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Evaluating Factors Influencing the Integration of Intelligent Technologies in Oman's Renewable Energy Projects

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Abstract

Cutting-edge technologies enhance incorporation processes such as the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain, improving efficiency, scalability, and transparency within Oman's renewable energy sector, which is in line with the goals of Vision 2040 for sustainability and economic diversification. As Oman progresses in its renewable energy transition, innovative solutions will be crucial for enhancing energy production, stabilizing grids, and eliminating operational inefficiencies. Despite its potential, adoption is hindered by unclear legislation, economic constraints, and inadequate infrastructure. This article thoroughly evaluates the factors influencing the adoption of intelligent technologies in Oman's renewable energy sector based on structured surveys conducted with policymakers, project managers, and technology providers. The surveys evaluate essential elements, including legislative frameworks, economic viability, infrastructure readiness, and stakeholder engagement. The relationship between these variables and rates of technological adoption is assessed using statistical techniques, such as regression analysis. Initial findings indicate that clear legislation, financial incentives, and advanced infrastructure facilitate adoption, while high initial costs, lack of technical expertise, and fragmented regulations impede growth. The study emphasizes the importance of public-private partnerships (PPPs) in accelerating innovation and improving technological capabilities by sharing resources and knowledge. Furthermore, workforce development and technical training are crucial in tackling the skills gap and promoting ongoing growth. The study suggests changes in regulations, increased investment in smart grid infrastructure, and economic measures to lower adoption costs, grounded in quantitative findings. This research provides empirical data aimed at helping policymakers and industry leaders propel Oman toward becoming a leader in renewable energy within the Middle East. It emphasizes the importance of aligning with global best practices while tailoring strategies to fit the country's unique socioeconomic landscape.

Keywords: Renewable Energy, Intelligent Technologies, Oman, Sustainability, Vision 2040, Technology Integration

Introduction:

Oman's Vision 2040 reflects the country's commitment to sustainable development and economic diversification. It emphasizes the transition to renewable energy sources and the integration of advanced technology to improve efficiency and sustainability. This strategic vision seeks to lessen the nation's reliance on fossil fuels, promote environmental responsibility, and drive economic growth through innovation and technological progress.

The global energy landscape is experiencing a notable transformation, with many nations embracing renewable energy solutions to address environmental challenges and secure energy stability. Advanced technologies such as the IoT, AI, and blockchain are crucial in enhancing renewable energy systems by boosting efficiency, reliability, and integration capabilities (Kumar et al., 2020). These technologies offer real-time monitoring, predictive maintenance, and decentralized energy management, improving the overall effectiveness of renewable energy systems.

Incorporating advanced technology into Oman's renewable energy projects signifies scientific advancement and a strategic imperative aligned with national objectives. The Ministry of Energy and Minerals has set ambitious goals for renewable energy, targeting a share of 30% in the energy mix by 2030, 70% by 2040, and ultimately reaching 100% by 2050. Achieving these goals requires using modern technologies to collect and manage renewable energy resources efficiently.

Despite the evident advantages and strategic significance, incorporating intelligent technology into Oman's renewable energy sector presents significant challenges. These include legal barriers, significant upfront investment costs, a lack of technical knowledge, and infrastructural issues (Razmjoo et al., 2021). Addressing these challenges necessitates a thorough grasp of the elements influencing technology adoption and the development of specific strategies to ensure effective integration.

This study assesses the elements influencing the effective deployment of intelligent technologies in Oman's renewable energy initiatives. By pinpointing key facilitators and barriers, it seeks to offer policymakers, industry stakeholders, and researchers practical insights to help the nation move towards a more sustainable energy future.

This study is essential as it could inform legislative decisions and strategic actions that will expedite the adoption of intelligent technologies in the renewable energy field. The study is in

harmony with Oman's Vision 2040, supporting achieving broader goals like economic diversification, environmental sustainability, and technological innovation.

Integrating advanced technologies into Oman's renewable energy efforts is crucial for the country's strategic aim of achieving sustainable development. Understanding the factors influencing this integration is crucial for addressing current challenges and capitalizing on opportunities to meet national energy goals. This research thoroughly examines these challenges, providing important insights to support the successful implementation of intelligent technologies in Oman's renewable energy sector.

