Chapter 3

Research Methodology & Data Analysis

3.1 Introduction

This chapter has been divided in two parts. In first part of the chapter, researcher has discussed about the methodological approach adopted for achieving the objectives conversed in last chapter. The chapter initially focused on the research philosophy, research design, target population, sample size and sampling design, data collection method, structure of questionnaire, scale formation and research quality. Further it also gives insight for the case study approach including triangulation, coding, within case and cross case analysis adopted in the study. The later part of the chapter highlights the data analysis and findings with the help of statistical tools used for analysis.

3.2 Research Philosophy

A research philosophy is basically a world-view / stance which is, "a basic set of beliefs that guide actions" (Creswell, 2009). The research philosophy helps the researcher to shape the research study, as to how one should carry the research study and how to gather effective data for further analysis and interpretation (Saunders, Lewis, & Thornhill, 2007). It is useful to know different research paradigms as one proceeds with discussions on methodological issues. There are different terminologies by different authors to explain research philosophies such as paradigms (Guba & Lincoln, 2005); epistemologies and ontologies (Crotty, 1998) or broadly conceived as research methodologies (Neuman, 2007).

The present research study have its place in the field of business and management, where there are often four main research world views (paradigms) which are post-positivism, constructivism, advocacy or participatory and pragmatism (Creswell, 2009). The table 3-1 shows the different paradigm along with underlying difference between them.

Table 3-1 Four Worldviews (adapted from Creswell 2007)

Postpositivism	**Constructivism**
• Determination • Reductionism • Empirical Observation • Theory Verification	• Understanding • Multiple Participants meanings • Social and Historical construction • Theory generation
Advocacy/Participatory	**Pragmatism**
• Political • Empowerment Issue-oriented • Collaborative • Change-Oriented	• Consequences of Action • Problem-centric • Pluralistic • Real World practice oriented

3.2.1 Pragmatism

The theoretical philosophy adopted to conduct this research study is pragmatism. It is understood as "debunking concepts such as 'truth' and 'reality' and focuses instead on 'what works' as the truth regarding the research questions under investigation" (Tashakkori & Teddlie, 2003). The theory of pragmatism is seen as a means of bridging the gap between the empirical singular scientific approach to research and the newer "freewheeling" inquiry of qualitative research theories (Tashakkori & Teddlie, 2003). In simple words pragmatism highlights the reasonable link between the two paradigms of inquiry; quantitative and qualitative so it becomes more appropriate to decide on such a worldview to conduct this research.

The pragmatism helps the researcher to focus on the significance of the research study along with the research questions to be answered along

with various data collection methods used during the research study (Creswell, 2009). Henceforth the researcher uses pragmatism for unpinning this study, which is most appropriate to this research as it uses mixed method design, which is best suited, to achieve the objectives of the study. Few reasons to support pragmatism are (Creswell, 2009):

- It gives the researcher a freedom of choice to choose the appropriate methods, techniques and procedures which can best answer the objectives of the study.
- Pragmatism applies to mixed methods research, which uses quantitative as well as qualitative methods to achieve the objectives of the research.
- Pragmatists do not see the world as an absolute unity. In mixed methods also researchers apply many approaches for collecting and analyzing data rather than applying only one method (e.g., quantitative or qualitative).
- Truth or assumptions in research are not based in a duality between reality independent of the mind or within the mind. Thus, in mixed methods research, investigators use both quantitative and qualitative data because they work to provide the best understanding of a research problem.

Therefore the theoretical philosophy adopted by researcher is pragmatism for this research study, as it opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis.

3.3 Research Design

Creswell and Plano Clark (2008) explain research design as "procedures for collecting, analyzing, interpreting, and reporting data in research studies".

3.3.1 Mixed Method Design

Mixed method design is a method to collect, analyze through quantitative and qualitative data at different or same stages of research. Mixed method is conducted to understand a research problem more completely (Creswell, 2009). Under the mixed method design both quantitative and qualitative methods complement each other and allow the researcher to have for in-depth analysis (Greene, Caracelli, & Graham, 1989), (Tashakkori & Teddlie, 2003). Thus mixed method design, combines quantitative and qualitative data collection techniques and analysis procedures as well as combining quantitative and qualitative approaches at different phases of the research (Saunders, Lewis, & Thornhill, 2007).

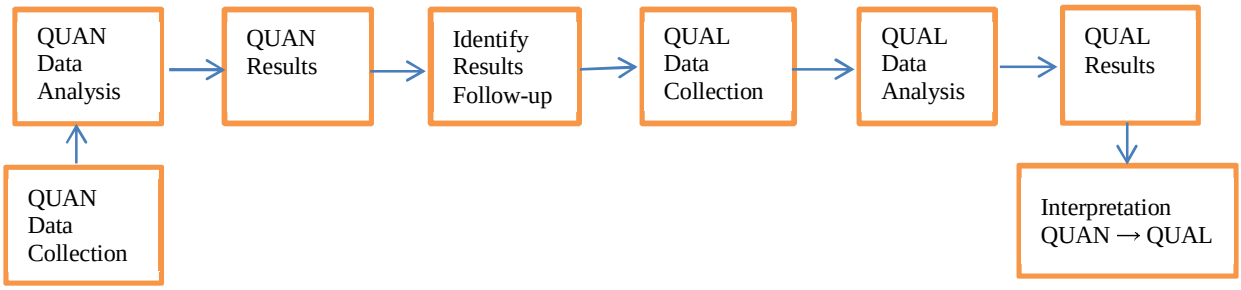
There are majorly six types of mixed method designs namely-

- Sequential Explanatory design,
- Sequential Exploratory design,
- Sequential Transformative design,
- Concurrent Transformative Design,
- Concurrent Embedded Design,
- Concurrent Transformative Design.

Sequential Explanatory Mixed Method Design has been chosen in this study as the research is conducted in two phases. This method is explained in the following section.

3.3.1.1 Sequential Explanatory Mixed Method Design

Sequential Explanatory Mixed Method Design is adopted for conducting the study as it conducts survey in first phase to identify the factors and thereafter, followed by interviews in the second phase. Through this design the researcher has collected the quantitative data followed by the qualitative data. In order to achieve the study objectives researcher conducted the study in two phases where the qualitative data build on the initial quantitative results (Creswell, 2009). The flow chart 3.1 explains the different phases of the study as per sequential explanatory mixed method design.



