Risk Analysis in Implementation of Solar Energy Projects in Kerala

Mohamed Shahid P A¹, Firoz N², Mohammed Sadhikh³, Mohith Dadu⁴.

¹Assistant Professor, Department of Mechanical Engineering, TKM College of Engineering, Kollam.
²Assistant Professor, Department of Mechanical Engineering, TKM College of Engineering, Kollam.
³Professor, Department of Mechanical Engineering, TKM College of Engineering, Kollam.
⁴Assistant Professor, Department of Mechanical Engineering, TKM College of Engineering, Kollam.
E-mail: shahidvaidyar@gmail.com

Abstract. India’s growth rate is slow in the deployment of solar power projects when compared to other developing and developed countries. The Ministry of New and Renewable Energy (MNRE) have often criticized Kerala for their inability to meet target for solar power projects installation. The aim of this study is to explore the state of solar projects in Kerala, with an objective to create a knowledge base of multifarious risks and control procedures. This study enables to identify the main risk in implementing solar energy projects and develop a guideline which could serve to reduce the risks associated with investments in solar projects. In this study, survey was conducted amongst the different players of solar power project installation and operation to identify the various risk factors and sub factors. These factors were categorised and further quantified using the decision making tool, Analytic Hierarchy Process (AHP). Political risk, technical risk, financial risk and environmental risk are the prominent risk factors involved in solar projects installation. The impact of the sub factors are identified using AHP. Payback period and non-approval of on grid small scale projects from KSEB are the critical factors. The inattention in reduction of risks at organizational level, and project level, can substantially affect the solar projects at a catastrophic level. Overall, the need for future research is established in this study for investigating the capability of Project Management Offices in risk assessment and management.

Keywords: Solar energy projects; Risk Analysis; AHP;

1. Introduction
The 6th largest energy consumer, India, consumes 3.4% of global energy consumption which accounts for more than 17% of population. The Public Sector Undertakings (PSUs) principally controls the energy policy of India, which is constituted by the Government of India's Ministry of Power, Ministry of Coal, and Ministry of New Renewable Energy. Renewable energy is defined as the continually replenished energy
that comes from resources such as sunlight, wind, rain, tides, waves and geothermal heat. The energy tapped from renewable resources amounts to 16% of net global consumption, with a split up of 10% energy from traditional biomass and 3.4% from hydroelectricity. The rest 3% is supplied by swiftly growing sectors namely small hydro, modern biomass, wind, solar, geothermal, and biofuels. Solar Power, the remarkable potential energy resource with zero emission, clean and renewable energy can be connected using a variety of devices. The solar energy systems are easily accessible for industrial and domestic use with an additional advantage of minimum maintenance as a part of recent developments. The rebates and incentive plans on government tax can make solar energy financially feasible. The missing targets in completion of execution has led to criticism in the area of consulting, contracting, policy framing related to solar projects and the growth rate of India is found to be sluggish when compared to other countries. In the State of Kerala also, solar energy generation rate is very low, for the target of 9% in annual solar energy production the achievable is less than 2% till now. This prime reason is due to the risks associated with the implementation of solar energy projects. The aim of our project is to analyses the risks in implementing solar energy projects. Risks are identified and analysed using survey and analytic hierarchy process.

2. Solar Technology Used in Large, Medium & Small Scale Projects

Sunshine is free mode of energy and never gets consumed. The solar radiation that hits on the earth surface in an hour has more energy potential than the energy consumption of people in a year. The solar cell can convert the solar radiation in to electric potential which is having zero harmful emission. It doesn’t even make any noise. A solar panel is a group of solar cells that work together. The energy is carried through space as electromagnetic radiation. Light and radio waves are types of electromagnetic radiation. Electromagnetic radiation travels like waves in water. Like water waves, it is a series of ups and downs. Solar power is the conservation of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirror and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for conventional power plant. Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect.