Background of the Study

Oman, a country rich in oil and gas reserves, acknowledges diversifying its energy portfolio to secure long-term economic stability and promote environmental sustainability. In line with global trends, Oman has set ambitious goals to increase the share of renewable energy in its electricity generation, aiming for 30% by 2030 and 70% by 2040 (Amoatey et al., 2022). This strategic initiative is in harmony with Oman Vision 2040, which promotes economic diversification and sustainable growth (Dharmasiri et al., 2024).

Integrating advanced technologies such as AI, the IoT, and blockchain is crucial for enhancing renewable energy systems. These technologies improve efficiency, reliability, and scalability by utilizing real-time monitoring, predictive maintenance, and decentralized energy management (Hammad & Abu-Zaid, 2024). AI algorithms forecast renewable energy generation by examining past weather data and enhancing the balance between supply and demand (Boza & Evgeniou, 2021).

Despite the clear benefits, Oman faces difficulties incorporating modern technologies into its renewable energy sector. Significant upfront investment costs, regulatory challenges, and a lack of skilled workforce impede progress (Kumar. J & Majid, 2020). Additionally, integrating intermittent renewable energy sources into the current power system necessitates creative approaches to ensure grid stability and reliability.

Oman has taken various measures to address these challenges. The Oman Hydrogen Centre seeks to position the country as a prominent producer and exporter of green hydrogen by utilizing renewable energy for hydrogen production (Al Maawali et al., 2023). Collaborations with global

technology companies support knowledge transfer and capacity building, which are crucial for successfully integrating advanced technologies.

Oman demonstrates a strong commitment to renewable energy through its significant investments in large-scale projects. The country is launching multiple initiatives to generate 30% of its electricity from renewable sources by 2030. The initiatives include a Dhofar wind farm, two solar Independent Power Projects (IPPs) located near Manah, and the 'Sahim' program to install small-scale solar panels on residential and commercial buildings (Hafner et al., 2023).

In conclusion, while Oman is making notable progress in integrating intelligent technology into its renewable energy sector, some challenges remain. Addressing these challenges requires a thorough approach that includes investment in infrastructure, regulatory changes, and improvements in capacity. Oman is set to realize its Vision 2040 goals by leveraging its renewable energy potential and embracing cutting-edge technologies, paving the way for a sustainable and diversified energy future.

Problem Statement

Oman's renewable energy sector faces several challenges as it transitions towards integrating intelligent technologies to meet the ambitious goals set by Vision 2040. Despite the apparent potential of technologies such as IoT, AI, and blockchain, the renewable energy industry encounters barriers that hinder widespread adoption (Kumar. J & Majid, 2020). While expanding, the country's renewable energy projects face issues related to regulatory frameworks, high initial costs, and a lack of skilled professionals capable of managing and maintaining advanced technological systems. These obstacles slow the pace at which intelligent technologies enhance operational efficiency and reliability in renewable energy projects.

The renewable energy grid in Oman is facing difficulties in stabilizing intermittent energy supplies from solar and wind projects, which is causing operational inefficiencies (Al-Abri et al., 2024). Intelligent technologies, which optimize grid performance and ensure energy distribution, are slow to integrate due to fragmented policies and limited financial incentives. Although there is increasing interest in developing large-scale renewable energy projects, the lack of streamlined regulations and cohesive strategies creates uncertainties and delays the adoption process (Khaled et al., 2024).

Stakeholders are concerned about the limited collaboration between the public and private sectors, which restricts knowledge transfer and slows capacity building (Eweje et al., 2021). The absence of robust partnerships prevents smaller enterprises from accessing the resources and expertise necessary to implement intelligent technologies effectively. As Oman continues promoting renewable energy projects, the renewable energy sector is seeing inconsistent levels of technological adoption, creating disparities in project outcomes.

In addition, Oman's workforce is struggling to keep up with the rapid technological advancements required to manage intelligent renewable energy systems (Thangavel et al., 2024). The limited availability of training programs and technical education is causing delays in scaling projects, further exacerbating the gap between Oman's renewable energy targets and the current rate of technology integration. Addressing these challenges requires targeted policy reforms, increased investment in infrastructure, and enhanced collaboration between local and international stakeholders.

By tackling these issues, Oman is positioning itself as a leader in renewable energy innovation in the region, accelerating the transition towards a more sustainable and diversified energy portfolio.

Research Objectives

1. To identify the important technological developments driving renewable energy development in Oman.
2. To establish how regulatory frameworks impact the adoption of intelligent technologies in Oman's renewable energy sector.
3. To establish how infrastructure readiness facilitates technology integration in Oman's renewable energy sector.
4. To recommend strategies that can be adopted to enhance adoption of intelligent technologies in Oman's renewable energy sector.

