Chapter 1

Introduction

1.1. Background

India is the second fastest growing economy in the World and third largest in Asia. According to Census of India (2011) it is learnt that India is a home to 17.5% of world's total population, though it has, no more than 2.5% of total global land available (Ramachandran, Singh, Kapoor, & Lamba, 2000). Indian population has grown by 181 million in the last decade from 2001-2011, thereby reducing the gap with China [1]. The population difference with China was 131 million in 2011 against 238 million in 2001 (Census India, 2011).

India has developed with an average growth rate of 7.3% since 1999 (RBI, 2011). After the global economy downturn in 2008, Indian economy regained a growth rate of 8.4% in 2010. To sustain this growth, all sectors namely Agriculture, Industry and Services need to contribute continuously at a positive rate. During 2011-2012 (April-November) Industrial sector comprising of Mining, Quarrying, Manufacturing, Electricity, Gas and Water supply had grew at a rate of 3.8% as compared to 8.4% in 2010-2011. Among other industries electricity sector had recorded the highest growth, which grew at 9.5% during the same period (2011-2012) (Ministry of Finance, 2012).

[1] *Most populated country in the World*

A report by International Energy Association (IEA) shows that India has a very low energy use, which was only 559.6 kg of oil equivalent per capita in 2009-10. The annual per capita consumption of electricity in the country was merely 570.9 units (kWh /capita) in 2009-10, which was only 1/5th of the world's average per capita consumption (IEA, 2011). As a developing country and with ever rising population, India's demand for energy consumption is also rising rapidly. As a developing country this consumption rate accounts to only 4.1% of world total energy consumed (CSE, 2012). Table 1-1 shows the stats for GDP growth, various sectors growth and related consumption and CO_2 emissions growth in India from 1999-2012.

Table 1-1 Statistics of India

Year	GDP Growth (RBI)	Industrial Growth % (WB)	Electricity Sector Growth % (WB)	Electricity Consumption per capita-kWh (IEA)	Energy use (kg of oil equivalent per capita) (IEA)	CO_2 emissions (metric tons per capita) (EC)
1999-20	6.04	4.6	3.58	383.9	432.7	1.03
2000-01	4.35	6.4	2.7	386.6	433.8	1.06
2001-02	5.81	2.7	4.46	387.4	433.6	1.08
2002-03	3.84	7.1	5.1	400.3	438.6	1.12
2003-04	8.52	7.4	4.95	417.5	442.6	1.15
2004-05	7.6	9.4	6.47	438.8	461.8	1.24
2005-06	9.49	9.7	8.11	455.9	471.8	1.29
2006-07	9.6	12.2	11.42	495.2	488.3	1.38
2007-08	9.3	9.7	8.93	539.5	508.2	1.48
2008-09	6.7	4.4	4.57	564.2	519.8	1.56
2009-10	8.4	8.4	2.7	570.9	559.6	1.69
2010-11	8.39	7.2	4.46	600.2	585.23	1.84
2011-12	6.88	3.9	3.45	612.4	618.43	1.98

***Source*:** (RBI, 2011; World Bank, 2013; IEA, 2011; EC, 2012)

In January 2014, India's electricity sector had a total generation installed capacity of 235 GW from all sources (CEA, 2014). The statistics show that country has been able to achieve an average of 51.33% of our planned generation capacity during last few Five Year Plans[2]. As a result of which the country faces an acute shortage of power consumption with a demand and peak demand deficit of 8.5% and 10.3% respectively (CSE, 2012). Table 1-2 shows the total generation capacity added during all Five Year Plans.

Table 1-2 Electricity generation capacity installed during all Five Year Plans

Plan	Years	Target MW	Achievement MW	Achievement %
I	1951-56	1300	1100	84.60%
II	1956-61	3500	2250	64.30%
III	1961-66	7040	4520	64.20%
Annual Plans	1966-69	5430	4120	75.90%
IV	1969-74	9264	4579	49.40%
V	1974-79	12499	10202	81.60%
Annual Pan	1979-80	2813	1799	64%
VI	1980-85	19666	14266	72.50%
VII	1985-90	22245	21401	96.20%
Annual Plan	1990-91	4212	2776	65.90%
Annual Plan	1991-92	3811	3027	79.40%
VIII	1992-97	30538	16423	53.80%
IX	1997-01	40245	11919	47.50%
X	2002-07	41110	21180	51.50%
XI	2007-12	78700	53922	68.52%

***Source*: (WEC, 2012)**

Being a developing nation, India requires energy for continuous and sustainable development. India has proven Oil and Gas reserves but still has to imports large part of it to meets its huge demands. India is rich in

[2] *Five Year Plans - VIII, IX, X, XI.*

coal reserves, but continuously imports from different countries due to low quality of domestic coal, having high ash percentage and low calorific value. Coal is major source for electricity generation in India, as it is in abundance in country, helps in generating per unit of electricity at a very low price. Large Hydro is next most used source for electricity generation which accounts to 22%, but it has its own demerits of affecting the ecology. Further the other source for electricity generation in India are Renewables and Gas contributing to 10% each followed by Nuclear and Diesel contributing to 3% and 1% respectively. Figure 1-1 shows the energy mix for electricity generation in India.

