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Fintech's Role in Green Finance: Procuring Funds for Sustainable Energy

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Abstract

Green financing is the furthermost significant name for the procurement of sustainable energy projects like renewable energy etc. Green bonds and green insurance are currently the two financing mechanisms for environmental businesses' sustainable procurement. There have been some problems that the issuing companies and the investors have encountered during the green bond procurement process. However, financial technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), cloud computing, blockchain, and robotics are promising solutions for green financing because they have already proven their significance and impact in a variety of fields such as finance and sustainable energy projects. The purpose of this study is to address and analyze the role and significance of fintech technologies in the procurement of green-financed sustainable infrastructure, as well as highlight research implications, limitations, and future work. In this study, we have followed inclusion and exclusion of the articles on the basis of key criteria. Following this, we have discussed the perspective of the different existing research on green finance, green bonds, insurance, fintech and sustainability for the sustainable energy procurement. The findings of the study are Fintech based high-level architecture proposed for the procurement process of funds for green financed sustainable energy projects. This study is the first attempt to group information from previously published research about green financing and integration of fintech for the smooth process of procurement of funds for sustainable energy projects.

Keywords: AI, Blockchain, Fintech, Green Finance, IoT, Sustainable Procurement.

Introduction

The most prominent problem with the energy projects is the carbon emission (1). This causes health and environmental issues. Due to high carbon emission, our environment has badly affected and there is need to save it as well as look forward towards the sustainability (2). The base of any economy is the business environment of that country, especially the power and energy projects (3). These projects should focus on the methods through which it can convert the things towards sustainability. It is required to take some actions to solve this serious problem. Due to all these reasons the importance of green energy projects has got increased. The better way is to raise maximum funds for the sustainable projects like renewable energy etc. (2-3). So, these projects would be better funded by green finance mechanisms. Some of them are green bonds, green insurance etc. Green financing then connects green financing mechanism (green bonds and green insurance) with green economy, sustainability procurement of funds for the environmental projects like renewable energy projects (4). Countries and the energy producing companies started using the natural resources such as wind, sun etc. When these natural resources are used then carbon emission is very low during the electricity generation process (5). In reverse of that, using natural resources for energy generation have some issues too (6). The biggest problem is that the initial cost for the fixing of green energy developments is very high, due to big establishments. High investment costs in turn gives less margins to the returns which in turn demotivate the excitement to earn profits from investment in

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sustainable energy projects. And for high installation costing projects the financing is the most important issue to be sorted out. Fundraising for energy projects through green finance mechanisms can encounter some challenges. There are a number of significant hazards and challenges that can jeopardize financial support for sustainable energy projects and prevent the introduction of desirable technology (7).

The above-mentioned issue leads to the importance for the understanding and adoption of financial technologies in the sustainable energy projects. The innovative and advanced technologies definitely affect to reduce the costing in the initial stage of these projects. Numerous associated advantages can be highlighted, and fintech apps enable the financial sector to deliver financial services simply, efficiently, and rapidly. For instance, quicker financial service delivery raises customer satisfaction, which helps to promote investments in green energy. Fintech tools also make it easier for green energy investors to get the money they need at a reasonable price. Therefore, incorporating fintech into green energy investments through green financing mechanisms like green bonds will promote the acquisition of funding for sustainable energy projects, which are crucial for the economic development of any country (8).

Problem Statement

The viability of investments in sustainable energy projects is threatened by a number of major hazards and obstacles and this can be prevented by the uptake of desirable technologies or the inclusion of fintech can resolve these issues (9). Barriers for sustainable energy is the Process of Moving Toward Financial Closure. In Figure 1, various barriers and hurdles related to the investments in sustainable energy projects are mentioned. These hurdles need to be removed through the inclusion of financial technologies.

"Key challenges in energy projects:
a) Costs: Capital-intensive investments
b) Evaluation: Limited data for a thorough evaluation of the project
c) Uncertainty: High or ambiguous risks, including problems in guaranteeing cash flows and lack of enforceable securities.'

Inherent hurdles of energy project sponsors:
a) Weak project developers and lack of project experience.
b) Limited financial and managerial capacity
c) Limited creditworthiness particularly due to lack of complimentary own resources.

External obstacles to energy projects:
a) Regulatory and policy issues that favor conventional types of energy or prevent uncertain legislation in the energy sector.
b) Energy market: Deficiencies in financial, legal and institutional framework conditions as well as imperfections in the market mechanism.
c) Lack of reliable partners for procurement/supply contracts.

Barriers in the financial sector of sponsors of energy projects:
a) Lack of funds or inappropriate financial conditions.
b) Lack of tools and lack of local financial institutions.
c) Lack of sectoral know-how and energy willingness to invest in energy projects, as well as insufficient information for prudent investment analysis.

Figure 1: Problems in Energy projects

Despite of so many barriers, the sustainability energy projects are growing at its fast pace because around the globe the government and regulators are focusing on the sustainable development and to save the environment (10). Sustainable energy projects are facing so many financial barriers which hinders the success of these projects which can be sorted if the regulators and issuers will focus on the funds specifically designed for the purpose of procurement for these energy projects. These are green finance mechanisms like green bonds and green insurance through which the funds can be raised with a specific thought of investor's contribution for the sustainability energy projects. It is very significant to consider the part that green money plays in energy effectiveness. As an outcome of increasing computerization and enhanced data analytics that effect in lower energy consumption, making digital has the potential to greatly quicken the use of green energy and energy-efficient technology (11).

Digital technology also creates fresh possibilities for the development of creative new funding models. Fintech is seen as a disruptive force because of its inventiveness, which has a big impact on the energy sector. Some significant conclusions were established thanks to the literature review. First, particularly in recent years, investments in green energy have become quite popular. There has been a noticeable increase in the number of studies done on this topic. Further analysis of these research revealed that high costs are the main barrier preventing the growth of green energy initiatives. In this situation, these expenses ought to be minimized by effective financial resources. Fintech apps are crucial in this situation for reaching this objective. One of the biggest issues with investments in green energy is expensive expenses, which can be reduced with the help of these apps. However, there aren't many studies on fintech applications for green energy investments in the literature.

Research Gap

The role of fintech applications in facilitating investments in green energy is increasingly acknowledged as pivotal, there exists a conspicuous gap in empirical studies exploring the efficacy, adoption patterns, and impact of fintech solutions specifically tailored for green energy investments. Despite the recognized potential of fintech apps in mitigating the cost barriers associated with green energy investments, the dearth of literature addressing this intersection constrains our understanding of the mechanisms through which these applications operate, the challenges they encounter, and the overall effectiveness in achieving sustainability objectives. Consequently, there is a pressing need for comprehensive research endeavors to bridge this gap and furnish insights crucial for informing policy frameworks, industry practices, and technological advancements aimed at accelerating the transition towards a greener economy.

Research Objective

1. To explore the adoption and utilization of fintech applications for green energy investments, examining factors influencing investor acceptance, financial institutions' acceptance, and other relevant variables.
2. To investigate the efficacy of fintech solutions in mitigating the cost barriers associated with green energy investments, employing empirical analyses to quantify the financial benefits, risk mitigation mechanisms, and overall cost-effectiveness facilitated by these applications.

This study aims to assess potential financial sources for green energy investment projects that are based on fintech. Also, to study the implementation of fintech for the procurement of funds through green finance of sustainable energy projects. The flow of the study is as follows: The study first focused on the sustainable energy projects which are required to maintain the sustainability to save our environment. The energy projects are also facing many barriers for the procurement of funds. So, the funds need to be raised with the source of green finance mechanisms which includes green bonds or green insurance. The novelty of the study is that study analyzed the different studies that have addressed the role of financial technologies in procurement of green finance for financing sustainable energy projects. This study is the first attempt to combine and integrate the concept of fintech with the fund

procurement process of green financial sources like green bond for sustainable energy projects.

In different ways, this study has added to the corpus of knowledge already in existence. The study's most notable contribution is the use of an innovative technique to uncover the key factors for green energy investment firms in relation to various fintech-based funding options.

- This is likely the first study to examine the financial inclusion and its link between, green financing, and energy efficiency while taking into account current improvements in financial technology and their potential impact on energy productivity.
- As we've said, the main role of fintech is to facilitate the distribution of green finance; as such, in recent discussions, fintech is crucial for supporting green financing in sustainable energy initiatives.
- Finally, article provides detailed suggestions for improvement in next work. One of the vital recommendations is the integration of green finance for energy projects processing with financial technologies empower. We developed a framework which supports the adoption of fintech in procurement process of funds for sustainable energy projects.

Methodology

The qualitative research approach has been used for the content analysis of the past literature and documents, using TAM as the theoretical base model proposed a framework for the fintech adoption in green financed sustainability energy projects.