Flow chart 3-1: Sequential Explanatory Mixed Method Design for the current study

3.4 Quantitative Study

The researcher has identified 57 variables through literature survey, which were confined to 34 variables. This confinement was done with the help of semi structured interview conducted with industry experts having a vast

experience and exposure in the field of solar energy. The questionnaire was designed on the basis of validated 34 variables, in an attempt to identify various challenges and barriers that impact the growth of grid connected solar PV installations in India. The following sections discuss target population, sampling frame, design and size for collecting responses on the 34 variables through survey method.

3.4.1 Target Population

The target population for survey includes the organizations or individuals associated with solar energy sector in the country. The focus was on grid connected solar PV power plants.

3.4.2 Sampling frame

The respondents who had stake in grid connected solar PV in India were identified as part of sampling frame. These participants can be associated directly or indirectly with the promotion of grid connected solar PV in the country. These identified stakeholders include solar PV manufacturers, policy makers, R&D institutions, project developers, consultants, academia, solar PV industry associations, regulatory agencies, financial institutions, EPC contractors, independent power producers and thought leaders in solar energy sector.

3.4.3 Sampling design

Quota sampling design is used for collecting the data from field. Quota sampling is a non-probability sampling design. In a quota sample, quotas are set up according to some specified characteristics and then investigator selects a certain number of sampling units from these quotas. Within the

quota the selection of sample items depends on personal judgment / convenience. For the current research the population was initially divided into different category like solar PV manufacturers, policy makers, R&D institutions, project developers, consultants, solar PV industry associations, regulatory agencies, financial institutions, EPC contractors, thought leaders etc., and then from each category a number of predetermined respondents were selected by convenience approach. The figure 3-2 shows the sample distribution for the study.

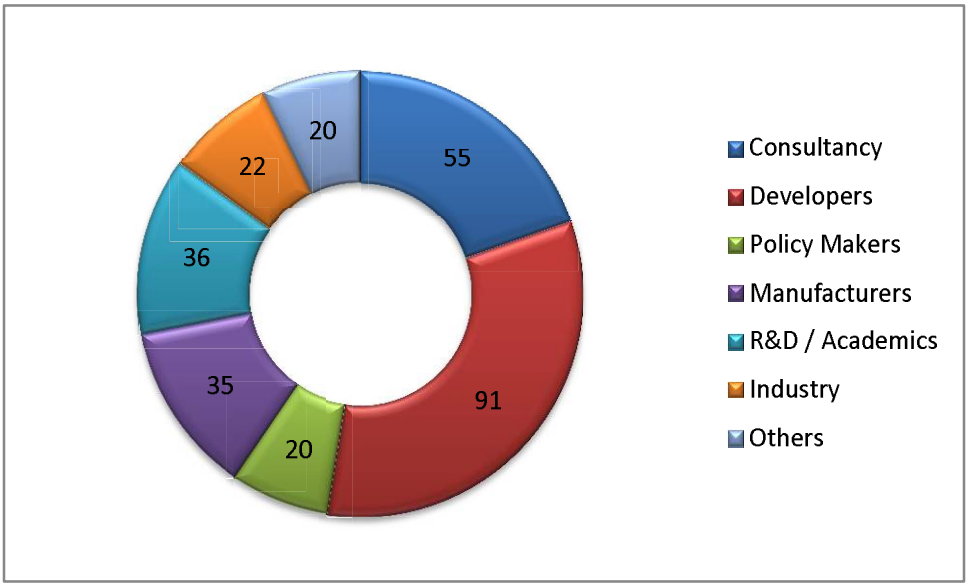


Figure 3-2 Sample distribution

3.4.4 Sample Size

The sample size required for this research study is obtained through Yamane's formula (Yamane, 1967). The formula is given as:

$$n = \frac{N}{1 + N.e^2}$$

n= Sample size needed

N = Size of the population

e= Level of precision (.05 at 95% confidence level)

Overall 900 people were identified as target population for the survey, those who were associated with solar PV energy in India. On applying Yamane's formula researcher arrived at the sample size of 258 where N = 900 and e= 0.05.

Formerly the questionnaire was sent to 550 respondents via mail and personal contacts, out of which a total of 320 responses were received. There were few incomplete responses which were removed from the list. Finally, 279 responses were considered for data analysis with a response rate of 51%. As a general norm, a specific ratio of responses is required for each variable in order to conduct factor analysis likewise 5:1 (Hair, Black, Babin, Anderson, & Tatham, 2008); 8:1 (Malhotra & Satyabhushan, 2011). Accordingly this survey consisted of 34 variables, requiring 272 responses. The minimum criterion was successfully fulfilled for conducting this study with a total of 279 responses on 34 variables.

3.4.5 Data collection Method

3.4.5.1 Survey

Survey is a technique for collecting primary data, mostly used for quantitative research. It is used to collect large sample size and develop statistical relationships. This technique relates to the studies which have a deductive approach used for exploratory and descriptive research. It is commonly used to answer questions like what, where, how much and how many (Saunders, Lewis, & Thornhill, 2007). Hence survey technique has been found most suitable for achieving the first objective of the study i.e.

1. To identify various challenges and barriers that impact the growth of grid connected Solar PV installations in India.

3.4.5.2 Questionnaire structure

Questionnaire survey is a highly structured data collection technique in which same set of questions are asked to the different respondents (Vaus, 2002). Questionnaire is basically a printed list of questions that respondents are asked to answer (Goddard & Melville, 2006). The questionnaire initially inquired the respondent's basic information followed by 34 questions specified for each variable identified in the study (Annexure 3). The questions were further divided into five sections on the basis of logical segmentation and clarity. At the end of the questionnaire respondents were asked to express their views under the heading "*your suggestions"*. The table 3-2 shows categorization of questions with a list of number of questions asked under each category.

The responses were collected on a five point Likert scale [*'1' as Not at all significant barrier* to *'5' as Very significant barrier*] (Vagias & Wade, 2006). The language in the questionnaire was tailored to the level of understanding of the respondents. The researcher made sure that wording of questions was precise, clear, concise and unambiguous (Bell, 1993). These sections were developed to keep the similar questions together and easier to be understood by the respondents.

