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Innovative Financial Models for Enhancing Affordability and Investment in Domestic Energy Resources: A Sustainable Approach to United States Energy Transition

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Abstract: As the United States progresses towards a cleaner energy future, investigating innovative finance models that improve investment viability and affordability is critical to attaining long-term sustainability. The transition to a sustainable energy system therefore necessitates innovative financial solutions that improve affordability and encourage investment in domestic energy resources. The purpose of this review is to explore financial models that can increase investment in domestic energy resources while ensuring cost affordability for consumers. The findings suggest these innovative finance models have the potential to overcome investment gaps, lower consumer financial barriers, and encourage large-scale adoption of clean energy technologies. In conclusion, a multifaceted approach integrating public, private, and community-driven financing channels is required to expedite the energy transition in the United States. Policymakers, investors, and stakeholders must collaborate to improve these models, integrate digital financial technologies, and establish favourable regulatory conditions.

Keywords: E*nergy Systems, Sustainable Development, Energy Transitions, Financial Innovation.*

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I. INTRODUCTION

The global energy environment is facing major transformation, owing to technological advancements, policy shifts, and the need to address certain environmental issues (Hassan et al., 2024). The United States, one of the major energy consumers worldwide, has made considerable strides in diversifying its energy supply by incorporating renewables like wind, solar, and bioenergy. Despite these advances, fossil fuels remain the primary energy generation and consumption source (Hassan et al., 2023). The high costs of renewable energy infrastructure, combined with inconsistent government incentives and market barriers, have reduced widespread adoption of sustainable energy solutions (Kariuki, 2018).

The United States is one of the world's top energy consumers, accounting for around 16 % of worldwide primary energy consumption despite having only about 4 % of the world's population (Central Intelligence Agency, 2024; United States Energy Information Administration -US EIA, 2024). The transition to renewable energy in the United States is critical for several economic, environmental, and social reasons. From an environmental perspective, reducing reliance on fossil fuels is critical for lowering greenhouse gas emissions, which contribute to global warming and extreme weather occurrences (Farghali et al., 2023). However, reaching the United States commitments to reach net-zero emissions will necessitate relevant investment in sustainable energy infrastructure, innovative finance structures, and legislative support. Economically, transitioning to renewable energy may offer growth prospects. In this regard, the renewable energy sector has been a key job creator, providing possibilities in solar panel manufacture, wind turbine installation, and energy storage development (Stern & Valero, 2021).

Additionally, minimizing reliance on imported fossil fuels improves national energy security and protects the economy from shifts in global oil and gas prices. Therefore, by investing in domestic energy resources, the United States can increase its energy independence while promoting economic resiliency (Paravantis & Kontoulis, 2020). Socially, energy affordability is a major challenge,

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particularly for low-income households, spending a disproportionate amount of their income on utilities. Rising energy costs and economic inequities make it critical to create finance options that promote fair access to renewable energy (Brown et al., 2020; Al Kez et al., 2024). Hence, addressing affordability through innovative finance methods may empower communities, improve quality of life, and ensure a fair transition to renewable energy.

Furthermore, financial constraints remain an essential issue in the United States energy transition, affecting both large-scale infrastructure projects and household-level adoption of clean energy technologies (Ugwu & Adewusi, 2024). While certain financing models may have driven initial investments in renewables, they are frequently insufficient to support long-term energy affordability and expansion. Low-income communities and small businesses face severe financial barriers to acquiring renewable energy alternatives, compounding energy disparities (Isah et al., 2023). Innovative financial models, frameworks, and decentralized financing mechanisms, may provide new avenues for bridging these financial disparities and promoting a more equitable energy transition. This review therefore explores sustainable approaches to the United States energy transition, relating to innovative financial models for enhancing affordability and investment in domestic energy resources.

II. CURRENT STATUS OF UNITED STATES DOMESTIC ENERGY RESOURCES

Previous research by Saundry (2019) and Alagoz & Alghawi (2023) has revealed that the United States' energy industry is transforming, shifting from a fossil fuel-dominated system and towards a more sustainable, diverse energy balance. This transition is being driven by a variety of causes, including advances in renewable energy technologies, evolving regulatory frameworks, and the growing urgency to address climate change. However, despite improvements, the United States confronts problems in increasing renewable energy use while maintaining affordability and long-term investment (Chipangamate & Nwaila, 2024). The energy transition is more than just a technology transformation; it necessitates fundamental adjustments in financing models, policy assistance, and market laws to ensure a fair transition for all stakeholders.

