Barriers to the Diffusion of Renewable Energy Technologies - A Case Study of the State of Maharashtra, India

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B. Sudhakara Reddy

CHAPTER 1
INTRODUCTION

1.1 Preamble

Recently, interest in "new renewable energy technologies" for electricity generation, mainly, wind and solar-based systems is at a peak. The reason may be that these are the least polluting and most inexhaustible of all known energy sources. While these energy sources have been available to mankind since pre-historic times, they have not been able to be utilised as effectively as other sources such as biomass. The energy that strikes the earth's atmosphere in the form of sunlight each year, and the wind that flows from it, represent the equivalent of nearly 1,000 trillion barrels of oil sufficient to fuel the global economy thousands of times over. Although, scientists and entrepreneurs all over the world pursued solar and wind energy technologies for the past four decades, they have never claimed the success (in terms of energy share in the market) that proponents hoped they would. This is because, creating a system which provides a reliable energy supply from solar and wind can be a technically difficult task. This forced many policy makers and equipment manufacturers to conclude that these technologies are unlikely to find a place in the modern energy systems. Yet, the past decade brought in a series of developments which suggests that the time has come for renewable energy technologies (RETs), particularly, solar and wind, that can compete with fossil fuel technologies. This may be due to environmental pressure and/or pure economic reasons. Both are consistent in direction, if not in strategic approach. Thus, the twenty-first century is likely to see the beginnings of a real energy revolution as the renewable energy sources are expected to be widely utilized and substitute the non-renewable ones. By relying on a new generation of efficient, high tech, and mass produced energy conversion devices such as advanced wind turbines and solar photovoltaics, the world can rapidly reduce its dependence on oil and coal, and the slow the build-up of greenhouse gases that causes climate change as well.

Thus, growing energy demand, environmental concerns, energy sector restructuring and global economic development are causing dramatic and positive changes in the market for renewable energy technologies. The rapid economic growth in many Asian countries is significantly increasing the demand for energy. Added to this are the responses to environmental concerns (e.g., local air pollution, and global climate change), increasing interest by consumers and the government’s support for the use of renewable energy technologies. At the same time, utility restructuring and privatization are leading to heightened retail competition among energy suppliers and increasing the role of consumers in energy choices. Taken together, these factors have created an opportunity for effective marketing of the environmental benefits of renewable energy technologies.

1.2 India: Energy Priorities

India's expanding economy and the strong growth expected in the next few decades (at around 10% per annum), will require additional energy. The use of fossil fuels is likely to dominate our strategy for meeting these needs in the near and medium term. However, our own reserves are finite and will only be available for a limited period – currently estimated to last about 250 years in the case of coal, and about 30 years for oil. Their cost will rise steadily as production and availability become increasingly constrained. We need to adopt measures to conserve the scarce fossil fuels that are available to us in view of their strategic importance to the country. Such measures could lead to increased import of fossil fuels, severely straining our foreign exchange reserves. Besides, the use of fossil fuels is not sustainable and is directly linked to environmental problems, particularly CO2 emissions and climate change. We may therefore need to cut back on their use for energy generation. Another important factor to be considered is the supply of grid electricity to the rural areas. As the 21st century nears, some one billion people, 65 percent of which live in rural areas, still rely on kerosene and fuel wood, and other biomass fuels for light and other energy end-uses (Reddy and Balachnadra, 2000). In these 100 million households, noxious fumes are a serious health risk; families are prevented from engaging in home-based income-earning activities after dark; and children who are unable to do homework at night are handicapped in school. The lure of bright lights draws millions of these people each year to already overcrowded cities.

The importance of the increasing use of renewable energy sources was recognized in India in the early 1970s. During the past quarter century, a significant effort has gone into the development, trial and induction of a variety of technologies for use in different sectors. Today, India has one of the world's largest programs for renewable energy. Our activities cover all the major renewable energy sources of interest to us, including biogas, biomass, solar, wind and small-hydro power and other emerging technologies. By the end of 20^{th} century nearly three million family-sized biogas plants (second in number in the world and next only to China's) and 30 million improved wood stoves have been established. These technologies could save about 15 million tons of fuelwood every year. Several other renewable energy technologies and products are now commercially available, and are economically viable in comparison to fossil fuels for some applications. However, there are many barriers to achieve the full potential of the renewable energy technologies.

Many state governments have responded to the rural energy needs with aggressive rural electrification programs, only to find that they cannot afford the massive power plants required or the cost of running wires to the thousands of villages that are off the electrical grid. Even if the grid could be extended to rural communities, most end-users would not be able to afford the monthly tariffs for electricity. And extending traditional fossil fuel-based electrification to all those households would increase the environmental deterioration by producing high levels of pollution. Hence the need for the technologies based on renewable energy sources.

Renewable energy sources, such as solar, wind biomass and small hydro, are all indigenous and cannot be depleted. Exploiting them can make significant contributions to improving energy supplies in our country: they can bring down the requirement for imported fuels, are environmentally benign, and are compatible with the overall strategy for sustainable development.

1.3 Maharashtra: The Power Centre of India

In order to study the potential and evaluate different RETs, we carried out a study of barriers to RETs in the state of Maharashtra, which accounts for about 16% of the Gross Domestic Product and 17% of the electricity supply in India.

The state of Maharashtra has been chosen for this study because of various considerations. It has the highest installed capacity in India and energy consumption per consumer. The Maharashtra State Electricity Board (MSEB) system has a peak demand of about 10,000 MW. The Maharashtra Energy Development Agency, established by the state government has been taking various initiatives to increase the power generation through renewables. Thus, the study of barriers to the diffusion of RETs in the state of Maharashtra is of paramount importance. Despite the focus on Maharashtra, the methodology, analysis and implementation plan developed in this study should be readily adaptable to other states with appropriate modifications for different technology configurations.

To make the evaluation manageable and at the same time develop a study that is significant in scope, it was decided to focus on two technologies, viz., solar and wind in consultation with the Secretary (Energy and Environment), Government of Maharashtra.

1.4 Objectives and Approach of the Present Study

This study focuses on the barriers to the diffusion of renewable energy technologies (RETs). Development of a viable renewable energy alternative is of crucial importance for sustainable development. The environmental benefits offered by renewables cannot be delivered unless barriers have been addressed. As the world's communities suggest through various studies, most recently the Kyoto meeting, it is important that the government and other agencies should provide a range of economic drivers to RETs which other industries have enjoyed until now. As "every problem is an opportunity" to another, this mounting environmental pressure is encouraging investors, inter alia, towards renewable energy technologies. The main objectives of this study were thus to;

(i) review experience with RETs, that have been installed in the State of Maharashtra including their costs and benefits,
(ii) selection of potential RETs for a detailed study including current policies, and
(iii) identification of the barriers to the diffusion of the selected RETs and analysing possible measures for overcoming the barriers,

Thus, the efforts were made to analyse the following issues:

- the costs and benefits through different RETs;
- the importance of various policies for the diffusion of RETs;
- the level of awareness among consumers, and energy developers; and
- understanding the barriers that play an important role in the penetration of RETs;

The present study takes up two RETs, viz., solar water-heating systems and wind energy. This is because several applications of these RETs are now being tested, and used by various consumers. In spite of many challenges, these technologies are making some progress towards supplying energy to the system. Solar water-heating units are cost-effective relative to other available energy sources, and deliver hot water far cheaper than electric heaters. Model projects in several Indian states have shown that demand for these systems is high and that households can afford them if financing is available.

Similarly the wind energy projects are also on the rise. In India a major wind boom was under way since 1994, as the government opened up the power grid to independent power producers, and offered tax incentives for renewable energy development. In Maharashtra, the installed capacity, by the end of the year 1998 was 17.5 MW and the immediate potential is estimated to be 500 MW. Many joint ventures are underway with European and US wind power manufacturers.

Why, then, aren't equipment manufacturers and individual households rushing to take advantage of the huge opportunities and buy these systems? There may be several reasons for this, but perhaps the most important is the fact that no market infrastructure yet exists for these RETs. The current infrastructure, which supports the construction of renewable power projects, relies on single-point lending and investment (where all the financing activity converges around a single large project); which may not be an appropriate model for financing the purchases of small and inexpensive renewable energy systems by millions of widely dispersed consumers. Although many programs have demonstrated several appropriate delivery mechanisms for getting credit as well as technologies to commercial units and to rural end-users, these relatively modest success stories have not been sufficient to raise the confidence of traditional investors.

No one familiar with the problems of promoting new technologies has any illusions about the speed with which the diffusion of renewable technologies can be achieved. In developing countries, learning to use energy through RETs may require long period of time as it involves overcoming the economic, market, social, institutional and other barriers that impede technological change. In this study we discuss all these barriers and then suggest some policy measures to overcome the same for the successful penetration of RETs. To study these issues in depth, stakeholder level surveys covering industries, households, commercial establishments and professionals have been carried out. This report presents the perceptions of the stakeholders, viz., consumers, equipment manufacturers, policy makers, etc., regarding the barriers to the effective penetration of RETs.

The stakeholder surveys are important because, it is widely recognised that the views and perceptions of the stakeholders need to be considered in the formulation of renewable energy programs and policy measures. Also, the survey of policy makers and energy developers is very important because they are the ones who work on these issues and for the effective penetration of RETs, the role they play is very crucial. Hence, it is important to find out their views to formulate an effective policy package for penetration of RETs. These are some of the issues that prompted for this survey with encouraging results.

This study contributes in many ways to identify the major barriers and rank them according to their relative importance in the residential, industrial and commercial sectors. It analyses the micro-level data using consumer level surveys to study the barriers. It also provides information on specific barriers for each technology, which can be used to relate the barriers to technology penetration levels.

1.5 Plan of the Study

The study has been carried out in two parts. In the first part analysis is done on two technologies, viz., solar and wind. For doing this, information is collected from various secondary sources such as energy policy documents, equipment manufacturers, tariff schedules, etc. In the second part analysis is carried out based on the data collected through stakeholder level surveys. For doing this, sample surveys of residential, commercial and industrial firms are conducted through structured questionnaires. Policy makers and wind energy developers were also interviewed to understand their perception on barriers to RETs. The barriers that emerged would help to understand the factors that need to be addressed which in turn play an important role in policy analysis and speedy implementation of these RETs.

CHAPTER 2
AN OVERVIEW OF RENEWABLE ENERGY TECHNOLOGIES

2.1 Introduction

Renewable energy technologies (RETs) are no longer the scientific dream of researchers and technologists. As the need for energy increases and the availability of traditional fuels decreases, RETs will become the technologies of choice in several countries. India is ideally placed to use the vast potential of renewable energy sources. There are many reasons for this. Much of India's land area is unserved by electricity grids unlike in developed countries like USA or Japan. India has an abundance of sun, wind, biomass and hydropower together with technological and managerial skills. India’s research and development (R&D) capacity is very strong. But, what is needed is a national vision and a coordinated and achievable strategic plan to make the Indian renewable energy industry a force to reckon with. Encouragingly, in recent years, there are some positive signs, which indicate that this scenario is now changing. Incentives given by the government of India and various state energy development agencies are part of that change and there are other welcome indications of shifts in the nation's attitudes towards the use of RETs.

India is generously endowed with renewable energy sources viz., solar energy, wind energy, biomass and hydro, which are widely distributed across the country, and can be utilized through commercially viable technologies to generate power/energy. India's renewable energy programme is the largest and most extensive in the developing countries of the world. The increased use of renewable energy technologies has been facilitated by a variety of policy and support measures from the Government of India. The programme is administered by the Ministry of Non-conventional Energy Sources (MNES).

There has been a general perception that renewable energy technologies can only give small amount of energy in certain locations and therefore their contribution to total energy requirements would be only marginal. Another perception has been that these are rather expensive compared to the conventional alternatives. Both of these perceptions are unfounded. However, due to lack of sufficient information and proper institutional mechanism the momentum and growth in renewable energy technologies and their application are not as expected as it would be. Availability of improved and efficient technologies coupled with incentive policies/packages of the Government of India has increased the attractiveness of these technologies though there are still some constraints in commercialization of these technologies.

India has been showing keen interest in RETs, ever since the first oil crisis of 1970s. During the past three decades, some effort has gone into the development, trial and diffusion of a variety of RETs for use in different sectors. There were apprehensions earlier about the survival of RETs and whether they can strengthen as a crucial national resource if India intends to derive true economic benefit from its strong science and technology base. After nearly thirty years of hard work, India has now become an extremely active contributor to the development of successful renewable energy technologies. The following sections report various RETs, markets and costs which are of special interest to India and particularly viable in the state of Maharashtra. The discussions confine to solar and wind energy technologies.

2.2 Renewable Energy Technologies and Markets

Until now, in India energy for cooking and heating in rural households is mainly met by renewable energy sources like fuelwood whose utilization is very inefficient (below 10%). In recent years efforts are being made to replace the existing inefficient technologies with efficient ones. Three million family-sized biogas plants (second in number only to China's) and 30 million improved wood stoves have been installed. Through this, there are saving of over 15 million tonnes of fuelwood every year. In addition, 3.2 million tonnes of enriched organic manure is produced from the biogas plants to supplement and complement expensive and environmentally degrading chemical fertilizers. In addition to the above mentioned technologies which can be directly used, there are other RETs which convert one form of natural energy into another usable form such as wind, solar photovoltaics, etc. for electricity generation. The marginal cost of energy generation through these RETs can compare favourably with that of traditional generation which is approximately around Rs.3.00 per kWh (Table 2.1).

2.2.1 Solar energy

In today's climate of growing energy needs and increasing environmental concerns when we look for alternatives to non-renewable and polluting fossil fuels, one source which immediately comes to mind is the solar energy. Solar energy is quite simply the energy produced directly by the sun and collected by the Earth. The radiation that reaches the Earth is the indirect source of nearly every type of energy used by the mankind today. The exceptions are geothermal energy, and nuclear fission and fusion. Even fossil fuels owe their origins to the sun; they were once living plants and animals whose life was dependent upon the sun. Much of the world's required energy can be supplied directly by solar power. More still can be provided indirectly.

