

## Dissertation

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## A STRUCTURED FRAMEWORK TO ELECTRIFIED RURAL INDIA WITH SOLAR ENERGY

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By: Ravi Narshibhai Kakadiya

Dissertation submitted to the University of Central Lancashire in partial  
fulfilments of requirements for the degree of Masters in Project Management  
BN4609 Masters Dissertation

Grenfell- Baines School of Architecture, Construction and Environment

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Supervisor: Dr. Champika Lasanthi Liyanage

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# DECLARATION

This work is submitted to the University of Central Lancashire in partial fulfilment of the Degree of Masters in Project Management. I declare that the work presented here is my own work. The work cited from mass literature is duly referenced using Harvard Referencing System.

*Ravi Narshibhai Kakadiya*

*15<sup>th</sup> of Jan 2016*

## **ACKNOWLEDGEMENT**

First and foremost, I would like to thank God for supporting me and helping me to complete this dissertation. I would like to thank my parents for their love, support and care. Also, I would like to take this opportunity to thank my supervisor Dr. Champika Lasanthi Liyanage for assisting me from the beginnings of my dissertation to its final revisions. Without my supervisor's guidance and support my dissertation would be incomplete and would be impossible to end.

# **ABSTRACT**

Renewable energy is a very crucial topic nowadays. The world is being aware of, how non-renewable energy has ruined the environment and the effects of such damage to the environment have also seen in past few decades. People are being aware of renewable energy and world leaders are making efforts to slow down the energy production with non-renewable sources. Here, as the research is about India, the solar energy has discussed mostly because of the easy and efficient availability of solar energy in India. India is facing another problem with demand-supply gap in electricity consumption. The demand is at its peak but the production is not enough to meet the demand. In that case, solar electricity with decentralised electricity supply system, makes the scenario better for India.

Interviews and case studies have adopted for the research. In which, 10 samples have interviewed and 2 case studies have done for the research purpose. Due to limitation of available time, instead of face-to-face interviews, e-mails have used for correspondence.

In conclusion from the research adopted, it is possible for India to go with the solar electricity, however, the solar electricity supply system might be proved a bit costly because of its current non-competitive stage. The decentralisation has its own limitations, the government can apply decentralised model of electricity supply by empowering the village, but it should be done in a specific manner so that the earlier stage damage can be minimised or eliminated.

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## ABBREVIATIONS

BTU	British Thermal Units
DRES	Decentralised Renewable Energy System
GDP	Gross Domestic Products
JSSNM	The Jawaharlal Nehru National Solar Mission
IEA	International Energy Agency
MoP	Ministry of Power
Non-OECD	Non-Organisation for Economic Co-operation and Development
OECD	Organisation for Economic Co-operation and Development
PPM	Parts Per Millions
REC	Rural Electrification Corporation

# 1 BACKGROUND

## 1.1 Introduction

Electricity is the prime need in this modern age. The use of it has shown a noticeable increment after evolutionary inventions in science and technology. “From 1973 to 2003, the amount of fuel delivered through electricity generation grew by over 170 percent” (Bradford, 2006, p- 41), significantly faster than the growth in basic energy demand. Electricity is also an indispensable ingredient of economic development. As the industrialisation takes place, the demand of electricity has also boosted up day by day. A dynamic analysis of electricity production distinguishes the developing nations where the per capita increase in electricity consumption is growing at the fastest rate. Meanwhile, already developed regions show a lower change in their electricity demand. But, the overall concept is, the world needs more electricity (Worldwide electricity production from renewable energy sources, 2013).

Table 1-1 Growth of electricity usage in different regions

Region	Growth in per Capita usage
East and South-East Asia	6.6%
North Africa	4.7%
South Asia	4.5%
Middle-East Asia	3.8%

Western Europe	0.1%
North America	- 0.3%

(Source: Worldwide electricity production from renewable energy sources, 2013)

However, the negative side is the way of electricity production. In the past, due to lack of technology, the conventional method is the only method to produce energy. Yet, in the past many of the wise people have opposed it by saying everything is not good. E.F. Schumacher (1973) drained the mentality of, “the problems of production in the industrialised world had been solved.” Usage of conventional resources for electricity production as ruined the Earth’s environment. Even such resources (i.e. fossil fuel) are non-renewable, so they are very limited and might only be available for few more decades. According to Nelder (2009), “By the end of this century, nearly all of the economically recoverable fossil fuels will be gone. From now until then, what remains will be rationed by price. There will be shortages.” It is a very bitter reality that the next generations will have to face.

There is only one way to avoid this critical situation. People should follow renewable energy concept, which is easily available and pollution free. As noted by Dril & Tilburg (2014), “Many renewable energy technologies would become highly competitive if these externalities were factored into the production costs of fossil fuels, and the considerable subsidies for both their production and consumption were removed (globally totalling US\$500-700 billion per year according to the IEA, OECD, and World Bank estimates)”. It illustrates a negative side of non-renewable energy. But, for renewable energy it is a massive positive financial aspect, which has attracted the investors. As a result, “Investing in renewable energy is becoming increasingly viable as technology advances and cost decreases. The growth is increasingly driven by non-OECD countries, especially large emerging economies including Brazil, China, and India.” As noted by Dril and Tilburg (2014).

Table 1-2 Investment in renewable energy worldwide

Year	Investment in clean energy (in US \$)
2008	180 billion
2009	186 billion
2010	238 billion

(Source: Dril & Tilburg, 2011)

According to statistics (Prabhu, 2014), “India is the fourth-largest energy consumer in the world after China, United States and Russia in 2011, and its need for energy supply continues to climb up because of industrial revolution in the country.” “Primary energy consumption in India has more than doubled between 1990 and 2012, reaching an estimated 32 quadrillion British thermal units (Btu)”, according to World Bank data (2012). But as far as renewable energy is concerned, India has shown a very small growth in it. The following table shows calculation of solar potential In India and pie chart shows Renewable energy contribution in total energy production in India.

As the table 1.3 shows, India has 200 clear sunny days and at the rate of 15% of conversion efficiency, India can produce 1,972 billion units by using only 0.5% of the total land. Well, this is a pretty huge figure and can fill the demand-supply gap. Addition to it, India will contribute into a positive change regarding the way of electricity production. The pie chart in the figure 1.1 demonstrates the current scenario of electricity production in India. As it reflects almost 2/3 production has been done by using non-renewable sources like coal and petroleum. So, India should come out from a well and should try new production processes and other alternative ways too.

Table 1-3 Potential of solar energy in India

Total land area in India (sq. km)	3,287,590
No. of sunny days	200
Unit potential from 1 sq. m	4 kwh/day
Conversion efficiency	15%
1 sq. km (Mn. units per year)	120
0.5% land use per km.	16,438
Potential units in billions.	1,972

(Source: Prabhu, 2014)

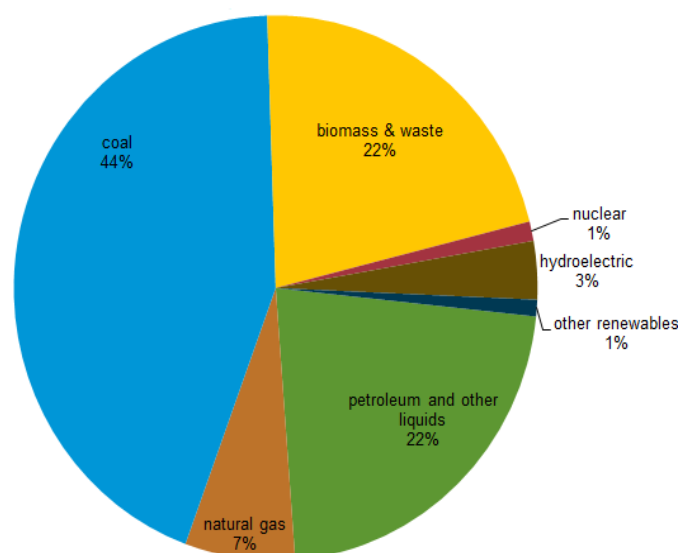


Figure 1-1 Pie chart of resources used for electricity manufacturing in India  
(Source: Prabhu, 2014)

India has understood the importance of electricity in terms of prosperity and is trying to identify strategies that could address the current issues they are facing. One of the strategies is the implementation of robust policies in the production of electricity through renewable energy. For example, although the Central Government of India has issued some comprehensive nationwide electricity policies in the years of 2005 and 2006, these have not been implemented well at local level and have not been revised for nearly a decade (Panagariya & Bhagwati, 2008).

Table 1-4 Policies of central government of India

Name of the policy	Year of declaration
National Electricity Policy	12 February, 2005
Tariff Policy	6 January, 2006
Rural Electrification Policy	23 August, 2006

(Source: Panagariya & Bhagwati, 2008)

To overcome from this situation, empowerment of the rural areas is an essential task for the government. By which they can reduce the cost of the electricity and more importantly people will use the eco-friendly and renewable energy. As the world is expecting a lot from Indian economy, these independents in the energy sector will help the rural people to expand their vision towards the success and ultimately it will help the country itself in the race of development.

## 1.2 Statement of problem

The world is passing through a very critical environmental problem. Still, the concept of using renewable energy is not widely accepted. In addition to it, People are suffering with the limited access to electricity in rural India. It affects their day-to-day activities as well as their occupational activities.

Here, the dissertation will discuss about the approach to solve both the problems and it will give suggestions and strategies to follow up as well.

### **1.3 Aim and Objectives**

The main aim of the project is to develop a structured framework to empower local government bodies in taking a lead role in the use of solar energy in the urban areas of India.

- To scrutinise the relations between electricity consumption and GDP (Economic growth) by using historic data.
- To distinguish the advantages and disadvantages of the use of renewable energy (especially solar energy), in general.
- To examine the essentiality of decentralisation and major issues in effective application of decentralisation.
- To analyse the roles of different levels of government in promoting the adoption of solar energy.
- To identify the policies and regulations available in promoting the appliance of solar energy.
- To develop a structured framework in empowering the local government to electrify remote area with solar electricity by decentralisation of electricity supply system.

### **1.4 Scope and Limitations**

The location for the research is chosen as Rajkot, India. Rajkot is one of the developing district of the Gujarat state. It includes around 90 small villages and most of the village people are occupied with the agricultural activities. However, due to limited sources like water and electricity, they could not utilise their farmlands very effectively.

Water is a natural resource and mankind does not have any control over it. Moreover, uncertainty of rain in the Saurashtra region (Gujarat) makes it more difficult to fulfil the



water demand of the people. But government can solve the problem of electricity. They should take some firm steps towards electrifying the villages.

As the district has more than 300 clear sunny days, there is a broad scope for solar electricity. Here, the dissertation will discuss about empowering the villages with the electricity as it will benefit the local people's business activities and moreover, villages are the very basic part of any country. Awareness of using renewable energy in the villages will inspire the people of the city to follow the same trend and ultimately, it will help to minimise many global environmental issues.

## **1.5 Methodology**

The location for the research is chosen as Rajkot, India. It is one of the major cities of Gujarat state. However, the research will only include a certain part of the city to avoid complexity. Qualitative methodology is chosen.

Reasons for choosing the qualitative method is, the research is about empowering local authorities. Central government's policies for state and municipality regarding energy supply will be verified. So, it will only include a small group of well-qualified people. Here, the research will work on two separate directions. Interviews of experts will help to list out gaps and case studies will suggest technical things.

### **1.5.1 Methods for qualitative analysis:**

- Interview
- Case study

#### *1.5.1.1 Interview*

The interview will be conducted for 8-10 people.

- Minister of the state.
- Key – persons of the Rajkot municipal corporation.
- Developer of the solar village in Bihar.
- Renewable energy experts.

They have the very sound background and sufficient knowledge within the research topic. The interviewed persons will have a very firm background in renewable energy

sector. The selection process of the possible candidates for interview will purely base on their experience and knowledge.

Online interviews are most preferable (I.e. Skype). But, as they are the key persons and possibly they have to follow a tight schedule. In this case, emails will be used for further correspondence. As they have a very rich knowledge of government policies. After gathering all the data, it will be easy to list out gaps in the current policy.

