Inspira-Journal of Commerce, Economics & Computer Science (JCECS)
(A National bi-lingual Quarterly Double Blind Open Access Peer Reviewed Refereed Journal)
ISSN : 2395-7069(Print), Impact Factor: (Cosmos 7.650 & I2OR 5.120), Volume 12, No. 03, July-September, 2026, pp. 70-82

Transition Towards Solar Energy Prosumerism: A TCCM-Based Review

Ashika M. Hussain[1*] & Dr. Prasanth S. Pai[2*]

[1]Research Scholar, P.G. & Research Department of Commerce, Sanatana Dharma College, Alappuzha, University of Kerala, Kerala, India.
[2]Assistant Professor, P.G. & Research Department of Commerce, Sanatana Dharma College, Alappuzha, University of Kerala, Kerala, India.

[*]Corresponding Author: ashikamh.research@sdcollege.in

Citation: *Hussain, A. & Pai, P. (2026). Transition Towards Solar Energy Prosumerism: A TCCM-Based Review. Journal of Commerce, Economics & Computer Science, 12(03), 70–82. https://doi.org/10.62823/jcecs/12.03.9274*

Abstract

This study provides a systematic literature review on solar energy prosumerism in the sustainable development context using the TCCM framework. The paper reveals recent trends in the prosumer research landscape and identifies research gaps that constrain the behavioural understanding of the household transition from passive energy consumer to active energy prosumer. This paper used the Theory, Context, Characteristics and Methodology (TCCM) framework for theory development and to identify gaps in existing research and future research directions. A total of 38 articles were used in the paper for the TCCM review. Articles were identified and screened following the PRISMA 2020 protocol using the Scopus and Web of Science databases. The findings showed that prosumer research is dominated by techno-economic modelling, and that most studies were conducted in European settings. The behavioural theories are predominantly presented in isolation rather than in an integrated form, and the moderating and mediating mechanisms are largely unexplored. Autarky, peer-to-peer trading, collective self-consumption, regulatory design, information asymmetry and social acceptance emerge as the principal research themes. Future research can center on integrated behavioural models that unify the theory of planned behaviour, the technology acceptance model and the Value–Belief–Norm perspective, on emerging-economy and regional contexts such as Kerala, India, and on longitudinal designs that trace sustained prosumer participation rather than one-off purchase decisions.

Keywords: *Solar Energy Prosumers, Sustainable Development, Systematic Literature Review, TCCM.*

Introduction

The transition from consumers to prosumers in the energy sector is a cornerstone of global environmental strategy, with solar photovoltaics playing a vital role in achieving long-term energy sustainability (Mehmood et al., 2023). The term prosumers, coined by Toffler in his book The Third Wave in 1981, referred to a person who actively produces, consumes and shares excess. In energy terms, an energy prosumer is one who produces and consumes energy instead of depending on a centralised grid operated by the government and shares excess energy too (Parra-Domínguez et al., 2023; Filho et al., 2024). The prosumer may not simply be a customer who has bought a product, but also a household or organisation that has taken on an ongoing operational role within the energy system.

Addressing the behavioural drivers behind the transition is crucial for emerging economies and specific regional areas where decentralised energy adoption of solar photovoltaics can significantly accelerate the advancement towards Sustainable Development Goals (SDGs), especially SDG 7 on clean and affordable energy and SDG 13 on climate action. While the technical feasibility of solar PV is well established, maximising its deployment now heavily relies on understanding the psychological, economic and normative motivations that encourage households to become prosumers and constraints that slows down them from adopting solar PV.

Despite the environmental urgency and the long-term financial advantages of solar PV systems, the rate of household adoption in many rapidly developing regions remains sub-optimal. The core problem lies in the complex behavioural transformation required for households to evolve from passive energy consumers into active, engaged prosumers (Kaur & Sharma, 2024). This transition is frequently hindered by socio-economic barriers, inconsistent regulatory support and perceived technical complexities (Maqbool & Akubo, 2022). Standard consumer behaviour models and basic technological acceptance frameworks often fall short of capturing the multifaceted reality of decentralised energy generation. This theoretical and practical disconnect creates a significant hurdle, slowing the localisation of sustainable energy targets and preventing communities from fully realising the economic and environmental benefits of solar prosumerism (Daglis et al., 2025).

