CHAPTER 1. INTRODUCTION

1.1 Introduction

The changing lifestyle with rapid industrialization has made the requirement of electricity as essential and important over the years. During the last few decades increasing price of electricity and decreasing reserves of fossil fuels has raised concerns for the policy makers, industrialist, investors and the general public\(^1\). Moreover the change in global climate is one of the significant environmental concern which leads to increase in greenhouse gases\(^2\). Many different measures are taken worldwide to reduce the level of greenhouse gases and save the environment. The electric power sector is one of the biggest source of greenhouse gas emission. Policy makers across the globe have been looking for sustainable and feasible input energy source for electricity generation. The use of renewable energy as an alternative source of energy to conventional sources of energy is considered as the most effective policy across the power sector in the world. Various options of renewable energy are available such as solar, wind, biomass, hydro, geothermal, tidal and so forth for electricity generation. Among all the sources solar energy is the cleanest and greenest form of renewable energy. The solar energy received by the earth is more than 15,000 times consumption of the world’s commercial energy and over 100 times the world’s conventional energy reserves like oil, coal and gas. And anybody can tap this readily available energy without any constraint or cost during daytime\(^3\). Besides this solar energy is pollution free and radiation free source of energy. It does not emit any hazardous gases during its generation of electricity.


\(^3\) “Solar radiant Energy over India,” IndiaMeteorologicalDepartment, Ministry of Earth Sciences, Government of India, 2009.
Initially solar energy was used to supply electricity for satellites but now due to advances in solar technology and its potential it is used for the production of electricity not only to supply to remote locations but also to supplement the national grid power at multimegawatt levels. Solar energy can be harnessed as Solar Thermal Energy for heating applications and as Solar Photovoltaic (SPV) Energy for direct conversion of sunlight to electricity, the only one-step technology to generate electricity, involving no moving parts / energy inter-conversion systems, unlike all other electricity generation systems.

1.2 Solar Energy Initiatives in India.

India is located in the northern hemisphere and is divided into almost two equal halves by the tropic of cancer. The southern half which coincides with peninsular India lies in the tropical zone, while the northern half belongs to the subtropical zone. There are about 250 to 300 sunny days every year in India as per its location on earth which imparts radiation of 200 MW/Km$^2$ per hour. Due to this advantage of solar energy in India, Government of India (GOI) has taken several initiatives for the development of solar technology in India.

For all matters relating to new and renewable energy, the MNRE (Ministry of New and Renewable Energy) works as the nodal Ministry of the GOI at the Federal level. The MNRE is facilitating the implementation of broad spectrum programmes such as harnessing renewable power, renewable energy to rural areas for cooking, lighting and motive power, use of renewable energy in industrial, urban and commercial applications and development of alternate fuels. It also supports R&D, design of technologies, products and services in the field of new and renewable energy.\(^4\)

In India, for the promotion of solar energy, Jawaharlal Nehru National Solar Mission (JNNSM) was launched on 11\(^{th}\) January 2010. It is a mission to fulfil the goals of National Action Plan on Climate Change (NAPCC). The Mission has set the ambitious target for deploying 20,000 MW of grid connected solar power by year 2022, by reducing the cost of generating solar power in India through (i) long term policy; (ii) deploying goals at large scale; (iii) dynamic R&D; and (iv) domestic

production of components, products and critical raw materials, in view of achieving grid tariff parity by year 2022. Along with the national policy several state solar policies were also introduced for the promotion of solar in different states of India. Gujarat State was the first state in India to introduce state solar policy before JNNSM was launched. Gujarat Solar Policy was launched in 2009. Gujarat state solar policy promotes the generation of solar power for both off grid and on grid applications. On grid applications help to feed electricity directly in the power grid. Residential customers in houses, villages, small communities can have solar panels on their roof tops to generate electricity. Houses or new constructions or large buildings can be used for such purpose. Industrial customers can also erect solar panels on their industry roof tops, farm houses, stables, office windows to generate electricity. Off grid applications involves using solar appliances such as solar heaters, solar cookers, solar electrification for lighting purposes, solar street lighting, solar cars, water pumping, etc. This helps in saving conventional electricity to a greater extent.

