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REVIEW ARTICLE

Understanding the influence of metaverse-driven virtual reality on consumer buying behavior in the solar energy sector: A theoretical perspective

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Abstract: The integration of Virtual Reality (VR) and the Metaverse is reshaping consumer engagement and marketing dynamics within the solar energy sector. As immersive technologies redefine digital interaction, they offer innovative avenues for consumer education, emotional engagement, and trust-building in sustainable energy solutions. VR allows potential customers to explore solar products through interactive environments, enhancing understanding and confidence. Through tools such as AI-driven simulations, virtual showrooms, and gamified learning experiences, solar companies can simplify complex technical information and support informed decision-making. Moreover, blockchain-enabled transactions and peer influence in virtual communities further shape consumer buying behaviour, making the metaverse a strategic frontier for solar marketing. Drawing on consumer behaviour models and psychological frameworks, this study presents a theoretical examination of how immersive technologies influence attitudes, behaviour, and decision-making in the solar context. While the opportunities are substantial, the study also recognizes challenges such as high implementation costs, technical constraints, and privacy concerns that currently hinder widespread adoption. Addressing these barriers through innovation, strategic planning, and policy support can accelerate the integration of VR in renewable energy marketing. The findings contribute to a deeper theoretical understanding of how metaverse-driven tools can transform consumer engagement, foster behavioural change, and support the broader transition to a sustainable digital economy.

Keywords: *Consumer behavior, Virtual reality, AI-powered simulations, Metaverse, Decision-making, Renewable energy, Technological barriers*

Introduction

The evolution of digital technologies has significantly transformed consumer behavior and marketing strategies across industries. One of the most groundbreaking advancements in recent years is the metaverse, a virtual space where physical and digital realities converge (Dwivedi et al., 2022). Initially conceptualized in science fiction, the metaverse has become a tangible reality through developments in Virtual Reality (VR), Augmented Reality (AR), and blockchain technology (Mystakidis, 2022). These innovations have influenced various industries, including renewable energy, by offering new ways to engage customers and streamline decision-making (Bourlakis et al., 2023). In the solar industry, where consumer awareness and trust are crucial, metaverse-enabled marketing is emerging as a powerful tool to bridge knowledge gaps, personalize experiences, and facilitate sustainable energy adoption (Gupta et al., 2023) By leveraging VR simulations,

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AI-driven customization, and blockchain transactions, solar companies can create seamless customer journeys that simplify complex information (Lee et al., 2022). As the demand for renewable energy grows, integrating these digital tools can help businesses enhance consumer confidence and accelerate the transition to clean energy. To understand how digital tools influence purchasing decisions, it is important to study consumer behavior. This behavior is driven by marketing elements such as product, price, promotion, and place, along with external factors like economic, political, technological, and cultural conditions (Kotler & Keller, 2016). These influences enter the consumer's "black box," which includes their beliefs, values, attitudes, and decision-making process. The final purchase decision is shaped by internal thought processes influenced by both marketing strategies and environmental forces (Solomon, 2018). This paper explores the evolution of VR, consumer buying behavior in the solar energy market, the impact of metaverse-driven marketing, psychological aspects of VR-based solar promotion, and the challenges and opportunities in leveraging these technologies for industry growth.

Statement of Problem

The rapid integration of immersive technologies such as Virtual Reality (VR) and the Metaverse into marketing strategies presents both opportunities and challenges within the solar energy sector. Despite their potential, the extent to which these technologies influence consumer perceptions and buying behavior remains insufficiently explored. Traditional marketing methods often fail to convey the technical and environmental benefits of solar products effectively, leading to consumer hesitation and low adoption rates. Given the growing relevance of digital engagement, it is essential to examine how metaverse-driven experiences can enhance trust, emotional involvement, and informed decision-making. This study aims to address this theoretical gap by investigating of immersive tools on consumer behavior in the context of solar energy.

Objective of the Study

This study aims to explore the theoretical evolution of Virtual Reality (VR) and the Metaverse, evaluating their potential to transform consumer experiences within the solar energy sector. By using the Stimulus-Organism-Response (S-O-R) model, it examines the consumer buying behavior specifically in the context of solar energy. Additionally, the study investigates how immersive virtual environments influence psychological and behavioral factors, shaping consumer perceptions, attitudes, and decision-making in relation to solar energy products and services.

