Risk Assessment in Installation of Solar Power Plants

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***Abstract*— Nowadays although photovoltaics (PVs) has been a major energy source, there are few publications that focus on the risks regarding the installation of Commercial Solar Power plant. There is no solution which can identify that later on what sort of risk or what sort of problem may occur after and during the installation of a renewable grid. After which we can provide the solution of Risk mitigation/reduction to identify future risks that may occur after and during the installation of a renewable grid. The above discussion is based on risk software using Monte-Carlo simulation and Analytical Hierarchical Process (AHP) Technique. Monte-Carlo simulation is used for finding the risk and the AHP Technique use in design making process. We made such a solution that will target the three different locations in three different weather The work is performed to manage the risk that may occur in the installation and after the installation of renewable grids. This research is crucial, especially when you consider how many new installations there will be because of the favorable Pakistani Policy. Additionally, there is little information available about accidents connected to the installation of PV Photo Voltaic (PV) plant. Consequently, it is challenging to develop a safety policy roadmap for PV installation. projects. This work has act as guidance towards future projects with similar conditions. At the end we have provide proper risk avoidance mechanism and report.**

***Index Terms* — Photo Voltaic (PV), Risk Management (RM), Mono Crystal (MC), Poly Crystal (PC), Feed-in Tariff (FIT), Analytical Hierarchy Process (AHP), Project finance (PF), Renewable Energy (RE), Renewable Energy Sources (RESs), Decision Maker (DM).**

I. INTRODUCTION

This chapter includes the introduction of all techniques and technologies included in this thesis work. It begins with the introduction to risk assessment. With the rise in population and energy demand as well as the challenges faced by climate change, the increasing reliance on imports with the rise in fossil fuel prices also puts great pressure on finding a source of renewable energy to meet demand [1]. According to the global survey, fossil fuel supplies such as oil, gas, and coal meet 80 per cent of energy demand. It is well known that, soon, these tools will run out [2]. Focusing on renewable energy options such as wind, solar, tidal, and so on is a must in today's world. The Sun is the source of all available sources of energy on earth. Solar energy is the energy force that sustains life for all plants, animals and humans on earth [3]. Earth receives radiation energy from sun which contains packets of energy which are constantly released by sun into space and towards earth. The solar energy can be used as solar energy (thermal and photovoltaic) directly [4]. This is the most creative technology that could be called technology of the future. Two processes, solar thermal and solar photovoltaic, can be used to harness solar energy in which solar rays can be transformed directly into electricity [5]. In next section describe a background of this research work.

A. Renewable Energy Resource:

Due to recent trends of environmental issue, climate change, decrease in fossil fuels along with the international acceptance of sustainable development goals are the main factors and motivations above all others in the increased investments in utilizing Renewable energy sources. Renewable energy comes from natural resources like the sun, wind, and water flow that replace themselves more quickly than they are used up [9] as shown in figure 1.

B. Monte-Carlo:

Monte-Carlo as shown in figure 2 and simulation performs risk analysis by building models of possible results by substituting a range of values a probability distribution for any factor that has inherent uncertainty. Microsoft Excel is utilized in conjunction with Risk since the inputs are delivered through the excel sheet [10].

C. AHP Technique:

AHP technique is one of the most complete tools for ranking alternatives by adding a decision framework to handle multiple objectives is the AHP, established by Thomas L. Saaty in the 1970s.

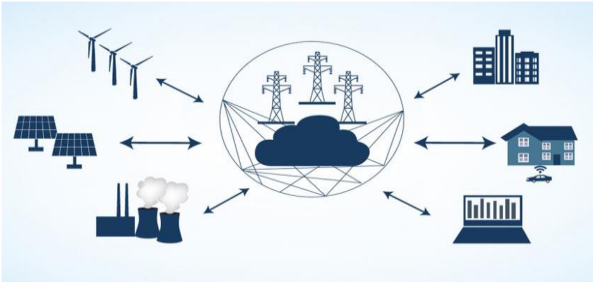

Figure1: Renewable Energy [10].