Figure 2 illustrates the methodology of the study. This study is analyzing the importance and progress of implementing the financial technologies for raising the funds for the sustainable energy projects through the green financing mechanism like green bonds, green insurance.

Data has been collected based on the study of the papers on energy projects financing. Then some articles on the barriers were focused and the gaps were found that financial technology inclusion is required for the changing scenario of the countries towards sustainability to overcome the barriers of procurement in energy projects. The research articles were funneled down and reached to the research objectives.

The complete research process adopted in this research has been mentioned in Figure 3. All processes are mentioned through stages. The qualitative research approach of framework analysis has been applied in which content analysis has been done.

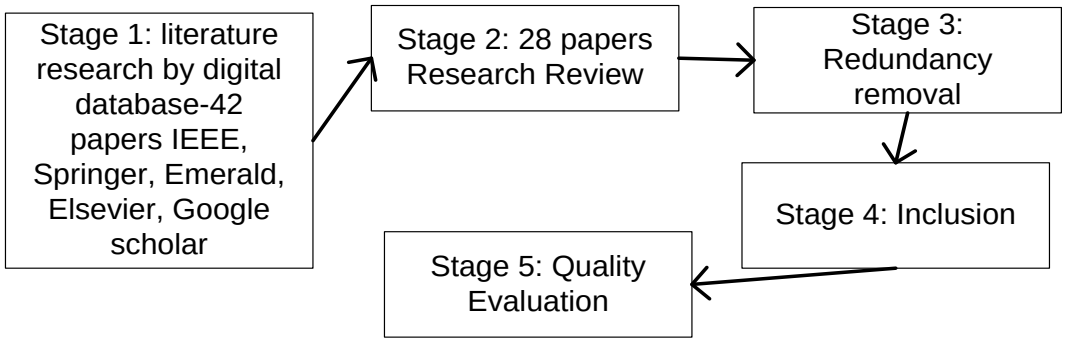

Figure 2: Data Selection stages

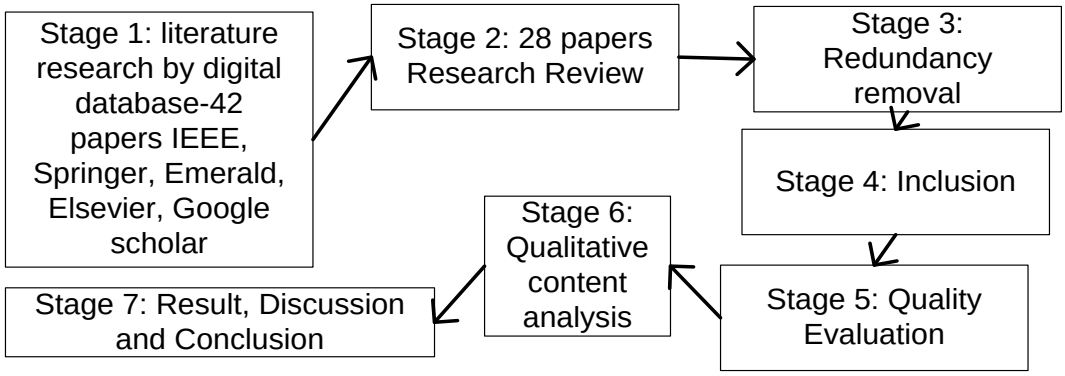

Figure 3: Complete research approach

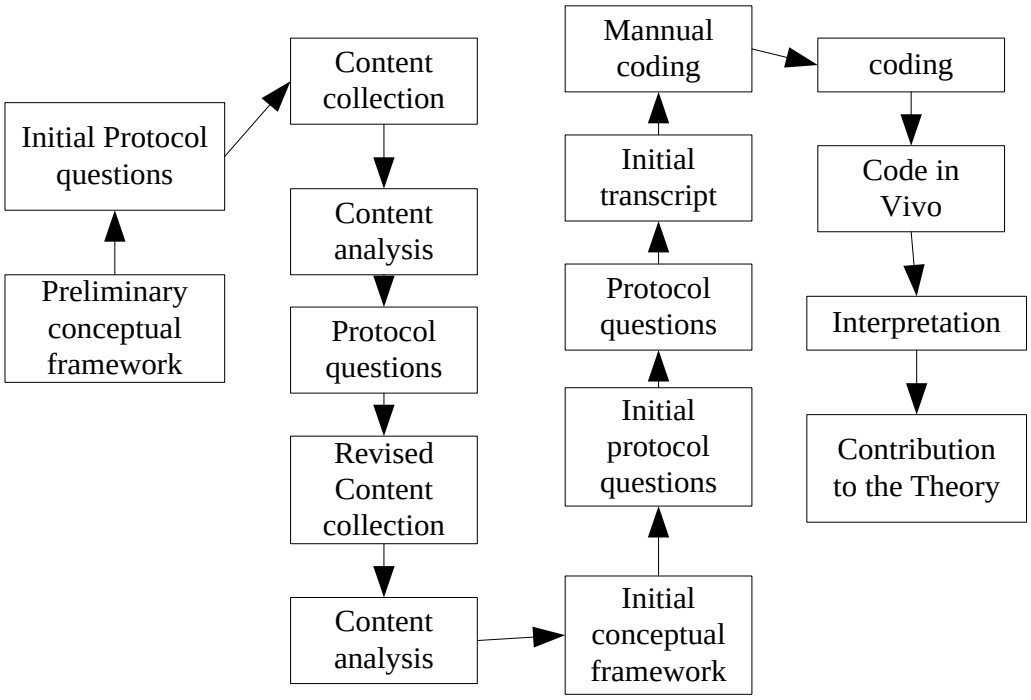

Figure 4: Content analysis process adopted in this research

The preliminary conceptual framework emerged from an extensive review of the literature, laying the foundation for the research endeavor in Figure 4. Drawing upon insights gleaned from existing studies, initial protocol questions were crafted to guide data collection. Subsequently, data collection was conducted in alignment with these protocol questions, allowing for the systematic gathering of relevant information. This iterative process, informed by the literature review and guided by the conceptual framework, facilitated the acquisition of valuable data essential for analyzing the adoption patterns and efficacy of fintech applications in green financed sustainability energy projects. Further the content has been analyzed through the Atlas-ti.

Initially preliminary conceptual Lense was made on the basis emerging trends in the related area, then protocol questions were drafted for the analysis of documents searched related to the subject area of blockchain and green bonds. In these documents many whitepapers are also included like Niti Aayog-2020, Meity National Strategy etc. Again, the protocol questions were revised and further more documents were analysed. After that initial conceptual framework was developed for the purpose of showing the strategy for the purpose of adoption of blockchain technology for green bond markets.

The framework is created in Atlas Ti, The transcript is transferred in Atlas Ti, and a auto code has been generated by manual coding and code in Vivo, the

code cleaning has been done and the outcome comes for the purpose of the adoption afterwards a new final framework has been generated which gives the final outcome of the analysis.

Findings

The findings of this study underscore the critical role of perceived usefulness, perceived ease of use, and external factors such as financial returns, customer expectations, operational efficiency, and market competency in driving the adoption of fintech solutions in green financed sustainability energy projects. Users are more inclined to adopt fintech when they perceive these solutions as beneficial for facilitating green energy investments and find them easy to use, with positive attitudes towards fintech usage leading to greater behavioral intention and eventual adoption. Moreover, the alignment of fintech offerings with user needs and industry standards, as well as the recognition of tangible benefits and streamlined processes, further reinforces the decision to adopt fintech. These findings highlight the importance of addressing both intrinsic and extrinsic factors in promoting the widespread adoption of fintech and advancing sustainability.

Role of Fintech Inclusion in Green Financing of Sustainable Energy Projects: Sustainable energy projects are utilizing resources that won't harm the ecosystem or the need for future energy supply (12). The most popular sustainable energy sources, such solar, hydroelectric, and wind, all incorporate renewable energy. As the production of biofuel depletes other ecological resources and produces greenhouse gases that have an impact on the climate, it is a particular type of renewable energy. One of the most important tasks of the twenty-first century is to solve the energy issue (13). There are many barriers in financing the energy projects that are limiting the scope and speed for the promotion and growth of these projects (14). Developers are continuously facing these barriers as mentioned in Table 1 below with several types of renewable energy projects.

With the help of the Table 1, we can easily find out the risk issues in energy projects and their considerations. The primary type of financing for energy development is bank loans, however they have proven to be insufficient. Alternative funding sources for energy efficiency could include green finance. Green bonds are a type of financing instrument designed specifically to raise money for ecologically friendly projects (3-5).

Table 1: Barriers and issues related to financing of sustainable energy projects.