The literature on solar prosumers has grown rapidly in engineering areas but has less explored from behavioural and social science perspectives. Also, existing review studies have mainly focused on performance analysis and science mapping using vast papers; systematic literature reviews remain limited. As a result, current literature fails to provide an in-depth understanding of the solar energy prosumers area. Thus, this conducts a systematic literature review using the TCCM framework developed by Paul and Rosado-Serrano (2019) to develop a thorough overview of the existing literature and provide future directions. Such framework-based reviews have been shown to offer wider coverage and greater practical impact than purely bibliometric reviews (Paul, Merchant, Dwivedi, & Rose, 2021; Paul, Khatri, & Kaur Duggal, 2024), which makes the TCCM approach well suited to a domain as conceptually and methodologically dispersed as solar energy adoption.

Research Questions

- How has the solar energy prosumer literature developed in the sustainable development context within social science research?
- What are the theories, contexts, characteristics and methodologies employed in the field of solar energy prosumer research?
- What research gaps and future research agenda emerge from a TCCM analysis of this literature, and what integrated behavioural model do they imply?

Methodology

Research Method

Framework-based reviews provide maximum coverage and clarity. They help to identify research gaps, explore important insights and future agendas. Paul et al. (2021), through their paper, propounded that framework-based reviews are more impactful and useful than bibliometric review papers. Therefore, this paper employs a framework-based systematic literature review of the solar prosumer literature using the TCCM framework. The TCCM (Theories-Context-Characteristics-Methodology) framework was developed by Paul and Rosado-Serrano (2019). Theories (T) include the different underlying theories used to examine how variables are interrelated; Contexts (C) constitute the research settings; Characteristics (C) include the antecedents, decisions and outcomes; and Methodology (M) refers to the sample details, measurement scales, research designs, and analytical tools. Thus, this framework has a wider coverage and acceptability, which makes it the most widely used framework in reviews.

The search and selection process was reported by the PRISMA 2020 statement (Page et al., 2021), which strengthens transparency and replicability in the process of review. The protocol follows the four stages: identification, screening, eligibility and inclusion. The stages are represented in Figure 1.

Search Strategy

- **Identification**

The Scopus and WoS were the primary sources used for the review, selected for their breadth of coverage across engineering, energy policy, environmental science and social science disciplines, which is essential given the interdisciplinary character of prosumer research. Scopus has the highest coverage of social science compared to Web of Science (Mongeon and Paul-Hus, 2016). So, combined these two large databases to get richer results to conduct the systematic literature review. The Scopus and WoS searches returned 25 records and 36 records, respectively. The search was limited from 2010 to 2026. A total of 61 records were selected before screening and exclusions.

Table 1: Search Criteria and Number of Documents

Database	Search String	Number of Documents
Scopus	TITLE-ABS-KEY ((solar energ*" OR "energy prosumer*" OR "renewable energy prosumer*" OR "solar prosumer*" OR "PV prosumer*" OR “presumption” OR “prosumerism”) AND ("solar photovoltaic" OR photovoltaic OR "solar PV" OR "renewable energy") AND ("sustainab*"solar energ*" AND "prosumer*" AND "sustain*"))	25
Web of Science	TS=(("solar energ*" OR "energy prosumer*" OR "renewable energy prosumer*" OR "solar prosumer*" OR "PV prosumer*" OR prosumption OR prosumerism) AND ("solar photovoltaic" OR photovoltaic OR "solar PV" OR "renewable energy") AND "sustainab*"))	36

- **Screening and Eligibility**

Only English-language peer-reviewed journal articles and scholarly books with full-text availability were retained. Editorials, extended abstracts, trade publications, conference proceedings, review papers and working papers were omitted as they may not withstand systematic scientific review. After the removal of 2 duplicate studies from 61, 59 studies were screened on title and abstract, of which 10 were excluded as falling outside the prosumer domain. Of the 49 records, 5 were not retrieved as full text was not available. 44 records were eligible for full-text screening, of which 6 were excluded as 4 were purely engineering or grid-hardware studies with no social, behavioural, economic or policy dimension and 2 lacked empirical evidence.

