives have been taken in recent years in global arena, little of these have been effective. For example, the Kyoto Protocol, has not been signed by USA which is the largest user of fossil fuel and account for about one fourth emission of carbon dioxide of the world.

1.2 Case for Renewable Energy

As the development process continues, the energy demand is increasing throughout the world. According IEA, total primary energy supply in the world increased 15 percent during 1990-2000.[5] Further, the energy used traditionally for centuries and decades are limited. This mainly includes fossil fuels like coal and petroleum. It takes millions of years for the earth to transform organic materials to coal and petroleum. Over exploitation of these fossil fuels will result in complete depletion of these fuels although not in very near future. The simple logic is that, these fuels are limited while demands are

[4] Deepender Kumar, "Redefining Security: An environmental approach", *Journal of Peace Studies*, Vol.10, no.1, Jan-March, 2003, p.40.
[5] IEA, n.3, p.64.

unlimited. This has captured the minds of world citizens in recent years. Proved reserves of fossil fuel is given in table1.1.

Table 1.1
Proved Reserves of Fossil Fuels

	(oil)		(natural gas)		(coal)	
Region	Reserves (Gt)	Share (%)	Reserves (10^9 cubic feet)	Share (%)	Reserves (Gt)	Share (%)
North America	4.9	3.8	259.8	5.2	249.2	24.0
Latin America	17.7	12.5	268.5	5.4	11.4	1.1
OECD Europe	2.2	1.7	191.1	3.8	96.9	9.3
Non-OECD Europe	8.1	5.8	2017.8	40.2	315.5	30.4
Middle East	89.6	65.8	1581.0	31.6	0.2	<0.05
Africa	8.2	6.2	343.5	6.9	62.1	6.0
Asia and Australasia	6.0	4.4	354.5	7.2	303.9	29.2
Total world	136.7	100	5016.2	100	1039.2	100
OECD	7.3	5.7	474.8	9.5	438.0	42.1
OPEC	104.9	76.5	2020.4	40.3	---	---

Source: Alan William and Mohammad Aslam Uqaili, "Sustainable Energy Development", in J.C. McVeigh and J.G.Mordue (ed.), *Energy Demand and Planning: Watt Committee Report Number 31*, (London: E& FN Spon, 1999), p.68.

Another fact is that these resources are non-renewable, i.e., these can't be produced again and again. In recent years alternative forms of energy have been sought which are environment friendly and are renewable in nature. These are the energy that are perennial in nature and which is to stay until the earth exists. Some of these are solar energy, wind energy, hydropower, ocean energy, geothermal energy, etc.

1.2.1 Solar Energy

The earth receives solar energy as a result of radiation from the sun. The amount of energy received by the earth is 10,000 times the current use of mankind.[6] But human beings have to exploit this energy by proper method and technology. Solar energy has been used for ages for drying purpose since the inception of the earth and human kind. In recent decades man has tried to exploit this energy resource for other purposes like lighting, electricity generation etc. The incidence of solar energy in various parts of the earth depends upon number of factors like latitude, the season and altitude. Unlike the fossil fuel, every country of the earth receives the solar energy in different degrees. It has relatively low intensity, with a peak of about 1 kw/sq.m at sea level.[7] R&D has been done in the past 20 years to develop technology and enhance its application in a profitable manner. Several types of solar technology have been developed throughout the world. Some of these technologies are now fully commercial and are available in the market for general public. Normally solar energy is used for heating and generating electricity. Electricity is generated from solar energy generally through two routes. One is solar photovoltaic (SPV) technology and another solar thermal power (STP) technology. In the former solar radiation is directly converted to electric energy by solar panels and in the latter, solar energy is converted first to heat energy and then to electric energy. This source of energy is environment-friendly because it has no toxic by-products.

---

[6] Alan William and Mohammad Aslam Uqaili, "Sustainable Energy Development", in J.C. McVeigh and J.G.Mordue (ed.), *Energy Demand and Planning: Watt Committee Report number 31*, (London: E& FN Spon, 1999), p.73.

[7] World Energy Council (WEC), *New Renewable Energy Resources: A Guide to the Future* (London: Kogen Page, 1994), p.26.

1.2.2. Wind Energy

Wind is the result of heating of the earth by the solar radiation. The intensity and the speed of the wind vary from region to region. Normally coastal areas and hilly areas receives good amount of wind. Wind energy has been used for centuries, mainly for pumping water. Only in recent years wind energy has been used for generating electricity. Most of the installed capacity in wind energy sector has been in the developed nations of Europe and America. The top five wind energy installed countries and the installed capacity is given in the table 1.2.

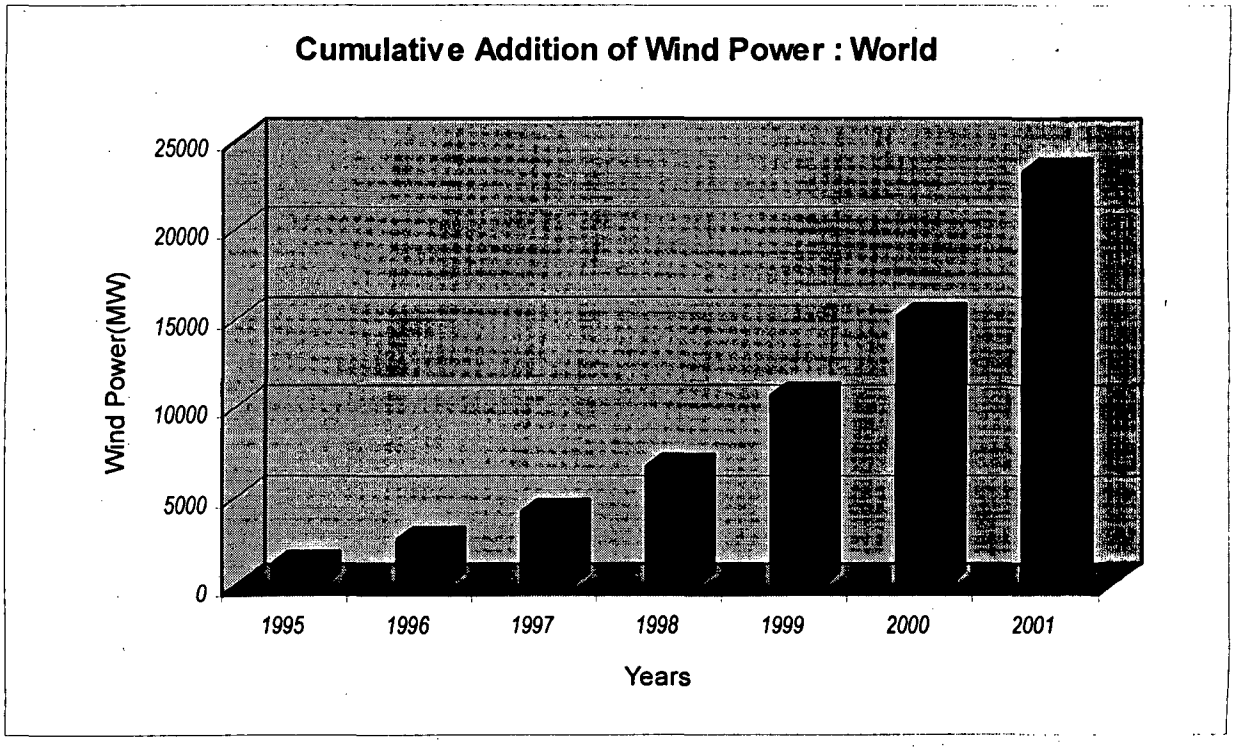
Table 1.2

Top Five Wind Power Installed Countries

Country	Cumulative installed wind power capacity (MW) till 2001
Germany	8,100
USA	4,240
Span	3,175
Denmark	2,417
India	1,426
Other countries	3,912
Total	**23,270**

Source: Paper presented by M/s Suzlon Energy Ltd., Pune, "Wind Energy- An Alternative Source of Energy" at the Joint-Indo-German workshop on wind energy utilization at Delhi, 29-30 January 2002.

Figure 1.2



Source: Paper presented by M/s Suzlon Energy Ltd., Pune at the Joint Indo-German Workshop on Wind Energy Utilisation, New Delhi, 29-30 January 2002.

1.2.3 Hydropower

The use of hydropower is quite old in comparison to other renewable sources of energy. In the year 2000 hydropower contributed about 2.5 percent of world's total primary energy supply.[8] Hydropower is often generated by building large dams on the course of rivers. These dams have some negative impacts. Lots of people are displaced. Small hydro power facilities have lower environmental impact than similar very large projects. They are less disruptive of the local land use and environment than larger facilities. Because of the traditional nature and some of the negative impacts, only small hydropower is

[8] Calculated from IEA, n.1, p.26.

considered as renewable form of energy. Hydropower upto 10 MW is considered small hydropower by WEC.[9] Major sites in the developed world have been exploited. But there is huge potential for hydropower in the third world countries.

1.2.4 Ocean Energy

Ocean energy includes several diverse, low-intensity phenomena that can be tapped for useful purposes, including thermal gradients, tides and waves. These resources are located in a wide number of coastal areas, with thermal gradients generally distributed in the tropical regions. Ocean thermal energy resources is estimated to be 10 times more than current global energy use. But the technology to tap this resource is in immature stage. The highest installed capacity is in France having a capacity of 240 MW.[10]

1.2.5 Geothermal Energy

Geothermal energy refers to the heat stored beneath the surface of the earth. It is manifold of the current energy use. It's intensity is low except along the boundaries of the tectonic plates. Commercial use of this energy has been developed in at least 20 countries.[11] Like ocean energy, technology in this source of energy is not developed much. At present, its contribution is only 0.14 percent of global energy consumption.[12]

---

[9] WEC, n.7, p.30.
[10] Ibid, p.30
[11] Ibid, p.28
[12] Williams, n.6, p.73.

1.2.6 Biomass energy

Biomass constitute a major portion in world's energy consumption especially in developing countries like India. It is the foremost source of energy used by human. Since no data is available it is virtually impossible to make a correct database about the use of biomass. Biomass encompasses wide range of products derived from the process of photosynthesis. The use of biomass is more in low income countries than in other countries. 43.7 percent of total energy use in low income countries is fulfilled by biomass. This is extreme in Nepal and Malawi where this figure is about 90 percent.[13] Inefficient use of biomass, contributes greater CO_2 emission to the atmosphere. In recent years different technologies have been developed to use this mode of energy more efficiently resulting in more output and less CO_2 emission.

The most important characteristic of these renewable sources of energy is that these have no negative impact on the environment. Another characteristic is that these sources are almost perennial in nature and will last as long as human beings exist in this world. In comparison to other sources of energy, the initial installment cost is high but the future maintenance is almost negligible. Renewable sources of energy is sometimes called decentralized energy. This is because, it can be harvested in very remote regions where it is very much difficult to connect grid power.

We can classify these renewable energy on the following basis.

a) Within the renewable energies, some energy comes from tangible source material. For example hydropower and biomass. These two types of energy

[13] World Bank, *World Development Indicators 2002* (Washington DC: World Bank, 2002), pp. 163-164.

sources are in material state, be it solid or liquid. By contrast energy sources like solar, wind and geothermal are intangible and the energy is tapped from the process. We can't generate electrical/mechanical energy from air but it is the movement of air that can be used for generating energy. Similarly the incidence of solar ray is used to generate energy.

b) We can stock and channelise water and biomass for generating energy but we can't stock solar rays and wind anywhere.

c) Unlike hydropower and biomass, we have to harness solar and wind energy where it occurs at that point of time. In case of hydropower and biomass energy, we can stock and channelise them to get the energy as and when needed.

So from the above discussion we can see that solar and wind energy are different from other renewable energy.

South Asia falls under tropical and sub-tropical region of the world. It inhabits one-fifth of the humanity and is one of the poorest regions of the world. Majority of the people don't have access to basic amenities like safe drinking water, proper housing and food. The majority population of this region live in villages. Commercial energy has not reached up to the village level although in recent years rural energy programme in these countries have been initiated. So most of the people in village use non-commercial energy sources such as biomass. But the problem is that inefficient use of biomass puts severe constraints to the natural environment. Even in urban areas a considerable amount of biomass is used for cooking purpose. So biomass is one of the chief sources of energy in this region.

For commercial energy, South Asian countries depend mostly on coal, hydropower and on imported petroleum products. A large share of their national budget is directed towards oil import from West Asian countries. The petroleum related import of two major countries of South Asia namely India and Pakistan constitute 20 percent and 19 percent of their total import respectively (1997-98). In recent years South Asian countries have paid attention to the renewable sources of energy. South Asian region receives good amount of sunlight for almost 300 days per year. It has large coastline. The potential for renewable energies is very high. But very small fraction of this potential has been exploited. If we take hydroelectricity alone, this region has the potential of 271690 MW out of which only 28722 MW is the current installed capacity, which comes around only 10 percent.[14] Only in recent years the national governments have taken this issue little bit seriously. They have created some sort of institutional mechanism to promote renewable energy exploitation and utilisation.

In South Asia, India constitutes three-fourth of the landmass. It has a large industrial base. It has good transport and communication infrastructure. For the development to continue at higher pace, India requires a large amount of energy. At present per capita energy consumption remains very low. In the year 2000, it was only 494 kilograms of oil equivalent compared to the world average of 1,694 kilograms.[15] It draws its commercial energy needs mainly from three sources. i) Petroleum products ii) Hydro-electricity and iii) Coal.

---

[14] Research Information system((RIS), *South Asia Development and Co-operation Report 2001/02* (New Delhi: RIS, 2002), p.201.
[15] World Bank, *World Development Indicators 2003*(Washington DC: World Bank, 2003), pp.145-46

Petroleum products used in India are mostly imported from middle eastern countries. As the population and the number of vehicles go up, it exerts tremendous pressure on national budget. In the year 2001-2002 share of oil import was 27.2 percent to the total import.[16] In hydropower sector, India has the potential of 75,400 MW out of which only about 30 percent has been exploited.[17]

All these energy sources have more or less environmental impacts. It is necessary to give our attention to renewable sources of energy. India receives 5000 trillion kwh of solar radiation per year. It is very much possible to generate 20 MW of solar power per square kilometre. Wind power potential of India is estimated to be about 45,000 MW out of which only 1,340 MW have been translated into reality. India holds 5th position in the world in this regard after Germany, USA, Denmark and Spain. In case of small hydro-power (up to 25 MW capacity), India have the potential of 15,000 MW out of which 1,361 MW capacity have been achieved. The potential for biomass energy is 19,500 MW.[18]

Increasing use of renewable energy in India was recognised at the governmental level in early 1970's. In 1981 government of India set up a Commission for Additional Sources of Energy (CASE) in the Department of Science and Technology with the mandate to promote R&D activities in this area. In the following year a Department of Non-Conventional Energy Sources (DNES) was created in the Ministry of Energy. In 1992, Ministry of Non-

---

[16] Ministry of Finance, Government of India (GOI), *Economic Survey 2002-03*(New Delhi: GOI, 2003), p.S-83.
[17] RIS, n.14, p.201
[18] Ministry of Non-Conventional EnergySources(MNES),*Annual Report 2001-02*(New Delhi:MNES,2002), p.24.

Conventional Energy Sources (MNES) was established to deal with all matters related to the exploitation and use of non-conventional/renewable energy. It undertakes policy making, planning, promotional and co-ordination of functions relating to all aspects of renewable energy, including fiscal and financial incentives, creation of industrial capacity, promotion of demonstration and commercial programmes, R&D and international relations. Indian Renewable Energy Development Agency (IREDA), a government undertaking is working for the promotion of renewable energy exploitation and utilisation. Under this organisation various programmes have been undertaken.

Under solar energy two major programmes have been undertaken. A) Solar Thermal Energy Programme and B) Solarphotovoltaic Programme. Solar Thermal Energy Programme includes solar water heating, solar air heating, solar cooker and solar building schemes. In Solarphotovoltaic Programme, village electrification, solar photovoltaic water pumping programme have been implemented. Besides these R&D, financing and training facilities were also been implemented under both programmes. Assessing huge potential, wind power programme was initiated towards the end of the sixth plan in 1983-84. Extensive R&D in this field was initiated. Centre for Wind Energy Technology (C-WET) was established to promote the same. Technology developed in India especially that of wind energy is also now being exported to the developed countries like USA. A number of commercial wind farm projects were undertaken under the initiative of MNES. Under the Biomass Gasification Programme, biomass gasifiers have been developed for water pumping and also for power generation up to 500 KW capacity. Biomass gasifiers of total

capacity of 42.8 MW have been installed in the country.[19] Investigation is going on different parts of the country for the exploitation of geo-thermal energy.

MNES have undertaken number of small hydro-projects having installed capacity of 1,423 MW.[20] Investigation is going on for the exploitation of geothermal energy. It is estimated that by the year 2012, about 10 percent of the total installed power generating capacity in the country is likely to be based on renewables.