Table 3-2 Categorization of sections in the questionnaire

Section	Category	Number of Questions
Section 1	The section covered the problems related to Cost incurred for developing a Solar PV Power Plant (Grid Connected) at different stages	5
Section 2	This section cover the problems faced at the	12

	Industrial & institutional level like, State Nodal Agencies, Financial Institutes, Data Centre, Manufacturing Units, Market Eco-System	
Section 3	This section covered the problems related to Infrastructure like Land & associated issues, Grid availability.	7
Section 4	This section covered the problems related to Regulations at National & State level	5
Section 5	This section covers the problems related to Government Policies, Political presence, Clarity in policies at different levels	5
Section 6	Your Suggestions	Open ended

3.4.5.3 Scale formation

Likert scales are non-comparative scaling techniques and are uni-dimensional (only measure a single trait) in nature. Respondents were asked to indicate their level of agreement with a given statement on an ordinal scale (Bertram, 2012). The scale used in this study were *Not at all significant barrier, Not so significant barrier, Neither significant nor insignificant, Quite significant Barrier, Very significant barrier [1 for Not at all significant barrier and 5 for Very significant barrier]* (Vagias & Wade, 2006).

3.4.5.4 Questionnaire Piloting

Hussey and Hussey (1997), describes that a questionnaire should be piloted before final execution of the survey. In addition to this, Hoinville and Jowell (1978) states that a good questionnaire is created after the process of piloting and not only on researcher's perspective. The important aim of piloting is to increase the reliability, validity and practicality of the questionnaires (Aldridge & Levine, 2001).

Hence the questionnaire was piloted with industry experts who had vast experience in the field of solar energy. Participation was also sought from developers who were having experience in executing grid connected solar PV power plants in India. The questionnaire was circulated to 30 experts' to which responses were received and it was further checked for reliability and validity of the questionnaire. Analyses from pilot questionnaire surveys showed that the factors were appropriate for use of survey.

3.4.5.5 Information sort

The list of variables identified through literature survey was presented to respondents in form of questions (statements). The respondents were asked to select from five options (based on a five point Likert scale) for a particular variable depending upon its significance to grid connected solar PV power plants in India.

3.4.5.6 Methods of Administration

The responses were collected via personal contact and through email. Specifically, the top management was contacted personally to discuss the questionnaire. Therefore some of the responses were collected through personal visits to the stakeholder's offices and workplaces. A number of responses were also collected via e-mail[13]. The questionnaire was e-mailed with a brief introduction about the researcher's background and research objective. An intense follow up was done through telephone or mail in order to get the questionnaires filled online. Researcher confirmed with respondents whether they were within the right population and ready to participate. This communication with potential respondents before final

[13] *The questionnaire was designed on Google docs*

questionnaire distribution was found very effective in increasing the response rate.

3.4.1 Data analysis

Critical Factors were extracted for each category using a principal component factor analysis, employing Varimax factor rotation with the help of SPSS 16 software. Factor Analysis has been explained in detail in section 3.6.1.

3.4.2 Research Quality

3.4.2.1 Convergent validity

Convergent validity is established when the scores obtained by two different instruments measuring the same concept are highly correlated. For convergent validity, Variance Explained should be 0.5 or greater to suggest adequate convergent validity (Hair, Black, Babin, Anderson, & Tatham, 2008). Almost 64% of the variance is explained by the 9 factors identified (as shown in figure 3-3). Here, all factors with Eigen values exceeding one were considered which also confirms the convergent validity (Hair, Black, Babin, Anderson, & Tatham, 2008).

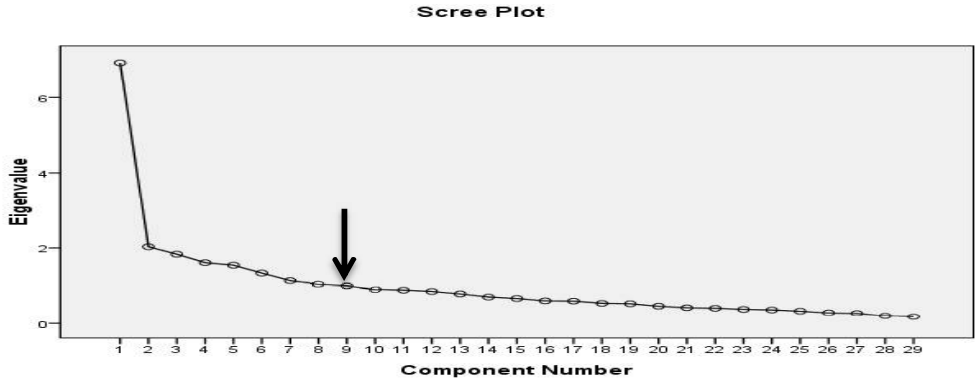


Figure 3-3 Scree Plot showing the Eigenvalue for 9 factors

The Kaiser-Meyer-Olkin (KMO) output ensures the sampling adequacy and Bartlett test of Sphericity score was significant at 0.05 levels (as shown in Table 3-3), thereby rejecting the null hypothesis that the variables are independent of each other and in a particular category the variables are correlated, which is a necessary condition to proceed with factor analysis.

Table 3-3 KMO and Barlett's Test

KMO and Bartlett's Test				
S. No.	**Test Statistics**		**Results**	**Interpretation**
1	Kaiser-Meyer-Olkin Measure of Sampling Adequacy (MSA)		0.815	**Significant**
2	Bartlett's Test of Sphericity	Approximate Chi-Square	2742	
a		Degree of Freedom	406	
b		Significance	0	**Significant**

3.4.2.2 Discriminant Validity

Discriminant validity is established when, based on theory, two variables are predicted to be uncorrelated, and the scores obtained by measuring them are indeed empirically found to be so. In simple words, one can easily distinguish between constructs that are not similar to each other. For, discriminant validity, no cross loadings of factors should take place for Discriminant validity (Hair, Black, Babin, Anderson, & Tatham, 2008). It was seen that there was no cross loading of factors in the given rotated component matrix shown in Annexure 4.

3.5 Qualitative Study

After the identification of leading barrier and challenges researcher went in to the field to collect data by conducting interviews with identified stakeholders (in Gujarat and Rajasthan), which assisted the researcher in developing case studies for Gujarat and Rajasthan. The following section explains case study method, case study design, data collection method and case analysis method.

3.5.1 Case Study

Robson (2002)defines a case study as "A strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence". Case study methods are the preferred strategy when a research work ask for 'how' or 'why' questions, when the researcher has a little control over events, and when the focus is on the contemporary phenomenon within real-life context (Yin, 2003)

Case study strategy was adopted to achieve the second objective of this study-

2. To find out how the State(s) of Gujarat and Rajasthan have responded to the role of identified leading barriers and challenges for the growth of grid connected Solar PV installations in their respective regions.