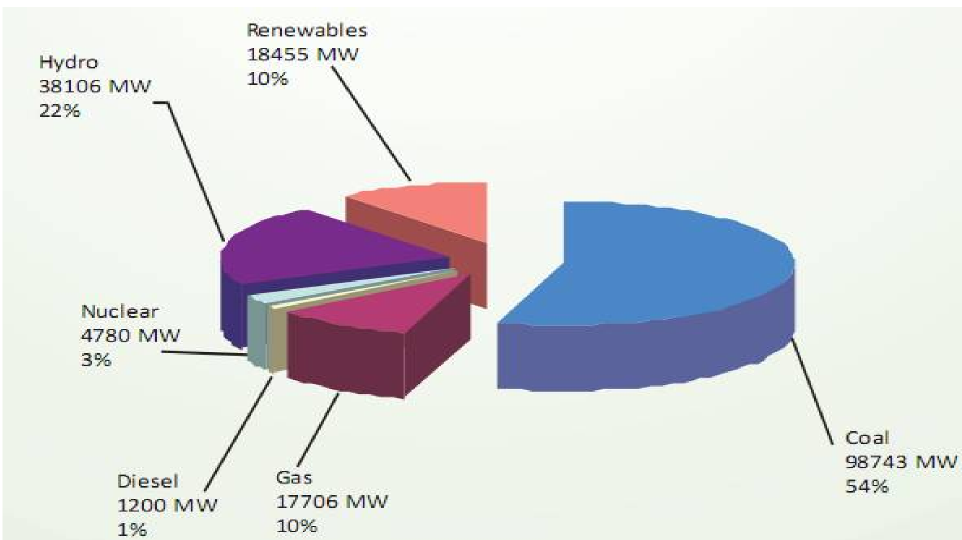

Figure 1-1: Energy mix for electricity generation in India ***Source*: (WEC, 2012)**

As discussed, Coal is most preferred source of fossil fuel to generate electricity in India, at the same time it proves to be very costly to human race by releasing great amount of CO_2 (GHG emissions). A report by World Bank (2013) states that, global average for CO_2 emissions from electricity sector is 41% followed by transport sector which contributes to 23%. These Green House Gas (GHG) emissions are causing great threat to life and habitat, by leading to climate change. Figure 1-2 shows that GHG emissions are combination of hazardous gases majorly being CO_2, CH_4, N_2O, in a proportion of 77%, 14%, 8% respectively. Coal plant releases maximum amount of CO_2 emissions per kWh generated in its life cycle which counts to approximately 1000 g CO_2/kWh (Erdem, 2010).