A number of technical institutions have been established in recent years to enhance the exploitation of renewable energy. Some of the institutions are Solar Energy Centre (SEC), Centre for Wind Energy Technology (C-WET), Sardar Swaran Singh National Institute of Renewable Energy, etc. In India solar energy is harnessed through two routes, i) Solar Photovoltaic system (SPVS) and ii) Solar thermal system (STS). In SPVS, solar energy is directly converted to electrical energy through solar cells. In STS, solar heat is captured and utilised for power generation, cooking purpose, etc. Wind energy is normally utilised for generating electricity and irrigation. Hi-tech wind turbines have been developed to generate electricity. Various types of technologies are used for biomass. Recently technology using rice husk to generate electricity have been invented.

In India, investment in this sector comes from the public sector. MNES have financed various projects. Individuals and institutions get financial assistance from MNES through IREDA. Recently developed countries have

[19] Ibid,p.4.
[20] Ibid, p.4.

came forward to install renewable energy projects under the CDM of the Kyoto Protocol.

1.3. Significance of the study

The proposed topic of study has considerable significance.

In the era of rapid industrial and technological development, energy is the primary need. For ages, fossil fuels have been used as the chief source of energy. This source of energy is not unlimited. In some days to come these sources of energy would be totally depleted. These sources of energy have negative environmental impacts. This combined with population explosion exerts tremendous pressure on the earth's ecosystem. In this context unless and otherwise renewable energy throughout the world is properly used, our forthcoming generation will face energy crisis with some acute environmental problems. If we consider the cost factor we will see that harnessing the untapped renewable energy is the need of the hour. This is because of the fact that, price of the fossil fuel is increasing and the stock is gradually diminishing.

South Asia falls under the tropical and sub-tropical region of the world. It has large renewable energy sources. It gets abundance of solar radiation. The prospect for wind power is enormous. Hydropower and other renewable energy potential are also very high. Proper exploitation of these resources will not only bridge the energy demand-supply gap but also contribute for faster development of the region. This will raise the living standard of the people and create another area for international cooperation.

India is a biggest country in this region in every sense; it's size, population, and economy. It draws its energy needs mostly from the fossil fuels.

Oil import constitutes more than 22 percent of the total import. This figure is rising day by day. TERI has projected that India's import dependence for oil will be 73 percent in the year 2006/7, which may rise up to 88 percent in the year 2046/7. Further, energy sector contributes 57 per cent of the total GHG emission in India. Given these facts it is very much important to study the exploitation of renewable energy sources. Only recently the government has taken measures in this field.

As the system of CDM is coming up, it will very interesting to study the working of CDM in renewable energy sector in this part of the world.

1.4. Scope and Objective of Study

Although the proposed study will include all types of renewable energy sources but the focus will be on solar and wind energy. The proposed study will have the following scope and objectives.

- To analyse the overall renewable energy scenario in South Asian region.
- To analyse the potential of renewable energy in India and the governmental policies to promote them.
- To study the financial and technical issues relating to the exploitation of renewable energy in India.
- To study the importance of Clean Development Mechanism (CDM) in renewable energy sector.
- To bring out the issues and barriers which come in the way of renewable energy promotion in India.

In the second chapter the renewable energy potential of South Asian Countries will be analysed. Various governmental policies for harnessing renewable energy will be studied. Renewable energy technologies available and utilised in these countries will also be studied. There will be an overview of how far these potentials have been exploited and what are the major barriers, may it be at the policy making level, policy implementation level or at the technical level.

In the third chapter renewable energy potential in India will be studied sector wise (solar, wind, small hydro, etc.). In the later part policies of the Indian government in this regard will be studied.

In the fourth chapter, available technology, R&D in renewable energy technology will be discussed. Investment in renewable energy exploitation in terms of both public and private sector will be studied. Issue of commercialisation and growth of renewable energy industry will also be studied. Interational co-operation particularly in relation to CDM in this area will also be studied in this chapter.

Last chapter will sum up the major findings of this study.

Chapter – II

II

RENEWABLE ENERGY IN SOUTH ASIA

South Asia remains one of the poorest regions of the world. It constitutes seven countries namely – Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. It is inhabited by one-fifth of the humanity. Nearly 40 per cent of the world's absolute poor live here.[1] Despite having enormous natural resources, per capita Gross National Income (GNI) remains at $ 450, which is the lowest if compared to other regions of the world even below sub-Saharan Africa.[2] This is the region where 63 per cent of the population do not have access to basic sanitation facilities. 45 per cent of the adult population are illiterate.[3] Majority of the population is engaged in agricultural and allied activities. Industrialisation has not gathered pace. In the recent decades the governments of South Asian Countries (SACs) have taken up initiatives to fight the menace of poverty, illiteracy and raising the standard of life of the people of the region. These have been the core philosophy behind the formation of South Asian Association for Regional Cooperation (SAARC).

2.1 Energy Scenario in South Asia

South Asia relies heavily on biomass, much of which is not accounted in any document or report. According to the International Energy Agency (IEA), in 1995,

[1] Mahbub ul Haq, *Human Development in South Asia 1997* (Karachi: Oxford University Press, 1997), p.8.
[2] World Bank, *World Development Report 2003*, (Washington DC: World Bank, 2003), Table.1, p.235.
[3] Ibid, p.235

biomass accounted for 56 per cent of the region's final energy consumption.[4] Around 20-30 per cent of South Asia's biomass use is animal waste, 20-30 per cent made up of agricultural residues and a small fraction is filled by charcoal.[5] The inefficient use of biomass exerts severe strains on the natural vegetation beyond sustainable level. This also gives rise to environmental pollution due to the emission of carbon dioxide from the fuel wood.

In commercial energy front, the per capita energy use in South Asia is 453 Kilogram of Oil equivalent.[6] This is the lowest in comparison to other regions of the world. South Asia accounts only 3.9 per cent of the world's commercial energy consumption.[7] South Asia's commercial energy composition in the year 2000 was: 44 per cent coal, 34 per cent petroleum, 13 per cent natural gas, 7 per cent hydro-electricity and the rest amount is filled by other sources.[8] But the country trends vary significantly. Natural gas dominates the commercial energy composition of Bangladesh having the share of 68 per cent in 2000. Bhutan relies on hydropower (55 per cent) while India relies on coal (53 per cent). Maldives is completely dependent (cent per cent) on imported petroleum. Nepal's major share of commercial energy comes from petroleum (57 per cent) where as in Pakistan natural gas constitutes 42 per cent of the total supply of commercial energy followed by petroleum (41 per cent). In Sri Lanka petroleum is the major component of commercial energy having a share of 78 per cent.[9] The gap between the production and consumption of commercial energy is fast widening

---

[4] Cited in 'South Asia Regional Overview' at http://www.eia.doe.gov/emeu/cabs/sasia.html as on 17 Feb. 2003.
[5] Ibid.
[6] World Bank, *World Development Indicators 2003* (Washington DC: World Bank, 2003), p.146.
[7] 'South Asia Regional Overview', n.4.
[8] Ibid.
[9] Ibid

day by day. The production and the use of commercial energy are given in the following table.

Table 2.1
Commercial Energy Production and Use in South Asia.

Country	Commercial Energy Production ('000 Metric ton)		Commercial Energy Use ('000 Metric ton)			Net Energy Import (% of Commercial Energy Use)	
	1980	2000	1980	2000	Average annual growth (%) 1980-1999	1980	2000
Bangladesh	6745	15053	8441	18666	4.1	20	19
India	221322	421565	241016	501894	3.8	8	16
Nepal	4403	6872	4576	7900	2.7	4	13
Pakistan	20997	47124	25472	63951	4.8	18	26
Sri Lanka	3209	4530	4536	8063	2.5	29	44
South Asia	**256676**	**495144**	**284041**	**600474**	**3.9**	**10**	**18**

Source: Compiled from World Bank, *World Development Indicators 2003* (Washington DC: World Bank, 2003), Table.3.7, pp.144-146.

From the above table, it is very much evident that the use of commercial energy is increasing day by day. It is also clear that there is huge increase in the energy import. This gives severe constraints to the national budget of SACs. Therefore, in recent years the governments have turned their eyes over to enormous renewable energy resources present well within their territory.

2.2 Renewable Energy Potentials in South Asia

South Asia possesses huge potential for renewable energy. This is mainly due to the geographical location of the region in the world. It lies in the temperate and tropical zone, which is suitable for harnessing solar energy. It has a large coastline having good wind speed. However, the potentials of renewable energy are not uniform throughout the region. It differs according to the geographical location of a particular country or parts of the country. It depends on the location, relief, forest resources, animal resources, etc. The following are the country wise renewable energy potentials in South Asia.

2.2.1 Bangladesh

On an average Bangladesh experiences more than 330 days of sunshine per year.[10] The average daily solar radiation varies from 5.05 Kwh/Sq.m. in winter to 8.76 Kwh/ sq.m. in summer and the calculated annual amount of solar radiation varies from 1840 to 1975 Kwh/sq.m.[11] Bangladesh has 724 Km. long coastlines. Southwesterly trade wind blows in summer months through this long coastline during March to September. Although there is little data available to assess the wind energy potentials in particular, wind speed in the coastal region varies from 2-4m./sec. at a height of 5-10m. above the ground level.[12] From a preliminary survey wind energy potential at Petanga alone is about 100 MW.[13] Recently

---

[10] 'Solar energy can help combat power crisis', *Bangladeh Observer*,Dhaka, 02 Oct. 2002.

[11] Ibid., also see paper presented by Mahbub-Ul-Alam Khan at the seminar on 'Renewable Energy Sources for Rural Area in Asia and the Pacific' held in Nadi, Fiji, 20-25 July 1998, compiled in Asian Productivity Organisation, *Renewable energy : Sources for Rural Areas in Asia and the Pacific*, (Tokyo : Asian Productivity Organisation, 2000), p.77, also see 'Boundless Sun and Wind', *Bangladesh Observer*, Dhaka, 07 Oct. 1997.

[12] Toufiqul Islam, 'The Potential of Wind Energy', *Bangladesh Observer*, Dhaka, 21 March 1998.

[13] Paper presented by Mahbub-Ul-Alam Khan at the seminar on 'Renewable Energy Sources for Rural Area in Asia and the Pacific' held in Nadi, Fiji, 20-25 July 1998, compiled in Asian Productivity Organisation, *Renewable energy: Sources for Rural Areas in Asia and the Pacific*, (Tokyo : Asian Productivity Organisation, 2000), p.81.

Renewable Energy Centre of Dhaka University has taken up a 30 months sub-project to map solar and wind resources in the country, which is expected to be completed by October 2004.[14]

Biomass constitutes more than 70 per cent of Bangladesh's total energy consumption.[15] According to Institute of Fuel Research and Development (IFRD), Bangladesh, potential of four-million biogas plant exists in Bangladesh. [16] Due to the country's topography, there is not much scope for hydro-power. In Bangladesh there exists potential of 10 GWh/year from mini hydropower projects.[17] Twenty-three sites for hydropower power plants of 10 Kw to 5 MW have been identified.[18] There exists a good potential for tidal and wave energy but no comprehensive data is available except some site-specific data.[19] There are also potentials for geothermal energy in Bangladesh, which needs further investigation.[20]

2.2.2 Bhutan

Bhutan is a small country sandwiched between India and China. Over 70 per cent of the area is under forest cover. Fuel wood constitutes more than 75 per cent of total energy consumption and all non-commercial energy consumption in rural areas.[21] This exerts tremendous pressure on the natural forest resources. The hydropower potential of Bhutan is 21,000 MW out of which only 355 MW is

---

[14] 'UNEP Project to Map Solar, Wind Resources', *Bangladesh Observer*, Dhaka, 21 August 2002.
[15] For details see World Energy Council (WEC), *Renewable Energy in South Asia : Status and Prospects*, Annex 1, available at http://www.worldenergy.org/wec-geis/global/downloads/saarc/saarca1.pdf as on 05 March 2003.
[16] 'Renewable Energy Policy Stressed', *Bangladesh Observer*, Dhaka, 04 Sept. 2002.
[17] Mahbub-Ul-Alam, n.13, p.77.
[18] Ibid, p.84.
[19] For details see Ibid.
[20] For details see Aftab Alam Khan, 'Geothermal Resources Potential in Bangladesh', *Daily Star*, Bangladesh, 09 Jan. 1997.
[21] WEC, *Renewable Energy in South Asia : Status and Prospects*, available at http://www.worldenergy.org/wec-geis/global/downloads/saarc/saarc.pdf, p.14, as on 05 March 2003.

installed capacity.[22] Besides, Bhutan has a high potential for other renewable energy especially solar and wind energy.

2.2.3 India

Due to India's geographical location and vast area, India possesses huge potentials for renewable energy. India receives more than 300 sunny days per year. According to the Ministry of Non-Conventional Energy Sources (MNES), the country receives solar radiation amounting to over $5x10^{15}$ Kwh per annum with daily average incident energy varying between 4 and 7 Kwh/sq.m. depending upon the location. So, the calculated potential Solar Photovoltaic system is 20 MW/sq. Km. Similarly, wind power potential is 45,000 MW out of which only 1,507 MW have been exploited. India is the fifth largest country in the world after Germany, USA, Denmark and UK in this regard. There is a potential of 120 Lakh of biogas plants. The potential for small hydropower is 15,000 MW.[23] We shall discuss lot more about India in the following chapters.

2.2.4 Maldives

Maldives is a small nation consisting of over one thousand islands. Maldives is completely dependent on the imported petroleum for it's commercial energy needs.[24] However, the potential for solar energy exists in the country. Some solar energy sites are in operation having a total capacity of 130 MW.[25] Other forms of energy are not in use in Maldives.

---

[22] Royal Government of Bhutan, *Seventh Five Year Plan 1992-1997* available at http://www.pcs.gov.bt/ as on 07 March 2003.

[23] Ministry of Non-Conventional Energy Sources (MNES), Government of India, *Annual Report 2001-2002*, p.49.

[24] 'South Asia Regional Overview', n.4.

[25] For details see WEC, n.21, p.32.

2.2.5 Nepal

Like Bhutan, Nepal is also a landlocked country of the region. It experiences about 300 days of sunshine per year. The country has the potential of generating 3-4 Kwh/sq.m. per day from the solar incidence.[26] There is little data available to assess the wind energy potential in the country. But it is obvious that very high potential exists in the high mountains of northern Nepal. Professor Kedar Lal Shrestha, Advisor at the Ministry of Science and Technology once remarked "it is indeed a good news that wind energy potential is very high in that areas where the government is finding it difficult to expand the national electricity grid." [27] More than 80 per cent of the total energy demand is met through the use of biomass. Inefficient use of these biomass resources has severe negative impacts. Theoretical estimated sustainable annual yield of fuel wood in Nepal is 25.8 million tones. Out of this, only 42 per cent of supply is accessible.[28] Hydropower potential of Nepal is 83,290 MW.[29] Out of this huge potential technically feasible potential is 42,000 MW of which only 254 MW is the total installed capacity.[30] So, there is a huge gap between the potential and harnessed hydropower, which needs special attention. In the field of geothermal energy, Nepal has several hot springs with surface temperature of 24° C to 75° C.[31] Detailed survey is needed in this field.

---

[26] Ibid, p.34.
[27] 'Windmills Could Power Nation's Remote Regions', *Kathmandu Post,* Kathmandu, 08 March 2001.
[28] Kamal Rijal (ed.), *Energy Use in Mountain Areas: Trends and Patterns in China, India, Nepal and Pakistan* (Kathmandu: ICIMOD, 1999), p.109.
[29] His Majesty's Government of Nepal, *Economic Survey 1996-97,* cited in M. P. Lama, *Energy Cooperation in South Asia :Issues, Challenges and Potential* (New Delhi: South-South Solidarity, 1999), p.5.
[30] Rijal, n.28, p.36.
[31] 'Developing Alternative Sources in Rural Areas', *Kathmandu Post,* Kathmandu, 18 May 1998.