#### *1.5.1.2 Case study*

- No. of case studies – 02
- Locations:
  1. Dharnai, India (Solar village)
  2. Masdar, Abu Dhabi (Zero Carbon city- under development)
- Both of them have adopted solar energy for electricity production.
- The data is available online and Dharnai's developer, Mr Manish Ram is one of the possible interviewees.
- The available data will be used to design the electricity generation as well as supply system.
- All the significant technical details regarding solar energy can be achieved from the case studies
- The study will provide rich technical data, which will carry the research to fulfil its main aim.

## **1.6 Structure of the dissertation**

The dissertation is divided into 5 chapters and the contents of the chapters are as follows:

Chapter 1 is an introduction to the dissertation aim and objectives. Chapter 1 also highlights the need for the study.

Chapter 2 is a detailed literature review on the subject of decentralised solar electricity system for remote areas. The main issues in solar electricity production, maintenance

and the problems with decentralisation are discussed in-depth at the end of the chapter.

Chapter 3 discusses the methodology adopted for the study in-detail. The justification of the methodology is also given in the chapter.

Chapter 4 explains the main findings of the open ended email-surveys obtained through the qualitative content analysis. The findings are given according to the main objectives of the research. Here, two case studies have also been obtained to analyse the solar electricity.

Chapter 5, finally, summarises the dissertation and provides the final conclusions, limitations and recommendations. The recommendations are provided for both the industry and for the academia.

## **2 LITERATURE REVIEW**

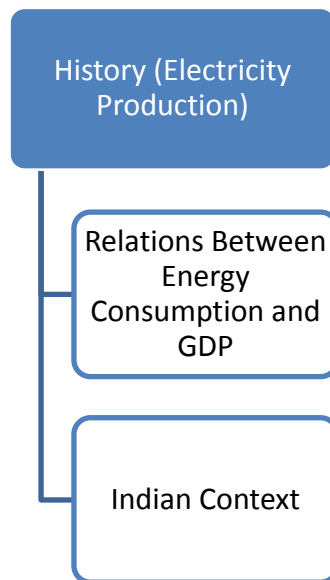
### **2.1 Introduction**

Chapter 2 is an on-depth literature review of the topic Solar Energy – A Green Way of Electricity Production. The chapter is mainly into four sections. The first section discusses the history of electricity production, in general, as well as it will also find out the relations between the electricity consumption and economic growth. Addition to this, it will describe the current situation of the Indian electricity system and the growth in it. The second part of the chapter highlights the significance of renewable energy and it will also include the possible environmental effects of this continuously growing demand of electricity. In the second section, solar electricity will be discussed in terms of its efficiency, advantages and drawbacks as well. The third part will analyse the importance of empowerment of local government with electricity and its range of positive effects on the local people's life. Then in the final part, an example of Sundarbans will be discussed and how different organisations have make it happen

Here, the explanations provided are thorough and technical where necessary, but overly technical language is avoided to eliminate complexity of the literature as the main aim of the literature is to explore the electricity sector in general.

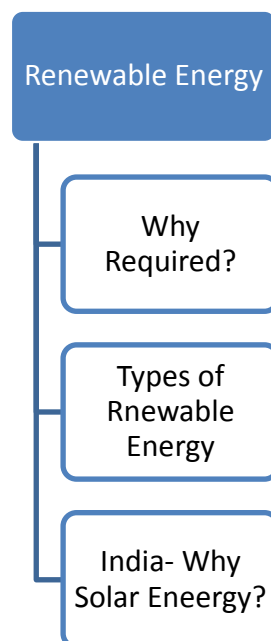
This chapter will explain 3 major things of the research. History of electricity production, Renewable energy and Empowerment of local government (Decentralisation).

History of electricity production discusses the various modes of electricity production and briefly explained the changes have taken place over time. However, the main highlight of the first part is to explain the relations between energy consumption and GDP as the research is in the context of India, it helps to examine the growth in India's energy demand. In the end, the statistics have provided to scrutinise Indian energy market.



*Figure 2-1 History of electricity production*

The second part discusses, the need of renewable energy. The reasons behind adopting renewable energy are explained in it. Within renewable energy, they types have listed out in a brief. As the renewable energy highly depends upon the geographic location and local climate conditions. The reasons have annotated behind the importance of solar energy in India. Here, both sides have scrutinised equally, advantages and disadvantages.



*Figure 2-2 Renewable energy*

The final part of the literature review discusses the core part of the research. Empowerment of local government has explained and how it can be adopted by decentralisation and privatisation. Few examples of the first world have also been provided to clarify the significance of such empowerment. After that, why is it required specially in India has discussed and at the end, the current stage of decentralisation in the renewable electricity sector has analysed and been discussed by providing an example of Sundarban.



*Figure 2-3 Empowerment of local government*

## **2.2 History of electricity production and current scenario**

The root of modern electricity production industries are based on the early and middle years of the 19<sup>th</sup> century and is gifted by the great inventions of Andre Ampere,

Michael Faraday, Benjamin Franklin and Alessandro Volta. Breeze (2014) has noted that, "Their inventions have made it possible to generate electricity with moving machinery rather than using it from chemical batteries." It was very creative idea of producing electricity from the moving body.

Hester and Harrison (1999) have reported that, gas remained a powerful lighting competitor for several decades and electric lighting schemes remained very small. Breeze (2014) supports this argument, the development of steam engine has encouraged widespread use of gas for fuel and lighting. However, this trend has ended when trams and railways were electrified and by the first decade of 20<sup>th</sup> century, electricity has begun to be an important source of motive power for industry.

This increased importance of electricity in different sectors had given birth to a new industry and that is Electricity Production Business. However, still the production was very limited in terms of quality and quantity. MacKerron (1999) has described that, most of the electricity units were depended on small, on-site forms of production and mostly by using reciprocating engines. Here ultimate sources of the production were coal and natural gas, which were used in steam engines. Royal Society of Chemistry (1999) has evaluated the history of the electricity and power generation and it has commented that, Second World War has started a revolution in electricity production methods and its quantity as well. However, the most remarkable change was in its supply system. After the Second World War, grid supply system has become the popular among the people due to its easiness. In support of this statement, Schewe (2007) has noted that, the electric grid has become irreplaceable and vital to many aspects of public and private life. This has directly affected the power generation, Cameron (1993) has pointed out that, world power production had increased fourfold between 1900 to 1950, and has more than quadrupled since then.

After the Second World War, nuclear energy became the vital source of energy for world as well. In 1950s the age of nuclear power was born. Breeze (2014) has mentioned that, once the principles were established, as safety was the major issue with this energy, construction of nuclear power stations accelerated.

Moreover, pointing out the relations between the electricity demand and the nation's GDP with the on-going discussion. Table-2.1 shows region's electricity production percentages during 1950 to 1989. Here several features of the table are worth noting. Very first thing is the preponderance of North America and Europe in 1950 and the 1980s in all types of electricity, in contrast to the small share of Africa and South America (Note: Oceania also contributes very less, but it has a far smaller population compare to other two regions). Secondly, dramatic decrease in the relative share of the North America and Europe during 1950 to 1989. However, this decline in the production does not show the negative figures in the demand. There are several alternative ways that has been used by the different regions. As noted by Cameron (1993), many European countries were diverted to the nuclear energy. For instance, France has produced 60 percent of its electricity from nuclear power. However, the most eye catching figures were Asia's.

Table 2-1 Production of Electricity, 1950 to 1989 (Percentage of World Total)

		<i>Total</i>	<i>Thermal</i>	<i>Hydro</i>	<i>Nuclear &amp; Other</i>
World	1950	100	64.2	35.6	0.1
	1989	100	64.8	18.3	16.8
Africa	1950	1.5	1.4	0.1	—
	1989	2.7	2.3	0.4	<sup>a</sup>
North America	1950	47.3	30.9	16.3	—
	1989	32.0	21.1	5.2	5.5
South America	1950	1.8	0.8	1.0	—
	1989	3.8	0.8	2.9	<sup>a</sup>
Asia	1950	6.5	1.9	4.5	—
	1989	20.8	14.9	3.5	2.4
Europe	1950	31.6	19.7	11.6	0.1
	1989	24.1	13.1	4.1	6.9
Oceania	1950	1.2	0.8	0.4	<sup>a</sup>
	1989	1.6	1.2	0.3	—
USSR	1950	9.5	8.2	1.2	—
	1989	15.1	11.3	1.9	1.9

Source: Cameron (1993)

Here the noticeable thing is, this demand proportions now actually represent the region's development index. For instance, after the World War II, European countries have decided to cooperate towards development and that's one of the reasons behind



higher share in world electricity production. Jumbe (2004) has characterised this relations by adding that, “countries with high per capita GDP have shown to have high per capita energy consumption.” Furthermore, Chen, Kuo and Chen (2007) have listed out the similar study, “a permanent increase in economic growth may result in a permanent increase in electricity consumption.”

Moving forward to the electricity production data during last couple of decades. Figure 2.1 demonstrates the global development of electricity production from 1985 to 2005. North America and European nations were the largest electricity producer since the mid-1980s. But the figure 2.1 describes the real scenario of relations between power generation and development. East Asia and Pacific region, led by China, became the second-largest producer in 2000 and they also had higher annual growth rates than other regions.

Between 1974 and 2004, East Asia and Pacific region have showed 6 percent annual GDP growth. Furthermore, it has followed by South Asia with 4.7 percent growth. Here one thing should be mentioned that, there was a little difference between East Asia and Latin American regions during 1980s. “But debt crisis during 1980 in Latin America and the Caribbean led to what is now known as “Lost Decade”. Meanwhile, growth in East Asia and Pacific has continued at a high and sustained rate” as noted by Yépez-Garcia, Johnson and Andrés (2011).

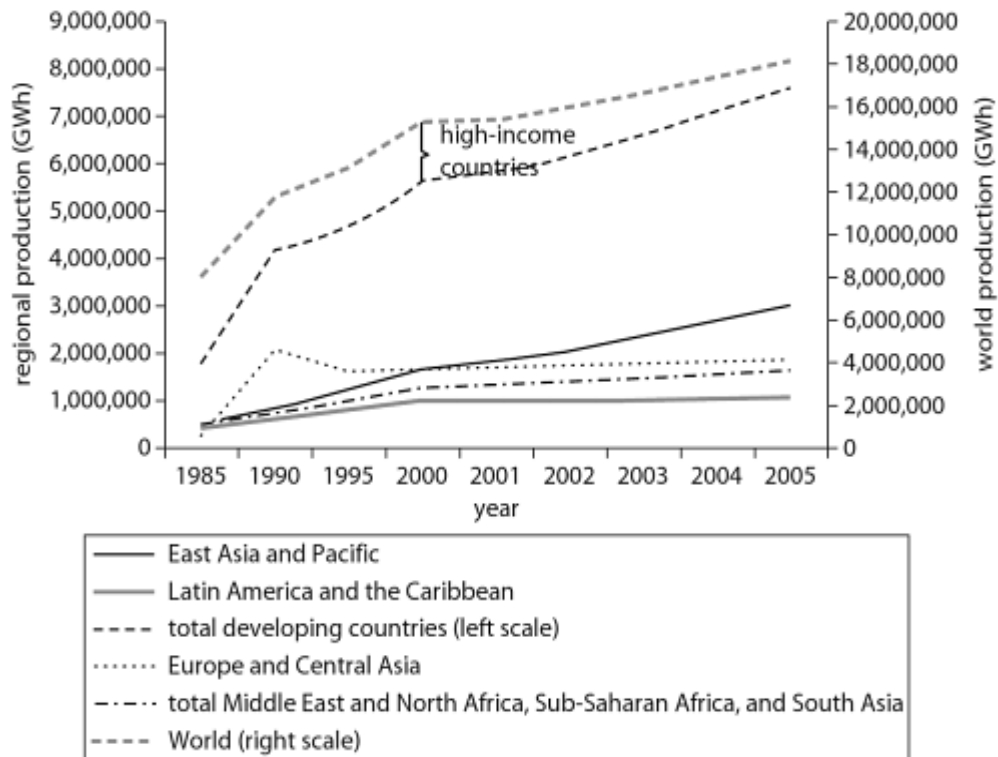


Figure 2-4 Electricity Production  
Source: (Yépez-García, Johnson and Andrés, 2011)

Nevertheless, the major difference is between the electricity demand of the world and developing countries. As the figure 2.1 describes this difference has minimised as the developing nations have made progress towards the prosperity.