Renewable Energy	Key Risk Issues	Risk Management Considerations
Geothermal (15)	● The cost of drilling and its risk (like blow- out). ● Risk of exploration (e.g non certain flow and temp). ● Failures of vital components, such as failures of pumps. ● Lead times Extended (like planning permission).	● Partial technological knowledge and operation experience in various places. ● Planning approvals might be challenging. ● Although not yet demonstrated, stimulation technology** can lower the risk of exploration.
Large PV (16)	● Parts breakdowns. ● Climate related harm. ● Stealing/devastation.	● Execution assurance available (e.g. up to 25 years). ● Common component that can be easily replaced. ● Performance can be ignored (especially in emerging nations).
Solar thermal (17)	● Hazards associated with prototypes and technology as project size grows and other factors combine. ● RETs like solar towers.	● Decent running record and record of loss (since 1984). ● Maintenance overlooked.

Small hydropower (18)	● Overflowing. ● Seasonal/ yearly supply unpredictability. ● Extended outages brought on by off-site monitoring time. With a scarcity replacement part.	● Long-term tested technology with minimal operative risks and running risk.
Wind power (19)	● Protracted lead times and upfront expenses (e.g., Planning approval & building expenses). ● Failure of critical component (e.g., geartrain / box, bearings, blades etc). ● Wind-resource variability. ● Off-shore cable laying.	● Make turbines model. ● Warranty coverage from equipment vendors for assembly. ● Good wind- resource data. ● Loss-control e.g., firefighting can be difficult off-shore due to height/ location. ● Creation of best practise guidelines.
Biomass power (20)	● Gas stock accessibility/unpredictability. ● Reserve price inconsistency. ● Ecological risk connected to the management and storage of fuel.	● Continuing agreement can address the issue of resources. ● Gas management costs. ● Ejection controls.
Biogas power (21)	● Supply danger (e.g. decrease in gas production and quality as a result of modifications to the organic feedstock). ● Organizing opposition bought on by smelling issues.	● Safety regulations are required as loss controls as firefighting tools and services. ● Elevated rate of wear & tear.
Tidal /wave power (22)	● Ability to endure in hostile aquatic conditions (mooring systems etc). ● A number of design and concepts, but no one has emerged as the winner. ● Low volume and protracted lead times.	● Many of projects are prototype and technologies demonstrations. ● Reliable data on resource size.

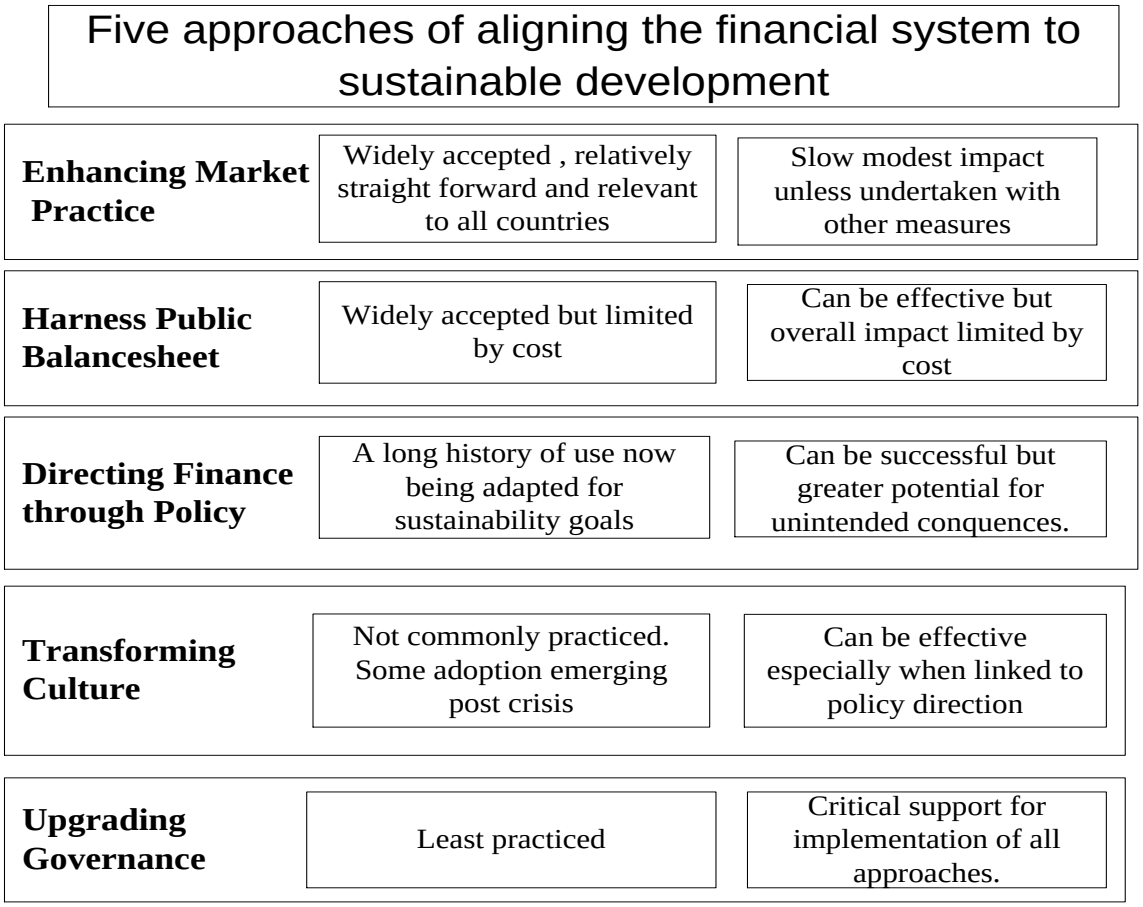

Figure 5: Five ways to make the financial system compatible with sustainable growth

Green Financing and Issues Related to Procurement of Funds for Sustainable Energy Projects: Green financing in the financial sector is crucial to meeting the world's pledges to protect biodiversity and the environment because it will provide the $1.5 trillion needed for the transition to green economies (23). Increased financial flows (including microcredit, banking, insurance, & investment) from the governmental, private, and non-profit sectors are intended to support supportable development initiatives. To accomplish this, it's critical to take on more responsibility, manage social and ecological risks properly, and take advantage of possibilities that will benefit the environment and yield a decent rate of return. An enormous shift in investment away from industries that utilize a lot of natural resources, fossil fuels, and greenhouse gases is necessary to get the world's economies moving in the direction of sustainable development. The financial industry will need to be at the forefront of this transition to sustainability. Figure 5 mentioned about the There are five ways to make the financial system compatible with sustainable growth. Mechanism of Green financing- A loan or investment that supports environmentally beneficial activity is known as "green finance." Green finance is a major topic of conversation when it comes to the sustainability of economic progress (24).

It is common practice to compromise the environment in order to attain quick growth in the economy. And we must encourage and employ green finance in order to reduce this environmental cost. Green bonds and green insurance are the two methods of green financing. Green bonds serve as a conduit between capital-raising efforts and investors' willingness to support projects that help the environment and sustainability. A form of insurance known as "green insurance" aids in preserving the environment and preventing climate change (25). One common green finance instrument is the green bond. The main financial asset of a green

bond is debt. As a fixed income instrument that pays a coupon payment, it is not significantly different from other bonds in terms of finances (26). The bonds, however, stand out since they are only used to finance green initiatives. Green bonds have already been in use by many financial institutions globally. World Bank Green Bonds provide funding to projects chosen by the bank's ecological and sector experts based on their compliance with predetermined standards for development initiatives aimed at reducing carbon emissions worldwide (27). Green insurance is a type of insurance that helps to protect the environment and combat climate change (28). Green funding aims to lower risk perceptions for green initiatives in addition to making money available for green projects. Massively promoting green financing implies that sustainable or green activities take precedence over regular corporate expenditures that may or may not be sustainable (29). By concentrating on such money, one can promote openness and a steady stream of investments for environmental goals. The expansion of this sort of finance will contribute to the increase of employment and business prospects. The end result of all this will be improved human life and amenities as well as sustainable development without endangering or harming nature (30).

Green financing in procurement of funds for sustainable green energy projects: It is very significant to consider the role that green money plays in energy efficiency (31). Energy initiatives are thought of as being powered by finance, and financial organizations show interest in these projects as well. There has been a significant shift in investment horizons from an Asian perspective, and several Asian nations are pushing green finance (Figure. 6). Green money is used to finance initiatives with environmental issues, according to the argument. Renewable energy, energy efficiency, and pollution avoidance are a few examples of projects that can be categorized as green, despite the lack of a universal definition. Green bonds are often utilized, especially in energy efficiency initiatives.

The Figure 7 proposed the structure for the procurement of funds for the sustainability energy projects. This structure sets out to evaluate the factors that constitute a way through to sustainable procurement of energy projects. The two mechanisms of green financing, i.e., green bonds and green insurance supports to procure the funds for the establishment of sustainable energy projects which in turn helps in financing maximum environmental business of sustainable energy production.