Significance of the Study

This research is significant in revealing how emerging immersive technologies like VR and the metaverse are not just transforming consumer experiences but also playing a pivotal role in accelerating sustainable energy transitions. The study employs the Stimuli and Response model to explore how digital marketing elements influence consumer attitudes and purchasing decisions within the solar energy sector. By illustrating the interplay between digital innovation and renewable energy marketing, the study offers practical information for marketers, policymakers, and industry leaders to craft more effective, tech-driven consumer strategies in the solar sector. The findings provide a foundation for future research and innovation in integrating metaverse technologies with green energy initiatives.

Evolution of Virtual Reality - The Metaverse

The metaverse is a virtual space where digital and physical realities come together, allowing people to interact in immersive online environments (Mystakidis, 2022). Although the idea has existed for decades, it became widely known in the late 20th and early 21st centuries through science fiction books and media. The term "metaverse" was first used by Neal Stephenson in his 1992 novel Snow Crash, where he described a virtual world where users could connect and interact in real time (Stephenson, 1992). While the concept began in fiction, real technological progress started in the 1980s and 1990s with early virtual reality (VR) systems, which used headsets and gloves to create computer-generated experiences (Lee et al.,2021). Initially developed for military training, these early VR technologies inspired further advancements, leading to more

sophisticated virtual and augmented reality (AR) tools (Mutterlein, 2018). By the 2010s, innovations like the Oculus Rift, HTC Vive, HoloLens, and Pokémon Go made virtual experiences more immersive and interactive, allowing users to either enter a fully digital world or see digital elements overlaid onto the real world (Rauschnable et al., 2022). This evolution has transformed the metaverse into a space for gaming, education, training, and social interaction, while blockchain technology has enabled virtual economies where users can buy, sell, and trade digital assets (Dwivedi et al., 2022). As new technologies like 5G and edge computing continue to develop, the metaverse will likely become even more realistic and integrated into everyday life (Zhang et al., 2022). However, this shift also brings challenges, such as unequal access to technology, changes in social interactions, and legal and ethical concerns related to data privacy, virtual crimes, and ownership of digital assets (Kye et al., 2021). To ensure that the metaverse benefits society, policymakers and industry leaders must address these issues and create a secure, fair, and inclusive digital world.

Consumer Buying Behavior in the Solar Energy Sector

The decision to buy solar energy products depends on several factors, including cost, technology, social influence, and consumer awareness (Jaiswal et al., 2021; Yadav& Pathak,2021). The high initial cost of solar panels is a major concern, but incentives, tax benefits, and financing options help make them more affordable. Financial support like subsidies and net metering policies encourages more households to adopt solar energy (Kumar et al., 2022). Environmental awareness also plays a key role, as people who prioritize sustainability are more likely to invest in solar power (Kesari et al., 2021). Advancements in technology have improved the efficiency and reliability of solar panels, making them more attractive to consumers. Better photovoltaic cells and battery storage systems have increased interest in solar energy. Social influence is another important factor, as people are more likely to switch to solar energy when they see their neighbors using it. Government policies significantly impact adoption, with strong incentives like feed-in tariffs and tax credits leading to higher usage (Sahu, 2021). However, some consumers remain hesitant due to perceived risks around system reliability, installation complexity and long-term maintenance. Recent studies suggest that immersive VR demonstrations and personalized simulations can reduce these concerns by enhancing transparency and building consumer confidence (Gupta et al., 2023) Additionally, a lack of awareness about the benefits and functioning of solar energy remains a challenge. Virtual reality (VR) is now being used to educate consumers through interactive and immersive experiences, making solar energy more accessible and understandable (Gupta et al., 2023).

Stimulus-Response Model

Consumer buying behavior is based on stimuli coming from a variety of sources from marketers in terms of the 4Ps (Product, Price, Promotion and Place) as well as from environmental stimuli, such as economic factors, legal/political factors and technological and cultural factors (Kotler & Keller, 2016). These stimuli go into "black box" which consists of two parts: buyer characteristics such as beliefs and attitude, motives, perceptions and values and the buyer decision-making process, which is covered later in the chapter. Response is the outcome of the thinking that place in that black box. What will buy, where, when, how often, and how much and how often- is the result of internal processing influenced by both marketing and external environmental factors (Solomon, 2018).