Finally, for the current scenario of electricity sector, table 2.2 illustrates the current situation regarding the energy consumption. Additionally, it also has given future projections of demand and consumption. “In 2010, electricity accounted for 51 percent of total energy consumption and its share will grow to 64 percent by 2040. OECD electricity use grows from 10.4 quadrillion Btu in 2010 to 15.7 quadrillion Btu in 2040, while Non-OECD electricity use grows from 4.3 quadrillion Btu in 2010 to 15.4 quadrillion Btu in 2040” (Energy Information Administration, 2013).

Table 2-2 Energy consumption by regions, 2010-2040 (quadrillion Btu)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
<b>OECD</b>	<b>20.2</b>	<b>20.9</b>	<b>22.0</b>	<b>23.2</b>	<b>24.4</b>	<b>25.5</b>	<b>26.5</b>	<b>0.9</b>
Americas	9.8	10.1	10.5	10.9	11.5	12.0	12.6	0.8
Europe	6.5	6.9	7.4	7.8	8.3	8.6	9.0	1.1
Asia	3.9	3.9	4.2	4.4	4.6	4.8	5.0	0.8
<b>Non-OECD</b>	<b>8.8</b>	<b>9.9</b>	<b>11.7</b>	<b>13.9</b>	<b>16.5</b>	<b>19.4</b>	<b>22.5</b>	<b>3.2</b>
Europe and Eurasia	2.2	2.3	2.5	2.8	3.1	3.5	3.8	1.8
Asia	4.2	4.9	6.0	7.4	9.1	11.0	13.1	3.9
Middle East	1.0	1.1	1.3	1.5	1.7	1.9	2.0	2.4
Africa	0.4	0.5	0.6	0.7	0.8	1.0	1.2	3.5
Central and South America	1.0	1.1	1.3	1.5	1.8	2.0	2.4	3.1
<b>World</b>	<b>28.9</b>	<b>30.8</b>	<b>33.6</b>	<b>37.1</b>	<b>40.9</b>	<b>44.8</b>	<b>49.0</b>	<b>1.8</b>

Source: (Energy Information Administration, 2013)

Then again, the eye catching thing is the massive growth in Non-OECD nation's energy consumption percentage. Non-OECD nations show much higher 3.1 percent annual growth compare to OECD nations of 0.9 percent. Ultimately, it reflects the level of development in the Non-OECD regions.

Yoo (2006) has given example of the study of Ferguson et al. (2000) about the issue in over 100 countries, and it has carried out that “as a whole there is a strong correlation between electricity consumption and economic growth.” Yang (2000) has explained this thing in a different way, he has noted that, increasing economic growth requires enormous consumption of energy. In short, it can be said that, electricity consumption is one of the most significant factor that plays a key role in economic development.

When it comes in context of Indian economy, it has also followed the same trend in terms of electricity consumption. However, it should also be analysed that, this sort of consumption is covering all the possible sectors of a country. Likewise, commercial, industrial and residential as well. India has shown a very potential growth in production of electricity during past few decades. Nevertheless, the turning point of Indian economy was 1991, when Prime Minister Mr. Narsinh Rao has ended up licence trend and gave a free path to expand the businesses. It was welcomed by all the business sectors and they had utilised it in a very decent manner.

Table 2-3 Plan wise growth in the electricity sector

Sl. No.	As on / during financial year ending with	Installed Capacity (MW)	No. of villages electrified	Length of T & D Lines (Ckt. kms.)(#)	Per Capita Consumption (\$) (kWh)
1	31.12.1947	1362	N.A.	23238	16.3
2	31.12.1950	1713	3061	29271	18.2
3	31.03.1956( End of the 1st Plan)	2886	7294	85427	30.9
4	31.03.1961( End of the 2nd Plan)	4653	21754	157887	45.9
5	31.03.1966 ( End of the 3rd Plan)	9027	45148	541704	73.9
6	31.03.1969( End of the 3 Annual Plans)	12957	73739	886301	97.9
7	31.03.1974( End of the 4th Plan)	16664	156729	1546097	126.2
8	31.03.1979( End of the 5th Plan)	26680	232770	2145919	171.6
9	31.03.1980( End of the 2 Annual Plans)	28448	249799	2351609	172.4
10	31.03.1985( End of the 6th Plan)	42585	370332	3211956	228.7
11	31.03.1990( End of the 7th Plan)	63636	470838	4407501	329.2
12	31.03.1992( End of the 2 Annual Plans)	69065	487170	4574200	347.5
13	31.03.1997( End of the 8th Plan)	85795	498836	5141413	464.6
14	31.03.2002( End of the 9th Plan)	105046	512153	6030148	559.2
15	31.03.2007 (End of 10th Plan )	132329	482864	6939894	671.9
16	31.03.2012 (End of 11th Plan )	199877	556633*^	8726092	883.6
17	31.03.2013(End of 1st year of 12th Plan )	223344	593732*^	8970112*	917.2*

Source: (Electricity Authority Ministry of India, 2015)

Table 2.3 shows plan wise growth in the electricity generation. The most significant change has taken place after the end of 7<sup>th</sup> plan of government. To simplify the table and to understand the deep meaning of late industrial revolution's effect in India on electricity production business, let's divide the table into two parts.

1. Before the economic liberation (1947-1990, 43 years)
2. After the economic liberation (1991-2013, 22 years)

Table 2-4 Electricity sector's difference between two time periods of Indian economic history

Sector	1947-1990	1991-2013
Installed Capacity	62,274	159,708
No. of villages electrified	467,777	122,894
Lengths of T & D Lines	4,384,263	4,562,611
Per capita consumption	312.9	588

Table 2.4 clearly indicates the effect of economic liberation on electricity consumption in India. The major changes can be seen in two departments, first is installed capacity, which has been grown by almost 300 percent and second is in per capita consumption,

which has been almost doubled within 22 years. However, it also demonstrates two negative sides of this industrial revolution, number of electrified villages and lengths of T & D lines have not shown the expected growth.

This part has scrutinised the relations between a nation's GDP and its electricity consumption rate in regards with the available historic data. Now next part will analyse the renewable energy market and reasons behind the change in seeing the world moving from non-renewable energy to renewable energy. The next part will also evaluate solar energy in depth with all the possible directions of analysis.

## **2.3 Significance of renewable energy**

When someone is developing a new energy policy or selecting different power generating equipment, even with the renewable resources, it is essential to have an effective means for contrasting the available technological options. Assessing the environmental impact of diverse combustion technologies can be complex, with a broad range of ecological concerns influencing each type of technology to a greater or lesser extent. As a result of this, it has become increasingly incumbent upon the power generating sector to incorporate impacts upon the environmental alongside balancing financial issues and benefits in various stages of strategic decision-making.

In short, the energy sector is passing through a massive change and it has not come up within few years, it has taken a long time to realise the world about the long term effects of current energy production processes. Few other factors have also played a key role in forcing the world towards the renewable energy options.

“Over the past 150 years, the content of Carbon Dioxide gas has risen from 280 parts per million (ppm) to approximately 380 ppm in the environment. Compared to the early 1990s, in the early 2000s the construction of natural gas plants doubled due to demand resulting in the higher fuel prices, though decrease in the emissions was minimal” as evaluated by Department of Energy (2003). This has created a very critical circumstances for the trend of producing energy by using non-renewable energy sources. As a result, there were few bold voices have risen against this harmful processes and it has also explained the long term effects of that trend, eventually, it

has shown mirror to the world about where the world is going with this spineless methods of energy production.

Abbasi and Abbasi (2004) has described two major issues regarding the energy production and has taken into account in their views, during the 1970s, two noteworthy socio-scientific movements surged across the world. The first one had thrust on environmental protection and the other one on renewable energy sources. Both movements had their base in fossil fuels. It was the uncontrolled combustion of fossil fuels by the world, especially the first world, which had raised the spectre of global annihilation by natural contamination. It was fossil fuel which had directly and indirectly contributed to the overconsumption processes of all the natural resources, generating various pollution effects. As said earlier in section 1, in 2009, fossil fuel accounted for 80 percent of electricity production in the world.

In addition to it, prices of fossil fuel are all time high and showing a new peak every month. There are many global factors which have affected this price scenario also, for instance, in 2011, political instability in Libya has hiked the prices to \$108 a barrel for the first time since 2008. Here, the bottom line is, higher cost of fossil fuel directly affects the prices of electricity too (Harvey, 2011).

All these turning events leads the world to think about renewable energy sources. However, renewable energy also requires a very high capital cost, so it cannot be called as economical energy source. But as soon as this higher capital cost covers up production as well as some of the maintenance costs, it can be made economical with few strategic, technical and political efforts. However, strategic and political aspects depend upon the location and economy of the country, it varies nation by nation which will be discussed deeply in the third section, but as far as technology concerns, the path for advancement in technology is going through some development stages.

Moving forward with the ongoing discussion about technicality of renewable energy, the development of such technologies contains certain stages in terms of making it user friendly as well as easily accessible. The earliest stage is known as Conceptualisation. In this stage, the idea for the technology is conceived. In the second stage of proof of concept, the idea is taken beyond the conceptualisation stage.

Moreover, it is converted the actual model on the smaller scale. The third stage includes tweaking the design until it has reached optimum performance. The last and final stage is marketing. As the product or methodology is now ready to use, market penetration plays an important role in making the product widely used and accepted. Here, in the case of renewable energy continuous government support is essential to make it more economical than the fossil fuel. Governments can provide subsidies on it (Smith and Taylor, 2008).

In the renewable energy sources, there are many options available nowadays. Such as Solar Energy, Wind Energy, Tidal Energy, Bio-mass Energy and so on. Such things mainly depend upon the geological factors. For instance, solar energy is worthy of developing in the hot places, where the temperature is high enough to generate the energy continuously. Whereas, wind energy is suitable for coastal areas where wind blows at certain speed, so that energy can be produced easily and such typical things required for the other renewable energies as well. As the literature is mainly based on a specific energy and its benefits and drawbacks and more importantly it is about India, solar energy will be discussed in depth over other renewable resources.

As far as energy or specifically electricity concerns, Lynn (2010) has commented in regards with the explaining the importance of solar energy, “we are entering into a new solar age. For the last few hundred years, humans have been using up fossil fuels that took around 400 million years to form and store underground.” The world has to act– technically and politically – into energy systems that use the solar energy more directly and such acts will directly affect the Earth’s environment also. Energy Informative (2012) states that, “one year’s worth of solar energy (including radiant light as well as heat from the sun) reaching the surface of the Earth would be twice the amount of all non-renewable resources, including fossil fuels and nuclear uranium. The solar energy that hits the earth every second is equivalent to 4 trillion 100-watt light bulbs.” All these numbers from various sources clearly indicate the massiveness of the available energy from the Sun. “The solar energy that hits one square mile in a year is equivalent to 4 million barrels of oil. Thus, the potential of solar energy is immense” as analysed by Maehlum (2014).

According to the leading English newspaper The Guardian (2003), BP's chief executive has commented that, "solar power will be key source for energy by 2050". Which directly shows the influence of solar energy on the world. There are many reasons behind it and Marculescu (2014) has listed out them by covering all the possible criteria:

- Except manufacturing and transportation, all the other processes for solar electricity production are pollution free.
- Even, some renewable fuels (e.g. wind turbines) can be noisy, but solar energy produces electricity very quietly.
- The distance really doesn't affect it. It is able to harness electricity in remote areas. As in space, where satellites are powered by high efficiency solar cells.
- High voltage wires and transmission lines cost much higher in remote areas than the solar panels.
- The power generation at the site itself will also solve the problem of voltage loss during supply.
- The required space is also lesser and it can be also installed on the roof, which eliminates the problem of finding the required space for solar panel placement.
- The main factor is its financial side. However, initial cost is high but it can be covered within few years.
- From the national side, the use of solar energy to produce electricity allows the users to become less dependent on the world's fossil fuel supplies.

Though having all these positive aspects, solar energy also contains few negative sides, which are the major obstacles towards its spread as a main source of energy. Current power grid system and inefficiency are the major obstacles for solar power. Williams (2014) describes the problems for solar energy with the power grid system and compares it with fossil fuel, "Today's power grid isn't able to store energy. As it's generated it flows through transmission wires to local utilities that deliver the power to homes and businesses in the neighbourhood. Fossil fuels are perfect for this power model." In fossil fuel plants, the energy production can easily be maintained.