2.2.6 Pakistan

Pakistan, the second largest country of the region, despite having tremendous energy potential depends heavily on imported petroleum products. On the renewable energy front Pakistan has huge potentials. In Pakistan the mean global radiation on horizontal surface is about 200-500 watt/sq.m. in a day which is 1.9 - 2.3 MW/sq.m. annually.[32] No data have been collected for assessing the wind power potentials. The only data available about the wind flow is with the Meteorological Department, which is not very much relevant for wind power potential assessment.[33] As Pakistan's economy is dominated by the agricultural sector, there is enough animal waste for the production of biogas. Hydropower potential in Pakistan is about 38,000 MW.[34] In the northern Pakistan alone micro-hydropower (up to 100Kw) potential is estimated to be 300 MW. Besides this there is high potential of hydropower in central Pakistan.[35]

2.2.7 Sri Lanka

About 75 per cent of national energy supply comes from biomass and large hydropower plants. Central Electricity Board (CEB) started work on wind energy from 1988. Study tells us that wind power capacity of 200 MW with an annual yield of 350 million Kwh can be exploited in the coastal belt from Hambantota to Kirinda.[36] The total hydropower potential is 2,000 MW and the potential for mini hydropower is 175 MW, which can be developed economically.[37] Mean power of

---

[32] WEC, no.21, p.52.
[33] Ibid, p.55.
[34] Finance Division, Economic Advisor's Wing, Government of Pakistan, *Economic Survey 1998-99*, cited in M. P. Lama, *Energy Cooperation in South Asia :Issues, Challenges and Potential* (New Delhi : South-South Solidarity,1999), p.5.
[35] WEC, n.21, p.55.
[36] Ibid, p.65, also see Sakuntala Perera 'Lanka's First Wind Power Project in H'tota', *The Island*, Sri Lanka, 09 July 1998.
[37] WEC, n.21, p.64.

40Kw/ m. is available in the ocean surrounding Sri Lanka. A theoretical potential of 40,000 MW is available from the deep sea (6 Km. from the coast).[38]

2.3 Institutions, Policies and Technology in Renewable Energy

There are no clear-cut policies or institutions at the governmental level to deal with the renewable energy sector in SACs with the exception of India. Various international agencies like World Bank, UNDP, FAO, and ADB have supported SACs in building the energy infrastructure, which also includes renewable energy. International non-governmental organisations like Solar Electric Light Fund (SELF) are also coming forward to harness and popularise the use of renewable energy in SACs.

2.3.1 Bangladesh

There is no exclusive ministry or department to deal with the renewable energy in Bangladesh. The Ministry of Energy and Mineral Resources (MEMR) is the principal authority to deal with energy-related activities in the country. In the 'National Energy Policy (NEP) 1996', it was suggested that a separate Renewable Energy Development Agency (REDA) under MEMR should be created. But this has not been translated into reality yet. Another policy namely 'Small Power Generation Policy 1998' encourages small electricity generation having capacity up to 10MW in the country by the private sector. The government doesn't have any separate policy for renewable energy. However a 'Draft Renewable Energy Policy' has been submitted to the Government of

[38] K. H. J. Wijayadasa, *Towards Sustainable Growth : The Sri Lanka Experience : The Evolution of Environmental Policies and Strategies in Sri Lanka 1978-1993.* (Colombo : Central Environmental Authority, Ministry of Environment and Parliamentary Affairs, 1994), P.200.

Bangladesh, which has not been approved yet.[39] Until the establishment of any specific governmental agency in this sector, MEMR has been given mandate for the following works in the field of renewable energy.[40]

- Identify and assess the potential of projects.
- Issue of licences for commercial projects sponsored by private institutions.
- Recommend financing and delivery mechanisms to increase affordability.
- Promote participation from the private sector and NGOs.
- Facilitate technology transfer for commercialisation of RETs.

Value Added Tax (VAT) and import duty have been lifted for Solar Photovoltaic System and wind turbines by the government of Bangladesh from 1998 to promote renewable energy sector. Solar Photovoltaic Programmes of different governmental agencies are subsidised. Under the present policy the government of Bangladesh (GoB) gives 5000 Taka subsidy for a family-size biogas plant used for cooking and lighting.[41] In order to increase private sector investment in renewable energy, the GoB has some fiscal incentives. Some of the incentives are :[42]

- Sponsors of renewable energy projects have been exempted from corporate tax for a period of 15 years from the date of commercial operation of the projects.
- 100 per cent depreciation in the first year for solar energy-based technologies and five years for wind, biomass, geothermal and hydro power projects.

---

[39] Mazharul Islam, *Utilisation of Renewable Energy in Bangladesh*, available at http://shakti.hypermart.net/publications/ebook2.pdf as on 07 March 2003, pp.2-3.
[40] R. K. Pachauri and G.Vasudeva, *Energy in the Indian Subcontinent* (London: Petroleum Economist Ltd., 2000), p.91.
[41] Islam, n.39, p.3.
[42] For details see Pachauri, n.40, pp.91-92.

- The sponsors will be exempted from customs duty, VAT and other surcharges on importing equipments other than manufactured indigenously and complying with international standards.
- Repatriation of dividends will be allowed.
- Foreign investors are free to form joint ventures.
- Private power companies are allowed to buy insurance.
- Tax exemption on interest on foreign loans.
- Full convertibility of the taka for international payments.

Government organisations like Bangladesh Power Development Board (BPDB), Rural Electrification Board (REB) and Institute of Fuel Research and Development (IFRD) are engaged in development and instalment of different type of RETs throughout the country. There are several academic institutions and non-governmental organisations working in this field. List of organisations and RETs are given in table 2.2. For end users of RETs, different financial schemes are available depending upon the implementing agency.[43] Different governmental organisations, academic institutions and non-governmental organisations have launched different renewable energy projects. Some of the principal projects are:[44]

Projects by Governmental Organisations

- Biogas Pilot Plant Project of IFRD.
- Chittagong Hill Tracts Solar Electrification Project of BPDB.
- Wind Resources Assessment Programme of BPDB.
- Micro Hydro Power Plant at Barkal by BPDB.
- Diffusion of Renewable Energy Technologies Project by REB.
- Feasibility study and R&D on Renewable Energies by IFRD.

[43] Islam, n.39, p.4.
[44] Ibid., p.7.

Table.2.2
Status of RETs Related R&D Activities of Different Organisations in Bangladesh

Technology	Involved Organisation	Remarks
Solar Photovoltaic	Grameen Shakti, CMES, IFRD, BUET	It is possible to manufacture all the balance of system components (like Charge controller, Cable, Inverter, Converter etc.) locally.
Solar Water Heaters	RERC, Dhaka University, IFRD, CMES	It is possible to manufacture with local design and fabrication facilities.
Improved Stoves	IFRD	Number of design have been developed at IFRD with three basic categories (I) improve stove without chimney (ii) improved stove with chimney and (iii)improved stove with waste heat utilisation.
Solar Cooker-Parabolic	IFRD, ANANDO	IFRD has successfully field-tested its design which can quickly raise water to boiling point under clear sunny days. ANANDO is also manufacturing and marketing its products with imported materials and design.
Solar Cooker-Box Type	IFRD, CMES	IFRD's design is made of locally available raw materials. The manufacturing cost of such a cooker is about Tk. 800.00 excluding the cost of utensils. The cookers are now being sold at IFRD.
Solar Dryer	IFRD, BRRI, BAU	Different types have been designed and tested with locally available materials.
Solar Wood Seasoning Plant	BFRI	A simple, inexpensive and effective solar kiln has been developed for seasoning timber using solar radiation. The kiln can be constructed conveniently with locally available materials. Timbers of different species and dimensions can be seasoned throughout the year in the solar kiln.
Solar Passive Architecture	BCSIR	A solar house has been designed and built in the BCSIR campus, the purpose is to keep the house warm in winter and cool in summer.
Briquette Machine	BIT Khulna, BRRI	Under the 'RET in Asia' program, BIT Khulna is developing better machines with longer screw life.
Biogas	IFRD, LGED, BAU	Fixed-Dome type plants are indigenously designed and constructed.
Water Current Turbine	Department of Mechanical Engineering (DME), BUET	DME, BUET is studying a model water current turbine for harnessing energy from river current and in the process of developing a prototype.
Wind Turbines	BUET	Computational models are developed for simulation of Horizontal and Vertical Axis Wind Turbines.

Source: Mazharul Islam, *Utilisation of Renewable Energy in Bangladesh,* available at http://shakti.hypermart.net/publications/ebook2.pdf as on 07 March 2003, p.6.

Projects by private sector and NGOs

- RET Programme of Grameen Shakti.
- Dissemination Programme of Centre for Mass Education in Science (CMES).
- Renewable Energy Programme of BRAC.

Projects by educational institutions

- RET Programme of Centre for Energy Studies (CES), Bangladesh University of Energy and Technology (BUET).
- Dissemination of RETs by Renewable Energy Research Centre (RERC).

Besides these there are number of bilateral and multilateral development partner assisted projects.

2.3.2 Bhutan

In Bhutan, biomass has been the traditional source of energy. On the commercial energy front, hydropower has emerged as the dominant source of energy. Department of Power undertakes all power related activities in the country. The first micro hydropower plant became operative in Thimpu in 1967 having a capacity of 360 MW. Chhuka Hydropower Project is the largest power project in Bhutan, which was commissioned with the help of Government of India (GoI) assistance. Solar power programme was launched in early 1980s to light remote institutions like monasteries, basic health care institutions, etc. Till the end of 7th Five Year Plan (FYP), 61.84 KW of solar home lighting system was distributed. The Government of Netherlands has been assisting in harnessing the solar energy in the country.[45]

[45] WEC, n.21, pp.14-15.

Department of Power has implemented a US $ 7.5 million Asian Development Bank (ADB) loan rural electrification Project in 1995 covering seven districts. As an extension to the above ADB project, the government has signed a loan agreement of US $ 10 million with the ADB to electrify approximately 6,000 households covering 16 districts in January 2000. Support for the rural electrification programme in two districts by grid extension has been agreed upon by the GoI. The proposed Sustainable Development Agreement (SDA) programme through the assistance of Government of Netherlands aims at solar home lighting in very remote areas of the country. UNDP through Global Environment Facility is going to finance few small hydropower plant in near future.[46] Besides these there are number of hydropower projects under construction which are mostly financed by foreign governments like India, Austria, Norway, Japan, and the Netherlands.[47]

2.3.3 India

Increasing use of renewable energy in India was recognised at the governmental level in early 1970s. In 1981 government of India set up a Commission for Additional Sources of Energy (CASE) in the Department of Science and Technology with the mandate to promote R&D activities in this area. In the following year a Department of Non-Conventional Energy Sources (DNES) was created in the Ministry of Energy. In 1992, Ministry of Non-Conventional Energy Sources (MNES) was established to deal with all matters related to the exploitation and use of non-conventional/renewable energy. It undertakes policy making, planning, promotional and co-ordination of functions relating to all

[46] Ibid., p.18.
[47] Ibid., p.18.

aspects of renewable energy, including fiscal and financial incentives, creation of industrial capacity, promotion of demonstration and commercial programmes, R&D and international relations. Indian Renewable Energy Development Agency (IREDA), a government undertaking is working for the promotion of renewable energy exploitation and utilisation. Under this organisation, various renewable energy programmes have been undertaken.

Under solar energy two major programmes have been undertaken. A) Solar Thermal Energy Programme and B) Solar Photovoltaic Programme. Solar Thermal Energy Programme includes solar water heating, solar air heating, solar cooker and solar building schemes. In Solar Photovoltaic Programme, village electrification, solar photovoltaic water pumping programme have been implemented. Besides these, R&D, financing and training facilities were also been implemented under both programmes. Assessing huge potential, wind power programme was initiated towards the end of the sixth plan in 1983-84. Extensive R&D in this field was initiated. Centre for Wind Energy Technology (C-WET) was established to promote the same. Technology developed in India especially that of wind energy is also now being exported. During the year 2001-2002, wind turbine equipment worth Rs. 25 Crores was exported.[48] Number of commercial wind farm projects were undertaken under the initiative of MNES. Under the Biomass Gasification Programme, biomass gasifiers have been developed for water pumping and also for power generation up to 500 KW capacity. Biomass gasifiers of total capacity of 42.8 MW have been installed in

[48] Publication Division, Ministry of Information and Brodcasting Government of India, *India 2003* (New Delhi : Publication Division, 2003), p.514-515.

the country.[49] Investigation is going on different parts of the country for the exploitation of geo-thermal energy.

MNES have undertaken number of small hydro-projects having installed capacity of 1,438 MW.[50] Under the Biomass Gasification Programme, biomass gasifiers have been developed for water pumping and also for power generation up to 500 KW capacity. It is estimated that by the year 2012, about 10 percent of the total installed power generating capacity in the country is likely to be based on renewables.

Number of technical institutions have been established in recent years to enhance the exploitation of renewable energy. Some of the institutions are Solar Energy Centre (SEC), Centre for Wind Energy Technology (C-WET), Sardar Swaran Singh National Institute of Renewable Energy, etc. In India solar energy is harnessed through two routes, i) Solar Photovoltaic system (SPVS) and ii) Solar Thermal System (STS). In SPVS, solar energy is directly converted to electrical energy through solar cells. In STS, solar heat is captured and utilised for power generation, cooking purpose, etc. Wind energy is normally utilised for generating electricity and irrigation. Hi-tech wind turbines have been developed to generate electricity. Various types of technologies are used for biomass. Recently technology using rice husk to generate electricity have been invented.

In India, investment in this sector comes from the public sector. MNES has financed various projects. Individuals and institutions get financial assistance

[49] MNES, n.23, p.4.
[50] Ibid.

from MNES through IREDA. Recently developed countries have come forward to install renewable energy projects under the CDM of the Kyoto Protocol.

2.3.4 Nepal

In the 6th Five Year Plan (FYP) 1975-80, hydropower and forestry sector received priority in Nepal.[51] Water Resource Act 1992 was the first legislation for compréhensive water resource development.[52] Similar legislation regarding hydropower came into effect afterwards. Legislation to encourage private sector participation was done. From the 7th FYP (1985-90), policies for the development of alternative energy was made. Alternative Energy Coordinating Committee was formed under Water and Energy Commission Secretariat (WECS). Upon the recommendation of the Alternative Energy Coordinating Committee, the government enhanced its policy in RET. Alternative Energy Centre was established by the end of the 8th FYP (1992-97). This organisation coordinates different activities in the renewable energy sector. Ninth plan has put forth some important objectives in relation to the renewable energy.[53] Institutions dealing with renewable energy development are given in the table 2.3. Most of the energy projects in Nepal have been assisted by bilateral and multilateral sources. Micro-hydropower projects have been financed by UNDP, USAID, ADB, etc. Besides these external sources, the Government of Nepal through WECS also provides indirect subsidy to the companies for the conduct of various level of training programme on micro-hydropower and biogas. Financing mechanism in Nepal in relation to the end users are not efficient.[54]

---

[51] Rijal, n.28, p.128.
[52] WEC, n.21, p.41.
[53] Ibid., p.41.
[54] Ibid., pp.42-43.

Table 2.3
Institutions Dealing with Renewable Energy Development in Nepal

Organisation	Area of Responsibility	Type of Organisation	Functions	Remarks
Ministry of Water Resources Nepal Electricity Authority Water and Energy Commission	Mainly water resources and hydropower development	HMG	Planning and project execution Survey and study reports	No R&D facilities Deals with diesel, power plants, solar, wind, and multi-fuel systems.
Ministry of Education and Culture Research Centre for applied Science and Technology(RECAST), Tribhuvan University Centre for Applied Research Institute of Engineering Institute of Science and Technology Institute of Agriculture and Animal Science	R&D on alternative energy	HMG	Planning and project execution Survey and study reports Teaching and R&D institutions	Centre for Research and Development (CARD) is a new centre established with Norwegian assistance
Ministry of Agriculture Department of Agriculture	Biogas, micro-hydropower	HMG	R&D activities	———
National Planning Commission Alternative Energy Promotion Centre	Alternative energy	HMG	Planning, coordination and promotion of alternative energy	Newly proposed organisation
Other government agencies Royal Nepal Academy for Science and Technology (RONAST) Research Centre for applied Science and Technology (RECAST),Tribhuvan University	Alternative energy	———	R&D on alternative energy	Ongoing project- New & Renewable Energy Development Centre (NRDC) for alternative energy with assiatance from Japan's International Cooperation Agency (JICA).

Source : Kamal Rijal (ed.), *Energy Use in Mountain Areas: Trends and Patterns in China, India, Nepal and Pakistan* (Kathmandu: ICIMOD, 1999), p.132.

2.3.5 Pakistan

There is no policy on renewable energy in Pakistan. National energy planning in Pakistan is the responsibility of the Energy Wing of the Ministry of Planning and Development. Water and Power Development Authority (WAPDA) takes care of the hydropower. In 1986, Small Hydropower Development Organisation (SHYDO) was established by the NorthWest Frontier Province Government. It was to prepare a master plan and identification of all the available potential for small hydropower projects. The name of this organisation has been changed to Sarhad Hydroelectricity Development Organisation (SHYDO). Now this

organisation also deals with larger hydropower projects.[55] In the area of Solar Photovoltaic, Director General Office of New and Renewable Energy Resources (DGNRER) exists.[56] There are a number of organisations/institutions exist in Pakistan which are engaged in developing and popularising the RETs. They are as follows:

- National Institute of Silicon Technology (NIST)
- Solar Energy Research Centre (SERC)
- Pakistan Council of Appropriate Technology (PCAT)

Besides there are several universities engaged in this field. For example, Electrical and Mechanical Engineering College of National University of Science and Technology is active in Solar thermal power generation, solar thermal power generation device. Similarly the Institute of Environmental Studies of the Ghulam Ishaq Khan Institute of Engineering Sciences and Technology is involved in solar thermal device testing. The Mechanical Engineering Department of the University of Engineering and Technology, Lahore, is dealing with solar radiation and other solar thermal activities.