Table 2.1. Cost of installation and generation through various RETs

Technology	Capital cost of generation (Rs. million)	Cost of power (Rs/kWh)
Wind	35 to 40	4.00 to 5.00
Solar PV	300	10.00 to 12.00
Small Hydro	30 to 60	1.00 to 2.00
Biomass power	30 to 40	2.50 to 3.00
Bagasse Cogeneration	25	2.75 to 3.00
Biomass gasification	25	2.25 to 2.50

Source: *Annual reports of the Maharashtra Energy Development Agency, 1996-97 and 1997-98*

The availability of solar energy at the Earth's surface varies in several different ways, and in different time scales. Most uses of energy require both constant and readily available energy. The greatest challenges to the designer of solar energy systems are to (i) forecast the availability of solar energy at some time in future, (ii) provide means to capture the energy, and store it when necessary (so that it will be available when needed), and (iii) make a device to capture the energy in the form of radiation, and to convert it to a useful form of energy. The amount of energy falling on a flat level surface of one meter square over the course of one day is roughly 5 kWh. For a period of 24 hours, the average works out 0.2 kWh/m^2. When compared to other modern energy sources, this is not very concentrated. For example, a 100 Watt light bulb at its surface has an intensity of about 12 kW/m^2 and an electric stove (500 W burner) has an intensity of about 25 kW/m^2. Thus solar energy systems need to have collectors over a relatively large area compared to other conventional energy sources. Another major challenge is economic. While the concepts of collection and storage of solar energy are simple, the collectors and the storage material must be built with real materials, and must compete economically in a world, which already has fairly inexpensive energy technologies.

However, solar power has two big advantages over fossil fuels. The first is the fact that it is renewable, i.e., it is never going to run out. The second is its effect on the environment. While the burning of fossil fuels introduces many harmful pollutants into the atmosphere and contributes to environmental problems like global warming and acid rain, solar energy is non-polluting. While many acres of land is destroyed to construct a fossil fuel power plant, the only land that must be destroyed for a solar energy plant is the land that it stands on. Indeed, if a solar energy system were incorporated into every business and dwelling, no land would have to be destroyed in the name of energy. This ability to decentralize energy systems is something that fossil fuel burning cannot match.

Several kinds of solar energy systems are in use today but a few general tasks consume most of the energy. These tasks include heating, cooling, and the generation of electricity. Solar energy can be applied to all these tasks with different levels of efficiency. In solar technologies, the most commonly used are solar water heating systems, and small stand-alone photovoltaic (solar electric) systems. These two applications of solar energy have proven themselves popular over a decade of use. They also illustrate the two basic methods of harnessing solar energy, i.e., solar thermal systems, and solar electric systems. The solar thermal systems convert the radiant energy of the sun into heat, and then use that heat energy as desired. The solar electric systems convert the radiant energy of the sun directly into electrical energy, which can then be used as most electrical energy is used today. Among the less popular, but still effective, solar energy systems are: remote solar powered water pumping systems, and remote electric power systems for radio repeaters.

Due to the nature of solar energy, two components are required to have a functional energy generator. They are a collector and a storage unit. The collector simply collects the radiation that falls on it and converts a fraction of it to other forms of energy (both electricity and heat or heat alone). The storage unit is required because of the non-constant nature of solar energy; at certain times only a very small amount of radiation will be received. At night or during heavy cloudy days, the amount of energy produced by the collector will be quite small. The storage unit can hold the excess energy produced during the periods of maximum productivity, and release it when the productivity drops. In practice, a backup power supply is usually added, too, for the situations when the amount of energy required is greater than both what is being produced and what is stored in the container.

Methods of collecting and storing solar energy vary depending on the uses planned for the solar generator. In general, there are three types of collectors and many forms of storage units. The three types of collectors are flat-plate collectors, focusing collectors, and passive collectors. Flat-plate collectors are the more commonly used types of collector today. They are arrays of solar panels arranged in a simple plane and can be of any size. The output that is directly related to a few variables such as size, facing, and cleanliness which affect the amount of radiation that falls on the collector. Often these collector panels have automated machinery that keeps them facing the sun. The other type is focusing collectors, which are essentially flat-plate with optical devices arranged to maximize the radiation falling on the focus of the collector. These are currently used only in a few scattered areas. Although they can produce far greater amounts of energy at a single point than the flat-plate collectors can, they lose some of the radiation while the flat-plate panels do not. Radiation reflected off the ground will be used by flat-plane panels but usually will be ignored by focusing collectors. Another problem with focusing collectors relates to temperature. The fragile silicon components that absorb the incoming radiation lose efficiency at high temperatures, and if they get too hot they can even be permanently damaged. The focusing collectors by their very nature can create much higher temperatures and need more safeguards to protect their silicon components. Passive collectors are completely different from the other two types of collectors. The passive collectors absorb radiation and convert it to heat naturally, without being designed and built to do so. All objects have this property to some extent, but only some objects (like walls) will be able to produce enough heat to make it worthwhile. Often their natural ability to convert radiation to heat is enhanced in some way or another (by being painted black, for example) and a system for transferring the heat to a different location is generally added.

Heating

Solar energy is used for a variety of uses of which heating is one end use for which solar energy is best suited. Solar heating requires almost no energy transformation, and hence it has a very high efficiency. This heat energy can be stored in a liquid, such as water, or in a packed bed (a packed bed is a container filled with small objects that can hold heat with air space between them). The energy of the collector is used to change the chemical to its liquid phase, and is as a result stored in the chemical itself. It can be tapped later by allowing the chemical to revert to its solid form. Solar energy is frequently used in residential homes to heat water. This is an easy application, as the desired end result (hot water) is the storage facility. A hot water tank is filled with hot water during the day, and drained as needed. This application is a very simple adjustment from the normal water heaters.

Solar water heating system

A solar water heating system consists of a solar collector, toughened glass, insulated storage tank, cold water supply tank and insulated piping. Sun rays penetrate through the glass and fall on absorber. The heat of sunrays is absorbed by the cold water inside the absorber and thereby its temperature gets increased. The heated water gets collected inside the insulated storage tank either through thermosyphon or forced flow system. Thermosypon system upto 3,000 liters per day can be installed, however, for higher capacity it is necessary to go for forced flow system only. The water temperature can be raised upto 85^0 C. The solar water heating system can be used for bathing, washing, boiler feed water and similar other purposes where hot water is required in domestic, commercial and industrial sectors. The cost of solar water heating system is around Rs.130/- to Rs.200/- per liter depending upon capacity of the system and the investment made can be recovered in 4 to 6 years time. The life of system is around 10-15 years if maintained properly. The operation and maintenance cost is very negligible. In Maharashtra solar water heating systems of total around 3.5 million liters per day have been installed. In Maharashtra eight manufacturers of Solar Flat Collectors have got ISI mark (denoting a standard product) for solar flat plate collectors from Bureau of Indian Standard (BIS). The basic requirements for the installation of solar water heating System are:

(i) plenty of sunshine during most part of the year
(ii) availability of space either on ground or on terrace free of shadow from at least from 0800 hrs till 1600 hrs of a day; A 100 Litres Per Day (LPD) system needs around 3-4 sq. mt. area.
(iii) Reasonably soft water; and
(iv) Electricity for operation of pump in forced flow system.

If the system is to be installed on terrace it is necessary to check load bearing capacity of the slab. The space selected should be very close to all use points in order to save on piping. The solar collectors are installed facing due south with a tilt equal to the latitude of that place plus 15^0. The hot water insulated tank shall be at least 50 cm above collector top and cold water tank shall be at least 50 cm above hot water tank in case of thermosyphon system. A typical domestic solar water-heating system is shown in Figure 2.1.

During the year 1997/98 the total installed collector area under solar water heating system was 30,000 sq. meters whereas the cumulative collector area was of the order of 410,000 sq. meters. Looking at the potential and resource availability, these figures are small. This is because, in India, solar hot water systems are yet to be financially competitive with other energy carriers such as electricity. In some states where electricity availability is less but plenty of sun is, solar hot water may be financially competitive with fossil fuel alternatives. The state of Maharashtra has the highest proportion of solar hot water services in India, which is around 20%. Some industries in Maharashtra now have solar hot water heating systems but the market penetration has been slow since the early 1990s due to sharpened competition from off peak electricity and gas. Hence, the government is providing various incentives such as subsidies and other fiscal benefits for the promotion of solar water heating systems. Once these technologies attain a certain level of commercialization, the subsidies can be gradually phased out.

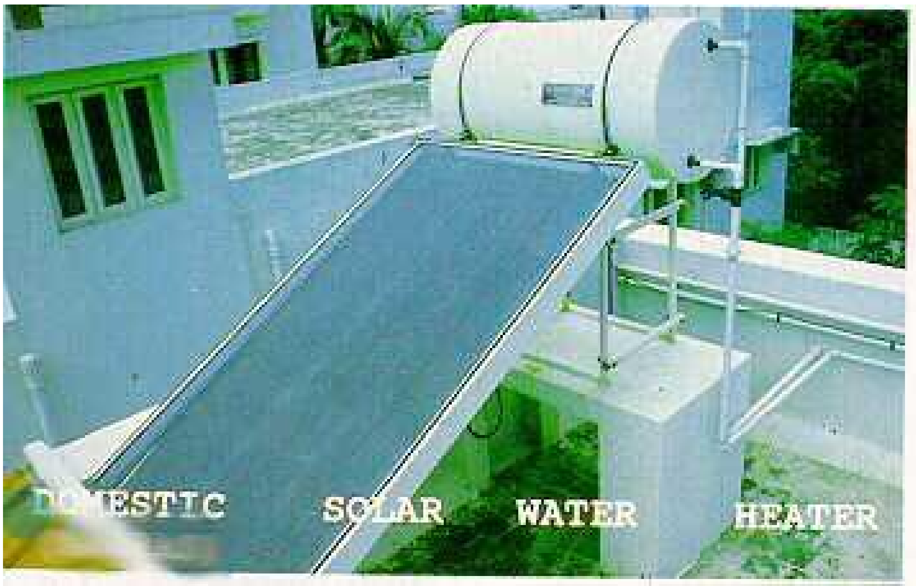


Figure 2.1; A solar water heating system

Electricity

Besides being used for heating, solar energy can be directly converted to electricity. Most of the machine tools in India are designed to be driven by electricity, so if electricity can be generated through solar power, one can run almost anything with solar power. The solar collectors that convert radiation into electricity can be either flat-plate collectors or focusing collectors, and the silicon components of these collectors are photovoltaic cells.

The photovoltaic cells, by their very nature, convert radiation to electricity. This phenomenon has been known for well over half a century, but until recently the amount of electricity generated was good for little more than measuring radiation intensity. This simple, reliable and environmentally benign technology is useful in providing electricity to the widely dispersed households and settlements in rural India. Over 400,000 solar photovoltaic systems, with an installed capacity of about 28 MW, have so far been installed in India. They involve around 25 different types of systems for domestic, industrial and commercial applications, including street lighting, water pumping and rural telecommunication systems. Solar lighting systems are now being used in 180,000 homes and are contributing to substantial savings in kerosene since most of rural households and urban poor still use kerosene for lighting.

Most of the photovoltaic cells available in the market today operate at an efficiency of less than 15%; that is, if all the radiation that falls upon them, then only 15% or less of it is converted to electricity. The maximum theoretical efficiency for a photovoltaic cell is only 32.3% at which the solar electricity is very economical. Most of the other forms of electricity generation are at a lower efficiency than this. However, actual efficiencies are less than 15%, which are not usually considered economical by most consumers, even if it is fine for toys and pocket calculators. Recently a solar cell was developed in laboratories with an efficiency of 28%. This type of cell has yet to be field-tested. If it maintains its efficiency in the uncontrolled environment of the outside world, and if it does not have a tendency to break down, it will be economical for power companies to build solar power facilities.

Scale of energy production

Of all the energy sources available, solar has perhaps the most promise. Numerically, it is capable of producing the raw power required to satisfy the entire planet's energy needs. Environmentally, it is one of the least destructive of all the sources of energy. Practically, it can be adjusted to power nearly everything except transportation with very little adjustment, and even transportation with some modest modifications to the current general system of travel. Clearly, solar energy can be considered as resource of the future. Also, among all the renewable resources, only in solar power do we find the potential for an energy source capable of supplying more energy than is used. The scale of solar thermal system installations in Maharashtra and India is provided in Tables 2.2 and 2.3. They provide information about the number and costs of various solar energy technologies.

As Table 2.3 indicates, solar thermal power generation can compare favorably with fossil fuel-based power generation. Apart from grid connected centralized power plants, solar thermal plants can also operate in stand alone mode in decentralized application like rural electrification and in remote locations like islands. The potential Indian market is predicted to be 800 MW per year. The Indian government is targeting the generation of an additional 3,000 MW of grid power from renewable during the 9th plan period (1997-2002), of which solar energy accounts for 150 MW.

Table 2.2. Solar thermal systems in Maharashtra and India

Type of system	Number of systems	
	Maharashtra	**India**
Industrial water heating systems	571	6142
Domestic SWHS	632	12517
Solar air-heated crop-drying systems	1	61
Solar timber kilns		71
Solar desalination system	145	10195
Solar cooker	37114	188028
SPV SYSTEM		
Solar lantern	3792	88920
Home light system	72	42845
Street light system	2941	30569
Power plants(kWp)	6.40	92330
Water pumps	102	1772

***Source**: Annual Report of MEDA (1997-98)*

Table 2.3. Costs of solar energy technologies and the Government subsidy

Technology	**Technology cost (Rs.)**	**Subsidy (Rs.)**
Solar Cooker	900 – 1500	
Solar lantern	3550	
Solar air heater	n.a	
Solar air desalination	n.a	
Subsidies :		
Solar Photovoltaic		
Domestic Lighting		50% of ex-work cost
Street Lighting		50% of ex-work cost
PV power plant		50% of ex-work cost
Solar lantern*		Rs. 1500 per lantern (Rs. 100 service charge)
SPV pumps		Rs. 150 per WP (max of Rs. 50,000 to Rs.100,000)

***Source**: CMIE , India's Energy Sector , Sep 1999*

** Costs of solar lantern vary but as an indicative estimate the Uttar Pradesh agency implementing the scheme has fixed the unit cost of this lantern at Rs. 3,500.*

2.2.2 Wind energy

India is one of the major wind power generators in the world. A major wind boom was under way in India during 1990s as the government opened up the power grid to independent developers, and offered tax incentives for renewable energy development. By the end of the decade 100 MW of wind power had been added. Most of the projects involve joint ventures with European and US wind power manufacturers (a wind farm in India is shown above). The wind power capacity in the world and the contribution from India are shown in Table 2.4.