New innovative technologies and all time growing science has improved the efficiency of solar energy but still scientists are very far from its peak potential. Byrnes (2013) has



described it by Carnot's theorem about the numeric efficiency of the solar energy, "a solar system that tracks and adjusts with the sun's movement would have a maximum efficiency of 85 percent, while a stationary system would have a maximum efficiency of 55 percent." It clearly indicates the poor efficiency is still a major issue to be solved.

### **2.3.1 Current Scenario in India**

Now, in the case of India regarding government policies. The government is providing enormous speed to the solar projects. According to PV Magazine (2014), "Minister delights Indian expo with 100 GW eight-year aim." The minister in August said "Renewable power is the future of the country and will be supported fully" as he announced the government was freeing up land for utility-scale projects, as part of Prime Minister Narendra Modi's ambitious electricity for all vision (The Australian, 2014). This is a real fact that Indian government has taken very effective steps towards solar energy. Though, it is only limited to mega cities. According to leading Indian newspaper The Times of India (2014), "just over half of rural India uses electricity as its main source of lighting. The report shows that 43% of rural households still use kerosene to light their houses. In urban India, the spread of electricity is more appreciable, with 93% of households using electricity as their primary source of light." These figures are clearly showing that, there is a gap in the policy of central government for remote areas.

This chapter has analysed the solar energy sector, its importance and benefits with few drawbacks as well. At the end, it has also risen the questions over rural development, as the rural development pilots the state and ultimately all these efforts contribute in the development of a nation, the prosperity of rural people cannot be neglected. This leads to the next section of the literature review. In which, significance and contribution of local government bodies in the development of the nation will be clarified.

## **2.4 Significance of empowering local government with electricity**

This is the core part of this literature. Recognising the importance of participation as a development objective this section attempts to trace the roots of the development process which will pass through the rural development. Villages are the small pillars of any nation, building cannot stand strong for long without constructing the strong and firm pillars. Same for the nation, it cannot maintain the growth rate if the villages are not well developed. To explain the importance of empowering the local government with electricity, this section has further classified in to two parts. The first part is about importance of electricity in rural life and role of the electricity in making life better. The second part is about government policies for villages, which will analyse the significance of empowering local government bodies to provide the facilities to the last person of the remote area.

### **2.4.1 Electrifying the villages**

Local government always has a key role to play in the fight against poverty and unemployment. Decentralisation from nation to state and state to local levels of responsibility, and privatisation from government to market forms of administration provision, are governance trends which emphasise competition and development over redistribution. For local governments in rural areas, these trends represent an important shift in policy (Warner and Hefetz, 2003). In support of this argument Warner (2006) has argued that it will provide competitiveness in the rural market, privatisation and decentralisation are both trends that promote competition as a source of governmental efficiency. Bennet (1990) has talked about local voices and empowerment of rural by decentralising and privatisation, “shifting from state to market via the privatisation of local government service delivery, and shifting from national to local levels of provision via decentralisation, are designed to increase local voice and local control over service delivery.”

Here, all the notes about rural development includes privatisation and decentralisation. Which clearly indicates that, for the betterment of rural people, central government has to provide resources to the rural people which mainly includes

empowerment of rural government bodies. But here the thing is what sort of other resources can change the rural lives, only empowering on administration level cannot change the current situation, even India does have “Panchayat Raj” in the country and local bodies have all the legal power. But, power without enough resources cannot help them to make their life better.

So, moving forward in ongoing discussion, financial aspect is the most important factor that can affect anyone’s life. It is essential to make the rural people financially stable for their betterment and it can be done by providing basic facilities regarding their occupation. No doubt, urbanisation is taking place in every corner of the world and developing nations cannot avoid this fact, though 80% of world’s 300-400 million households live in rural areas of developing nations (Singh, 1997). Now moving towards the poverty rate in rural area and their relevant occupations, according to World Bank data (2015), “for the 70 percent of the world's poor who live in rural areas, agriculture is the main source of income and employment.” No doubt there are more than one factors are responsible behind it, for instance, depletion and degradation of land, insufficient irrigation facilities and electricity and so on. Here, government might not be able to change the geographical structure of the land or soil (long term process) as well as well government is not responsible for lack of rain in the region. But yes, at least the government should electrify the villages so that the remote people can have enough opportunities if fortune favours them.

Electricity can help them to increase their living standard and it will bring many development opportunities as well. Electricity is an essential thing and it has a great impact on the socioeconomic life of rural people. Barnes (1998) has very precisely researched on electrifying villages that, rural electrification projects affect regions, communities and household. The expansion of empirical knowledge concerning the impact of rural electrification project can be responsible for macro level change and it is the most significant impact.

Moving towards the importance of electricity in rural life. Lenin has given a very famous and fruitful equation, “Soviets (cooperative villages) + Electricity = Socialism.” It clearly underscored the importance of electricity and the Russian government has launched a massive electrification program in 1920. As a result, 90% of villages were

electrified within next 2 decades (Coopersmith, 1992). Similarly, during 1935 to 1955, about 5 million rural farms were electrified under the Rural Electrification Act, 1936 in the United States. Meanwhile, Western Europe also has applied the same strategies for their villages.

Everyone can see the impressive results of such very visionary and advanced steps. These are the most developed part of the world now. It clearly indicates that, if any nation wants to be developed, it should start with developing their villages first and, providing enough electricity to the rural areas is like introducing the villages with plenty of opportunities in all the possible directions.

In context of Indian power supply systems, India has launched many rural electrification projects and few of them have successfully applied as well. But the reality is, even after allocating too many financial efforts the results are not as expected and still many of the Indian villages do not have access to electricity. Here is the list of some major electrification programmes launched by the Government of India in past few years.

Table 2.7: Various Indian government's schemes for rural electrification

Kutir Jyoti:	Government of India launched in 1988–1989 a single point connection programme for the poor living below poverty line (called Kutir Jyoti, KJ for short, or Bright Home programme). The central government bears the entire cost of service connection and internal wiring and is provided to the states as a grant. The funds are diverted through the REC and the state governments/utilities are in charge of the execution of the project. As per Rural Electrification Corporation, more than 5.8 million family units in the country ranges have profited from this plan at an expense of 4.5 billion rupees.
REC programmes	Two major push areas of REC are irrigation pump electrification and village electrification. REC acts as the nodal agency for the centrally financed projects and claims to have encouraged electrification of 62% of the Indian villages and 59% of electrified irrigation pump sets.
Prime Minister's Village Development Programme (Pradhan Mantri Gramodaya Yojana):	This programme was brought in 2000–2001 with an objective of accomplishing sustainable human development at the village level. This project concentrated on providing fundamental services and in 2001–2002 rural electrification was incorporated to cater to rural electricity supply through rural electrification. The plan offered to finance through loans (90%) and grants (10%). The states have the adaptability to deciding the distribution among six essential and fundamental services. This programme is composed and observed by the Rural Development Division of the Planning Commission.
Minimum Needs Programme	This programme provides 100% loans from the federal government for last mile integration for rural electrification projects in less electrified states.

Accelerated Rural Electrification Programme:	<p>This scheme is intended for electrification of non-electrified villages. States can borrow funds from various financial institutions and receive interest subsidies for undertaking rural electrification. The federal government repays the interest subsidy sponsored by the different financial foundations. States can likewise utilise funds available from other standard governmental sources (such as Rural Infrastructure Development Fund, Local Area Development funds of Members of Parliament, etc.)</p>
The Jawaharlal Nehru National Solar Mission (JNNSM)	<p>The Jawaharlal Nehru National Solar Mission was propelled on 23 November 2009 in an announcement to Parliament by the Union Minister for New and Renewable Energies. This mission is a piece of the 2008 Indian National Activity Plan on Climate Change (NAPCC) which looks to diminish India's future dependence on non-renewable vitality sources. The National Solar Mission is a noteworthy activity of the Government of India and State Governments to advance naturally reasonable development while tending to India's vitality security challenge. It will likewise constitute a significant commitment by India to the worldwide push to meet the difficulties of environmental change. Before the end of the thirteenth Five-Year Plan, in 2022, the JNNSM ought to have prompted an introduced limit of 20000 MW and the sending of 20 million sunlight based lighting frameworks in country territories</p>

Source: (Ministry of Power, 2015; Sahu, Shandilya and Bhardwaj, 2014)

These are the very effective schemes and Sivanagaraju has described the effects of these schemes as well as also evaluate the situation and given newly raised problems with them, 86% of the villages are electrified and 13 states have declared 100% electrification of selected villages. However, despite from this impressive growth, the new problem is maintenance of power transmission lines and distribution networks. Because of the largeness of the country, it is hard to inspect supplying chains in person. Moreover, it is a time consuming and cost effective process and developing country like India, definitely cannot afford such things.

In economic terms, as described by Urban, Benders and Moll (2015), "India has a steeply increasing GDP growth and an expanding economy. At the same time, India hosts a large population living below poverty line, namely 35% of its total population in 2003. High variances between urban and rural areas prevail." One thing should be noted very precisely that even after urbanisation has taken place in every corner of the world including India, out of the country's total population 1.25 billion, around 920 million (i.e. 73.2 percent of total population) still live in villages. Therefore Gandhi said long ago, "India lives in villages and villages constitutes the very heart of India." The Indian economy is highly dependent on services and industries but non-mechanised agricultural activity is the major occupation of the country as 65-70 percent of country's population dependent on it for their livelihood and its produce cater to the basic necessities of life of the people. Bender and Moll (2015) have further described statistics "Energy poverty is clearly an issue: electrification rates were as low as 50% in rural areas and 62% in total India in 2005. Electricity consumption in the rural areas is estimated as ranging between 0.3 kW h and 1 kW h per household per day." The rural India still uses traditional biofuels for routine works and such fuels also have negative impacts on the health. In spite of overall economic growth of the country as a whole, there is no significant change in the living conditions of the rural population, on the other hand the disparities between the urban and rural population have increased tremendously and to bridge these economical differences between urban and rural people, the government should provide some extra efforts for rural people (Urban, Benders and Moll, 2015).

Here, one thing can be said very clearly that rural poverty is a global problem. Not only in India, but many of the world's developed countries had faced this problem in past.

In short, by electrifying the villages, the government is extending the rural people's limits to a new level and it will definitely lead them to a prosperous and well-set life with high-quality socio –economic stability.

## **2.5 Empowerment of Local Government Bodies (Decentralisation)**

As discussed earlier in “Electrifying the Villages”, decentralisation and privatisation are essential things to empower Local bodies. Faguet (1997) has come up with his and several other researcher's studies and has derived that it has made competitive success and competitive failure with few nations and both the effects have noticed in numerous. Yet, the pros and cons behind this are not completely understood. It has always noted that, the decentralisation model and it's working pattern always remain mystery, it is next to impossible to derive the reasons behind it, whether is it the poor design or is it complex structure, responsible for it. Following are the positive and negative effects from the studies of Faguet (1997) and several others (notably Veira 1967, Rondinelli et. al. 1981, Cheema and Rondinelli 1983 and Bennet 1993):



Table 2.8: Positive and negative results of decentralisation

	Positive Results	Negative Results
1.	Decentralisation has expanded the access of people in previously neglected rural regions and local communities to central government resources and its policies, if only incrementally, in the vast majority of the LDCs where it has been attempted.	Decentralisation and privatisation of state exercises tend to make more prominent disparities among groups and areas with diverse levels of organisational capacity.
2.	Decentralisation appears to be in some places to have enhanced participation and augmented the capacity of local administration to put pressure on central government agencies, subsequently making available to them large quantities of national resources for local development.	The absence of or weakness in supporting institutions (public or private) expected to supplement the administrative limit of local governments, as well as weaknesses in the linkages and interaction between local and central administrations, have prompted to disappointing results from decentralisation in Africa and Asia.
3.	The administrative and technical capacity of local organisations is said to be gradually improving, and new organisations have been built up at the local level to plan and oversee development.	Programs are normally advocated on grounds of efficiency and administrative adequacy, but then judged on their political results. Where political aims are significant, considerable deviation from best practice is endured. Not surprisingly then, decentralisation seldom lives up to expectations.
4.	National development strategy now progressively takes account of regional and local level planning.	This opens the door for local elites to play a disproportionate role in the planning and management of projects.