Problems and challenges to sustainable energy projects for fund procurement through green finance: The various problems and challenges faced by the sustainability energy projects (Figure 8) are: current and future levels of competition: Barriers that are both activity- and country-specific, which have a negative impact regarding the allure of such investments when it comes of risk and investment returns, limit private investment in green growth in developing nation (32). The amount of private funding for environmental growth that will increase will depend on how appealing these investments are compared to other alternatives, both domestically and internationally. Governments could be required to put into action a several public actions to make the opportunities for green investments more alluring because international investors might look for opportunities across multiple nations. Mispricing and no pricing of risks: A nation's general investment and policy climate has an impact on its capacity to attract private investors. Financial markets in some countries find it difficult to appropriately value the risks connected with green economy (33).

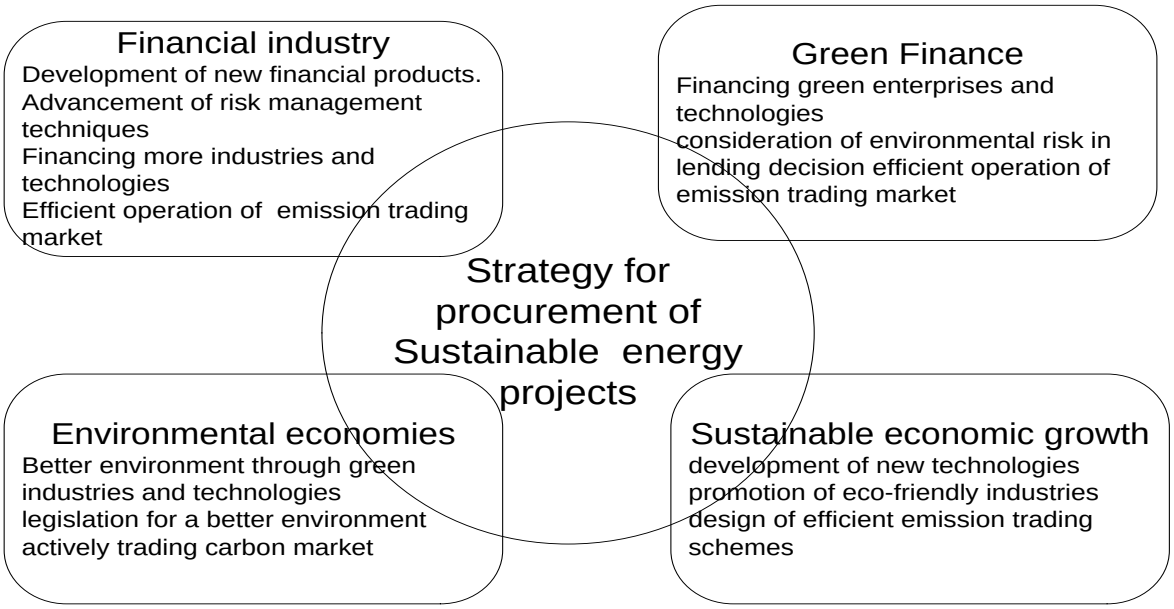

Figure 6: Financial Plan to Promote Green Economy Development

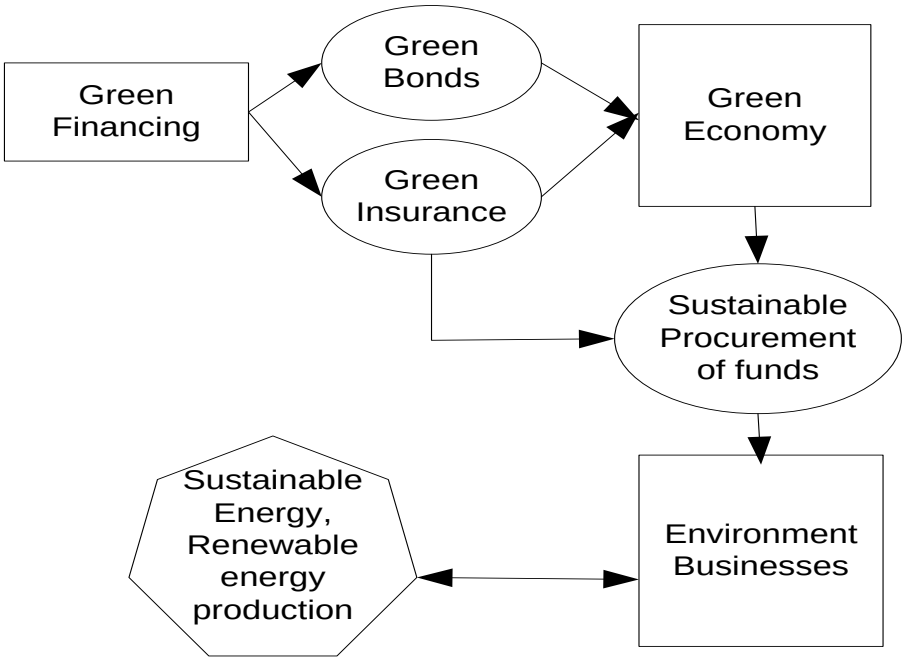

Figure 7: Proposed the structure for the procurement of funds for the sustainable energy projects

A barrier is how poorly or unwillingly the market valued these risks. These risks often include those connected to newly developed technology or processes as well as those connected to the stability and transparency of domestic policies. Market alterations and limitations: Investment in green energy will struggle to provide investors with enticing returns for as long as environmental outcomes are not considered and subsidies for fossil fuels continue to distort energy market prices. Another factor is the restricted availability of various green financing products and the marketplaces on which they can be traded (34). Competing objectives: Public green finance providers aspire to accomplish the greatest environmental improvement; private investors

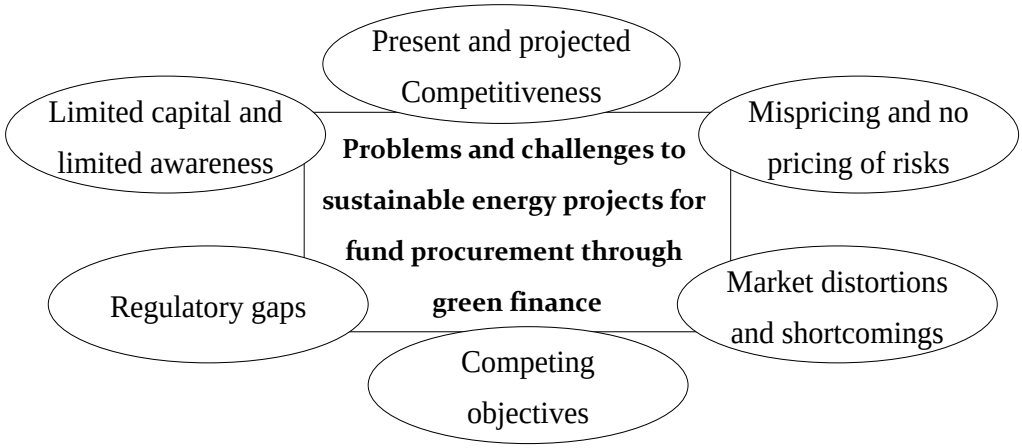

Figure 8: Various problems and challenges to sustainable energy projects fund procurement through green finance

seek to maximize their risk-adjusted investment returns and host-country authorities are concerned with obtaining the finest growth prospects. Limited resources and knowledge: Small and medium-sized businesses often face limited liquidity and access to capital, making interaction in the green financing market difficult. The existing short-term firm strategy is a significant obstacle to private funding, which ignores opportunities that could result from green industries in the far years. Additionally, there aren't enough professionals who are aware of the intricate connections between concern for the environment and the financial markets. Regulatory gaps: The lack of suitable legislative and technical infrastructure to evaluate, appraise, and analyses green corporate strategy and financing is another obstacle to the growth of green finance (35). These challenges need to be sorted out with the help of financial technologies. Like if we talk about the issues of limited capital and limited awareness, mispricing, competitive objectives, mispricing etc. can be resolved with the inclusion of financial technologies like crowdfunding, big data analytics, blockchain technology, AI, etc. The worldwide community has established a number of objectives, taking into account the Sustainable Development Goals, the Climate Change Paris Pact, and other objectives. Towards achieving these goals, however, the existing level of investment in energy efficiency and renewable energy projects is insufficient. Therefore, the research's objective is to identify ways to use fintech to close these financial gaps.

Technology Inclusion in Procurement of Green Financed Sustainable Energy Projects: There are many barriers which creates hurdles in procurement of funds for financing the green financed sustainable energy projects (36). With the inclusion of financial technologies like blockchain, artificial intelligence, big data, machine learning, etc., these barriers can be removed. FinTech fundamentals simplifies monetary operations for businesses, enhancing accessibility and frequently cutting costs (37). It can also apply to companies that utilize AI, data science, and encoded blockchain to allow very secure internal network operations (38). Trends in Fintech has changed and expanded throughout time in response to shifts in the larger technological sector. This increase in 2022 was marked by a number of dominating traits, including: Digital banking is still expanding Access to digital banking is now more straightforward than ever. Consumers currently use digital-first banks to handle their finances, apply for and pay for loans, and buy insurance (39). By 2026, it is anticipated that the worldwide market for digital banking systems would develop at a CAGR of 11.5 percent, which will probably fuel further growth in this industry.

