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Risk Assessment of Sustainable Renewable Energy Resources on CPEC Route

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Abstract

China and Pakistan have collaborated to start the project China Pakistan Economic Corridor (CPEC). Major part of this project is the formation of different special economic zones (SEZs) to boost industrial growth. Additional energy plants would be required once these zones are set up. As the world is shifting its trend towards renewable energy, therefore major focus will be on risks related to renewable energy. Literature was studied, different risk factors were identified and risk solutions/measures were also identified. In the second phase, three renewable energy technologies. The main method used for research was Multi Criteria Decision Making (MCDM) through the Analytic Hierarchy Process (AHP) tool. Expert Choice software was used based on AHP structural concept. Pairwise questionnaire was formed while data were collected through three groups consisting of government officials, company representatives and officials and end users. The high risks were identified as a result according to each group and the risk solutions. The results provided priority of risks which were most important according to each group. The solutions were also ranked as identified by each group. The results obtained from second phase indicated which renewable technology was most affected by each of risk factor. This risk assessment can provide overview to government and investors about different risks. The evaluation of results and taking necessary steps can reduce these risks and provide better business and working conditions for this industry.

Keywords: *Risk Assessment, Renewable Energy, Multi Criteria Decision Making, Analytic Hierarchy Process*

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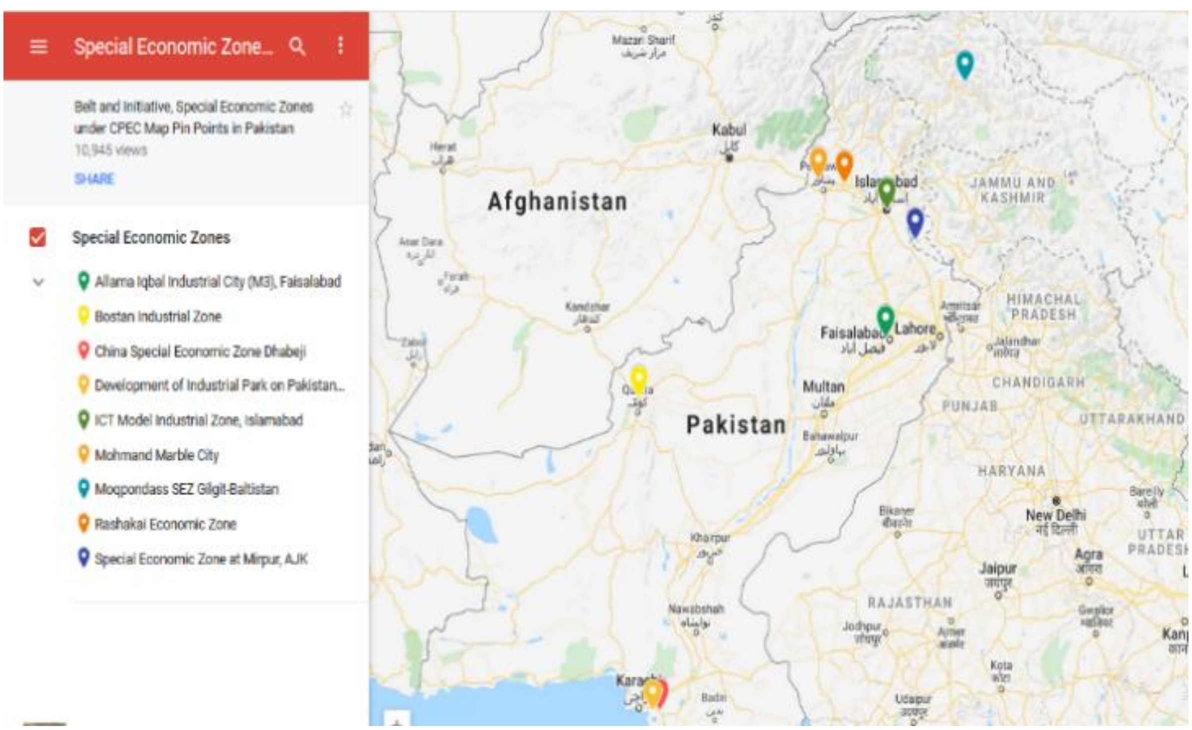
1. Introduction

The China-Pakistan Economic Corridor (CPEC) is a project that has been intimately started by both the governments. It involves a major investment in different fields like infrastructure, power and energy projects, among others. CPEC includes formation and development of different cities as economic zone. An economic zone is a vicinity in which the production and traffic laws are different from rest of the country (Shah & Rasheed, 2020). If efficiently executed, these projects will certainly enhance the economy of the country. Under CPEC, different cities were designated Special economic zones (SEZs) to focus on the industrial development. These zones will be center of attention for the investors and industrialists. It would help produce large number of jobs and strengthen the economy of Pakistan. These economic zones include Rashakai (KPK), Dhabeji (Sindh), Bostan (Baluchistan), Faisalabad (Punjab), Islamabad, Karachi (Sindh), Mirpur (AJK), Mohmand (KPK), Moqpondass (GB) (Khan & Anwar, 2016). These economic zones are presented in figure 1.