Source: Faguet (1997)

“Decentralisation is seen by both international development agencies (IDAs) and governments of developing nations as a means of achieving increased participation and good governance. The Organisation for Economic Co-operation and Development’s Development Assistance Committee (DAC) Expert Group on Aid Evaluation describes it as a means of promoting participatory development and good governance” (Bryld, 2001). Now, all these thoughts are about decentralisation and it really means that, rural areas are the core of the nation and the people of rural areas are needed to encourage to contribute their contribution in the process of developing the nation. Which confirms that without the decentralisation of administration, it is next to impossible, or it takes very long to provide opportunities to the last person of the village, for any country to bridge the gap between urban and rural people’s income and their living standard.

Since independence in 1947, the government has tried to encourage local participation in the process of development through decentralisation, the government usually focus on the re-structuring the very traditional Panchayats. As noted by Rath, Jena and Sahoo (1993), “Panchayat implies assembly of five and is the name of the customary self-governing village councils, which wielded legal and police powers in the local village in pre-colonial times. Here, the structure has three tiers: Grama Panchayat (one for every five to ten villages), Taluka Panchayat (sub-regional level, five to 15 Grama Panchayats) and Zilla Panchayat (district level).” However, there is also one additional tier named Grama Sabha or Village Meeting. The arrangement of such meetings depend upon the local circumstances. But generally it happens twice a year in which villagers can give suggestions to the committee and can debate with the Panchayat and its members. One can show satisfaction or dissatisfaction towards the work carried out by the Panchayta in past few months. In short, it is an evaluation of work progress (Rath, Jena and Sahoo, 1993; Desai, 1994).

The discussion mentioned above, clearly states that, India does have a unique and well set governance body with all the administrative support from the higher level government authorities, but it still does not work for development of local people. They are still living under the poverty and they are not able to fulfil their basic requirements and these are the main reasons behind not showing expected growth in

the number of electrified villages and lengths of T & D lines, which leads the discussion on the next point of this literature.

India has too much variety in its geographical structure. Northern India has snowy mountains and Southern part has thousands of mile long sea shore, where Eastern part has hundreds of top green mountains which also includes world's wettest city called Cherapunji and western part has hundreds of miles long desert. All these very precisely describe that, the central government cannot apply the same development strategy to each part of the country. The government has to think out of the box to create equal opportunities for all the citizens.

No doubt, India has a stable and very democratic government formation system, which ultimately gives all the rights to the people of India to choose their leaders. But when it comes to various resources and its allocation, the central government has all the control in its hand and, unfortunately, the main problem starts from here. However, it also does not mean that all these power should be in the hand of common people because it will definitely make the situation worst and worst as it will lead the nation to never-ending debate over allocation and actual allocation cannot be done on time. So, instead of providing all the power to local bodies, the central government can give some additional authorities to the local government bodies with sort of responsibilities as well. After going through all the discussions over decentralisation, one thing is very clear, central government cannot evaluate the needs of local people as precisely as their own local leaders can. As the literature is about empowering the local government with renewable electricity, now the discussion is entering into the final stage to fulfil the objectives of the report.

Based on their experience of the past 15 years United Nations (2015) has noted that, "DESI Power and its partners are convinced that centralised electrification alone will neither make electricity supply profitable nor promote the economic and social development of remote villages in India."

Table 2-5 The empower partnership programme

DESI Power, Development Alternatives/Tara + other companies	Village partner organization(s) (i.e. local village team)	Investors, banks, grants, subsidies, selling CO <sub>2</sub> emissions savings
EmPower Partnership for Village Development		
<b>Independent rural power producer</b> Provision of electricity and energy services	<b>Village enterprises</b> Water supply, agro-processing, small industries, fuel supply and processing, agro-forestry, workshops.	<b>Cluster centre</b> Organization and project development, training, extension services and refresher courses.

(Source: United Nations, 2014)

Table 2-6 Activities under the 100-village empower programme

The Indian 100-Village EmPower Partnership Programme		
<b>Decentralized EmPower village projects:</b> <ul style="list-style-type: none"> <li>• 10 Clusters with plants in neighbouring villages with a total of about 500 kW each</li> <li>• Identification, organization and training of promoters / owners of each village plant</li> <li>• Support for plant construction</li> <li>• Cluster development</li> <li>• Cluster management</li> </ul>	<b>Financing:</b> <ul style="list-style-type: none"> <li>• Government subsidies and loans</li> <li>• Equity: local and external.</li> <li>• Commercial loans</li> <li>• Grants</li> <li>• CDM: sale of CO<sub>2</sub></li> <li>• Fund management</li> </ul>	<b>Capacity-building/extension services</b> <ul style="list-style-type: none"> <li>• Initial capacity-building and orientation for project development</li> <li>• Technical and managerial training of local trainers, managers and staff</li> <li>• Training tools for local refresher courses</li> <li>• Women's capacity-building</li> <li>• Performance audit and continuing support services</li> </ul>

(Source: United Nations, 2014)

They also have come up with the strategy for decentralisation of electricity in Indian villages. This road map has been shown in table 2.5 and table 2.6 includes all the aspects of development such as privatisation, decentralisation and finally empowerment. All three stages have support from different organisations and for instance, independent rural power producer will be supported by private companies, village enterprise will be carried out with the help of local bodies and local people which will give them opportunities to share their expectations and requirements and cluster centre will be run by various financing organisations to continue this cycle of empowerment. Here, most significant thing is contingency. By arranging training

programmes and awareness seminars, the process will become immortal and the future of this empowering activity will be secured.

Table 2.6 demonstrates the administrative information of this project. In which, decentralised empower village projects describe the blue print of this mission by including, required support structure. Financing part gives information regarding available options for funding and generating the cash flow. The third part is capacity-building/ extension services which provide all the technical support, from training to an exchange of technology, to the project.

The reasons behind encouraging such empowerment projects are, it gives certain authorities to the local government bodies to deal with. As discussed earlier India is a country of geographical and communal diversities, by applying such projects to villages, central government is giving opportunities in choosing appropriate technology to the relative economy and it will also give chance to rural people to develop themselves and to contribute in the prosperity of nation.

### **2.5.1 Sustainability Relevance of the Sundarbans Experience**

Sundarbans (India) is a living example of using renewable energy sources to electrify villages. Sundarbans region, including Sagar Island and Mousuni Island, has generated a great deal of interest among planners and decision-makers on the replicability of this experience elsewhere (Chaudhuri, 2007). Although India has highly connected and stabilised grid system for electricity supply, still there are many residents left, who does not have direct access to the electricity and it also affects the possible benefits gained from the proper electricity supply. They kind of leaving in a dark phase, where there is no opportunity just because of improper electricity supply system in that particular region. For instance, rural areas like Sundarbans. It is located in the delta region which is made of two great and holy rivers of India, the Ganges and the Brahmaputra. "It is estimated that 1.5 million people live in this area, crisscrossed by many islands and rivers, who have only marginal supplies of electricity generated primarily from diesel generators and batteries. Working with the regional non-governmental organisation (NGO), the Ramakrishna Mission and the West Bengal

Renewable Energy Development Agency, the governments of India and the US initiated a rural electrification initiative in Sundarbans” as explained by Stone and Ullal (1999). However, as it was the first experiment for Indian government in terms of electrifying the villages with solar energy, after a precise evaluation, local authorities have listed out few points those need to be taken care during any further similar projects.

From the previous discussion, it can be easily concluded that, decentralisation can play a key role in fighting against poverty and in making rural lives better. Electricity is a very significant part of rural life and the whole rural economy is dependent on the energy supply, it is important that central government pays enough attention towards the major issues of rural people. Moreover, the given example of decentralised electricity project for rural India is a blue print. It can be used for various renewable energy sources in different regions of India, but as the literature is based on the solar electricity, the project has represented as the solar electrifying project.

## **2.6 Summary**

As described in the introduction part of chapter 2, all the things have explained and now it leads to the next chapter and the questionnaires used for the next chapter are mostly raised from the literature review.

For instance, one of the questions is, “how does rural electrification fit into a broader strategy of rural development? What complementary conditions or inputs make for success or failure? Can one rank the complementary conditions and inputs in order of importance and evaluate their relative importance to rural electrification itself?” which explains the issue raised in chapter 2 regarding overall rural development and significance of electricity in rural development.

## **3 METHODOLOGY**

### **3.1 Introduction**

The chapter discusses the methodology adopted for the research. Considering pros and cons of research methodologies and considering the objectives of the research. The chapter will also provide reasons behind choosing any specific methodology. Moreover, it will also define, within the selected methodology what sort of sub-methods have chosen to collect the data and to analyse the data.

### **3.2 Methodology**

Research methodology for the research is an important task to figure out. It requires analysing all the possible sides of the research. Here, the research subject is about solar electricity and empowerment of local government with these renewable energy sources. By using a suitable methodology enrich data and information can be gathered to find out the problems or gaps and it also helps to justify the questions, raised from the research and gives support to the arguments made in the report.

For this research, qualitative methodology has been chosen. Qualitative methodology provides very limited data or information but the received data or information is very standard and subjective in terms of its quality as they are gathered from the real life experience. One of the definitions of qualitative methodology is given by Mills and Birks (2014), "If the researchers choose to collect the experiential data more than measurement, they call it qualitative method." "The qualitative, naturalistic approach is mostly used when observing and interpreting ground reality with the aim of generating a theory that will explain what was experienced" as said by Newman and Benz (1998). Tracey (2013) has explained the qualitative research methodology as a focused study, includes rich and holistic data, on live experience, placed in its context.

From the discussion provided above, it can be said that, the qualitative research methodology can be applied to the subjective type of research. Here the research is

about empowerment of local government bodies with the solar electricity, which is a very subjective topic. Common people may not have enough knowledge about solar electricity production processes and administrative procedure to make it happen in the villages. They may not know about the various governmental electricity policies, their applications, roles and funds provided to different levels of government. Moreover, people may not be aware of the demand-supply gap in electricity and many more other governmental energy related statistics. So clearly, using the quantitative methodology and random surveys to gather the data for such topic is not acceptable. Such data may also not show the reality and the reliability of such data is also questionable. With consideration of all these points, the qualitative methodology is chosen.

### **3.3 Research methods adopted**

Under qualitative methodology, mainly interviews and case studies have chosen. Basically, the research is about two major aspects, empowerment of local government bodies and solar electricity. Here interviews have only used to collect the data regarding the procedures of empowerment and the roles of different levels of government in establishing new policies. Meanwhile, case studies have used to analyse the effectiveness of solar electricity and examining the real facts about levels of realistic approaches to go with the solar electricity.

Following are the steps that will explain the structure of methodology.

#### **3.3.1 Step 1- Development of the research instrument**

This section is about the development of the questions (Available an Appendix A) for the interviews and the analyses of the information gathered from the case studies.

##### Interviews

Questionnaires have been developed on the basis of the objectives of the research. However, as said earlier, the interviews have only been conducted to scrutinise the



government policies and the role of different levels of government in decision-making processes. So the effectiveness of solar electricity is not considered in the questionnaires, though a couple of questions is about the renewable electricity, just to know the views over renewable energy. As the expert views somehow affect the future government policies. Moreover, the questionnaires are open-ended because when someone is discussing government policies, a simple one word answer with 'YES' or 'NO', cannot justify the respondent's answer. So open-ended questionnaires have been chosen to provide enough space to respondents to justify their answers with appropriate explanations and to increase the level of satisfactory.

### Case study

Meanwhile, case studies also have conducted in two ways to draw the actual picture of solar electricity. Primarily, the first solar village of the India has been studied to know the ground realities about effectiveness of solar electricity in India. The case study has helped to show the realistic side of solar electricity in India. Moreover, the problems regarding the actual implementation are also been analysed. In short, the study of the solar village gives a broad view over realistic situations in India in context of solar electricity.

The case study of world's first 'zero carbon' city, Masdar (Abu Dhabi), shows the peak of usage of renewable energy sources, especially solar energy. The reasons behind choosing Masdar city as one of the case studies are:

To know, how the extent use of renewable energy sources can be beneficial to the environment.