3.5.2 Case Study Design

Under the case study design researcher discusses number of cases, unit of analysis, selection criteria for cases (Yin, 2003). The two important aspects of case study design are

- Case study protocol
- Data collection process.

The Case study protocol contains the instrument and the procedures and general rules that should be followed in using the instrument. In addition to increasing the reliability, the case study protocol prompts the investigator what the case study is about and helps the investigator to carry out the same (Yin, 2003). There are three major components included in the case study protocol: purpose, key features of the case study method, and the organization of the protocol. The organization of the protocol outlines the procedures of how to carry out the field visits, design case study questions and the analysis plan (Annexure 5).

3.5.2.1 Unit of Analysis

Case study research focused on a State (Gujarat and Rajasthan) as a single holistic unit of analysis. A State is defined as one of a number of areas or

communities having their own governments and forming a federation under a sovereign government.

3.5.2.2 Number of Cases

In order to adopt a case study method, it is necessary to make a choice between a single and a multiple case study design. The single case study design helps to represents a critical case in testing a well formulated theory, or a unique case or a revelatory case (Yin, 2003). None of the mentioned conditions applies to the current research study. Furthermore, as per the study's research questions and objectives, researcher was inspired to go for multiple case study design (Gujarat and Rajasthan). In multiple case studies, each case serves a specific purpose within the overall scope of inquiry (Yin, 2003). The selection of case studies should follow 'replication' logic in order to be able to compare findings from multiple cases (Yin, 2003). Replication logic helps in presenting and explaining the similar and contrasting results (giving predictable reasons). Moreover the replication logic helps to increase the external validity of research (Eisenhardt, 1989; Yin, 2003).

3.5.2.3 Selection of Cases

The selection of cases was based on the total generation capacity installed through grid connected solar PV power plants in a state. The maximum generation capacity installed through grid connected solar PV power plants was found in the state of Gujarat followed by Rajasthan. The final selection of the two cases was made on practical considerations.

- Case Study 1: Gujarat
- Case Study 2: Rajasthan

3.5.3 Data Collection Method

Case study research involves gathering of evidence from a variety of sources: documents, archival records, questionnaires, interviews, observations and physical artifacts (Eisenhardt, 1989; Yin, 2003). The validity of a study is increased through triangulation of data collected from multiple sources and it also allows for an in-depth study of a phenomenon from different angles. The interviews gave insightful information of who did what, when, and why, as these information were documented into knowledge, experience, opinions, and feelings of the interviewees. Further the audio recordings of meetings and interviews were transcribed for data coding and analysis purposes. ATLAS.ti 7.1 (Build 3) - software was used for qualitative data analysis. The contents of the interviews were coded in accordance with a coding scheme. The coding process was repetitive, and rigorous. Interpretation of the coded data was a three-step process, data selection and presentation, within-case analysis, and cross-case analysis.

The collection of data for the study was collected between March 2013 and July 2013. The researcher contacted prospective participants via email and telephone. During the telephonic interaction with the participants, brief outline of research was discussed along with factors affecting the promotion of grid connected solar PV power plants in India. The criteria for inclusion/exclusion of participants were addressed at this point to ensure that they were eligible for the interview before a meeting was arranged.

It is often difficult for people to find out time out of their daily routine work, so considering all the possibilities the arrangements were made with participants willing to participate as per their convenience and availability. The researcher agreed to meet the participants at their preferred place as

per their convenience. Letters confirming these arrangements were sent to all participants prior to the first face to face meeting (Annexure 6). The data collection mostly occurred in participant's office.

The researcher also went through observation process by spending full one day visit to plant site in Phalodi district in Rajasthan where a 17 MW grid connected solar PV power plant is installed. Researcher was fortunate enough to spend quality time and interact with Plant manager and site engineers to gain ground level experience on plant operations and technology performance. The visit also helped researcher to gain insight on the experiences of employees, during construction phase of the plant. The second opportunity availed by researcher, was one day visit to Gujarat Solar Park in Charanka district in Gujarat, which is Asia 1st Solar Park. The researcher had interactions with officials and gained valuable insights on implementation of solar park. Further, researcher accessed documents such as, gazette orders by the regulators of state and central government, policy documents, reports by various organizations etc.

3.5.3.1 Triangulation

Tashakkori and Teddlie (2003) define triangulation as "the combinations and comparisons of multiple data sources, data collection and analysis procedures, research methods, and/or inferences that occur at the end of a study". The various methods of data collection provide diverse perspectives and produce data that potentially inherited weaknesses regarding the overall aims of a particular research and/or practical obstacles the researcher may encounter (Denscombe, 2003). As mentioned in the previous section data was collected through interviews, documents and observations which resulted in fulfilling the criteria for Triangulation.

3.5.3.2 Interviews

Interviews with participants were conducted over a period of five month period from March 2013 to July 2013 as shown in table 3-4. The interviews were semi-structured and open-ended based on interview guides. The interviews were built on two interviewing strategies, first being through interview guide approach (Patton, 2002), and second being the informal conversational interview, "questions emerge from the immediate context and are asked in natural course of things" (Patton, 2002). Semi structured interviews helped researcher in increasing validity and reliability and reducing the chances of biasness in research (Eisenhardt, 1989; Yin, 2003). The interviews were recorded and transcribed in accordance with confirmation of participants interviewed, along with follow-up questions.

Table 3-4 Steps in data collection during interviews

S.no	Steps in collection	Gujarat	Rajasthan
1	Initial contact and arrangement	February 2013	February 2013
2	Visit	March – April 2013	May – June 2013
3	Review of case report for internal validity	March – April 2013	May – June 2013
4	Additional data collection	July 2013	July 2013
5	Total number of interviews	7	7

3.5.3.3 Documents

The researcher's primary purpose in reviewing documents was to study the state of Gujarat and Rajasthan power sector scenario, renewable energy sector specifically the growth of grid connected solar PV sector growth. To gather necessary information, researcher extensively reviewed all documents with regards to the solar PV energy. Documents for review

comprised many types of documents such as solar PV projects implementation reports, national and federal solar missions, sector development reports, national and federal regulation and power sector regulations.