The Technologies That Power FinTech: Artificial intelligence, big data, and blockchain-based technology are the key drivers of modern fintech, and they have profoundly changed how

organizations move, store, and protect digital currency (Figure 9). AI can help businesses, in particular, better understand their customers by providing analytical data on customer behavior and purchasing trends. Big data analytics can assist businesses in anticipating market developments and developing innovative, data-driven business plans (40). Blockchain, a more recent financial technology, uses a network of users to keep track of potential upgrades or additions to encrypted data, enabling decentralized transactions without the need for a third party. The usage of information technology is strongly encouraged by new generation energy projects, with blockchain emerging as one of the most popular technologies. Decentralized transactions are made possible by blockchain technology without the participation of a government agency or another independent organization. Blockchain technology for several years, and usage have been expanding significantly, and it is projected that this trend will continue as more sectors adopt cutting-edge data encryption. Internet of things: In the world of the Internet of Things, the financial market risk and wealth distribution capacity of the green credit economic development based on neural network technique, machine learning, boost the cash flowing to the sustainable environmental protection industry. The capital market's debt business is the study's research object, and by improving the financial transaction structure, it enhances the capacity for allocation of resources (38).

The method and diversity of the use of robots (IRA) affecting environmental advancements in the worldwide manufacturing sector is revealed using automated robotic data and making green technology invention data. The adoption of Digitalization is in favor of the industrial robotics' stimulating impacts for the development of green technology. The application of cloud computing is the interconnection of data using the cloud services model architecture principles. The majority of today's huge data is kept in the cloud. Mainly through the project, big data creation and promotion were made for the specified application of the big data strategy. AI and ML technologies have changed how financial organizations scale by reinventing the services that they offer to clients. With the use of AI and ML, operational costs may be decreased, customer value can be grown, and fraud can be detected. Consider these technologies playing a bigger part in the growth of fintech as they become more accessible and affordable, especially as more traditional banks switch to digital banking (39). Another well-known fintech application, is already influencing solar PV sector financing structures. More and more community solar systems are being installed and financed through crowdsourcing. Often, Communities decide to move from fossil to renewable electricity sources. This change may be accompanied by a few challenges. For instance, photovoltaic systems demand a down payment that is reimbursed over the course of the plant's life and the space in which it is installed. Not everyone has the money or space to install solar panels. Crowdfunding initiatives are helpful in cases like these. Additionally, new investment in these kinds of projects decreased even more after the COVID-19 pandemic because of the uncertainty, the financial downturn, and the fact that investors' futures are not very clear. This indicates that the situation is even more dire now than it was before the COVID-19 pandemic. The research's objective is to find a way to close this funding gap (9, 25, 37).

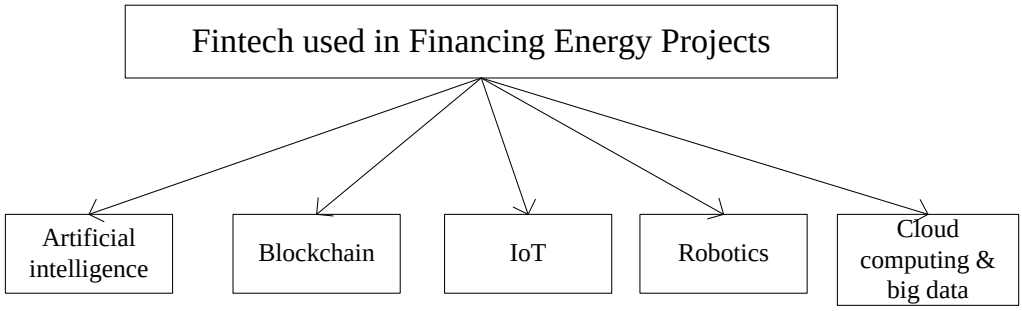

Figure 9: Various financial technologies used in financing the fund procurements

Technical Frameworks for Measuring, Evaluating, and Analysing Green Business Finance: The Figure 10 shows how green finance technologies can be adopted for finance procurement of sustainable energy projects. The mechanism of green finance includes green bonds and green insurance which raise the sustainable procurement of funds through which specifically green projects will be financed, that in turn promotes the environment businesses and supports sustainable projects of energy production with the use of financial technologies in a productive manner.

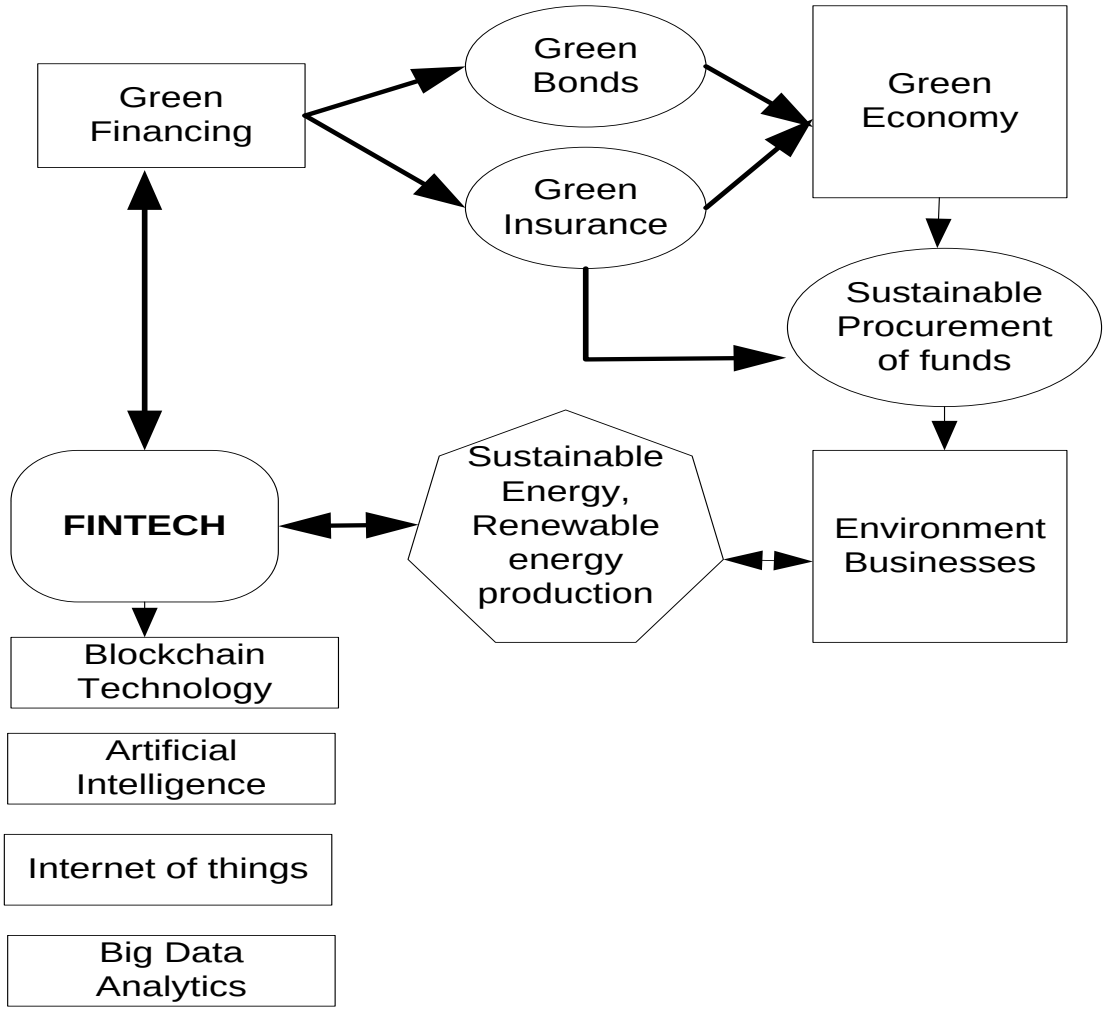

Figure 10: Fintech implementation and adoption in financing sustainable energy projects