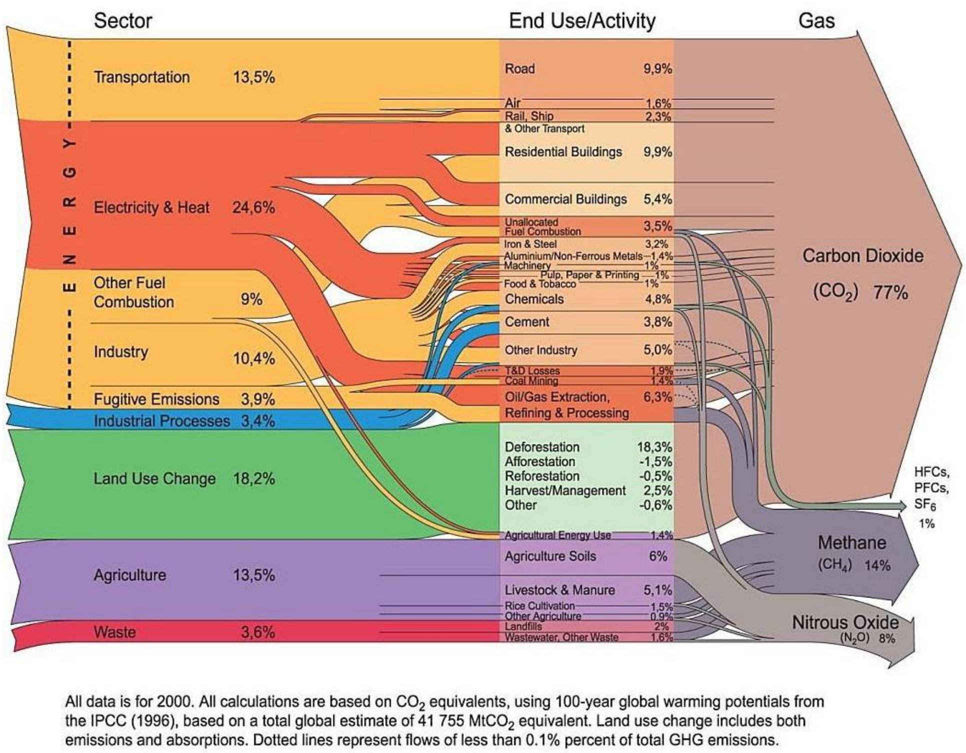

Figure 1-2: Components of Greenhouse Gas emissions ***Source*: (WRI, 2005)**

According to World Bank report (2013), India is the 3rd largest emitter of CO_2 through Coal thermal plants after China and United States. The total emissions from Coal plant is close to 70% in India (CO_2 per capita > 1.84%). World Energy Council (2012)projects India's average annual growth for CO_2 emissions to be approximately 2.7% by 2035 which will be two times the world average annual growth. Table 1-3 shows the CO_2 emitters in the World with their future forecast.

Table 1-3 World Co_2 emitters with their future forecast

Region/ Country	History (Million Tons)			Projections (Million Tons)					Annual Growth
	2006	**2007**	**2008**	**2015**	**2020**	**2025**	**2030**	**2035**	**%**
United States	5,918	6022	5838	5680	5777	5938	6108	6311	0.3
Canada	594	607	595	569	582	608	635	679	0.5
Japan	1,240	1254	1215	1125	1142	1136	1110	1087	-0.4
South Korea	484	503	522	533	562	597	634	678	1
Australia/New Zealand	440	449	464	466	477	492	509	528	0.5
Russia	1668	1618	1663	1648	1607	1603	1659	1747	0.2
China	5817	6257	6801	9386	10128	11492	12626	13441	2.6
India	1281	1367	1462	1802	2056	2398	2728	3036	2.7
Brazil	380	397	423	528	579	644	739	874	2.7
Total OEDC	13606	13742	13742	13031	13252	13549	13882	14323	0.2
Total Non-OECD	15152	15786	16718	20426	21958	24383	26758	28897	2.1
Total World	28758	29529	30190	33457	35210	37932	40640	43220	1.3

Source: WEC (2012)

The problem of climate change is faced by many developing countries like China, India, and Brazil as well as other developed nations. All nations are continuously working out to frame sustainable ways to growth for coming generations. On realization of fast depleting fossil fuels, many international and national organizations have been working closely together to find out efficient ways to produce energies which are continuous and clean in nature (free of GHG emissions). According to a report by United Nations Environment Program (2013) 78% of world's final energy consumption was largely met by fossil fuels in 2011, which had apparently reduced from 81% in 2009. Figure 1-3 shows Global final energy consumption from 2009-2011.