3.5.3.4 Coding

Coding is a process of organizing the material into chunks or segments of text before bringing meaning to information (Rossman & Rallis, 1998). The process of coding involves categorizing the collected data (interviews, documents, images or text), labeling the categories with a word or term known as code which mostly resembles the term used in actual language of participant or document (Creswell, 2009). The current study uses recorded interviews, official brochures, policies and regulation documents, reports, which were coded with the help of Atlas.ti 7.1 (Build 3) software. This software facilitated the analysis process by helping in coding, linking codes and text segments, creating memos, searching, editing and reorganizing, and for visual display of data and findings (Miles & Huberman, 1994; Weitzman & Miles, 1995; Creswell, 2009). The figure 3-4 shows an example of coding from the current study.

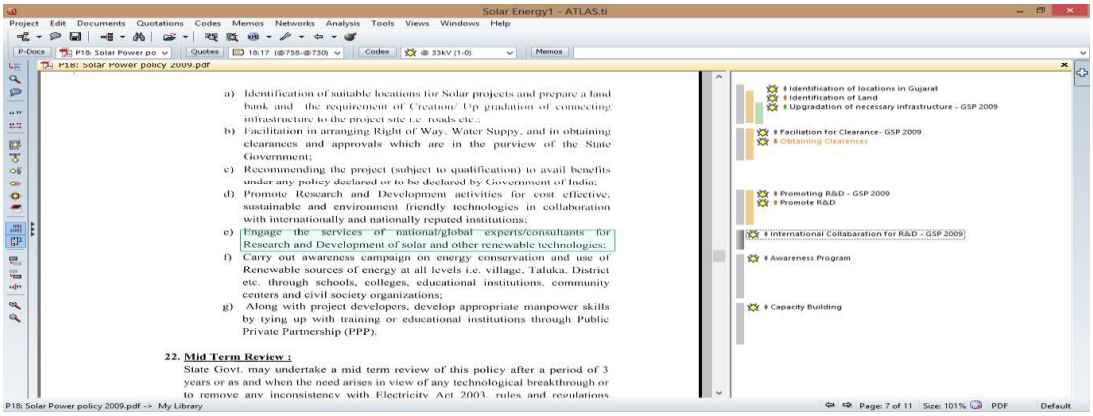


Figure 3-4 Process of Coding through Atlas.ti

3.5.4 Case Analysis Methods

The researcher uses both within-case analysis and cross-case analysis to provide a detailed analysis; a combination of the two approaches can help to counteract information-processing biases and keep research away from "premature and even false conclusions" (Eisenhardt, 1989).

3.5.4.1 Within-case analysis

Within-case analysis leads to detailed write ups for each site in the form of respective case study. This method of in-depth study helped the researcher to manage the volume of data during data collection (Eisenhardt, 1989). The practice of in-depth analysis helped the researcher to become familiar with each case individually, documenting it and organizing the data for specific cases (State). In this research, all semi-structured interviews were recorded along with extensive hand written notes taken during the interviews. The transcripts along with secondary data were the sources for case study findings. All the data collected during the interviews either through recording and hand written notes, were analyzed through a coding process. There were several interviews conducted from each state and a comparison across different respondents from the same state was carried out, which helped the researcher to better understand the response of the State (Gujarat and Rajasthan) on the role the identified barriers and challenges for grid connected solar PV in that State. This process facilitated the researcher to develop the strong base for the cross case analysis.

3.5.4.2 Cross Case analysis

Cross case analysis is defined by (Eisenhardt, 1989) "select pairs of cases and then to list the similarities and differences between each pair". In the study, after reviewing each case individually, through within case analysis, the researcher conducted the cross case analysis as the second phase of data analysis, by comparing the findings for the different states.

3.5.5 Research Quality

In evaluation of the quality of any case study research, two broad characteristics need to be determined: Validity and Reliability.

Validity is characterized as construct validity, internal validity, and external validity/generalization. Since the present research study is an explanatory and descriptive in nature, and does not intend to investigate casual relationships, therefore internal validity (Gibbert, Ruigrok, & Wicki, 2008) is not found relevant for discussion here. Furthermore the following section discusses how the construct and external validity is achieved for the present study.

3.5.5.1 Construct validity

Yin (2003) defines construct validity as "correct operational measures for the concepts being studied". This means that the construct validity needs to be considered during the data collection and composition phases (Yin, 2003). The construct validity for study was achieved through triangulation which is a technique of combining different sources of evidence in a single study. The collection of evidence from a variety of sources essentially provides 'multiple measures of the same phenomenon' (Yin, 2003) .

Researcher collected and included relevant data through various sources like interviews, documents, federal policy and regulation documents through website, artifacts and personal visits to the sites in Gujarat and Rajasthan. The interviews as well as the documents were transcribed and used in data analysis, which enhanced the construct validity by providing multiple perspectives of phenomena.

3.5.5.2 External Validity

External validity, also known as 'generalizability', as discussed by Yin (2003) it requires that a study's findings should be generalizable beyond the immediate case study. The design of multiple case studies and cross-case analysis were undertaken according to replication logic, which is the same as that which underlies the use of experiments and allows researchers to generalize from one experiment to another (Yin, 2003) .

3.5.5.3 Reliability

Yin (2003) discusses it as "demonstrating that the operations of a study, such as the data collection procedures can be repeated, with the same results". The goal of reliability is to minimize the errors and biasness in a study. In the present study researcher ensured consistency in applying procedures for data collection and analysis. Firstly, the case study protocol was used to guide the research process. Secondly, interviews were taped and transcribed to reduce the instances of forgetting or misunderstanding the data which allowed for an independent data analysis Third, use of Atlas.ti qualitative software allowed systematic and consistent analysis of qualitative data (Weitzman & Miles, 1995) and increased the reliability of research because the procedures can be repeated (Yin, 2003).

3.6 Data Analysis

This section deals with analysis of the data which includes checking the validity of the questionnaire using Cronbach's alpha, conducting a factor analysis using the SPSS tool to identify the underlying structure of the data.

As already discussed in previous section 3-4, that researcher has identified 57 variables through literature survey and then confines these variable in to 34 with the help of semi structured interview conducted with industry experts having a vast experience and exposure in the field of solar energy. The questionnaire was designed by using these 34 variables to identify the leading challenges and barriers that impact the growth of grid connected solar PV installations in India.

The questionnaire's scale reliability was checked by using Cronbach's Alpha (statistical tool). As per the definition by Nunnally (1978), an alpha value (α) of 0.70 and higher is often considered the criterion for internally consistent established factors (Hair, Black, Babin, Anderson, & Tatham, 2008). Cronbach's alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach's alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale. The table 3-5 shows the results of Reliability Statistics.