In the state of Maharashtra, various initiatives taken for the development of wind power program had led to the nearly complete commercialization of this sector. The details of windfarms and potential for wind farms in Maharashtra are provided in Tables 2.5 and 2.6.

Table 2.4. Operational wind power capacity worldwide (1998)

Country	Installations (MW)	Country	Installations (MW)
Europe	4000	**North America**	**1622**
Germany	1800	USA	1601
Denmark	992	Canada	21
Spain	342	**Asia**	**1072**
Netherlands	333	India	926
UK	293	China	146
Sweden	106	**South and Central America**	**34**
Greece	29	Costa Rica	20
Ireland	11	Argentina	9
Portugal	20	Brazil	3
Austria	20	Mexico	2
France	10	**Pacific Region**	33
Finland	10	Japan	18
Belgium	7	Australia	11
Czech Republic	7	New Zealand	4
Russia	5	**Middle East/Africa**	**24**
Ukraine	1	Iran	9
Norway	4	Israel	6
Luxembourg	2	Egypt	5
Switzerland	2	Jordan	1
Latvia	1	Africa	3
Poland	11		
Grand Total	**6781**		

Source: *Maharashtra Energy Development Agency, Annual Report (1998-99)*

Table 2.5. Details of windfarms in Maharashtra

Characteristic	
Waste lands (ha)	5980
Ultimate wind speed (M/S)	12845
Wind power density (W/sq.km) (100-150)	10
> 150	3
Specific output at 25 km/hr	5.22
Energy Generation	1584
Cost of electricity generation (Rs/kWh)	2.91

Source: *Maharashtra Energy Development Agency, Annual Report (1988-99)*

Table 2.6. Potential for windfarms in Maharashtra

Total potential (MW)	1000
Immediate potential (MW)	500
Estimated cost (Rs.million)	22500
Potential sites identified (no)	18 .
Monitoring in progress (no)	18 .
Annual Wind speed range available (kmph)	18 -- 23

Source: *Maharashtra Energy Development Agency, Annual Report (1988-99)*

In addition, the introduction of fiscal and promotional incentives provided a fillip for the deployment of wind technology by the private investors. There is a five year tax holiday on wind projects. There is also 100% accelerated depreciation and exemption or concessional duties on wind electric generators additional incentives by the state government. Guidelines for wheeling, banking, and purchasing power from wind power projects have been sent to the states. It has been proposed that they may consider purchasing power at least at the rate of Rs. 2.25 per kWh. Supplementary guidelines provide for an annual escalation of 5%. As a result, several state governments have announced policies relating to the purchase price of power generated by wind, wheeling and banking fees, terms of third-party sale, capital subsidy, and industry status. In addition to this private sector can also avail soft loans from the Indian Renewable Energy Developing Agency. A credit worth US $78 million for the development of wind farms by the International Energy Development Agency has been extended to the private sector. This line of credit also includes $31 million that accrue due to the environmental benefits through the installation of windfarms.

Costs

Electricity from the wind can now be produced for around Rs 5.00/kWh from large wind turbines in good wind regions, and is close to becoming competitive with fossil fuel generated electricity in some applications. While not competitive with grid, such machines will be attractive in diesel based hybrid mini-grids. Table 2.7 provides information about wind energy technologies.

Table 2.7. The costs of wind energy technologies

Details	**Cap cost (Rs. million/MW)**	**Generation cost (Rs./ kWh)**
Wind power generation	40—45	Rs. 4.00 - 5.00
Cost of setting up wind farm projects		Rs. 35 .- 40 mill
Average cost of wind power generation		Rs. 1.75 - 2.25

***Source**: CMIE , India's Energy Sector, Sep 1999*

Technologies and Markets

Apart from traditional water pumping and other age old uses, market opportunities lie mainly in grid connected, stand alone RAPS or mini-grid electricity generation. The opportunities in developing countries like India to 'leapfrog' to this technology is enormous as they search for electricity sources that free them from dependence on fossil fuels which are often imported or have heavy transportation costs to remote areas.

Wind power at the end of 1998 was over 20 MW in Maharashtra, and over 120 MW would be added during the next year. Maharashtra, in the 70's decided to base a significant portion of energy future on indigenous resources and its own technological ingenuity by focusing on wind power in which it had much experience. The MEDA developed the electricity generating wind turbine in the year 1995 and have advanced the technology ever since its inception. Today it dominates India’s wind power industry. The Maharashtra government played a crucial role in developing wind energy and help in MSEB to purchase the electricity at a fair price. As a consequence the wind turbines in operation in 1999 with a capacity of 10 MW.

At the end of the Eleventh Five Year Plan, i.e., by the year 2012, around 10 per cent of the total installed power generating capacity in India is likely to be based on renewables. A comprehensive renewable energy policy and a separate legislation are being prepared for accelerated thrust to the development of this sector. If correct policy initiatives are taken, India can achieve a leadership position since it has the potential to emerge as a truly major global player in this sector.

CHAPTER 3
METHODOLOGY

The information required for studying the barriers to the adoption of renewable energy technologies could be obtained from mainly two sources, namely primary and secondary. The information on these barriers, which can be viewed from macro perspective, could be obtained from secondary sources. The possible secondary sources for this purpose could be energy policy documents, energy pricing policy documents, electricity acts, custom tariff schedule, documents on tax structure on the renewable energy technologies, etc.

The information on those barriers, which can be viewed form micro perspective, should be obtained through consumer level surveys in various sectors such as residential, commercial and industrial enterprises through structured questionnaire. In conducting such survey, sample size and sampling design are two crucial elements.

3.1 Design of the Study

The surveys were designed to study the barriers for the penetration of renewable energy technologies (RETs) such as solar and wind and to gain insights from the user as well as policy maker perspective. In particular the survey questionnaires were designed to throw light on the perceived benefits of RETs, the awareness of users on their costs and savings and the barriers for the use of RETS, the role of the Maharashtra Energy Development Agency, which plays an important role in the diffusion of RET, etc. The SWH surveys covered residential, industrial and commercial sectors. Policy makers, and wind energy developers were also interviewed. The surveys were conducted in the urban areas of Bombay and Pune in the state of Maharashtra.

Solar Water Heaters: A sample of 80 households was selected in the residential sector. In the industrial sector, 10 companies (or firms) were randomly selected covering various categories such as fertiliser, iron and steel, non-ferrous, pharmaceutical, engineering, textile and chemicals. In the commercial sector, 25 establishments were selected which include hotels, shops and offices. Information was solicited from SWH manufacturers. In the case of wind, 10 wind energy developers were interviewed and information obtained. 15 persons connected with policymaking process were also interviewed to get their opinion both on SWH and wind energy.

The survey was conducted through an administered questionnaire which contains detailed information on the education level of the respondent, income of the household (turnover in the case of a firm), quantity and type of energy carrier used for water-heating, electricity cost, awareness about RETS, barriers for adopting them, reasons for satisfaction/dissatisfaction with the role of MEDA, etc. Several barriers were listed and the respondents were also asked to rank the barriers.

The survey was conducted during the month of April-May, 1999. Before the interview, respondents were briefed about the aims of the survey which were to find out (i) their perception about RETs, (ii) their awareness levels, particularly about solar water heaters and wind energy, (iii) the awareness of users on their costs and savings and the barriers for the use of RETS, and (iv) the role of the MEDA in the diffusion of RETs. The surveys covered residential, industrial and commercial sectors. In addition to the structured questionnaire, the consumers were also asked about their experience with RETs and their views on the role of the information diffusion in creating awareness among consumers. Each respondent was asked whether they would like to use RETs or not and why.

To make the evaluation manageable and at the same time develop a study that is significant in scope, it was decided to focus only to selected areas and structure statewide scheme based on the results. The consumers being very large spreading across a wide area, it was necessary to narrow the sample coverage to some areas which covers a large number of household, industries and commercial establishments and bears a close resemblance to the total system in important aspects. We have selected two urban centres, viz., Mumbai and Pune from the Western part of the Maharashtra State in India. Thus from the point of view of management of the survey as well as overall representativeness of the sample it was an ideal geographical region for the purpose of the coverage of the survey.

3.1.1 Residential sector

Residential electricity consumption is categorised into various end-uses such as: water heating, lighting and air-circulation. In a study of urban areas in India, it was found that water-heating account for the largest share of residential electricity consumption accounting for about 20 to 30% of the total consumption. In the energy budget of a family, water heating accounted for about 25%. Electricity was the main carrier used for water heating. Most of the urban households in India use geysers (average rating of 2 kW) for heating purposes (Reddy B.S. 1998).

3.1.2 Industrial sector

The industrial sector is the largest end-use consumer of electricity accounting for 40% of the total consumption (MSEB, 1998-99). This sector includes manufacturing, primary metal, chemicals, electronics, food products, etc. The industrial sector is desegregated into various categories, viz., iron & steel, chemicals, textiles, engineering, etc.

Based on the voltage, at which power is supplied, the industrial sector is divided into Low Tension (LT) and HighTension (HT) groups. For LT industries, the connected load is 150 kW per installation, and for HT; the load should be above 150 kW per installation. Electricity is being consumed in the industrial sector for a variety of end-uses. Shaft power/mechanical drive, compressing, pumping and process heating are the main end-uses of electricity accounting for 85 per cent of the total electricity consumption. Of the total electricity consumed 26% goes for shaft power, followed by compression with 24%, pumping and process heating share 19 and 18% respectively. The other major end-uses are blowing (11%) and lighting (4%). Energy generated through hot water is used for industrial purposes and in canteens (Parikh *et al*, 1994)

For collecting the data in the industrial sector, the first step was to identify the categories of consumers so that priorities (in terms of the need for water heating) could be identified. In particular, the choice of fuel for water heating and the awareness on the consumers' side was to be assessed. We have chosen 10 firms (industries) covering the categories such as iron and steel, chemicals, textiles, engineering, paper, etc.

3.1.3 Commercial sector

The commercial sector consists of a diverse group of consumers ranging from offices, shops, lodgings and restaurants to railway stations, hospitals and movie theaters. Water heating, lighting and air-cooling are the main uses of electricity in this sector. A representative sample, covering 25 establishments, in Mumbai and Pune, was chosen among the various commercial establishments.

3.1.4 Policy Makers

In addition to the above mentioned sectors policy makers in the state department of energy, State Electricity Board, MEDA, etc., were interviewed. This was to seek their opinion about the barriers for the effective implementation of renewable energy technologies, policies for removing the barriers, etc. This survey is important because the existing policies of the government play a crucial role in determining the approach to be adopted for the faster diffusion of a technology. The views expressed by the policy makers are thus significant.

3.1.5 Wind Energy Developers

Interviews were also held with some wind energy developers (who produce wind energy) to ascertain their views on the cost of energy produced, the method of their relation with MEDA and their views on services provided by MEDA, etc. According to the guidelines prepared by the department of energy, government of Maharashtra, a professional wind energy developer should have the following characteristics:

(i) ability to adapt, modify and develop new technology (R & D level);

(ii) awareness of technical developments, the recognition of a relevant technology for a country/region/service and the ability to assess, select and utilise the new technologies (Production, O & M, etc); and

(iii) Competencies to select appropriate technology, study the cost-effectiveness, identify the barriers and suggest policies for their speedy implementation (policy/government level).

Interviews were held with 10 wind energy developers to ascertain their views on various aspects of the diffusion of RETs.

3.2 Design of Consumers Surveys

To appreciate the consumers' perspective, surveys were designed to study the barriers for the penetration of RETs and view it from the perspective of the consumer. In addition to residential, industrial and commercial consumers, some policy makers and wind energy developers were also interviewed. This is necessary to throw light on the benefits of RETs, their level awareness, long term implications of energy substitution, their views on barriers for renewable technologies, etc. Interviews were also held with some wind energy developers to ascertain their views on the cost and savings of wind energy.

In developing the sampling design, it is necessary to identify the population that is relevant for the study. The relevant population for the present survey purpose is the residential, commercial and industrial enterprises, which are, located in a geographical area that are electrified. Thus, the first step in developing the sampling design is to identify the geographical areas that are electrified. The sample survey has been carried out only in these areas.

To achieve the above objectives a representative sample in households, industries and commercial establishments had to be selected first. Since the electricity supply system in Maharashtra is very large with millions of consumers spread across a wide area, it is necessary to narrow down the sample coverage to some areas with higher concentration of consumers. Hence, two urban areas are chosen, viz., Mumbai and Pune were selected.

Ideally, the sample size should have been determined by examining the standard deviations of the variables under consideration. In their absence, the survey of large sample size would have been better. Due to the time and budget constraints, it was decided to limit the sample size of about 50 (varying from 10 to 80) in each sector. For minimizing any adverse effect on the accuracy of estimates due to small sample size, a sampling design using the simple random technique was used.

The questionnaires were a detailed one consisting of the education level of the respondent, income/turn over, electrical appliances used, electricity consumption, awareness about RETs, barriers for using them, etc (Annexure 1). The respondents were personally interviewed and asked to answer the questions.

The survey was conducted during the month of April-May, 1999. People were interviewed at their homes/firms by an unbiased third party. Before the interview, people were briefed about the aims of the survey which were to find out (i) their perception about RETs (ii) their awareness level, (iii) the role of MEDA, (iv) the costs and benefits of RETs and (iv) the barriers for using RETs.

Information on income/turn over of the household/firm, end-use pattern of energy, the costs and durability of RETs, were recorded during the course of the interview. Other information gathered from the survey includes: the attitude of the people towards RETs, their knowledge about the costs and savings, barriers for the adoption of RETs, etc. Each respondent was asked whether they would like to use RETs or not and why.

In addition to the structured questions the consumers were also asked about their experience with SWH and their views on the role of the information diffusion in creating awareness among consumers. For each consumer, the survey team also recorded their impressions about the consumers' attitude and their perceptions about various renewable energy technologies.