Figure 1

CPEC Special Economic Zones SEZs



Source: Google Maps Image

Among the many opportunities for economic growth, power sector has a big potential in CPEC zones in terms of transforming the transpiration project into an opportunity for clean energy generation. By 2019, almost 10,000 MW of production capacity has been increased and this number is expected to be around 16,000 MW when CPEC project will be completed in 2030 (Sheikh et al., 2019). These SEZs that will be developed in the near future, will certainly require power generation plants to operate smoothly, as new industries mean more power consumption. To fulfill needs of these economic zones, focus will be to utilize the renewable energy resources available in Pakistan (Solangi et al., 2019). Around the world, focus on renewable power generation and energy resources has increased rapidly (Kamran et al., 2020). Nations around the globe, are now investing more and more on these sources for their energy generation and more sustainable and pollution free environment. Pakistan has great potential and conditions for renewable energy but it has not been utilized properly. The major portion of power plants in Pakistan comprises of thermal energy (mostly coal based). Focus on the thermal fossil fuel has caused Pakistan to rank the seventh in Global climate risk index (Kreft & Eckstein, 2014).

The major renewable energy resources under consideration are wind, solar and micro hydel. The solar power capacity is estimated to be the most around 2900 GW (Rauf et al., 2015). The solar power capacity generally refers to the maximum output (production) of a power plant. The weather is hot in Sindh and Baluchistan provinces, which make them suitable for solar projects. Same is the case for wind energy, which has an estimated capacity of 346 GW and the Sindh and Baluchistan provinces are most suitable due to the coastal regions (Bhutto et al., 2013). The micro hydel resources are mainly situated in KPK and some areas in Punjab. As the most potential is in KPK therefore many projects are under consideration, total estimated capacity for micro hydel is around 1500 MW (AEDB, Ministry of Energy, Power Division). The rapid installation of renewable energy alternatives means that there will be number of risks which will be encountered and faced by stake holders. These risks should be analyzed in context of the real-world situations in CPEC zones. In this study, the risks associated with the energy projects in CPEC zones including wind, solar and micro-hydel power plants will be analyzed to recommend scientifically reinforced national policies. The risks can be technology related, financial, political and social, among others.

The wind, solar and micro hydel projects each have their own risks. As the projects will grow, the risks related to them will also increase. These risks can cause different problems for the developers and stake holders. This research study provides the assessment of risks related to the renewable energy resource for the CPEC zones. Based on those risks, specific policy or alternatives will be provided to overcome risks.

2. Literature Review

2.1. Risk Factors

In the study of Wing and Jing (2015), major risks are classified as the political, market, operational, credit, market and liquidity risks. These risks are mainly faced by the stake holders and investors. The study in MITRE Corporation, Risk Impact Assessment and Prioritization (2014), proposed that for renewable energy projects and wind projects, the classification of risks is done as business/strategic, legal/liability, sales/ market, operation/maintenance, regulatory/policy and counter party risks. Accordingly, each program or project can have different risks related to its nature and scope. These studies have been done according to related countries conditions. Another study conducted by Ioannou et al. (2017) to evaluate risks related to renewable energy resources resulted in the categorization of risks as technological, environmental, political, social and economic. Similarly, the study done by Franklin (2019) in India, risks are categorized as political, operational, market, liquidity and credit risks. The detailed study for European Union by Noothout et al. (2016) suggested nine identified risks while in a similar study in European Region on the policy risk and regulatory risks for the renewable energy resources conducted by Gatzert and Kosub (2016) basically categorized these risks into business, construction/completion, policy, regulatory, political, legal, maintenance, and counter party risks.