The United States' energy environment remains varied, with fossil fuels, nuclear power, and renewables all contributing to the national energy supply. (Ang et al., 2022)

According to Farnoosh (2022), fossil fuels such as coal, natural gas, and petroleum continue to account for a major part of energy generation. Natural gas, in particular, has emerged as a dominant energy source due to its lower carbon footprint compared to coal and cost competitiveness. However, despite being an environmentally friendly fossil fuel, natural gas still contributes to greenhouse gas emissions, necessitating a shift to more renewable alternatives. In addition, wind, solar, hydro, and biomass are examples of renewable energy sources that have developed rapidly due to technology improvements and cost reductions (Ang et al., 2022). Wind and solar power have added record capacity in the last decade, due mostly to federal tax breaks, state-level renewable portfolio regulations, and business commitments to sustainability. The growing affordability of solar panels and battery storage systems has strengthened the case for renewable energy integration into the grid (Ibrahim et al., 2023). However, difficulties such as infrastructure advancement, energy storage limits, and intermittent generation remain major obstacles to creating a completely renewable energy-powered economy.

Recently, nuclear power continues to play a part in the United States' energy, assisting to provide a steady, low-carbon electrical supply (US EIA, 2022). However, concerns about nuclear waste disposal, plant decommissioning costs, and public safety views have reduced the development of new nuclear projects. Meanwhile, hydropower, formerly a prominent renewable energy source, has experienced slower growth due to environmental concerns and the difficulties of establishing new large-scale hydroelectric projects (Ye, 2016). Therefore, as the United States transitions to a low-carbon future, innovative financing and investment techniques will be critical for increasing renewable energy generation while addressing affordability concerns.

- *Challenges in Energy Affordability and Investment*

The transition to better, more sustainable energy sources has notable financial and structural obstacles, especially in relating to cost and investment (Saleh & Hassan, 2024). Despite advances in renewable energy technology and falling costs for solar and wind power, high upfront capital needs, legislative uncertainties, market volatility, and infrastructure constraints continue to hinder large-scale adoption and fair access to clean energy (Wang et al., 2024). Therefore, addressing these problems is critical to securing an affordable, equitable, and sustainable energy transition in the United States.

A barrier to energy affordability and investment is the large initial capital expenditure necessary for renewable energy installations. Unlike fossil fuel-based power facilities, which can be built incrementally and extended as demand develops, solar farms, wind turbines, and battery storage systems require a significant upfront investment before yielding returns (Ang et al., 2022). In this regard, solar and wind power plants require substantial infrastructure investments, such as land acquisition, transmission lines, and grid integration. Battery storage technologies, which are critical for balancing intermittent renewable power output, remain expensive, restricting their widespread adoption. Grid modernization to accommodate decentralized energy production and smart grid technology demands high costs in investment (Hassan et al., 2024). As such, these large upfront costs are a financial hurdle for many utilities, enterprises, and residential consumers, especially in poor neighbourhoods with limited access to reasonable financing. While tax credits and subsidies help to cover these costs, they are not always enough to balance the investment gap.

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Energy investments are long-term commitments necessitating policy and market stability. However, inconsistencies in government policy, fluctuating energy prices, and changing rules cause uncertainty for investors, limiting large-scale financial inflows into renewable energy projects (Olujobi et al., 2023). Uncertain federal and state policies such as changes in government administrations frequently cause alterations in energy policy, altering subsidies, tax breaks, and carbon pricing. Investors demand long-term stability before committing capital, but policy reversals, such as the elimination of clean energy incentives or changes to net metering rules, generate risks that discourage investment (Adeniyi & Isah 2023). Additionally, price volatility for fossil fuels in which price fluctuations in oil and natural gas have an impact on the energy markets. When fossil fuel prices fall sharply, renewable energy investments may become less appealing, impeding the transition to cleaner alternatives. Similarly, complex permission processes, interconnection delays, and lengthy approval schedules all increase financial and operational costs to renewable energy projects (Esmaeili et al., 2024).