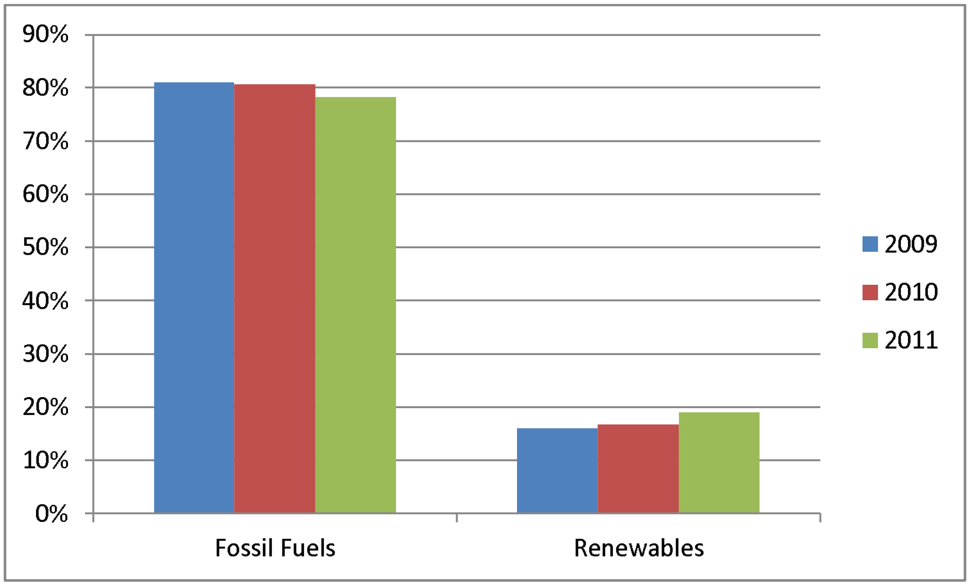

Figure 1-3 World's Final energy consumption through different sources of energy from 2009-2011 ***Source*****: (UNEP, 2011)**

It is also apparent from figure 1-3 that during the same period renewable energy has been continuously contributing to final energy consumption with a positive growth rate.

Earth is blessed with enormous forms of energy for its use, in which non-renewable sources are fast depleting and scarcity is prioritized at World level. As a result, countries are continuously working on alternative ways to generate electricity through cleaner and promising sources. Moreover to achieve sustainable growth, Renewable Energy Source (RES) can be one of the sustainable ways to meet the increasing global electricity demands.

According to Intergovernmental Panel for Climate Change (2012) Renewable Energy (RE) is defined as:

“Renewable energy is obtained from the continuing or repetitive currents of energy occurring in the natural environment and includes non-carbon technologies such as solar energy, hydropower, wind, tide and waves and geothermal heat, as well as carbon-neutral technologies such as biomass.”

The figure 1-4 shows different forms of Renewable Energy Sources (RES).

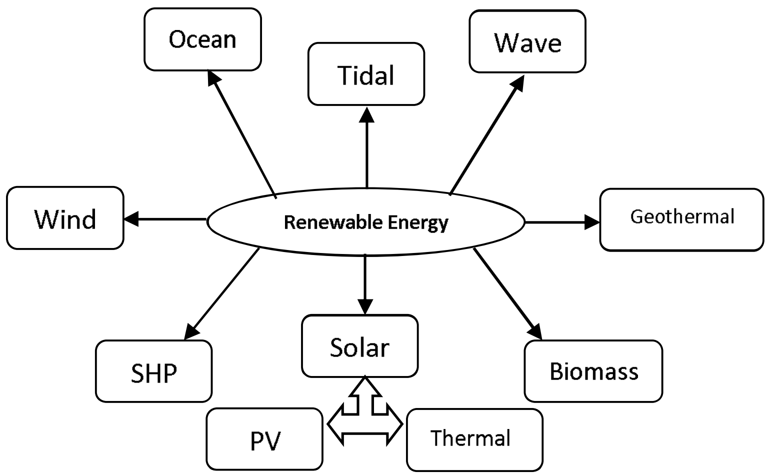

Figure 1-4: Renewable Energy Sources (RES)

RES are indigenous and distributed in nature and it can help us in achieving energy security, reduce dependency on imports, and ease fossil fuel prices volatility.

Realizing this fact, many countries have framed policies for different renewable sources. As a result of which cumulative installed capacity from RES[3] was approximately 480 GW in 2012, which was almost 21.7% of World’s total installed capacity (UNEP, 2012).

A report by IPCC (2012) states the technical potential for RES. Table 1-4 shows the global technical potential for all RES.

[3] *Excluding hydro which is 990 GW.*

Table 1-4 Global Technical Potential for Renewable Energy Sources

Renewable Energy Sources	Global Technical Potential (in EJ)	
	Minimum	**Maximum**
Direct Solar Energy	1575	49837
Geothermal Energy (Electricity)	118	1109
Wind Energy	85	580
Biomass	50	500
Ocean Energy	7	331
Geothermal Energy (Heat)	10	312
Hydropower	50	52

***Source*: (IPCC, 2012)**

It is apparent that, Direct Solar energy has the highest potential which can be harnessed in different forms for meeting global energy demands. The total annual solar radiation falling on earth is more than 7500 times the World's total annual primary energy consumption (Kumar & Kumar, 2010).

The amount of solar energy that Earth receives, theoretically if only a small fraction of it could be used, it can meet current global energy needs (Singhal & Varun, 2006). According to Rai (2002) if we can use only 5% of solar energy incident on Earth, it will be 50 times of energy what the World requires[4].