Recently Ministry of Science and Technology has proposed the creation of Council for Renewable Energy Technology by merging PCAT, NIST and the Solar Energy centre of Pakistan Council of Science and Industrial Research (PCSIR).[57]

---

[55] M. Abdullah and K. Rijal, "Pattern of Energy Use in the HKH Region of Pakistan" in Rijal, n.28, p.171.
[56] Ibid., p.172.
[57] Ibid, p.173 also see "Council for RET in offing", *Business Recorder*, Bangladesh, 11 March 1998.

2.3.6 Sri Lanka

In Sri Lanka about 75 per cent of national energy supply comes from renewable sources of energy, i.e. biomass and large hydro power plants.[58] The Ceylon Electricity Board (CEB) started popularising solar photovoltaic for rural domestic lighting in the early 1980s. Gradually private sectors started working on the solar energy. A government institution named National Engineering Research and Development Centre (NERD Centre) has developed a new method of biomass production using patented "Sri Lanka Semi-Dry-Batch Biogas system" for which, it won an international award in 1996 in Geneva.[59]

In 1998, the government of Sri Lanka set up the Renewable Energy and Capacity Building Project with the assistance of UNDP and GEF.[60] This project will finance investment in selected renewable energy sources by the private sector and CEB. and contribute to Capacity-building. The total investment in the Renewable Energy and Capacity Building Project sponsored by UNDP and GEF is US $ 2.1 million.[61] The Government of Sri Lanka has also contributed some amount for this. Recently in July 2002, International Development Agency (IDA) provided US $ 75 million as a credit and the Global Environment Facility (GEF) has contributed US $ 8 million as a grant for the "Renewable Energy for Rural Economic Development Project."[62]

---

[58] WEC, n.21, p.61.

[59] Paper presented by P. A. S. Fernando at the seminar on 'Renewable Energy Sources for Rural Area in Asia and the Pacific' held in Nadi, Fiji, 20-25 July 1998, compiled in Asian Productivity Organisation, *Renewable energy : Sources for Rural Areas in Asia and the Pacific* (Tokyo : Asian Productivity Organisation, 2000), p.162.

[60] WEC, n.21, p.67.

[61] Ibid, p.68.

[62] 'More foreign funds for renewable energy project uplifting rural life', *The Island*, Sri Lanka,18 July 2002.

2.4 Barriers to Renewable Energy in South Asia

In spite of having enormous renewable energy sources in South Asia, it has not been utilised even in small fraction. In Bangladesh out of 52,000 MW of hydropower potential only 230 MW has been harnessed.[63] Only 20 Kw of energy has been harnessed from the wind and 10,000 biogas plants have been installed.[64]

In Bhutan only 355 MW (out of potential of 21,000 MW) have been developed[65] and 1500 Solar Panels have been installed.[66] Similarly in Nepal only 283 MW of hydropower has been harnessed out of the potential of 83,290 MW.[67] Around 1,00,000 biogas plants have been installed in Nepal.[68]

The achievement in India is much more higher than other SACs,[69] which will be discussed in the following chapters. In Pakistan only 12.7per cent of the potential hydropower have been harnessed and in Sri Lanka it is almost half i.e., 56.45 per cent.[70]

There are certain factors in SACs, which come on the way of maximum utilisation of renewable energy. They can be summed up as follow:

a) Lack of local data on renewable.

---

[63] Reasearch Information System(RIS), *South Asia Development Report 2001/02*,(New Delhi :RIS,2002), p.201.
[64] Islam, n.39, p.2.
[65] RIS, n.63, p.201.
[66] 'Lack of maintainance skills renders solar power ineffective', *Kuensel Weekly*, Bhutan, 04 May 2002.
[67] RIS, n.63, p.201.
[68] 'Biomass the chief source of energy in country' *Kathmanu Post*, Kathmandu, 01 March 20002.
[69] For details see MNES, n.23, P.4.
[70] RIS, n.64, p.201.

b) Lack of co-ordination among the agencies engaged in this area and between public and private sector.

c) Lack of clear-cut policy on renewable (except India). Policies regarding renewable energy is included in general energy policy.

d) Lack of awareness and training.

e) Lack of R&D and Technology transfer.

f) No co-operation at the regional on sub-regional level.

g) Inadequate investment due to high initial cost.

h) Not combined with other rural development programmes.

Chapter – III

III

RENEWABLE ENERGY IN INDIA: POTENTIAL AND POLICIES

India constitutes three-fourth land of South Asia. It is one of the growing economies of the world. It has a large industrial base and good transport and communication infrastructure. The growth of industry and transport sector have gathered higher pace since independence. For the development process to continue and to accelerate, India needs huge amount of energy. Current energy consumption of India is very low keeping in eye the vast population. According to World Bank sources, in the year 2000, India's per capita energy consumption was only 494 Kilograms of oil equivalent compared to the world average of 1,694 kilograms.[1] India's average annual growth in commercial energy use is 3.8 per cent.[2] Planning Commission of India estimates that energy demand is expected to grow at a rate of 5.2 per cent during Tenth Plan period i.e., 2002-07.[3] In 2001-02 India imported 29.41 per cent of its primary commercial energy supply.[4] On the supply front coal dominates the commercial energy supply mosaic of India. More than 70 per cent of commercial energy need comes from coal. Coal contributed 77.4 per cent of total electricity production in the year 2000.[5] Coal production during the year 2001-02 was 327.79 million tonnes.[6] Still then India's coal import was 2.2 per cent of the total import in the same year.[7]

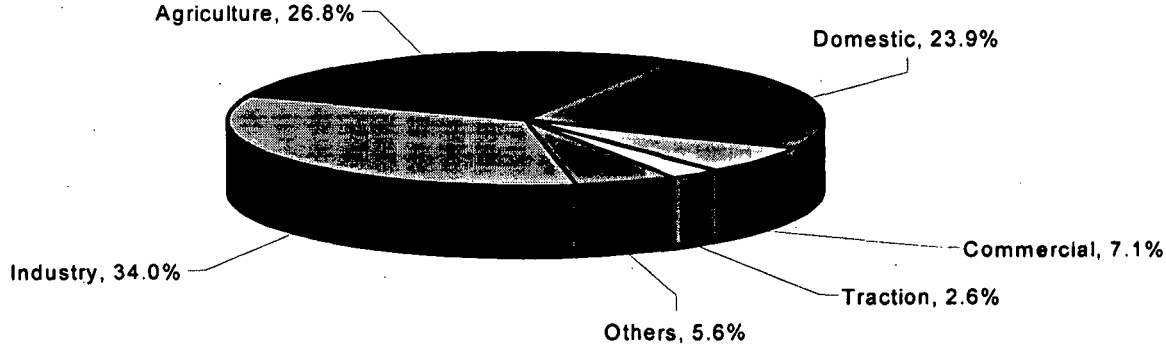
---

[1] World Bank, *World Development Indicators 2003* (Washington DC: World Bank, 2003), p.145.
[2] Ibid, p.145.
[3] Planning Commission, Government of India (GoI), *Tenth Five Year Plan 2002-2007, Vol.2* (New Delhi: Planning Commission, 2003), p.759.
[4] Ibid., p.765.
[5] World Bank, n.1, p.153.
[6] Ministry of Finance, Government of India (GoI), *Economic Survey 2002-03* (New Delhi: GoI, 2003), p. S-25.
[7] Ibid., p.S-83.

According to Tata Energy Research Institute (TERI) estimates, by the year 2006-07, India will be importing 12 per cent of its total coal needs which may go up to 61 per cent by the year 2046-47.[8] After coal, petroleum is the chief sources of energy. Crude oil production in the year 2001-02 was 32.03 MMT[9] and India's petroleum, oil and lubricant import was 27.2 per cent of the total import in the same year.[10] If we see the power sector in India, thermal power (including gas and diesel) dominates the scene. In the year 2001-02, total power generation was 1,04,917.50 MW. Out of this 74,428.82 MW was thermal power; 26,261.22 MW was hydro power; 2,720 MW was nuclear power and 1,507 MW was wind power.[11] Figure 3.1 shows the pattern of electricity consumption in India.

Figure 3.1

Pattern of Electricity Consumption in India



Source: Data from Ministry of Finance, Government of India (GoI), *Economic Survey 2002-03* (New Delhi: GoI, 2003), p.S-27.

[8] cited in David Townsend, "Challenging Times", *Petroleum Economist,* Vol.69, no.5, May 2002, p.28.
[9] Publication Division, Ministry of Information and Broadcasting, GoI, *India 2003* (New Delhi: GoI, 2003), p.520.
[10] Ministry of Finance, n.6, p.S-83.
[11] Publication Division, n.9, p.493.

After analysing these facts, one can conclude that India's energy demand is increasing day by day which can't be met with the prevalent sources of energy. Further import of energy exerts severe pressure on the national budget, which is increasing day by day. Therefore, it is very much essential to exploit new sources of energy, which exits within the country. Some of these energy sources are solar, wind, biomass, geothermal, etc. These sources of energy are known as renewable sources of energy. This is because of the fact that, these sources of energy are perennial in nature and has little negative impact on our environment. We shall now discuss the potential of these energy sources in India.

3.1 Potential of Renewable Energy in India

Indian mainland extends between 8° 4' and 37° 6' north latitude; 68° 7' and 97° 25' east longitude. It covers an area of 32,87,263 sq. Km. It has total coastline of more than 7,000 Km. It experiences good sunshine and good amount of rainfall. Besides these India is rich with vast biodiversity. Number of perennial rivers flow through the country. Due to its geographical location, most part of India experiences more than 300 days of good sunshine. Due to its large coastline and relief it also experiences good amount of wind throughout the year. India is having vast population and natural resources including fauna. So it has large source of biomass. From the above discussion it can be assessed that India possesses huge potential for renewable energy. However, the potential assessed by the Ministry of Non-Conventional Energy Sources (MNES), which is the sole ministry dealing with renewable energy in India are given in the table 3.1.

Table 3.1
Renewable Energy Potential and Achievement in India

Renewable Energy Sources/System	Potential	Achievement as on 31.12.2001
Biogas Plant	120 Lakh	32.75 Lakh
Improved Chullhas	1,200 Lakh	338 Lakh
Wind Power	45,000 MW	1,507 MW
Small Hydro Power	15,000MW	1,423 MW
Biomass Power/Co-generation	19,500 MW	358 MW
Biomass Gasifiers	---	42.8 MW
Solar PhotoVoltaic	20 MW/Sq.Km.	82 MW*
Waste-to-Energy	1,700 MW	17.1 MW
Solar Water Heating	1,400 Lakh Sq.m.Collected Area	6 Lakh Sq.m. Collected Area

*Of this 29 MW SPV products have been exported

Source: MNES, *Annual Report 2001-02* (New Delhi: MNES, 2002), p.4.

MNES's medium term goal is to ensure electrification of 18,000 remote villages and to achieve a minimum of 10 per cent share or 10,000 MW from renewable energy in the power generation capacity to be added by 2012.[12] Currently renewables contribute about 3,400 MW, which is 3.5 per cent of the total installed generating capacity from all sources. Out of this, wind power alone accounts for 1,507 MW.[13] Out of the assessed 45,000 MW from wind, the technical potential, assuming 20 per cent grid penetration, it is estimated to be 13,000 MW and so far 11.5 per cent of the technical potential has been achieved.[14] As many as 219 potential sites for wind projects have been identified. Muppandal in Tamil Nadu is one of the largest concentrations of wind firms in the country. State wise power potential and installed capacity has been given in table 3.2.

[12]Ministry of Non-Conventional Energy Sources (MNES), *Annual Report 2001-02* (New Delhi: MNES, 2002), p.4.
[13] Ibid., p.7.
[14] Ibid., p.7.

Table 3.2
State wise Wind Power Potential and installed Capacity

(in MW)

State	Gross Potential	Technical Potential (as on 31.03.2001)	Installed Capacity (as on 31. 12.2001)
Andhra Pradesh	8275	1550	91.9
Gujarat	9675	1750	166.9
Karnataka	6620	1025	54.8
Kerala	875	605	2.0
Madhya Pradesh	5500	1200	22.6
Maharasthra	3650	2990	320.2
Orissa	1700	680	---
Rajasthan	5400	885	14.0
Tamil Nadu	3030	1700	832.3
West Bengal	450	450	1.0
Others	---	---	1.6
Total	**45195**	**12835**	**1507.3**

Note: (i) the figures are based on the assumption of 1.0 per cent of land availability for wind power generation in potential areas.
(ii) the technical potential is as on 31.03.2001, assuming 20 per cent grid penetration. The grid capacities include the share of capacity allocated to states from the power stations of the central sector power generating utilities.

Source: MNES, *Annual Report 2001-02* (New Delhi: MNES, 2002), pp.76 & 78.

4,096 small hydro power sites have been identified with an aggregate capacity of 10,000 MW. However, only 420 small hydro project (up to 25 MW each) with an aggregate capacity of 1423 MW (less than 10 per cent of the potential) have been installed. According to MNES, 187 projects with total capacity of nearly 520 MW are under implementation.[15] So, in small hydro power sector, there exists huge untapped potential.

Besides providing power, renewables have huge carbon mitigation potential. With the Kyoto Protocol on the table, it is very much essential for developing countries like India to assess their renewable energy potential. This will attract foreign capital and technology under the Clean Development Mechanism (CDM) of the protocol. There also exists a huge employment

[15] Ibid., p.99.

potential. According to a study by Indian Institute of Applied Manpower Research, New Delhi, the employment generation due to small/medium hydro power projects in rural areas is about one person per Rs. one lakh investment. Similarly, for 20,000 MW potential for wind power generation, the employment generation will be that of two million people all in rural areas.[16] As the use and popularity of renewable energy is increasing, there is high potential for Renewable Energy Industry (REI).

3.2 Institutions

The use of renewable energy in India was recognised in the early 1970s. One of the reasons may be the oil crisis of 1973. Till 1973, the whole world was of the assurance that energy would be available to them forever at a reasonable price. For the first time in 1973, the world community realised that getting oil may not be as easy as they thought it to be. This oil shock may be the first to make the governments to think of renewable source of energy as an option. This combined with the global concern for climate change and the concept of sustainable development facilitated the promotion of renewable energy.[17] Back at home rural energy crisis in the 1970s also prompted the same.[18]

The first step to promote renewable energy began in India with the formation of the Fuel Policy Committee in 1971 which gave its report in 1974. This was followed by the creation of the Working Group on Energy Policy in 1977. In order

[16] cited in K. C. Gupta, *Energy and Environment in India: A Study of Energy Management* (New Delhi: Gyan Publishing House, 2002), pp.61-63.

[17] N. H. Ravindranath et. al., *Renewable Energy and Environment: A Policy Analysis for India* (New Delhi: Tata McGraw-Hill Publishing Ltd., 2000), pp.55-56.

[18] P. R. Shukla, Amit Garg, Debyani Ghose and P. Venkata Raman, "Renewable Energy Technologies: Mitigation Potential and Operational Strategies", in P. R. Shukla, Subodh K. Sharma and P. Venkata Ramana (eds.), *Climate Change and India: Issues, Concerns and Opportunities* (New Delhi: Tata McGraw-Hill Publishing Company Ltd., 2002), p.250.

to analyse issues arising out of the need to meet the growing demand for energy and to advise policies to meet the demand, an Advisory Board was set up in 1983.[19] Two years before this i.e., in 1981, the Government of India created a Commission for Additional Sources of Energy (CASE) in the Department of Science and Technology. CASE was given full executive and financial power of the government to formulate, implement, and coordinate policies and programmes in the renewable energy sector. Research and Development (R&D) was also incorporated in CASE.

Department of Non-Conventional Energy Sources (DNES) was established in 1982 under the Ministry of Energy. CASE was transferred to DNES from the Department of Science and Technology. A number of programmes such as National Programme on Biomass Development and National Programme on Improved Chulhas were launched under DNES.[20]

After 10 years of working of DNES, it was converted into a full fledged ministry named Ministry of Non-Conventional Energy Sources (MNES) in July 1992. With this, India is possibly the only country in the world to have an exclusive ministry dealing with renewable energy. The ministry was given the mandate for policy making, planning, promotional and co-ordination of functions relating to all aspects of renewable energy, including fiscal and financial incentives, creation of industrial capacity, promotion of demonstration and commercial programmes, R&D and international relations.[21] The ministry is broadly organised into six groups. i) Rural Energy ii) Solar Energy iii) Power from Renewables iv) Energy from Urban and Industrial Wastes v) New Technology

[19] Ravindranath, n.17, p.57.
[20] MNES, n.12, pp.25 & 37.
[21] Publication Division, n.9, p.507.

and vi) Administration and Coordination. India is implementing largest renewable energy programme in the world. Besides providing budgetary resources for R&D, demonstration, the ministry also extends institutional finance for commercially viable projects and also subsidies to end-users of Renewable Energy Technology (RET). The ministry also give fiscal incentives to promote Renewable Energy Industries (REI).