Furthermore, despite the lower cost of renewable energy technology, many households continue to struggle with energy affordability. Low-income populations, especially those in rural areas, may suffer higher energy prices due to restricted access to competitive electricity markets, antiquated infrastructure, and reliance on inefficient energy sources (Martinez-Reyes et al., 2024). Certain places with deteriorating power infrastructure or limited competition in the energy market have higher electricity prices, making it difficult for consumers to purchase sustainable energy options (Brown et al., 2020). Therefore, while households with higher incomes can adopt other alternatives such as the installation of solar panels or participate in energy-efficient programs, lower-income earners and multi-family residents may sometimes lack the financial resources to invest in these solutions, compounding energy inequality.

The inadequacy of existing energy infrastructure is a major barrier to energy transition investment. The United States' power system was constructed primarily for centralized fossil fuel power plants, leaving it unprepared to handle the increasing influx of decentralized and intermittent renewable energy sources (Strielkowski et al., 2021). Investment is therefore required to expand transmission networks between renewable energy-rich regions and high-demand urban centres. Table 1 shows the possible causes and associated factors of the burden of high energy.

Table 1. Possible Causes of United States High Energy Burden

Causes	Specifics	References
Behavioural factors	Inadequate knowledge, misplaced incentives, lifestyle cultural influences, a lack of control over energy bills, and high non-monetary costs.	Brown & Sovacool 2018; Sovacool & Griffiths, 2020
Housing characteristics	Building characteristics (manufactured, multifamily, or single-family), rental and public housing and type of appliances utilized.	Brown et al., 2020; Drehobl et al., 2020
Location and geography	Climate, population density, Urban morphology (impacting job access and energy efficiency), rural, urban, native American, island territory.	Shoemaker et al., 2018; Chun et al., 2025
Energy pricing and policies	Energy costs and rate designs, energy mix and availability of natural gas, availability and efficacy of low-income energy programs and appliances.	Drehobl & Ross 2016; Brown et al., 2020
Socioeconomic situation	Income, ethnicity and race, immigrant or native born, number of inhabitants.	Jaske, 2016; Thorve et al., 2018; Hernández et al., 2016

III. OVERVIEW OF FINANCIAL MODELS FOR THE ENERGY SECTOR

According to Bulkot et al., (2024), significant financial investment is required in renewable energy infrastructure, system modernization, and energy storage options, for an effective transition to a sustainable energy future. As fossil fuel-based energy systems are phased out in favour of cleaner alternatives, financial models must evolve to accommodate new technology and corporate structures. The energy sector uses a variety of financial models, ranging from investment techniques to developing approaches designed to reduce risk investments and improve energy affordability (Qadir et al., 2021). Understanding these models is therefore critical for guaranteeing long-term funding flow into renewable energy projects while also addressing consumer, end-user and company affordability concerns. Previously, the energy sector has been funded by a combination of government subsidies, business investments, and debt financing. Some of the most often used financial strategies are presented in Table 2.

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Table 2. Financial Strategies in the Energy Sector

Strategy	Description	Opportunities	References
Government subsidies	Direct financial assistance from the government to reduce the cost of energy projects. Used for renewable energy projects, tax credits, and subsidies.	Renewable energy projects, tax credits, and grants.	Yang et al., 2019; Qadir et al., 2021
Debt financing	Borrowing money from banks or bond markets to support initiatives, with payback scheduled over time. Used for large-scale infrastructure projects such as power plants and transmission lines.	Large-scale infrastructure projects such as power plants and transmission lines.	Nechifor et al., 2022; Dixit, 2017
Investments	Energy projects are funded by private sector enterprises using their capital. Utility and energy companies fund large-scale solar, wind, and storage projects.	Utility and energy companies fund large-scale solar, wind, and storage projects.	Groobey et al., 2010; Ugwu et al., 2024
Carbon pricing and emission trading	Market-based method in which corporations pay to emit carbon or sell carbon credits.	Encourages investment in low-carbon technologies and carbon-capturing initiatives.	Raina et al., 2024; Trouwloon et al., 2023

A. Innovative Financial Models for Energy Transition

The energy transition from fossil fuels to renewables presents financial challenges and opportunities. Innovative financing models are crucial for increasing affordability and investment in domestic energy resources (Saleh & Hassan, 2024). These models optimize the flow of funds into sustainable energy projects, making them more affordable for consumers and investors. Each of these models provides distinct benefits regarding risk management, profitability, and scalability. The following are descriptions of some of the most innovative financial models utilized in the energy sector to enhance affordability and investment.

➢ *Revolving Funds*

Revolving funds are self-sustaining financing mechanisms used to fund ongoing energy efficiency and renewable energy projects. In contrast to typical grants or one-time financing options, a revolving fund reinvests repayments from prior projects into new ones, providing long-term sustainability and continued investment in energy transition initiatives. As described by Wasser et al., (2020), revolving funding operates as in the cycle (Figure 1).