3. Literature Review

The current heavy dependence of human population on fossil fuels is considered as escalated factor in climate change and the piling difficulties in overcoming the renewable energy targets. The use of renewable energy has been considered as a solution to the formerly mentioned issues [1]. The poor risk-mitigating strategies has led to the prime reason for the deficiencies. The successful mitigation of the project-associated risks is a key factor to complete the projects on time and is well within the control of Indian contractors. An approach proposed by Rodney [2] is to model, simulate and to evaluate project risks in term of quality, delay and cost; which aims to reproduce the behaviour of the project, evaluate its performance and anticipate its probable drifts while valuing the following specifications applicable to the entire process of risk management with dynamic and multi-views which consider all aspects of the project and represent different levels in detail. Sudi Apak studied the evolving mechanisms in financial risk management that will cater the needs of the renewable energy sector in both the EU and Turkey [3]. The study analysed their renewable energy investments with reference to managerial and theoretical implications and concluded that the encouragement in increased number of renewable energy projects is driven by improvement of technology-
specific insurance cover public and private financial institutions. Yurii Rolik determined that McKinsey expert rating supports to calculate the attractiveness of the area of activity and the competitiveness of the project in the form of weighted averages for subsequent positioning [4].

Goh H.H. And S.W. Lee clearly identifies the relationship states for the project development in wind power for Malaysia [5]. The wind speed prediction and site survey can calculate the annual wind power generated which is essential for the further analysis. Similar methodology could be adopted for the calculating the power generated from solar in reference to the geographical conditions. Renewable energy is not only to reduce the carbon dioxide to the atmosphere but also considered to be as more environmental friendly compared with other criteria’s [6]. In the book “Project Management, Planning and Control” by Albert Lester designates the project management plan (PMP) should include an outline of the risk management plans, which defines the scope and applicable areas of risk management, particularly the investigation of risk types [7]. The government revised the target for renewables from 20 GW to 175 GW, including 100 GW of grid-connected solar projects, by 2022 [8].

In the Annual report by (MNRE 2014-15) clarifies that, over the years, renewable energy sector has emerged as a significant player in the grid connected power generation capacity in India. It has been recognized that renewable energy has to play a much profounder role in attaining energy security in the years forward and be a vital part of the energy planning progression.

4. Methodology

Risks associated with solar projects are identified by means of literature review and important ones are selected based on the survey at 10 institutes in Kerala. These risks are prioritised using AHP as the decision tool. Finally a framework is developed illustrating the relationship between each risk. The detailed steps are shown in Figure.1

4.1 Risks Associated with Solar projects

A research on solar projects based contractors, their capacity and practices in order to manage risks would be required to frame the state of the current situation. The main risks related with solar projects can be classified as political, financial, social and technical which is further classified into the following.

- Identification of Risk Associated with Solar Projects
- Preparation of the Questionnaire
- Experts Survey
- Analysis of Survey Reports Using Risk Matrix
- Identification of Major Risks
- Risk Prioritisation Using AHP
- Plotting of Relationship Diagram

Figure.1. Methodology framework
4.1.1 Political Risks
The delays in clearance and approval from government organizations is of prime importance as the risk of constraints in getting regulatory sanctions and achieving financial closure is relatively high. The failure to achieve financial closure inflates the required funds to execute a project if a project does not obtain the mandatory approvals. There are several political risks associated with solar projects in India which is illustrated in Table 1.

| Classification of Risks | Risks/Barriers Description                                                                 | Reference                  |
|-------------------------|-------------------------------------------------------------------------------------------|----------------------------|
| Policy Risk             | High costs and unfavorable power pricing rules                                              | Beck & Martinot 2004       |
|                         | Environmental externalities                                                                |                            |
|                         | Institutional and regularity barriers                                                      |                            |
|                         | High rate for consumers                                                                   | Riedy 2008                 |
|                         | Frequent changes in government policy                                                     |                            |
| Licensing, commissioning and approvals risks | Payment guarantee mechanisms are not reliable.                                           | Kurth 2007                 |
|                         | Risks due to contracted parties not recognizing the contracts binding nature and the judicial system is plagued by lengthy, intractable delays and “banked up” cases | Finley-Jones 2004          |
|                         | Problems in obtaining clearances and certifications                                       |                            |
|                         | Delay in receiving payments                                                               |                            |
| Contract                | Risks based on parties to a contract not recognizing their binding nature and the judicial system being plagued by substantial intractable delays “bank up” cases | Kurth 2007                 |
|                         | Payment guarantee mechanisms are not reliable                                             |                            |