Besides headquarter at New Delhi, the ministry have nine regional offices whose locations and jurisdictions are given in the table 3.3. These offices monitor and inspect projects with the state government and State Nodal Agencies (SNAs).

Table 3.3
The location and Jurisdiction of Regional Offices of MNES.

Location of Regional Offices	Functional Jurisdictions in States/ UTs
Chandigarh	Jammu & Kashmir, Punjab, Haryana, Himachal Pradesh, Chandigarh and Delhi
Ahmedabad	Gujarat, Rajasthan, Dadra & Nagar Haveli and Daman & Diu
Lucknow	Uttar Pradesh and Uttaranchal
Guwahati	Assam, Arunachal Pradesh, Manipur, Mizoram, Nagaland, Tripura and Meghalaya
Bhopal	Madhya Pradesh, Maharastra and Chhattisgarh
Hyderabad	Andhra Pradesh, Karnataka and Goa
Bhubaneswar	Orissa, West Bengal and Shikkim
Chennai	Kerala, Tamil Nadu, Andaman & Nicobar, Pondicherry and Lakshadweep
Patna	Bihar and Jharkhand

Source: MNES, *Annual Report 2001-02* (New Delhi: MNES, 2002), p.11.

There are three specialised technical institutions working in the country under MNES. They are Solar Energy Centre (SEC), Centre for Wind Energy Technology (C-WET) and Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE). These institutions are very much crucial in R&D in their respective area of operation. Indian Renewable Energy Development Agency

(IREDA) is the financing arm of MNES. It promotes renewable energy exploitation by providing funds on commercial terms. Till the financial year 2000-01, IREDA have sanctioned Rs. 4589.27 crores for different sectors of renewable energy.[22] Besides all these govenmental agencies, there are a number of non-governmental, non-profit making organisations engaged in the promotion of renewable energy. The prominent organisations are Tata Energy Research Institute (TERI), Centre for Science and Environment (CSE), Development Alternative, Winrock International India (WII), etc.

3.3 Policies

There are no policies known as 'Renewable Energy Policy' in India till date. However, MNES has prepared a draft "Renewable Energy Policy Statement" which needs further approval. This policy statement targets of generating 10,000 MW or upto 10 percent of total grid capacity from renewables by the year 2012.[23] However, under the present scenario, different government policies have been moulded to promote renewable energy in the country. They are as follows.

3.3.1 Financial and Fiscal Incentives

IREDA is the primary financing agency in India as far as renewable energy is concerned. IREDA provides financial assistance to both the producer and end-users of renewable energy and Renewable Energy Technology (RET). The interest rates for the producers ranges from 0-16 per cent for period upto 10 years depending upon the manufacturers, users, etc. However, direct users of RET get loan at much lower interest rates. In order to get financial assistance, a

[22] Indian Renewable Energy Development Agency (IREDA), *Annual Report 2000-01* (New Delhi: IREDA, 2001), p.34.
[23] MNES, *A Factsheet of Achievements: Renewable Energy Programmes* (New Delhi: MNES, 2002), p.11.

manufacturer should approach with a minimum requirement of 0.25 million to minimise the loan processing cost.[24] IREDA gives these soft loans on its own and also through nationalised banks and other financial institutions. The fiscal incentive aims at the corporates and potential investors in the private sector. These incentives are:-[25]

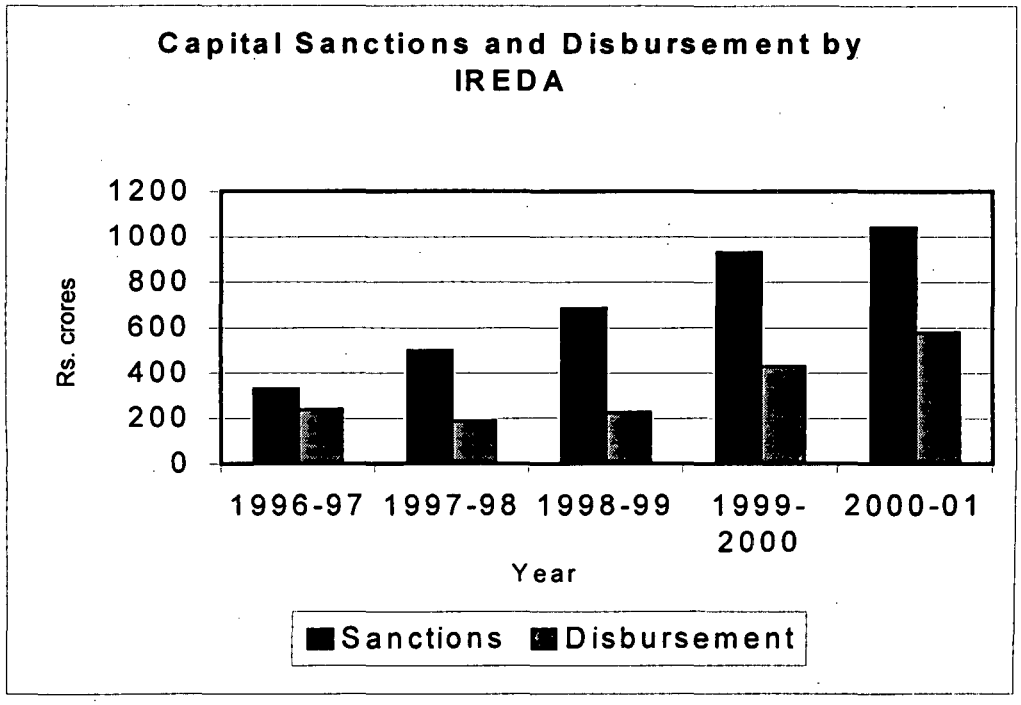
- 100 per cent depreciation for tax purpose in the first year of the installation of projects/systems.
- No excise duty on manufacture of most of the finished products.
- Low import tariffs for capital equipment and most of the materials and components.
- Five year tax holiday for power generation projects.
- Remunerative price under alternate power purchase policy by state government for the power generated through renewable energy systems, fed to the grid by private sector.
- Facility for banking and wheeling of power.
- Facility for third party sale of renewable energy power.
- Financial Incentives/Subsidies for devices with high initial cost.
- Encouragement to NGOs and small entrepreneurs.
- Special thrust to renewable energy in North-Eastern region of the country. 10 per cent of plan earmarked for North-East towards enhanced and special subsidies.

Besides these, 14 states have announced their policies to promote renewable energy.[26] Renewable energy sector is mainly supported by the central budget

[24] Ravindranath, n.17, p.159.
[25] MNES at http://mnes.nic.in/frame.htm?invopp.htm as on 21st April 2003.
[26] MNES, n.12, p.13.

allocation to MNES. However there is lack of efforts from the state governments. This may be one of the reason for existence of few commercial projects in the country. IREDA has sanctioned large amount of capital but actual disbursement remains low. This is very much evident from the Figure 3.2.

Figure 3.2



Source: Data from IREDA, *Annual Report 2000-2001* (New Delhi: IREDA, 2001), pp.34 & 37.

Further the procedural aspect of loan sanctions and disbursement by IREDA discourage many borrowers. If we analyse the sectoral aspect, IREDA has done well in wind power sector. IREDA has sanctioned 35 per cent of capital in wind energy.[27]

3.3.2 Industrial Policy

Industrial policies for the exploitation of renewable energy sources are as follows:-[28]

- Industrial clearance is not required for setting up renewable energy industry.

[27] Calculated from IREDA, n.22, p.34.
[28] MNES, n.25.

- No clearance is required from Central Electricity Authority for power generation projects up to Rs.100 crores.
- Facilities for promotion of export oriented units are available for renewable energy industry.
- Financial support is available to renewable energy industries for taking up R&D projects in association with technical institutions.
- Power project import allowed.
- Private sector companies can set up enterprises to operate as licensee or generating companies.
- Customs duty concession is available for renewable energy parts/equipments, including for machinery required for renovation and modernisation of plants.
- Excise duty on a number of capital goods and instruments in the renewable energy sector has been reduced/exempted.

3.3.3 Foreign Investment Policy

Foreign policies of the Government of India in regards to renewable energy are as follows:-[29]

- Foreign investors can enter a joint venture with an Indian partner for financial and/or technical collaboration and also for setting up renewable energy based power generation projects.
- Liberalised foreign investment approval regime to facilitate foreign investment and transfer of technology through joint ventures.
- The proposals for up to 74 per cent foreign equity participation in a joint venture qualifies for automatic approval.

[29] Ibid.

- 100 per cent foreign investment as equity is permissible with the approval of Foreign Investment Promotion Board (FIPB).
- Various Chambers of Commerce and Industry Associations in India can be approached for providing guidance to the investors in finding appropriate partners.
- Foreign investors can also set up a liaison office in India.
- Government of India is also encouraging foreign investors to set up renewable energy based power generation projects on Built-own and Operate basis.

3.3.4 Research and Development (R&D) Policy

Research and development (R&D) in renewable energy have started in 1982 with the establishment of DNES which has achieved considerable success. The focus of R&D is cost-reduction and improvement in efficiency of renewable energy devices. Three specialised institutions have been set up. They are Solar Energy Centre (SEC), Centre for Wind Energy Technology (C-WET) and Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE). Besides it has been networked with Indian Institutes of Technologies (IITs), Indian Institute of Science (IIS), Banglore and other such educational and research organisations. The ministry has created an R&D Advisory Committee comprising of eminent personalities in the area of research including industry, academic institutions, national laboratories, IITs, etc. to consider R&D project proposals and make recommendations for taking them up keeping in view the short-term as well as long-term goals. Until 2001, the Ministry has supported 261 projects with cumulative investment of Rs.55.66 crores.[30]

[30] MNES, n.12, p.23.

3.3.5 Awareness Programme

The MNES has tried to aware the general public and policy makers about the benefits of RETs through print and electronic media, seminars/conferences, exhibitions and also through mobile exhibition vans and energy parks. A number of programmes have been telecasted from the national television and radio networks. The ministry has been supporting governmental, technical institutions and NGOs financially to organise seminar, conference, awareness programmes, etc. The ministry also participates in India International Trade Fair. The Ministry gives 50 per cent of financial support towards the cost of mobile vans exhibiting renewable energy products. MNES provides 100 per cent funding towards procurement of systems and devices for setting up energy parks in public places and educational institutions. Till December 2001, a total of 259 energy parks have been sanctioned in the country.[31] Over the years the awareness has been increasing in the country. Seminars/conferences/workshops had little impact on the general public as they are basically aimed at the policy makers and industry groups.[32]

3.4 Renewable Energy Projects and Programmes

Besides overall policy for the exploitation of renewable energy, the Government of India has initiated a number of programmes and projects in the country. This was to give sectoral emphasis in renewable energy. This is because different renewable energy sources requires different policy, technology and incentives. But the thing to be kept in mind is that, these programmes are not always

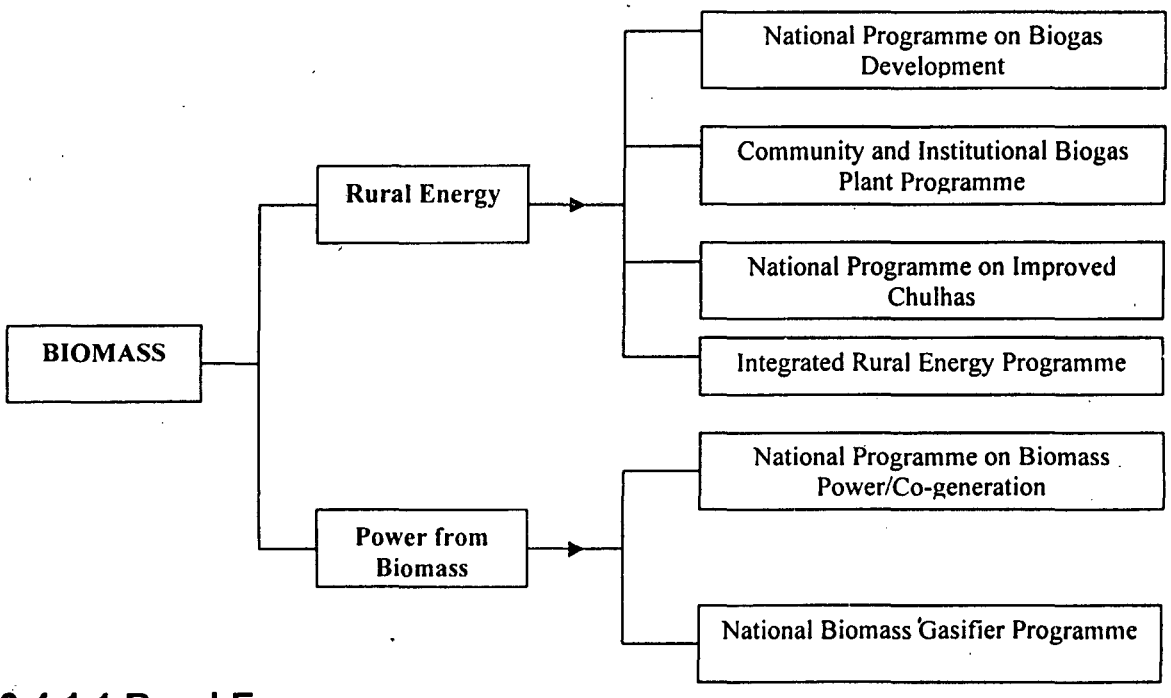
[31] Ibid., p.21.

[32] Ravindranath, n.17, p.162, also see Ashok Parthasarathi, "Non-Conventional Energy Sources in India - Progress and Policy Perspective" in Pradeep Chaturvedi (ed.), *Sustainable Energy Supply In Asia, Vol.2* (New Delhi: Concept Publishing Company, 1997), p.43.

mutually exclusive. Depending upon the source, we shall study the renewable energy programmes/projects implemented in India.

3.4.1 Biomass

The principle programme involving biomass as the energy source can be categorised under two headings and further sub headings.



3.4.1.1 Rural Energy

National Project on Biogas Development (NPBD)

India has the world's second largest biogas programme only next to China. This project was started in 1981-82 under CASE. The principal objectives of this projects are (i) to provide clean and convenient fuel for cooking and lighting purposes in rural areas; (ii) to produce enriched organic manure for use in conjunction with chemical fertilisers in agricultural fields; (iii) to improve sanitation and hygiene by way of linking household biogas plants with toilet and reduce the drudgery of women.

Different subsidy and finance schemes are available depending upon the capacity, end-users and nature of the biogas plant. Reserve Bank of India (RBI)

and National Bank for Agriculture and Rural Development (NABARD) have been supporting this project. Biogas Development and Training Centres (BDTCs) have been in operation to provide training and technical support to the SNAs and also to end-users. A large number of NGOs are also implementing this project. Out of 12 millions of potential plants, 3.20 millions of plants have been installed.[33] One of the reasons for such limited success is the high cost of biogas plants in comparison to the fuel wood which is available almost free of cost in rural areas. Another problem is inadequate funding at the national level for the programme. These combined with the shortage of trained manpower for construction and maintenance and inadequate dung availability exert severe constraints to the programme.[34]

National Council for Applied Economic Research (NCAER) conducted a nation wide survey and reported that 66 per cent of the installed plants are in use. NCAER identified two basic cause for this. One is structural (construction related) and another is operational (usage related) problems. Lack of adequate user education also hinder this programme.[35]

Community and Institutional Biogas Plant Programme (CBP/IBP)

This programme was initiated in 1982-83. The basic objective was to recycle the large quantity of cattle-dung available in the villages and institutions for the benefit of the weaker sections as well. Financial assistance is provided for this programme by the central government. 3487 such plants have been installed so far.[36] Majority of the plants are not working. The principle reasons are (i) inadequate dung availability; (ii) unequal distribution of cattle in the village; (iii) no

[33] MNES, n.12, p.25.
[34] Ravindranath, n.17, p.96.
[35] Kamal Rijal, *Renewable Energy Technology: A Brighter Future* (Kathmandu: ICIMOD, 1998), p.50.
[36] Ibid., p.31.

institutional arrangement at the village level to implement; (iv) no mechanism for the payment of rural household for the cooking gas.[37]

National Programme on Improved Chulhas (NPIC)

NPIC was initiated in 1986-87 under DNES having objective of (i) fuel wood conservation; (ii) elimination/reduction of smoke; (iii) reduction in drudgery of women and children from cooking in smoky kitchens and collection of fuel wood; (iv) environment up-gradation and checking deforestation and (v) employment generation in rural areas. Like NPBD, different financial and subsidy schemes are available for installing improved chulhas. Government agencies along with NGOs are implementing this programme in rural areas. 338 lakhs improved chulhas have been installed till 31 December 2001.[38] MNES disbanded this programme in April 2002, following the report submitted by NCAER. The report describes this programme as a failure. The main cause of this was rampart corruption. NCEAR also found that this programme lacks adequate people's participation. The basic objectives of this programme, i.e., reducing the smoke, saving in fuel wood consumption, etc. could not be met. Further 89 per cent household did not know whom to contact for repairs. Now the fate of the programme lies with the Chief Ministers of the States which will be decided at the National Development Council meeting in June 2003.[39]

Integrated Rural Energy Programme (IREP)

This programme aims at developing the planning and institutional capabilities at the State, District and Block levels to formulate and implement area-based micro-level energy plants and projects for promoting the utilisation of optimum mix of

[37] Ravindranath, n.17, pp.97-98.
[38] MNES, n.23, p.3.
[39] for details see Richard Mahapatra, "Up in Smoke", *Down To Earth*, Vol.11, no.17, 31 January 2003, pp.25-28.

various energy sources. This programme started from 1997-98. This involves active participation of Panchayats, NGOs and other institutions. Central government provides the necessary funds for the staff and training. State government provides for the implementation of plans and projects. So far 860 Blocks have been sanctioned for implementation of IREP.[40]

3.4.1.2 Power from Biomass

Two programmes were launched in 'Power from Biomass' category.