Table 1-5 shows the total installed capacity from RES in World along with the leading countries in respective sources. It also shares the status for India along with its leading federal state. Ocean Thermal and Wave

[4] *The solar power where sun hits atmosphere is 10^{17} Watts, whereas the solar power on earth's surface is 10^{16} Watts. The total worldwide power demand of all needs of civilization is 10^{13} Watts. Therefore the sun gives us 1000 times more power than we need.*

Energy are largely under demonstration phase as it still needs to achieve a significant commercial breakthrough.

Table 1-5 Total capacity installed from RES in World with leading country and India's status with leading federal State

RES	World Status	World Leader	India Status	Potential	Leader
Biomass	83GW	United States	3.7 GW	23,700 MW	Uttar Pradesh
Wind	283GW	China	17.6 GW	47,000 MW	Tamil Nadu
Small Hydro[5]	-	-	3.71 GW	15,000 MW	Karnataka
Geothermal	11.7 GW	United States	203 MW	10,000 MW	J&K
Solar PV	100 GW	Germany	1.84 GW	4-7 kWh/m^2/day	Gujarat
Solar Thermal	2.5 GW	Spain	52MW	4-7 kWh/m^2/day	Rajasthan
Tidal Energy	527 MW	South Korea	No such commercial breakthrough		

Source**:** (World Bank, 2013)**;** (IEA, 2011)**;** (IPGSRL, 2010)

It is evident from table 1-5 shows that India has the maximum technical potential for solar energy among all RES.

1.2. Context

India is among the leading countries having good Direct Normal Irradiance [6] (DNI), Figure 1-5 shows the total Global Horizontal Irradiance[7] (GHI) for India, which depends on the geographic location, earth-sun movement, tilt of Earth rotational axis and atmospheric attenuation due to suspended particles. Thus India is estimated to have huge potential for solar energy.

[5] *In India hydro is considered to be renewable source of energy up to 25 MW only.*
[6] *DNI is solar radiation that comes in a straight line from the direction of the sun at its current position in the sky* (3TIER, 2014)
[7] *GHI is the total amount of shortwave radiation received from above by a surface horizontal to the ground. The value of GHI includes DNI* (3TIER, 2014)

India has vast potential for solar energy which is about 5,000 trillion kWh per year (Pandey & Singh, 2012). The solar radiation incident over India is equal to 4-7 kWh per square meter per day (Kumar & Kumar, 2010). It has an average of 250 - 300 clear sunny days (Kumar & Kumar, 2010) and 2300-3200 hours of sunshine per year (Sharma & Tiwari, 2011). Kumar (2010) further mentions that theoretically India's electricity needs can be met on a total land area of 3000 km^2 which is equal to 0.1% of total land in the country.