Table 3-5 Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	*No. of Items*
0.890	34

As the value of Cronbach's alpha coefficient is above 0.89 and is closer to 1 which means that the scale is highly reliable and has greater internal consistency of the items in the scale.

The Kaiser-Meyer-Olkin (KMO) measures the sampling adequacy, for the appropriateness of factor analysis. This test confirms that Factor Analysis should be further progressed for extraction of factors. The Bartlett test of sphericity is a statistical test for the presence of correlations, as it compares the correlation matrix with a matrix of zero correlations. Measure of Sampling Adequacy (MSA) value of above 0.6 can is considered to be significant. Similarly the Bartlett's Test of Sphericity value should also be significant (i.e. the significance value should be 0.05 or smaller) and the value of KMO statistic greater than 0.6 is considered to be adequate (Kaiser & Rice, 1974). The results for KMO and Bartlett's Test are shown in table 3-6 (sample size of 279) which support the factorability of the correlation matrix.

Table 3-6 Results for KMO and Bartlett's Test

S. No.	Test Statistics	Results	Interpretation
1	Kaiser-Meyer-Olkin Measure of Sampling Adequacy (MSA)	0.815	**Significant**
2	Bartlett's Test of Sphericity	0.00	**Significance**

3.6.1 Factor Analysis

The questionnaire was sent to various stakeholders of grid connected solar PV in India and 279 valid responses were received. These responses were fed into the SPSS tool for factor analysis wherein all the 34 variables loaded on 9 factors.

The main aim of conducting factor analysis is to reduce the data to smaller number of factors which can explain the whole set of variables are under observations. The reduction of the data critically depends on the number factors extracted. If the numbers of factors extracted are larger, then it can cause difficulties in interpretation of the results whereas on the other hand the lesser number of factor extracted can cause in loss of important information which can be very vital for the study conducted. It can even divert the main aim study being investigated. For conducting the analysis, criteria of eigenvalues, percentage of variance explained criteria, Scree Test criteria, were combined and used to determine the appropriate number of factors, as suggested by Pallant (2007) and Hair et al. (2010).

Factor extraction determines the smallest number of factors that best represent the interrelations among the factors being observed (Pallant, 2007). Statistical Package for Social Sciences (SPSS) provides several techniques for factor extraction, namely, principal component, principal factors, image factoring, maximum likelihood factoring, alpha factoring, un-weighted least squares and generalized least squares. The choice of technique depends on the purpose of analysis. This study aims to explore the barriers and challenges that impacts the promotion of grid connected solar PV power plants in India. Accordingly principal component was preferred also as it is the most popular technique and set as the default technique in the SPSS system, PCA was used as the factor extraction technique.

As the value of KMO statistic is greater than 0.6 the sample size is considered to be adequate and the appropriateness of factor analysis is ensured.

Furthermore Exploratory Factor Analysis (EFA) and Principal Components Analysis (PCA) are used to represent a large number of relationships among variables in a simpler way.

The conceptual difference between EFA and PCA is that in EFA the variables under observations are transformed into smaller set of unobserved constructs or latent variables, whereas in PCA one tries to mathematically derive a relatively small number of variables to convey as much information as in the observed/measured variables as possible (Leech, Barrett, & Morgan, 2005). Hair et al, (2008) states that when an investigator goes for data reduction, PCA is the most appropriate technique. Here the researcher seeks to reduce the data to identify key determining factors through PCA, which is often used as a data reduction method (Hair, Black, Babin, Anderson, & Tatham, 2008; Pallant, 2007).

For factor rotation the researcher employed Varimax rotation, as it helped the researcher in finding a clear and meaningful factor grouping. The purpose for employing Varimax rotation was to find the independent common key factors that impact the promotion of the solar PV power plants in India. Hair et al. (2010) explains that factor rotation is an important step to improve the factor patterns and help to interpret the result of factor analysis.

Eigenvalue was employed as it has the advantage of simplicity and objectivity. Hair et al. (2010), states that if the number of factors are in the range of 20-50, factors with eigenvalues greater than 1 should be retained as they are regarded as significant. The researcher has gone ahead with the default selection of eigenvalue greater than 1 for the analysis to get suitable number of factors.

3.6.2 The significance of factor loadings

Factor loading is the correlation between a measured variable and its factor (Hair, Black, Babin, Anderson, & Tatham, 2008). These factor loadings help in deciding which factors should be fused into which comprehensive factors (Field, 2005), as they are the means of interpreting the role of each variable in defining the factors. Hair et al. (2008), suggests that the higher the loadings, the more important the factors are in interpreting the result. According to Hair et al. (2008) factor loadings from ±0.30- ±0.40 are considered to meet the minimal level for interpretation, factor loadings of ±0.50 or greater are practically significant.

The criteria of statistical significance of factor loading accepted for the current study is ±0.50 and greater. The results of factor analysis with 34 variables are shown in Table 3-7 shows the Factor Loading for 34 variables the factor loadings are more than 0.49. This indicates that the extracted factors are reliable significant for the study.

3.6.3 Factor Loading and Results

The factor loadings in Table 3-6 show that the variables V3, V5, V10, V20 and V24 are having lower loadings (below ± 0.50), hence the 5 variables were omitted. Further the percentage of the total variance explained by the 34 variables was 59.438%.

Table 3-7 Factor loading for 34 variables

	1	2	3	4	5	6	7	8	9
V1	0.016	-0.025	0.064	-0.009	-0.05	0.018	0.745	0.069	0.075
V2	0.152	-0.016	-0.047	0.057	0.079	0.027	0.763	0.002	0.086
V3	0.054	**0.394**	0.023	0.071	-0.071	-0.098	0.416	0.171	0.359
V4	0.048	-0.017	0.063	0.123	0.224	-0.029	0.11	0.07	0.787
V5	0.076	0.184	0.015	-0.106	0.028	0.022	**0.388**	0.219	0.41