There are different concepts and definitions of risk. According to Aven (2012), the meaning of risk depends on the use which the projects go through. Accordingly, Ragwitz et al. (2007), applied the concept of risk on renewable energy in European region and indicated that major risks can be further divided into smaller categories such as financial, market, political and technological divided into administrative, resource availability, market risks, financial support system, planning risk, access to grid, complexity of support risk. In addition, Waissbein et al. (2013), in a United Nations (UN) study on the renewable energy, indicated risk factors to help policy makers and stake holders, which include power market risks, permit risks, resource and technology risks, social acceptance risks, counter party risks, grid and transmission risk, financial sector risks, currency/macro-economic risks, and political risk. Bature et al. (2018) developed a research questionnaire developed for the bio energy sector to indicate and find the different risks present in process, which identified the risks as technological risks, weather risks, construction risks, political risks, operational risks and environmental risks. The study concluded that as the project proceeds, it would grow more complex and the risks will also be more complex.

The number of power companies including the renewable energy resources is growing day by day. According to Segal (2011), the Enterprise Risk Management (ERM) process includes the several risk factors, which have factors like risk identification (categorization, definition, qualitative assessment, identification), risk quantification, decision making regarding risk and in the end risk messaging. This is supported by the analysis conducted by Mirkheshti and Feshari (2017) for the renewable energy projects which included offshore wind projects in Iran using the AHP method. According to the PMBOK, each risk should be considered by the four points: affect/impact, frequency, like hood/possibility and time period. As the study utilized these variables with cost and quality to perform analysis, the risks identified were strategic/business risks, legal/liability risks, sales/market risk, transport and construction/ completion risks, counter party risks, operations/maintenance risks and political/policy/regulatory risks.

The study on sustainable energy system planning by Michelez et al. (2011) revealed that probability and variance can be used to measure the risk factor where as MCDM approach can be used for the non-statistical parameters. The study classified risk factors and their sub categories into political (country, regulatory and bureaucracy), social (lack of public surety and acceptance, major health risks), legal (energy and climate policy), economic (market, financial, business), technological (project development, construction, operations, infrastructure, decommissioning) and environmental. The study of Santoyo and Azapagic (2014) on sustainability assessment of the energy systems used life cycle approach to determine the most sustainable option. Methods like life cycle costing (LFC), life cycle assessment (LCA), scenario analysis, social sustainability assessment (SSA) and MCDM were utilized. Accordingly, Guerrero et al. (2016), in the Dominican Republic for the renewable energy resources, used the different methods such as Delphi method and check list to mark and identify the risks. SWOT analysis was also used which identified as price risks, technical risks and financial risks. AHP was used to prioritize the risks.

According to Gatzert and Kosub (2016), the risks are dependent mainly on the drivers and the policies, categorized as to costs related to grid management, size and type of financial support provided, controlling mechanism, national and regional targets, moral hazard, risks of acceptance, political uncertainty and institutional determinants. This clearly illustrates that policy risks are very important part of the renewable energy projects. In this context, Shapiro and Koissi (2015) indicated that there are different methods used for the assessment of the risk on basis of fuzzy logic. These include quantitative and semi-quantitative methods and approach. But the fuzzy approaches were found to be more time consuming if seen from data collection end but they are more intensive and for solutions, results and decision making. According to Ioannou et al. (2017), the renewable energy has been in the spotlight for the researchers in the recent years. As few studies were conducted on these topics, risks related to Pakistan as possibly good location for renewable energy is of great interest for researchers. For instance, Beltrán et al. (2014) indicated different risk factors in the selection of solar thermal power plants in different investment projects which are political, economic, technical, market, financial and time delay risks. Similarly, Jin et al. (2014) on wind power market and industry in China, indicated several risk factors projects have to face such as policy risks, investment risks, marketing risks, design risks, operational and ecological risks.

In another study, Liebreich (2005) indicated several risks for renewable energy projects and their financing categorized as operational and maintenance, legal, technical risk, construction risks permit risks. Meanwhile, Jinrong and Enyi (2011) conducted a study on Energy Performance Contracting (EPC) and identified risks which could occur in EPC projects as market risk, technology risk, legal and political risk, financial risk, management risk, quality risk and client risk. In addition, Prostean et al. (2014), the wind power projects in China have different risks such as construction, transportation, quality risks, order fulfillment risk. Risk assessment done by Chebotareva et al. (2020) on renewable energy projects in Russia indicated different risks for projects as gid access risks, administrative risks, political risks, financial risks, technical and managerial risks and risks of public acceptance or social risks. While Wu et al. (2019) mentioned that renewable energy projects along the China's project Belt and Road initiative have mainly political risks, technical risks, economic risks, social and environmental risks and resource risks, Agrawal (2012) indicated that different risk factors in renewable energy projects are market, construction, performance, credit, financial, legal, regulatory and political risks.

Table 1 provides the various risk factors/criteria identified from the literature.