1.2.1 Objectives of Gujarat state solar policy

1) Promote generation of green and clean power in the State using solar energy.
2) Put in place an appropriate investment climate, that could leverage the Clean Development Mechanism (CDM).
3) Productive use of the wastelands, thereby engendering a socio-economic transformation.
4) Generate employment and enhance skills of local youth.
5) Promote R&D and facilitate technology transfer.
6) Establish core technical competence in professionals in the State to initiate and sustain use and effective management of newer applications.
7) Promote local manufacturing facilities
8) Create environmental consciousness among citizens.

1.3 Promotional strategies of Government of India to promote Solar

Central Government as well as the State Government are offering several incentives to promote solar on large scale. Several measures are undertaken by MNRE to promote the use of solar. Due to high cost of solar several financial incentives are provided by the government in the form of capital subsidies for buying of solar equipment, loan from banks at less interest rates, selling of REC (Renewable Energy Certificate) in the market for extra income, selling of electricity generated by solar technology to the national grid, etc. It is very important to bring large scale awareness among the people for the use of solar applications. It has been observed that there is lack of information regarding solar technology among the public which is to be considered as an important constraint to the promotion of solar. Following are the promotional activities of GOI:

1.3.1 Institutions and agencies

MNRE has developed several institutes and agencies for work on several activities related to renewable energy. They are:6

1. National Institute of Solar Energy ((NISE): It is the autonomous institution formed by MNRE in September 2013 to carry out research and development in solar technology. It coordinates research technology, skill development, training, consultancy, incubation and other work related to solar energy.

2. National Institute of Wind Energy (NIWE): It has been established in Chennai in 1998 as an autonomous R&D institution by MNRE. It is a knowledge-based institution of high quality and dedication, offers services and seeks to find complete solutions for the kinds of difficulties and improvements in the entire spectrum of the wind energy sector by carrying out further research.

3. Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE): Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE), Kapurthala (Punjab) is an autonomous Institution of MNRE. The objectives of the Institute are to carry out and facilitate research, design, development, testing, standardization & technology demonstration eventually leading to commercialization of RD&D output with a focus

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6 MNRE : http://www.mnre.gov.in/
on bioenergy, biofuels & synthetic fuels in solid, liquid & gaseous forms for transportation, portable & stationary applications, development of hybrid / integrated energy systems, to undertake & facilitate human resource development at all levels including postdoctoral research.

4. The Indian Renewable Energy Development Agency (IREDA): It is a nonbanking financial institution under MNRE for providing term loans for renewable energy and energy efficiency projects.

5. Solar Energy Corporation of India (SECI): SECI, New Delhi is registered under Section 25 of Companies Act, 1956, as a Company not for profit, under the administrative control of MNRE. As a part of mission activities SECI has taken up following activities and projects:
   a) Implementation of JNNSM Phase-II – Initially 750 MW PV Power Plants as a part of 3000 MW to be implemented through central scheme with an estimated project cost of Rs. 30000 Crores.
   b) Solar Thermal installations for water/air heating and industrial process.
   c) Solar Thermal Pilot Power Plants.
   e) Development and dissemination of low cost solar lanterns.
   f) Grid connected solar power plants.
   g) Solar Mini/Micro Grids.
   h) Research and Development including solar resource assessment

### 1.3.2 Renewable Purchase Obligation (RPO)

Under this mechanism the State Electricity Regulatory Commissions (SERC) are required to purchase a specific percentage of power from renewable energy sources. RPO is being implemented throughout India to create demand for renewable energy. It was implemented to meet the target of supplying 15% of the energy demand in the national grid through renewable by year 2020. Each state is given the responsibility of implementing the policy. Every state framed their independent state policies for the implementation of the policy.

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[7](www.shansolar.com/rpo/)
[8](https://girishshivakumar.wordpress.com/2013/10/13/renewable-purchase-obligation-rpo-in-india/)
1.3.3 Renewable Energy Certificate (REC)

A roadmap is provided by the Electricity Act 2003\(^9\), the policies framed under this Act and the National Action Plan on Climate Change (NAPCC) for increasing the share of renewable in the total generation capacity in the country. However, Renewable Energy (RE) sources are not evenly spread across different parts of the country.

On one hand, there are states (like Uttar Pradesh and Haryana) which have very less potential of RE sources. On the other hand, there are States (like Gujarat, Rajasthan and Tamil Nadu) where there is very high potential of RE sources. In such States there are avenues for harnessing the RE potential beyond the RPO level fixed by the SERCs. However, the high cost of generation from RE sources discourages the local distribution licensees from purchasing RE generation beyond the RPO level mandated by the State Commission.