National Programme on Biomass Power/Co-generation (NPBP/C)

This programme aims at optimum utilisation of a variety of biomass materials for power generation through the adoption of conversion technologies, either for generation of power alone or for co-generation of more than one energy forms, namely steam and power, of minimum one MW capacity connected to the grid. By the year 2000-01, total biomass power installed capacity was 292.30 MW in the country.[41] Bagasse generated by sugar industries has vast potential for power generation. But for that purpose sugar mills have to be upgraded. The major constraints to this programme are: (i) high investment cost (ii) lack of policies in respect of wheeling, banking etc. (iii) channelising sugar cane bagasse for other purposes.[42]

National Biomass Gasifier Programme (NBGP)

NBGP was initiated in the year 1986. This programme was modified in 1999-2000 and 2000-001. Biomass gasifiers convert solid biomass (wood chips, twigs, rice husk, bagasse, etc.) into gas through thermo-chemical gasification process. The gas can be burnt to get thermal energy or can be used for replacing diesel

[40] MNES, n.12, p.87.
[41] Ibid., p.87.
[42] TERI, *Teri Energy Data Directory and Yearbook (TEDDY) 2000-2001* (New Delhi: TERI, 2000), p.160, also see Shukla, n.18, p.254.

engines to get mechanical or electrical energy. Under this programme, 1756 gasifier systems with aggregate capacity of 42.82 MW (equivalent) have been installed in the country.[43]

3.4.2 Small Hydro Power

Hydro power projects up to 25 MW comes under the purview of MNES.

3.4.2.1 Small Hydro Power Programme (SHP)

420 small hydro projects having the total capacity of 1423 MW have been installed. Under this programme, special incentives are given to the North-Eastern States. A capital grant up to Rs. 7.5 crores per MW has been offered for SHP projects in the north eastern region.[44] IREDA has so far sanctioned loans for 92 SHP projects with aggregate capacity of over 268 MW in the country.[45]

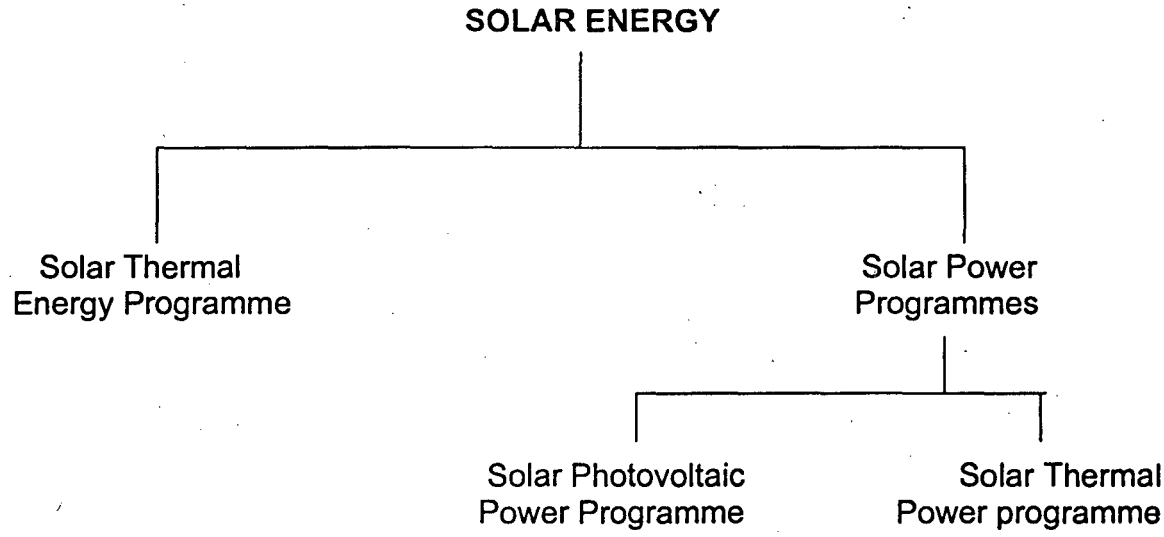
There are certain barriers which comes in the way of maximum exploitation of small hydro power. They are: (i) investment cost for small hydro power development are high due to difficult terrain and lack of transportation linkage to the hilly areas; (ii) sites where the potential is high, the demand is low; (iii) inadequate State plan allocation; (iv) delay in clearance for private sector projects; (v) low priority of State Electricity Boards, etc.[46]

3.4.3. Solar Energy

Sun is the source of all energy on this earth except nuclear energy. India receives solar radiation more than 5 $X10^{15}$ KWh per annum. In order to tap this huge energy source MNES has launched several programmes. Solar Energy programmes can be categorised and sub-categorised as under.

---

[43] MNES, n.12, p.97.
[44] Ibid., p.97.
[45] Ibid., p.102.
[46] Shukla, n.18, p.251.



3.4.3.1 Solar Thermal Energy Programme

The principal components of this programme are (i) Solar Water Heating Programme; (ii) Solar Air Heating Programme; (iii) Solar Cooker Programme and (iv) Solar Building Programme. For all these programmes interest subsidy scheme is being implemented through IREDA and public sector banks.

Solar Water Heating Programme

Hot Water is our day to day need, both for domestic and industrial purpose. In India, Solar radiation is utilised for heating water through flat plate collectors. The life period of such system is 15-20 years. This saves a huge consumption of electricity used in geysers. The technology and the manufacturing base for solar heating are well established. The solar water heating system are now commercially available in the market. Although its initial cost is high but in long run it is very economical as it saves a huge electric power. So far about systems having collector area of about 6 lakh sq.m have been installed in the country out of potential of 140 million sq.m. The need of the hour is to create awareness among the general public. State Nodal Agencies (SNAs) and NGOs can play important role in this regard.

Solar Air Heating Programme

Hot air is needed in agriculture and industry. Industries like tea, food, processing, dal mills and spice manufacturers need air heating. Traditionally, conventional fuel is used for this purpose. Now solar air heating system have been promoted and covered under the soft loan programme of IREDA. Although, this programme has not gathered much pace like Solar water Heating programme, still it has attracted the attention of policy makers and industrialists.

Solar Cooker Programme

Launched in 1982-83, in this programme different types of solar cookers are promoted in the country. On sunny days it is possible to cook both for noon and evening meals with the solar cooker. This in return will save much of our fuel used for cooking. Different types of cookers are used in India. Some of them are box solar cooker, steam cooker, solar meal maker etc. It has been seen that box solar cooker have advantage over the others. For community kitchen and for industrial purpose solar bowls are used for cooking which gives much higher heat.

Solar Building Programme

The objective of this programme is to promote energy-efficient building designs and construction with optimum use of available solar energy and other forms of ambient energy in energy management. Under this programme few solar buildings have been constructed in the hilly areas of Himachal Pradesh.

3.4.3.2 Solar Power Programme

In India, electric power is derived from solar radiation in two routes. They are solar photovoltaic power and solar thermal power. In solar photovoltaic power, solar radiation are directly converted into electrical energy through solar

photovoltaic (SPV) panels. In solar thermal power system, solar energy is first converted into thermal energy and then to electrical energy.

Solar Photovoltaic Power Programme

This programme was first started by the Department of Science and Technology in 1975. This programme have three principal components. (i) Demonstration and Utilisation Programme (ii) Village Electrification Programme (iii) SPV Water Pumping Programme. Under Demonstration and Utilisation programme, use of solar lanterns, street lighting systems, fixed type solar home systems and stand alone, small-capacity, village level power plants have been promoted. The SPV technology in India is quite good and still R&D is going on to make the systems more efficient and user-friendly. Different financial schemes are also available to the users. SPV panels have been installed in hospitals and other such institutions. Stand alone SPV power plants have been installed in some parts of the country. Under SPV power programmes street lighting systems, solar lantern, water pumping system, domestic lighting systems, community televisions, power plants for decentralised village electrification, telecommunication systems, etc. have been installed in different parts of the country.

It has been estimated that about 18,000 villages in India can't be penetrated through conventional grid electricity. It has also been seen that these villages can be electrified through local resources available to them like SPV, small hydropower (SHP) and biomass. These villages are to be electrified with in next two Five Year Plans (FYPs) i.e. by the year 2012.

The MNES has also been implementing a programme on the deployment of SPV water pumping system for agriculture and related uses. This programme

was implemented through IREDA and state Nodal Agencies (SNAs). 4208 SPV water pumping systems have been installed by 31 December 2001.[47] High investment cost remains to be one of the major impediments to the SPV programme. The investment cost for SPV power is now Rs. 20 crores/MW and the cost of electricity generated is 10 times higher than the cost of electricity coming from coal-based thermal plant.[48] In regards to SPV water pumping system, a study by Administrative Staff College of India shows that 75 per cent of users are satisfied. In street lighting front, the failure is higher than success. This is because of the malfunctioning of the battery systems.[49]

Solar Thermal Power Programme

In solar thermal power technology, solar heat is utilised for generating power by adopting various methods. An Integrated Solar Combined Cycle (ISCC) power plant is being set up in Rajasthan with a capacity of 140 MW[50]. In this plant, power can be generated even in non-sunshine periods with the support of a combined cycle gas plant. This project is funded by the Government of India with the grant of Rs. 50 crores, The World Bank / Global Environment Facility (GEF) with the grant of US $ 49 million and the Government of Germany which will provide a composite loan of DM 50 million.[51] However, the economic viability of such plants for commercial use is yet to be established.

[47] MNES, n.12, p.94.
[48] Shukla, n.18, p.255.
[49] Ravindranath, n.17, p.83.
[50] MNES, n.12, p.84.
[51] Ibid., p.84.

3.4.4. Wind Energy

3.4.4.1 Wind Power Programme

The Wind Power Programme was initiated in India in 1983-84. From the very inception, a market oriented strategy was adopted. This programme includes activities like (i) resource assessment; (ii) research and development support; (iii) implementation of demonstration projects; (iv) development of infrastructure; (v) development of capability and capacity for manufacture, installation, operation and maintenance of wind electric generations; and (vi) policy support. Now India has the total wind power installed capacity of 1507 MW and is fifth largest wind power producing nation in the world. Wind Resource Assessment Programme is being implemented by the centre for Wind Energy Technology (C-WET), in coordination with the State Nodal Agencies (SNAs). The state wise wind power potential and installed capacity have been given in the table 3.2.

MNES, supports research and development (R&D) activities at research institution, national laboratories, universities and industries for the development of cost effective technologies and systems to improve the capacity utilisation of wind power projects. R&D activities are co-ordinated through C-WET.

The programme for demonstration of wind firms was started in 1985. These demonstration projects are implemented through the State Governments, SNAs or State Electricity Boards. Demonstration projects with capacity of 63 MW have been established at 29 sites in nine states. The demonstration project at Kapatagudda in Karnataka has achieved the highest capacity utilisation factor of 32 percent attracting the attention of private sector for development of commercial projects in the State.[52]

[52] Ibid., p.77.

Table 3.4
State-wise Wind Power Installed Capacity

(in MW)

State	Demonstration Projects	Private Sector Projects	Total Capacity
Andhra Pradesh	5.4	86.5	91.9
Gujarat	17.3	149.6	166.9
Karnataka	2.6	52.2	54.8
Kerala	2.0	0.0	2.0
Madhya Pradesh	0.6	22.0	22.6
Maharashtra	6.4	313.8	320.2
Rajasthan	6.4	7.6	14.0
Tamil Nadu	19.4	812.9	832.3
West Bengal	1	0.0	1.0
Others	1.6	0.0	1.6
Total	**62.7**	**1444.6**	**1507.3**

Source: MNES, *Annual Report 2001-02* (New Delhi, MNES, 2002), p.78.

Commercial projects with capacity of 1444 MW have been established mainly in Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh and Karnataka. The State of the World-Watch Institute Report had recognised India as a new 'Wind Super Power'. The state wise demonstration projects and private sector projects have been given in the table 3.5.

There are several incentives to promote wind power projects available in various states in addition to the central incentives. It was proposed that the State Governments should purchase wind power at least @ Rs. 2.25 /KWh (base year 1994-95).

Even if the government has implemented such programmes, the wind energy installed capacity remains at 1507 MW. Wind power plants perform much below the expectations. One of the reasons may be poor adoption of wind turbines (European designs are for stable grids) for operation in weak Indian grids.[53] The other reasons are that the central and state policies remain unhelpful. State Electricity Boards (SEB) are not paying actual price of the power generated from wind and further different SEBs are following different pricing policies.[54]

[53] N. K. Bansal and Inderjeet Singh "Indian Wind Energy Programme: An Overview", paper presented by at *Joint Indo-German Workshop on Wind Energy Utilisation* at New Delhi, 29-30 January 2002.
[54] "Tapping the Wind", *Business India*, Bombay, 13-26 May 2002.

Chapter – IV

IV

RENEWABLE ENERGY IN INDIA: ISSUES AND CHALLENGES

India is implementing world's largest renewable energy programme. This is because of its geographical location and vast natural resources. It has a separate ministry named Ministry of Non-Conventional Energy Sources(MNES) to deal with renewable energy at the union level if not at state levels. It has a good R&D and technological base in this regard. In spite of all these, at present renewables contribute only 3.5 percent of the total installed capacity from all sources.[1] We discussed the current status of renewable energy in details in the last chapter. In this chapter we will discuss the issues related to renewable energy in India. The principal issues that we shall discuss are finance, technology, renewable energy industry, commercialisation and international cooperation. This will be followed by challenges to the promotion of renewable energy in India.

4.1 Finance

Financial issue is the major issue through-out the implementation of renewable energy programmes from early 1980s. Till the Fifth Five Year plan (FYP), there was no financial allocation for renewable energy. Modest allocations were made only since the Seventh Five Year Plan. The financial allocation for the energy sector in India over the FYPs are given in the table 4.1.

[1] Ministry of Non-Conventional Energy Sources (MNES), *Annual Report 2001-2002* (New Delhi: MNES, 2002), p.7.

Until the Sixth FYP, pilot study for feasibility of technologies like solar photovoltaic and wind were conducted. During the Sixth Plan focus was given to the demonstration of Renewable Energy Technology (RETs). During this period Department of Non-Conventional Energy Sources(DNES) was formed. During the Seventh FYP, intensive R&D for development of indigenous technology combined with awareness creation and fiscal incentives were emphasised. During

Table 4.1
Financial Support for the Energy Sector in India Over the FYPs

Five Year Plan	Period	Total plan outlay (Rs. cores)	Energy sector outlay (Rs. crores)	Share in the total plan allocation (%)				
				Power	Oil/gas	Coal	Renewables	Total
Third	1961-66	8,580	1,587	14.6	2.6	1.3	-	18.5
Fourth	1969-74	15,780	3,345	18.6	1.9	0.7	-	21.2
Fifth	1974-79	39,430	9,936	18.7	3.6	2.9	-	25.2
Sixth	1980-85	109,290	20,751	16.7	7.8	3.5	0.1	28.1
Seventh	1985-90	218,729	61,689	17.3	7.3	3.3	0.3	28.2
Eighth	1992-97	434,100	115,561	18.3	5.5	2.4	0.3	26.5
Ninth	1971-02	859,200	222,375	NA	NA	NA	NA	25.9
Tenth	2002-07	1525,639	403,927	NA	NA	NA	NA	26.5

Note: Ninth and Tenth FYP challenges have been made broad sector-wise.