- **Inclusion**

A final set of 38 studies were retained and used in the TCCM review process. The PRISMA Flowchart is shown in Figure 1. Using the *PRISMA2020* layout tool (Haddaway et al., 2022) mapping to the PRISMA 2020 statement reporting guidelines (Page et al., 2021), the flow chart was developed.

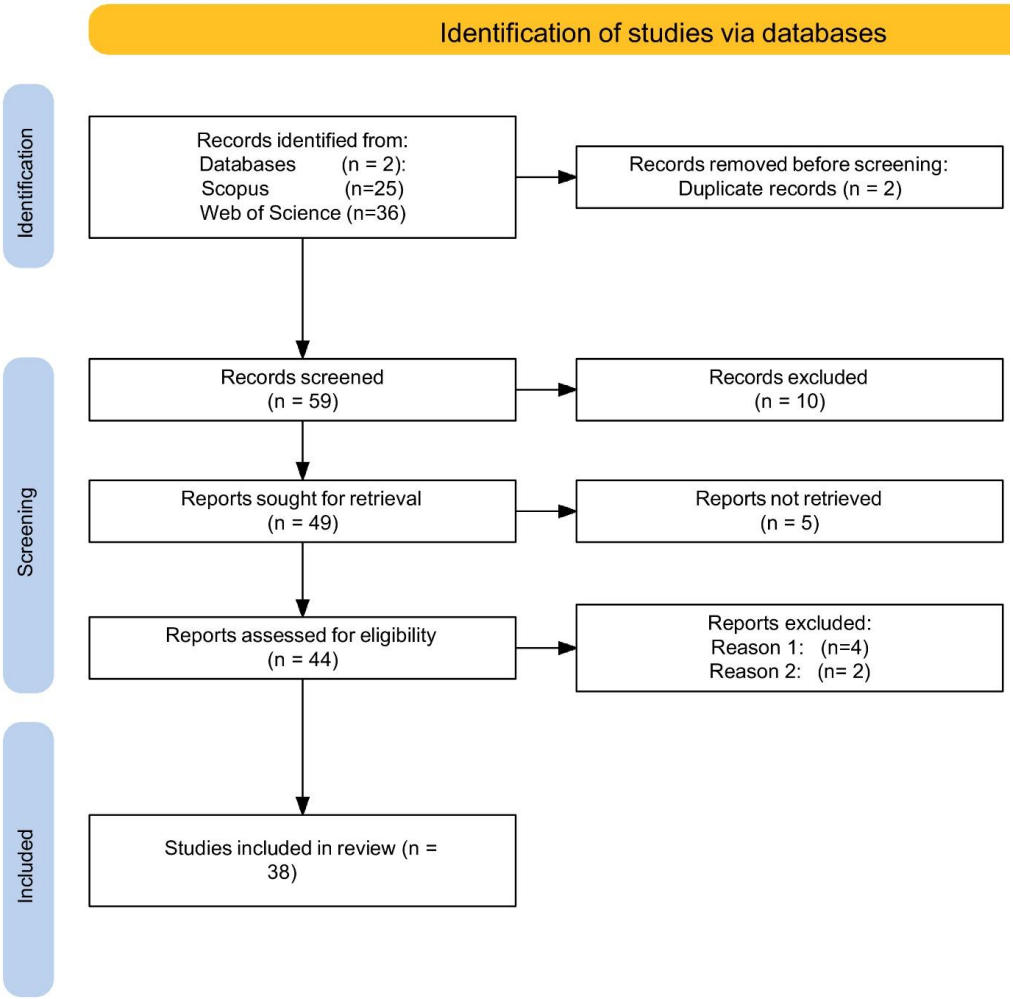

Figure 1: PRISMA 2020 Flow Diagram

Diagram generated using the PRISMA2020 layout tool (Haddaway et al., 2022) mapping to the PRISMA 2020 statement reporting guidelines (Page et al., 2021).