It is in this context that the concept of Renewable Energy Certificates (REC) assumes significance. This concept seeks to address the mismatch between availability of RE sources and the requirement of the obligated entities to meet their RPO. It also encourages the RE capacity addition in the States where there is potential for RE generation as the REC framework seeks to create a national level market for such generators to recover their cost.

There is a central level agency of RE generators participating in the scheme. This Central Agency issues the REC to RE generators. The RE generators have two options - either to sell the renewable energy at preferential tariff fixed by the concerned Electricity Regulatory Commission or to sell the electricity generation and environmental attributes associated with RE generation separately. On choosing the second option, the environmental attributes can be exchanged in the form of REC.

The value of REC is equivalent to 1 Mega Watt hour (1000 electricity units) of electricity injected into the grid from renewable energy sources. Renewable Energy Certificates are divided into two categories – Solar and Non Solar. The REC can be

\(^9\) Renewable energy certificates (REC) Mechanism in India, www.indianenergysector.com
exchanged only in the Power Exchanges (Indian Energy Exchange and Power Exchange of India Limited) within the band of a floor (minimum) price and a forbearance (maximum) price which is determined by CERC from time to time.

1.3.4 Roof Top SPV Schemes

Roof top solar photovoltaic (SPV) scheme is introduced by GOI to generate electricity by installing solar panels on roof tops. Government subsidy is available for the installation of roof top solar panel. Along with roof top scheme, they have also introduced net metering policy which monitors the electricity supplied to the national grid after deducting the electricity used for household applications. Roof top solar system is useful to generate electricity for your household requirements plus can be feed to the national grid and earn extra income. At initial stage all government offices, residents and institution buildings were mounted with solar roof top panels. Loan from bank is also available for this purpose.

1.3.5 Solar Parks

Solar Parks consists of installing solar panels on a larger area. Big landscapes or unused land or infertile land can be utilised to erect solar parks to generate electricity in larger quantity. The Scheme proposes to provide financial support by Government of India to establish solar parks with an aim to facilitate creation of infrastructure necessary for setting up new solar power projects in terms of allocation of land, transmission and evacuation lines, access roads, availability of water and others in a focused manner.

Solar Energy Corporation of India (SECI)\textsuperscript{10}, a central public sector enterprises under MNRE, has been implementing various schemes to develop solar sector in the country. As per the policy, these solar parks will be developed in collaboration with the State Governments. The implementation agency would be Solar Energy Corporation of India (SECI) on behalf of Government of India (GOI).

\textsuperscript{10} http://seci.gov.in/content/innerpage/solar-park.php
1.3.6 Canal Banks and Roof Tops

The objective of this scheme is to achieve fruitful utilization of the area on top of Canals and also the available vacant Government land along the banks of Canals, for setting up Solar PV power generation plants for feeding the generated power to Grid and to set up a total capacity of 100 MW solar PV power projects to achieve targets set under National Solar Mission (NSM) announced by the GOI.

1.3.7 Subsidies and loan

Subsidy from GOI is available for different schemes of solar such as solar roof top, solar water heaters, decentralised solar systems, solar water pumps etc. Loan from different banks are available at less interest rates for purchasing of solar equipment and installing them.

1.3.8 Workshops, Seminars and Training Programmes

Workshops, seminars and several training programmes are conducted by MNRE from time to time for bringing public awareness for renewable energy and developing manpower to meet the requirements of the new renewable technologies. Several courses are conducted on solar to train the people for installation, repairing and maintenance of solar systems. Information for various programmes is available on the website of MNRE.

1.3.9 State Solar Policies

States have also come up with encouraging State Solar policies like Accelerated Depreciation (AD) on capital investment, soft loan for financing, reduced or no transmission and wheeling charges, no cross subsidy surcharge for open-access

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transactions, reduced or no intra-state Availability-Based Tariff (ABT), nonapplicability of merit order dispatch principles, exemption from electricity tax, tax concessions, refund of stamp duty and registration charges paid for land purchase, single window clearance, faster power evacuation approval, and so forth.  