Source : Data compiled from Ministry of Finance, Govt. of India, (GOI), *Economic Survey 2002-2003* (New Delhi: GOI, 2003), pp.S-39 - S-44.

this period initiatives was taken to set up nodal agencies at the state level and Indian Renewable Energy Development Agency (IREDA) was established mainly for market oriented programmes. Ninth Plan was the phase of consolidation with implementation of various programmes with a view to increase the base of renewable energy in the country.[2] Besides the Government of India, several bilateral and multilateral assistance has been received by IREDA which is presented in Table 4.2.

Table 4.2
International Assistance Received by IREDA

Government of Netherlands Guilder	18 million Dutch
Asian Development Bank	100 million US$
The World Bank/GEF	143 million US$
DANIDA	15 million US$
Germany	120 million DM
GEF: Global Environmental Facility **DANDA:** Danish International Development Agency	

Source: World Energy Council at http://www.worldenergy.org/wec-geis/global/downloads/p5c_p_p.pdf. as on 27 May 2003.

Till 2000-2001, IREDA has sanctioned Rs. 4589.27 crores for the promotion of renewable energy in India. However, sectoral sanction differ significantly which can be analyzed from the table 4.3. From the table it is very much clear that highest sanctions have been made to the wind energy sector (1611 crores). This is followed by small hydro power of the figure 988.13 crores. Biomass sector when grouped have attracted considerable amount of sanctions.

[2] N.H. Ravindranath (et al.), *Renewable Energy and Environment : A Policy Analysis for India* (New Delhi :Tata McGraw-Hill Publishing Company Limited, 2000), pp. 64-69.

Solar photovoltaic sector has attracted moderate sanctions. Solar thermal sector has lower sanctions because of the fact that solar heaters are produced and marketed on commercial basis.

Table 4.3

Sector Wise Sanctions by IREDA (1987-2001)

Sector	Cumulative sanctions (1987-2001) (Rs. Crores)
Biomass briquetting	19.19
Biomass co-generation	778.46
Biomass gasification	10.42
Biomethanation from industrial effluents	72.47
Biomass Power Generation	356.96
Biogas (Small Scale)	0.25
Energy efficiency and conservation	166.17
High efficiency world banking burning stores	0.49
Solar thermal	67.57
Solar photovoltaics	499.57
Small hydro	988.13
Waste to energy	17.04
Wind energy	1611.00
Miscellaneous	1.61
Total	**4589.27**

Source: IREDA, *Annual Report 2000-01* (New Delhi: IREDA, 2001), p.34.

IREDA is getting financial assistance from the World Bank and other multilateral agencies. Besides financing, IREDA also provides subsidy to the end users of RET and also to the intermediaries. In the year 2000-01 alone, IREDA provided total subsidy of Rs. 15.7 crores under different schemes. In initial years,

the subsidy schemes were related to the number of units installed and ignored the quality and performance factors. This did not promote the manufactures incentives to improve the quality and performance of the products.[3] In recent years, the subsidy is being withdrawn slowly and market oriented policies have been adopted.

Wind energy sector has attracted considerable private sector investments in comparison to other sectors of renewable energy. This is the result of governmental policies which is discussed in the previous chapter. This includes cent per cent depreciation for tax purpose in the first year of the installation of the projects/systems and five year tax holiday. Further only five per cent basic custom duty is imposed on the wind energy system spare parts.[4] 95.8 percent of wind power comes from the private sector projects.[5] This is so because of the demonstration programme by MNES. However investment declined from mid 1996 to the end of 1998. The alternatives of private investment in wind power projects declined with the imposition of MAT (Minimum Alternate Tax)[6]. The risks associated with the investment in wind powers as stated by N.K. Bansal and Inderjeet Singh:-[7]

---

[3] R.K. Pachauri, "Renewable sources of energy : prospects and policies", *Yojana,* Vol. 42, no.1, January 1998, p.24.

[4] MNES notification No.17/2001 available at http://mnes.nic.in/frame.ntm?invopp.htm as on 21st April 2003.

[5] Calculated from MNES, n.1, p. 78

[6] P.R. Shukla, Amit Garg, Debyani Ghosh and P. Venkata Raman, "Renewable Energy Technologies: Mitigation Potential and Operational Strategies" in P.R. Shukla, Subodh K. Sharma, P. Venkata Ramana (ed.), *Climate Change and India : Issues, Concerns and Opportunities* (New Delhi: Tata McGraw-Hill Publishing Company Ltd., 2002), p.253.

[7] N.K. Bansal & Inderjeet Singh, "Indian Wind Energy Programme: An Overview", paper presented at *Joint Indo-German Workshop on Wind Energy utilization*, 29-30, January 2002 at New Delhi.

(i) The return from investment is largely dependent on the government policies. Hence change in governmental policies hampers the consistent private investment.

(ii) The main 'fuel 'controlling generation is the wind speed and this is beyond the investor's control. There is always the risk that actual generation in any year could be below the expected level.

(iii) Wind power assessment may not be accurate. Therefore, there may be huge difference between the expectation and realisation.

(iv) Poor grid availability also acts as one of the impediments for private investment.

4.2 Technology

Technology used in India for renewable energy is primarily developed within the country. This is possible because of the extensive R&D in India. However, the technologies currently used in India are categorised by Ravindranath and others into four categories.[8]

(i) *Technologies that are mature and proven in the field and have reached the commercialisation phase*: This includes wind energy technology and solar water heaters.

[8] Ravindranath, n.2, pp. 227-28.

(ii) *Technologies that are developed and cost-effective but still in the dissemination phase* : These include technologies such as biogas, improved stove and small hydropower. These are still supported, managed and implemented through government programmes.

(iii) *Technologies that are cost-effective and reaching maturity but whose performance is yet to be significantly proven in the field situation*: This includes biomass gasifier technology.

(iv) *Technologies that are emerging and which are in the demonstration phase*: This includes Solar Photo–Voltic (SPV) technology. This is because of the fact that SPV is a high cost option now. However its cost may come down in future.

Due to the cheap technology, cost of conventional energy in comparison to the RET, limit the spread of RET. The current cost of RET is estimated by different organization and given in the table 4.4.

From the table it may be observed that the investment costs (other than SPV) are at par or even lower than conventional energy. In the unit cost small hydropower is the least cost option. Solar photovoltaic remains the most expensive option for power generation. Expectations are there that, this cost will decrease as the R&D is further advanced.

Table 4.4
Cost of Electricity Generated from Different Renewable Energy Technologies

Investment cost (Rs. Million per MW)				
Renewable Energy Technology	**ERM**	**CII**	**CMIE**	**TERI**
Wind	35	35-45	35	37-45
Solar photovoltaic	NA	150-200	300	NA
Small Hydro	40	35-60	35-60	NA
Unit Cost of Generation (Rs./Kwh)				
Wind	2.95	-	2.25	4.04-4.52
Solar PV	13.24	-	15-20	NA
Small Hydro	1.43	-	1.5-3.5	NA

Note: ERM: Environment Resource Management ; CII: Confederation of India Industries; CMIE: Centre for Monitoring India Economies; TERI: Tata Energy Research Institute

Source : N.H. Ravindranath (et al.) *Renewable Energy and Environment : A Policy Analysis for India* (New Delhi :Tata McGraw-Hill Publishing Company Limited, 2000), p119.

Besides these renewable sources of energy which are discussed above there also exist several other sources of renewable energy like ocean energy, geothermal energy, hydrogen energy, etc. MNES is conducting R&D in chemical source of energy in different laboratories in the country. Battery operated transport vehicle also has been developed. But, it has been limited only to demonstration and exhibition. It will take some time for its commercial use. Another clean source of energy is hydrogen energy which is also at the R&D and demonstration level. R& D on geothermal and ocean energy is going on.

4.3 Renewable Energy Industry

With the increasing use of RET, the industries dealing with renewable energy products also rising through the years. In 1995, the total private sector renewable energy industry's annual turnover reached about Rs. 2000 crores.[9] Leading public sector enterprises, industrial houses and multinationals have started realising the potential of renewable energy and putting their money into this sector.

India is the second largest producer of single crystal silicon solar cells in the world. There are around 60 manufacturers of solar flat plate collection used in solar water heater approved by Bureau of Standards of the Government of India. Similarly the number of manufacturers for other solar energy applications are increasing day by day.

In wind energy sector, India has a larger industrial base for wind generation, technical and management capacity and developed institutional arrangements. Now the annual production capacity of domestic wind turbine industry is about 500 MW and this capacity can be expanded to 750MW.[10] Centre for wind Energy Technology(C-WET) is providing possible assistance to the wind turbine manufactures. India has started exporting wind turbines. Five wind turbines of 600 KW capacity have been exported to Sri Lanka.[11] Medium to Small Scale Industry are coming up in biomass energy sector.

---

[9] Ashok Parthasarathi, 'Non-conventional Energy Sources in India- Progress and Policy Perspective", in Pradeep Chaturvedi (ed.), *Sustainable Energy Supply in Asia Vol.2* (New Delhi: Concept Publishing Company, 1997), p.44.
[10] MNES, n.1, p.129.
[11] Ravindranath, n.2, p.80

4.4. Commercialization

Till date almost whole of the renewable energy sector is subsidy driven. This is because of poor penetration of RET. But recently in an interview, Dr. V. Bhakthavatsalan, Managing Director, IREDA said that, "Most of the technologies are commercially viable without subsidy support".[12] He however also emphasized that, technology like solar photovoltaics, fuel cells etc. are still in development stage and should continue to get government subsidy. MNES have provided direct and indirect subsidy to different RETs since its inception. It has announced different financial and fiscal incentives for the Renewable Energy Industry (REI). Still the sector is not ready to take up larger commercial programme. P. Venkata Raman has identified some drawbacks for commercialization and suggests some measures which are as follows:[13]

1. **Streamline Promotion**

   Two different approaches for promotion of the same renewable energy product should be avoided. For example, at a time, the MNES was providing 50 percent subsidy for SPV products and there was a parallel programme by IREDA which was trying to promote solar photovoltaic system by providing soft loans. Both programmes were targeting the same market but had contradictions in promotion strategies.

[12] *Renewable Energy India,* Vol. 1, no.1, p.55.
[13] P. Venkata Ramana, "Renewable Energy Commercialization", in Mahesh Vipradas (ed.), *Renewables: Products and Markets* (New Delhi: TERI, 2001), pp. 60-61.

2 . Rationalise incentive structure

Only providing subsidy does not solve the problem. The nature of subsidy largely, i.e., to whom it is given whether to the user, producer, facilitator or the intermediaries is relevant. The subsidy should be given to the appropriate party after examining the technology and the users.

3 Define clear public-private partnership

There is no clear cut strategy for private sector participation which often generate confusion in the minds of potential investors. Currently renewable energy in rural areas has been propagated as mostly cooking or heating paradigm. So we have to link renewable energy with various diverse applications.

4.5 International Cooperation

Several multilateral agencies have given assistance to renewable energy projects in India. These are The World Bank, Asian Development Bank and others. The assistance received by IREDA from these agencies has been given in table 4.2.

Article 12 of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) provides for Clean Development Mechanism (CDM). Developing countries including India are listed under Annex II of the protocol which means developed countries (Annex I) can get certified emission reductions by investing in clean projects[14] in developing countries. This will meet their carbon emission reduction obligations. The government of India

[14] Clean project means that project which do not produce Green House Gases (GHG).

has approved six such projects under CDM sponsored by the government of Netherlands.[15] This shows India's commitment towards the 1997 Kyoto Protocol. According to a Indian government official, "India has made a start and showed commitment to the Kyoto Protocol".[16] These projects are i) 7.5 MW biomass Power project in Maharashtra; ii) 7.5 MW biomass project in Rajasthan; iii) 15 MW wind-biomass Project in Tamil Nadu; iv) 14.5 MW wind power project in Tamil Nadu; v) 15 MW wind power project in Tamil Nadu; vi) 15 MW wind power project in Karnataka. [17]

India has large potential for attracting CDM projects in renewable energy sector. This is because of the fact that it has large renewable energy potential.

However, R. K. Pachauri, Director-General, TERI, is not much optimistic about this as he thinks, we should not have "very high expectations from CDM because the extent of money that will be available through CDM will be very limited."[18] But whatever the amount of money comes, it is very clear fact that, the technology which have been denied for years will come to stay here through CDM.

4.6 Challenges

India has huge renewable energy resources which are untapped. India also has adequate manpower. It has a separate ministry for the purpose. World's largest renewable programme is implemented in this country. Still the results are not up to the expectations. At least the purpose for which different renewable energy

[15] *Down To Earth*, Vol.11,no.12,15 November 2002, p14.
[16] Ibid, p.14.
[17] Available at www.teriin.org/events/docs/cop826c.pdf
[18] *Renewable Energy India*, Vol.1, no.1, p.26.

programmes and projects were started have not been fulfilled. There are some basic impediments on the road to the maximum utilization of renewable energy resources. The prominent among them are as follows.

High Initial Cost

The existing initial cost of installing RETs are high although the maintenance cost is very low. For example, wind power technology which is commercially viable technology, costs around Rs. 35-45 million per MW. Further transportation cost to potential sites are also high. In northeastern states, the potential for small hydropower is high but due to difficult terrain, the transportation costs of machinery is high. Another factor is that, in spite of two decades of R&D, the costs of RETs have not gone down significantly to the commercially viable level.

Cost of Renewable Energy vis-a-vis Conventional Energy

Due to high costs of RETs, the government has provided both direct and indirect subsidy. One aspect of the subsidy is to popularise the RETs so that large scale use of RETs can be undertaken with diminished installment cost . But another thing that must be kept in the mind is that, the government is also providing subsidy to some of the conventional energy projects for example kerosene and Liquefied Petroleum Gas (LPG).After subsidy, the price of these conventional energy sources is less than that of the renewable energy. So, people are going for conventional energy for their day to day needs.

Lack of Finance and Financial Mechanism

As the government through IREDA is the only financing source, it is not possible to finance all the projects with private initiatives adequately. Further the RETS

have not achieved that stage of development where common people and different financing agencies could put their trust . Therefore, other financing institutions are not coming up in a big way to finance projects. Only recently, some of the nationalised banks have started financing renewable energy projects and that too in collaboration with IREDA.

Inadequate Post-installment Maintenance Mechanism

Once the RETs are installed, no body cares about the future maintenance requirements. In some cases, the user does not even know whom to contact in case of any problem. Spare parts are not available in nearby areas. This is a serious problem faced by the users especially individual/domestic users. Inadequate training to the users about the system also hinders the promotion of renewable energy.

Lack of Indigenous R& D and Demonstration

Most of the grid-connected RET systems used in India are either imported or a result of joint venture of an Indian company with the company from Europe or USA. Those systems do not fully suit Indian site and gird conditions. Further demonstration projects are located in urban and semi-urban areas. few rural people are touched upon by this demonstration projects.

Lack of Awareness

Lack of awareness is one of the major hurdle in the path to the promotion of renewable energy. Unless, the people are aware of the facts about renewable energy, the use and commercialization of RETs are difficult.

Chapter – V

V

CONCLUSIONS

The importance as well as use of renewable energy sources has increased in recent years. Environmental degradation and climate change have further increased the importance of the renewable energy. Another factor is that, fossil fuels are limited and will be diminished from the earth although not in near future. The development of appropriate technology for the exploitation of renewable sources of energy has contributed for the promotion of the same. More cost-effective and efficient technology will come in future as the R&D is going on. Developed countries have achieved upto a considerable level. India has gone at par with these countries in this sector. Now, India is the fifth largest wind power producer in the world.

In South Asia, except India, renewable energy has not been developed although little progress has been made. In Bangladesh there is no separate ministry for this purpose. Ministry of Energy and Mineral Resources deals all the energy sources. Some incentives have been offered in this field in recent years. 'Draft Renewable Energy Policy' has been submitted which needs approval by the Government of Bangladesh. Different renewable energy projects have been initiated by governmental as well as non governmental agencies.

Bhutan has high potential for renewable energy especially in hydro power. The hydropower potential has been estimated upto 21,000 MW. The major

problem is that Bhutan lacks in capital as well as technology. With the help of the Government of India several hydro power projects have been developed in Bhutan in past years. In recent years several multi-lateral agencies like Asian Development Bank (ADB), United Nations Development Programme (UNDP) are assisting the Government of Bhutan in hydro power Projects. Besides India, other countries like Austria, Norway, Japan and Netherlands are assisting the Government of Bhutan. It is upto the leadership in Bhutan to examine, how they can exploit these opportunities. Nepal is also endowed with water resource which can be utilised for power generation. It has an estimated hydro power potential of 83,290 MW. It also receives good amount of sunshine. Besides it has large biomass resource which can be used efficiently. Like Bhutan, Nepal is also getting assistance from several multilateral agencies. One of the major problems in Nepal for the promotion of renewable energy is that the financial mechanism does not suit the end uses of Renewable Energy Technology (RET).

