

ABSTRACT

Thesis Title: DEVELOPMENT OF AN ENTERPRISE RISK MANAGEMENT MODEL FOR RENEWABLE POWER PROJECTS IN INDIA

Conventional resources for electricity generation produce over three-fourths of the anthropogenic emissions responsible for climate change. Therefore, the world is swiftly transitioning to embrace renewable resources, such as solar, wind, and hydropower, to control climate change and decarbonization. Further, they proved to be a potential solution to energy access and security concerns. However, developing renewable power projects imposes numerous challenges, distinct from developing projects with conventional resources, that require unique risk management strategies to ensure improved performance and sustainable development.

Risk management in practice is far from the theoretical background and is one of the primary reasons for derailed project performance, i.e., time and cost. Given the unique characteristics and the exclusive challenges it imposes, the conventional approach to risk management may not be adequate. Further, risk management is an enterprise's top management's prerogative, and the adoption of any approaches depends heavily on their risk perception. Furthermore, the perception of risks and management perspectives can significantly differ depending on the enterprise's role in the project (i.e., developer/ owner and principal contractor) and its listing types (i.e., public and private). Accordingly, the following questions arise: How do risk perceptions and approaches vary with respect to the enterprise role and listing type that influence renewable power project performance? What are the governing factors, and how do we develop a risk management model tailor-made to the renewable sector to influence their performance and sustainability parameters?

Prevailing literature has rarely examined the enterprise risk perception towards risk management in developing renewable power projects, especially solar power projects. Moreover, limited studies have been conducted to investigate enterprises' approach to managing risk based on their roles and listing types. Further, limited studies are available on investigating solar power project risks and their impact on project performance, primarily based on empirical evidence, while analyzing the

underlying contractors' approach to addressing them. In addition, risk issues and mitigation strategies concerning the enterprises' sustainability and the precise analysis of their underlying structure and influences in the context of renewable resources are seldom reported. Although past studies illustrated several risk management practices, their actual impact on project performance and sustainability through empirical evidence is seldom reported. Further, the aspects were rarely available in the prevailing literature, especially in the case of addressing the unique characteristics of renewable power project development.

The study aims to evaluate the risk perceptions and management approaches by an enterprise in developing a renewable power project concerning its role in the project, i.e., developer and principal contractor, and its listing types, i.e., public and private. The study also aims to identify the critical risk management practices specific to the sector and evaluate their influence in improving project performance and sustainability parameters. Moreover, the study focuses on identifying the critical risks in renewable project development and the appropriate risk mitigation strategies to control the risk impact.

To address the research objectives, it was essential to identify and understand the current state of risk management practices in renewable sector enterprises and test hypotheses for their influence on performance and sustainability parameters. Thus, pragmatism research philosophy, which combined the use of both positivism and interpretivism philosophies, was adopted in this study. Moreover, the study adopted a combination of deductive and inductive approaches to address the questions, enabling data collection through quantitative and qualitative means.

The study explored the differences in risk perceptions and management approaches concerning enterprise role in the project and listing types, as well as the governing underlying factors through case studies with similar attributes. The study revealed significant differences in the risk management approaches, primarily in risk planning, risk sharing between the stakeholders, decision-making systems, and coordination and reporting mechanisms, leading to differences in the project outcomes. While public enterprises are more process-oriented, the private sector has a result-oriented inclination. Further, public entities are document-driven, inflexible, and bound by bureaucratic decision-making systems that

consume more time, thereby preferring conventional approaches to risk management. Further, developers in developing renewable projects, regardless of their listing types, prefer to transfer all the project risks to the contractor through a lumpsum turnkey (LSTK) mechanism. In contrast, contractors, irrespective of their listing types, consciously accept the conditions. Contractor entities are result-oriented, flexible, quick in decision-making, and perform collaborative risk management. By determining and evaluating the differences in enterprises' perspectives and approaches under their listing types and role in the project, underlying factors leading to their adoption, and their efficacy in developing solar (renewable) power projects, the study fills a critical gap in the body of knowledge.