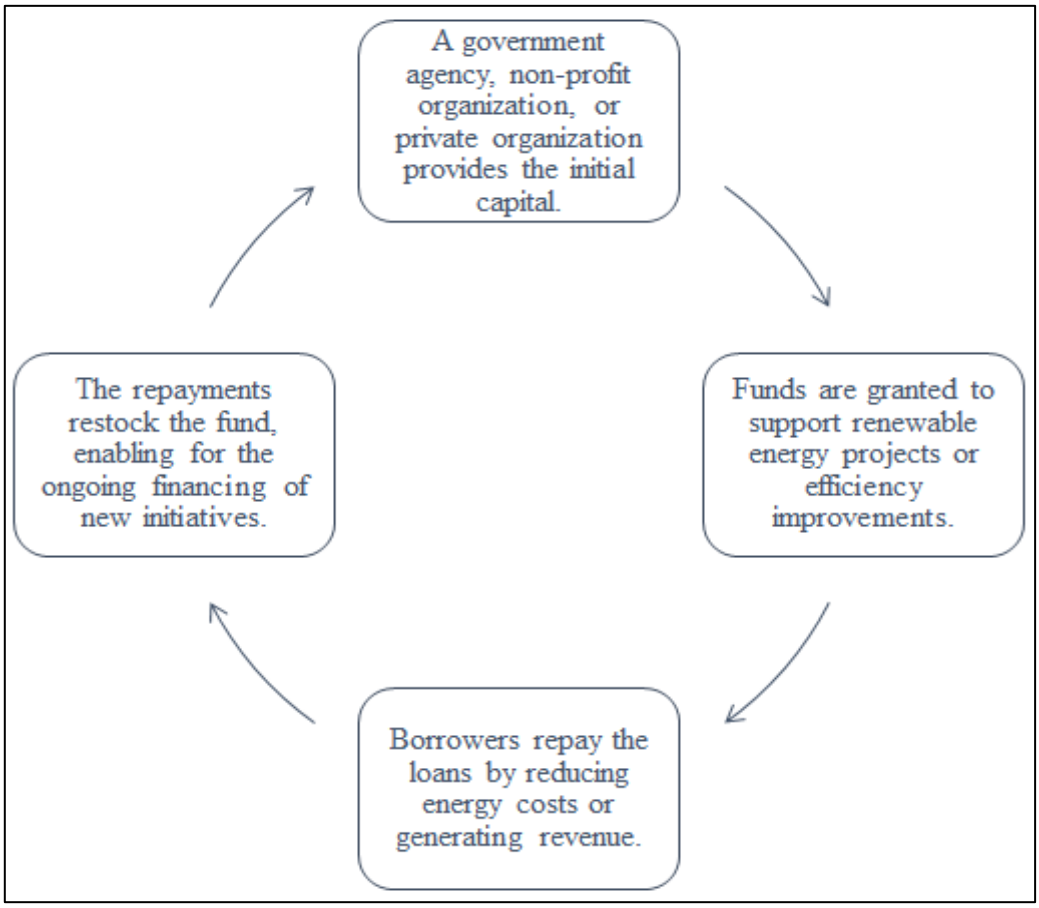

Fig 1. Cycle of Revolving Funds

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➢ *Energy Performance Contracting*

Energy Performance Contracting (EPC) is an innovative financing approach that enables energy efficiency improvements and renewable energy projects to be completed without needing an initial cash investment from property owners or organizations. Instead, an Energy Service Company (ESCO) takes on the full project, including design, execution, and maintenance, while ensuring cost savings that will be used to repay the investment over time (Guo & Zhang, 2020). This strategy recoups project expenses through future energy savings, making it an appealing alternative for commercial buildings, governments, schools, and hospitals without the financial wherewithal to make upfront investments (Liu et al., 2017). The main advantages of EPC include: immediate affordability, risk mitigation and scalability. EPC is a cost-effective method for organizations to implement energy efficiency measures without upfront costs. It can be used in various settings, but may face challenges like contract complexity and measurement issues.