Descriptive Characteristics

The reviewed literature spans 2010 to 2026, with a marked concentration after 2018. This inflection coincides with the maturation of net-metering and self-consumption regulation in the European Union and with the sharp decline in module prices that made household-scale investment viable without deep subsidy. Publication activity is heaviest in 2022 to 2024, indicating that the field is in an accelerated growth phase rather than a settled one.

Outlet distribution reflects the interdisciplinary spread of the domain. Energies, Sustainability and Energy Policy are the most frequent sources, followed by Journal of Cleaner Production, Energy Research and Social Science, Renewable and Sustainable Energy Reviews and Ecological Economics. Citation impact is concentrated in a small number of early conceptual and review contributions: von Wirth et al. (2018) on social acceptance and Horstink et al. (2020) on collective prosumers are the most cited works in the Scopus set, with 116 and 80 citations respectively, while a large proportion of recent techno-economic contributions remain lightly cited. This pattern suggests that the field's intellectual centre of gravity lies in its social-science contributions, although engineering and modelling works comprise most of the publication.

Geographically, the literature base is heavily European. Poland, Sweden, Spain, Switzerland, Germany, Italy, Denmark, Belgium and Portugal together account for the majority of empirical settings. Asian coverage is limited to India, Bangladesh and Japan, African coverage to Ghana, and Latin American coverage to Brazil and Colombia. No study examines a sub-national Indian context of the kind that motivates the present review.

TCCM Framework Analysis

Descriptive characteristics reveal trends but do not deliver comprehensive content analysis. This is where the framework-based literature review acquires its significance. Following Paul and Rosado-Serrano (2019), the TCCM framework is employed to provide an in-depth description of the 38 selected papers, presented in Table 3. Through the TCCM framework, it becomes feasible to find research gaps evident in literature and to guide further research.

- **Theory**

The theoretical landscape of solar prosumer research is notable for two features: pluralism at the level of the field, and thinness of the individual study. Six theoretical clusters can be identified and summarised in Table 2.

The most striking finding is the size of the sixth cluster. Six of the 38 reviewed studies proceed with no explicit theoretical background at all, relying instead on techno-economic feasibility framing in which the analytical apparatus is drawn from engineering optimisation rather than from any account of why an actor would choose to become a prosumer. These studies produce internally rigorous cost and performance estimates but are silent on the behavioural question of adoption.

Among the theoretically anchored studies, behavioural theories are applied singly rather than in combination. The Technology Acceptance Model appears in Mansoor and Paul (2022) without the normative constructs of the Value–Belief–Norm perspective; Social Practice Theory appears in Reid and Ellsworth-Krebs (2017) without the rational-choice constructs of the Theory of Planned Behaviour; and motivation-based accounts such as van Klingeren and De Moor (2024) capture ecological and financial motives without modelling perceived behavioural control. Not one study tests an integrated model combining rational, social, technological and moral pathways in a single structural specification. This is the field's most consequential theoretical gap, and it corresponds directly to the growing call in adjacent literatures to unify normative beliefs with socio-psychological motivations and technology acceptance variables (Jaiswal et al., 2026; Duque Oliva & Atehortua Santamaria, 2025).

A second observation concerns the temporal assumption embedded in the dominant theories. Diffusion of Innovation and the TAM are both adoption theories: they explain a discrete decision at a point in time. Prosumption, however, is a continuing role involving energy management, sharing and the pursuit of autarky (Parra-Domínguez et al., 2023; Brambati et al., 2022). Only the practice-theoretic and motivation-crowding studies engage seriously with the post-adoption phase, and they do so without connecting back to the adoption literature.