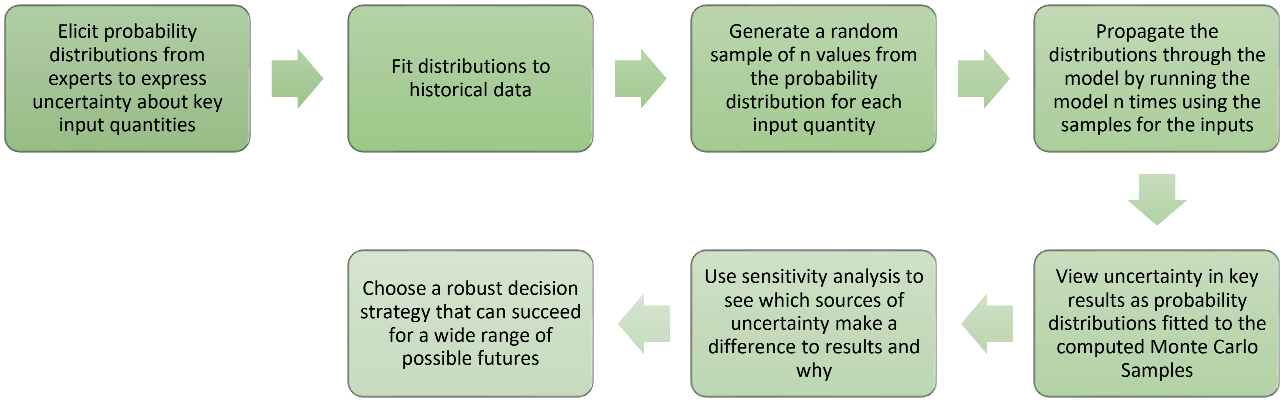

Figure 2: Monte-Carlo Block Diagram

AHP enables the blending of qualitative and quantitative inputs, providing a useful method for addressing challenging issues in energy planning [11].

D. *Definition of Risk:*

To explain the methodology of risk management requires that risk be correctly defined. Risk used to be defined as "loss" in the past. However, by that point, the concept of risk had altered, and it now included both positive and negative aspects. AHP block diagram as shown in figure 3 and fundamental concept, risk can now be explained in a variety of ways [13].

E. *Paper Organization:*

The research on methodology of a proposed work in discuss the four different stages of the research methodology first one is problem identification second is literature review third is modelling and the last forth stage is result and simulation. we have use two different methods for mitigate the risk of solar power plant. In next section we will provide the detail of problem identification because it is a part of a project.

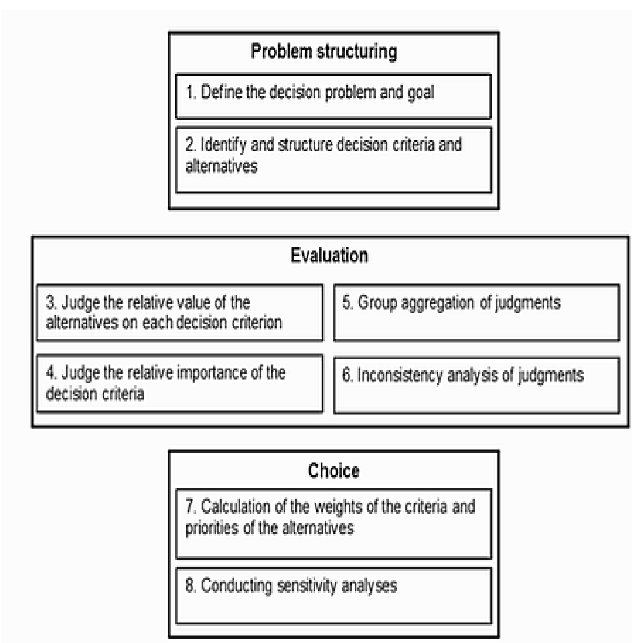

Figure 3: AHP Block Diagram [12].

II. LITERATURE REVIEW

This section provides the literature of the related works according to the works performed in this dissertation. The survey is in accordance with risk assessment in installation of solar power plant. The work has been performed on risk assessment reverent to the solar installation projects.

