The Role of Sustainable Energy Digitalization in Monitoring SDG Progress

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Abstract

Digital technologies are increasingly transforming energy systems by enabling real-time monitoring, data-driven decision-making, and enhanced system efficiency. Sustainable energy digitalization plays a critical role in tracking and accelerating progress toward the Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action). This study examines the role of sustainable energy digitalization in monitoring SDG progress by analyzing the impact of perceived digital system effectiveness and perceived sustainability transparency on sustainable energy monitoring adoption intention, with stakeholder trust acting as a mediating variable. A quantitative research design was adopted, and primary data were collected from 420 respondents including energy managers, policymakers, and digital technology professionals. Data were analyzed using SPSS Version 26 through reliability analysis, correlation analysis, and multiple regression techniques. The findings reveal that digital system effectiveness and sustainability transparency significantly enhance stakeholder trust, which in turn positively influences adoption intention. The study highlights energy digitalization as a strategic enabler for evidence-based SDG monitoring and sustainable energy governance.

Keywords: Sustainable Energy Digitalization; Sustainable Development Goals; Energy Monitoring Systems; Digital Energy Platforms; Stakeholder Trust; Sustainability

Introduction

The achievement of the Sustainable Development Goals (SDGs) requires continuous monitoring, evaluation, and adaptive policymaking based on reliable data. In the energy sector, progress toward clean energy access, efficiency improvements, and emissions reduction depends heavily on accurate measurement and transparent reporting. As energy systems become more complex and decentralized, traditional monitoring approaches are increasingly

insufficient. Sustainable energy digitalization has emerged as a powerful solution for enhancing visibility, accountability, and performance across energy systems.

Digitalization in the energy sector refers to the integration of digital technologies such as smart meters, Internet of Things (IoT) sensors, big data analytics, artificial intelligence, and blockchain into energy generation, distribution, and consumption processes. These technologies enable real-time data collection, predictive analysis, and automated control, supporting more efficient and sustainable energy management.

The United Nations SDGs emphasize the importance of data-driven decision-making and transparency in sustainable development. SDG 7 focuses on access to affordable and clean energy, SDG 9 promotes innovation and resilient infrastructure, and SDG 13 calls for climate action supported by accurate emissions data. Sustainable energy digitalization directly supports these goals by enabling continuous monitoring of energy performance and environmental impacts.

From a sustainability perspective, digital energy systems improve efficiency by optimizing energy flows, reducing losses, and enabling demand-side management. They also facilitate the integration of renewable energy sources by improving forecasting and grid flexibility. These capabilities are essential for achieving SDG-aligned energy transitions.

Energy digitalization also enhances transparency and accountability in SDG monitoring. Digital platforms can track progress on key indicators such as renewable energy penetration, energy intensity, emissions reductions, and energy access. This transparency supports evidence-based policymaking and strengthens stakeholder confidence in sustainability reporting.

Despite its potential, the adoption of sustainable energy digitalization faces challenges. Data privacy concerns, cybersecurity risks, high implementation costs, and limited digital skills can hinder deployment. Stakeholder perceptions of digital system effectiveness—defined as confidence in accuracy, reliability, and usability—play a critical role in adoption decisions.

Perceived sustainability transparency is equally important. Stakeholders must trust that digital systems provide credible, unbiased, and meaningful sustainability data aligned with SDG

indicators. Without trust in data integrity and transparency, digital monitoring systems may fail to influence decision-making.

Existing research on energy digitalization has primarily focused on technical architecture, grid optimization, and smart energy applications. While these studies provide valuable insights, limited empirical research examines behavioral and perceptual factors influencing adoption of digital energy monitoring systems within an SDG-oriented framework. In particular, the mediating role of stakeholder trust remains underexplored.

This study addresses this gap by examining the role of sustainable energy digitalization in monitoring SDG progress. Specifically, it investigates how perceived digital system effectiveness and perceived sustainability transparency influence adoption intention through the mediating role of stakeholder trust. By integrating digitalization, sustainability, and behavioral analysis, the study contributes to energy governance and SDG literature.

Literature Review:

Recent literature highlights the growing role of digital technologies in enabling sustainable energy transitions. Studies emphasize that digital energy systems enhance efficiency, support renewable integration, and improve system resilience, contributing directly to SDG-aligned outcomes (IEA, 2022).

Perceived digital system effectiveness has emerged as a key determinant of adoption of energy digitalization. Research indicates that stakeholders prioritize system accuracy, reliability, interoperability, and real-time capabilities. Digital platforms perceived as ineffective or unreliable face limited acceptance regardless of potential benefits.

Perceived sustainability transparency is also critical in SDG monitoring contexts. Empirical studies conducted after 2020 show that stakeholders increasingly demand transparent and verifiable sustainability data. Digital systems that clearly link energy performance data to SDG indicators are more likely to gain trust and policy relevance (Zhang et al., 2021).

Stakeholder trust has been widely identified as a mediating variable in the adoption of digital and sustainability technologies. Trust reduces concerns related to data misuse, manipulation,

and technological uncertainty. Recent studies confirm that trust is essential for effective digital governance of sustainable energy systems (Wang et al., 2022).

Research Gap

Although research on energy digitalization is expanding, limited empirical studies integrate perceived digital effectiveness, sustainability transparency, stakeholder trust, and adoption intention within an SDG-based analytical framework. This study addresses this gap by empirically examining behavioral drivers of sustainable energy digitalization for SDG monitoring.