To relate it with the Indian context, no doubt there is no comparison between Masdar and the solar village of India, but yet, both have the same concept and which is the use of solar electricity. The only difference is Indian village has developed solar electricity concept to fulfil the basic needs of the people, while in the case of Masdar, they have also paid enough attention over luxuriousness of the city.

To define, the broad scope of solar electricity as Masdar city is fully developed on the electricity. For instance, the transportation modes run by solar electricity.

### **3.3.2 Step 2- Piloting**

As far as the questionnaires concern, the questionnaires have been sent to the 10 people from the various fields. Here, all types of groups of people have been considered to get the fair and clear response. Which includes government officials, i.e. Minister of State (Energy department), chairpersons of Municipal Corporation and local authorities as well as it also includes the policy advisors regarding different government schemes along with renewable energy experts. Which increase the reliability of the received data.

The final analysis has made using the main comments from the respondent's responses and their answers.

### **3.3.3 Step 3- Choice of sample**

The developed questionnaires were then sent to the selected sample. The most significant thing while choosing the respondents is, it should cover both the parts of Indian decision-making process and in the research it is taken care of.

As per the Indian constitution, India has a very firm and somewhat transparent decision-making system. Majorly the decision-making system has two interested parties. One is political leaders, elected by the people through the election and the other is government officials, who have been placed, based on their talent and knowledge. Both the parties have their unique significance in establishing new schemes. In short, each and every decision-making process follows the two way procedures and after the agreement between both the parties, new schemes can be developed (Palermo and Alber, 2015). Here, the political leader's main duty is to raise the voice of the common people and the government official's duty is to give a decent scheme to the government for any possible development in social structure or economic structure along with analysing the limitations of government.

So for this research, 4 government officials, 4 political leaders and 2 renewable energy experts have chosen for the interviews. The government officials include, the collector of the Rajkot city and 3 other city level government personnel. Nevertheless, minister

of state (Energy sector), mayor of the Rajkot city and 2 other political leaders have also included in the research. They are responsible for the implementation of solar electricity development policies and also responsible for empowering the communities on driving the agenda towards the renewable energy. Additionally, 2 experts on renewable energy have also chosen for the interviews as they can provide the ground reality regarding the actual concept of solar electricity in villages of Rajkot. They can also give very honest comments over the government's stand over electricity supply in villages.

### **3.3.4 Step 4- Data collection and recording**

#### *3.3.4.1 Mode of data collection:*

##### Interviews

For interviews, email correspondence has used. In which, firstly, the main questions have been sent to the selected samples and they have responded. Then after analysing the answers, if there is any additional clarification needed then they have been contacted again and they have given very clear justification. Here, the reason behind conducting interviews via e-mail is, as mentioned earlier, they are the key personnel of the government (politically and administratively) and experts, they do have a tight schedule to follow. So it makes easier for both the sides to follow the email correspondence. Though in starting, it has been tried to do face to face interviews by using Skype, couples of them have given the appointments as well. But as Gujarat is passing through the tough time because of some social issues, all of them have postponed and it becomes time consuming. As a result, it is much better and efficient to use email services for the surveys.

##### Case study

For the case study, the data has been collected by using their respective websites and by reading various articles about the selected places. In short, by using observation, the data has been collected. Here, the most important thing is, reliability of data has been cross checked by comparing the data with various sources of information.

#### *3.3.4.2 Time duration:*

The questionnaires have sent to the selected samples and they were given 1 week time to respond. However, in the first week, none of them has replied. So a gentle reminder was sent to the selected samples. In the second week 3 of them have replied and 2 of them have asked for more time. So, to increase the response percentage the deadline was extended till next week and as the already replied answers were analysed, few doubts regarding it were sent to them again but only 1 of them have replied. Fortunately, in the third week 3 of them have answered, which takes the response percentage to almost 60%. So the data was sufficient and the data was scrutinised. Meanwhile, 1 more respondent has replied after contacting by phone. The last respondent has replied via mail in the fourth week. So in summary, 7 out of 10 samples have replied and it took the response percentage to the 70%.

#### *3.3.4.3 Recording of the data:*

The data have been received via emails. As discussed earlier, face-to-face interviews are time consuming because of the tight schedules of respondents.

### **3.3.5 Step 5- Data Analysis**

Data validity and reliability:

The data received is highly reliable. Following are the reasons for it:

Expertise of the sample used for the research: As far as government officials concern, they are all highly qualified. Even it takes many years to reach the post like the samples. They all have more than 10 years of experience in governmental decision-making committee. They have enough knowledge about various government schemes and their different statistics. One of them is the advisor to the Minister of State (MoS). So, there is no question regarding their qualifications in the policy-making department and their response is very reliable as they have very firm background in this sector.

The political leaders, who were interviewed, know all the prime needs of the local people. They are aware of the major issues in the rural areas of the Rajkot city.

Addition to it, they have many years' experience in policy-making processes. They have very good knowledge about the roles of different levels of government in decision-making processes. Moreover, they were living in the Rajkot for many decades. So they are incredibly aware of the local climate and their views over solar electricity and its efficiency can be very reliable.

As far as, the experts concern, so called experts are the professors in the department of mechanical engineering in the local university and they are working with the university for 7-9 years. So they also have both, the knowledge and experience, in the renewable energy sector and their views over solar electricity in rural areas are very helpful in analysis.

## **4 ANALYSIS AND INVESTIGATION**

### **4.1 Introduction**

This chapter discusses the main findings derived from the interviews and case studies. The questionnaires and the answers will be analysed. The main findings are presented in 3 main sections. The first section discusses the generic details of the participants/organisation/case studies. The second section discusses the main findings of the questionnaire/interviews, according to the research questions presented. The final section presents a data synthesis to bring main findings of the literature.

### **4.2 Details of the participants/organisations/case studies**

As explained earlier in chapter 3, the selected samples for the interview have firm experience in this area and most of them are working with the government as leading government officials or elected people from the elections. The other 2 experts also have many years' of experience and they are also working with the university.

All the government officials work in the either Department of Electricity Supply Board or in the Rural Development Board. Currently, they are working on the various projects to replace the non-renewable electricity supply into renewable electricity supply. Their focus is mainly laid upon the solar electricity as Gujarat has very high possibility in the solar energy sector. The 2 experts, one of them his head of Mechanical engineering department and the other is the professor of the Mechanical engineering branch in the university in Rajkot.

The government officials are on various posts. They lead a certain number of people in the government offices. It is hard to tell the exact figure of the workers working under them. But couples of them are on the top most position of the department. The political leaders lead many government officials under them and they also deal with the multi-interest projects.

### 4.3 Role and average years of experience

Table 4.1 below shows the type of role carried out by the respondents and their average years of experiences.

Table 4-1 Role and experience of the group of respondents

Role	Code	Number of Responses	Avg. years of Experiences*
<b>Political leaders</b>	PL	2 (50%)	3
<b>Government Officials</b>	GOV	3 (75%)	7
<b>Experts</b>	EXP	2 (100%)	8
<b>Total</b>		7	6

According to Table 4.1, the number of responses from Architects, Contractors and Project managers are somewhat similar. This tells that the answers given by the respondents are not heavily biased towards one category of respondents. This, therefore, means the findings are valid.

Table 4-2 Role and experience of the respondents

Interviewee	Code	Role	Years of Experience	Remarks
<b>Interviewee 1</b>	INT1	Minister of State	2.5	INT1 is involved in many rural electrification projects
<b>Interviewee 2</b>	INT2	Chairman, Standing Committee	3.5	INT2 has no experience in sustainable construction, however, he holds a Master's degree in sustainable construction
<b>Interviewee 3</b>	INT3	Personal Advisor of Minister of	9	INT1 is involved in many rural electrification projects. He was one of

		State		the senior member of rural electrification department few years back
<b>Interviewee 4</b>	INT4	Chairman, Rural Development Board	8	He got promotion to the chairman post last year after serving as vice chairman for 2 years
<b>Interviewee 5</b>	INT5	Member of Rural Electrification Committee	5	He is current member of INT 4's team in Rajkot and he represents the group of 9 villages in the Rajkot Municipal Corporation
<b>Interviewee 6</b>	INT6	Head of Department (HOD), Mechanical Engineering	11	He is connected with the university for over 7 years and he got promoted to the most valuable post of HOD in 2011 and still working on the same position
<b>Interviewee 7</b>	INT7	Professor, Mechanical engineering	4	He did his master's in 2010 and after working in the industry, he joined this educational institution and currently he works under INT 6.

Table 4-3 Details of places selected for case study

Case study	Code	Type of project	Remarks
<b>Case study 1</b>	CS1	Dharnai, Bihar	First solar village of India. After spending 30 dark years, the village



			finally has electrified itself by using solar electricity.
<b>Case study 2</b>	CS2	Masadar, UAE	It is the world's first zero carbon city and it is developed as a whole new city in UAE which is an ideal place for living without harming the exciting nature.

#### 4.4 Main findings of interviews

The main findings of the research are generated on the basis of questions developed in the questionnaires. In which, firstly the questions will be provided and then the main findings from the selected sample's answers will be discussed. Here, three of the respondents answer sheets has provided in the report (Available an Appendix B, C and D).

**Question 1: Does rural electrification generate additional productivity, higher income, greater employment and structural change in rural areas? Does it contribute to greater regional equity and reduce excessive migration to urban areas?**

The purpose of this question is to understand the importance of electricity in rural lives, its positive effects and to clear the issue regarding the heavy migration of rural population to urban areas.

Each of the selected samples has replied this question positively. Electricity does change the life of rural people. Specifically, it attracts new investments and which generates plenty of opportunities for the rural people. Especially, INT 4 has explained, "statistics about employment and productivity in Gujarat since, it has become one of the fully electrified states of India. Gujarat's rural unemployment ranking in 2011 was

2nd, tied with Madhya Pradesh, versus 5th in 1999. Overall, Gujarat's gross state domestic product (GSP) has increased at an average of 16.6% a year from 2001 to 2010, up from an annual average of 5.1% from 1980 to 1990 and 8.2% from 1991 to 1998. It is a critical infrastructure on which the socio-economic improvement of the country depends on. The supply of electricity at a sensible rate to rural India is key for its overall development. Equally important is the accessibility of reliable and quality power at competitive rates to Indian industry to make it globally competitive and to enable it to exploit the tremendous potential of employment generation. The services sector has made a significant contribution to the growth of Indian economy. Availability of quality supply of electricity is very crucial to the sustained growth of this segment."

INT 4 has added that, "Rural electrification with providing continuous and quality power supply contributes to reduce the excessive migration from rural to urban areas increase in use of electrical appliances by housewives in rural area, enhance opportunity for local employment, Development of home industries and small scale industries, provision of better health services and infrastructure facility." However, when it comes to migration issues regarding the rural people, INT 1 has described that, "by providing electricity, the government is introducing new opportunities to the rural people but the migration issue still remains as it is. He has added that, there are several other factors that also play a significant role in stopping or minimising the migration rate (i.e. proper road connections)."

**Question 2: How does rural electrification fit into a broader strategy of rural development? What complementary conditions or inputs make for success or failure? Can one rank the complementary conditions and inputs in order of importance and evaluate their relative importance to rural electrification itself?**

The question was asked to discover the links between rural electrification with the rural development. Additionally, it has also helped to list out the complementary conditions or inputs to make it happen on ground level and to give the conditions rank in accordance with its importance.

All the respondents have accepted the universal fact that the electricity is one of core issues for developing countries and it becomes very crucial for rural development and the welfare of rural people.

INT 1 has responded that, “electricity is an essential commodity and hence rural electrification result into rural development itself. Coordination for the development of the rural area by industrial development in addition to Agriculture development. One can rank electrification is relative important but, others aspects are required to be taken care of. He has made his point that, electricity solely cannot change the life of rural people but it affects the life of people very dramatically.”

As far as complementary conditions or inputs from the government require, INT 2 has explained that, “the city like Rajkot, it is not an easy job to provide electricity to the last person of the remote area. Though, the government is doing its best by applying suitable strategies to overcome the issues related to the electricity (i.e. purchasing the electricity from the state government, rebuilding the supply structure, motivating the people to save the electricity and so on).”

However, when it comes to complementary conditions and its ranking all the respondents have followed almost the same pattern of ranking.