4.1.1 Environmental Risk
There are several environmental risks related with solar projects in India which is demonstrated in Table 2.

| Classification of Risks | Risks/Barriers Description                                                                 | Reference                  |
|-------------------------|-------------------------------------------------------------------------------------------|----------------------------|
| Environment             | Forthcoming environmental legislation that may affect the project                         | Herbert 2010, Stanton 1996, Pasqualetti 2002, Gipe 1995 |
|                         | Biodiversity protection issues                                                            |                            |
|                         | Workers Health and Safety issues                                                          |                            |

4.1.3 Financial and Ethical Risks
The list of financial risks associated with solar projects in India which is shown in Table 3.
Table 3. Classification of Financial and Equity Risks

| Classification of Risks | Risks/Barriers Description | Reference |
|-------------------------|-----------------------------|-----------|
| Financial and equity risk | Unsteadiness of taxation environment in India with frequent changes to significant guideline in renewable energy sector of India. | Bansal, Bhatti & Kothari 2002 |
|                          | Difficult to fund working capital because a) banks are hesitant to lend to rural entrepreneurs b) banks are reluctant to approve consent raw materials as collateral | |
|                          | Unpredictable rates in borrowing, lending and returns. | |
|                          | Skewed financial incentives | |
|                          | Inadequate funding in long-term basis | |
|                          | Loss in capital is high | |

4.1.4 Technical Risks

The numerous technical risks associated with solar projects in India is listed in Table 4

Table 4. Classifications of Technical Risks

| Classification of Risks | Risks/Barriers Description | Reference |
|-------------------------|-----------------------------|-----------|
| Technology              | Technology tie-up/Joint venture, expected lead time issues if any | Lippert, Kishor & Dhingra 2006 |
| Operation & Maintenance | Issues such as machinery breakdown and downtime | Reddy 2002 |
| Procurement             | Indigenization percentage in reference with project cost and its impact on project cost | ESMAP 2010 |
|                         | Overall hike in Indigenization percentage | |
| Human resource risk     | Difficulty in finding suitable skilled and unskilled employees to work in this field | Kurth 2007 |
| Land feasibility        | Selection of appropriate site | Reddy 2002 |
|                         | Land acquisition issues | |
| Transparency risk       | Prevalent corruption in administrative, bureaucratic and business circles. | Kurth |

4.1.5 Identification of risks associated with Solar Energy Projects

From the above mentioned risks, about 200 questions are formulated for identifying the risks. For the easiness of survey from the above mentioned, about 60 questions are sorted for the survey. Survey are conducted in three stages that are

1. Before Installation
2. During Installation
3. After Installation
4.2 Questionnaire preparation
Questionnaire is prepared on the basis such that for each question ratings from 1-5 is given and for each question there have PRIORITY & IMPACT columns. PRIORITY - priority of each question towards the solar projects IMPACT - impact of each question towards the solar projects .5-5 rating means High priority & High Impact

4.3 Experts Survey
The following are the experts & selected organizations where the questionnaire based survey is carried out. ANERT, KELTRON, CIAL, PRANA GRIDS, 5. KC KOPAR ENERGY SOLUTIONS, KSEB (Kollam), DOMESTIC – 1(Kallada), DOMESTIC – 2 (Keralapuram) ,Technical Educational Institute.

4.4 Analysis of survey reports using risk matrix
The survey results are then analysed using matrix to find out the main risks specified by all the experts and then all the survey reports are merged together for Political/Policy risk, Financial Risk, Technical Risk Environmental Risk. The Weightage is given for each question and then from this collective result, the Weightage above 40 are taken as the most important Risk for the technical risk there are 19 questions. For each questions the survey results from each experts are different, in the table for each question relevant scores given by the experts are noted and the total Weightage is calculated.