A. *Survey of the Related Works:*

Although there was a perception that the feed-in tariff (FIT) was financially appealing, unclear revenue was caused by short deadlines, low technology-specific capacity constraints, and no project size restrictions. FIT largely helped intermittent technologies with a quick development and construction cycle, including solar and wind [14]. Installers and project developers, with the assistance of scientists and engineers, regularly search for alternate locations for photovoltaic (PV) system installations in recognition of the difficulties of land shortage and growing concerns for conserving natural areas. The so-created hybrid system (PV-hydro) might become significantly more efficient in the case of hydroelectric dams since the variable solar energy would be balanced by the adaptability of hydropower. Finally, we discovered a significant number of already-existing water reservoirs in Africa that are either unpowered or underutilized. PV system installation can also increase that untapped energy potential. The results have been quite positive, showing that installing PV systems on dam faces is a good choice for producing renewable energy [15]. To maximize the amount of solar energy that can be converted into electrical energy, photovoltaic (PV) systems are often designed and built with efficiency and dependability in mind. These regulations aim to reduce fire safety concerns by establishing the minimum level for the architecture, design, and installation of solar PV systems [16]. Presents a standard industry method for risk analysis, identifies its drawbacks and hazards, and offers solutions. The primary dangers of integrating solar photovoltaic (PV) systems into an existing commercial electric power infrastructure are then briefly discussed. The main threat identified in this analysis is the possibility of clouds obstructing the sun and introducing fluctuation in power production output. In order to decrease the risk of decreased power production output during times of high demand, it is also crucial to review the backup capacity policies and take alternative storage options into consideration when solar PV becomes a larger portion of an electric company's energy portfolio [17]. A lot of attention is being paid to photovoltaic (PV) plants right now because of their inherent capacity to convert solar energy directly into electrical energy. The goal of the current study is to evaluate several technical obstacles related to the state of PV systems today, including those related to energy policies, different cell technologies, energy management and scheduling strategies, dependability, power quality, and control system issues. Solar PV has attracted a lot of attention as one of the promising developing technologies to address the rising need for power, the depletion of fossil fuel supplies, and the need to reduce carbon dioxide emissions [18]. For either the primary power source or a backup source of electricity, solar panels or modules are becoming more and more common in home and commercial sites. This article briefly reviews how photovoltaic power systems are built before addressing some potential safety concerns [19]. Pakistan has a large amount of solar energy potential that can be used to generate electricity. Each of the primary criteria and sub-criteria has initially been given a priority using the analytical hierarchy process (AHP) method. According to the current analysis, Khuzdar (C2), Badin (C3), and Mastung (C7) are the cities in Pakistan that are best suited for the implementation of solar PV power projects. A difficult decision dilemma exists when choosing the location for the solar power installation. Considering that there hasn't been a thorough investigation into site selection for solar power projects in Pakistan. Experts from the government, academia, and stakeholders participated in the implementation of AHP to offer their informed judgment regarding the decision criteria and alternatives. First, the 6 main criteria and 20 sub-criteria weights gathered from the various experts through pair wise comparison matrices were determined using the AHP approach [20]. This paper's major goal is to determine how solar energy technology would affect aviation safety when the solar system is being built in the airport. Aviation technology risk is being identified using the FEMEA and risk matrix [21]. To overcome the crisis and ensure sustainable economies, countries must urgently make the switch from fossil fuels to green energy, according to Covid-19 answers. The analytic hierarchy method (AHP), which has been used for the first time to determine the most suitable places, has been carried out as a country in a seismically active zone that heavily depends on imported fossil fuels. The AHP approach was then used to rank the places with ideal efficiency scores. The sites with the greatest potential for solar energy were prioritized using five carefully chosen evaluation criteria (site features, technical, economic, social, and environmental) and the sub-criteria of each [22]. For solar tower or parabolic trough power plants, thermal energy storage is not economically advantageous. Since the findings indicate that the NPV associated with some solar power plant projects is nearly zero, increased carbon bond prices or a slight drop in fuel prices could increase some private NPV. As a result, it is reasonable to assume that while planning the growth of power systems, policy makers (especially those from developing nations like Chile) will pay closer attention to the regional context of the power markets [23]. The economic development of a nation depends on its access to energy. The only source of energy for Pakistan, like many other developing nations, is conventional fossil fuels. There is a significant need for energy due to its enormous population and recent industrial expansion. Meanwhile, the cost of fossil fuels has lately soared, and since there are no other ways to produce energy in the country, there are now energy shortages. However, as a result of the Quaid-e-Azam Solar Park and other similar initiatives, more people are now aware of solar energy and the advantages that come with it. However, it now makes up a tiny portion of the nation's overall energy mix. In conclusion, solar energy has the potential to quickly alleviate Pakistan's energy shortages [24].

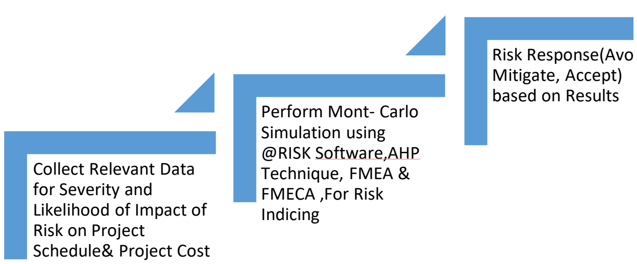

Figure 4: Research Flow Methodology.

III. Methodology

In a risk analysis, we primarily determine each risk's impact and likelihood of occurrence. The risk level, also known as risk exposure, is then calculated. Whether a risk analysis is qualitative or quantitative, calculating risk exposure depends on that method. Scales are combined to produce a risk (mapping) matrix in the most typical qualitative approach. AHP and Monte-Carlo simulation are two frequently used quantitative techniques. Research flow methodology as shown in figure 4 and then based on their risk exposure, risks are prioritised to assist identify the best risk response approach for the following risk management process [25].