The survey was done to study the awareness about various renewable energy technologies (particularly SWH) and determine the barriers for their penetration. By bringing the two together, the possibility of assessing the consumers knowledge about renewable energy technologies as well as potential for their use could be assessed. For this, a representative sample had to be selected first. Since Maharashtra State is very large with millions of consumers spread across a wide area, it was necessary to narrow the sample coverage to some areas with a large number of consumers. The consumers that are located in such area are classified into two groups: those, which require using hot water and those, which do not. Therefore, the focus of the survey had to be essentially on that group of consumers using hot water. These consumers were requested to answer the questions. Some more personal visits were made to seek clarifications, explanations and for discussions on possible barriers for the penetration of RETs.

Residential Sector

The sample was designed to yield a total of 80 households from two cities of Mumbai and Pune. The survey was based on personal interviews. The questionnaire was a detailed one consisting of the family income, electrical appliances used, perceptions about renewable energy technologies, barriers for the utilisation of SWH, etc. Before the interview, the households were briefed about the aim of the survey, which was to determine the barriers for the penetration SWH. With regard to income, questions were asked in different ways to elicit more reliable information. In almost all cases, the head of the household (who happened to be the decision-maker for purchasing the appliances) answered the questions. When a household was unwilling to divulge its monthly income, the households were asked to indicate the income brackets they belonged to -- < Rs 5000, Rs 5000-10000, > Rs 50,000, etc. Information about the energy use pattern was obtained.

Industrial Sector

The industrial survey was conducted through an administered questionnaire. A sample of 10 randomly selected industries, in various categories, each having more than 100 firms were selected. The sample had a category-wise profile similar to that of the Maharashtra. The survey covered various categories, viz., cement, fertiliser, paper, pharmaceutical, engineering, textile and chemical. The firms were interviewed and following information collected.

(a) Sample characteristics, viz., maximum demand, energy consumed and electricity bills, (b) industry attitudes towards renewable energy technologies, viz., involvement of top management, energy audits conducted, and the level of awareness for each technology, (c) potential for SWH, barriers to accepting SWH, (d) elements that are desirable for effective adoption, and (e) ranking of barriers that are detrimental to the penetration, and (f) institutions, measures and incentives which should help to remove the barriers and meet the expectations of the consumers.

Commercial Sector

The sampling survey of the commercial sector was conducted in the urban areas of Mumbai and Pune. The commercial sector was stratified into three groups viz., hotels, shops and offices. About 10 hotels and 5 shops were selected randomly for carrying out the sample survey. These were selected randomly for carrying out the sample survey. Finally offices were stratified into two groups: private and public. About five offices each from these two groups were selected randomly for conducting sample survey. The rest has been from other commercial groups. As in the case of residential sector, selected hotels, shops and offices are surveyed though structured questionnaire to obtain information relating to the barriers to the adoption of various energy-efficient technologies.

CHAPTER 4
RESULTS OF THE SURVEY

4.1 Residential Sector

4.1.1 General information

The household survey was designed to study the barriers for the penetration of renewable energy technologies (mainly solar water-heaters). This is necessary to throw light on the perceived benefits of solar water-heaters, the awareness of households on the costs and savings of this technology, the barriers to their penetration and the role of the Maharashtra Energy Development Agency (MEDA) in the penetration of these technologies.

To appreciate the households' perspective surveys were conducted in the urban areas of Mumbai and Pune. In order to obtain a generally representative sample, 66 households were chosen. Information on household income, appliances used for water-heating, perceptions about solar water-heaters (SWH), role of MEDA, barriers for their use, etc., were recorded during the course of the interview. In most cases, the head of the head of the household answered the questions. The remaining responses came from the other family members (Table 4.1.1). This information is important since, in many instances, it is the head of the household who takes decisions. In some cases, if the head of the household is not educated, then the educated son plays an important role in selecting a technology to be installed at the house. Hence, the perception of the head of the household and his/her son is important.

Table 4.1.1. Respondents position in the family

Position	No. of households	%
Head	32	48.48
Wife	11	16.67
Son	17	25.76
Daughter	2	3.03
Others	4	6.06
Total	66	100

Table 4.1.2 gives the sample distribution according to the level of education. The level of education provides a person the necessary information about the cost and benefits of a particular technology. If the household consists of illiterate persons, then, they have to depend on other's opinion and that may not be a rational one. Thus, the level of education and the adoption of a

new technology are related. Most of the respondents as well as decision-makers (regarding the purchase of electrical appliances) studied up to graduation level (around 40%). The education levels of the rest are: Engineering (19%), PG/MBBS (16.7%) and primary/secondary (9%).

Table 4.1.2. Education level of the respondent and the decision-maker

Education level	**No.**	**%**
Respondent		
Primary/Secondary	6	9.1
Graduate	26	39.4
PG/MBBS	11	16.7
Eng.	12	18.2
Others	11	16.7
Total	66	100
Decision maker		
Primary/ Secondary	6	9.1
Graduate	25	41.7
PG/MBBS	10	16.7
Engg.	12	20.0
Others	13	16.7
Total	66	100

Occupancy status of the household is a crucial factor in determining the efforts of the consumer towards installing SWH. If the owner is the occupant of the house, there is a greater probability of installing a SWH. In the case of a tenant the probability is less. In the sample, 50 (76%) of the respondents stayed in their own homes and the rest were tenants. In Mumbai, the percentage of owners was 43% whereas 80% of the respondents in Pune areas resided in their own homes (Table 4.1.3). Regarding the size of the house 40% had 2 to 3 rooms, 50% had 4 to 6 rooms, and only 3% had > 6 rooms per dwelling. In the case of the occupancy area majority of the respondents (47.5% of households) stayed in the occupancy range of 500-1000 sq.ft.

Table 4.1.3. Details about the residence

Occupancy status	**No.**	**%**
Owner	50	75.76
Tenant	16	24.24
Total	66	100

Information was solicited from the respondents on the size of the family because, family size plays an important role in determining the capacity of water-heating appliances used. With increasing family size, the consumption of hot water increases and there is a greater probability of using a SWH since the use of electricity may be quite expensive. Nearly 75% of the households had a family size of 3 to 5 (Table 4.1.4).

Table 4.1.4. Details about the size of the family

Size of family	Nose	%
< 3	9	13.64
3 to 4	30	45.45
4 to 5	19	28.79
> 5	8	12.12
	66	100

Most of the respondents derive their livelihood primarily from services (47%) and business (23%). These households were grouped into six monthly income categories, viz., < Rs. 5,000, RS 5,000-10,000, RS 10,000-25,000, RS 25,000-50,000, and > RS 50,000. This categorization has been done to understand the income distribution of households since income plays an important role in the utilisation of energy carriers. It will provide us an idea about the affordability of households in installing a solar water-heater. Out of 66 households, 40 are in the range of households with Rs.10,000 – 25,000 income per month while only three households belong to lower-income group, i.e., Rs <5,000 per month. The remaining households are from the middle and very high-income groups (Table 4.1.5).

Table 4.1.5. Occupation of respondents and their income levels

Occupation	Number of respondents in various income groups					%
	<5000	5000- 10000	10000- 25000	>25000	Total	
Services	2	5	21	3	31	46.97
Self employed	0	2	5	2	9	13.64
Business	0	1	7	7	15	22.73
Others	1	2	7	1	11	16.67
Total	3	10	40	13	66	100.00

4.1.2 Electricity and hot water use

The awareness about the electricity price and consumption about the cost of water heating is an important factor, which leads to greater commitment to the substitution of SWH for electric water-heaters (EWH). Information was obtained from the respondents on the electricity consumption, electricity bill and the price of electricity. The EWH, referred to as geysers, are in use in both Mumbai and Pune. Nearly 90% of households use EWH. 25 (38% of total) respondents from Mumbai and 15 (22% of total) from Pune gave the correct electricity tariff (with 10% variation). Thus, out of 66 households only 40 were aware about the electricity tariff charged per unit of electricity (Table 4.1.6).

Table 4.1.6. Electricity consumption

	Range				
Consumption (kWh/month)	<100	100 to 200	200 to 300	>300	Total
Households (no.)	4	13	15	34	66
Electricity Bill (Rs/month)	<200	200 to 500	500 to 1000	>1000	
Households (no.)	5	16	13	32	66
Average price (Rs/kWh)	<3	3 to 4.5	4.5		
Households (no.)	32	5	3		40

Almost all the households use hot water for bathing purposes. Electric Geysers, Gas and Kerosene stoves and Solar water heaters were the technologies used for these purposes. The quantity of hot water used depends on the size of the family and the season. As the table shows majority of the households use hot water to the extent of 50 to 100 litres per day (Table 4.1.7).

Table 4.1.7. Consumption of hot water and the type of technology used

Fuel used	**Number of households**	**Hot water (l/day)**				
		< 50	50 to 100	100 to 200	> 200	Total
Electricity	18	23	26	16	1	66
Electricity & Kerosene	3					
Electricity & Gas	6					
Electricity,Gas & Kerosene Count	2					
Solar water heater	14					
Electricity and Solar	19					
Other fuels+ solar	4					
Total	66					

Note: *The utilisation of hot water is same irrespective of the type of energy carrier used. That is why the data is provided in only one row.*

4.1.3 Barriers to SWH

Renewable energy technologies face different barriers. The main barriers for the solar water-heaters, can be as follows:

(i) lack of sufficient information;
(ii) non-availability in the market;
(iii) high initial cost;
(iv) low electricity bill and hence no incentive;
(vi) uncertain savings;
(vi) uninterested consumers; and
(ix) maintenance problems.

These barriers can be classified into (i) awareness and information, (ii) financial and economic and (iiii) technical barriers.

It is desirable to rank the barriers according to their order of importance. For example, the barrier given as the first preference will have the maximum effect on the adoption of a technology while the one that was given last preference will have the least effect. Generally the ability to make qualitative distinction is represented by attributes, viz., equal, weak and strong or to put it differently, rejection, indifference and acceptance. Each of these can be subdivided into low, medium and high indicating nine scales of distinction. However Green and Carmone (1970) indicated that one would need only five point scale to distinguish between rejection and acceptance. Since this method is simple and appropriate we used this method to provide weights to various preferences. The weighted average was found out using normalised weights and ranked them according to the order of importance. Accordingly, the first preference is given 5/15 points, second 4/15, third 3/15, fourth 2/15 and fifth 1/15 so that the total becomes one. These weights are multiplied by the number of responses for each barrier and the weighted average is found out. The barriers are ranked based on these weighted averages. The following section deals with each type of barrier and finally they are ranked according to their order of importance.

(i) Awareness and information

The awareness about the costs and savings of SWH contributes significantly to its installation. Questions were asked whether they were aware about SWH or not. In the case of SWH the awareness levels were high. According to the survey data only about 4 of the sample households are not aware about SWH. Based on the above information, it can be concluded that: awareness levels are high for SWH (Table 4.1.8).

Table 4.1.8. Awareness about solar water heaters

	Yes	No	Total
Awareness	62	4	66
Installed	37	29	66

Information relating to SWH is often asserted to be inadequate and therefore discourages the consumer to invest. This information may be relating to the cost saving of the technology, durability, etc. The consumer may undertake an extensive search and acquire this information. Since many households have not installed SWH, even though they are aware of it, questions were asked about the type of reasons for not installing it.

(ii) Economic and financial

(a) Cost

The cost of a device plays an important role in procuring it. In the case of SWH, the cost varies according to its capacity. Majority of the households has SWH of capacity about 100 to 250 l. The details about the capacity of various types of SWH and their costs are provided in Table 4.1.9.

Table 4.1.9. Details of SWH

Capacity (l/day)	No. SWH	Cost (Rs.)
<100	2	12500
100-200	16	20000
200 – 300	13	30000
> 300	6	40000
Total	37	

(b) Views of consumers on the cost of SWH

The perceptions of consumers about the cost of SWH can be an important consideration for adopting this technology. To solicit the opinions of consumers about this aspect, the following alternatives were provided to them. They are: (i) very high (ii) high (iii) Average (iv) Don't know. After obtaining the perceptions about the cost of SWH, the respondents were asked whether they

Table 4.1.10. Respondents views on costs of SWH

	No. of responses	%
View on cost		
Very high	9	14.52
High	38	61.29
Average	5	8.06
Don't know	10	16.13
Total	6	100.00
Decision to buy		
Will not go	10	16.13
Undecided	27	43.55
Will go	11	17.74
Don't know	14	22.58
Total	62	100

would opt for the technology at the prevailing costs. The options were : (i) will not go (ii) undecided (iii) will go and (iv) Don't know. The responses provided by the households are given in Table 4.1.10. The responses indicate that only 17% of the respondents were in favour of adopting SWH at the prevailing market prices. Some of the respondents said that they were undecided about the adoption and some were unwilling to give any comment.

(c) Simple payback period

Questions were posed to find out the views of the respondents about the acceptable payback period for investing in SWH. The payback period varies with the investment amount and the consumer category. For SWH, 24 respondents felt it should be between 3 and five years while nine felt less than three years. Generally, majority of the respondents felt that a simple payback period of three years would be acceptable (Table 4.1.11).

Table 4.1.11. Payback period for investing in SWH

Simple payback period (years)	No. of responses
<1	0
1 to 2	5
2 to 3	4
3 to 4	12
4 to 5	12
>5	4
Total	37

Obtaining loan for the installation of SWH is like making investments for which the consumers have to borrow money either from the commercial banks or some private sources. The interest rates vary with the source. In order to assess the respondent's views on the source of obtaining the loan, questions were asked. Of the 21 respondents who obtained the loan, 10 got it from banks while six obtained from banks as well as private sources (Table 4.1.12).

Table 4.1.12. Getting loan for the installation of SWH

	Tried	**Obtained**	**Interest rate (%)**
Yes	23	21	10
No	27		
Source	**Interest rate (%)**		
	Responses	Rate (%)	
Bank	10	<10	
Bank and Private source	6	12 to 15	
Private source	3	15-20	
IREDA[1]	2	<10	
Total	21		

[1] *Indian Renewable Energy Development Agency*

(d) Consumers' borrowing and investing rates

Generally we try to find out the consumer behaviour in making investments. For this we attempt to estimate the implicit discount rates that consumers use when they make decisions. Some times we speculate the correct discount rate and some times we compare their borrowing rates with their investment. Using this information we can find out to what extent these rates differ from the social discount rate that ought to be applied in evaluating an investment. (For the present study, we assume that an increase in investment in an SWH should be based on the conclusion that the Expected Rate of Return (ERR) in investing in SWH is greater than the rate of return available in the economy. This implies that ERR on SWH exceeds social rate of return on other investments means that current investments in any technology is inadequate when evaluated at the appropriate private investment). This is because (i) it can be advanced for any investment taking place in the economy and hence current investment is inadequate everywhere (ii) ERR may be high due to several factors (including distortion, risk, factor immobility, lack of perfect market, expectations and son on).