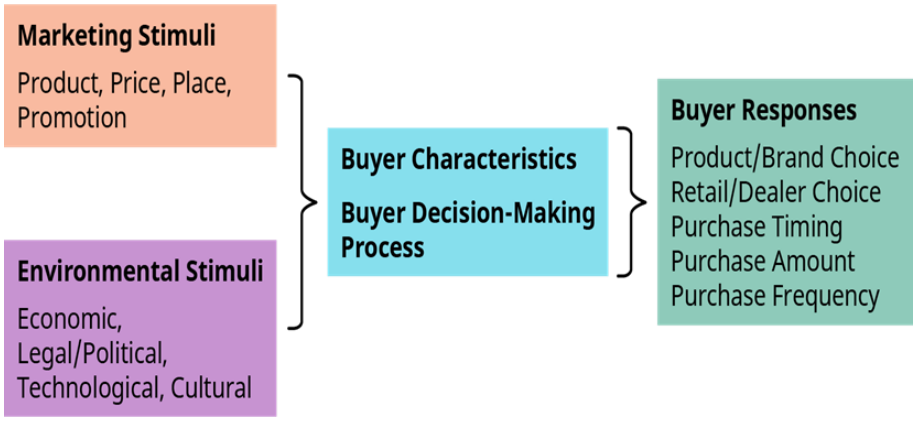

Figure 1: Stimulus-Response Model

(Source: Stimulus-Response Model/Buyer's Black Box (attribution: Copyright Rice University, OpenStax, under CC BY 4.0 license)

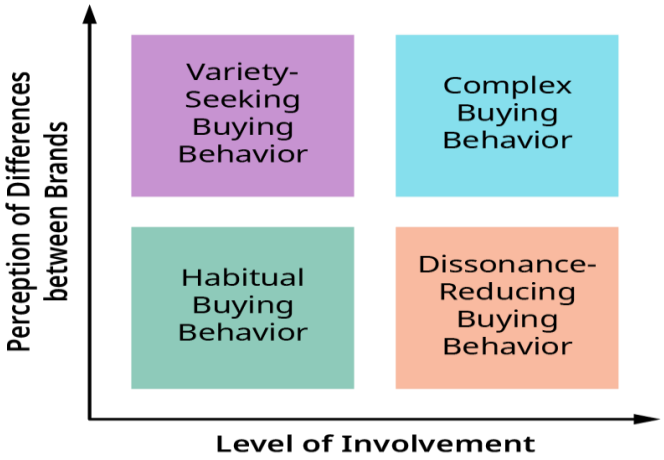

Figure 2: Level of involvement in analysis of consumer buying behavior

(Source: Types of Consumer Buying Behavior (attribution: Copyright Rice University, OpenStax, under CC BY 4.0 license)

Types of Consumers Buying Behavior

There are four types of consumers buying behavior. Variety-Seeking Buying Behavior where consumers perceive only minor differences between brands but still switch for the sake of variety, not dissatisfaction. For example, a consumer exploring different VR-based solar product demos not because one is better, but to experience the novelty each brand offers. (Schiffman et al. 2020). The next is Complex Buying Behavior which occurs when the purchase involves high involvement and significant perceived brand differences. Example is choosing a residential solar energy system using a metaverse simulation involves research, comparison, and high engagement due to cost and technical complexity (Kotler & Keller 2016). Additionally, Habitual Buying Behavior takes place when consumers have low involvement and see little difference between brands purchases become routine. For example, when customers repeatedly choose the same solar company's app for bill tracking without exploring alternatives due to habit, not preference (Solomon 2018). There is Dissonance-Reducing Buying Behavior also where consumers are highly involved in the purchase but see few differences between brands, leading to post-purchase doubts. For example: A customer selects a solar product via VR tour but later worries if they chose the right brand due to similar offers in the market (Schiffman et al.2020).

Kotler and Keller (2016) state that complex buying decisions arise when products are expensive, infrequent, and self-expressive—like solar installations. Schiffman et al. (2020) explain that in low-involvement scenarios with multiple perceived options, consumers tend to switch brands for variety. Schiffman et al. (2020) explain that marketers can reduce dissonance through reassurance, follow-ups, and customer

support. Solomon (2018) notes that habitual behavior is common for low-risk, routine decisions where brand perception is minimal.