V6	-0.192	0.226	0.055	0.262	0.595	0.217	-0.039	0.083	0.108
V7	-0.018	0.197	-0.02	0.034	0.637	-0.15	0.016	0.245	0.282
V8	0.137	-0.006	0.095	0.205	0.647	0.06	0.075	0.042	0.133
V9	0.264	0.142	-0.042	-0.046	0.686	-0.048	0.028	0.164	-0.161
V10	-0.077	0.14	0.251	0.274	0.226	0.067	**0.474**	0.101	-0.256
V11	-0.017	-0.077	0.114	0.149	0.149	0.135	0.207	0.621	0.053
V12	0.091	0.057	0.092	0.21	0.241	-0.112	-0.022	0.598	-0.007
V13	0.066	0.236	0.083	-0.102	0.038	0.105	0.072	0.656	0.118
V14	0.082	0.668	0.151	0.03	0.015	0.199	0.057	0.184	-0.041
V15	0.123	0.714	0.102	0.139	0.18	0.21	0.029	0.029	-0.011
V16	0.083	0.726	0.122	0.1	0.226	-0.043	-0.09	-0.145	0.041
V17	0.248	0.589	0.076	0.126	0.024	0.081	0.102	0.12	0.18
V18	0.035	0.195	0.126	0.183	0.044	0.807	0.02	0.055	-0.038
V19	0.119	0.148	0.119	0.224	-0.017	0.818	0.043	0.063	-0.009
V20	**0.487**	0.255	-0.154	0.368	0.135	0.255	0	0.093	-0.088
V21	0.145	0.148	0.096	0.788	0.065	0.24	0.053	0.052	0.024
V22	0.286	0.012	0.13	0.662	0.174	0.16	0.036	0.044	0.144
V23	0.159	0.292	0.21	0.64	0.104	0.06	0.052	0.114	0.008
V24	0.171	**0.43**	0.167	0.344	0.098	0.064	0.008	0.18	-0.105
V25	0.604	0.021	0.1	0.242	-0.028	-0.098	0.182	0.178	-0.013
V26	0.603	0.111	0.205	0.147	-0.062	-0.196	0	0.092	-0.16
V27	0.56	0.289	0.085	0.314	0.086	0.169	0.091	-0.156	0.159
V28	0.569	0.235	-0.036	0.157	0.133	0.146	0.062	-0.122	0.274
V29	0.534	0.144	0.234	0.035	0.007	0.27	-0.068	0.28	0.202
V30	0.587	0.088	0.39	-0.044	0.362	0.155	0.044	-0.081	0.041
V31	0.519	0.077	0.547	-0.126	0.336	0.174	0.071	0.017	-0.048
V32	0.248	0.252	0.579	0.115	0.101	0.102	0.139	0.06	-0.217
V33	0.104	0.13	0.81	0.202	-0.069	0.038	0.069	0.103	0.113
V34	0.083	0.14	0.808	0.154	0.016	0.1	-0.052	0.167	0.104

As discussed by Hair et al. (2008) the purpose of percentage of variance criterion is to ensure achieving a specified cumulative percentage of total variance extracted by successive factors. He further suggests that it is common to consider a solution that accounts for 60% of total variance as satisfactory due to less precise information in social sciences.

The researcher conducted the analysis after removing those five variables wherein he found that the total variance explained increased to 63.868%. The total variance explained by the 9 factors extracted is 63.868% which satisfies the condition (Hair, Black, Babin, Anderson, & Tatham, 2008). The table 3-8 shows the total variance explained using PCA.

By the application of factor analysis, 29 identified variables were reduced to 9 major factors shown in table 3-9, which act as barriers and challenges for promotion of grid connected solar PV grid connected power plants in India are shown in figure 3-5.

Table 3-8 Total variance explained using Principle Component Analysis

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.939	23.927	23.927	6.939	23.927	23.927	2.558	8.821	8.821
2	2.031	7.003	30.931	2.031	7.003	30.931	2.352	8.111	16.932
3	1.836	6.331	37.261	1.836	6.331	37.261	2.332	8.041	24.973
4	1.613	5.563	42.824	1.613	5.563	42.824	2.25	7.759	32.732
5	1.547	5.333	48.158	1.547	5.333	48.158	2.022	6.972	39.704
6	1.34	4.622	52.779	1.34	4.622	52.779	1.963	6.769	46.472
7	1.144	3.944	56.723	1.144	3.944	56.723	1.894	6.533	53.005
8	1.058	3.648	60.371	1.058	3.648	60.371	1.649	5.685	58.69
9	1.014	3.497	63.868	1.014	3.497	63.868	1.502	5.178	63.868
10	0.909	3.136	67.004						
11	0.889	3.067	70.071						63.868
12	0.856	2.953	73.023						
13	0.791	2.729	75.752						
14	0.711	2.45	78.202						
15	0.673	2.321	80.523						
16	0.61	2.105	82.627						
17	0.604	2.083	84.71						

18	**0.545**	**1.878**	**86.588**						
19	**0.535**	**1.844**	**88.432**						
20	**0.469**	**1.619**	**90.051**						
21	**0.429**	**1.479**	**91.529**						
22	**0.414**	**1.426**	**92.956**						
23	**0.385**	**1.326**	**94.282**						
24	**0.369**	**1.273**	**95.555**						
25	**0.336**	**1.16**	**96.715**						
26	**0.291**	**1.004**	**97.72**						
27	**0.275**	**0.948**	**98.668**						
28	**0.204**	**0.703**	**99.371**						
29	**0.182**	**0.629**	**100**						

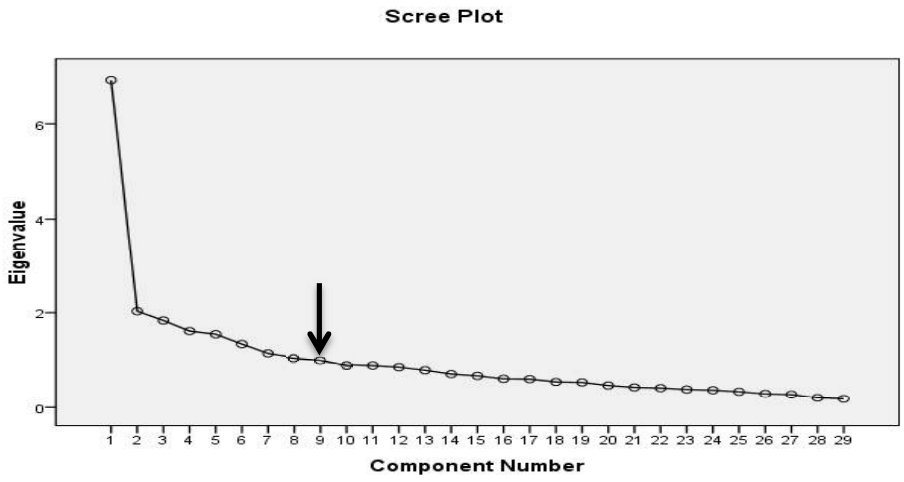


Figure 3-5 Scree plot

Table 3-9 Identified Factors as Barrier and Challenges

Variable No.	*Variable*	*Communalities*	*Factor Loading*	*Factor name*
V 14	**Inadequate encouragement by the financial institutes for Solar PV (grid connected) power plants**	**0.59**	**0.694**	***Financial Barriers***
V 15	**Difficulties in project finance availability**	**0.662**	**0.739**	