A. Monte-Carlo Simulation:

Risk uses Monte Carlo method to predict the best possible outcomes using different Probability distributions, so it is important to choose a distribution that best suits best the scenario. In this work, according to the available data [26]. In this simulation we can set & apply the input data then find out the output results shown in figure 5. Input data at three different sites 1.2MW, 2MW & 18MW and three different locations, find

Project Scheduling													
	All Values in Days				All Values in Days			All Values in Days			All Values in Days		
Work	1.2 MW System	2 MW System	18 MW System		1.2 MW System			2 MW System			18 MW System		
After Project Confirmation				Possible Maxmim Delays	LOW	BASE	HIGH	LOW	BASE	HIGH	LOW	BASE	HIGH
Civil Material Order	7	8	20	Local Delays 10 to 15%	7	7.7	8.05	8	8.8	9.2	20	22	23
Structure Order	20	22	60	Local Delays 10 to 15%	20	22	23	22	24.2	25.3	60	66	69
Panel & Inverter Order	33	30	10	1% to 50%	33	33.33	49.5	30	30.3	45	10	10.1	15
Cable & Switch Gear Order	20	1	2	Local Delays 10 to 15%	20	22	23	1	1.1	1.15	2	2.2	2.3
After Material Arrangement													
Structure Install	21	33	70	Weather Delays Unexpected but upto	21	24.36	27.93	33	38.28	43.89	70	81.2	93.1
Civil Work	14	22	60	Weather Delays Unexpected but upto	14	16.24	18.62	22	25.52	29.26	60	69.6	79.8
Panel Installation	20	28	60	Material shortage Delays upto 15 %	20	21.5	23	28	30.1	32.2	60	64.5	69
Inverter & Switch Gear Install	2	3	10	Maximum Delays of 5%	2	2.05	2.1	3	3.075	3.15	10	10.25	10.5
Cabeling	7	12	25	Maximum Delays of 5%	7	7.175	7.35	12	12.3	12.6	25	25.625	26.25
Commissioning	2	3	8	Maximum Delays of 3%	2	2.03	2.06	3	3.045	3.09	8	8.12	8.24
Total Time	146	162	325		146	158.385	184.61	162	176.72	204.84	325	359.595	396.19

Figure 5: Survey Data Simulate Through Monte-Carlo Simulation

the low, base, high value then find out the Average delay in total system.

B. *Basics of AHP:*

Analytical hierarchy process fundamentals One of the most complete tools for ranking alternatives by adding a decision framework to handle multiple objectives is the AHP, established by Thomas L. Saaty in the 1970s. AHP enables the blending of qualitative and quantitative inputs, providing a useful method for addressing challenging issues in energy planning. If the decision maker's (DM) evaluations are inconsistent, the AHP takes this into account. One of the most popular methods for combining AHP with other decision support strategies is to employ AHP applications.

1) Let's expose the preference score of criteria to criteria using the nine-integer value scale proposed by Saaty as shown in represents the item in the (i^{th}) row and the (j^{th}) column of the matrix m entries of preference score P_{ij} and P_{ji} must meet the following constraint. in Eq. (1),

$$P_{ij}.P_{ji} = 1 \qquad (1)$$

2) Second, each column's sum must equal 1 to create a normalized pair wise comparison matrix. This can be acquired by computing$\bar{P}_{ij}$ for each entry of the matrix m using Eq. (2),

$$\bar{P}_{ij} = \frac{P_{ij}}{\sum_{l=1}^{n} P_{ij}} \qquad (2)$$

3) Then, using Eq. (3) the average across rows is calculated to get the relative weights. The relative weight for each component is between 0 and 1; a larger weight denotes a component's stronger influence on the location of the solar PV power plant.

$$w_i = \frac{\sum_{l=1}^{n} \bar{P}_{ij}}{n} \qquad (3)$$

4) Finally, Eq. (4) has been applied to every study area layer pixel to produce the solar PV suitability map (SSM). Which results in the SSM value of an inappropriate site if restriction (*r*) exits If not, SSM could be derived by adding up each criterion's value (x_i) times its associated criterion weight(w_i),

$$SSM = \sum_{i=1}^{n} x_i . w_i \, rwherer \in \{0,1\} \qquad (4)$$

5) The *CR* is given by$\frac{CI}{RI}$, where RI is the random consistency index, which changes depending on how many comparison criteria are used (*n*). When calculating the consistency index (*CI*), is calculated using Eq. (5),

$$CI = \frac{(\lambda_{max}}{(n-1)} \qquad (5)$$

where λ_{max} is the maximum eigenvalue of the comparison matrix. Provides the eigenvalue derived from pair wise comparisons of the criteria about choosing the optimal solar PV installation site.

6) If risk factor $CR \leq 0.10$, otherwise, there are significant inconsistencies in the pair wise comparison; the level of consistency is regarded as sufficient. As a result, the AHP might not produce useful findings.

There are seven elements in the current study that are connected to choose criteria, or *n* = 7. Therefore, *RI* = 1.32 and *CR* = 0.02, which are within acceptable limits. The original high-level maturity and cutting-edge embedded features make it possible for the GIS to be a potent instrument for strategic planning of energy development projects, including solar technologies. The vector (points, lines, or polygons) and raster (pixels or cells) files of the study area's dataset were processed and modified spatially in the current study using Arc Map 10.3. To provide composite map results and clever visualizations for wise decision-making, it has been employed to overlay the various layers.