Table 1

Risk factors/criteria

Risk Factor (Criteria)
Political Risk
Financial/Economic Risk
Operational/Maintenance Risk
Market/Sales Risk
Technical Risk
Policy/Regulatory Risk
Social Risk
Legal/Liability Risk
Environmental Risk
Construction/Transport Risk
Counter Party Risk
Management/Administrative Risk
Resource Risk
Strategic/Business Risk
Grid Risk
Permit Risk

2.2 Risk Mitigation/ Alternatives

According to Wing and Jin (2015), renewable energy investors and developers perform their own initial assessments of the project regarding the finances and risk that can occur. As large amount of time and capital is invested, therefore this initial assessment is necessary. The developers can then deduce amount of loss and setback their company can take. However, they are dependent on the policies and regulations of the government. Decisions of the government will have direct impact on their projects. Therefore, they expect the government to cooperate with them and derive investor friendly policies to reduce the risk factor. This is supported by Noothout et al. (2016) that government action can have effect on the renewable energy projects and help the companies in improving their finances. The government can improve the relation between public sector and private institutions to create better research and development. The collaboration will help in the risk sharing between government and companies. If unfortunate that some project faces set back, the government is there to support the company.

According to Liebreich (2005), the insurances and subsidies provided by the government have very principal support on the renewable energy projects. The only form of risk reduction acceptable for investors is the insurance. The insurance from government safeguards the investors and their capital. As Noothout et al. (2016) states that different renewable energy projects can help the government in strengthening the economy of a country, the government therefore provides different insurances and subsidies to the companies. The different methods of production of electricity have different costs (Gatzert & Kosub, 2016) wherein the government can provide subsidies to renewable technology which can reduce the cost of hardware required for the projects and eventually increase the profits for the investors.

According to Noothout (2016), the involvement of government can reduce the risks to very extent in financing sector. The government connection with private organizations can be very helpful for projects. The government can also provide loan guarantee as well as credit facilities to the investors. The proper implementations of the regulations ensure project safety for the investors and equity providers. Accordingly, Waissbein et al. (2013) states that banks play an important role in providing assistance to project developers and investors in securing funding and capital. For this, Frisari and Micari (2015) suggest that multifarious banks are present that can provide loans to the development organizations to ensure complete successful running of the projects. This ensures the financial security for the organizations and helps them decrease the risk at much lower cost.

According to Agrawal (2012), there are many multilateral organizations and agencies which provide political risk insurance for the investors and developers. These agencies ensure safety of capital and provide services for proper transfer of currency. In many instances, Frisari and Micari (2015) asserts that government itself provides the political risk insurance to investors as it is directly responsible for political and economic condition of a country. As the government is directly involved, these guarantees are very effective in satisfying development firms and investors.

Noothout et al. (2013) explains that best strategy is risk sharing by government, in acquisition of permits and lands. The Not in my backyard (NIMBY) mentality makes people in favor of the renewable energy projects but are not ready to provide land for projects. Awareness and information campaign can be started to remove any misunderstanding regarding renewable energy projects with proper communication. The government can provide financial support to the legal landowners to reduce the risk. As Soflaei et al. (2017) suggest, the strategy for the acceptance risk includes a proper campaign by the government to develop a consensus among general population regarding renewable energy projects.

In summary, table 2 lists the alternatives/ risk solutions obtained from literature.

Table 2

List of Alternatives/ risk solutions

Risk Mitigation/Solution (Alternatives)
Government Collaboration (Risk Sharing)
Government Insurance & Subsidies
Political Risk Insurance (PRI)
Financial Reforms & Contracts
General Awareness Campaign
Business Diversification
Risk & Security Consultants
Better ROI

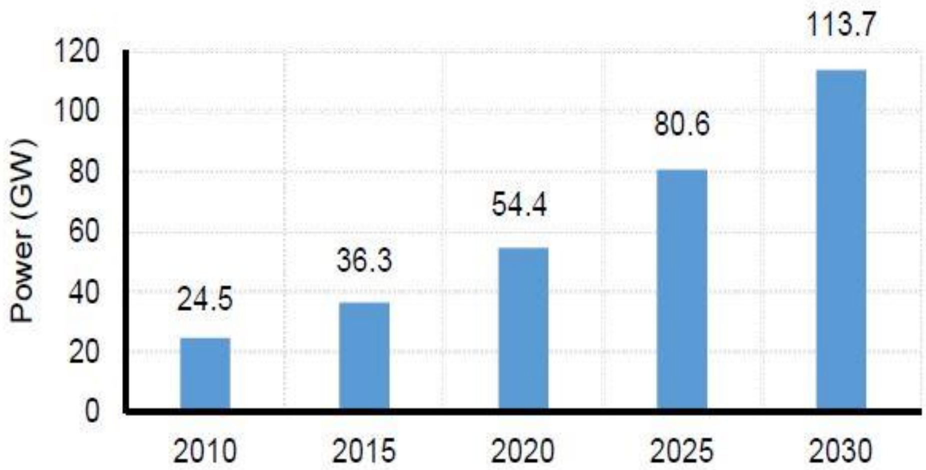
2.3 Renewable Energy Resources in Pakistan