Role of Fintech for Funding of Sustainable Energy Projects: It is very significant to consider the role that green money plays in energy efficiency. Energy initiatives are thought of as being powered by finance, and financial organisations show interest in these projects as well. There has been a significant shift in investment horizons from an Asian perspective, and several Asian nations are pushing green. Regarding green finance, it is a method of financing environmental projects. Renewable energy, energy efficiency, and pollution avoidance are a few examples of projects that can be categorised as green, despite the lack of a universal definition. Green bonds are often utilised, especially in energy efficiency initiatives (23, 25, 32). Additionally, The Energy Web bases their green energy credentials on blockchain. A relatively new financial sector called "fintech" uses technology to improve financial action. Fintech is defined as “any fresh ideas that enhance financial function requires through the delivery of technology solutions catered to unique business needs. "Financial technology, also referred to as "fintech," is an innovative idea that is fundamentally disrupting every part of the current

financial system. Fintech includes anything from High-Frequency Trading (HFT) to mobile payment applications, crowdsourcing, digital currencies, and blockchain. During the worldwide economic emergency of 2008, improvements in e-finance and mobile technology for financial institutions led to the creation of the fintech industry. This trend has been defined by the integration of internet technology, e-finance innovation, social networking services, AI and big data. Many old-style financial institutions, including banks, are being compelled to reconsider their business strategies as a result of recent breakthroughs in financial technology. Even now, fintech businesses are beginning to provide services like health coverage, wealth management, and lending. As a result of increasing computerization and enhanced data analytics that result in lower energy consumption, Automation could lead to greatly accelerate the acceptance of energy effectiveness and sustainable energy technologies (36). Digital technology also opens up new opportunities for the development of creative new funding models (IEA 2021). Fintech is seen as a disruptive force because of its inventiveness, which has a big impact on the energy sector. It significantly affects the societal, environmental, & ecological advantage of encouraging the use of funds for energy efficiency. Furthermore, it argues that bank is vital to play a role in funding low-carbon energy initiatives. The main reason behind the energy transformation is Greentech via fintech. The numerous applications of fintech are not only for specialists in the energy sector but also for interested parties from many sectors, government agencies, and researchers who are examining the subjects included in its coverage (37). And to understand the adoption we need to connect the theoretical base with the help of some underpinning theories.

Theoretical base: The research aims to comprehensively investigate the adoption, efficacy, and impact of fintech applications in green energy investments. Firstly, it seeks to understand the adoption patterns and utilization dynamics among investors, financial institutions, and stakeholders, exploring factors like perceived usefulness and ease of use. Secondly, it aims to assess the effectiveness of fintech solutions in mitigating cost barriers associated with green energy investments by examining users' perceptions of their financial benefits and ease of implementation. Finally, the research endeavors to evaluate the broader impact of fintech interventions on the scale, scope, and sustainability outcomes of green energy projects, considering how these applications contribute to enhanced investment flows, project viability, and environmental performance within the renewable energy sector. The goals outlined in this research align well with the technology adoption.

Many authors have developed theories related to the various technologies few of them are discussed below:

Theory of Reasoned Action: The Theory of Reasoned Action (TRA) states that a person's desire to engage in a behaviour is impacted by their perception of the behaviour and specific social norms (Figure 11). The three fundamental components of the reasoned action theory are assumptions, attitudes, and desires.

Theory of Planned Behavior: The Theory of Planned Behavior (TPB) was advanced by Ajzen in 1991 as shown in Figure 12. According to the Theory of Planned Behavior, people behave logically in accordance with their attitudes,

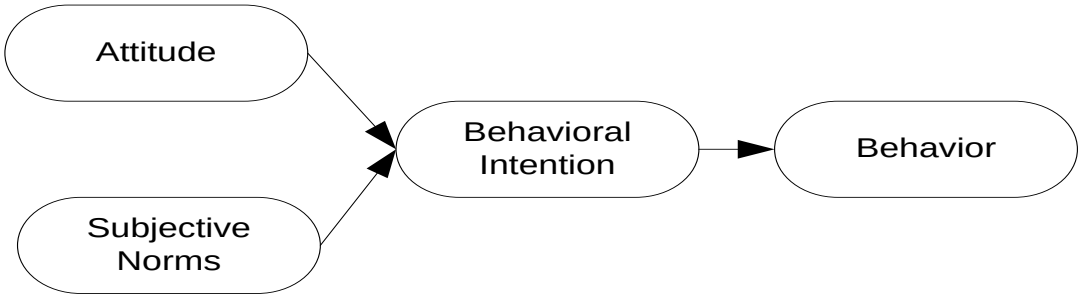

Figure 11: Theory of Reasoned Action

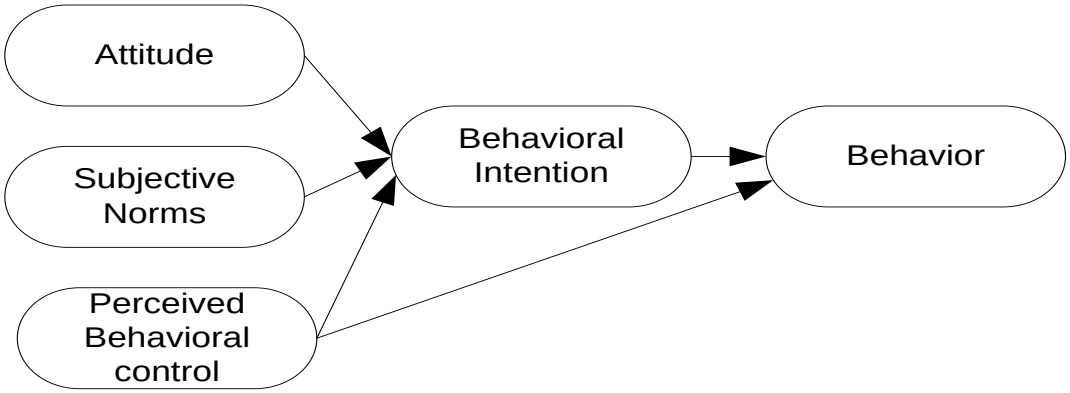

Figure 12: Theory of Planned Behavior (TPB)

arbitrary standards, and apparent behavioral control. These factors provide the context for decision-making, although not being frequently actively or consciously considered (40, 41). Any behaviors can be characterized in terms of four elements, according to the theory: action (i.e., the specific act carried out by a distinct), target (i.e., Toward whom or what the actions is geared), context (i.e., the situation in which the behaviors occur).

The Technology Acceptance Model: Technology Acceptance Model (TAM), a widely recognized framework for understanding and predicting user acceptance of technology. TAM suggests that perceived usefulness and perceived ease of use are critical determinants of an individual's intention to adopt and utilize a technology.

Davis, 1989 represents the Technology Acceptance Model, one of among the most prevalent technology acceptance models (Figure 13). It focuses on perceived usability and ease of use, the two main factors influencing a person's intention to use new technology. According to this paradigm, Apparent usefulness measures how much someone thinks utilising the system will boost their performance, while apparent usability measures how much they think using the system will involve minimal effort. The perceived comfort of routine influences the perceived value of a product. The way a person views the advantages of using a system determines how beneficial they feel it to be. These two factors, which indicate the person's significant expense of utilising the system, are taken into account when discussing cost-benefit and difficulty-of-use issues. Taylor and Todd propose compatibility, Perceived usability, and perceived utility as backgrounds of attitude (largely consistent with TAM). Additionally, they contend that subjective norms have Sensible usability and superior inspiration as their backgrounds. Then, as factors of perceived behavioural control, they represent self-efficacy, resource-enabling circumstances, and technologically enabling circumstances.

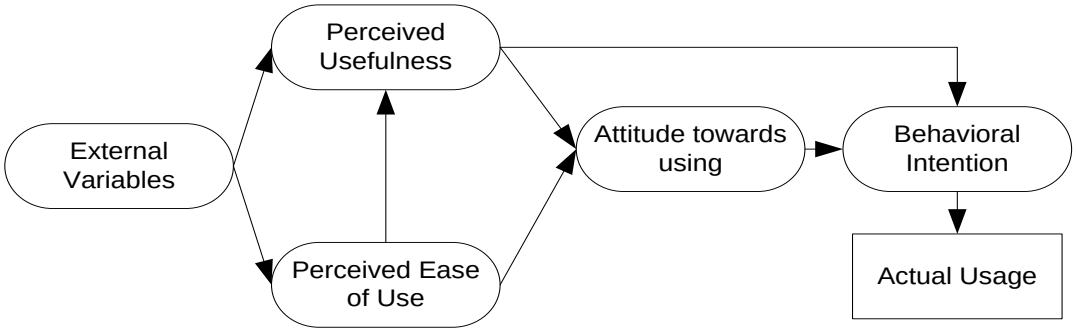

Figure 13: Technology Acceptance Model

Davis in 1986 established the Technology Acceptance Model (TAM) and utilised this model to explore how internal beliefs and attitudes are influenced by external factors. He claimed that TAM also took into account how individual attitudes about accessing the information system affected

behavioural intentions (42, 43, 26). The primary elements impacting user adoption in the market, according to the TAM Model, include:

- Perceived ease of use (PEOU) - The degree to whereby a one who feels that utilising a certain system would be completely free of effort.
- Perceived usefulness (PU) - The extent to which someone holds a specific belief that technique would increase his or her capacity to perform at task.