IV. Result &Discussion

These simulation findings are included in this section, which includes the risk of solar power plant. After using the two techniques then we find the different risk of solar power plant. The first one is monte-carlo and the second one is AHP technique. According to IEEE standards, all the findings of the simulated model are within the IEEE standard limitations.

Monte-Carlo Technique:

After using the monte-carlo technique, two different types of

	In Percentage	Cost (18 MW)			(Profit 3%)	(Profit 5%)	(Full Cost)			
		PKR	USD @180.4 PKR		LOW	BASE	Full	Average	Standard Deviation	SIMULATED
Civil Work	8%	240,000,000	1,330,377		$ 1,370,288	$ 1,396,896	$ 1,330,377	$ 1,365,853.66	$ 33,480.42	$ 1,401,455
Panels	42%	1,260,000,000	6,984,479		$ 7,194,013	$ 7,333,703	$ 6,984,479	$ 7,170,731.71	$ 175,772.20	$ 7,301,731
Inverter	10%	300,000,000	1,662,971		$ 1,712,860	$ 1,746,120	$ 1,662,971	$ 1,707,317.07	$ 41,850.52	$ 1,854,739
Structure	7%	210,000,000	1,164,080		$ 1,199,002	$ 1,222,284	$ 1,164,080	$ 1,195,121.95	$ 29,295.37	$ 1,175,925
Cables	7%	210,000,000	1,164,080		$ 1,199,002	$ 1,222,284	$ 1,164,080	$ 1,195,121.95	$ 29,295.37	$ 1,196,950
Switchgear & Transformers	7%	210,000,000	1,164,080		$ 1,199,002	$ 1,222,284	$ 1,164,080	$ 1,195,121.95	$ 29,295.37	$ 1,191,182
Labour	6%	180,000,000	997,783		$ 1,027,716	$ 1,047,672	$ 997,783	$ 1,024,390.24	$ 25,110.31	$ 1,015,142
Misc. Items	3%	90,000,000	498,891		$ 513,858	$ 523,836	$ 498,891	$ 512,195.12	$ 12,555.16	$ 517,929
Firefighting	1%	30,000,000	166,297		$ 171,286	$ 174,612	$ 166,297	$ 170,731.71	$ 4,185.05	$ 172,486
Security	1%	30,000,000	166,297		$ 171,286	$ 174,612	$ 166,297	$ 170,731.71	$ 4,185.05	$ 171,680
RO Plant	1%	30,000,000	166,297		$ 171,286	$ 174,612	$ 166,297	$ 170,731.71	$ 4,185.05	$ 174,477
Weather Station	1%	30,000,000	166,297		$ 171,286	$ 174,612	$ 166,297	$ 170,731.71	$ 4,185.05	$ 178,114
Transport	6%	180,000,000	997,783		$ 1,027,716	$ 1,047,672	$ 997,783	$ 1,024,390.24	$ 25,110.31	$ 1,026,295
Total	100%	3,000,000,000	16,629,712		$ 17,128,603	$ 17,461,197	$ 16,629,712			$ 17,378,104
								Probability Exceed Base Estimate		$ 17,378,104
								Profit		4.500%

Figure 6: 18MW Site Cost Risk

Structure Order	Local Delays 10 to 15%	60	66	69	65.00	4.58	75.46
Panel & Inverter Order	1% to 50%	10	10.1	15	11.70	2.86	22.79
Cable & Switch Gear Order	Local Delays 10 o 15%	2	2.2	2.3	2.17	0.15	13.48
After Material Arrangement							
Structure Install	Weather Delays Unexpected but upto 33%	70	81.2	93.1	81.43	11.55	97.95
Civil Work	Weather Delays Unexpected but upto 33%	60	69.6	79.8	69.80	9.90	74.77
Panel Installation	Material shortage Delays upto 15 %	60	64.5	69	64.50	4.50	67.57
Inverter & Switch Gear Install	Maximum Delays of 5%	10	10.25	10.5	10.25	0.25	21.02
Cabeling	Maximum Delays of 5%	25	25.625	26.25	25.63	0.63	37.76
Commissioning	Maximum Delays of 3%	8	8.12	8.24	8.12	0.12	19.14
						$ 0.09	
Total Time		325.00	359.60	396.19			
				Simulated Total Time			383
				Delay in %			3.329%

Figure 7: Time Scheduling.

risks are to be considered,

- cost risk and
- time scheduling risk.

A. Cost Risk at 18MW Site:

Finding the cost risk through using the Risk software Civil as shown in figure 6 work value in project is 8% using the percentage value then find cost in (PKR/USD) then second step is select the different profit values for example (3%, 5%) and full cost then apply the average formula when you find out the values then apply the standard deviation after finding the values then start the simulation then find out the profit results process.