Solar Energy Resource

The energy demand in Pakistan is growing at a rapid rate of about 8% annually (Rehman & Deyuan, 2018) which is quite high. The nature of solar power is distributive which can be used to overcome the shortage. According to the Renewable Energy Attractiveness Index (RECAI) report in October 2017, Pakistan is included in top 40 countries which are suitable for renewable energy development. The solar utilization in Pakistan is so far not very good because the country has not properly utilized its potential for development of solar power energy plants (Rafique et al., 2020). According to some reports, the solar capacity in Pakistan is at around 2900 GW (Rauf et al., 2015). The increase in demand of solar energy can be seen in figure 2.

Figure 2

Increase in demand of power projection



Source: Rafique et al. (2020)

The geographical location of Pakistan allows each part of country to utilize different solar technologies and generate power. As Pakistan is very rich in solar potential, half of the country can be used to develop major power plants for energy. For instance, Baluchistan has the most solar potential followed by Sindh and Punjab. Major part of Pakistan's population is associated with the agricultural sector therefore their power needs can be fulfilled by using solar power (Yazdani & Pascale, 2017). The world is shifting its trends towards the renewable energy because by 2035 the fossil fuel production of energy will be greatly reduced due to depletion of sources. Therefore, it is inevitable to look for other sources of power production, which renewable energy will provide and fill that gap.

Wind Energy Resource

Over the last few decades, the world has progressed showcasing the growth in every field sector and increased dependency on technology. Thus, there is need for more energy and power to fulfill. The population of Pakistan has also increased in the past years which requires more energy generation. The conventional methods of energy production like oil, fossil fuel, and coal are covering majority of production in Pakistan. But as these sources deplete, there is a need to look for other sources for energy production (Opricovic & Tzeng, 2004). There is huge potential for wind energy in Pakistan. According to reports, the wind site in Pakistan Gharo-Keti Bandr alone has potential to produce around 60 GW of energy and US Aid reports suggest that total potential is about 150 GW. There are few projects related to wind power that are producing energy. The coastal regions of Sindh and other North-West regions are suitable for the wind power. It is also important that these plants be set in 12-18 months and ready to be used where conventional methods like dams can take 5-6 years (Linkov et al., 2004).

Micro Hydel Resource

The growing need of energy in Pakistan is one of major problems of country. The high growing population and new developing areas are causing shortage of power. Due to this, there are new and cleaner ways of producing power being utilized. One of them is micro hydel plants. Hydro plants produce clean and efficient energy. These can be considered as source of greatest renewable energy production throughout the world. One of major advantage of micro hydel is that it can be used in small streams and rivers where water flows and doesn't require storage of water. Micro hydel plants can range from kilo watts to few megawatts (Linkov et al., 2004). Accordingly, there is potential of about 1200 MW that can be produced using micro hydel in Pakistan but only 4-5% is being generated. Therefore, by using micro hydel as major source of power production, the short fall of energy can be overcome (Umer & Hussain, 2015).

3. Methodology

Multi criteria decision making (MCDM) tools have wide range of use. These are applied in various fields whenever there are multiple alternatives with different selection criteria and factors. These are known for solving real complex problems due to their potential to select alternatives with reference to different criteria. There are different techniques in MCDM used for the problem solving which are Analytic Hierarchy Process (AHP), Weighted Product Model (WPM), VIKOR, ELECTRE and Multi Attribute Utility Analysis (MAUA) (Emovon, 2020). The first step in the MCDM approach is to set different objectives for the achievement of overall objective. In this study, the main objective is the risk assessment of renewable energy resources. The risk factors are the overall criteria and their mitigation techniques are the alternatives. These criteria and set of alternatives are important part of MCDM (Saaty, 1990).