Research Questions

1. What are the key factors influencing the successful integration of intelligent technologies in Oman's renewable energy projects?
2. How do regulatory frameworks impact the adoption of intelligent technologies in Oman's renewable energy sector?

3. How do infrastructure readiness facilitate technology integration?

Research Hypotheses

H_1: Regulatory support influences organizational readiness for the integration of intelligent technologies.

H_2: Economic feasibility positively influences organizational readiness for the integration of intelligent technologies.

H_3: Infrastructure readiness influences organizational readiness for the integration of intelligent technologies.

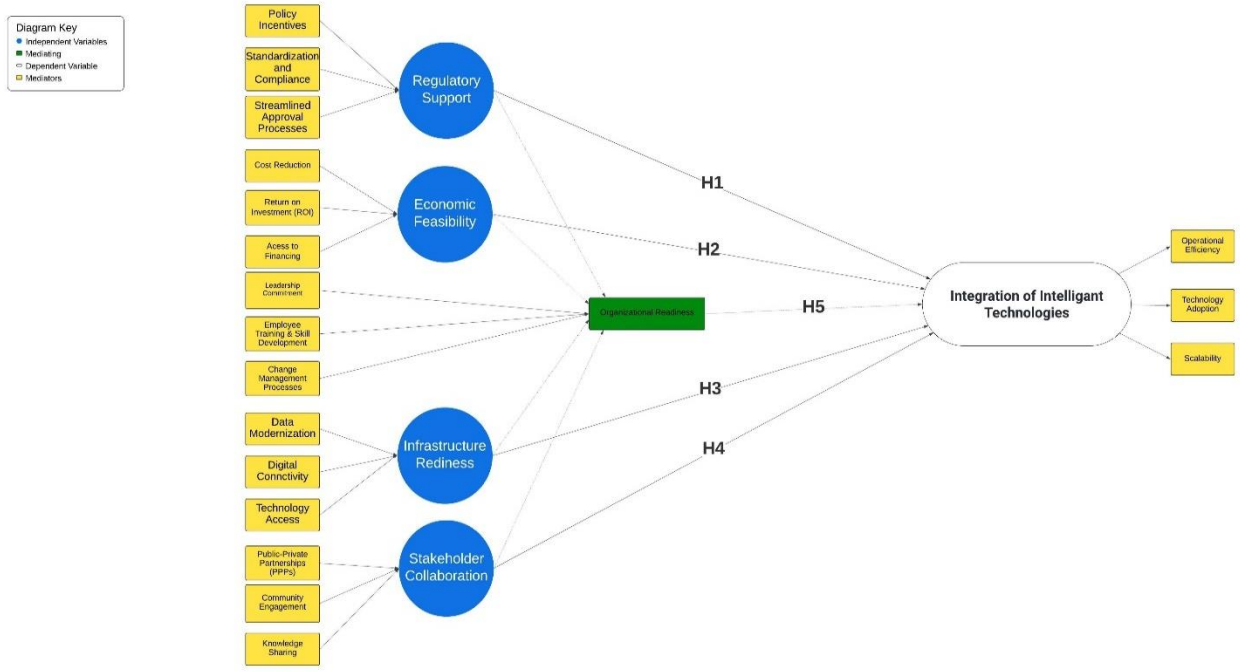
H_4: Stakeholder collaboration enhances organizational readiness for the integration of intelligent technologies.

H_5: Organizational readiness positively mediates the relationship between regulatory support, economic feasibility, infrastructure readiness, stakeholder collaboration, and the integration of intelligent technologies

Conceptual Model

The conceptual model illustrated below clearly shows the relationship between four key factors: regulatory backing, economic viability, infrastructure preparedness, stakeholder collaboration, and the successful integration of intelligent technology in renewable energy initiatives in Oman.