### 1.4 Challenges and Constraints in Promotion of Solar

Consumers consistently report a preference for energy produced from renewable energy sources but invariably fail to purchase renewable energy in sizeable numbers. There are several barriers in the adoption of solar applications due to various reasons. Consumers are aware about the advantages of solar energy, its impact on the environment but still there are certain constraints which resist them from adopting solar. The constraints and the challenges that the Government has to face to promote solar are:

a) **Technical Barriers:** It is related with lack of technical knowledge awareness among the people. Solar technology is new to the public. No proper expertise is available in this field. There is lack of skilled technicians for installation and maintenance of solar systems. Also the solar cell manufacturing technology is under development. Lot of research is required to bring the perfect and reliable technology in the market. Need for storage/backup technologies to supply during night raises cost.

b) **Economical Barriers:** High capital cost is one of the biggest barriers in the promotion of solar energy. Due to high price of solar cells, solar panels are expensive and hence the whole project becomes costly. Also solar electricity is slightly expensive than conventional sources which restricts the people in adoption of solar electricity. High payback periods and insufficient financial incentives from Government are some of the barriers.

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c) Social Barriers: Lack of information dissemination and consumers awareness is responsible for less acceptance of solar energy. Also there are several myths and wrong perceptions for use of solar which has to be resolved through awareness programmes. Also poor perception of people towards renewable aesthetics is one of the problem for acceptance.

d) Policy and Regulatory Barriers: Policies have been issued for RE (Renewable Energy) but the plans for the development of RE do not match the policies. Lack of coordination and cooperation within and between various ministries, agencies, institutes and other stakeholders delays and restricts the progress in RE development. Gaps in implementation of policies because of absence of inter-institutional coordination reduce the faith of investors in the investment climate for RE.

e) Market related barriers: There is lack of established market for solar power commercialisation. Several trade barriers exist such as high import duties for solar modules. There is a high risk perception of private investors towards adoption of high cost technology and uncertainties in serving rural market. Investment becomes unattractive under high discount rates and low payback periods. Subsidy on fossil fuels hinders development. Large preinvestment risk associated with the cost of marketing, contracting and collecting the information.

1.5 Importance of Study

Electricity is of prime importance in today’s world of industrialization. It is responsible for the economic development of the country. The demand for electricity is increasing day by day and the supply is available from limited conventional sources of power like coal, gas, petroleum and other fossil fuels, which have the additional drawback of being harmful to the environment. So it is high time to think of alternative sources of energy which are long-lasting / abundantly available as well as eco-friendly, thus enabling reducing carbon footprints. World today is moving towards non-conventional, renewable energy sources such as wind, solar, tidal, hydropower, geothermal, biogas, etc. Solar energy is one of the cleanest forms of renewable energy, which has no radiation hazards, nor does it release any hazardous gases into the atmosphere. Solar energy is readily available during the day, free of cost.
Despite of all these advantages, solar energy is not gaining its popularity due to its high initial cost of installation and lack of sufficient knowledge and awareness about the technology. In spite of such high potential and numerous efforts done by government and private sectors to promote it, solar energy only contributes to less than 1% of world’s energy demand.

Government of India has taken major steps for promoting solar energy all over India through its numerous incentive schemes for the state governments as well as for the public, in general. Solar Photovoltaic (SPV) systems can be stand-alone or grid-connected and either Domestic or Commercial or Industrial systems. Gujarat is the first state to take initiatives in the promotion of solar energy even before the Jawaharlal Nehru National Solar Mission was launched. Gujarat government had launched its first Solar Power Policy in 2009, introducing number of schemes to motivate the general public to participate in the generation of electricity from Solar Energy.

Objective of this study is to know the awareness and perception of citizens of Gujarat towards promotional strategy of solar applications and to understand the State solar policy of Gujarat. Several promotional incentives are available from The Gujarat Government but they will be effectively implemented if people are aware about the solar policies and advantages of solar energy. There is a need of large awareness campaigns for increasing the adoption of solar technology. Also there are several myths and misconceptions of people regarding solar. It is important to guide the people in right direction for the use of solar applications. Also there are several barriers in using solar technology which has to be understood. The research tends to understand the difficulties faced by the people of Gujarat towards using solar applications. It is necessary to know the reasons for not adopting solar energy for electricity generation. The demographic factors responsible for the behaviour of people towards adoption of solar energy are also identified.
1.5.1 Awareness

Awareness\textsuperscript{14} is the ability of a person to directly feel, know and perceive, or to be conscious of events. In a broader sense, it is the state or quality to know about something. It is the knowledge through interaction between the person and its environment. In simple words is ‘to know about what is going on’. Awareness is how individual monitors and perceives the information about the surroundings of the environment they are in. Awareness is of different types depending upon the situation one is dealing with.