Table 4-4 Rankings of complementary conditions

Complementary conditions	Possible effects	Rank
<b>Production of the electricity by the municipal corporation itself.</b>	The expenditures used to buy the electricity will be eliminated and municipal corporation can owned its very own production unit.	1
<b>Rebuild the storage capacity</b>	As the district’s demand varies with time, by building the storage unit, the corporation can store surplus power during low demand and can encounter the peak demand	2

	situations very easily.	
<b>Grass root level changes in supply system</b>	The problems with the supply chain is, it requires a very high maintenance cost as well as power loss during supply is also very high especially during hot summer. The government needs to think about it and INT 5 has mentioned decentralised renewable electricity system to eliminate the whole supply chain issue.	3
<b>Unit rate of electricity</b>	It is one of the core issues with the corporation, INT 2 has confessed that, government could not control the prices of electricity. Especially during last couples of decades, as the privatisation boost the economy of India and it has changed the life style of people, the demand is at its peak and the government is raising the prices to control the demand. Which is a very negative side. Because generally, higher demand leads to higher production and ultimately it leads to lower cost.	4

**Question 3: What are the effects of rural electrification on “equity” in development for example, in providing benefits to different income classes or in widening opportunities for small farmers, landless agricultural workers, and artisans? How does rural electrification affect the role of women and children?**

This question was asked to unfold the social side of rural electrification and its wide range of effects on socialism.

The question is very simple and straight forward. Everybody has replied positively and they have accepted the fact about the crucial effects of rural electrification on employment and women empowerment. INT 1 has discussed that, “rural electrification always affects equity in development as helping growth of BPL (Below Poverty Line). In the same way small farmers, landless agricultural workers and artisans get equity in development. Women and children benefit more directly from having electricity in the house than man, since they generally spend more time in home. Children spend more time reading in households with electricity. Women have better light for working and reading and appliance may well eliminate some of the labour work involve in household work. Women's routine home chores eased, which allows for daughters to be freer to attend school.”

**Question 4: What are the benefit-cost ratios of rural electrification (a) in financial and (b) social terms?**

After unfolding financial as well as social sides of rural electrification, this question was aimed to solve the statistics over benefit-cost ratio. As it is one of the crucial factors to determine the success ratio.

Here, all the respondents have explained this question in a common benefit-cost ratio, as the government does not consider them separately as a ground reality, eventually, they consider is as socio-economic terms. Moreover, they have also mentioned that, it is hard to provide benefit-cost ratio in general, but yes the affecting factors can be explained and they have discussed them so.

As discussed by INT 2 and INT 3, there are four major types of measurement to evaluate the success rate of any project. Namely:

1. Meeting "targets" or "forecasts"
2. Financial viability
3. Impact analysis
4. Benefit-cost analysis.

Meeting "targets" or "forecasts": "In which, the lenders have most commonly asked that, was the project completed? Were the pre-planned numbers of lines constructed in pre-defined time period? The funds spent prescribed way?"

"In national rural electrification projects, the success rate is defined by fulfilling the possible "targets". It includes, number of villages electrified, kilowatt hours sold, pump set connections "released"."

Financial viability: "Secondly, the success rate is measured by the project's financial viability. However, as social benefit and cost are excluded from it, this approach does not give a satisfied success rate. A venture lacking financial viability may still have a positive monetary rate of return, nonetheless, since uncounted social benefits will quite often outweigh the uncounted social costs."

Impact analysis: "Third and somewhat more useful approach for this purpose of rating the project is Impact analysis. It is the way of evaluating success rate of the project by ascertaining its "impact on the users". What changed after electrification? This methodology can assume different levels of sophistication, from just listing potential advantages that might result from electrification."

Benefit-cost analysis: "A fourth way of assessing these effects is benefit-cost analysis. Since investment resources in developing countries are rare and have numerous competing uses, ideally every single social costs and benefit ought to be estimated in money terms, and net benefits of rural electrification projects calculated and compared with the net benefits of different uses for capital. Benefit-cost analysis seems to be the most appropriate framework of the four described above to use for getting the success rate of any rural electrification project. It is thus perhaps surprising, at first glance, that this approach has not been widely used in the evaluation of rural electrification programs. One obvious reason for this neglect is the difficulty of evaluating and measuring impacts and linkages, as discussed above."

Here, INT 1, INT 4 have directly explained the benefit-cost ratio in regards with rural electrification project. Their main comment was about the actual difference between benefit-cost ratio for urban electrification and rural electrification. As in urban

electrification ratio, there are many more aspects to be examined before result and in the case of rural area, it is quite a simple job to do.

“First, it should be realised that the quantities of electricity consumed in rural areas tend to be very small, both in the aggregate and consumed in rural per consumer, as compared to urban areas--less than one fourth of urban Bank figures” (World Bank, 1975b, pp. 25-26). Secondly, the weight of electricity consumption by various sector varies enormously in rural areas. More specifically, INT 4 has provided actual competitive figures, “the residential-commercial share being quite low--about 25 to 60 percent in the surveyed areas, where agricultural or industrial uses predominate and consume most of the total in some rural areas.”

### **Benefits from the rural electrification**

- Irrigation systems utilising electric system equipment, tube wells, etc., allowing for time-saving multiple cropping systems.
- Property formulated livestock of surplus crops for long time.
- Cold storages can be constructed for storage of farm agricultural products and utilised to store the milk as well.
- Electrically equipped grain drying, processing, storage systems and fumigation.
- Conservation of export quality timber (electricity replaces wood for cooking and heating).
- Working through his Cooperative provides the farmer with some level of leverage in the global marketplace.
- Agriculture employment opportunities can be generated.
- Electrically powered handicraft industries allowing for varied and increased production. (During off peak seasons of agricultural cycles, cottage or home produced items can be made).
- Refrigeration of medical supplies by hospitals or clinics.
- Increased security due to night lighting. Crime rate decreases.
- It can be utilised as educational and entertainment source.
- It also helps to improve people-government relations.

### **Indirect benefits**

- Environmental improvement
- Impacts on migration and fertility
- Encouraging innovation and modernity
- Political stability

### **Cost of the rural electrification**

Interestingly INT 1 has made a very crucial point, “the marginal costs of electricity are higher in the rural areas than the urban areas. One of the major reasons is lower demand and higher maintenance demand due to remoteness.”

One of the other major point made by INT 5 was, “when the government is attending such ratio, it should always look after other possible aspects as well.” As INT 5 has supported the decentralisation of electricity especially for the remote areas, he has explained the cost things in detail by comparing the centrally generated supply versus self-generated supply.

It can be measured by using three major aspects.

The cost of generation: “The generation cost of the centrally generated electricity is quite cheaper than the auto generated electricity as the capital cost of renewable energy is always higher than the conventional energy production.”

Distance from the grid and density: “But obviously, centrally generated electricity supply have massively high maintenance and supply cost than the auto generated electricity supply system.”

Load factors: “The load factor is the ratio of average to peak consumption for the system. If use and load factors are high, then costs for the more capital-intensive central generating facility will be lower, since they can be spread out over more units of demand.”



In conclusion, the respondents have replied two different aspects, for having a low benefit-cost ratio, INT 1, INT 2, INT 3, INT 4 have favoured the grid electric system over auto generation or decentralised system and on the other hand, INT 5 and INT 7 have favoured decentralised system over benefit-cost ratio. INT 6 have responded that, auto generation electric system should be used as an optional supply system in the case of grid system fails. In short, according to the selected samples, it is quite difficult to adopt the decentralised electricity concept even though it has many positive sides.

**Question 5: What are the most effective types of rural electrification policies and strategies to maximise the overall benefit-cost ratios (including priorities in selection of project areas, subsidies, and tariff structure)?**

The question is made to analyse the government policies regarding rural electrification as well as the implementation of previous strategies.

INT 4 has explained that, “there are mainly three types of government policies. First is made by the central government, second is made by state government and the third one is made by the municipal corporations. In which, the financial and strategic supports will be provided by the respective government. However, local government does play a very significant role as implementation of such policies is in their hands.”

Here, none of the samples have talked about the past government policies, they all have replied a kind of similar and very broad answers, which does not clearly indicates the specific strategy but the responses does make sense regarding the benefit-cost ratio. In which, all the respondents have replied that, the policies always aimed to achieve the highest possible the benefit-cost ratio.

According to INT 1, following are the main aims of the government policies in which they always keep benefit-cost ratio as high as possible:

- Access to Electricity- Available for all households
- Availability of Power to all.
- Supply of Reliable and Quality Power of specified standards in an efficient manner and at reasonable rates.
- Per capita availability of electricity to be increased.

- Financial Turnaround and Commercial Viability of Electricity Sector.
- Protection of consumers' interests.

As far as other factors like subsidies and tariff structure concern, the government policies made to complete the circle of income and outcome. INT 2 has specifically explained that, “the government’s way of looking at the electricity sector is totally different from the other sectors. As it is one of the very prime need of people. Government policies do have some soft spots in favour of people.”

**Question 6: Does central grid electrical service for rural areas more effective compare to decentralise forms of electricity/energy production, including solar, biogas and other forms of energy? How?**

The question was asked to compare both the approaches of electricity supply in rural areas. In which, grid electrical service is the traditional and current way of supply and decentralisation of electricity supply is the whole new concept which includes an eco-friendly way of electricity production at reasonable rate.

This question has got the most satisfied responses and there were definitely some variances in the opinions of the selected samples. Which has provided very rich information and very strong arguments.

Here, INT 1, INT 2, INT 3, INT 4 were in the favour of the traditional grid system. However, they have not clearly rejected the decentralisation concept. But their views were, the decentralisation will damage the finance sector of the state government, as people will have their own electricity production unit. In that case, there is no role left for the government between production and supply. Which will lead the government to loss of tradition profit from the state electricity board and the annual taxes on the house holders will also be eliminated. The other major argument made by INT 4 was, “in the case of failure of self-production of electricity, there is no other temporary option available in the case of fully renewable energy decentralisation and the government cannot afford the grid supply system as an optional service, as the maintenance cost will be far higher than the actual income.”

On the other side, INT 5 and INT 7 has supported the decentralisation system for the rural areas, as sometimes the government is not capable of providing the electricity 24\*7. Moreover, it has its very strong positive side in terms of environmental benefits which makes it cheaper as well and as far as the financial damage concerns, the government can make surplus income from the taxes collected from the various solar equipment.

Meanwhile, the INT 6 has partially responded in favour of the government. He has explained that, “the solar electricity should be used as an option of grid electricity supply system.”

Here, the main finding is, the government officials favour the grid electricity supply, as they are more concern about the government’s role in highly profitable electricity supply system and as an exceptional case, the INT 5 did support the decentralisation of electricity. But, INT 5 and INT 7 has made firm points regarding government’s financial issues by solving it with additional tax income from the solar equipment. Moreover, about the worst case scenario, in which the decentralised structure failure, group of few villages can develop a small solar farm, which should be capable of storing the electricity power of minimum 30 days. This additional arrangement can help to overcome from the worst case scenario.

**Question 7: How do different rural electrification policies affect the impact and implementation of rural electrification in various cities of Gujarat?**

The question is asked to analyse the interference of state government or central government in the implementation stage. The question was also aimed to solve the mystery of political aspect, as it could be possible that state government is made of a ruling party and Municipal Corporation is made of a very different political party from the state government.

As described by INT 4, “the different rural electrification policies do not give any specific advantage or disadvantage as they are made for the whole state. But the results can be varied, because the implementation of any policy is in the hand of Municipal Corporation, the state government does not interfere a lot in it.” INT 3 has made a very clear point that, “the job of the state government is to observe the

strategies accepted by the different cities and report them to the central government. The main job of the state government is to provide the enough resources to the municipal government to make it happen.”

INT 6 has shown a slight possibility that, “the allocation of resources can be affected by very few numbers, however other than him, no one had shown any possibilities about such crucial things to happen as they all are working on the motto of Nation First.”

## **4.5 Main finding from case study**

### **4.5.1 CS 1**

Dharnai is a small village of Bihar. It has lost its power supply due to Maoist violence back in 1981. Since then, the Dharnai was pushed into the darkness for more than 3 decades. But fortunately, due to some interest of private organisations and mainly the adoption of new innovative idea of decentralised renewable energy supply system, Dharnai is out of the nights of darkness.