Given that when developing renewable power projects, developers prefer to transfer the risks, perceived or non-perceived, to the contractor through an LSTK contract, the risk perception and approaches of a contractor enterprise become more significant. To address the research questions, the contractors' risk perceptions in their differing listing types, i.e., public and private, were studied through case studies with similar attributes. While analyzing the contractors' management approach, the case study evaluated the risks encountered and the impact they had on the project outcome. The study outlined 16 key risk factors and their impact on project outcome, such as reworks, cost and time variance, imposition of liquidated damages, loss of revenue, and disputes and claims. Further, the discussion with the project team and functional leaders suggested potential mitigation measures. Further, the study revealed that irrespective of the contractor's listing type, the approach toward risk management remains casual, leading to derailed project outcomes. Moreover, lax planning, absence of formal risk management, and non-adherence to the risk portfolio during all project phases were revealed. By identifying the critical risks encountered and evaluating the contractors' perspective and adopted approaches in their management through empirical evidence from India, the study fills the crucial gap in the body of knowledge.

The comprehensive literature review identified limited studies that were focused on existing practices and their state of implementation, critical risk issues, and mitigation strategies in the context of the renewable industry. Further, the influence of these practices on improving the performance and sustainability objectives was rarely explored. Therefore, this study investigates the current state of

practice of risk management, focusing on Indian renewable sector enterprises, based on discussions with risk management practitioners and a questionnaire survey. The first section (referred to as Q1) of the questionnaire evaluated the influence of risk management practices on projects' performance and sustainability parameters. The analysis of Q1 survey data, using exploratory factor analysis (EFA), determined the critical risk management practices such as inclusive and long-term planning, engaging dedicated risk officers, identifying, documenting, and updating risk management policy, and systematic risk assessment, recording, and training. Further, by analyzing data using structural equation modeling (SEM), the study determined that these practices significantly and positively influence the renewable power project's performance and sustainability parameters. The study also provided comprehensive insights into the current risk management practices being followed in Indian renewable power sector enterprises. The study fills the critical gap by narrowing the vital practices and determining their level of implementation in the Indian renewable power sector. Moreover, by determining their influence on improving performance and sustainability, the study expands the existing body of knowledge.

The second section of the questionnaire survey (referred to as Q2) evaluated the influence of risk mitigation strategies in containing the risk issues. The analysis of Q2 survey data, using EFA and SEM, determined the key risk issues and mitigation strategies that were tailored for the development of renewable power projects. Critical risk issues included a lack of project management, operational issues, resource and infrastructure constraints, supply chain constraints, impractical regulations and expectations, lack of technical standards, and industry and business risks, covering the entire gamut of risks to the enterprises in the development of renewable power projects. Further, critical mitigation strategies, such as digitalization, standardization, creating databases, policy framework, proactive planning and process development, and improved stakeholder interaction and liaison, were found to have a significant positive impact in mitigating risk issues. The study would allow enterprises to recognize risks proactively, adopt an appropriate mitigation strategy, allocate risks appropriately, and avoid disputes. This study adds value to the existing body of knowledge by exploring the risk mitigation measures, their underlying structure, and their precise influence in reducing the impact on renewable sectors' sustainable development through empirical evidence.

The risk professionals and enterprises can adopt the output of the study to modify/ adopt appropriate approaches to address risk issues and enhance performance and sustainability. Further, practitioners can plan the identified risks in this study proactively and adopt appropriate mitigation strategies to minimize the impact. Proactive action from decision-makers can provide a pronounced understanding of risks and their impact. Further, it allows the timely deployment of appropriate mitigation measures, thereby minimizing threats and maximizing opportunities. Moreover, enterprises and practitioners can adopt the identified critical risk management practices to align project objectives with the enterprise's long-term goals.