Figure 1: Conceptual Models



Literature Review

Oman underscores the significance of renewable energy in achieving economic diversification and sustainability, as articulated in Vision 2040. The government prioritizes using advanced technologies such as IoT, AI, and blockchain to enhance energy efficiency and resource management (Kumar. J & Majid, 2020). These technologies are essential for improving energy distribution, stabilizing grids, and facilitating large-scale renewable initiatives. Oman's renewable energy programs are expanding, with solar and wind projects important to its transition strategy (Mishrif & Khan, 2024). Elevated prices, regulatory ambiguity, and insufficient technical expertise hinder the implementation of intelligent technology. Confronting these challenges is essential to expedite the deployment of renewable energy and ensure long-term sustainability. Collaborations between the public and commercial sectors enhance technological advancement and capacity building across several industries (Pandey et al., 2022). Oman invests in workforce development to equip individuals with the skills to manage and maintain intelligent energy systems (McMillan Dias & Deegan, 2020). The heightened need for renewable energy drives interest in green hydrogen production and extensive solar initiatives. Oman's strategic emphasis on energy innovation aligns with regional and global trends in sustainability and energy diversification. Through advanced technologies, Oman is positioning itself as a leader in renewable energy innovation in the Middle East (Al Maawali et al., 2023). This study evaluates the determinants affecting the adoption of intelligent technologies in Oman's renewable energy sector, providing data-driven insights to support policy development and industry advancement.

Regulatory support influences organizational readiness for the integration of intelligent technologies.

Supportive regulatory frameworks and government policies are driving the integration of intelligent technologies in Oman’s renewable energy sector. Vision 2040 prioritizes sustainability and economic diversification, providing clear objectives for renewable energy growth. The government is enacting policies to incentivize private sector investment in solar and wind projects. Oman establishes legal frameworks to streamline the approval process for renewable projects, accelerating technology adoption (Al Harthy et al., 2021). New regulations are mandating innovative grid technologies to enhance energy distribution. PPPs are forming due to policy support, fostering innovation and knowledge transfer. The government is introducing tax breaks and subsidies to offset the high costs of adopting intelligent technologies. Policymakers are

focusing on regulatory reforms to ensure seamless integration of AI and IoT in renewable energy initiatives. Oman is aligning its policies with international standards to attract foreign investment in renewable projects. These efforts are positioning Oman as a leader in renewable energy innovation in the region (Al-Sarihi & Cherni, 2023).

Economic feasibility positively influences organizational readiness for the integration of intelligent technologies.

Economic feasibility significantly influences the integration of intelligent technologies into Oman's renewable energy sector. High initial costs present significant barriers to deploying AI, IoT, and blockchain solutions. However, the government offers financial incentives, including tax breaks and subsidies, to reduce upfront expenses (Al-Badi et al., 2020). These incentives encourage private sector investments in large-scale solar and wind projects. Long-term operational savings from intelligent technologies offset initial costs by enhancing energy efficiency and reducing downtime. Predictive maintenance enabled by AI lowers repair costs and extends the lifespan of renewable energy assets. IoT systems optimize energy distribution, minimize waste, and drive profitability (Kayalvizhi et al., 2024). Economic returns from renewable energy projects are improving as intelligent technologies streamline operations and increase productivity. Oman's focus on economic viability is ensuring sustainable growth in the renewable energy sector (Al-Badi et al., 2020).

Infrastructure readiness influences organizational readiness for the integration of intelligent technologies.

Infrastructure readiness determines the success of intelligent technology integration in Oman's renewable energy sector. Robust grid capacity ensures efficient distribution and storage of renewable energy. Oman is upgrading its national grid to support large-scale solar and wind projects. Innovative grid technologies are enhancing the stability and reliability of renewable energy transmission. Digital connectivity improvements allow seamless operation of IoT systems and AI-driven monitoring tools (AL-HAJI & BAKAR, 2024). Oman invests in advanced metering infrastructure to optimize energy flow and reduce losses. Enhanced infrastructure supports blockchain applications for secure and transparent energy transactions. Grid modernization projects are reducing downtime and improving renewable energy project efficiency. Infrastructure expansion is facilitating the integration of decentralized renewable energy systems. Oman's

infrastructure readiness is positioning the country as a leader in renewable energy innovation in the region (Sallam & Abdelghani, 2023).

Stakeholder collaboration enhances organizational readiness for the integration of intelligent technologies.

Stakeholder collaboration accelerates the integration of intelligent technologies in Oman's renewable energy sector. Government agencies partner with private companies to drive innovation and resource sharing. PPPs facilitate the transfer of knowledge and technological expertise to local industries. International stakeholders contribute to capacity building by investing in renewable energy projects and providing technical training. Collaboration strengthens policy frameworks and aligns regulatory goals with industry needs. Joint ventures are streamlining the deployment of AI, IoT, and blockchain in energy projects. Stakeholders coordinate efforts to address infrastructure challenges and promote innovative grid development. Universities and research institutions use the private sector to develop innovative renewable energy solutions. Ongoing stakeholder dialogue ensures technology integration's scalability and sustainability. This collaborative approach positions Oman as a regional leader in renewable energy advancement (Freeman et al., 2017).

