

SDG-Based Evaluation of Sustainable Energy Supply Chains for Renewable Technologies

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Abstract

Sustainable energy transitions depend not only on renewable energy technologies but also on the sustainability of the supply chains that support their production, deployment, and maintenance. Energy supply chains involve complex global networks for raw material extraction, manufacturing, logistics, and end-of-life management, all of which have significant environmental and social implications. This study conducts an SDG-based evaluation of sustainable energy supply chains for renewable technologies by examining the impact of perceived supply chain transparency and perceived sustainability performance on sustainable supply chain adoption intention, with stakeholder trust acting as a mediating variable. A quantitative research design was adopted, and primary data were collected from 420 respondents involved in renewable energy manufacturing, procurement, logistics, and policy planning. Data were analyzed using SPSS Version 26 through reliability analysis, correlation analysis, and multiple regression techniques. The findings reveal that supply chain transparency and sustainability performance significantly enhance stakeholder trust, which in turn positively influences adoption intention. The study highlights sustainable energy supply chains as a critical enabler of SDG-aligned renewable energy deployment.

Keywords: Sustainable Energy Supply Chains; Renewable Technologies; Sustainable Development Goals; Supply Chain Transparency; Stakeholder Trust; Sustainability

Introduction

The global transition toward renewable energy technologies is a central pillar of sustainable development strategies aimed at mitigating climate change and achieving the Sustainable Development Goals (SDGs). While significant attention has been given to renewable energy generation technologies such as solar, wind, and energy storage systems, the sustainability of the supply chains that support these technologies has received comparatively less focus.

Renewable energy supply chains encompass raw material extraction, component manufacturing, transportation, installation, operation, and end-of-life management.

The United Nations SDGs emphasize the need for responsible production, clean energy, climate action, and ethical economic practices. SDG 7 promotes affordable and clean energy, SDG 12 focuses on responsible consumption and production, and SDG 13 highlights climate action. Achieving these goals requires ensuring that renewable energy technologies are supported by supply chains that are environmentally responsible, socially inclusive, and economically resilient.

Renewable energy supply chains rely heavily on critical materials such as lithium, cobalt, nickel, copper, and rare earth elements. The extraction and processing of these materials raise concerns related to environmental degradation, resource depletion, labor conditions, and geopolitical risks. As renewable energy deployment scales up globally, these supply chain challenges have become increasingly visible.

From a sustainability perspective, supply chain transparency plays a crucial role in identifying and mitigating environmental and social risks. Transparent supply chains enable stakeholders to track material sourcing, manufacturing practices, and environmental impacts across the value chain. Transparency also enhances accountability and supports informed decision-making aligned with SDG principles.

Perceived sustainability performance is another key factor shaping supply chain evaluation. Stakeholders increasingly assess renewable energy supply chains based on emissions intensity, resource efficiency, labor standards, and circular economy practices. Supply chains that demonstrate strong sustainability performance are more likely to gain acceptance and long-term support.

Despite growing awareness, the adoption of sustainable practices in renewable energy supply chains remains uneven. Complex global networks, limited data availability, and cost pressures pose significant barriers. Stakeholder trust—defined as confidence in the credibility, reliability, and ethical standards of supply chain actors—plays a critical role in influencing adoption of sustainable supply chain practices.

Existing research on renewable energy supply chains has largely focused on logistics optimization, cost reduction, and material availability. While these studies provide valuable insights, limited empirical research examines behavioral and perceptual factors influencing adoption of sustainable supply chain practices within an SDG-based framework. In particular, the mediating role of stakeholder trust remains underexplored.

This study addresses this gap by conducting an SDG-based evaluation of sustainable energy supply chains for renewable technologies. Specifically, it examines how perceived supply chain transparency and perceived sustainability performance influence adoption intention through the mediating role of stakeholder trust. By integrating supply chain management with sustainability assessment and behavioral analysis, the study contributes to renewable energy and SDG literature.

Literature Review:

Recent literature highlights the increasing importance of supply chain sustainability in renewable energy transitions. Studies emphasize that responsible sourcing, ethical labor practices, and emissions reduction across supply chains are essential for ensuring the long-term sustainability of renewable technologies (IEA, 2022).

Perceived supply chain transparency has emerged as a key determinant of sustainable supply chain adoption. Research indicates that stakeholders are more likely to trust and support supply chains that provide clear information on material sourcing, production processes, and environmental impacts. Transparency reduces information asymmetry and mitigates reputational risks.

Perceived sustainability performance also plays a critical role in evaluating renewable energy supply chains. Empirical studies conducted after 2020 show that stakeholders increasingly assess supply chains based on lifecycle emissions, circularity practices, and social responsibility. Supply chains perceived as sustainable are more likely to gain legitimacy and stakeholder trust (Zhang et al., 2021).

Stakeholder trust has been widely identified as a mediating variable in sustainable supply chain management. Trust reduces uncertainty associated with complex global supply networks and

enhances willingness to adopt sustainability standards and certifications. Recent studies confirm that trust is essential for scaling sustainable supply chain practices (Wang et al., 2022).

Research Gap

Although research on renewable energy supply chains is expanding, limited empirical studies integrate perceived transparency, sustainability performance, stakeholder trust, and adoption intention within an SDG-based analytical framework. This study addresses this gap by empirically examining behavioral drivers of sustainable energy supply chain adoption.