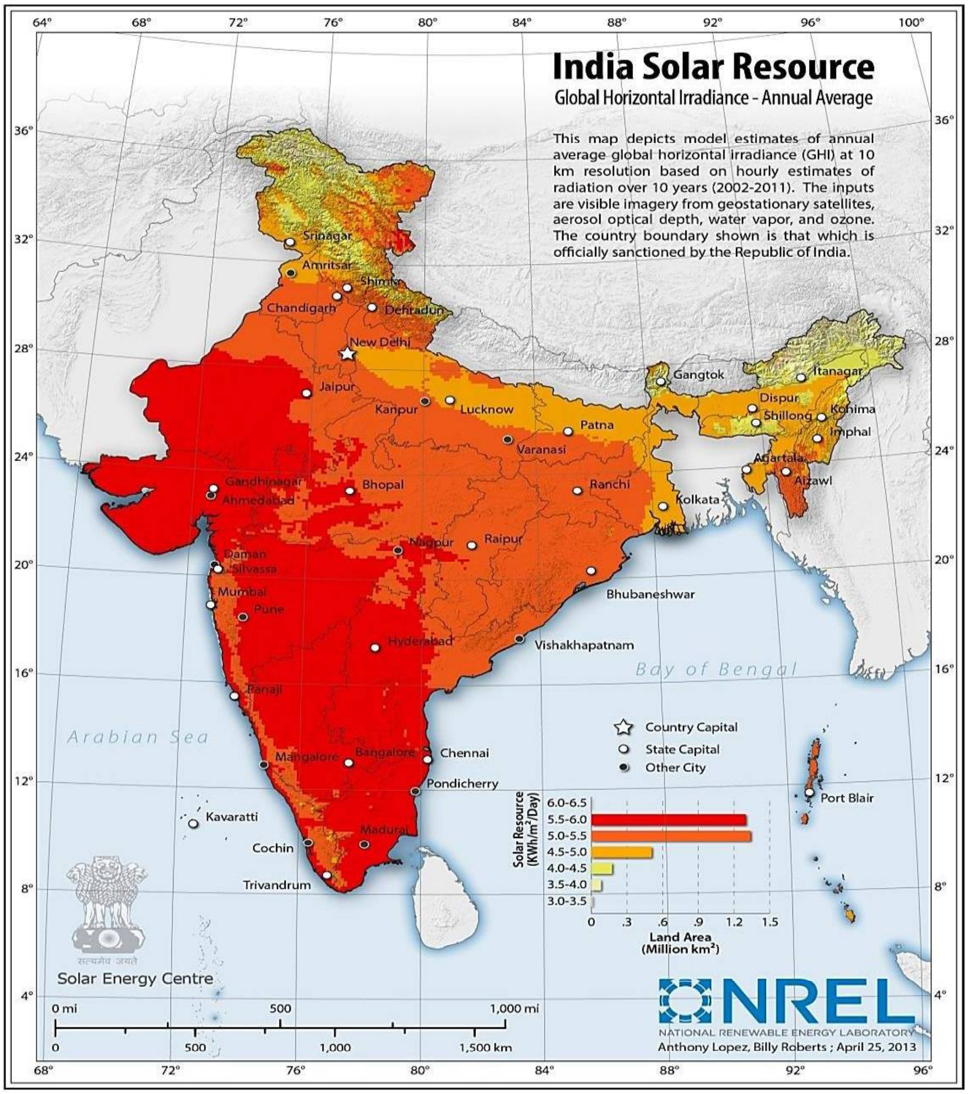

Figure 1-5 India Solar Resource Map ***Source*: (NREL, 2013)**

Hence, India realizes its potential of solar energy and seeks opportunities to utilize this energy as an alternative source to meet its electricity demands. The commercially proven technologies to convert solar radiation into heat and electricity are solar thermal and solar photovoltaic respectively. India can successfully exploit these technologies to enormous scalability to meet it electricity demands. Figure 1-6 shows the different technologies for converting solar energy into electricity and heat.

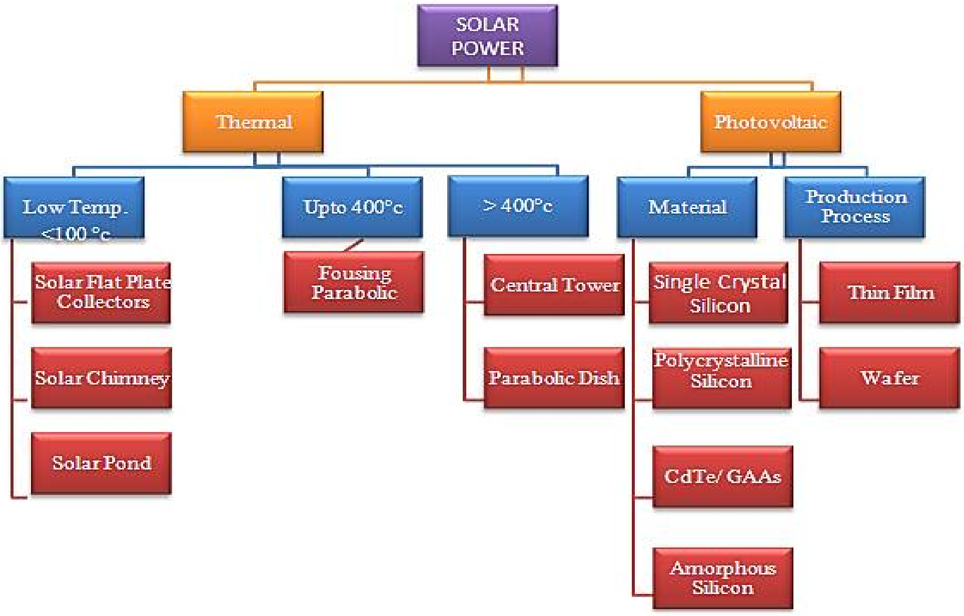

Figure 1-6 Different types of technologies for converting solar energy to electricity and heat

Few of the mentioned technologies like Solar Pond and Solar Chimney are still under demonstration stages, whereas Solar PV has been most adopted technology across the globe, for tapping solar and converting it into useable form of energy. The next section explains the penetration of solar PV technology across the world and especially India.

1.3. Significance and Motivation

Solar PV has realized highest average growth rate in last five years across the World as seen in Figure 1-7. Solar PV became the third most installed source of RES after Hydro and Wind in 2012 (UNEP, 2013). A report by

European Photovoltaic Industry Association (2012) states that, the total energy generated through solar PV across the World, was equivalent to 80 billion kWh in a year.