In Pakistan the hydro power sector has made considerable progress. But other from of RET have not been developed up to the expected level. There is a proposal to create 'Council for Renewable Energy Technology'. After its creation, renewable energy in Pakistan may get new impetus. In Sri Lanka major portion of national energy supply comes from biomass and large hydro power plants. However the Ceylon Electricity Board (CEB) has started popularising solar photovoltaic for rural domestic lighting. Non- Government agencies like Solar Electric Light Fund (SELF) and others are working in this field.

Factors which came in the way of renewable energy exploitation are many. First among them is improper assessment of the renewable resources. Lack of data also impinge upon the potential foreign investment. So the South Asian Countries (SACs) need to asses their potential in order to attract foreign investment. Except India, SACs don't have separate ministry or department to deal with this sector. Several agencies are working but due to lack of co-ordination, the efforts have not being fully materialised. Corollary of this is lack of clear out policy on renewable energy. Another factor is lack of proper R&D facilities in these countries. Further, there is no cooperation among the SACs in this field. Except India little success have been achieved in these countries. But the increasing awareness on the part of the governments have raised the hope.

India has a large middle class. The energy use is increasing at a rate of 3.8 percent per year. India imports almost 30 percent of its primary commercial energy needs. This is expected to rise at a higher pace as we have discussed in the second chapter. In order to fulfill India's ever-rising energy demand, two strategies can be adopted. One is to use energy efficiently and another is to look for alternative sources of energy. The alternative sources include solar, wind, small hydropower, biomass, geothermal energy etc. Although exploitation of renewable energy was initiated in 1970s at the government level, the major thrust was given in the 1990 after the creation of the Ministry of Non- convention Energy Sources (MNES). Since then MNES is working extensively in this sector on its own

and through its regional offices and State Nodal Agencies (SNAs). MNES has established number of specialised institutions for R&D in different aspects of the renewable energy. For financing, it has established Indian Renewable Energy Development Agency (IREDA). IREDA has been plying a crucial role in the promotion of renewable energy in India.

On the policy front, MNES has implemented policies covering almost every aspect of renewable energy. The ministry also have initiated awareness programme to increase the popularity and acceptability of RETS. MNES has implemented different programmes related to different sources of renewable energies.

On the ground level, the things are not so encouraging. Due to lack of interest at the leadership level, the programmes have not yielded results as expected. For example, through the years, the difference between capital sanctions and disbursement by IREDA has been increasing. Similarly, due to rampant corruption, National Programe on Improved Chulhas(NPIC) was stopped. Post installment maintenance is inadequate. Once the system is installed, nobody bothers about its maintenance. Lack of availability of spare parts and trained personnel also hinder the successful implementation of these programmes. On wind energy front, India is fifth in the world. This is because of the wind availability combined with governmental policies, which encouraged private investment.

Finance has been the major constraint for the renewable energy promotion. Not much share of budgetary allocation is directed towards renewable energy sector. Although foreign aid has been received by IREDA, they are not adequate. Further, except wind power and solar water heater RETs in India have not been developed upto that stage that it can be used fully on commercial basis. The cost of these technologies have to be minimised through extensive R&D. New technologies for the exploitation of ocean energy, geothermal energy and hydrogen energy have to be developed.

Policies have been made to encourage Renewable Energy Industry(REI). But except wind energy industry, it has not been successful. One of the causes is the high cost of generated power in comparison to the power generated from coal and large hydro projects.

Clean Development Mechanism (CDM) provides a platform by which India can hope for more foreign investment in this sector. The Government of India has approved some renewable energy projects under CDM. Another advantage of CDM is that, developing world including India will get the appropriate technology through CDM. In order to attract more CDM projects, India will have to be ready by assessing the resources base correctly and improving the infrastructure.

Bibliography

BIBLIOGRAPHY

PRIMARY SOURCES

Haq, Mahbub ul, *Human Development in South Asia 1997* (Karachi: Oxford University Press, 1997).

IEA, *CO_2 Emission from Fuel Combustion 1971-2000: Highlights* (Paris: IEA, 2002).

Indian Renewable Energy Development Agency (IREDA), *Annual Report 2000-01* (New Delhi: IREDA, 2001).

International Energy Agency (IEA), *World Energy Outlook 2002: Highlights* (Paris: IEA, 2002)

Ministry of Environment and Forest (MoEF),Government of India, *Agenda 21: An Assessment* (New Delhi: MoEF, 2002).

Ministry of Finance, Government of India (GoI), *Economic Survey 2002-03* (New Delhi:GoI,2003)

Ministry of Non-Conventional Energy Sources (MNES), Government of India, *Annual Reports* (New Delhi: MNES, various years).

Ministry of Non-Conventional Energy Sources, Government of India, *Renewable Energy in India: Business Opportunities* (New Delhi: MNES, 2001).

MNES, *A Factsheet of Achievements: Renewable Energy Programmes* (New Delhi: MNES, 2002).

Planning Commission, Government of India (GoI), *Tenth Five Year Plan 2002-2007, Vol.2* (New Delhi: Planning Commission, 2003).

Publication Division, Ministry of Information and Broadcasting Government of India, *India 2003* (New Delhi : Publication Division, 2003).

Research Information System (RIS), *South Asia Development and Co-operation Report 2001/02* (New Delhi: RIS, 2002).

Tata Energy Research Institute, *TERI Energy Data Directory & Year Book.* (New Delhi: TERI, various years).

World Bank, *World Development Indicators* (Washington DC: World Bank), various years.

World Bank, *World Development Report 2003* (Washington DC: World Bank, 2003).

SECONDARY SOURCES
BOOKS

Bansal, N. K. and Kamal Rijal (ed.), *Profiting from Sunshine: Passive Solar Building in the Mountains* (Kathmandu: ICIMOD, 2000).

Birundha, Dhulasi, Varadarajan and K. R. Jeyakumar, *Economics of Wind Energy* (New Delhi: Ashish Publishing House, 1994).

Brown, Norman L. (ed.), *Renewable Energy Sources and Rural Application in the Developing World* (Boulder: Westview Press, 1978).

Centre for Energy Studies and IIT, Delhi, *Wind Energy Utilisation,* Joint Indo-German Workshop, 29-30 January 2002.

Chaturvedi, Pradeep (ed.), *Sustainable Energy Supply in Asia. Vol.1&2,* (New Delhi: WEC, Concept Publishing Company, 1997).

Dayal, Maheshwar, *Renewable Energy: Environment and Development* (Delhi: Konark Publishers, 1990).

ESCAP, *New and Renewable Energy for Development* (Bangkok: UN, 1988).

Ghose, Pradip K. (ed.), *Energy Policy and the Third World Development* (Westport: Greenwood Press, 1984).

Goldemberg, Jose, *Energy, Environment and Development* (UK: Earthscan,1996).

Goldemberg, Jose, Thomas B. Johanson, Amulya K. N. Reddy & Robet H. Williams, *Energy for a Sustainable World* (New Delhi: Wiely Eastern Ltd., 1998).

Gupta, K. C., *Energy and Environment in India: A Study of Energy Management* (New Delhi: Gyan Publishing House, 2002).

Johanson, Thomas B., Henry Kelly, Amulya K. N. Reddy, Robert H. Williams, *Renewable Energy: Sources for Fuels and Electricity* (Washington D.C.: Island Press, 1993).

Kishore, V. V. N. (ed.), *Renewable Energy Utilisation: Scope, Economics and Perspectives* (New Delhi: TERI, 1993).

Kozloff, Keith Lee and Roger C. Dower, *Renewable Energy Policy For The Ninties and Beyond* (USA: World Resource Institute, 1993).

Lama, Mahendra P., *Energy Cooperation In South Asia: Issues, Challenges and Potential* (New Delhi: South-South Solidarity, 1999).

McVeigh, J. C. and J. G. Mordue (ed), *Energy Demand and Planning: Watt Committee Report Number 31* (London: E & FN Spon, 1999).

Monga, G. S. and V. J. Sanctis, *Nonconventional Energy Growth, Resources and Policies Vol.1* (New Delhi: Vikas Publishing House Pvt. Ltd., 1994).

Pachauri, P. K., G. Vasudeva, *Energy in the Indian Subcontinent* (London: The Petroleum Economist Ltd., 2000).

Pachauri, P. K., Leena Srivastava, Kapil Thukral (ed.), *Energy-Environment-Development Vol.2* (New Delhi: Har Anand and Vikas, 1991).

Prasad, S. S. R. (ed.), *Sun and Small Energy Needs* (New Delhi: Oxford & I. B. H. Publishing Co. Pvt. Ltd., 1995).

Ramana, P.Venkata (ed.), *Rural and Renewable Energy: Perspective from Developing Countries* (New Delhi: TERI, 1997).

Ravindranath, N.H. (et al.), *Renewable Energy and Environment: A Policy Analysis for India* (New Delhi: Tata McGraw-Hill Publishing Company Limited, 2000).

Rijal, Kamal (ed.), *Energy Use in Mountain Areas: Trends and Patterns in China, India, Nepal and Pakistan* (Kathmandu: ICIMOD, 1999).

_____, *Implications of National Policies on Renewable Energy Technology: Report of the Regional Expert Consultation* (Kathmandu: ICIMOD and Cannadian Cooperation Office, 1998).

_____, *Renewable Energy Technology: Brighter Future: Policy Options to Mountain Communities in HKH and Agenda for Action in Nepal* (Kathmandu: ICIMOD, 1998).

Shukla, P.R., Subodh K. Sharma, P. Venkata Ramana (ed.), *Climate Change and India : Issues, Concerns and Opportunities* (New Delhi: Tata McGraw-Hill Publishing Company Ltd., 2002)

Southgate, Douglas D. and John F. Disinger (ed.), *Sustainable Resource Development in the Third World* (Boulder and London: Westview Press, 1987).

Vipradas, Mahesh (ed.), *Renewables: Products and Markets* (New Delhi: TERI, 2001).

Wijayadsa, K.H. J., Towards Sustainable Growth: The Sri Lanka Experience: The Evolution of Environmental Policy and Strategies in Sri Lanka 1978-1993 (Colombo: Central Environmental Authority, Ministry of Environment and Parliamentary Affairs, 1994).

World Energy Council, *New Renewable Energy Resources: A guide to the Future* (London: Kogan Page, 1994).

ARTICLES

"Council for RET in offing", *Business Recorder,* Bangladesh, 11 March 1998.

'Biomass the chief source of energy in country' *Kathmanu Post,* Kathmandu, 01 March 20002.

'Developing Alternative Sources in Rural Areas', *Kathmandu Post,* Kathmandu, 18 May 1998.

'Lack of maintenance skills renders solar power ineffective', *Kuensel Weekly,* Bhutan, 04 May 2002.

'More foreign funds for renewable energy project uplifting rural life', *The Island,* Sri Lanka,18 July 2002.

'Renewable Energy Policy Stressed', *Bangladesh Observer,* Dhaka, 04 Sept. 2002.

'UNEP Project to Map Solar, Wind Resources', *Bangladesh Observer,* Dhaka, 21 August 2002.

'Windmills Could Power Nation's Remote Regions', *Kathmandu Post,* Kathmandu, 08 March 2001.

"Tapping the Wind", *Business India*, Bombay, 13-26 May 2002.

Bansal, N.K. & Inderjeet Singh, "Indian Wind Energy Programme: An Overview", paper presented at *Joint Indo-German Workshop on Wind Energy utilization*, 29-30, January 2002 at New Delhi.

Barnes, Douglas F. and Willem Floor, " Biomass Energy and the Poor in the Developing World", *Journal of International Affairs,* Vol.53, no.1, Fall 1999, pp.237-259.

Bull, Stanley and Lynn L. Billman, "Renewable Energy: Ready to Meet Its Promise?", *Washington Quarterly,* Vol.23, no.1, Winter 2000, pp.229-44.

Centre for Science and Environment, "Gone with the Wind", *Down to Earth,* Vol.8, no.3, June 30, 1999, pp.35-42.

Christensen, John and Jay Paul Wagner, "Double-digit Growth to Continue", *Petroleum Economist,* Vol.68, no.8, August 2001, pp.12-16.

Deepender Kumar, "Redefining Security: An Environmental Approach", *Journal of Peace Studies*, Vol.10, no.1, Jan-March, 2003.

Espenhahn, Sarah, "Powering Development", *The World Today,* Vol.58, no.3, March 2002, pp.22-24.

Flavin, Christopher and Seth Dunn, "A New Energy Paradigm for the 21st. Century", *Journal of International Affairs,* Vol.53, no.1, Fall 1999, pp.167-190.

Islam,Toufiqul, 'The Potential of Wind Energy', *Bangladesh Observer,* Dhaka, 21 March 1998.

Khan, Aftab Alam, 'Geothermal Resources Potential in Bangladesh', *Daily Star,* Bangladesh, 09 Jan. 1997.

Kolhe, Mohanlal and Sunita Kolhe, J. C. Joshi, "Economic Viability of Stand-alone Solar Photovoltaic System in Comparison with Diesel-Powered System for India", *Energy Economics,* Vol.24, no.2, March 2002, pp.155-165.

Lovins, Amory and Chris Lotspeich, "Energy Surprises for the 21st. Century", *Journal of International Affairs,* Vol.53, no.1, Fall 1999, pp.191-208.

Mahapatra,Richard, "Up in Smoke", *Down To Earth*, New Delhi, Vol.11, no.17, 31 January, 2003

Pachauri, R.K., "Renewable Sources of Energy: Prospects and Policies", *Yojana,* Vol. 42, no.1, January 1998.

Parthasarathi, Ashok, 'Non-conventional Energy Sources in India- Progress and Policy Perspective", in Pradeep Chaturvedi (ed.), *Sustainable Energy Supply in Asia Vol.2* (New Delhi: Concept Publishing Company, 1997).

Perera,Sakuntala, 'Lanka's First Wind Power Project in H'tota', *The Island,* Sri Lanka, 09 July 1998.

Ramana, P. Venkata, "Renewable Energy Commercialization", in Mahesh Vipradas (ed.), *Renewables: Products and Markets* (New Delhi: TERI, 2001).

Rigden, Dan, "The Green Challenge", *Petroleum Economist,* Vol.69, no.8, August 2002, pp.32-35.

Shukla, P.R. Amit Garg, Debyani Ghosh and P. Venkata Raman, "Renewable Energy Technologies: Mitigation Potential and Operational Strategies" in P.R. Shukla, Subodh K. Sharma, P. Venkata Ramana (ed.), *Climate Change and India : Issues, Concerns and Opportunities* (New Delhi: Tata McGraw-Hill Publishing Company Ltd., 2002).

Taylor, Jerry and Peter Van Doren, "The Soft Cause for Soft Energy", *Journal of International Affairs,* Vol.53, no.1, Fall 1999, pp.209-235.

Townsend, David, "Challenging Times", *Petroleum Economist,* Vol.69, no.5, May 2002, p.28.

William, Alan and Mohammad Aslam Uqaili, "Sustainable Energy Development", in J.C. McVeigh and J.G.Mordue (ed.), *Energy Demand*

and Planning: Watt Committee Report number 31, (London: E& FN Spon, 1999).

William, Neville, Ken Jacobson and Harold Burris, "Sunshine for Light in the Night", *Nature,* Vol.362, no.6422, 22 April 1993, pp.691-692.

NEWS PAPERS, JOURNALS AND PERIODCALS

Bangladesh Observer (Dhaka)

Business India (Bombay)

Business Recorder (Bangladesh)

Daily Star (Bangladesh)

Down To Earth (New Delhi)

Energy Economics (Williamstown, US)

IREDA News (New Delhi)

Journal of Peace Studies (New Delhi)

Journal of Solar Energy Society of India (New Delhi)

Kathmandu post (Kathmandu)

Kuensel (Bhutan)

Nature (London)

Petroleum Economist (London)

Renewable Energy India (New Delhi)

Renewable Energy World (London)

The Island (Sri Lanka)

Yojana (New Delhi)

WEBSITES

Energy Information Administration, US Department of Energy
http://www.eia.doe.gov

Indian Renewable Energy Development Agency
http://ireda.nic.in

International Energy Agency
http://www.iea.org

Ministry of Environment and Forest, Government of India
http://envfor.nic.in

Ministry of Non-Conventional Energy, Government of India
http://mnes.nic.in

Planning Commission of India
http://planningcommission.nic.in

Planning Commission Secretariat, Royal Government of Bhutan
http://www.pcs.gov.bt/

Renewing India
http://www.renewingindia.org

Solar Electric Light Fund
http://www.self.org

South Asia Regional Initiative for Energy Cooperation and development
http://www.sari-energy.org/

Tata Energy Research Institute
http://www.teriin.org

Utilisation of Renewable Energy in Bangladesh
http://shakti.hypermart.net/publications/ebook2.pdf

Wind Energy Development Secretariat
www.winrockindia.org/weds/

Wind Power India
http://www.windpowerindia.com

World Energy Council
http://www.worldenergy.org