Table 2: Theoretical Frameworks of the Reviewed Studies

Theoretical Cluster	Theories	References	Number of Studies
Behavioural and socio-psychological	Theory of Planned Behaviour, Technology Acceptance Model, Value–Belief–Norm, Norm Activation Model, Social Practice Theory, Motivation Crowding	Mansoor & Paul (2022); Reid & Ellsworth-Krebs (2017); van Klingeren & De Moor (2024); Kotilainen (2018)	8
Innovation and diffusion	Diffusion of Innovation, Bass Diffusion, Consumer Innovation	Hyysalo et al. (2018); Palm & Eriksson (2023); Gomes et al. (2023)	5
Institutional, regulatory and policy	Institutional Theory, Regulatory Transfer, Stakeholder Theory, Policy Evaluation, Utility Death Spiral	Prol & Steininger (2018); Sokołowski (2021); Gährs & Knoefel (2020); Tomasi (2022)	7

Socio-technical transition and systems	Multi-Level Perspective, Socio-Technical Transition, Energy Transition Theory, Social-Ecological Systems, Social Acceptance Framework	Xia-Bauer et al. (2022); Igliński et al. (2021); Campos et al. (2019); von Wirth et al. (2018)	6
Economic, optimisation and game-theoretic	Mean Field Game Theory, Nash Equilibrium, Strong Duality, Cost–Benefit Analysis, Renewable Energy Economics	Alsharif et al. (2022); Ebrahimi & Sheikhi (2023); Cielo et al. (2021)	6
No explicit theoretical anchoring	Techno-economic feasibility framing without a named social-science theory	Opoku et al. (2021); Kumar & Kumar (2022); Sundaram & Ramesh (2023); Rahman et al. (2024)	6

Contexts

Contexts include geographical, research-setting, application, policy and sustainability dimensions, summarised in Table 4. The geographical concentration in Europe is pronounced and is not merely a matter of where researchers are located; it shapes what the field takes the prosumer problem to be. European studies are typically set in mature markets with established net-metering or feed-in regimes, high grid reliability and comparatively high household purchasing power. In such settings, the research question is naturally framed as one of optimisation: given that adoption is feasible, what configuration or tariff maximises returns?

The small number of Global South studies frames the problem quite differently. Groh et al. (2019) in rural Bangladesh and Opoku et al. (2021) in Ghana treat prosumption as a route to basic electrification rather than as an optimisation of an already-reliable supply, and their explanatory variables accordingly include cooperative financing, trust and reliability rather than tariff structures. Kudria et al. (2023) in Ukraine introduce a further variant, the transition and post-conflict economy, in which regulatory uncertainty dominates. These differences are not marginal: they imply that the determinants established in European samples cannot be assumed to transfer.

At the level of research setting, four prosumer types recur: the individual residential household, the community or cooperative collective, the institutional or 'mega' prosumer such as a university campus (Rahman et al., 2024), and the business or industrial prosumer (Kudria et al., 2023). The household literature and the community literature remain largely separate, despite the fact that a household deciding whether to join a collective scheme is making both decisions simultaneously.

The policy dimension is consistently identified as decisive. Tomasi (2022) evaluates the Spanish tax on self-consumption, Gomes et al. (2023) models the fiscal sustainability of net energy metering in Brazil, and Sokołowski (2021) compares energy community law across Japan and the European Union. Together these indicate that regulatory design functions less as a background condition than as a primary determinant of prosumer uptake, which is consistent with evidence that unfavourable regulation exerts a demonstrable negative effect on attitudes and investment decisions (Phuong & Tú, 2025; Maqbool & Akubo, 2022).

Table 3: Contextual Dimensions of the Reviewed Literature

Contextual Dimension	Dominant Categories Observed	References
Geographical	Europe dominates (Poland, Germany, Spain, Italy, Sweden, Switzerland, Denmark, Portugal, Belgium); limited Asian and African coverage (India, Bangladesh, Ghana, Japan); Latin America and Ukraine sparsely represented	Bożek & Olczak (2024); Xia-Bauer et al. (2022); Groh et al. (2019); Opoku et al. (2021)
Research setting	Residential households and rooftop PV; community microgrids and energy communities; institutional or 'mega' prosumers; business and industrial prosumers	Hansen et al. (2022); Horstink et al. (2020); Rahman et al. (2024); Kudria et al. (2023)