The main procedure involves the risk factors labeled as criteria. The stakeholders including the government officials, renewable energy firms and organizations and end-users select the criteria/risk factors according to their own preference. They assign weight to each factor according to its importance and level of occurrence. These weights decide which risk is more likely important in the eyes of decision-makers. The next step is the selection of alternatives or risk solutions. The alternatives are ranked according to the stakeholders and the alternative with highest ranking is selected as best risk mitigation alternative. The AHP was used in this study. It is a process in which problem is divided into different levels. At each level, the factors are compared to each other in the form of pairwise comparison matrix. The factors of certain level are compared to adjacent level factors which generate set of weights or priorities. These weights are values which are assigned by the decision makers. The further solution of problem is done on basis of these weights (Saaty, 2014).

Analytic Hierarchy Process (AHP)

The AHP is used in MCDM and has been applied to many decision-making to solve practical problems. According to Lee et al. (2001), it is easy to choose by providing a very structured multi-criteria framework to evaluate the alternatives. AHP enables decision- makers to analyze qualitative and quantitative data using multi-criteria analysis. It also utilizes simple hierarchy structure which is easy to use for decision makers (Marle & Gidel, 2012). According to Saaty (1980), whenever there are large number of alternatives and selection factors are present, they can be analyzed using AHP. It is a powerful decision-making tool that can help decision makers deal rational and irrational data. It uses MCDM approach in which decision makers can evaluate several criteria and alternatives at the same time with the support of feedback and trade-offs. It also helps in simplifying the complex problems and converting them into natural decision-making. AHP is a technique designed to evaluate complex problems and break those complex problems into 4 steps which consist of hierarchy construction, the pair-wise comparisons, generating priority vector and synthesis.

The first step of AHP is to construct a structural hierarchy. This helps in solving decision problem. This step does not contain a certain rule which needs to be followed in constructing a hierarchy. The hierarchy, in descending form, contains the main objective or goal, followed by criteria, and sub criteria. The main part is to brainstorm objective, criteria and alternatives and then form hierarchy in which lower-level elements are compared with higher level elements.

After establishing the hierarchy, next step is to make priorities for criteria and alternatives included in the hierarchy. The AHP utilizes technique of pairwise comparison between the elements. The first step is to compare elements against the given criteria. The comparison of elements in the lower levels is done with respect to each element present in upper levels. The nine-point is used in this step.

The relative rankings of each hierarchy level are obtained by pairwise comparisons. The number of matrices is related to number of elements present at each level of hierarchy. The order of matrix depends on the links of elements on lower level. After constructing all the matrices, the next step is to calculate max eigen value (l.max), relative weights or global weights of each matrix (Saaty, 1990).

The first word in AHP is Analytic, which means dividing or separating material into its parts. Whereas synthesis is complete opposite of it, it means to combine or form new part. According to Saaty (1980), it consists of the following three steps.

The primary step in synthesis is to sum the values of each column in pairwise comparison matrix. This is followed by dividing each column value with the column total sum resulting to the normalized pairwise comparison matrix. In the next step, the average of rows on normalized matrix is obtained by adding and then dividing the average value with the number of entries in each row. In this way, relative priorities of elements are obtained.

To develop overall priority for ranking, synthesis is used. The ranking of alternatives depends on composite weights, which are developed by using relative weights of elements at different level.

The decision-makers' consistency is very important in every decision. The consistency of judgments in the pairwise comparison matrix can be checked. According to Saaty (1990), it is very difficult to achieve overall good consistency. In AHP, the inconsistency in hierarchy is checked. The acceptable amount of inconsistency ratio is 10%, or anything less than this. Any value higher than this is not acceptable (Saaty, 1990).

The following are used to measure consistency: Weighted Sum vector (W), Consistency Ratio (CR), Consistency Index (CI) and Ratio Index (RI).

w is obtained by using following equation:

D.w=l.max.w

Where D is pairwise comparison matrix, l.max is the eigen value of matrix D and w is right eigen vector.

According to Saaty (1990), consistency consists of following steps:

1. The relative weight or eigenvector and l.max for each matrix is calculated in order n.

2. The consistency index (CI) is calculated using the formula: CI= (l.max-n)/(n-1)

3. Consistency ratio (CR) is calculated using the formula: CR=CI/RI

Generally, if the CR value is less than 10% it is acceptable; higher than 10% the judgments should be rechecked and done again. If the consistency index of entire hierarchy is to be obtained, the CI of each matrix is multiplied by priority of criteria. The consistency of entire hierarchy can also be checked by comparing CI of hierarchy with random CI of matrices of same size. If CR is less than 10%, it is good and acceptable; higher than 10% then judgments should be reviewed and rechecked (Badalpur & Hafezalotob, 2015).

4. AHP Analysis. According to the cited literature, the number of criteria and alternatives were identified. However, the number were large, which is impossible to use for pairwise comparisons. Therefore, the team of experts were presented with the first questionnaire, which they selected the 7 most important criteria and 5 most important alternatives. Table 3 presents the criteria and alternatives used in the risk assessment.