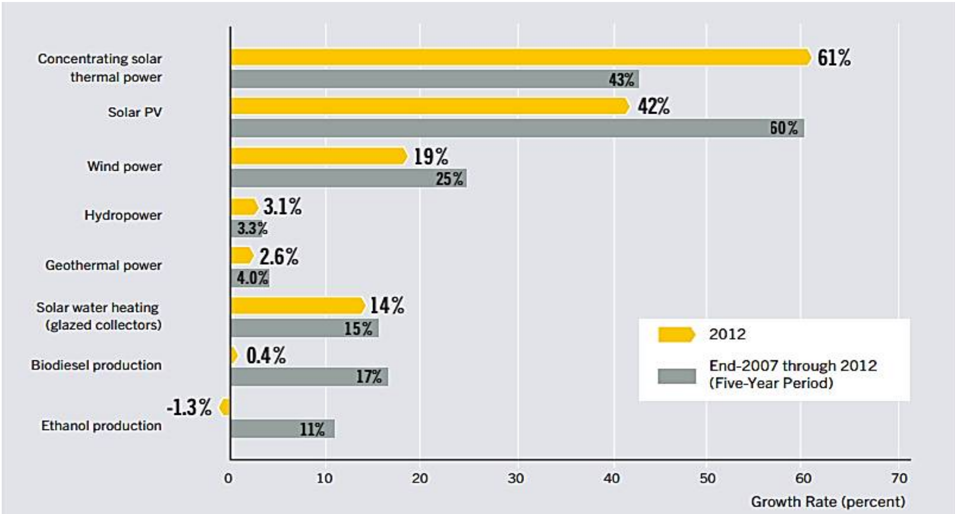

Figure 1-7 World Annual growth for Renewable Energy Capacity

Source: (UNEP, 2013)

Germany was the leading country in terms of maximum installed solar PV capacity followed by Italy, Japan, Spain and USA whereas India ranked 10th on that list in 2012 (UNEP, 2013).

Government of India had announced various policies and regulations signifying the need and priority for development of RES for generation of electricity in the country.

India stands as one of the top countries in promoting RES largely through Wind, Hydro and Solar. Promotion of solar has been one of the national action plans in country. GoI has promoted Jawaharlal Nehru National Solar Mission (JNNSM, 2010) with strong objectives to achieve 20,000 MW through grid connected and 2000 MW off grid solar energy installations by 2022.

As of January 2014 India's total installed capacity through grid connected solar PV had crossed 2 GW with major contribution coming through grid connected solar PV power plants and a modest 140 MW through off grid PV systems (MNRE, 2014).

The off grid installations are primarily meant for standalone purposes where grid connectivity has low penetration possibility and are unviable (as in the interior and remote areas).

Further India has not been able to demonstrate significant progress through solar thermal technology. According to a report by Bridge to India (2013) recently a 50 MW project has been commissioned through grid connected solar thermal technology taking the total to only 55.5 MW in comparison to 2000 MW through grid connected solar PV. According to another report by MNRE (2014) this 50 MW plant was one of the few plants which have been successfully commissioned against the total allocated capacity of 470 MW in December 2010. Consequently, maximum installation has come through grid connected solar PV power plants. In near future, it is possible that targets under JNNSM may largely be met by solar PV due to its ease of installation and operation.

Out of the total capacity installed through grid connected solar PV, maximum installations have come up in Gujarat followed by Rajasthan. Hence, there must be some strong reasons as to why only these two States have been able to attract maximum investments for grid connected solar PV power plants installation, in spite of the fact, there is a Central Solar Policy and twelve other State specific solar policies. Moreover these States must have adopted some strong initiatives or practices to create an environment to attract investments in their region. It is a known fact that Gujarat and Rajasthan has high radiations and huge land banks which are barren and unsuitable for agriculture, but there are few other States having alike conditions but still have not been able to attract similar quantum of investments as Gujarat and Rajasthan did. Henceforth, it becomes a strong reason for the researcher to find out factors supporting and inhabiting grid connected Solar PV power plant installation in other parts of country. That is, finding various barriers and challenges hampering promotion, and development of grid connected Solar PV. Furthermore, researcher would like to find out initiatives or practices adopted by Gujarat and Rajasthan for mitigating these certain barriers and challenges persisting in Indian environment.