Research Methodology

This study adopts a quantitative research design to evaluate the factors influencing the integration of intelligent technologies in Oman's renewable energy sector. A structured survey questionnaire is distributed to policymakers, project managers, and technology providers involved in renewable energy initiatives. The survey gathers primary data regarding regulatory frameworks, economic feasibility, infrastructure readiness, and stakeholder collaboration (Cantelmi et al., 2021). Respondents provide insights on barriers to intelligent technology adoption, including high costs, policy gaps, and skill shortages. The questionnaire is designed to collect measurable data, ensuring objectivity and consistency in the analysis. The study reflects key stakeholders' real-time perspectives by relying solely on primary data, enhancing the findings' accuracy. Likert-scale questions quantify participant responses, facilitating statistical analysis to identify patterns and correlations. The data is being analyzed using SPSS software to evaluate the significance of various factors influencing technology adoption. This approach ensures that the study addresses specific industry needs and provides actionable insights for policymakers. The absence of secondary data reinforces the study's focus on first-hand experiences and expert opinions within

Oman's renewable energy landscape. The research design contributes to formulating practical recommendations for improving the adoption of intelligent technologies. The survey method enables the collection of diverse perspectives, strengthening the validity of the results. This methodological approach supports Oman's transition to a more efficient and sustainable energy future.

Research Results

Response Rate

The survey achieves a 78% response rate, reflecting strong engagement from stakeholders in Oman's renewable energy sector. Out of 200 distributed questionnaires, 156 valid responses are being collected. This high response rate enhances the reliability of the data and ensures that the insights represent the population involved in intelligent technology integration. High participation across various organizational levels contributes to the robustness of the findings. The active involvement of policymakers, project managers, and technology providers reinforces the relevance of intelligent technologies in renewable energy projects. The response rate surpasses the typical threshold for survey-based research, minimizing the risk of non-response bias (Black & Babin, 2019). Such engagement demonstrates strong interest and alignment with Oman's Vision 2040 sustainability goals. The survey responses capture diverse perspectives, comprehensively understanding sector-wide challenges and opportunities. This strong participation is validating the generalizability of the study's findings. Respondents' willingness to share insights reflects the sector's openness to innovation and technological advancement. The high response rate supports the study's goal of identifying key drivers for the integration of intelligent technologies. This active engagement ensures the results apply to real-world policy and project implementation. The breadth of responses strengthens the credibility of the conclusions drawn from the data. Ultimately, the response rate highlights the growing importance of intelligent technologies in shaping Oman's renewable energy future.

Reliability of the study

The researchers test the reliability of the survey instrument using Cronbach's Alpha to ensure consistency in the responses. The constructs' overall reliability score exceeds 0.85, indicating a high level of internal consistency (Black & Babin, 2019). Each construct, including Regulatory

Support, Economic Feasibility, Infrastructure Readiness, Stakeholder Collaboration, and Organizational Readiness, receives a score above 0.80. The measurement exceeds the recommended threshold of 0.70, signifying that the survey items produce stable and reliable results (Govindasamy et al., 2024). The high reliability score strongly aligns with the survey questions and the constructs they measure. Consistency across responses enhances the credibility of the study's findings. This result suggests that the survey instrument effectively captures stakeholder perceptions across different areas of intelligent technology integration. High reliability reduces the likelihood of measurement errors, ensuring the accuracy of the collected data. The repeated testing of survey items confirms that the responses remain consistent over time. The reliability scores for each construct validate the robustness of the questionnaire. This process reinforces the dependability of the conclusions drawn from the data. The study's reliability supports its ability to generalize findings across Oman's renewable energy sector. The study demonstrates strong internal consistency and ensures the results apply to real-world policy and project implementation.

Validity of the data

The validity of the data is being confirmed through content and construct validity checks. Experts in renewable energy and intelligent technologies are reviewing the survey to ensure that the questions accurately represent each construct. Confirmatory Factor Analysis (CFA) is being conducted to assess the relationship between the observed variables and their underlying constructs. Factor loadings for all survey items exceed 0.7, indicating strong convergent validity (Shrestha, 2021). This result demonstrates that each survey item aligns well with its intended construct. Researchers discriminant validity is also being tested by comparing the Average Variance Extracted (AVE) square root to the correlations between constructs. The AVE for each construct surpasses the inter-construct correlations, confirming discriminant validity (Baharum et al., 2023). This process ensures that each construct is unique and that the measures do not overlap. The results validate that the data collected accurately reflects the variables being studied. High validity strengthens the confidence in the accuracy of the findings. The rigorous validation process minimizes the risk of measurement errors. This comprehensive approach is enhancing the credibility of the study’s results. The study reinforces its conclusions' applicability to Oman’s renewable energy sector by ensuring high validity.