Table 3

Selected criteria and alternatives from literature

Criteria/Risk Factors	Alternatives
Political	Government Collaboration (Risk Sharing)
Financial/ Economic	Government Insurance & Subsidies
Operational/ Maintenance	Political Risk Insurance
Market/ Sales	General Awareness Campaign
Technical	Financial Reforms & Contracts
Policy/ Regulatory	
Social	

As the procedure of MCDM was used, the AHP was also applied. In applying AHP, the hierarchy is established first. Using the framework of AHP, the hierarchy was constructed using the factors and alternatives derived from the literature. The first hierarchy is presented in figure 3.

Figure 3

Derived Hierarchy

The second hierarchy was also constructed using the same risk factors/criteria but with different alternatives which are renewable resources. The data were collected related to the risk factors to renewable energies with risks. The second hierarchy is presented in figure 4.

Figure 4

The Second Derived Hierarchy

The questionnaire was developed using the selected criteria/factors and alternatives from the hierarchy. The main purpose of this questionnaire was to obtain expert judgement regarding the research objectives. The questionnaire consisted of pairwise comparisons of criteria and alternatives. It also contains a cover letter which explained the steps and procedures on filling out the questionnaire and the use of data in the study. The language of the questionnaire was kept simple to be comprehensible. It contained the following: preliminary information about the questionnaire, pairwise comparison of criteria/risk factors, and the pairwise comparison of alternatives with respect to each criterion. The questionnaire was based from the data collected from literature, which were factors and alternatives.

A total of 74 questionnaires were distributed, out of which, 71 were retrieved from the participants, 8 were returned with inconsistent answers, which were discarded. The 71 experts comprising 17 end-users, 28 government officials from different regions and 26 renewable energy company officials operating in different regions were the participants of the study. The demographic profile of the participants showed that majority of them are majority of them are 20-30 years old (N=29) and 31-40 years old (N=28), male (N=47) with 2 – 5 years' work experience (N=25).

The major advantage of AHP is that, it does not require large statistical sample size to obtain good results (Doloi, 2008). According to some researchers, AHP is a subjective method which only focuses on issue, which does not require large sample. Others argue that in AHP expert judgments matter so even one qualified expert judgment can be represented as final. It can also be used in studies with large sample size, but if cold experts provide unpredictable answers, it could affect the consistency of data (Cheng et al., 2002).

4. Results & Discussion

Table 4

Results of pairwise comparison of factors & their ranks. (first hierarchy)

Criteria/Risk Factors	Government Officials		Company Officials		End Users	
	Priority	Rank	Priority	Rank	Priority	Rank
Political	0.201	2	0.164	4	0.175	3
Financial/ Economic	0.224	1	0.179	3	0.220	2
Operational/ Maintenance	0.147	4	0.258	1	0.119	4
Market/ Sales	0.104	5	0.081	5	0.233	1
Technical	0.102	6	0.200	2	0.097	5
Policy/ Regulatory	0.183	3	0.080	6	0.069	7
Social	0.039	7	0.037	7	0.086	6

Table 4 shows the pairwise comparison of the first hierarchy for three groups of respondents. The results indicate the rankings of the criteria/risk factors accordingly as financial/economic (government officials), operational/maintenance (company officials) and market/sales (end-users).

Table 5

Results of pairwise comparison of alternatives & their final ranks. (first hierarchy)

Alternatives	Government Officials		Company Officials		End Users	
	Priority	Rank	Priority	Rank	Priority	Rank
Government Collaboration (Risk Sharing)	0.299	1	0.296	1	0.266	1
Government Insurance& Subsidies	0.245	2	0.260	2	0.236	3
Political Risk Insurance	0.144	4	0.151	4	0.152	4
General Awareness Campaign	0.078	5	0.075	5	0.089	5
Financial Reforms & Contracts	0.233	3	0.219	3	0.247	2

Table 5 shows the result of alternatives pairwise comparison and their rankings for the first hierarchy. The pairwise comparison of alternatives showed government collaboration (risk sharing) at rank 1.

Table 6

Results of pairwise comparison matrix (2nd hierarchy)

Criteria/Risk Factors	Priority	Rank
Political	0.244	1
Financial/ Economic	0.183	2
Operational/ Maintenance	0.095	6
Market/ Sales	0.083	7
Technical	0.136	4
Policy/ Regulatory	0.157	3
Social	0.101	5

Table 6 shows the second hierarchy results of pairwise comparison. The second hierarchy showed political factor at rank 1 and financial/economic at rank 2.