In order to assess the respondent's views on the acceptable borrowing costs and expected return on investment, questions were asked on willingness to pay/receive after one year while borrowing / lending an amount of Rs.1, 000. The responses varied between respondents from Mumbai and Pune. Of the 80 respondents in the sample, 17% said that they can not say how much money they were willing to receive and declined to answer the question. Of those who responded 31% categorically mentioned that they do not need to borrow to invest in efficient appliances. Among those who answered the questions, 16% said that the cost of the borrowing the money (Rs. 1000) they were willing to pay in the Rs.50-100 range, 11% in the Rs 100-150 range, and 10% in the Rs 150-200 range. (Note: this is the amount of money the consumer is willing to pay per annum). In the case of lending the money 6% of the respondents mentioned that they were willing to lend RS.1000 for a return of <50, while 10% reported they would lend for a gain greater that Rs.300. Twenty percent said that they are unable to answer this question (Table 4.1.13).

Table 4.1.13. Responses regarding borrowing and lending money

Range of Amount (Rs/year)	**Responses**			
	Borrowing		Lending	
	Responses	%	Responses	%
50-100	13	16.25	5	6.25
100-150	9	11.25	5	6.25
150-200	8	10.00	11	13.75
200-300	7	8.75	9	11.25
>300	4	5.00	8	10.00
Don't know	14	17.50	16	20.00
I don't need	25	31.25	26	32.50
Total	80		80	

(e) Expected Savings through SWH

The general perception of percentage incremental cost for SWH over EWH is between 20 and 200%. The level of annual savings was studied for SWH. According to major respondents, the saving level varies between 5 and 50% depending on the capacity and utilisation of SWH. Majority of the respondents felt that 20 to 30% savings are being achieved through SWH (Table 4.1.14).

Table 4.1.14. Level of expected savings from SWH

Level of savings (%)	Responses	%
<5	0	
5 to 10	2	5.41
10 to 20	4	10.81
20 to 30	13	35.14
30 to 40	9	24.32
40 to 50	7	18.92
>50	2	5.41
Total	37	100

(iii) Technical

The performance of a device induces the consumers to purchase it. Out of 37 households who installed SWH, 21 were satisfied with the performance while 12 households showed some dissatisfaction. Some were not sure about the problems they encountered (Table 4.1.15).

Table 4.1.15. Performance of SWH

Performance	Responses	%
Satisfaction	21	56.76
Not satisfied	12	32.43
Not sure	4	10.81
Total	37	100

Questions were asked about the reasons for the dissatisfaction with the performance of SWH. Those who were aware and satisfied, the general perception about SWH is that it has no barriers. Those who were not satisfied with SWH the reasons were found out. Although SWH is being preferred by many consumers, it is interesting to note that most of them felt that "it is ineffective during the winter season". The reason "it takes longer time to heat water unlike that of electric water heater" is another reason mentioned by the consumers. Some were of the opinion that "water does not get heated upto the required temperature. Table 4.1.16 summarises the barriers and ranks them according to their importance.

Table 4.1.16. Reasons for not using SWH

Reason	Responses (Nos.)				
	Rank				
	1	2	3	4	5
(i) it takes longer time to heat water unlike that of electric water heater	5	2	1		
(ii) ineffectiveness during winter and rainy days	6	3	1		
(iii)no noticeable savings in electricity	2		1		
(iv) water does not get heated up to the required temperature	1	1		1	
(vi) difficulties in finding technicians to repair		1	1	1	
(iv)spare parts not easily available		2			
(vii) shorter life than that was mentioned in specification		1			
(viii) others (specify)				1	
Total	14	10	4	3	0

4.1.4 Ranking of barriers

It is desirable to rank the reasons according to their order of importance. For example, the reason given as the first preference will have the maximum effect on the adoption of a technology while the one that was given last preference will have the least effect. Generally the ability to make qualitative distinction is represented by attributes, viz., equal, weak and strong or to put it differently, rejection, indifference and acceptance. Each of these can be subdivided into low, medium and high indicating nine scales of distinction. However Green and Carmone (1970) indicated that one would need only seven-point scale to distinguish between rejection and acceptance. Since this method is simple and appropriate we used this method to provide weights to various preferences. Weights were given to each response and the weighted average was found out using normalised weights and ranked them according to the order of importance. Accordingly, the first preference is given 9/25 points, second 7/25, third 5/25, fourth 3/25 and fifth 1/25 so that the total becomes one. Some respondents have not ranked all the barriers and hence "0" was given for no response. These responses are multiplied by the weights for each barrier and the weighted average is found out. The barriers are ranked based on these weighted averages. The results show that lack of information (awareness) about the costs and benefits is the main barrier (weighted average 0.28) followed by economic and financial constraints (cost of equipment, etc.) with a weighted average of 0.22 (Table 4.1.17).

Table 4.1.17. Ranking of barriers

Barrier	Number of responses					No response	Weighted average
Awareness and Information	12	9	4	1	2	0	0.28
Economic and Financial	4	8	11	1	3	1	0.22
Social and Institutional	4	5	5	4	7	3	0.16
Market	5	5	3	2	3	10	0.15
Technical	3	1	3	6	3	10	0.11
Total Responses	28	28	26	23	20		

4.1.5 Role of MEDA

Maharashtra Energy Development Agency (MEDA) was established by the government of Maharashtra in the year 1985. The main activities of MEDA are to propagate the diffusion of various renewable energy technologies of which developing solar energy devices was the main programme. In this programme, diffusion of Solar Water heaters (SWH) is an important activity. By the end of 1997-98, the total solar water heating systems installed, since the inception of MEDA, was 2.5 million Lpd**.** Among these 1.5 million Lpd are in the domestic sector, 0.9 million Lpd are in commercial sector and the rest in the industrial sector.

Questions were asked about the role of MEDA in the installation of SWH. Out of 37 households where SWH had been installed, nearly 75% were installed by MEDA and the rest from other sources including their own (Table 4.1. 18).

Table 4.1.18. Installation of SWH

Installing Agency	No.of responses
MEDA	28
Own	4
Others	5
Total	37

Out of 28 households, 18 did mention that they were satisfied with the services rendered by MEDA whereas six households were not satisfied and four were not sure (Table 4.1.19).

Table 4.1.19. Satisfaction with MEDA's service

Satisfied	No. of responses
Yes	18
No.	6
Can't say	4

The respondents were asked to identify the reasons for their satisfaction/dissatisfaction with the services of MEDA. Most respondents felt that there were happy with MEDA. "No professional approach" and "no prompt service" were the major reasons for those who were not happy with MEDA (Table 4.1.20).

Table 4.1.20. Reasons for satisfaction/dissatisfaction

Reasons	Yes	No
(1) Professional approach	6	2
(2) Prompt service	5	1
(3) Technical expertise	2	1
(4) High quality product	1	1
(5) Easy access	4	1
(6) Adequate subsidy	2	0
(7) Others, if any		

4.1.6 Concluding Remarks:

Although SWH is preferred by many households, most of the households were not aware that it takes longer time to heat water (in comparison to electric geyser) and in it is not useful during winter seasons. Not all the households interviewed answered all the questions. The main barriers, according to the households were lack of information, high initial cost, and non-availability. Although price is the main barrier, SWH are available in a wide range of prices and quantities. information was a major barrier.

4.2 Industrial Sector

4.2.1 General information

The main purpose of the industrial survey, as already mentioned, is to determine the level of awareness about Solar Water Heaters (SWH) and find out the perception of industries regarding their effective penetration and the role of Maharashtra Energy Development Agency (MEDA) in the diffusion of SWH. It involved a survey of industrial firms in Maharashtra to get an insight into the structure of electricity demand, determine the priorities of the industries and find out the barriers for the utilisation of SWH. Since a large number of the industries are concentrated in cities, two such urban centres viz., Mumbai and Pune are the focus of survey. The industries in these cities were requested to fill out the questionnaires prepared by the authors. This was followed by personal visits to seek clarifications, explanations and for discussions on possible barriers. The sampling procedure and analysis of questionnaire are already presented in the methodology section (Chapter 3).

(i) Education level of the respondents

The respondents were asked to mention their education level. Out of a total of 10 respondents, majority was from the Engineering background (50%) where as 7.5% hold diploma in Engineering. The remaining respondents were graduates, post-graduates, etc (Table 4.2.1.).

Table 4.2.1. Education level of the respondent in the sample

Education level	**No. of respondents**	**%**
Graduate	1	10
Post-graduate	3	30
BE	3	30
Engg. Diploma	2	20
Others	1	10
Total	10	100

(ii) Category of industry

The distribution of firms by industrial categories in Maharashtra suggests that chemical, textile, iron and steel and engineering industries on the whole account for a major bulk of consumers in the system. However, many of the other firms, which are not classified by specific categories, are included in the miscellaneous category and this accounts for over 40% of the total firms indicating the degree of heterogeneity in the system.

In the sample 25% of the industries are from Engineering, 12% each from Chemical and Textiles, 10% each from Iron and steel and Pharmaceuticals, 5% each from glass, metallurgy non-ferrous and paper and 20% from miscellaneous industries.

(iii) Size of industry:

The annual turnover of the industry varied from Rs.10 million to 1000 million. Majority of them is in the range of Rs.10 to Rs.100 million turnover range (Table 4.2.2).

Table 4.2.2. Annual turnover of industries

Turnover (Rs. million)	**No. of industries**	**%**
<10	2	20.00
10 to 100	5	50.00
> 100	3	30.00
Total	10	100

(iv) Power demand

The sample distribution according to operating demand indicates that 2 firms were in the < 1000 kW range, 3 in the 1000-2000 kW range, 3 (27.5%) were in the 5000-10000 kW range while the rest were in the >10000 kW range.

The distribution of the industries in the sample according to maximum demand is as follows: 1 firm was in the < 1 MVA range, 2 in the 1-2 MVA range, 4 were in the 2-5 MVA range, 1 were in the 5-10 MVA range and the rest were in the >10 MVA range.

(v) Electricity consumption

The sample distribution according to the quantity of the electricity consumption indicates that 3 firms had an annual electricity consumption in the < 5 GWh range, 2 in the 5-10 GWh range, 3 in the 10-20 GWh range and 1 (12.5%) each in the 20-50 GWh and > 50 range.

Respondents were asked to give a break up of the yearly electricity bill. Data for one year's electricity charges (in million rupees) was obtained. Table 4.2.3 gives the sample distribution according to the value of the electricity bills. In the sample, 12 firms (30%) had an annual electricity bill in the < Rs.10 million range, 5 (12.5%) in the Rs 10-20 million range, 6 (15%) in the Rs 20-50 million range, 5 (12.5%) in the Rs 50 to 100 million range and 12 (130%) in the >Rs 100 million range (Table 4.2.3).

Table 4.2.3. Electricity bill of the industries in the sample

Electricity bill (Rs. million/year)	No.of industries	%
<10	4	40.00
10 to 20	2	20.00
20-50	2	20.00
50-100	1	10.00
>100	1	10.00
Total	10	100

(vi) Percentage of electricity cost in total cost

Respondents were requested to indicate the extent of electricity costs as a percentage of the total cost of production. It is revealed that electricity cost accounted for a very low share of production cost in engineering industries. Textile industry indicated a figure of 6 to 7%, pharmaceutical 8%, iron & steel industry between 7 and 12%. In the sample, 15 firms (37.5%) had less than 5% of their production cost as electricity cost, 10 (25%) had 5-10%, 9 firms (22.5%) had 10-20% of its production cost as electricity cost and 6 (15%) had > 20% of their production cost as electricity cost.

4.2.2 Hot water utilisation

Information was solicited from the industries on the type and number of water-heating appliances used. The average number of EWH per industry in each of the above mentioned categories were 40, 36, 39, 38, and 10 respectively. The distribution of hot water in these industries for various end uses is given in Table 4.2.4.

Table 4.2.4. Consumption of hot water

Activity	Quantity (k litres/day)		
	< 50	50 to 100	>100
Industrial use	2	2	3
Canteen	1	1	
Others	1		
Total	4	3	3

4.2.3 Barriers to the adoption

The main barriers, according to the firms are:

(i) lack of sufficient information
(ii) high initial cost
(iii) high operation and maintenance cost
(iv) water heating not the main end use
(v) uncertainty in benefits
(vi) uninterested consumers
(vii) maintenance problems

There were some other technical barriers. Some preferred larger size water-heaters and expected some control over the heat that it generates. Most engineering firms purchased SWH only as stopgap arrangement and did not risk using them as they lacked the technical expertise to do so. SWH may not be very lucrative for industries of very large size since the water heating is only a marginal service .

These barriers are classified into the following categories:

(i) <u>Awareness and Information</u>

Questions were asked about the awareness of the respondents with respect to SWH. In the sample, 9 firms (77.5%) expressed that they were aware of the SWH. Among those, 7 firms had already been using SWH. Some firms indicated that they were in the process of deciding on the purchase. One of the firms was not aware of this option (Table 4.2.5)

Table 4.2.5. Awareness about SWH

	Aware (nos.)	**Installed**
Yes	9	7
No	1	3
Total	10	10

Source of awareness about SWH

In order to find out the source of information about SWH a question was asked to provide the source. Among those who were aware about SWH, 3 firms said "News paper/magazine" was the source, 2 firms indicated their source as "supply agents" and "leaflets". Trade fair/exhibition were the prime sources each for 4 firms. This shows that “trade fair/exhibition” play effective role in the adoption of a new technology by the industry.