The theory of reasoned action (TRA), on which TAM is founded, has also been used to comprehend and forecast how consumers will react to new technology. The model can be utilised from the standpoint of technology management to comprehend consumer behaviour, target markets, and assist in predicting usage across various domains of technology-based developments. Another significant model that was created and is based on the TAM Model is the Unified Theory and Acceptance and Use of Technology (UTAUT) model. Additional significant factors influencing behavioural intention are described by UTAUT as presentation belief, determination belief, community influence, and easing situations (41).

Attitude: The attitudes that people develop from using new technologies, whether they be good or bad. A person will behave more intentionally when they have a stronger favourable attitude toward employing new technologies. Perceived utility and perceived usability have a role in determining it.

a) "How strongly a person feels that embracing a certain technology will boost their efficiency" is the definition of perceived usefulness. On the other hand, if a user believes the new technology will be helpful, they will adopt a better outlook towards something.

b) The degree to which a person thinks utilising new technology is effortless is referred to as perceived ease of use. It's more likely that a new innovation to be embraced by consumers when people believe it to be simple to use and involves little effort and time.

Behavioral intentions: a person's level of readiness to use a new technology.

External variables: Factors including user traits, system attributes, and ambient variables all have an indirect impact on behaviour. Numerous researchers have focused on the relative benefit, usability, compatibility, trialability, visibility, outcome demonstrability, image, and voluntariness as characteristics that influence the deployment of new technologies.

The goals outlined in this research proposal align well with the Technology Acceptance Model (TAM), a widely recognized framework for understanding and predicting user acceptance of technology. TAM suggests that perceived usefulness and perceived ease of use are critical determinants of an individual's intention to adopt and utilize a technology as mentioned by Chen, 2020.

Understanding Adoption Patterns and Utilization Dynamics: TAM posits that perceived usefulness influences the intention to use a technology. In the context of fintech applications in green energy investments, investors, financial institutions, and stakeholders are likely to adopt these solutions if they perceive them as beneficial for facilitating green energy investments. Previous research has shown that perceived usefulness positively impacts the adoption of various technologies, including fintech solutions. Therefore, investigating factors such as perceived usefulness and ease of use among different user groups is essential for understanding adoption patterns and utilization dynamics.

Assessing Effectiveness in Mitigating Cost Barriers: TAM also suggests that perceived ease of use influences the intention to use a technology. Fintech solutions designed to streamline green energy investments may be perceived as effective if users find them easy to implement and use. This perception of ease of use can mitigate the perceived barriers associated with the complexity of green energy investments, thereby increasing adoption rates. Prior studies have demonstrated that perceived ease of use significantly impacts users' attitudes and intentions to use technology. Therefore, assessing users' perceptions of the financial benefits and ease of implementation of fintech solutions can provide insights into their effectiveness in mitigating cost barriers.

Opinions of utility and accessibility affect the adoption of new technology, which are impacted by outside influences, such as personal characteristics, system characteristics, and organisational support. The study gathered the relevant prior research literatures that are connected to variables affecting

the application of new technology and discovered that many scholars utilized TAM as their main theoretical framework and created a wide range of empirical bases. Because the Fintech Service is a cutting-edge high-tech product, using it as a study subject and TAM to investigate consumers who use it or may use it is becoming a crucial issue (12, 29, 39). This is because it allows researchers to determine whether consumer attitudes toward the Fintech Service have a significant impact on behavioural intentions to use it. The Influence of returns, expectations of customers, operational efficiency and market competency on Attitude towards using Fintech Services Figure 14 explains the Technology adoption model for fintech in green financed sustainable energy projects with the witness of four external factors includes, financial returns, customer expectations, operational efficiency and market competency. The Effects of Perceived Utility and Perceived Usability on Perception of Using Fintech Services: Attitude" is based on both perceived value and perceived usability. It is vital to give possible users the impression that the new technology is simple to they can both use and profit from utilising it in order to encourage their willingness to adopt. "Perceived usefulness" said that prospective users believed the new technology was beneficial for improving job performance and that they could

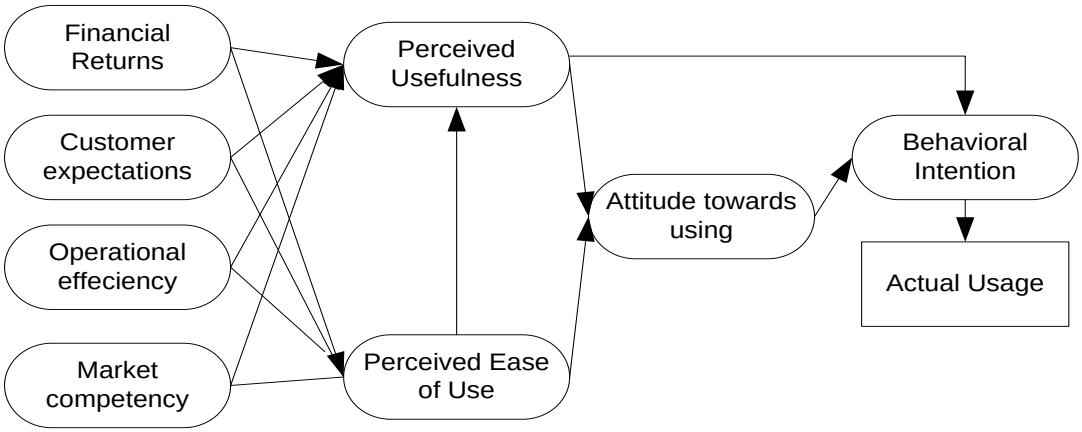

Figure 14: TAM Model for fintech adoption in green financed sustainability energy projects

reap future benefits. "Perceived ease of use" related to the degree to which potential users thought the new technology was simple to use (22, 34, 41).

Technology adoption factors such as effectiveness and ease of use have a positive impact on personality. Positive attitudes toward fintech services are influenced by users' perceptions of the benefits as practical and easy to use. Consumers' attitudes toward using fintech services are also more favorable if they believe the services are more useful for their jobs or easier to use (17). As a result, consumer perceptions of the usability and utility of fintech services influence their acceptance. Influence of Attitude on Desire to Use Fintech Services: The majority of past studies have shown that a personality has a considerable impact on their behaviour. Using subjective norms, it was possible to the behaviour of future users, while existing users' behaviour was based on their behaviour and views. The "attitude on to using" and "intention of using" of a consumer for a fintech service should be significantly correlated. If consumers believe excellent feedback, people will be even more willing to use fintech, which will improve their belief that doing so is a good experience. Customers will urge others to use fintech services when they perceive it as a useful resource, which will influence and improve client views of digital services. As a result, there is a positive correlation between attitude and behavioural intent (44).

Results

The study's key findings have important managerial implications, according to the findings. The significance of comprehending behavioural intentions toward using fintech services is demonstrated by this research. Firstly, the principal components analysis of customer behaviour found that the absorption of new technology was

influenced by five domains (brand and company trust, recognized utility, perceived ease of use, attitude toward using, and behavioural intentions to use). When evaluating people's acceptance of innovative technology experiences, people may take into account positive experiential components like social cognition interaction with their clients or the businesses, controlling costs of the goods for the manufacturers, process comfort, and conflict-related qualities that this investigation with the reliability of the latest tech.

Technology Acceptance Model (TAM) augmented with external factors such as financial returns, customer expectations, operational efficiency, and market competency, this study aimed to unravel the complexities surrounding the adoption of fintech in green financed sustainability energy projects. By examining the interplay between perceived usefulness, perceived ease of use, attitude towards fintech usage, behavioral intention, and actual adoption, we elucidated the underlying mechanisms driving the uptake of fintech solutions in this critical domain.

Our analysis revealed that perceived usefulness and perceived ease of use are pivotal determinants shaping users' attitudes towards fintech adoption in green energy investments. Individuals are more inclined to embrace fintech solutions when they perceive them as beneficial in facilitating green energy investments and find them easy to use. Moreover, external factors such as financial returns and operational efficiency significantly influence these perceptions, highlighting the importance of tangible benefits and streamlined processes in driving acceptance.

Users' attitudes towards fintech usage are strongly influenced by their perceptions of usefulness and ease of use, as well as external factors such as customer expectations and market competency. Positive attitudes are fostered when individuals perceive fintech solutions as effective tools for advancing sustainability objectives and meeting industry standards. Additionally, the alignment of fintech offerings with user needs and market demands enhances attitudes towards adoption.

The study found a clear link between attitudes towards fintech usage and behavioral intention, with favorable attitudes leading to a greater intention to adopt fintech solutions in green energy investments. Users who view fintech positively are more likely to express their intention to integrate these solutions into their investment strategies, driven by the perceived benefits and ease of implementation offered by fintech applications.

