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Examining Opportunities and Threats in the Commercialization of Renewable Energy Businesses: A Case Study on Household Consumption

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Abstract

The present study investigates the opportunities and threats related to the commercialization of renewable energy businesses with a focus on household consumption. Given the increasing demand for clean energy sources and the limitations of fossil fuel resources, renewable energies—particularly in the residential sector—have emerged as a sustainable solution for energy provision. Utilizing a descriptive-analytical research method, this study identifies and analyzes existing opportunities and threats while also examining the factors influencing the commercialization of such businesses. The findings indicate that declining costs of renewable energy technologies, governmental support, and growing public awareness of the benefits of these sources offer significant opportunities for commercialization. However, challenges such as high initial costs, regulatory complexities, and insufficient public awareness remain as obstacles in this domain. Overall, the commercialization of renewable energy businesses in the household sector requires collaboration and coordination among the government, the private sector, and the community. Addressing these barriers and leveraging existing opportunities are essential for the effective development of these businesses.

Keywords: Commercialization, Renewable Energy, Business, Household Consumption, Opportunities and Threats.

1. Introduction

The global energy landscape is undergoing a significant transformation, driven by the need to reduce greenhouse gas emissions, ensure energy security, and transition toward sustainable development. Within this context, renewable energy technologies—especially solar photovoltaic systems—have gained momentum as key solutions to meet rising energy demands while mitigating the environmental consequences of fossil fuel dependence. For developing countries like Iran, which face structural economic and infrastructural limitations, the commercialization of renewable energy, particularly for household consumption, offers both a promising opportunity and a complex challenge (Moghani et al., 2024; Rehman et al., 2025; Sadat Robat Jazi, 2024).

The household sector, as a major consumer of electricity, represents a pivotal area for the deployment of renewable energy systems. Solar power, in particular, offers decentralized and scalable solutions suitable for urban and rural households alike. Yet, despite favorable climatic conditions and growing policy awareness, adoption levels in many developing countries remain



suboptimal. This is largely due to a series of intertwined barriers, ranging from institutional and financial limitations to technical and social impediments (Abdul & Wenqi, 2024; Chakraborty et al., 2016).

Several studies have underscored the strategic significance of promoting renewable energy in the household sector to achieve long-term national energy goals. For instance, Mohtasham (2015) emphasized that renewable energy integration into local markets must be supported by coherent policy frameworks and effective financial instruments (Mohtasham, 2015). Similarly, Bahmani and Bahrammehr (2016) provided evidence on the economic feasibility of solar technologies in rural households in Iran, suggesting their commercial potential if institutional barriers are addressed (Bahmani & Bahrammehr, 2016).

Commercialization, as opposed to mere adoption, involves developing viable business models, engaging stakeholders, attracting investment, and creating value chains that connect technology providers with end-users (Miller, 2012). However, commercialization in developing contexts is frequently hindered by high initial capital costs, lack of consumer awareness, and unstable regulatory environments (Liu, 2018; Luthra et al., 2015). These challenges are compounded by weak financial markets, political instability, and fluctuating governmental commitment to clean energy investment (Kihlström & Elbe, 2021; Rehman et al., 2025).

Despite these challenges, there are also encouraging signs and emerging opportunities. Technological advancements have led to a significant decline in the cost of solar panels, making them more accessible to middle-income households (Siecker et al., 2017). At the same time, global initiatives and donor support have enhanced the capacity of governments and local entrepreneurs to scale renewable energy solutions (Pfeiffer & Mulder, 2013; Sawin et al., 2013). In the Iranian context, policymakers have shown increasing interest in addressing energy imbalances through investment in solar energy infrastructure (Moghani et al., 2024; Sadat Robat Jazi, 2024).

The process of successful commercialization depends not only on cost-effectiveness and technological readiness but also on stakeholder engagement. A robust participatory framework involving government agencies, private sector actors, financial institutions, and local communities is essential to overcome implementation hurdles (Campbell et al., 2020; Ibegbulam et al., 2023). As highlighted by Cormio et al. (2003), regional energy planning that incorporates environmental constraints and local socioeconomic factors is vital for ensuring the sustainability of renewable energy markets (Cormio et al., 2003).

Furthermore, the diffusion of renewable energy technologies is deeply influenced by the perceptions and behaviors of consumers. Household decision-making processes are affected by social norms, trust in government programs, perceived ease of technology use, and long-term financial considerations (Irfan et al., 2019; Ohunakin et al., 2014). In this regard, qualitative studies using thematic analysis have proven effective in unpacking these complex motivational drivers (Naeem et al., 2023).