4.5 Identification of Hierarchy Risk
From the data the most important technical risk were identified and the questions were chosen which has weightage greater than or equal to 40, then it is graphically represented by as shown in Figure 2.

4.6 A.H.P (Analytic hierarchy process)
Analytic Hierarchy Process, AHP belongs to the multi-criteria decision making methods (MCDM). In AHP, inputs like price, weight, or area, or even subjective opinions such as feelings, preferences, or satisfaction, can be translated into measurable numeric relations.

The basic steps in the formulation of solution for decision problem with the aid of AHP are not tedious: 1. Define the decision goals 2. Hierarchy structure formulation for the decision problem regarding the categories and criteria those figure into the decision 3. Comparison of pair criteria in each category 4.
Calculate the priorities and a consistency index in reference with logical comparisons and consistency 5. Evaluation of alternatives according to the identified priorities.

5. Results and Discussion

In this section survey results are analysed to determine the important risk factors in each category.

5.1 Survey Results

The different political risks are evaluated and their weightage is shown in figure 3 and major risk factor identified and listed in Table 5.

**Figure: 3** Risk Matrix - Graphical Representation for Political Risk

| **Table 5. Major Political Risk** |
|----------------------------------|
| **P2** | Lack of Public Awareness about solar energy projects & government policies |
| **P13** | Payback period is larger in case of projects below 200kw |
| **P19** | Solar Scam badly affected the projects |
| **P20** | KSEB Do not approve on grid projects due to their technical issue |

The different technical risks are evaluated and major risk factor identified and listed in Table 6.
The different financial risks are evaluated and major risk factor identified and listed in Table 7.

**Table.6. Major Technical Risks**

| T8     | Availability of skilled technicians is very less in executing solar energy projects |
|--------|-----------------------------------------------------------------------------------|
| T12    | Feasibility of land for solar energy projects is very less                           |
| T13    | Effect of weather changes (temperature, rain etc) is badly affect in solar energy projects |
| T14    | Periodic maintenance schedule & cost for solar energy projects after installation (off grid) is very high |
| T19    | Availability of technicians for rectifying complaints after installation is very less |

The different environmental risks are evaluated and major risk factor identified and listed in Table 8.

**Table.7. Major Financial Risks**

| F1     | The financial status of solar energy projects compared to other renewable energy projects is less |
|--------|--------------------------------------------------------------------------------------------------|
| F8     | The return rate of investment compared to other renewable energy projects is less                 |
| F9     | Capital investment of solar energy projects compared to other renewable energy projects is very high |
| F15    | The initiatives taken by the agency for financial awareness to potential customers in implementing projects is less |

The different environmental risks are evaluated and major risk factor identified and listed in Table 8.

**Table.8. Major Environmental Risks**

| E5     | Chance of health hazards to the workers/technicians is high                                 |
|--------|--------------------------------------------------------------------------------------------------|
| E7     | Weather condition in Kerala to implement solar projects is negatively affected                  |
| E9     | Availability of land for solar projects in Kerala is very less                                   |
| E11    | Recycling of solar modules is not possible                                                       |

5.2 AHP Results
Using Analytic Hierarchial Process method weightage for each important risk were determined. The input of AHP, pairwise comparisons is performed by interviewing the experts from industry. Results are illustrated in Table.9, Table 10.Table 11 and Table 12.
### Table 9. Political risk resulting weights for the criteria

| Category | Priority   | Rank |
|----------|------------|------|
| 1        | Restriction of KSEB towards on grid projects | 36.40% | 1 |
| 2        | Lack of Awareness | 36.40% | 1 |
| 3        | Solar scam negatively affects | 18.20% | 3 |
| 4        | Larger payback period | 9.10% | 4 |