(ii) <u>Economic and financial</u>

(a) Cost

The following levels of perceptions are identified about the cost of SWH and the willingness of the industries to opt at that level are found out. The identified levels were: (i) very high, (ii) high, (iii) average, (iv) don’t know. In the sample, one of the respondents said that the cost of SWH is very high and 2 said it is high. 2 respondents indicated that the cost is reasonable and the rest were not sure about it. Questions are asked whether the firm will go for SWH at that level. One firm said that they will not opt and 1 indicated it was undecided. One firm indicated their willingness to install SWH and the rest were not sure. (Table 4.2.6).

Table 4.2.6. Respondents views on costs and savings of SWH

Views	Responses	
	No.	%
Very high	1	20
High	2	40
Average	2	40
Don't know	0	0
Total	5	100
Decision		
Will not go	1	33.33
Undecided	1	33.33
Will go	1	33.33
Don't know	0	0.00
Total	3	100

(b) Expected borrowing and return rates

The firms were questioned on the e rates of interest they expected to pay to borrow money to install SWH and their r expected rate of return on investments. . Two firms mentioned that they could borrow money at an interest rate of 6-10% while 1 firm said that it could borrow at the rate of 10-15%. If they were to invest money, the expected rate of return in case of 2 firms was 15-20%, 20-25% in case of 3 firms and , and 2 expected a return above 25%. Two firms did not respond to this question.

(c) Payback period

It was felt that the investment criteria employed would indicate the importance that the management gives to clean energy (or RETs). The smaller the acceptable payback period, the greater its commitment to the renewable energy. The response was as follows; 4 firms (13.8%) felt it should be about one year, 18 firms (62.1%) between 1-2 years, and six (20.7%) between 2-3 years. Only one firm said that a payback period of more than three years is acceptable. Thus, it was found that for the majority of the firms (75%) a simple payback period of less than two years would be acceptable (Table 4.2.7).

Table 4.2.7. Simple payback period

Payback period (years)	Responses (nos.)
<1	1
1 to 2	3
2 to 3	4
3 to 4	1
4 to 5	
Total	9

(iii) Technical

The reported life of a SWH is between 20 and 25 years. When the life of SWH is compared with that of electrical water heater (EWH), the later fared better. According to 3 firms the life of SWH is 5 % less than that of EWH, five firms (31.3%) mentioned that the life of SWH is 5-10% less that that of EWH. However, one firm is of the view that the life of SWH is 10% more than that of EWH.

Regarding electrical savings, 3 firms felt that energy savings through SWH are less than 5%, 2 firms (13%) felt that savings would be between 5 and 10% and 1 firm (6%) felt that the savings would be more than 10%, but everyone conceded that it was difficult to quantify energy savings (Table 4.2.8).

Table 4.2.8. Performance satisfaction

Response	No. of responses	%
Yes	3	43
No	4	57
Total	7	

4.2.4 Ranking of barriers

The barriers that were categorized should be ranked in the order of priority as perceived by the consumer. Hence, the firms were asked to rank the barriers on a scale of 1 (9/25 being the most important barrier, followed by 7/25, etc.), and weighted average of ranking of each barrier was obtained.

Of the 10 firms, one was unaware about SWH. Others were asked to rank the important barriers for the successful penetration of SWH. Table 4.2.9 gives the details of the responses.

As the table shows, "technical barrier" is ranked first followed by "economic and financial”. “Institutional barriers" is the next major one.

Table 4.2.9. Barriers for the utilisation of SWH

Reasons	Number of responses					No response	Weighted average
Technical	5	2	1	1		0	0.30
Economic and financial	2	3	1	2		1	0.22
Institutional	2		1		2	4	0.10
Others		1	1	1	1	5	0.06
Total responses	9	7	4	4	3		

4.2.5 Role of MEDA

Maharashtra Energy Development Agency (MEDA) was established to propagate the diffusion of various renewable energy technologies of which Solar Energy Programme is the main one. In this programme Solar Water heater diffusion is an important activity. During the year 1997-98, work was undertaken to install systems in the industrial sector with a total capacity of 0.083 million litres per day (lpd). After completing this work, the total solar water heating systems installed in the industrial sector since the inception of MEDA reached 0.25 million lpd.

Questions were asked about the role of MEDA in the installation of SWH. Out of 8 firms that had SWH, 6 had the SWH installed by MEDA and the rest from other sources including their own (Table 4.2.10).

Out of 6 firms, 4 mentioned that they were satisfied with the services rendered by MEDA where as one firm was not satisfied and one was not sure (Table 4.2.11).

Table 4.2.10. Installation of SWH

Installing Agency	No. of responses
MEDA	6
Own	1
Others	1
Total	8

Table 4.2.11. Satisfaction with MEDA's role

Satisfied	No. of responses
Yes	4
No.	1
Can't say	1

The respondents were asked to identify the reasons for their satisfaction/dissatisfaction with the services of MEDA. Those that were not happy felt because of "no prompt service" and “lack of technical expertise” (Table 4.2.12).

Table 4.2.12. Reasons for satisfaction/dissatisfaction

Reasons	Yes	No
(1) Professional approach	2	
(2) Prompt service	1	1
(3) Technical expertise		1
(4) High quality product		
(5) Easy access	1	
(6) Adequate subsidy		0
(7) Others, if any		

4.2.6 Concluding remarks

Although SWH is being preferred by many industries, most of them were not aware that it heats water quickly.

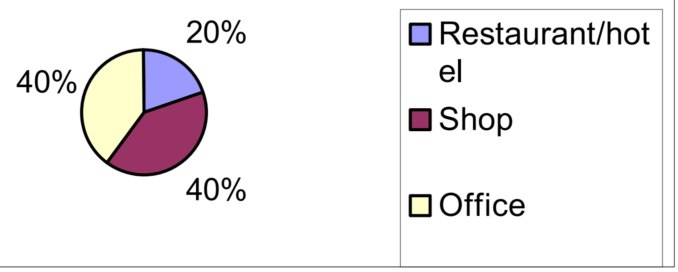
4.3 Commercial Sector

4.3.1 General Information

As mentioned earlier, the commercial sector survey was carried out to assess the consumer awareness about the Solar Water Heater and study the barriers for their penetration. This will provide us the possibility of identifying various barriers as well as suggesting policy measures to remove those barriers. For this, a representative sample had to be selected first. Since the state of Maharashtra is very large with over millions of consumers spread across a wide area, it was necessary to narrow the sample coverage to some areas with a large number of commercial establishments. The cities of Mumbai and Pune were selected and the survey was carried out during the month of May-June, 1999.

The Commercial sector can be categorised mainly into three categories, viz., offices, shops, and hotels/restaurants. Twenty five establishments were surveyed covering 10 offices, 10 restaurants and 5 shops (Figure 4.3.1).

Figure 4.3.1: Distribution of commercial establishments



The position of the respondent who answered the questionnaire was found out. 14 respondents were the managers of the establishments while six were the owners of the establishments. Education of the decision maker plays an important role in the selection of a technology. A question was asked about the education level of the respondent. It was found that 4 (13%) had primary/secondary education, 13 (43%) were graduates while 6 (20%) were Post-graduate/BE/MBBS (Table 4.3.1). This information is useful whether the respondent can understand the importance and substitution of various technologies and whether he will be in a position to influence the management if he is convinced about the importance of technological substitution.

Table 4.3.1. Education level and designation of the respondent

	No.	%
Education level		
Primary/secondary	4	13.33
Graduate	13	43.33
PG/Engg.	6	20.00
Others	7	23.33
Total	30	100
Designation	No	%
Manager	14	46.67
Owner	6	20.00
Accountant	4	13.33
Others	6	20.00
Total	30	100.00

Regarding the occupancy status of the establishment, 25 (83%) were owners while the rest rented the establishment premises (Table 4.3.2). Generally, if the establishment is a rented one, the possibility of installing a SWH will be difficult. Otherwise, it will be easy to install the SWH.

Table 4.3.2. Details about the establishment

Occupancy status	**No.**	**%**
Owned	25	83.33
Rented	5	16.67
Total	30	100.00

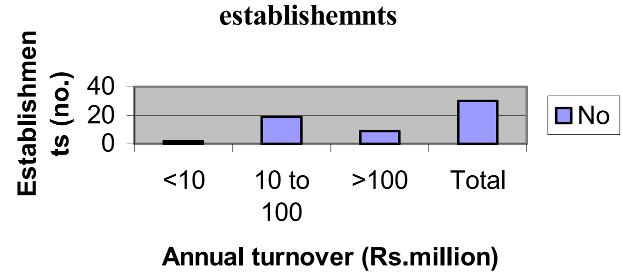
The details of the size of the establishment are provided in Table 4.3.3. Four (13%) were staying in < 5 room establishments, 11 (37%) were occupying 5 to 10 rooms while 15 stay in > 10 room establishment. Regarding the area, 6 establishments (20%) were staying in establishments occupying <100 sq. meter (mt) area, 6 in 100 to 200 sq. mt area, and the rest in >200 sq. mt area.

Table 4.3.3. Details about the size of the establishment

Size of establishment					
Rooms	Nos.	%	Area(Sq. mt)	Nos.	%
<5	4	13.33	<100	6	20.00
5 to 10	11	36.67	100 to 200	6	20.00
10 to 20	12	40.00	200 to 500	8	26.67
>20	3	10.00	> 50000	10	33.33
Total	30	100		30	100

Figure 4.3.2 gives the sample distribution according to the income of the establishment. In the sample 3 establishments (13%) had a monthly income of < Rs 10,000, 5 (21.7%) in the Rs 10,000-20,000 range, 7 (30.4%) in the Rs 20,000-50,000 range, 4 (17.4%) in the Rs 50,000-100,000 range, and 4 (17.4%) in the > Rs 500,000 range.

Figure 4.3.2: Distribution of commercial establishemnts



The distribution of the establishment in the sample, according to electricity consumption, is shown in Table 4.3.4. In the sample 7 establishments were consuming < 5000 kWh per month, 3 were in the 5,000 to 10,000 kWh range, and the rest were in the >10,000 range.

In the case of electricity bill, 9 establishments were paying < Rs.10,000 per month, 8 were in the Rs.10000-20000 range, and the rest were in the >Rs.50,000 range.

Table 4.3.4. Average electricity consumption

	Electricity Consumption Range (kWh/month)				Total
Consumption (kWh/month)	< 5000	5 to 10000	>10000		
Establishment (no.)	7	3	5		15
Bill (Rs/month)	< 10000	10000 to 20000	20 to 50000	>50000	
Households (no.)	9	8	6	5	28
Average price (Rs/kWh)	3 to 5	>5			
Households (no.)	11	8			19

4.3.2 Use of Solar water heaters

Almost all the commercial establishments (excluding the theaters) use water heaters. Electric geysers, gas stoves and solar water heaters are the technologies used for this purpose. The quantity of hot water varies with the type of establishment and the purpose of utilisation. There are also seasonal variations (Table 4.3.5).

Table 4.3.5. Consumption of hot water

Fuel used	**No. of establishments**	**%**
Electricity	3	10.34
Electricity & Coal	2	6.90
Electricity & Gas	4	13.79
Solar water heater	18	62.07
Others	3	6.90
Total	30	100.00

Details of Solar water heaters

Information was solicited from those establishments who have installed SWH. Majority of the commercial establishments has SWH of capacity of 2000 lpd. The details about the capacity of various types of SWH and their costs are provided in Table 4.3.6.

Table 4.3.6. Details of SWH

Capacity (l/day)	No.of SWH	Average Cost (Rs.)
<100	1	20000
100 - 500	5	20000-50000
500 - 1500	4	50000-100000
1500 - 4000	6	100000-20000
>4000	4	300000
Total	20	

4.3.3 Barriers to the adoption of SWH

In this section various barriers were identified and ranked according to the order of importance given by the respondent. This means that the reason given as the first preference will have the maximum effect on the adoption of SWH while the one that was given last preference will have the least effect. The weighted average was found out using normalised weights and ranked them according to the order of importance. For example, if there are five barriers, the first preference is given 5 points, second 4, third 3 and so on. These weights are multiplied by the number of responses for each barrier and the weighted average is found out. The barriers/reasons are ranked based on these weighted averages.

Following barriers were identified;

(i) <u>Information and awareness about SWH</u>

Awareness about SWH and electricity price (alternate fuel for heating) is an important factor in substituting solar energy for electricity. Questions were asked to find out awareness on these two aspects from the commercial establishments. The results indicate that the awareness levels were high. According to the survey data only 3 of the sample establishments were not aware of the SWH. And of those establishments that were aware, 67% had installed SWH (Table 4.3.7). 15 establishments (50% of the total) gave the correct electricity tariff for their consumption. However, most of them were unaware of the water-heating temperature, i.e., the temperature required to heat water for bathing purposes. Those who indicated that they knew about SWH were asked about their source of information. It is seen that majority of the respondents knew about SWH through News papers/magazines.

Table 4.3.7. Awareness about solar water heaters

	Yes	% of total
Aware	27	90.0
Installed	18	66.7

(ii) <u>Economic and Financial Barriers</u>

(a) Cost

One important consideration that plays an important role in the penetration of any technology is the initial cost. The cost of SWH varies according to its capacity. Information relating to SWH is often asserted to be inadequate and therefore discourages the consumer to invest. This information may be relating to the cost saving of the technology, durability, etc. The consumer may undertake an extensive search and acquire this information. Since many establishments have not installed SWH, even though they are aware of it, questions were asked about the reasons for not installing it. The views of consumers about the cost of SWH can be an important consideration for adopting this technology. The opinions of the respondents from commercial establishments are summarised in the Table 4.3.8 . The respondents were also asked whether they would opt for the technology at the prevailing cost or not. 14 establishments (48%) felt that the cost of SWH is high while 6 establishments (21%) felt that the cost is average. Some respondents expressed their inability to express any opinion on the cost . On decision to purchase SWH at the current costs, 30% said that they would opt for SWH. 5% indicated that they would not go for SWH at current prices and 9 (30%) said that they were undecided. (Table 4.3.8).

Table 4.3.8. Respondents views on costs and savings of SWH

Views	Responses	
	Nos.	%
Very high	3	10.34
High	14	48.28
Average	6	20.69
Don't know	5	17.24
Low	1	3.45
Total	29	100
Decision		
Will not go	5	16.67
Undecided	7	23.33
Will go	9	30.00
Can't say	9	30.00
Total	30	100.00

(b) Savings through SWH

Since there is significant difference between the cost of SWH and the electrical water heaters, consumers expect a higher saving from SWH. The general perception of percentage incremental cost for SWH over EWH is between 20 and 200%. The levels of annual savings were studied for SWH. According to respondents, the saving level varies between 20 and 50% depending on the capacity and utilisation of SWH. Majority of the respondents felt that 20 to 30% savings are being achieved through SWH (Table 4.3.9).