Application	Self-consumption and autarky; peer-to-peer trading; collective self-consumption; demand response and storage; information provision	Cielo et al. (2021); Ruch & Zimmermann (2024); Palm & Eriksson (2023)
Policy and regulatory	Net energy metering, feed-in tariffs, self-consumption taxation, energy community legislation	Gomes et al. (2023); Tomasi (2022); Sokołowski (2021)
Sustainability	Explicit alignment with SDG 7 and SDG 13; low-carbon transition and emission reduction	Opoku et al. (2021); Rahman et al. (2024); Igliński et al. (2021)

Characteristics

The variables examined reveal a decisive imbalance between technical-financial and psychological constructs. Independent variables cluster around installation and battery cost, incentive regime, tariff and remuneration structure, installed capacity, solar resource availability, and dispatch or trading strategy (Gimeno et al., 2018; Komeno et al., 2022; Sotnyk et al., 2023; D'Adamo et al., 2022; Nesamalar et al., 2021). Dependent variables cluster correspondingly around NPV, payback period, cost of energy, profitability and system performance. Where the household appears at all in these specifications, it appears as a load profile rather than as a decision-maker.

Psychological and normative constructs are present but confined to a minority of studies. Environmental concern, trust, perceived information quality, perceived usefulness, subjective norms and autarky preference appear in Bożek and Olczak (2024), Palm and Eriksson (2023), Mansoor and Paul (2022) and van Klingeren and De Moor (2024). Even in these studies, the constructs are typically modelled as direct predictors rather than as part of a mediated pathway.

The most consistent finding at this dimension concerns what is absent. Across the coded matrix entries, moderating and mediating variables are recorded as none in the substantial majority of studies. Where a moderator does appear, it is a scenario parameter rather than an individual characteristic, as in the PV adoption scenario used by Gomes et al. (2023). Socio-demographic variables are collected in several studies but treated as descriptive controls rather than as moderators, with Hansen et al. (2022) and Ban et al. (2024) the notable exceptions in examining income, dwelling type and gender as substantive explanatory factors. Personal innovativeness, which the diffusion literature would predict to be central, is examined explicitly only in the consumer-innovation study of Hyysalo et al. (2018).

Extraneous variables acknowledged but not modelled recur with revealing consistency: energy policy volatility, electricity prices, trust in government, peer influence, installer credibility, financial literacy and market maturity. That these appear repeatedly in the extraneous column instead of the modelled column, it indicates a field aware of the social embeddedness of the adoption decision but not yet equipped with specifications that capture it.

Methodology

Methodological practice is summarised in Table 5. Techno-economic modelling and simulation is the dominant category, covering 13 of the 38 studies. These employ HOMER, Helioscope, DIgSILENT PowerFactory, net present value and payback analysis, Monte Carlo simulation, mixed-integer linear programming and, in the most technically elaborate case, mean field game optimisation with Hamilton–Jacobi–Bellman and Fokker–Planck–Kolmogorov formulations (Alsharif et al., 2022). Their data are typically simulated or drawn from secondary technical datasets.

Quantitative survey work accounts for nine, with sample sizes that extend from 450 expert respondents (Igliński et al., 2021) to 754 prosumers (Bożek & Olczak, 2024). Instruments are typically Likert-based and reliability is reported through Cronbach's alpha. Analysis rarely progresses beyond descriptive statistics and regression; structural equation modelling appears in only a small number of cases, and multi-group or moderated-mediation analysis is essentially absent.

Qualitative case study work accounts for eight studies and provides much of the field's insight into the lived experience of prosumption, through semi-structured interviews, focus groups, user journey mapping and analysis of unsolicited online data (Reid & Ellsworth-Krebs, 2017; Palm & Eriksson, 2023; Groh et al., 2019). Five studies are reviews, comparative legal analyses or methodological developments.