1.4. Business Problem

From the above discussions it has emerged out that in spite of various barriers and challenges affecting the progress and development of grid connected solar PV in India, only Gujarat and Rajasthan were able to achieve a remarkable installation. Among all fourteen States which have declared solar policies, Gujarat followed by Rajasthan has attracted maximum investments for grid connected solar PV power plants installations in their region.

Hence the business problem for the current study can be stated as

Despite of having specific policy for solar energy development at national and State level, why Gujarat followed by Rajasthan have been able to attract maximum investments for grid connected solar PV power plants installation in their region?

1.5. Scope of Study

This study is in context to India. The study tried to find out the factors which hamper the growth and development of Mega Watt Scale Grid Connected Solar Photovoltaic Power Plants in India (hereinafter "grid connected solar PV"). Henceforth, it focuses on identifying barrier and challenges persisting in Indian environment. Furthermore, an attempt has been made to find plausible initiatives and practices adopted by Gujarat and Rajasthan to mitigate identified barriers and challenges. The research study has its place in the field of business and management therefore technical aspects of grid connected solar PV power plants does not fall under the scope of study.

1.6. Organization of the Study

The study consists of nine chapters which are as follows:

Introduction:

The first chapter presents the background and context of study; furthermore it conveys the significance of study followed by motivation behind current research. Finally it states the business problem and scope of study.

Literature Review:

The second chapter discusses evolution of solar PV, gives an overview of different organizations involved in development and promotion of solar PV in the country, further it discusses major policies and regulations announced by Government of India, along with State specific solar policies encouraging grid connected solar PV power plants in the country. Finally the chapter focuses on current issues, identified as barrier and challenges for grid connected solar PV worldwide.

Research Methodology and Data Analysis:

Chapter three discusses the philosophical stand for current study; it explains the rationale for using mixed method as research design, furthermore it explains the methods of data collection and tools used for analysis of data. The chapter also discusses the pragmatic results of quantitative study. Factor analysis was used for identification of various barriers and challenges for growth of grid connected solar PV power plants in India.

Developers' Perspective:

The chapter four covers the various perspectives of identified barrier and challenges according to developers' in Gujarat and Rajasthan specifically. The basis for the discussion in this chapter is driven by developers' perspective, as to how they perceive these barriers and challenges identified in chapter 3, as it helped the researcher to create a strong background for developing the case studies of Gujarat and Rajasthan.

Case Study of Gujarat:

Chapter five discusses the details of Gujarat as a State. Also this chapter reports the opinions of developers gathered through interviews conducted in the State. This chapter explains Gujarat response to the role of identified barriers and challenges.

Case Study of Rajasthan:

Chapter six discusses the details of Rajasthan as a State. Also this chapter reports the opinions of developers gathered through interviews conducted in the State. This chapter explains Rajasthan response to the role of identified barriers and challenges.

Cross Cass Analysis:

The seventh chapter provides a meta-analysis of case studies and presents the cross case analysis on identified barriers and challenges among two States.

Conclusion and Recommendations:

Finally, the chapter eighth gives the conclusion of study and recommendations with defining limitations and further scope of study.

1.8 Epilogue

This chapter discussed the potential of India as a developing economy. To achieve a sustainable growth, all sectors namely Agriculture, Industry and Services need to contribute continuously at a positive rate. India's ever growing population demands for high energy consumption, to which contributions from electricity sector will plays a pivotal role in meeting them.

India faces an acute shortage of power consumption having a demand deficit of 8.5% and peak demand deficit of 10.3%, although the current installed generation capacity of electricity sector stands at 235 GW from all sources. India depends heavily on Coal for meeting its electricity demands which largely contributes to nation's GHG emissions. Coal plant releases maximum amount of CO_2 emissions per kWh generated, which accounts to approximately 1000 g CO_2eq / kWh (Erdem, 2010).

As a developing country India recognizes it morale responsibility to reduce carbon emission and save the environment. Hence, GoI promoted Jawaharlal Nehru National Solar Mission (JNNSM, 2010) as one of its National Action Plans on Climate Change, with strong objectives to achieve 20,000 MW through grid connected and 2000 MW off grid solar energy installations by 2022.

India has current installed capacity which is little over 2 GW through grid connected solar PV power plants. Out of this 2 GW installed, maximum installation has come up in Gujarat and Rajasthan. Inspite of the fact that there is a Central Solar Policy and twelve other State specific solar policies, researcher attempts to find out what are various barriers and challenges hampering the improvements, promotion, and development of grid connected Solar PV power plants that survive under Indian conditions. Further why and how States of Gujarat and Rajasthan have been able to attract maximum developers in their region. This completes the discussion on first chapter, the next chapter debates on literature review on following lines discussed above.