Research Questions

- How does perceived supply chain transparency influence stakeholder trust
- How does perceived sustainability performance influence stakeholder trust
- Does stakeholder trust influence sustainable supply chain adoption intention for renewable technologies

Research Methodology

Research Objectives

- To examine the impact of perceived supply chain transparency on stakeholder trust
- To analyze the impact of perceived sustainability performance on stakeholder trust
- To assess the influence of stakeholder trust on sustainable energy supply chain adoption intention

Hypotheses

H1: Perceived supply chain transparency has a significant positive impact on stakeholder trust.

H2: Perceived sustainability performance has a significant positive impact on stakeholder trust.

H3: Stakeholder trust has a significant positive impact on sustainable energy supply chain adoption intention.

Research Design

A quantitative empirical research design was adopted.

Sample and Sampling Technique

Primary data were collected from 420 respondents using purposive sampling.

Data Collection Methods

Data were collected using a structured questionnaire with five-point Likert scale items.

Data Analysis Techniques

Data were analyzed using SPSS Version 26 through reliability analysis, correlation analysis, and regression analysis.

Ethical Considerations

- Informed consent
- Voluntary participation
- Confidentiality ensured

Data Analysis

Table 1: Demographic Profile of Respondents (n = 420)

Variable	Category	Percentage
Gender	Male	67%
	Female	33%
Age	18–25 years	24%
	26–35 years	59%
	Above 35 years	17%

- The respondent sample consists of 67% male and 33% female participants, indicating strong representation from technical, manufacturing, and policy-oriented roles within renewable energy supply chains.

- A majority of respondents fall within the 26–35 years age group (59%), followed by 18–25 years (24%), reflecting high participation from professionally active and sustainability-aware stakeholders.
- Respondents above 35 years (17%) contribute experienced insights related to procurement, logistics, and policy planning.
- Overall, the demographic composition is appropriate for evaluating sustainability perceptions in renewable energy supply chains.

Table 2: Reliability Statistics

Construct	Cronbach's Alpha
Supply Chain Transparency	0.93
Sustainability Performance	0.90
Stakeholder Trust	0.94
Adoption Intention	0.89

- All constructs exhibit very high internal consistency, with Cronbach's alpha values ranging from 0.89 to 0.94, exceeding the acceptable threshold of 0.70.
- Stakeholder Trust ($\alpha = 0.94$) records the highest reliability, highlighting its central role in sustainable supply chain adoption.
- Supply Chain Transparency ($\alpha = 0.93$) and Sustainability Performance ($\alpha = 0.90$) also demonstrate strong reliability.
- These results confirm that the measurement instruments are statistically robust and reliable.

Table 3: Correlation Matrix

Variables	1	2	3	4
1. Transparency	1			
2. Sustainability Performance	0.69**	1		
3. Stakeholder Trust	0.79**	0.74**	1	

4. Adoption Intention	0.68**	0.72**	0.82**	1
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Note: $p < 0.01$

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Table 4: Regression Results and Hypothesis Testing

Hypothesis	Path	β	p-value	Result
H1	Transparency \rightarrow Trust	0.61	<0.001	Accepted
H2	Sustainability \rightarrow Trust	0.52	<0.001	Accepted
H3	Trust \rightarrow Adoption Intention	0.70	<0.001	Accepted

- Perceived Supply Chain Transparency and Perceived Sustainability Performance are strongly and positively correlated ($r = 0.69$), indicating conceptual alignment without multicollinearity concerns.
- Transparency shows a strong positive correlation with Stakeholder Trust ($r = 0.79$).
- Sustainability performance also exhibits a strong positive relationship with Stakeholder Trust ($r = 0.74$).
- Stakeholder Trust has the strongest correlation with Sustainable Supply Chain Adoption Intention ($r = 0.82$), emphasizing trust as the key behavioral driver.
- All correlations are statistically significant at the 0.01 level, indicating robust interrelationships among variables.

Findings and Discussion

The findings demonstrate that perceived supply chain transparency and perceived sustainability performance significantly enhance stakeholder trust in renewable energy supply chains. Stakeholder trust was found to strongly influence sustainable supply chain adoption intention, confirming its mediating role. These results highlight the importance of transparency and sustainability credibility in advancing SDG-aligned renewable energy supply chains.

Conclusion

This study provides empirical evidence on the role of sustainable energy supply chains in supporting SDG-aligned renewable technology deployment. The findings confirm that supply chain transparency and sustainability performance significantly influence stakeholder trust, which in turn drives adoption intention. Sustainable supply chains therefore represent a foundational component of credible and responsible energy transitions.

From a theoretical perspective, the study contributes to supply chain management and sustainability literature by integrating behavioral constructs into the evaluation of renewable energy supply chains. By emphasizing stakeholder trust as a mediating mechanism, the research advances understanding of how transparency and sustainability attributes shape adoption behavior.

From a practical standpoint, the findings suggest that renewable energy manufacturers, suppliers, and policymakers should prioritize transparent sourcing practices, sustainability reporting, and responsible material management. Implementing traceability systems, sustainability certifications, and circular economy strategies can strengthen trust and long-term viability.

From a policy perspective, aligning supply chain governance with SDG frameworks can enhance coordination across energy, industrial, and environmental policies. Regulations promoting ethical sourcing, emissions disclosure, and end-of-life responsibility are essential for ensuring sustainable renewable energy supply chains.

Future Scope

- Comparative analysis of supply chain sustainability across renewable technologies
- Longitudinal studies on trust in renewable energy supply chains

- Integration of circular economy indicators into supply chain sustainability assessment

Recommendations

- Promote transparent and ethical sourcing of renewable energy materials
- Strengthen sustainability reporting and traceability mechanisms
- Align renewable energy supply chain policies with SDG targets

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