As discussed by Greenpeace India, the major advantages of having decentralised power renewable power supply system are as following (Dharnailive, 2015):

- Locally available renewable sources
- Significantly less transmission and distribution losses
- Viability in remote areas as compared to grid electricity
- Financial accessibility to small investors due to lower capital cost
- Low involvement of scarce government resources
- Capacity building of local community
- Job creation through operations and maintenance

Decentralised Renewable Energy System (DRES) or distributed micro grids can be designed to meet the specific power requirements of local people according to their needs. Additionally, in the context of poor rural communities, micro grids offer clear financial advantages for low-income end-users, as access to electricity results from an ongoing service that is locally produced and managed.

Here, the most interesting thing is the development of DRES in the village. Sen (2015) has explained in one of his blogs that, one can see the changes in the village now. The roofs of the houses are covered with the solar panels. The reason behind doing so, is to allocate the responsibility to the respective house holders. However, the village also has one small solar farm which can provide the electricity for more than 2 months in the case of crucial situations (i.e. weather change, breakdown in any of the house holder's generation system and so on).

One of the major findings is the support from the government. After partition of Bihar in two different states. Most of the coal mines, which are main source for power generation in India, went into the new state named Jharkhand. Bihar was facing energy crisis at that time and it continues even after many decades. But now government is widely adopting the DRES for the state and till now it goes really well. The main advantage for the government is, as Bihar was buying the electricity from the other states, now with this new approach, Bihar can eliminate that extra burden on the government's finance department.

#### **4.5.2 CS 2**

"The low-carbon development of Masdar City has an integral role in transforming Abu Dhabi's economy from an oil foundation to one with a knowledge and innovation base", says the developer of the Masdar city (2015). The city is an ideal model for the world and it can be proven as test ground for the various multinational renewable companies. The city is intended to minimise the impact over environment.

"A 10-megawatt solar photovoltaic plant and an array of building-mounted solar panels offsets nearly all of the electricity in Phase 1, diminishing the need for power generated by fossil fuels. Streets boost shade all day long, capturing cooling breezes and reducing the need for air-conditioning" as reported by BBC (2015).

Furthermore BBC (2015) has analysed the residents in Masdar city, "A mix of educational and recreational, housing, retail, manufacturing, and office spaces give commuters and residents easy access to everything they need, declining transport needs. Buildings are densely populated, permitting residents to live and work in the same area. This reduces heating, cooling and internal transportation needs." In short,

even though, the area is populated and many businesses are running as usual in the city, with the help of firm transportation and unique construction methods, somehow the city has reduced its carbon level.

Finally about the water conservation and supply system, the official site of Madar city (2015) has described their water supply and conservation system as followed, “Water conservation is ensured by high-efficiency appliances, low-flow showers, a water tariff, smart water meters and treated wastewater, which is recycled for plant irrigation.” Many of these things look smaller in ‘to do’ list, but at the end, it makes a huge difference in actual life and Masdar has done very well so far.

## **4.6 Discussion and synthesis**

As discussed earlier, there was some opinion of difference in the responses of selected samples. But they do have justified their opinions and answers in very generous manner. Here, the negative sides have been shown in the responses do have very common link with the matters discussed in the chapter 2. For instance, the government will face huge financial trouble and ultimately it will affect the other development programmes as well. In addition to it, one issue regarding the alternative option in the case of the failure of decentralised supply system is also there. As discussed in chapter 2, decentralisation creates a kind of void in the interaction between the local government and central government. Many of the government officials have supported this thing as discussed in main findings section.

It will also lead the local government to play disproportionate role in the planning, management and execution of any project. However, INT 1 has clearly stated that, there is no doubt in the capability or ability of the local leaders or local administrators, but the thing is, people on the higher post do have vast knowledge and experience than the locals. That is why, it might be sort of risky to give complete independence to local governments.

There are possibilities, like many of the local governments may show a very positive and more the just satisfied results, but Rajkot is a big district. Everyone might not be able to afford such decentralised system, as the capital cost creates a massive

difference with grid system. In such case, they will be helpless. Though, government is taking steps towards the clean energy, but it takes time to create grass-root awareness among the people as some of selected samples have also mentioned such things in their overview over solar electricity and decentralisation with such new approach.

In the main findings, the most eye catching thing is, the government is not in favour of decentralised electricity supply. Many of the government officials and the minister state itself, did not favour the decentralised electricity supply system. However, they did have interest in renewable electricity and they are currently working on many solar projects. As the central government is leading all the states to maximise the renewable electricity production which will also help to modify the picture of India on the global stage.

As it does have both the negative and positive sides, positive in the sense, the remote people can be connected with the urban people in terms of opportunities, life style and living standard. Moreover, the government can solve many other issues related to remote areas by just decentralising the electricity supply. The benefits of electricity in rural areas have discussed earlier in the main findings section.

The advantages of decentralisation were also discussed in chapter 2 and the respondents did reply some sort of same answers. No doubt, the matters discussed in chapter 2 was a result of a study derived by the experts all around the world, so it is a kind of bigger picture and the selected samples have replied in regard with a particular state only, so it is a kind of smaller picture compare to the global study. However, many mutual interesting things are there between both the studies. As discussed many negative sides are the results from the both the studies and in the same manner, many positive things are also available between them particularly regarding, the needs of people.

## **4.7 Summary**

Government is not in complete favour of decentralised electricity system. However, they are in the favour of conservation of environment and they want to work towards

the adopting the new approach. But still there are some issues to be sort out by government as far as decentralisation concerns.

The administrative gaps should be bridged under special circumstances. Which should give some administrative power to the upper body of the government as well. Under this situation, the system cannot be called fully decentralised, but as per the current Indian situation, the upper body of the government should give some kind of independence to the local authorities and if it gives fruitful results, then there is a new way that state government or central government can adopt.



## **5 CONCLUSION**

### **5.1 Overall conclusion**

As said earlier, the relations between electricity consumption and GDP of the nation is highly relative. One can see at as two sides of a coin. As discussed in chapter 2 and as analysed in chapter 4, this is ground reality, electricity can make a very high Impact over the development of the nation. The growth of the nation can be boosted by developing very reliable electricity supply system. However, as the production of the electricity is one of the major disadvantages for developing countries. It damages the environment and additionally, the traditional resources of electricity generation are also limited. As they are non-renewable, it might create a very crucial situation in the nearby future.

The advantages and disadvantages of renewable energies have discussed very deeply in chapter 2. In chapter 4, such things have responded from the selected samples. However, as most of the world is still following the conventional methods to produce the electricity and the figures of the usage are massive, it takes long period of time to make the world idea, where all the nations are generating the electricity by using suitable renewable energy sources.

One of the major challenges is the availability of solar energy. It highly depends upon the geographical location of the place. But as the research is about the Rajkot, it does not have such problem with the availability of solar energy. Though, Rajkot might have to face few problems in Monsoon as the cloudy weather may break the production cycle. That is why, as discussed in chapter 4, either the government can develop small solar farms which can provide the electricity to the surrounded places for certain period of time. Moreover, the capital cost of the installation is much higher currently and it may put some extra burden on the government in financial terms. That is why, as said by the minister, the government is waiting to be the solar energy more competitive and then the solar electricity mission can be started very aggressively in remote areas.

In, chapter 2 and chapter 4, the role of different level of government as per Indian constitution have discussed and explained. The conclusion regarding the roles of any specific level's government makes the whole scenario, for new adoption or new implementation of any policies, somewhat transparent and speedy. However, the government is failed to make supportive links between different department's government officials and that is why many of the projects and policies are implementing very slowly.

The decentralisation of the electricity supply system by using solar energy is a very complex task in a country like India. Though, there are rich possibilities of adopting or applying semi-centralised supply system. The government can adopt fully centralised system as well, but as the local leaders and governments may not be able to handle such crucial responsibilities in such short period of time, so it is wise full to apply such new approach in different phases.

#### **5.1.1 Phase 1**

The upper-level government body can educate lower level government bodies regarding the decentralisation and its process.

#### **5.1.2 Phase 2**

The upper-level government bodies can give some additional independence to local authorities in some fields (i.e. paper work regarding site selection, planning and implementation strategy and so on). The upper-level government bodies can monitor each of the activities and can analyse the performance of local authorities. Based on which, the eligible local government bodies can enter into the next phase.

#### **5.1.3 Phase 3**

Now it is time to give some sound responsibilities to the local authorities in which, the local government bodies can have authorities to publish the tender after proper evaluation, they could also be authorised to select the available tenders from the various interested parties and they can also participate in actual implementation of planning on the ground level. However, they still have to report all the ongoing things to the upper authorities and upper authorities can guide them in any particular issue.

#### 5.1.4 Phase 4

This is the time when authorities with the responsibilities will be fully transferred to the local authorities. Now the role of upper bodies in such case is to provide administrative and financial help to the local authorities. The upper government bodies can generate income through collecting certain amounts of taxes on the solar farms build near each remote area or upper bodies can give the lands on the lease for the solar farms to local authorities. In both the cases, upper authorities can generate very stable flow of income.

As discussed in chapter 2 and chapter 4, the government is aware of potential of solar energy in India and that is why they are taking many firm steps towards it. The available subsidies on solar appliances are almost the highest in India compare to any other renewable energy appliances. Additionally, the government is eager to attract the foreign investment in energy sector and they are continuously moving towards it.

In short, there are ways to adopt the approach of decentralised solar electricity supply system, but the government has to have some strategy before giving such independence to the local authorities as it can cause conflict between local and upper authorities which will ruin the whole supply system.

## 5.2 Limitations

The study was limited to the state government officials, but the representatives from the central government were not included because of limited time, cost consideration and most significantly, availability of them. It could have unfolded another dimensions of the study.

As far as results concerns, mainly there are two limitations of the results concluded from the research. In which, one is political and another one is financial.

**Political:** There are certain possibilities lying and these are the actual risks in decentralisation. Giving more power to the lower authorities may sometimes result in a huge conflict or difference of opinion between the Municipal Corporation and State

Government or between the State Government and Central Government. However, this is the worst case scenario but if it happens than it will damage the government's other development programmes as well.

Additionally, there are some possibilities that, it may not be limited to the electricity sector only. Other crucial and sensitive sectors may also raise their voices to have an independent decision-making system which will result in plenty of self-running small governments in a single state or district.

**Financial:** Still solar energy sector is not very competitive, the demand is way high than the supply. It makes solar appliances more costly and when government will think of changing whole traditional grid system into the solar electricity supply system, definitely a small change of price will cost massive amount of money.

## **5.3 Recommendations**

### **5.3.1 To the industry**

The industry should be always innovative and creative. Today's best may become tomorrow's worst. The solar energy industries have a very bright future, as the world wants to change the ways of energy production. One should not surprise if he will see electricity as the life line of the human. New innovations are highly based on electricity.

As the consumption of electricity grows, the demand of solar appliances will also grow. The industry needs to make it more affordable by developing new production processes, so that the very last person of the world can be benefited from this very advantageous approach.

### **5.3.2 To the Academia**

The academia should find new ways to make the decentralisation acceptable everywhere. As limitations have stated in the last section, the solution of such root problems will encourage everybody to participate in the development of the new world.

The academia can also figure out possible ways to discover the world of renewable energy. They can mainly focus on solar electricity if they are working on the context of India.

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## APPENDIX A

1. Does rural electrification generate additional productivity, higher income, greater employment and structural change in rural areas? Does it contribute to greater regional equity and reduce excessive migration to urban areas?
2. How does rural electrification fit into a broader strategy of rural development? What complementary conditions or inputs make for success or failure? Can one rank the complementary conditions and inputs in order of importance and evaluate their relative importance to rural electrification itself?
3. What are the effects of rural electrification on “equity” in development for example, in providing benefits to different income classes or in widening opportunities for small farmers, landless agricultural workers, and artisans? How does rural electrification affect the role of women and children?
4. What are the benefit-cost ratios of rural electrification (a) in financial and (b) social terms?
5. What are the most effective types of rural electrification policies and strategies to maximise the overall benefit-cost ratios (including priorities in selection of project areas, subsidies, and tariff structure)?
6. Does central grid electrical service for rural areas more effective compare to decentralised forms of electricity/energy production, including solar, biogas and other forms of energy? How?
7. How do different rural electrification policies affect the impact and implementation of rural electrification in various cities of Gujarat?