Table 4.3.9. Level of expected savings from SWH

Level of savings (%)	No. of responses	%
<5	0	0.00
5 to 10	0	0.00
10 to 20	3	16.67
20 to 30	8	44.44
30 to 40	4	22.22
40 to 50	3	16.67
>50	0	0.00
Total	18	100.00

(c) Simple payback period

If there were an investment in new technologies, then the consumers would think in terms of the payback period. Questions were posed to find out the views of the respondents about the acceptable payback period for investing in SWH. The payback period varies with the investment amount and the consumer category. For the commercial establishments, 5 respondents felt it should be less than three years while 2 felt that it should be 3 to 4 years. Generally, majority of the respondents felt that a simple payback period of four to five years would be acceptable (Table 4.3.10).

Table 4.3.10. Simple payback period for investing in SWH

Acceptable simple payback period (years)	**No of responses**	**%**
<1	0	0.00
1 to 2	2	12.50
2 to 3	3	18.75
3 to 4	2	12.50
4 to 5	9	56.25
>5	0	0.00
Total	16	100.00

(b) Borrowing and lending money

In order to assess the level of interest rates the consumers prefer for borrowing as well as for lending money, respondents were questioned on interest rate at which they are willing to borrow to invest in SWH, and also their expected rate of return on their investment. It was found that for borrowing, 8 establishments (32%) wanted the interest rates to be < 10%, 4 establishments (16%%) 10 to 15% and 5 (20%) were prepared to pay above 15%. Eight establishments did not respond to the question. Regarding the expected rate of return, 6 establishments (24%) wanted the rate to be more than 20% while 8 (32%) wanted it to be > 25% (Table 4.3.11).

Table 4.3.11. Responses on acceptable interest rates for borrowing and lending money

Interest rate (%)	**Responses**			
	Borrowing		Lending	
	No. of responses	%	No. of Responses	%
< 10	8	32		
10-15	4	16		
> 15	5	20		
> 20			6	24
> 25			8	32
Don't know	8	32	11	44
Total	25		25	

(iii) Technical Barriers

(a) Performance

Those establishments that possess SWH were asked about its performance; i.e. whether they were satisfied or not. Out of 18 establishments who installed SWH, 10 were satisfied with the performance. Some were not sure about the problems they encountered (Table 4.3.12).

Table 4.3.12. Performance of SWH

Satisfaction	**No. of respondents**	**%**
Yes	10	55.56
No.	7	38.89
Not sure	1	5.56
Total	18	100

While using the SWH some problems may be encountered. Questions were posed in this direction to indicate the problems encountered while using SWH. The major problem for SWH was that it takes longer time to heat water. Some felt that SWH had shorter life then was mentioned in the brochure. The establishments were asked about the reasons for the dissatisfaction of the performance of SWH. Ineffectiveness during winter season, with a weighted average of 0.34 and taking longer time to heat water (weighted average 0.26) were the main reasons for their dissatisfaction (Table 4.3.13).

Table 4.3.13. Reasons for dissatisfaction

Reasons	Number of responses					No response	Weighted average
Ineffectiveness during winter and rainy days	4	1				2	0.23
Water does not get heated up to the required temperature	2	1	2	1	1	0	0.22
It takes longer time to heat water unlike that of electric water heater	1	2		2		2	0.17
No noticeable savings in electricity		1	3	1	1	1	0.15
Difficulties in finding technicians to repair		1	2	1	1	2	0.11
Spare parts not easily available		1		1		5	0.07
Others					1	6	0.01
Total Responses	7	7	7	6	4		

4.3.4 Ranking of Barriers

Now we have the information on various barriers. It is important to rank them according to their order of importance. As mentioned earlier, the ranking has been done by giving appropriate weights to various preferences. The weighted average was found out using normalised weights and ranked them according to the order of importance. The first preference was given 9/25 points, second 7/25, third 5/25 and so on. These weights were multiplied by the number of responses for each barrier and the weighted average was found out. The reasons are ranked based on these weighted averages. As the results show (Table 4.3.14), "Information" is ranked as the main barrier (weighted average 0.25) followed by "Financial and Economic" (with a weighted average of 0.2).

Table 4.3.14. Reasons for not installing SWH

Barrier	Number of responses					No response	Weighted average
Information	7	1	1		1	2	0.25
Financial and Economic	4	1	2	2	3	0	0.21
Market	1	2	3	1	2	3	0.14
Technical	1	2	2	1	1	5	0.12
Institutional			1	1		10	0.04
Others	3	4	2	2	0	1	0.24
Total	12	10	9	7	7		

4.3.5 MEDA's role in the penetration of SWH

During the year 1997-98, the Maharashtra Energy Development Agency (MEDA) undertook the work to install SWH systems with a total capacity of 0.35 million Lpd in the commercial sector. After completing this work, the capacity of the solar water heating systems installed in the commercial sector will increase significantly. In the survey sample, out of 18 SWH installed, 13 had been installed by the MEDA (Table 4.3.15).

Table 4.3.15. Installation of SWH

Installing Agency	No.	%
MEDA	13	61.11
Others	3	27.78
Own	2	11.11
Total	18	100.00

Out of 13 establishments that utilised MEDA's services in installing the SWH, 8 mentioned that they were satisfied with the services rendered by MEDA where as five establishments mentioned that they were not sure.

The respondents were asked to identify the reasons for their satisfaction/dissatisfaction with the approach of MEDA. Most respondents felt that they were satisfied with the MEDA's services. Those of the establishments that were not satisfied, "no professional approach" and "no prompt service" were the reasons. There were others who felt that the subsidy is not adequate (Table 4.3.16).

Table 4.3.16. Reasons for satisfaction/dissatisfaction

Reasons	No. of responses	
	Yes	No
(1) Professional approach	2	1
(2) Prompt service	1	1
(3) Technical expertise	1	
(4) High quality product		1
(5) Easy access		1
(6) Adequate subsidy	3	1
(7) Others, if any	1	
Total	7	4

4.3.6 Concluding Remarks

The survey showed that many commercial establishments are beginning to install SWH. They were willing to shift completely to solar energy provided the cost of SWH is within their reach and the technology is efficient. According to some respondents, lack of information about the availability , cost and benefits are the major hurdles in the speedy penetration of SWH.

4.4 Policy Makers and Experts

4.4.1 General information

In addition to the consumers in various sectors, some policy makers (from the Government of Maharashtra) and experts from the Maharashtra State Electricity Board, Energy Researchers, Practitioners, etc. were interviewed to find out their perception about the barriers for the effective penetration of renewable energy technologies and the role of the Maharashtra Energy Development Agency in diffusing RETs. The number of respondents was 15, of which 10 were from the government agencies while the rest from Research Institutions.

Access to journals on renewable energy technologies (RETs) and holding memberships in National/International organisations were considered important factors in assessing the awareness and possible efforts of the respondent in penetration of the any technology. Table 4.4.1 shows the details of the respondents on organisational affiliation, literature source, etc.

Table 4.4.1. Professional affiliation details of the respondent

Member of organisation	**No.**	**%**
National	4	26.7
International	2	13.3
Access to literature on RETs	12	80.0
Commercial Journals	8	53.3
Scientific journals	9	60.0
Hand books	10	66.7
Others	1	6.7
Sources of literature		
Office	9	60.0
Local library	9	60.0
Others	5	33.3

In the sample, only 6 (40%) were members of organisation working in the area of renewable source of energy. Regarding the access to journals, 12 (80%) had access to various literature on RETs (which include commercial and scientific journals and handbooks). The source of literature is manly from office and local library.

4.4.2 Barriers to the adoption of RETs

After soliciting information from the experts, it is necessary to rank them according to their order of importance. The ranking has been carried out by giving appropriate weights to various preferences. The weighted average was found out using normalised weights and ranked them according to the order of importance. The first preference was given 5 points, second 4, third 3 and so on. These weights were multiplied by the number of responses for each barrier and the weighted average was found out.

(i) Infrastructure related barriers

The level of awareness among professionals about various technologies and their costs were explored (Table 4.4.2).

Table 4.4.2. Problems encountered in the Wind/SWH Program

	No. of responses					**No response**	**Weighted average**
Lack of infrastructural facilities	5	3	3	2	2	0	0.24
Seasonality of power generation	4	4	2	2	1	2	0.22
Problems in land acquisition	2	2	3		3	5	0.13
Problems in getting clearances	2	1	2	2		8	0.11
Difficulty in finding skilled personnel	1	1	1	2	1	9	0.07
Available technology /equipment quality is not good	1	1	1	1	1	10	0.07
Difficulty in getting equipment and spare parts		1		1		13	0.03
Others (pl. specify)	0	1		1	2	11	0.03
Total	15	14	12	11	10		

According to the table, most of the respondents were aware about the cost of solar water heaters and wind energy. Regarding the institutional barriers in the Wind/SWH programme, lack of infrastructural facilities was considered as the main problem followed by seasonality of power generation. Problems in land acquisition was ranked third

(ii) <u>Institutional and regulatory barriers</u>

Questions were posed to elicit opinion of the respondents on the institutional and regulatory issues. In the sample, five respondents expressed the view that the agencies such as MEDA, Wind Energy Manufacturer's Association (WEMA) and MSEB are satisfactorily working. However, ten respondents mentioned that the functioning of these agencies is not in line with the policy intentions of the government. They expressed the opinion that the approach of these agencies to the renewable energy programme needs to be modified. The suggestions given by the respondents to upgrade the renewable energy programme of different agencies is shown in Table 4.4.3

Table 4.4.3. Upgradation of approaches for RETs program

Approach	**Agencies**		
	MEDA	WEMA	MSEB
Professional approach	1	4	3
Technical expertise	3	4	
Accessibility	1	0	2
Sensitive to programme	2	1	2
Needs	2	1	2
Others (if any)	1		1
Total	10	10	10

Some of the respondents suggested that the government should create separate department to take up the entire renewable energy programme. They felt that there is no need for creating further regulations and the present ones are enough for promoting the RE programme.

(iii) <u>Economic and social barriers</u>

Each RE technology may face different barriers due to differences in costs, savings potential, risks involved and perceived reliability. The respondents were asked to rank the barriers for the effective penetration of solar and wind energy programmes. Most of the respondents felt that the Cost of wind power generation is high. They also felt that prices of alternative fuels such as electricity and kerosene are low. They are ranked as the first and second barriers. The next major barrier is uncertain economic benefits (Table 4.4.4).

Table 4.4.4. Barriers to the effective penetration of RETs

Barriers	No. of responses					No response	Weighted average
Cost of wind power generation is high	5	5	2	2	1	0	0.26
Price of alternative fuels such as electricity and kerosene is low	4	3	3	1	1	3	0.20
Uncertain economic benefits	3	2	2		2	6	0.15
Selling surplus power is difficult	2	2	1	1		9	0.11
Inadequate incentives	1	2	2			10	0.09
Problems in transmitting the power for sale			2	2	1	10	0.05
Lack of policy implementation			1	3	3	8	0.05
Problems in incentive schemes / subsidy			1	3	2	9	0.04
High discount rate of consumers		1			1	13	0.02
Consumers want their investments in a short time				2	2	11	0.02
Total	15	15	14	14	12		

(iv) <u>Information and awareness</u>

Most of the respondents felt that the awareness about RETs such as their costs and benefits is not enough among stakeholders, viz., consumers, entrepreneurs, NGOs, etc. They felt that the conservative attitude of stakeholders is hampering the penetration of RETs. Majority (nearly 60%) of the respondents felt that the a lack of commitment among stakeholders is hampering the penetration of RETs even though there is a social acceptance to adoption of these technologies. Some of the respondents suggested that there exists a need for the design of demonstration projects. Nearly half of the respondents felt that there is not enough interest in the RET programmes.

4.4.3 Ranking of barriers

Since we have the full information on various barriers, they should be ranked according to their order of importance. As mentioned earlier, the ranking has been done by giving appropriate weights to various preferences. The weighted average was found out using normalised weights and ranked them according to the order of importance. The first preference was given 9/25 points, second 7/25, third 5/25 and so on. These weights were multiplied by the number of responses for each barrier and the weighted average was found out. The reasons are ranked based on these weighted averages. “Economic and Financial” is ranked as the main barrier (weighted average 0.27), followed by "Regulatory" with a weighted average of 0.18.

“Information and awareness" and "Institutional” are the other important barriers. The main reasons/barriers are given in Table 4.4.5 along with their ranking.

Table 4.4.5. Reasons for ineffectiveness of RETs programme

Barrier	No. of responses					No response	Weighted average
Economic and financial	6	4	2	1	1	0	0.27
Regulatory	3	3	2	2		4	0.18
Information and awareness	3	2	1	2	1	5	0.15
Institutional	2	1	3	1	1	6	0.13
Market	1	2	1	3	2	5	0.11
Technical		2	2	1	1	8	0.08
Social		1		1	2		0.12
Total	15	15	11	11	8		

When the respondents were asked whether, in the light of experience, there is a need for the RET policy to be updated, most of them gave positive indication. According to the survey, the main areas that are required to have a re-look are: project implementation and marketing.

4.4.4 MSEB Perspective

There some questions specifically aimed to get feedback from the Maharashtra State Electricity Board (MSEB) only. Accordingly some of the officers of the MSEB were interviewed. When questioned about the pricing policy of MSEB, they answered that the price offered by MSEB to the wind energy developers is not only above the LRMC of electricity generation, but it is also above its marginal cost of power generation from existing thermal plants. The price per unit offered by MSEB is well above its average revenue realisation. The respondents also opined that the wind energy programme no way affects the MSEB adversely.

This being the first survey, it had a broad sweep to quickly size up the situation and to indicate the types of additional information required. It points out barriers where further information needs to be obtained to bridge gaps of information. Various policy measures are suggested which will be discussed in the next chapter.