Ultimately, positive behavioral intentions translate into actual adoption of fintech in green financed sustainability energy projects. Users who exhibit a strong intention to adopt fintech solutions are more likely to follow through and integrate these tools into their investment practices. Moreover, the influence of external factors such as market competency and financial returns further reinforces the decision to adopt fintech, as users recognize the strategic advantages offered by these solutions in navigating the evolving landscape of green energy investments.

Discussion

If customers are happy with the companies' (brand/company reputation/trust) execution of the service, such as if the payment processes and outcomes are correct or the payment gateway is secure and reliable, they will have high amounts of brand and facility trust in fintech services. Customers' favorable perception of using fintech services will rise if they can complete transactions in real-time and without constraints on time or place, or efficiently, conveniently, and rapidly get pertinent information about businesses as mentioned by Gomber, 2018 (44). This technology will impact how customers feel about utilising fintech services if the methods of operation are friendly and the application programs are simple to download.

The research provided a comprehensive understanding of the adoption dynamics of fintech solutions in green financed sustainability energy projects, integrating insights from the Technology Acceptance Model (TAM) with external factors such as financial returns, customer expectations, operational efficiency, and market competency. By examining the interplay between perceived usefulness, perceived ease of use, attitudes towards fintech usage, behavioral intention, and actual adoption, the study identified key drivers shaping the uptake of fintech in the energy sector, facilitating informed decision-making for stakeholders. The findings offer practical implications for

policymakers, financial institutions, investors, and other stakeholders involved in green energy investments, highlighting the importance of addressing both intrinsic and extrinsic factors to promote the widespread adoption of fintech solutions.

Limited availability of comprehensive data on fintech adoption in green financed sustainability energy projects posed a challenge in conducting empirical analyses and drawing robust conclusions, necessitating reliance on theoretical frameworks and hypothetical scenarios. The complex interactions between perceived usefulness, perceived ease of use, and external factors required careful analysis and interpretation, making it challenging to isolate the specific influence of each variable on fintech adoption.

Adopting a holistic approach that considers both intrinsic and extrinsic factors is essential for understanding and promoting fintech adoption in green energy investments, as highlighted by the integration of TAM with external variables in this research. Further research is warranted to explore additional factors influencing fintech adoption, such as regulatory frameworks, technological advancements, and market dynamics, to enhance our understanding and inform strategic decision-making in the energy sector. Continuous evaluation and refinement of fintech solutions based on user feedback and market insights are crucial for maximizing their effectiveness and driving sustainable outcomes in green financed sustainability energy projects.

The most significant factor influencing whether customers will utilise fintech services is the degree of good and negative rating of those who have used those services (Table 2).

Table 2: Discussion achievements, difficulties, and takeaways from incorporating fintech solutions into green finance projects.

Achievements	Comprehensive Understanding: The research provided a comprehensive understanding of the adoption dynamics of fintech solutions in green financed sustainability energy projects, integrating insights from the Technology Acceptance Model (TAM) with external factors such as financial returns, customer expectations, operational efficiency, and market competency. Identification of Key Drivers: By examining the interplay between perceived usefulness, perceived ease of use, attitudes towards fintech usage, behavioral intention, and actual adoption, the study identified key drivers shaping the uptake of fintech in the energy sector, facilitating informed decision-making for stakeholders. Practical Implications: The findings offer practical implications for policymakers, financial institutions, investors, and other stakeholders involved in green energy investments, highlighting the importance of addressing both intrinsic and extrinsic factors to promote the widespread adoption of fintech solutions.
Difficulties	Data Availability: Limited availability of comprehensive data on fintech adoption in green financed sustainability energy projects posed a challenge in conducting empirical analyses and drawing robust conclusions, necessitating reliance on theoretical frameworks and hypothetical scenarios. Complexity of Interactions: The complex interactions between perceived usefulness, perceived ease of use, and external factors required careful analysis and interpretation, making it challenging to isolate the specific influence of each variable on fintech adoption
Takeaways	Achievements: Comprehensive Understanding: The research provided a comprehensive understanding of the adoption dynamics of fintech solutions in green financed sustainability energy projects, integrating insights from the Technology Acceptance Model (TAM) with

external factors such as financial returns, customer expectations, operational efficiency, and market competency.

Identification of Key Drivers: By examining the interplay between perceived usefulness, perceived ease of use, attitudes towards fintech usage, behavioral intention, and actual adoption, the study identified key drivers shaping the uptake of fintech in the energy sector, facilitating informed decision-making for stakeholders.

Practical Implications: The findings offer practical implications for policymakers, financial institutions, investors, and other stakeholders involved in green energy investments, highlighting the importance of addressing both intrinsic and extrinsic factors to promote the widespread adoption of fintech solutions.

Difficulties:

Data Availability: Limited availability of comprehensive data on fintech adoption in green financed sustainability energy projects posed a challenge in conducting empirical analyses and drawing robust conclusions, necessitating reliance on theoretical frameworks and hypothetical scenarios.

Complexity of Interactions: The complex interactions between perceived usefulness, perceived ease of use, and external factors required careful analysis and interpretation, making it challenging to isolate the specific influence of each variable on fintech adoption.

Takeaways:

Holistic Approach: Adopting a holistic approach that considers both intrinsic and extrinsic factors is essential for understanding and promoting fintech adoption in green energy investments, as highlighted by the integration of TAM with external variables in this research.

Continued Research: Further research is warranted to explore additional factors influencing fintech adoption, such as regulatory frameworks, technological advancements, and market dynamics, to enhance our understanding and inform strategic decision-making in the energy sector.

Iterative Improvement: Continuous evaluation and refinement of fintech solutions based on user feedback and market insights are crucial for maximizing their effectiveness and driving sustainable outcomes in green financed sustainability energy projects.

Conclusion

The adoption of fintech applications in green energy investments holds significant promise for advancing sustainability objectives and driving positive environmental outcomes as mentioned by Udeagha, 2023 (43). Through the lens of the Technology Acceptance Model (TAM) augmented with additional external variables such as financial returns, customer expectations, operational efficiency, and market competency, this research has sought to elucidate the factors influencing the adoption and efficacy of fintech solutions in green financed sustainability energy projects.

The first objective was to assess the adoption patterns and utilization dynamics of fintech applications tailored for green energy investments. Drawing on TAM principles, we investigated factors such as perceived usefulness and ease of use among investors, financial institutions, and stakeholders. The findings reveal that perceived usefulness is a critical driver of adoption, with users more likely to embrace fintech solutions that offer tangible benefits in facilitating green energy investments. Moreover, factors such as customer expectations and market competency emerged as significant influencers, suggesting the importance of aligning fintech offerings with user needs and industry standards.

The second objective focused on investigating the efficacy of fintech solutions in mitigating the cost barriers associated with green energy investments.

By employing empirical analyses, we quantified the financial benefits, risk mitigation mechanisms, and overall cost-effectiveness facilitated by these applications. Results demonstrate that fintech solutions play a pivotal role in enhancing operational efficiency and reducing transaction costs, thereby improving the financial viability of green energy projects. Additionally, the ability of fintech applications to provide real-time insights and analytics contributes to better decision-making and risk management, further bolstering their efficacy in overcoming cost barriers.

In conclusion, this research underscores the transformative potential of fintech applications in green financed sustainability energy projects. By leveraging insights from the TAM framework along with external variables such as financial returns and market competency, we have shed light on the drivers of adoption and the mechanisms through which fintech solutions enhance the financial feasibility of green energy investments. Moving forward, continued efforts to innovate and refine fintech offerings, while addressing user needs and industry standards, will be essential for accelerating the transition towards a more sustainable energy future. Moving forward, efforts to enhance perceived usefulness, ease of use, and alignment with external factors will be instrumental in accelerating the adoption of fintech and advancing sustainability objectives in the energy sector.

Limitation and Future Research

It would be conceivable to introduce other industries as the sampling frame in comparison the adoption of fintech services for various businesses. The servicing sector is the focus of this study; it is suggested that future research expand sample objects to other industries in demand to better comprehend the various aspects of consumer acceptance of the Fintech Service method. Further research should concentrate on examining the effects of other elements that influenced the link between purchase intention, such as social norms, servicing costs, and other factors, which have a significant impact on whether consumers accept fintech services, and the fintech services' products, which have an impact on consumers' attitudes. In extra words, future research on the relationship between quality and approval should take into account additional or alternative antecedents that could influence behavior or mitigate these effects.

Abbreviation

Nil

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Author Contributions

First author contributed in conceptualization or developing the initial idea for the study and drafting the initial version of the manuscript. Second author involvement in designing the research or the methodology also in gathering specific information. Third author role in overseeing the research process and providing guidance.

Conflict of Interest

The authors declares that there is no conflict of interest regarding the publication of this paper.

Ethics Approval

The research does not involve human participants.

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