Table 7

Results of pairwise comparison of alternatives & their final ranks. (2nd hierarchy)

Alternatives	Priority	Rank
Solar	0.433	1
Wind	0.327	2
Micro Hydel	0.239	3

Table 7 shows the results of the second hierarchy pairwise comparison of alternatives. The results showed solar at rank 1 followed by wind and micro hydel at ranks 2 and 3, respectively.

Discussion

The government officials identified financial/ economic, political and policy/regulatory as the most important risk factors with high chances of occurrence. Meanwhile, the solutions were ranked as government collaboration, government insurance & subsidies and financial reforms and contracts. On the other hand, the company experts identified operational/ maintenance, technical and financial/ economic as the important risk factors while the alternatives or risk solutions were ranked as government collaboration, government insurance & subsidies and financial reforms and contracts. The third group of participants, the end-users, ranked risk factors as market/ sales, financial/ economic and political. The risk solutions or alternatives identified by this group were government collaboration, financial reforms & contracts and government insurance and subsidies. It can be observed that all three groups have almost same opinion for the risk solutions that the government factor is the key point in risk reduction mechanisms.

The political risk is identified as the most important risk factor by the three groups. Related literature and studies showed that political risk is identified as a factor in most risk management and assessment. Similarly, Waissben et al. (2013) identified political and financial risk as the most important factors. The second risk factor, financial/ economic, also confirmed the results of the previous studies while the other factors such as policy/regulatory, operational/

maintenance and market/sales risk affirmed the results of Franklin (2019), Gatzert and Kosub (2016), Noothout et al. (2016) and Ragwitz et al. (2007). Meanwhile, the results of Wu et al. (2019), Protean et al. (2014) and Jin et al. (2014) mainly focused on political and operational/maintenance and technical risks.

The literature and studies as well as the results of the current study indicated that government support is the most important factor in risk reduction. Whenever the government backs the investors and ensures its support, the risks can be reduced and their chances of occurrence can be minimized. The studies within the European region identified government collaboration and government insurance and subsidies as important risk solution. It is true that the machinery of the government ensures all projects maintain their growth efficiently and are completed in time. As the same trend pattern was identified, all three groups of respondents (government officials, renewable energy company experts and end-users) have same opinion on risk alternatives. Therefore, government factor was identified as the most important. Financial reforms and contracts alternative is within the government jurisdiction.

5. Conclusion

The study identified different risk factors that renewable energy projects can face in general. As the CPEC project is progressing, there is a need for more energy plants in regions along its route. The study also identified the solutions or measures necessary to eliminate or reduce these risks. Three groups of individuals served as participants, which include government officials, company officials and experts and end-users. MCDM approach through the Analytic Hierarchy Process (AHP) method was used in data analysis. The questionnaire was designed from cited literature and studies, which identified the risk criteria as political risk, financial/ economic, market/sales, operational/ maintenance, technical. policy/regulatory and social risk. Each group of participants identified the risks according to their importance and probability of occurrence, which were ranked based on their priorities. Similarly, risk solutions contained government collaboration, government insurance & subsidies, political risk insurance, general awareness campaign and financial reforms and contracts. The groups also identified the most important risk solution to reduce the risk identified in the first step. These solutions were also ranked on basis of their preferences.

The results showed that one of major risk factor is financial/ economic. Majority of the stakeholders are more concerned about financial and economic conditions of the country. Therefore, government should take steps in order to ensure good market conditions for business and investors. As they have also identified government collaboration as major risk solution, it means government's support for renewable industry needs to be more efficient. These can be done in form of different risk sharing and financial contracts in which government becomes the partner to boost the industry. Political risk was also identified as major risk factor. If political condition of country is not stable, foreign investors back out. Therefore, government should also provide insurances to investors and renewable energy companies to help them operate easily in changing political conditions. This will bring foreign investment and jobs for local industry. In addition, the government insurance and subsidies is one of major risk solutions selected by the experts.

The involvement of government in backing renewable energy projects should be maximum, as it would present better political image and attract more investors. The government has provided many facilities to renewable energy companies and investors in Alternative Renewable Policy (ARE) 2019, which include duty free import of plant and machinery for local industries. But these points can be improved in terms of more financial benefits and good financial and political situation on country.

The results of the current study showed similarity to many previous studies. Through this result, the important risk factors in the region were identified. These results can help government officials to derive policy and set their focus on better policies and regulations to help foreign investors and local manufacturers working in field of renewable energy technology. Further studies can be explored using the same method to identify different risks factors from other industry or technology.

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