B. Time Scheduling:

The Max & Min average delay value and apply the low, base, high value and then find the average value & standard deviation then start the simulation process when we find the simulated delay time through using the Risk software.

C. Tornado Graph:

Due to their ability to compare the effects of one variable (or uncertainty) on the result (value) of an independent variable, tornado charts are frequently employed in sensitivity analysis. Also helpful for comparison purposes are tornado charts. because all attribute's simulated values are individually shown in this graph Figure 7. For example, the panel simulated value is (.965) and the inverter value is (.166). Then we can easily comparison of each attribute. Tornado graph reading is very simple because big bars need more attention than the smaller bars.

D. Monte-Carlo Output Graph:

The output graph is showing the output simulated value. The 18MW output graph mean value is (0.235) are shown in Figure

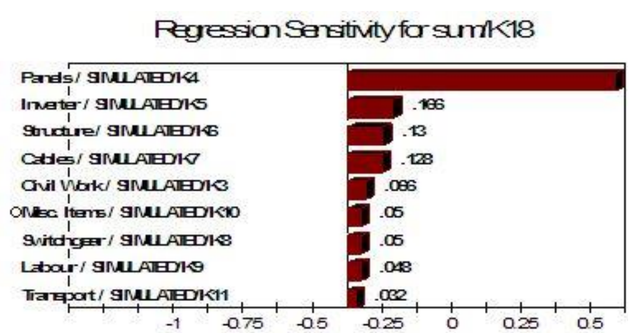

Figure 8: Tornado Graph.

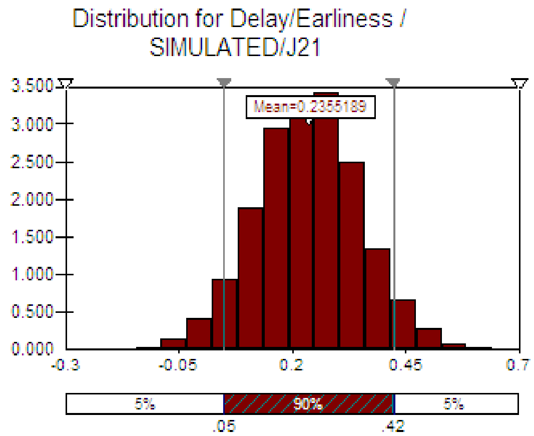

Figure 9: Cost Risk at 18MW Site Output Graph

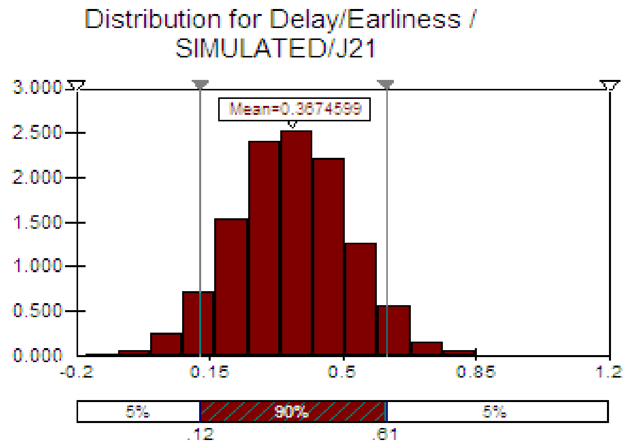

Figure 10: Cost Risk at 2MW SiteGraph

8. This graph is shown the delay/earliness and the simulated value (J21) are shown in figure 8. The minimum value is (.30) and the maximum value is (.70). Left p and the right p value is (5%) the minimum mean value is (.05) and the maximum mean value is (.42). Left x value is (3.4).

The 2 MW output graph mean value is (0.367) are shown in Figure 9. This graph is shown the delay/earliness and the simulated value (J21) are shown in figure 9. The minimum value is (-0.20) and the maximum value is (1.2). Left p and the right p value is (5%) the minimum mean value is (.12) and the maximum mean value is (2.50). Left x value is (3.4).

E. AHP Technique:

After using the AHP technique then we find the different types of risk as shown in figure 10. The AHP is decision making method when your decision making is correct then our risk is minimizing further decision-making process is following.

F. Decision making on following through AHP analysis:

The decision making of the system strictly depends on the following important parameters,

a) Solar panel Selection
b) Cable Selection
c) Inverter Selection
d) Site Selection
e) Structure Selection

G. Solar panel Selection:

In this design making process we select the best solar panel type to our site. Normally there are five mainly attributes are use in solar panel selection first one is cost per watt second one is life third is efficiency fourth is site selection and Panel Selection Hierarchal Model as shown in figure 11 and the last one is aspect ratio. Apply the scoring procedure on all attribute's behalf of value in our project. When complete the scoring process then apply the AHP formulation method this process.