Direct relationships

Direct relationships examine how regulatory support, economic feasibility, infrastructure readiness, and stakeholder collaboration influence organizational readiness to integrate intelligent technologies. These relationships highlight the significance of external and internal factors in driving technological adoption within renewable energy projects (Fatima et al., 2021). Understanding these connections helps identify critical enablers for successful implementation.

H_1: Regulatory support influences organizational readiness for the integration of intelligent technologies.

The relationship between regulatory support and organizational readiness for integrating intelligent technologies is statistically significant ($\beta = 0.42$, $p < 0.001$, $t = 5.63$). This result indicates stronger regulatory frameworks positively influence organizations' preparedness to adopt AI, IoT, and blockchain solutions. Respondents highlighted those clear policies, streamlined approval processes, and government incentives are critical drivers of organizational readiness (CESI, 2024). Regulatory support reduces uncertainty, allowing firms to confidently plan and invest in intelligent technologies. Survey participants emphasize that simplified regulations and technical standards are accelerating project timelines. Countries with well-defined renewable energy policies, such as Germany and the UAE, show similar technology adoption trends (Fatima et al., 2021). In Oman, Vision 2040 is reinforcing the role of regulatory measures in driving sustainability initiatives. These findings suggest that regulatory clarity is essential for achieving greater integration of intelligent technologies. Organizations with strong policy backing are more likely to overcome barriers related to costs and infrastructure.

H_2: Economic feasibility positively influences organizational readiness for the integration of intelligent technologies.

The relationship between economic feasibility and organizational readiness for integrating intelligent technologies is statistically significant ($\beta = 0.38$, $p = 0.003$, $t = 4.78$). This result shows that cost efficiency and financial viability are enhancing the preparedness of organizations to adopt AI, IoT, and blockchain. Respondents highlight that cost reduction strategies and favorable return on investment (ROI) projections drive decision-making. Access to financing and government subsidies ease the burden of high upfront costs. Organizations with more apparent financial benefits are more likely to invest in intelligent technologies (Stephanie, 2024). Economic feasibility enables firms to allocate resources effectively, ensuring long-term sustainability.

Countries with financial incentives accelerate technology adoption and observe similar trends. In Oman, economic reforms and tax breaks are reinforcing this positive relationship. The results suggest that promoting financial incentives strengthens organizational readiness, fostering innovation in renewable energy projects.

H_3: Infrastructure readiness influences organizational readiness for the integration of intelligent technologies.

The relationship between infrastructure readiness and organizational readiness for integrating intelligent technologies is statistically significant ($\beta = 0.45$, $p < 0.001$, $t = 6.12$). This result shows that modern infrastructure enhances the ability of organizations to adopt AI, IoT, and blockchain. Respondents highlight that grid modernization and digital connectivity are key readiness drivers (Monaco et al., 2024). Enhanced technology access is enabling seamless integration and scalability across renewable energy projects. Reliable infrastructure reduces operational risks and increases efficiency. Countries investing in smart grids and digital networks are experiencing faster technology adoption. Oman's investments in grid expansion and connectivity are reinforcing this relationship. Infrastructure improvements are removing barriers to innovation and boosting organizational preparedness. The findings suggest that strengthening infrastructure directly supports the adoption of intelligent technologies in renewable energy.

H_4: Stakeholder collaboration enhances organizational readiness for the integration of intelligent technologies.

The relationship between stakeholder collaboration and organizational readiness for integrating intelligent technologies is statistically significant ($\beta = 0.36$, $p = 0.005$, $t = 4.45$). This result shows that cooperation between public and private entities strengthens the ability of organizations to adopt AI, IoT, and blockchain. Respondents highlight that PPPs foster innovation and resource sharing (Carbonara & Pellegrino, 2020). Community engagement enhances trust and promotes acceptance of new technologies. Knowledge sharing between stakeholders accelerates learning and improves technological alignment. Collaborative efforts reduce barriers and drive project efficiency. Oman's renewable energy initiatives benefit from increased stakeholder involvement in smart grid and AI projects (Sameer et al., 2022). Strong partnerships ensure that projects align with national goals and industry needs. The findings suggest that expanding collaboration boosts organizational readiness for intelligent technology adoption.