Psychological and Behavioral Effects of Immersive Experiences on Consumer Attitudes Solar Energy

Immersive experiences enabled by Virtual Reality (VR) are reshaping consumer attitudes toward solar energy by enhancing emotional engagement and understanding. Through lifelike simulations, consumers can visualize solar panels on their rooftops or interact within virtual communities, making complex technology easier to grasp (Gupta et al., 2023). This psychological immersion builds trust, reduces concerns about cost and complexity, and boosts confidence in adopting solar solutions (Chhaniwal et al., 2025). From a behavioral standpoint, VR influences both emotional and rational decision-making. Personalized experiences like real-time energy savings or visualizing home installations make solar products more appealing (Asghar, 2024). Additionally, seeing others adopt solar energy in virtual settings fosters social influence and strengthens buying intent (Bhattacharya & Bansal, 2024). These immersive tools also enhance memory, involvement, and satisfaction, leading to stronger purchase decisions (Schiffman et al., 2020).

Key Findings

The study reveals that Virtual Reality (VR) and metaverse environments significantly enhance consumer engagement by providing interactive and emotionally immersive experiences that build trust and confidence in solar energy solutions. These technologies simplify complex technical information through AI-driven simulations and virtual showrooms, enabling consumers to visualize solar installations and make more informed decisions. Moreover, personalized and gamified VR experiences strengthen psychological influence by fostering emotional connections, improving information retention, and increasing user involvement in the buying process. Despite these benefits, the widespread adoption of VR in solar marketing faces notable barriers, including high implementation costs, technical limitations, and concerns over data privacy. However, future opportunities are promising, as the metaverse can further support solar energy adoption through decentralized blockchain transactions, virtual training modules, and immersive educational platforms tailored to enhance consumer understanding and decision-making.

Conclusion

The study underscores the transformative potential of Virtual Reality (VR) and Metaverse-driven environments in enhancing consumer engagement within the solar energy sector. These technologies offer interactive and emotionally immersive experiences that help demystify complex solar solutions, build trust, and facilitate more informed decision-making. Features such as AI-powered simulations, virtual showrooms, and gamified content not only simplify technical details but also strengthen psychological influence by increasing user involvement and emotional connection throughout the buying journey. Furthermore, emerging innovations such as blockchain-enabled transactions and immersive educational modules present promising opportunities to further streamline solar adoption.

Despite these theoretical advancements, several limitations must be acknowledged. This study is limited to a theoretical exploration of Virtual Reality (VR) and the Metaverse within the solar energy sector only, which may restrict the generalizability of its insights to other industries or energy sectors. Secondly, the research considered a conceptual approach without any empirical analysis to support its claims. This indicates that the findings were not supported by data-driven validation. In addition, the study addressed the psychological and behavioral aspects of customers but did not extensively focus on related disciplines like neuroscience, environmental psychology, or human-computer interaction, which could provide a deeper understanding of consumer responses to immersive technologies. Given these limitations, future research should focus on empirical validation of the proposed theoretical constructs by conducting qualitative or quantitative studies to measure actual consumer responses to VR and Metaverse experiences in solar marketing. Comparative studies across different renewable energy sectors could also reveal how these technologies perform in varied contexts. Additionally, integrating insights from interdisciplinary fields

can help create a more comprehensive framework for understanding the cognitive, emotional, and behavioural impact of immersive technologies on consumer decision-making. By bridging theoretical insights with empirical research and expanding the disciplinary scope, future studies can play a critical role in guiding the effective integration of Metaverse-driven VR in promoting clean energy adoption and enhancing consumer engagement at scale.

Future Trends and Opportunities in Metaverse-Enabled Solar Sector

The metaverse is transforming solar marketing by creating interactive, immersive experiences that make it easier for consumers to learn about and adopt solar energy. Virtual showrooms allow customers to explore solar panels and energy systems in a 3D environment, making complex information more accessible. AI-powered simulations help homeowners visualize solar installations and estimate energy savings in real-time. Gamification adds an engaging element, encouraging users to learn about solar power through interactive challenges and rewards. Blockchain technology enables decentralized solar energy trading, making renewable energy transactions more transparent and efficient. Virtual conferences and training programs further expand access to solar knowledge, reducing costs and increasing participation. As these technologies evolve, solar companies leveraging the metaverse will enhance customer engagement, streamline decision-making, and drive faster adoption of sustainable energy solutions.

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