Different categories of awareness depending upon the type of information being obtained or maintained is given below:

- Informal awareness is the sense of knowing who’s around you and what are they up to.
- Social awareness is the information you maintain considering the social context.
- Group-structural awareness is the knowledge of responsibilities, roles, status of others in a group. It is an understanding of group dynamics and the relationship of individuals within group.
- Workspace awareness – It is focused on the workspace’s influence and intervention of awareness information, specially the location, activity, and changes of elements within the workspace.

Awareness is a relative term. It is always expressed with respect to a particular situation, event, location, problem, information etc. This research is related to the awareness of the people towards renewable energy especially with reference to solar energy. Awareness with respect to several aspects is studied such as:

1. Knowledge - Are people aware of the term renewable energy. Do they have any information regarding various sources of renewable energy?
2. Benefits: Are people aware about the benefits of using solar energy and its applications.

\textsuperscript{14} Wikipedia retrieved on 20/4/2017 from https://en.wikipedia.org/wiki/Awareness
3. Government policies: Are people aware about government initiatives regarding promotion of solar. Government has framed solar policies national as well as state wise for the development and promotion of solar technology. Are the citizens aware of these policies and incentives given by government?

4. Information: Are people aware about where to get the necessary information regarding the use, availability, schemes, projects of solar applications and its use.

Awareness towards solar energy can be increased by conducting several workshops and activities related to solar technology. Proper promotion through television, newspaper, websites, hoardings, training camps, seminars, demonstrations is required to make people know, understand and accept the new trends of solar technologies to save the environment from the carbon footprints. It has become utmost important to think about sustainability regarding the energy sector as requirement of electricity is increasing day by day and the conventional sources are on the verge of extinction as well as they are main reasons for global warming.

1.5.2 Perception

Perception is the ability to see, hear or become aware of something through senses. It is also defined as the way in which something is regarded, understood or interpreted. Perception of any particular matter is different for every individual. There are three components of perception:

1. The perceiver, the person who becomes aware of something and comes to a final understanding. There are several factors which will influence the understanding or interpretation process of the person such as experience of the person as well as motivational and emotional state of the person. In different motivational or emotional states person tries to perceive the same thing in different ways. Many times in different situations he or she might see what they want to see. Perception is also related to some misconceptions or misunderstanding of a particular matter in our mind.

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2. The target is the person, thing, situation or event which is judged or is perceived. Lack of information or doubtfulness about the target leads to wrong perception. So it is required that the person should gather true and enough information before judging any matter. Else the perception may go wrong.

3. The situation matters a lot in perception because different situations may call for additional information of the target.

Types of perception: There are different types of perception such as visual, sound, speech, face, social, haptic (touch), taste etc.

This research deals with the perception of people of Gujarat state towards making use of solar technology for electricity generation and other applications. There are several understandings and misunderstandings of people towards use of solar energy. The research is to understand the way the people think about using solar technologies with respect to its benefits, problems, requirements and uses.

Benefits: Perception of the people of Gujarat state towards the benefits associated with the applications of solar energy.

Problems: Barriers for the use of solar technology. What people think or understand for not adopting solar energy for electricity generation.

Requirements and uses: Perception regarding the usage of solar applications.

1.6 Chapter Plan

- Chapter 1 consists of introduction of the research conducted. It depicts the solar initiatives taken by GOI for the promotion of solar. It also reveals the barriers which restricts the adoption of solar applications by the general public. It also tells us the importance of the study conducted.
- Chapter 2 deals with industry overview of solar. History and Development of solar technology in India as well as across the world is described in this chapter. Also the current status of solar and its development in India is discussed in this chapter.
• Chapter 3 is of review of literature. It is the review of the work of researchers across the globe and in India regarding awareness, perception and barriers towards adoption of solar technology. Also the papers relating to recent trends in solar in India as well as abroad are reviewed.

• Chapter 4 relates with the research methodology adopted for the research. It uses non-probability convenience based sampling technique with sample size of 754 respondents from five major cities of Gujarat state. Questionnaire has been used as a tool for sampling. The data collected will be analysed by using different statistical methods for parametric as well as nonparametric data.

• Chapter 5 comprises of Data analysis and interpretation.

• Chapter 6 deals with Findings of the research study.

• Chapter 7 consists of conclusion, views, recommendations, limitations and scope for further research which will be followed by Bibliography, Appendix I (Questionnaire is attached), Publication and Conference details.