Research Questions

- How does perceived digital system effectiveness influence stakeholder trust in energy digitalization
- How does perceived sustainability transparency influence stakeholder trust
- Does stakeholder trust influence adoption of sustainable energy digitalization for SDG monitoring

Research Methodology

Research Objectives

- To examine the impact of perceived digital system effectiveness on stakeholder trust
- To analyze the impact of perceived sustainability transparency on stakeholder trust
- To assess the influence of stakeholder trust on sustainable energy digitalization adoption intention

Hypotheses

H1: Perceived digital system effectiveness has a significant positive impact on stakeholder trust.

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

H3: Stakeholder trust has a significant positive impact on sustainable energy digitalization 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	69%
	Female	31%
Age	18–25 years	22%
	26–35 years	61%
	Above 35 years	17%

- The respondent group consists of 69% male and 31% female participants, reflecting strong representation from technical and policy-oriented energy professionals.
- A majority of respondents fall within the 26–35 years age group (61%), followed by 18–25 years (22%), indicating high participation from digitally skilled and professionally active stakeholders.
- Respondents above 35 years (17%) contribute experienced perspectives on governance and SDG monitoring.
- Overall, the demographic profile is appropriate for examining digital energy systems and SDG monitoring adoption.

Table 2: Reliability Statistics

Construct	**Cronbach's Alpha**
Digital System Effectiveness	0.94
Sustainability Transparency	0.91
Stakeholder Trust	0.95
Adoption Intention	0.89

- The respondent group consists of 69% male and 31% female participants, reflecting strong representation from technical and policy-oriented energy professionals.
- A majority of respondents fall within the 26–35 years age group (61%), followed by 18–25 years (22%), indicating high participation from digitally skilled and professionally active stakeholders.
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Table 3: Correlation Matrix

Variables	**1**	**2**	**3**	**4**

1. Digital System Effectiveness	1			
2. Sustainability Transparency	0.72**	1		
3. Stakeholder Trust	0.82**	0.77**	1	
4. Adoption Intention	0.71**	0.75**	0.84**	1

Note: $p < 0.01$

- Digital System Effectiveness and Sustainability Transparency are strongly and positively correlated ($r = 0.72$), indicating conceptual alignment.
- Digital system effectiveness shows a very strong positive correlation with Stakeholder Trust ($r = 0.82$).
- Sustainability transparency also exhibits a strong relationship with Stakeholder Trust ($r = 0.77$).
- Stakeholder Trust has the strongest correlation with Sustainable Energy Digitalization Adoption Intention ($r = 0.84$).
- All correlations are statistically significant at the 0.01 level, confirming robust relationships.

Table 4: Regression Results and Hypothesis Testing

Hypothesis	**Path**	**β**	**p-value**	**Result**
H1	Digital Effectiveness → Trust	0.64	<0.001	Accepted
H2	Transparency → Trust	0.55	<0.001	Accepted
H3	Trust → Adoption Intention	0.72	<0.001	Accepted

- Perceived Digital System Effectiveness significantly enhances Stakeholder Trust ($\beta = 0.64$, $p < 0.001$), supporting H1.
- Perceived Sustainability Transparency significantly influences Stakeholder Trust ($\beta = 0.55$, $p < 0.001$), supporting H2.
- Stakeholder Trust significantly predicts Sustainable Energy Digitalization Adoption Intention ($\beta = 0.72$, $p < 0.001$), confirming H3.

- All hypotheses are accepted, validating the trust-mediated digital monitoring adoption model.

Findings and Discussion

The findings demonstrate that perceived digital system effectiveness and perceived sustainability transparency significantly enhance stakeholder trust in sustainable energy digitalization. Stakeholder trust was found to strongly influence adoption intention, confirming its mediating role. These results highlight the importance of credible, transparent, and effective digital systems in monitoring and advancing SDG progress.

Conclusion

This study provides empirical evidence on the role of sustainable energy digitalization in monitoring SDG progress. The findings confirm that digital system effectiveness and sustainability transparency significantly influence stakeholder trust, which in turn drives adoption intention. Sustainable energy digitalization therefore represents a critical enabler of data-driven, transparent, and accountable SDG implementation.

From a theoretical perspective, the study contributes to energy governance and sustainability literature by integrating behavioral constructs into the analysis of digital monitoring systems. By emphasizing stakeholder trust as a mediating mechanism, the research advances understanding of how digital and transparency attributes translate into adoption behavior.

From a practical standpoint, the findings suggest that governments, utilities, and energy organizations should invest in reliable and user-friendly digital energy platforms that clearly link performance data to SDG indicators. Strengthening cybersecurity, data quality assurance, and stakeholder communication can further enhance trust and adoption.

From a policy perspective, integrating digital energy monitoring systems into national SDG reporting frameworks can improve accuracy, transparency, and accountability. Support for digital infrastructure, capacity building, and interoperability standards is essential for maximizing the contribution of energy digitalization to sustainable development.

Future Scope

- Integration of artificial intelligence in SDG energy monitoring
- Comparative analysis of national digital energy platforms
- Assessment of data governance and ethics in energy digitalization

Recommendations

- Promote adoption of digital energy systems for SDG monitoring
- Strengthen transparency and data governance frameworks
- Invest in digital skills and capacity building for energy stakeholders

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