V 16	Bankability of Power Purchase Agreements (grid connected Solar PV power plants)	0.636	0.727	
V 17	Limited financial incentives for promotion of the technology related to Solar PV	0.509	0.600	
V 31	Clarity in policy guidelines at state level	0.753	0.505	***Policy and Political Barriers***
V 32	Clarity in installation planning policy at state level (regarding the solar PV power plants)	0.597	0.524	
V 33	Political instability at national level	0.814	0.849	
V 34	Political instability at state level	0.79	0.837	
V 6	Uncertainty on the reliability of the Data available	0.607	0.595	***Institutional Barriers***
V 7	Limited Research and Development activities and facilities on solar energy in India	0.63	0.655	
V 8	Interaction between universities and industry for knowledge diffusion is limited	0.507	0.642	
V 9	Limited Presence of institutions providing technical education which help in capacity building for the sector	0.614	0.687	
V 21	Lack of data on Land title	0.748	0.793	***Land Information Challenges***
V 22	Complex area zoning and planning by the Local government	0.635	0.689	
V 23	Lack of data on potential sites for solar PV (grid connected) power plants	0.594	0.646	

Variable No.	Variable	Communalities	Factor Loading	Factor name
V 4	Cost involved in transition of a Technology from development phase to commercialization phase is high	0.573	0.467	***Administrative Challenges***

V 27	**Multi-tiered government approvals**	**0.657**	**0.609**	
V 28	**License complexity due to lack of single window clearance**	**0.595**	**0.678**	
V 29	**Unequal distribution of subsidies at state level by the central government**	**0.64**	**0.595**	
V 25	**Capital cost benchmarking by the regulators for the developer**	**0.529**	**0.525**	***Regulatory Barriers***
V 26	**Reverse Bidding by the regulator**	**0.58**	**0.689**	
V 30	**Clarity in policy guidelines at national level**	**0.687**	**0.489**	
V 18	**Land Availability**	**0.759**	**0.813**	***Land Acquisition Challenge***
V 19	**Difficulties in acquiring land for solar PV (grid connected) power plant**	**0.796**	**0.828**	
V 11	**Limited presence of registered PV manufacturers in India**	**0.541**	**0.675**	***Market and Technology Barriers***
V 12	**The existence of unqualified PV manufacturers can hamper the growth of the reliable solar PV sector**	**0.551**	**0.557**	
V 13	**Present technological development of solar PV cells/ modules**	**0.561**	**0.676**	
V 1	**Requirement of Pre-installation investments for Solar Power Plant is high**	**0.694**	**0.821**	***Development Cost Barrier***
V 2	**Up-front cost (net worth of a developer) for installing solar power plant is high**	**0.674**	**0.801**	

3.7 Discussion

Factor 1: *Financial Barriers*

The factor "Financial Barrier" explains that, Banks were not encouraging in nature to promote grid connected solar PV power plants in India, developers faced difficulties in getting the project funded by the bankers,

whereas bankability of power purchase agreement (PPA) were also questioned by banks.

Factor 2: *Policy and Political Barriers*

The factor "Policy and Political Barrier" explains that, clarity in policy guidelines at state level was an issue and political instability at national level and state level created hindrance in smooth process of events.

Factor 3: *Institutional Barriers*

The factor "Institutional Barrier" explains that, there are issues of availing reliable data on radiation of specific location, moreover there is limited R&D activities and facilities and interaction between universities and industry for knowledge diffusion in the country. The factor also covers issues related to low dissemination of technical education which help in capacity building for the sector.

Factor 4: *Land information Challenges*

The factor "Land Information challenges" explains that, there is a lack of information on land title, potential sites for solar PV and how planning has been done for a zone by the government.

Factor 5: *Land Acquisition Challenges*

The factor "Land Acquisition challenges" explains that, there are difficulties in land availability acquisition for grid connected solar PV power plant.

Factor 6: *Administrative Challenges*

The factor "Administrative challenges" explains that,. There are challenges to multi-level government approvals which create complexity

and consume time. The distribution of subsidies at State level by central government is somewhat unequal for helping the sector grow at State level and similarly technological development cost for commercialization is very high.

Factor 7: *Regulatory Barriers*

The factor "Regulatory barriers" explains that, challenges related to capital cost benchmarking by regulators for the technology, the process of reverse bidding by regulator and lack of clarity in policy guidelines at national level.

Factor 8: *Market and Technology Barriers*

The factor "Market and Technology barriers" cover the issues to limited presence of registered PV manufacturers in India because of which existence of unqualified PV manufacturers can hamper the growth of reliable solar PV sector moreover the present technological development of solar PV cells/ modules is also questionable in India.

Factor 9: *Development Cost Barriers*

The factor "Development Cost barrier" covers requirement of pre-installation investments and up-front cost (net worth of a developer) for installing solar power plant.

3.8 Epilogue

This chapter has outlined the theoretical framework for the study, pragmatism, and discussed why it is particularly suited to this study. The chapter also discussed the importance a mixed methods sequential explanatory design and how it best suits the current study under

consideration. The quantitative and qualitative methods used in the study have been explored and explained, with detail given to choice of method along with consideration to attain overall research quality.

Further the chapter informs the sample size and study population in relation to the current study. The data collection method for quantitative and qualitative methods was discussed. Data analysis, including quantitative, qualitative, and integration of data, has been described and discussed with reference to its importance in a mixed method design.

Following the discussions on methodology used for the study, this chapter list the factor identified as barrier and challenges to grid connected solar PV power plants in India. It discusses how 279 responses on 34 variables helped researcher to extract 9 factors through factor analysis. The various Barrier and Challenges identified are Financial Barrier, Policy and Political Barrier, Institutional Barrier, Land Information Challenges, Land Acquisition Challenges, Administrative Challenges, Regulatory Barrier, Market and Technology Barrier and Development Cost Barrier.

This completes the discussion on the research methodology adopted for the study as well as the fulfillment of first objective.

The next chapter discusses the developers' perspective on various identified barriers and challenges in Gujarat and Rajasthan.