After scoring the attributes of solar panel then we can start the second step. In second step, the pair wise comparison after finding then find the normalized pair wise comparison matrix then third step is calculating the consistency then find the criteria weight and weight sum value and then we find the λ_{max} and then find the consistency index finally we calculate the consistency ratio which is given by dividing a consistency index with Random index (*RI*). The *CR* value is less then by 0.10 which is the standard. We can assume that the matrix is reasonably consistent.

Attributes:	Cost per Watt	Life	Efficiency	Site Selection	Aspect Ratio				
Types of panels	Mono	Poly	Mono-Crystalline	Poly-Crystalline	Monoperc Half cut	Polyperc Half cut	Tiger Series		
			Select this type for lahore						
How important is	***Cost per Watt***	*with respect to*	***Life***	1/9		Scale of Relative Importance		Scoring	
How important is	***Cost per Watt***	*with respect to*	***Efficiency***	1/5		1	Equal Importance	cost	1
How important is	***Cost per Watt***	*with respect to*	***Site Selection***	1/3		3	Moderate Importance	life	9
How important is	***Cost per Watt***	*with respect to*	***Aspect Ratio***	1/5		5	Strong Importance	site selection	3
How important is	***Life***	*with respect to*	***Efficiency***	1 4/5		7	Very Strong Importance	aspect ratio	5
How important is	***Life***	*with respect to*	***Site Selection***	3		9	Extreme Importance	efficiency	5
How important is	***Life***	*with respect to*	***Aspect Ratio***	1 4/5		2,4,6,8	Intermediate Values		
How important is	***Efficiency***	*with respect to*	***Site Selection***	1 2/3		1/3, 1/5, 1/7, 1/9	Values for Inverse Comparison		
How important is	***Efficiency***	*with respect to*	***Aspect Ratio***	1					
How important is	***Site Selection***	*with respect to*	***Aspect Ratio***	1					

Figure 11: Panel Selection Hierarchical Model.

Pair Wise Comparison					
Attributes:	Cost per	Life	Efficienc y	Site Selectio	Aspect Ratio
Cost per Watt	1	1/9	1/5	1/3	1/5
Life	9	1	1 4/5	3	1 4/5
Efficiency	5	5/9	1	1 2/3	1
Site Selection	3	1/3	3/5	1	1
Aspect Ratio	5	5/9	1	1	1
SUM	23.00	2.56	4.60	7.00	5.00

Column	x
Row	Yx
divide row element with coloum eleme	

Normalised Pair Wise Comparison						
Attributes:	Cost per Watt	Life	Efficienc y	Site Selectio n	Aspect Ratio	Criteria Weights
Cost per Watt	0.04	0.04	0.04	0.05	0.04	0.044
Life	0.39	0.39	0.39	0.43	0.36	0.392
Efficiency	0.22	0.22	0.22	0.24	0.20	0.273
Site Selection	0.13	0.13	0.13	0.14	0.20	0.184
Aspect Ratio	0.22	0.22	0.22	0.14	0.20	0.249

Consistency Calculation									
Criteria Weights	0.044	0.392	0.273	0.184	0.249				
Attributes:	Cost per Watt	Life	Efficienc y	Site Selectio n	Aspect Ratio	Weighte d Sum Value	Criteria Weights	Ratio of Weighted Sum Value and Criteria Weights	
Cost per Watt	0.04	0.04	0.05	0.06	0.05	0.25	0.044	5.79	
Life	0.39	0.39	0.49	0.55	0.45	2.27	0.392	5.79	
Efficiency	0.22	0.22	0.27	0.31	0.25	1.26	0.273	4.63	
Site Selection	0.13	0.13	0.16	0.18	0.25	0.86	0.184	4.67	
Aspect Ratio	0.22	0.22	0.27	0.18	0.25	1.14	0.249	4.59	
							ʎ max	5.10	
							Consistency Index	0.024049541	=(ʎ max-n)/(n-1)
							Consistency Ratio	0.021472804	=CI/RI

Random Index	
n	RI
1	0
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Figure 12: Panel Selection Design Making Process.

H. *Inverter Selection:*

In this design making process we select the best inverter selection type to our site. Normally there are five mainly attributes are use in inverter selection first one is efficiency second one is life third is cost fourth is repair & maintenance and the last one is manufacturer profile. On behalf this attribute we can select the best cable selection. All procedure is shown in hierarchical model and Panel Selection Design Making Process as shown in figure 12.

After scoring the attributes of solar panel then we can start the second step. In second step, the pair wise comparison in Inverter Selection Hierarchical Model as shown in figure 13 and after finding then we find the normalized pair wise comparison matrix then third step is calculating the consistency then find the criteria weight and weight sum value and then we find the λ_{max} Inverter Selection Design Making Process as shown in figure 14 and then find the consistency index finally we calculate the consistency ratio which is given by dividing a consistency index with Random index (RI). The CR value is less then by 0.10 which is the standard. We can assume that the matrix is reasonably consistent.