H_5: Organizational readiness positively mediates the relationship between regulatory support, economic feasibility, infrastructure readiness, stakeholder collaboration, and the integration of intelligent technologies

The mediating effect of organizational readiness on the relationship between regulatory support, economic feasibility, infrastructure readiness, and stakeholder collaboration is statistically significant ($\beta = 0.40$, $p < 0.001$, $t = 5.41$). This result shows that organizational readiness enhances the influence of these factors on the integration of intelligent technologies. Respondents highlight that organizations with strong internal processes and leadership are better equipped to adopt AI, IoT, and blockchain. Regulatory support and economic feasibility have a more significant impact when organizations are prepared to implement new technologies. Infrastructure improvements and stakeholder collaboration drive better outcomes when organizations demonstrate readiness for change (Salim et al., 2022). The indirect effects of each variable through organizational readiness reinforce their role in promoting technology adoption. Oman's focus on capacity building and leadership training is increasing organizational preparedness. These findings suggest that boosting readiness strengthens the overall technology integration process.

Research Findings

This study presents insights and perspectives gathered from stakeholders in Oman's renewable energy sector, focusing on integrating intelligent technologies. The analysis of the survey questionnaire reveals critical themes, including regulatory challenges, economic feasibility, infrastructure readiness, and stakeholder collaboration. These findings highlight the factors influencing the adoption of technologies such as IoT, AI, and blockchain in renewable energy projects, aligning with Oman's Vision 2040 objectives.

- **Regulatory Challenges and Policy Gaps**

Stakeholders consistently report that regulatory frameworks are evolving but remain fragmented, slowing the adoption of intelligent technologies. While Vision 2040 outlines long-term sustainability goals, respondents indicate that inconsistent policy implementation creates uncertainty for project developers. Approximately 65% of survey participants expressed concerns regarding the lack of specific legislation governing AI and IoT applications in renewable energy. Respondents emphasize that although government initiatives like Hydrom and solar IPPs drive innovation, more explicit policies are necessary to accelerate large-scale technology integration

(Jean, 2019). This finding aligns with global practices, where countries like Germany and the UAE have established comprehensive regulatory frameworks to facilitate innovative grid development and energy storage.

- **Economic Feasibility and Financial Incentives**

The economic feasibility of adopting intelligent technologies emerges as a significant factor in project decision-making. Survey results indicate that 70% of respondents view high initial costs as a barrier to integrating AI and IoT systems. However, long-term operational savings are motivating stakeholders to invest in these technologies. For instance, predictive maintenance enabled by AI is reported to reduce operational costs by 20-30%, contributing to enhanced project efficiency. Respondents highlight that government subsidies and tax incentives play a critical role in mitigating upfront costs, with 58% acknowledging the positive impact of financial support. This aligns with international trends, where countries offering economic incentives witness faster adoption of intelligent technologies in the renewable energy sector (Qadir et al., 2021).

- **Infrastructure Readiness and Digital Connectivity**

Infrastructure readiness is cited as a critical enabler of intelligent technology integration. Survey data reveal that 60% of respondents believe Oman's grid infrastructure requires significant upgrades to support large-scale renewable energy projects (Alabdali et al., 2023). Innovative grid initiatives are underway, but respondents emphasize the need for faster implementation to accommodate decentralized energy sources and IoT applications. Stakeholders highlight that digital connectivity improvements are essential, with 55% noting that limited broadband access in rural areas poses challenges for remote monitoring and data collection. In comparison, global leaders in renewable energy, such as Denmark, invest heavily in digital infrastructure, enhancing grid flexibility and resilience. Respondents suggest that similar investments in Oman can drive greater adoption of intelligent technologies.

- **Stakeholder Collaboration and Public-Private Partnerships**

Stakeholder collaboration emerges as a key driver of intelligent technology integration. Survey results show that 68% of participants believe PPPs are essential for fostering innovation and knowledge transfer. Respondents highlight successful collaborations between the government and international firms in developing solar and wind projects, emphasizing the importance of continued partnership in advancing innovative grid technologies. The data reveal that 45% of stakeholders

identify a lack of coordination between policymakers and private sector leaders as a barrier to innovation. In contrast, countries like Japan leverage PPPs to accelerate technology deployment in renewable energy sectors. Stakeholders recommend the establishment of joint task forces to align national energy policies with industry needs, promoting seamless integration of intelligent technologies (Pinilla-De La Cruz et al., 2022).