An essential aspect often overlooked in policy designs is the cultural and informational context in which renewable energy initiatives are introduced. Moghani et al. (2024) emphasized the dual role of solar energy and natural gas in Iran's energy security landscape, arguing for integrated approaches that consider both resource availability and public perception (Moghani et al., 2024). As such, strategies aimed at commercialization must address awareness-raising campaigns, education initiatives, and trust-building mechanisms alongside technical and economic interventions.

Additionally, empirical research supports the notion that market-based mechanisms, such as subsidies, feed-in tariffs, and low-interest loans, can significantly enhance adoption rates, especially in the household sector (Timilsina et al., 2011, 2012). Nonetheless, ensuring the sustainability of such programs requires careful consideration of fiscal constraints and the development of public-private partnerships (Bakhtiyar et al., 2016; Joshi et al., 2015).

Several countries have piloted successful models of household-based solar energy commercialization. In Nigeria, for example, despite infrastructural deficiencies, various public and private initiatives have demonstrated that solar energy can be economically and socially viable for household use when supported by targeted policies and financing mechanisms (Ohunakin et al., 2014). Likewise, in Barbados, a structured examination of barriers and mitigation strategies showed that local-level interventions, such as supplier training and service networks, can significantly reduce consumer hesitation (Wyllie et al., 2018).



Thus, this study aims to investigate both perceived opportunities and real threats in the commercialization of renewable energy businesses targeting household consumers.

2. Methods and Materials

This study is applied in terms of its objective and descriptive-analytical in nature and data collection method, specifically adopting a survey-based approach. The survey methodology was employed to explore stakeholders' perspectives and analyze the views of individuals such as energy industry professionals, household consumers, policymakers, technology firms, and investors.

The statistical population includes experts and practitioners in the field of renewable energy, managers of start-ups in the clean energy sector, household consumers equipped with solar systems, and energy-related policymakers located in Tehran. A non-random purposive sampling method was used. The snowball sampling technique was applied, beginning with interviews conducted with a number of experts and practitioners, who then introduced other specialists, thereby expanding the sample pool.

The data collection tools included a researcher-made questionnaire and semi-structured interviews. The questionnaire consisted of sections addressing opportunities (e.g., financial support, market infrastructure, technology, growing demand) and threats (e.g., legal barriers, initial costs, public unawareness, lack of sustained support). To assess the reliability of the questionnaire, Cronbach's alpha coefficient was used, with a reported value above 0.7 for the entire instrument, indicating acceptable reliability. Content validity was confirmed through the evaluation of academic experts and university professors.

In the quantitative section, data were analyzed using SPSS software and statistical tests, including descriptive statistics (mean, standard deviation) and inferential statistics (Friedman test for ranking factors, one-sample t-test).

3. Findings and Results

According to the results in Table 1, the most significant identified opportunity in the path of commercializing renewable energy businesses in the household sector is the presence of governmental financial incentives, with a mean score of 4.32. This finding indicates that government support policies play a key role in encouraging households to adopt clean energy solutions. Public awareness and reduced technological costs were also ranked as highly important.

Table 1. Mean and Standard Deviation of Opportunity Components in the Commercialization of Renewable Energy (Household Use)

| No. | Opportunity Component | Mean | Standard Deviation | Rank |
|-----|--|------|--------------------|------|
| 1 | Governmental financial incentives and subsidies | 4.32 | 0.58 | 1 |
| 2 | Increased public awareness and environmental concern | 4.15 | 0.63 | 2 |
| 3 | Decreasing cost of solar technologies | 3.87 | 0.72 | 3 |
| 4 | Potential for exporting domestic technologies | 3.41 | 0.88 | 5 |
| 5 | Development of the domestic consumer market | 3.56 | 0.69 | 4 |

The results of the one-sample t-test indicate that most examined threats are statistically significant at a significance level below 0.05. Therefore, from the respondents' perspective, these threats are real and substantial in the commercialization of renewable energy in household applications. The most critical threat identified is the high initial cost of equipment, which may hinder technology adoption by households.