### Table 10. Technical risk resulting weights for the criteria

| Category | Priority   | Rank |
|----------|------------|------|
| 1        | Off grid maintenance is high | 31.20% | 1 |
| 2        | Less availability of skilled technician | 27.30% | 2 |
| 3        | Land availability is very less | 19.90% | 3 |
| 4        | Weather changes negatively affects | 16.10% | 4 |
| 5        | Less availability of technician after installation | 5.40% | 5 |

### Table 11. Financial risk resulting weights for the criteria

| Category | Priority   | Rank |
|----------|------------|------|
| 1        | Capital investment is high | 59.10% | 1 |
| 2        | Financial awareness from agencies is less | 25.40% | 2 |
| 3        | Payback period is higher | 9.70% | 3 |
| 4        | Financial status is bad compared to other REP | 5.70% | 4 |

### Table 12. Environmental risk resulting weights for the criteria

| Category | Priority   | Rank |
|----------|------------|------|
| 1        | Availability of Land is very less | 40.00% | 1 |
| 2        | Recycling of module is not possible | 20.00% | 2 |
| 3        | Chances for health hazards is more | 20.00% | 2 |
| 4        | Weather changed negatively affects | 20.00% | 2 |
5.3 Major Findings

From the analysis 14 risks are sorted as the important risk in implementing solar energy projects they are

i. Lack of Public Awareness about solar energy projects & government policies
ii. Payback period is larger in case of projects of capacity below 200kw
iii. Solar Scam has badly affected the projects
iv. KSEB do not approve on grid projects due to additional technical liabilities
v. Availability of skilled technicians is very less in executing solar energy projects
vi. Periodic maintenance schedule & cost for solar energy projects after installation (off grid) is very high
vii. Availability of technicians for rectifying complaints after installation is very less
viii. The financial status of solar energy projects compared to other renewable energy projects is less
ix. The return rate of investment compared to other renewable energy projects is less
x. Capital investment of solar energy projects compared to other renewable energy projects is very high
xi. The initiatives taken by the agencies for the financial awareness to potential customers in implementing projects is less
xii. Chance of health hazards to the workers/technicians is high
xiii. Weather condition in Kerala to implement solar projects is negatively affected
xiv. Availability of land for solar projects in Kerala is very less

All the above 14 risks are equally important. For identifying the most important risk, again it is sorted by avoiding repeated risks with. Then the final risks analysed is as follows

i. Lack of public awareness about solar energy projects & government policies
ii. KSEB do not approve on grid projects due to their technical issue
iii. Availability of skilled technicians is very less in executing solar energy projects
iv. Periodic maintenance schedule & cost for solar energy projects after installation (off grid) is very high
v. Capital investment of solar energy projects compared to other renewable energy projects is very high
vi. The return rate of investment compared to other renewable energy projects is less
vii. Availability of land for solar projects in Kerala is very less
viii. Recycling of solar modules is not possible
ix. Effect of weather changes (temperature, rain etc) badly affect in solar energy projects
x. Chance of health hazards to the workers/technicians is high
xi. Solar Scam have badly affected the projects
xii. The initiatives taken by the agency for financial awareness to potential customers in implementing projects is less

5. Conclusion

Risk analysis in implementing solar energy projects in Kerala using AHP technique is conducted and following are the proposed solution for the reduction of the identified major risks.
1. Promote awareness about the policies and new schemes through the Newspapers, Social media, Televisions, etc.
2. KSEB needs to change their policy towards on grid connection from all type consumers irrespective of the capacity.
3. Government should promote proper loan facilities, subsidies, incentives & tax reductions
4. Government should take initiative to conduct the training courses to develop skilled technicians, and also promote awareness programs for future generation
5. Promote more “On Grid connections” than “Off Grid connection”
6. Reduce the risk of “Availability of land for solar projects in Kerala is very less” by promoting floating panel projects, canal top projects, roof top projects, car port projects etc
7. Reduce the risk of “Chance of health hazards to the workers/technicians is high” by implementing safety rules, safety programs & by providing safety measures
8. Reduce the risk of “Recycling of solar modules is not possible” by providing R&D work on Recycling of modules to develop new technologies.

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