4.5 Wind Energy Developers

The present chapter deals with the results of the survey we have conducted with respect to wind energy developers. As we have seen in the last few sections, less than one percent of consumers in the households, industrial and commercial establishments in Maharashtra are equipped with solar water heaters. Similarly the contribution from wind energy to the total is less than 0.01%. Given this historical background of diffusion it seemed to be of interest to know from the wind energy developers about the driving forces and the barriers for a speedy diffusion of. Here we concentrate only on wind energy since the information on wind energy development in the literature is negligible.

4.5.1 Survey objectives and results

In this part of the study we interacted with the state owned energy agency MEDA (Maharashtra Energy Development Agency) and wind energy developers. We have tried to (i) study the development of this market and analyse the fluctuations, (ii) elaborate the determinative factors, (iii) derive the barriers for diffusion (iv) identify the crucial factors of success or failure in the diffusion of this technology and suggest policy measures.

We identified 25 wind energy developers all over Maharashtra and sent a written questionnaire to them asking them about their views on the factors responsible for the present state of affairs and their future expectations and plans. Ten responses were received and intensive interviews were held with representatives of these companies.

According to the available information, most of the windmills were of recent origin (in 1990s). The installed capacities range from 100 kW to 2 MW (230 kW x 9 wind turbines). The cost of installation was about Rs.40 million per MW (1998 prices). The annual cost of operation vary from Rs.400 to 800 per kW depending on the installed capacity. On an average, per kW the generation was about 150 units (kWh) per annum.

4.5.2 Barriers to wind energy penetration

(i) Financial and policy

Six out of 10 companies are not satisfied with present policies. According to them the present policy of not giving the sales tax benefit, 100% depreciation, etc., which earlier used to encourage the wind energy developers is a major barrier.

(ii) Economic Barriers

Table 4.5.1 summarises the responses about the economic barriers from respondents which include cost of wind power, obtaining loan, price the wind energy developers get, etc. The following levels of perceptions are identified about the cost of producing energy from wind, which include: (i) very high, (ii) high, (iii) average, (iv) don't know. In the sample, 7 of the respondents said that the cost of SWH is high and only one respondent indicated that the cost is reasonable and one is not sure about it.

Table 4.5.1. Respondents views on cost of producing wind energy

Cost of wind energy production	**No. of responses**	
	No.	**%**
Very high	3	30.00
High	4	40.00
Average	2	20.00
Don't know	1	10
Total	10	100

In order to find out the problems in obtaining loans for the wind power project questions were posed. It was found that 4 firms reported that they have faced problems in borrowing money while the rest mentioned that they did not face any problems. The problems mainly related to delay in receiving money.

When asked about the buying price of the electricity offered by the Maharashtra State Electricity Board, seven respondents mentioned that it is not adequate. They expected the increase in price from the present Rs.3.75 to around Rs.5.00 per unit. One respondent said that he is satisfied with the present price while the rest did not provide any information about the price they want.

(iii) Institutional Issues

According to the survey, majority of the respondents felt that various organisations such as the ministry of energy at the state level and the ministry of non-conventional energy sources at the central level and other small organisations involved in the windmill program are not sensitive to the needs and concerns of the wind energy developers. Some of the wind energy developers wanted the full control over the wind energy sites so that they can develop them by providing good infrastructure facilities and others who want to develop wind energy at that site should get their permission. This will not only improve the infrastructure facilities but also involve the developers in attracting more energy developers.

When asked about the role of MEDA, out of 10 respondents, six developers obtained help from the Maharashtra Energy Development Agency (MEDA) in installing the wind power project. Among these four were satisfied with MEDA's role while the rest were not happy. Their views on MEDA services are given in Table 4.5.2.

Table 4.5.2. Reasons for satisfaction/dissatisfaction

	Yes	No
(1) Professional approach	3	
(2) Technical expertise	1	1
(3) Easy access	1	1
(4) Adequate subsidy	1	2
(5) Others, if any		
Total responses	6	4

(iv) Need for regulations

Questions were asked about the existing regulations. Out of 10, six responded that the present regulations are not adequate for promoting the windmill program while two said that they are satisfied with the present regulations. The remaining two were non-committal.

When asked what three hurdles need to be addressed (including through legislation), most of them said that there should be some legislation to remove the bottlenecks. They also felt that some regulations are obsolete and create problems in smooth operations of the project. However, they were not specific about the way the government should deal with these issues.

A summary of barriers and their ranks (importance) as perceived by respondents is given in Table 4.5.3.

Table 4.5.3; Barriers to the wind energy development

Sl. no	Problems	No. of responses					Weighted average
		Rank					
		5	4	3	2	1	
1	Problem in land acquisition	5	3	1		1	8.2
2	Lack of infrastructure	3	3	2	1		7
3	Changes in govt. policies	2	1	2	3	1	5.4
4	Problems in getting clearances		1	1	2	2	2.6
5	Inadequate incentives		1	1	1	2	2.2
6	Delay in receiving payments				1	1	0.6
7	Others (specify)			1			0.6
	Total	10	9	8	8	7	

4.5.3 Role of MEDA

At present the role of the Maharashtra Energy Development Agency (MEDA) is confined to providing financial assistance to the wind energy developers. Some of the respondents suggested that MEDA should be more active in providing the necessary information about the state-of-art technologies, act as a mediator between the Maharashtra State Electricity Board and the Wind Energy Developers. According to the respondents, at present, there is no need to involve some more organisations in the windmill program

CHAPTER 5
THE POINTERS

Energy generation through the renewable energy technologies (RETs) is a topic that has been discussed in India for a long time. However, effective utilisation of renewable energy such as solar and wind is yet to become a reality. This may be due to various factors. These factors need to be identified and based on that appropriate strategies need to be developed to induce a growth in RETs. First task in this direction is the development of a methodology to study the factors that affect the penetration of RETs, which is not so far available. In order to give RETs the role they deserve in strategic planning, it is essential to empirically study the barriers for penetration, market imperfections and the factors influencing the technology choice of consumers. The main contribution of this study is to identify the major barriers in the residential, industrial and commercial sectors and rank them according to their relative importance. This has been done by conducting surveys in various sectors and analysing the data from the perspective of the consumer. It provides information on specific barriers for two renewable energy technologies; solar water heaters and wind energy. The information can be used to design programmes for penetration of these technologies. The barriers that are identified and ranked here play an important role in policy analysis and implementation.

The RETs that were studied here include: (i) solar water-heater, and (ii) wind energy. The costs and savings for the consumers of these technologies that replace the respective standard technologies were obtained from the equipment manufacturers and the utilities. To appreciate the consumers' perspective, surveys were administered, to 80 households (60 in Pune and 20 in Mumbai), 10 industries, 25 commercial establishments, 15 energy experts/policy makers and 10 wind energy developers in Mumbai and Pune. The inclusion of policy makers was considered important since they play an important role in technology penetration by providing appropriate incentives. The analysis of survey data provided critical insights into consumers awareness about RETs and the barriers for using them. The perceptions of the consumers and the policy makers about the required policies were also revealed.

The survey results indicated that awareness of RETs is a major policy issue. What is surprising is that even some of the policy makers who are supposed to have a good knowledge of RETs were not fully aware about the costs and savings of these technologies. In the sector-wise analysis, industries were aware of the RETs such as solar water heaters and wind energy. However, in the residential and commercial sectors the awareness levels are not very high. The survey found that many consumers have not really thought about the possibility of adopting the RETs under present costs. The major findings of the study are as follows:

(i) Adoption levels for various RETs

In the case of SWH, the adoption levels were very low. As already mentioned, electric water heaters are being used by majority of the consumers in all the sectors. A small percentage of commercial and industrial establishments use SWHs (< 10% of total) while wind energy developers supply a small amount of energy (less than 1% of the total) to the utilities. Wind Energy Developers are not satisfied with the present incentives and want further.

(ii) Awareness levels

The awareness about the electricity price and about the costs and savings (if solar energy is used in place of electricity) is an important factor that leads to greater commitment to the fuel substitution for water heating. 35% from the residential sector, 80% from the industry and 75% from the commercial establishments were aware of the actual electricity tariff paid by them (with 10% variation). Only 50% of the policy makers provided the correct information about the appropriate policies that are required for the penetration of RETs.

The awareness level about RETs varies with the type of consumer. In the commercial and industrial sectors, majority of the consumers are aware about the SWH, its costs and benefits. In the case of residential sector, a significant percentage are still unaware about this technology.

The source of information of the consumers about the RETs varies with the sector. In the sample, News papers/magazine were the major source of information for majority of the residential consumers, supply agents for industry and commercial establishments and Seminar/Workshops for the policy makers.

The percentage of incremental cost for a RET over a standard one depends on the technology which varies between 20 and 200%. Similarly the electricity savings also vary. According to major respondents, the saving level for SWH was < Rs.50 per month.. Regarding the cost of RETs, majority of the respondents felt that the cost of SWHs is significantly higher than that of electrical water heaters (EWH) and it was not possible to adopt them under the present costs.

(iii) Consumer discount rates

Consumer discount rates are good indicators of the potential of energy conservation programmes that can be used to evaluate the penetration of different efficient technologies. These discount rates which effect the decisions are not easy to come by, and hence those obtained from the survey data have some margin of error. In the residential sector, 14% of the respondents would like to borrow money at the rate of < 10%, and 12% at the rate of greater than 15%. 33% of the respondents categorically mentioned that they do not need to borrow in substituting SWH for EWH. In the industrial sector majority (68%) wanted the interest rate to be <10% while the commercial establishments wanted to borrow money between 6 and 20% to invest in SWH. The returns the consumers expect can be considered a proxy for consumer discount rate (CDR). The industrial and commercial sectors expect the returns to be around 20% where as this figure is more for the residential consumer.

(iv) Simple payback period

In the residential sector, for SWH, most of the respondents felt that the payback period should be less than one year. The responses from the commercial sector indicate that two to three years payback period was acceptable. In the case of industrial sector most of the respondents felt that a simple payback period of two years would be acceptable.

5.1 Barriers to various RETs

Renewable energy technologies encounter a variety of barriers, as summarised below.

- (i) Information and awareness;
- (ii) Financial and Economic;
- (iii) Technological;
- (iv) Institutional; and
- (v) Market.

The survey of consumers in various sectors and the analysis of the data so obtained underlined the need to remove the barriers to the RETs. The question arises what should be done to remove these barriers. The following section deals with this issue.

(i) Information and Awareness

Knowledge about various RETs is the major barrier in the implementation of RET programmes. Due to lack of proper knowledge consumers might not be certain about the savings that accrue due to the installation of RETs. Hence, it is necessary to establish a comprehensive database or manuals regarding the technology and utilization practices for the staff responsible for operations. New industries and commercial establishments, which opt for RETs, can screen the available options before deciding on new equipment/technology.

Availability, reliability and knowledge of RETs are some of the factors that need to be taken into account in the implementation of RETs. As shown by this study, lack of appropriate information is a major impediment in the effective penetration of RETs. As the results of the survey indicated, majority of the consumers are not aware of the RETs. RETs are often under-used because of the lack of demand from consumers or lack of knowledge about them or both. It is necessary that a comprehensive data base or manuals regarding various RETs and the practices to be adopted should be readily available to the users. Public education about the importance of renewable sources of energy can be achieved through publications, media coverage, etc. Regulatory measures may be required to enforce measures like labeling of appliances with the details of energy efficiencies and estimates of operating costs, minimum efficiency standards, etc. Similarly, policies can be formulated to facilitate the production of RETs and help the consumers to substitute RETs for the standard ones.

(ii) Economic and Financial

High initial cost of RETs is a major barrier for their effective penetration. Since customer discount rates are 25% and above whereas the government/utility discount rates are around 14%, it is necessary to offer an appropriate financial package along with every RET. Even after considering the financial package, the cost of saved demand is much lower than that of augmenting supply in centralised power plants. Possibilities for these packages need to be examined for every technology. Since the utility benefits if the demand reduction is significant, it can provide financial assistance for a particular technology on an installment basis, which can be recovered along with monthly electricity bills.

The speedy implementation of RET programmes require explicit financing mechanism. In the developed countries this is achieved by providing incentives to consumers through utilities, and the utilities are compensated through pricing policies. The cost of a programme is thus met from the savings that accrue to utilities and consumers. A programme should be able to finance itself for its success in the long term. In India there is no mechanism currently to finance the RET diffusion programmes. However, in the absence of a viable institutional mechanism, no financial mechanism for the penetration of RET survives.

(iii) Technical

In the industries, lack of technical expertise is one of the barriers in selection of RETs revealed by the respondents during the survey. No effective mechanism for exposure of industries' personnel to the state of the art RETs exists at present. At present, the exposure is limited to the existing technology of their own industry. Under these circumstances, even if the government takes up the implementation of RETs, it can not be expected to know about the various equipments and their applications at the consumer's end. Hence, industries should conduct well-designed training programmes for their personnel to upgrade their knowledge on emerging technologies and also empower them to implement feasible alternatives. This can ensure that improvements made in an industry get replicated in other industries also.

(iv) Institutional

The implementation of the RET programmes require not only technical inputs, and financial support, they also require an appropriate institutional mechanism that has been lacking at present in India. There is an urgent need to form an agency consisting of representatives from the utility, financial institutions, equipment manufacturers and consumers to implement various RETs. This agency is required to (a) evolve a strong consensus for an appropriate institutional arrangement for formulating and implementing RET programmes in various sectors on an on-going basis. This could be in the form of a nodal agency by itself or supported by smaller, regional or sectoral energy service companies (ESCOs), and (b) formulate the structure, scope of functions, funding mechanism, mode of operations, etc. This agency can take up the responsibility for awareness and diffusion of RETs.

(v) Market

It is important that individual technologies need to be tailor-made to overcome specific barriers, e.g., SWH need to be tested for their reliability and performance guarantees should be provided. The availability of RETs needs to be tailor made to the specifications of consumers.

5.2 A strategy for future

For the effective penetration of RETs, it is necessary for the consumers, utilities and the government to enlarge their role by active participation in the penetration programmes. The cost of saved demand is much lower than that of augmenting supply in centralised power plants. Hence, programmes for implementing these technologies needs to be integrated into the power planning and management process. It would be very desirable if every State Electricity Board (SEB) formulates a renewable energy plan when requesting allocations for new power plants. The question is not whether this can be done or not but when and how fast?

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