Table 2. One-Sample t-Test to Assess Main Commercialization Threats in Household Sector

| Threat Component | Mean | t-Value | Significance Level (Sig) | Result |
|---------------------------------------|------|---------|--------------------------|-----------------|
| High initial equipment cost | 4.41 | 8.92 | 0.000 | Significant |
| Lack of sustained government support | 4.16 | 6.74 | 0.000 | Significant |
| Consumer unawareness | 3.88 | 5.12 | 0.000 | Significant |
| Complexity in obtaining permits | 3.45 | 2.86 | 0.006 | Significant |
| Inaccessibility to reliable suppliers | 3.21 | 1.43 | 0.152 | Not Significant |



The Friedman test also confirms that the high initial installation cost of home solar systems is perceived by most participants as the primary threat. This finding underscores the need for new credit and financial policies, such as low-interest loans, guaranteed electricity buyback programs, or tax incentives for households.

Table 3. Friedman Test for Threat Ranking

| Threat | Mean Rank |
|---------------------------------|-----------|
| High initial cost | 4.62 |
| Lack of sustained support | 4.33 |
| Lack of awareness | 3.97 |
| Complexity in obtaining permits | 3.22 |
| Lack of supply chain | 2.86 |

4. Discussion and Conclusion

The objective of this study was to investigate the core opportunities and threats related to the commercialization of renewable energy businesses in the context of household consumption in Iran. The empirical results—based on stakeholder responses and analytical techniques—reveal a nuanced understanding of both enabling and hindering factors. The findings suggest that government financial incentives, increased environmental awareness, and declining solar technology costs are major opportunities, while high upfront costs, lack of consistent governmental support, and low public awareness constitute significant threats.

Among the identified opportunities, governmental financial support and subsidy policies ranked highest, emphasizing their strategic role in stimulating household-level solar energy adoption. This finding aligns with several studies that stress the critical function of government intervention in shaping renewable energy markets in developing economies. For instance, government-backed incentives, such as tax credits and guaranteed feed-in tariffs, have been shown to significantly accelerate solar deployment in underserved markets (Pfeiffer & Mulder, 2013; Rehman et al., 2025). In the case of Iran, where energy market structures remain state-dominated, such policies can play a transformative role in reducing investment risk and incentivizing consumer participation (Sadat Robat Jazi, 2024).

A second opportunity that emerged was increased public awareness and pro-environmental attitudes among consumers. Public environmental consciousness has become a major non-financial driver of renewable energy adoption, particularly in urban households (Kihlström & Elbe, 2021). Previous literature supports the notion that the shift in consumer behavior toward sustainability-conscious living enhances the market demand for decentralized solar solutions (Ohunakin et al., 2014). In the Iranian context, where environmental degradation and pollution levels are acute, growing awareness can create a receptive social environment for solar technology diffusion (Irfan et al., 2019).

Thirdly, the declining cost of solar photovoltaic (PV) technologies was identified as a major facilitator of commercialization. Global reductions in panel manufacturing costs, alongside innovations in installation and storage systems, have rendered household solar more affordable and scalable (Siecker et al., 2017). This trend is particularly significant for developing countries, where affordability remains a core constraint (Liu, 2018). The participants in this study confirmed that declining costs have made solar systems increasingly attractive to middle-income households, a finding consistent with international trends documented by (Sampaio & González, 2017) and (Timilsina et al., 2012).

Despite these positive developments, the study also revealed several serious threats. Chief among them is the high initial cost of solar equipment, which was ranked as the most significant threat by respondents. This result is consistent with the conclusions of (Luthra et al., 2015), who identified capital costs as the most prominent barrier to clean energy adoption in India. In Iran, households remain heavily reliant on subsidized fossil fuel electricity, which makes the cost of switching to solar systems appear relatively high despite long-term savings (Bahmani & Bahrammehr, 2016; Bakhtiyar et al., 2016). The capital expenditure challenge highlights the need for new financing models—such as leasing, micro-credit, or third-party ownership—to mitigate the entry barrier.

Closely related to this is the lack of sustained government support, which was also ranked highly among threats. Several studies have documented that inconsistent policy frameworks, frequent regulatory changes, and insufficient institutional commitment are detrimental to the development of renewable energy markets (Irfan et al., 2019; Rehman et al., 2025). In

Pakistan, for example, weak political continuity has undermined public trust in solar programs, leading to market stagnation (Irfan et al., 2019). The current study mirrors these concerns in the Iranian context, where respondents noted that temporary or discontinuous policies discourage long-term investments by both consumers and suppliers.