Hierarchial Model							
Goal:	Inverter Selection						
Attributes:	Efficiency	Life	Cost	Repair & Maintena	Manufacturer Profile		
How important is	***Efficiency***	*with respect to*	***Life***	1 2/5		Scale of Relative Importance	
How important is	***Efficiency***	*with respect to*	***Cost***	2 1/3		1	Equal Importance
How important is	***Efficiency***	*with respect to*	***Repair & Maintena***	1		3	Moderate Importance
How important is	***Efficiency***	*with respect to*	***Manufacturer Prof***	7/9		5	Strong Importance
How important is	***Life***	*with respect to*	***Cost***	1 2/3		7	Very Strong Importance
How important is	***Life***	*with respect to*	***Repair & Maintena***	5/7		9	Extreme Importance
How important is	***Life***	*with respect to*	***Manufacturer Prof***	5/9		2,4,6,8	Intermediate Values
How important is	***Cost***	*with respect to*	***Repair & Maintena***	3/7		1/3, 1/5, 1/7, 1/9	Values for Inverse Comparison
How important is	***Cost***	*with respect to*	***Manufacturer Prof***	1			
How important is	***Repair & Maintena***	*with respect to*	***Manufacturer Prof***	7/9			

Figure 13: Inverter Selection Hierarchical Model.

Pair Wise Comparison					
Attributes:	Efficiency	Life	Cost	Repair & Maintain	Manufacturer
Efficiency	1	**1 2/5**	**2 1/3**	**1**	**7/9**
Life	5/7	1	**1 2/3**	**5/7**	**5/9**
Cost	3/7	3/5	1	**3/7**	**1**
Repair & Maintain	1	1 2/5	2 1/3	1	**7/9**
Manufacturer Profile	1 2/7	1 4/5	1	1 2/7	1
SUM	4.43	6.20	8.33	4.43	4.11

Column	x
Row	Yx
divide row element with coloum elemen	

Normalised Pair Wise Comparison						
Attributes:	Efficiency	Life	Cost	Repair & Maintain	Manufacturer Profile	Criteria Weights
Efficiency	0.23	0.23	0.28	0.23	0.19	0.229
Life	0.16	0.16	0.20	0.16	0.14	0.164
Cost	0.10	0.10	0.12	0.10	0.24	0.163
Repair & Maintain	0.23	0.23	0.28	0.23	0.19	0.287
Manufacturer Profile	0.29	0.29	0.12	0.29	0.24	0.309

Consistency Calculation									
Criteria Weights	0.229	0.164	0.163	0.287	0.309				
Attributes:	Efficiency	Life	Cost	Repair & Maintain	Manufacturer Profile	Weighted Sum Value	Criteria Weights	Ratio of Weighted Sum Value and Criteria Weights	
Efficiency	0.23	0.23	0.38	0.29	0.24	1.37	0.229	5.96	
Life	0.16	0.16	0.27	0.20	0.17	0.98	0.164	5.96	
Cost	0.10	0.10	0.16	0.12	0.31	0.79	0.163	4.84	
Repair & Maintain	0.23	0.23	0.38	0.29	0.24	1.37	0.287	4.77	
Manufacturer Profile	0.29	0.29	0.16	0.37	0.31	1.43	0.309	4.64	
							ʎ max	5.23	
							Consistency Index	0.05818203	=(ʎ max-n)/(n-1
							Consistency Ratio	0.051948241	=CI/RI

Random Index	
n	RI
1	0
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Figure 14: Inverter Selection Design Making Process.

V. CONCLUSION

Before concluding the thesis, some important data must be shared which shows how critical this thesis is to keep in mind Solar Industry’s continuous upward growth. Between 2019 and 2024, renewable energy capacity will grow by 50 per cent, led by solar energy. The methodology for risk analysis presented in this work is both qualitative and quantitative, based on probability analysis, thorough risk definitions, and professional judgement. This work combines entire probabilistic functions and Monte Carlo simulation to produce more complete findings for the same database than the AHP methodology, which uses triangular numbers that are eventually simplified. This allows for a better analysis. The use of Monte Carlo simulation and AHP technique is appropriate for measuring the risk.

The results and simulations derived using the monte-carlo tool provide the detail information on the future prediction of cost risk at 18 MW site. The profit prediction of 18 MW site is 1.105% and conclude with a profit of 1.105% on 18 MW site. The results for solar power plant also present total dela earliness to be 1.239%. The results derived using the AHP tool provide the correct decision making for Solar panel selection. The *CR* value is less then by (0.10) which is the standard. Using the AHP tool for the solar panel selection CR value is (0.0214) as calculated through simulations.

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