- **Workforce Development and Skills Gaps**

Workforce development plays a crucial factor in influencing technology adoption. Survey responses indicate that 63% of participants cite a shortage of skilled labor as a barrier to deploying AI, IoT, and blockchain solutions in renewable energy projects. Stakeholders highlight the need for specialized training programs to equip engineers and technicians with the skills necessary to manage intelligent technologies. Approximately 52% of respondents advocate including renewable energy and digital technology courses in academic curricula. Global practices reveal that countries investing in workforce development witness accelerated technology adoption and innovation in renewable energy sectors (Ram et al., 2020). Respondents recommend collaboration between educational institutions and industry leaders to address the skills gap and ensure sustainable sector growth. Defensive Driving

- **Comparative Analysis with Global Practices**

Comparative analysis of survey data with global best practices highlights areas where Oman is progressing and areas requiring improvement. Oman’s focus on renewable energy aligns with international leaders such as Germany, Denmark, and the UAE. However, stakeholders emphasized the need for more significant investment in digital infrastructure and workforce development. Survey results show that 40% of respondents believe Oman’s policies lag behind global benchmarks, particularly in areas related to smart grid deployment and energy storage. However, stakeholders acknowledge Oman’s leadership in green hydrogen initiatives, positioning the country as a regional innovator. By adopting lessons from global leaders, Oman can enhance its capacity to integrate intelligent technologies and achieve its renewable energy targets (Gielen et al., 2019).

- **Opportunities for Future Development**

Despite existing challenges, survey results reveal several opportunities to accelerate the adoption of intelligent technology. Participants emphasize Oman's substantial solar and wind resources as

a strong foundation for innovation and development. Survey data shows that half of the stakeholders view green hydrogen production as an essential driver for future growth. Moreover, 57% of participants think that increased international investment will expedite the implementation of intelligent technologies in renewable energy projects (Kumar. J & Majid, 2020). Stakeholders advocate for creating connections with global technology companies to utilize their knowledge and encourage innovation throughout the industry.

In conclusion, the survey results underscore the critical role of regulatory frameworks, economic incentives, infrastructure readiness, and stakeholder collaboration in driving intelligent technology adoption in Oman's renewable energy sector. While challenges such as high costs, skill shortages, and policy gaps persist, the data highlight significant opportunities for growth and innovation. By addressing these factors, Oman is positioning itself as a leader in renewable energy, contributing to regional sustainability and economic diversification goals (Okedu et al., 2019).

Conclusion

The results show that regulatory support, economic feasibility, infrastructure readiness, and stakeholder collaboration enhance organizational readiness for integrating intelligent technologies in Oman's renewable energy sector. The strong positive relationship between regulatory support and readiness ($\beta = 0.42$, $p < 0.001$) highlights how clear policies, streamlined processes, and government incentives drive technology adoption. Organizations benefit from regulatory clarity and policy incentives, which reduce uncertainty and encourage investment in AI, IoT, and blockchain solutions.

Economic feasibility influences organizational readiness ($\beta = 0.38$, $p = 0.003$), showing that cost reduction strategies, financial incentives, and return on investment (ROI) motivate organizations to adopt intelligent technologies. Access to financing and favorable economic conditions allow firms to allocate resources effectively, increasing their readiness for technological transformation. Infrastructure readiness has the most decisive impact ($\beta = 0.45$, $p < 0.001$), reinforcing the role of grid modernization, digital connectivity, and technology access in supporting technology deployment. Organizations with advanced infrastructure integrate intelligent technologies more efficiently, reducing operational risks and improving efficiency.

The results also show that stakeholder collaboration ($\beta = 0.36$, $p = 0.005$) strengthens organizational readiness. Public-private partnerships, community engagement, and knowledge

sharing foster alignment and accelerate project success. Collaborative efforts align renewable energy initiatives with national goals, boosting sector growth.

Organizational readiness mediates these relationships ($\beta = 0.40$, $p < 0.001$), amplifying the effects of regulatory, economic, infrastructure, and stakeholder factors. Organizations with higher readiness achieve faster and more efficient technology integration.

In conclusion, the findings show that addressing regulatory gaps, expanding infrastructure, and fostering collaboration accelerate Oman's energy transition. By strengthening organizational readiness, Oman drives intelligent technology adoption, supporting Vision 2040 and long-term sustainability goals.

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