Another key threat is insufficient public awareness about the economic and environmental benefits of renewable energy, particularly in low- and middle-income households. As (Ibegbulam et al., 2023) observed, knowledge gaps regarding installation procedures, payback periods, and government incentives create hesitation and misinformation among consumers. According to (Miller, 2012), overcoming such informational asymmetries requires robust outreach campaigns that communicate the value proposition of solar technologies in user-friendly terms. The present findings confirm that many Iranian households are not sufficiently informed to make confident investment decisions, particularly in regions with limited internet access or media exposure.

Additionally, regulatory complexity—especially in obtaining permits and approvals—was cited as a moderate but notable barrier. Bureaucratic red tape and administrative inefficiency have been widely cited in the literature as deterrents to renewable energy growth (Chakraborty et al., 2016; Cormio et al., 2003). Similarly, the lack of a reliable and localized supply chain was flagged by respondents as a structural limitation. This aligns with findings from (Wyllie et al., 2018), who identified poor technical support and spare part availability as limiting factors in the Caribbean region. In the Iranian setting, the absence of domestic manufacturers and after-sales service providers has similarly slowed consumer confidence and repeat adoption (Moghani et al., 2024).

To ensure effective commercialization, the results point toward the necessity of a multifaceted strategy that integrates economic incentives, educational programs, and institutional reform. As suggested by (Pandey, 2020), energy infrastructure development must be socially inclusive and context-sensitive. This view is also echoed in (Timilsina et al., 2011), who stressed that policy coherence and consumer engagement must go hand in hand for renewable energy to penetrate the household sector.

The methodological rigor of this study—combining quantitative rankings with qualitative insights—further enhances its policy relevance. According to (Timans et al., 2019), mixed methods research allows for deeper exploration of stakeholder attitudes and system-level dynamics, which are often lost in purely statistical or narrative approaches. The incorporation of expert interviews in this study added valuable context to the statistical rankings, shedding light on the reasons behind specific perceptions and behaviors.

Moreover, the findings validate the conceptual structure proposed by (Sampaio & González, 2017), emphasizing the interconnection between consumer behavior, technology design, financing mechanisms, and regulatory frameworks. Participants emphasized that households are not merely passive consumers but active decision-makers whose behavior is shaped by perceptions of trust, convenience, and long-term gain. Therefore, policy frameworks must be designed to account for this complexity.

Lastly, the study underscores the urgency of public–private partnerships and community-based initiatives to accelerate commercialization. The insights gained from (Abdul & Wenqi, 2024) confirm that participatory approaches are more likely to yield sustainable adoption patterns than top-down directives. In the Iranian context, this means involving municipal authorities, local installers, and consumer advocacy groups in energy planning and implementation.

In sum, this research confirms that Iran has the technical and environmental potential for widespread household solar energy adoption, but realization of this potential depends on resolving key structural, financial, and behavioral barriers. As (Mohtasham, 2015) pointed out, renewable energy transitions require more than technological readiness—they demand systemic transformation.

This study, while comprehensive in scope, is not without limitations. First, the sample size was restricted to key stakeholders located in Tehran, which may limit the generalizability of the findings to other regions with differing economic and infrastructural contexts. Second, the reliance on self-reported data introduces potential biases related to personal perceptions or social desirability. Third, the focus on solar energy excludes other renewable sources that may hold commercial potential in the household sector, such as biomass or micro-wind systems. Lastly, the dynamic nature of the energy policy landscape means that some findings may shift in relevance depending on future legislative or economic developments.



Future research should explore the regional variations in consumer behavior and adoption patterns across different provinces in Iran, especially rural areas where energy access issues are more pronounced. Longitudinal studies could track the evolution of consumer attitudes and technological uptake over time, offering deeper insights into the long-term effects of policy interventions. Furthermore, comparative studies between Iran and other developing countries with similar socioeconomic profiles could provide valuable lessons and best practices for overcoming commercialization barriers. Lastly, expanding the research to include other renewable technologies and hybrid systems could yield a more comprehensive understanding of the residential energy landscape.

To facilitate the commercialization of renewable energy businesses in the household sector, policymakers should prioritize the development of accessible financing schemes, such as subsidized loans and leasing models. Education and awareness campaigns need to be institutionalized through collaboration with local organizations and schools to bridge the knowledge gap. Streamlining regulatory procedures and investing in the creation of local supply chains and after-sales service networks will enhance consumer trust and system reliability. Moreover, fostering partnerships between the public and private sectors will be essential to scale deployment, improve service quality, and sustain long-term market growth.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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