➢ *Crowdfunding*

Crowdfunding is an emerging financial paradigm that allows individuals and corporations to donate small sums of money to support renewable energy initiatives (Katseli & Paraskevi Boufounou, 2020). Crowdfunding platforms facilitate investment using two major models: Equity crowdfunding, which allows investors to own shares in renewable energy projects, and earn returns based on project performance. Donation-Based crowdfunding in which advocates donate money to community-driven energy initiatives with no expectation of receiving a financial return (Menyeh & Acheampong, 2024).

The main benefits of crowdfunding include democratized investment that enables average citizens to invest in sustainable energy initiatives with limited capital, crowdfunding platforms offering a quick and scalable approach to raise capital for energy initiatives and increased public engagement promoting community involvement in the energy transition (Lam & Law, 2016).

➢ *Green Bonds*

Green bonds are fixed-income financial products issued to raise funds for renewable energy and climate-related initiatives. These bonds entice institutional and retail investors by providing returns while assuring that funds are directed towards renewable energy, energy efficiency, and sustainable infrastructure initiatives (Ning et al., 2022). Specifically, green bonds may be issued by national governments, municipalities, or private enterprises, with the proceeds distributed only for environmentally beneficial projects. Green bonds also appeal to institutional investors striving for sustainable investment portfolios due to their environmental and financial benefits. Green bonds offer lower capital costs, lower interest rates, and increased market confidence. They support large-scale renewable energy projects, but require standardized impact reporting to prevent greenwashing and ensure sustainability goals are truly achieved (Han & Yang, 2024).

IV. ROLE OF GOVERNMENT AND POLICY IN PROMOTING INNOVATIVE FINANCING

Government policies and regulatory frameworks must reinforce innovative financing mechanisms for sustainable energy production, encouraging private investment, technical innovation, and fostering a more equitable market. These strategies aim to reduce investment risks, eliminate financial obstacles, and speed the implementation of renewable energy technology, resulting in a more resilient and low-carbon energy industry.

A. Carbon Pricing and Taxation Policy

Carbon pricing systems, such as carbon taxes and cap-and-trade schemes, are effective policy tools for encouraging investments in clean energy by factoring the full environmental cost of carbon emissions into market transactions. These policies provide a substantial financial incentive for businesses and investors to migrate to renewable energy, energy efficiency improvements, and low-carbon technology by increasing the cost of fossil fuel-based energy sources (Tapia Granados & Spash, 2019).

Specifically, the carbon tax charges for each ton of CO_2 emitted encourages firms to use greener energy sources and increase energy efficiency to lower tax responsibilities. Market-based strategies reduce emissions and generate revenue for renewable energy projects and low-income programs (Pan et al., 2024). Hence, carbon dividend schemes balance higher energy prices, encouraging investment in grid modernization, energy storage solutions, and sustainable financing models like green bonds and crowdfunding.

B. Incentives and Subsidies

Government incentives and subsidies help to reduce the financial burden of renewable energy projects, making them more appealing to investors, businesses, and consumers (Yang et al., 2024). These financing solutions reduce the upfront capital expenditures of clean energy infrastructure, ensuring that projects are cost competitive with traditional fossil fuels. The Investment Tax Credit (ITC) and Production Tax Credit (PTC) are significant federal incentives for renewable energy technologies, driving growth in residential and commercial markets (Dwivedi, 2018).

V. CONCLUSION

The shift to a sustainable and affordable energy system in the United States necessitates a new way to finance domestic energy resources. Existing financial mechanisms have played an important role in financing energy infrastructure, but they frequently fall short of addressing critical constraints such as high upfront capital costs, limited access for low-income populations, and investor uncertainty. However, innovative financial models provide viable alternatives for increasing investment while maintaining affordability and inclusivity in the energy industry.

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The research revealed a single financial model may not be capable of solely handling all of the issues surrounding energy affordability and investment. Instead, a multifaceted approach that combines public, private, and community-driven funding structures is required to speed the deployment of sustainable energy technologies. To foster long-term investment, government policies, regulatory frameworks, and market incentives must all operate in tandem with these innovative financial tools. Furthermore, promoting public-private partnerships and encouraging decentralized energy ownership via cooperative and community-based finance may potentially democratize the energy transformation process. Therefore, while these financial models provide considerable benefits, difficulties such as regulatory constraints, risk perception, and financial literacy gaps must be addressed in order to maximize their impact. Scaling these processes will require more financial transparency, investor confidence, and the development of standardized reporting frameworks. Furthermore, incorporating digital technologies, such as blockchain for smart contracts and AI-driven risk assessment, may improve the efficiency and dependability of energy financing models.

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