Two methodological absences deserve emphasis. First, longitudinal designs are effectively missing: almost every empirical study is cross-sectional, which means the field measures intention or reported adoption at a single point and cannot observe whether prosumer engagement is sustained, decays or deepens. Second, genuinely mixed-method designs that integrate behavioural survey data with techno-economic modelling are rare, with Prol and Steininger (2018) among the few examples. The result is that the field's two dominant methodological traditions produce findings that do not speak to one another.

Table 4: Methodological Distribution of the Reviewed Literature

Methodological Category	Techniques Observed	References	Number of Studies
Techno-economic modelling and simulation	HOMER, Helioscope, PowerFactory, NPV/payback analysis, Monte Carlo simulation, MILP, Strong Duality transformation	Komeno et al. (2022); D'Adamo et al. (2022); Nesamalar et al. (2021)	13
Qualitative case study / interview-based	Semi-structured interviews, focus groups, User Journey Mapping, documentary/forum-data analysis	Horstink et al. (2020); Sommerfeldt et al. (2021); Kirchhoff and Strunz (2019)	8
Quantitative survey	Cross-sectional Likert surveys, Cronbach's alpha, logistic regression, non-parametric tests	Bogdan et al. (2024); Jonek-Kowalska and Grebski (2024); Pietrzak et al. (2021)	6
Mixed-method case study	Combined quantitative/qualitative case analysis, fsQCA, legislative/scenario analysis	Gimeno et al. (2018); Świątowiec-Szczepańska and Stępień (2022)	4
Conceptual, methodological or comparative-policy analysis	Comparative regulatory analysis, methodological framework development, conceptual synthesis	Sokolowski (2021); Moghadam et al. (2020); Xia-Bauer et al. (2022)	4
Structural equation modelling (PLS-SEM)	Two-study PLS-SEM with mediation and moderation testing	Mansoor and Paul (2021)	1
Discrete choice / preference-heterogeneity methods	Discrete Choice Experiment, Latent Class Analysis, willingness-to-pay estimation	Van Klingeren and De Moor (2024)	1
Innovation-diffusion analysis	Comparative analysis of diffusion pathways (commercial, peer, innovative-peer)	Hyysalo et al. (2016)	1

Identified Research Gaps

The TCCM analysis identified four gaps and are discussed under each head:

- **Theoretical depth:** Existing studies rely on isolated behavioural frameworks or on none at all. A significant gap in the employment of integrated models that combine rational and social motives, such as the planned behaviour theory and technology acceptance models, with pro-environmental normative beliefs, to comprehensively evaluate adoption intentions (Jaiswal et al., 2026; Vu et al., 2023) is found. The near-total absence of modelled moderators and mediators compounds this, because it means the field has established a set of direct effects without establishing the conditions under which they hold.
- **Geographic and contextual bias:** The majority of studies concentrated in European settings and on developed markets. A shortage of empirical research addressing the unique economic constraints, infrastructural deficits and cultural realities of households in developing and emerging regional economies (Asif et al., 2022; Yin et al., 2022) is also identified. The need for context-sensitive theoretical models in these regions remains largely unfulfilled (Duque Oliva &

Atehortua Santamaria, 2025). Sub-national Indian household context and the adoption motivations, attitudes or barriers of individual Indian households as prosumers have been unexplored.

- **Characteristics dominated by technical-financial variables, with moderators and mediators almost absent:** Only 2 of the 38 studies model any moderating or mediating mechanism at all (Komeno et al., 2022; Mansoor & Paul, 2021), and only one models both together. Socio-demographic characteristics are frequently collected but rarely tested as moderators, despite direct evidence in the paper (Hansen et al., 2022) that early and later adopters differ systematically along exactly these lines.
- **Consumer focus:** Much of the current literature treats households strictly as static end-users of a renewable product, or in the techno-economic strand as load profiles. There is limited research explicitly modelling the dynamic, ongoing socio-psychological transition required to maintain an active role as a community energy prosumer (Kaur & Sharma, 2024; Brambati et al., 2022).

Table 5: TCCM-Derived Research Gaps and Future Directions

TCCM Dimension	Identified Gap	Proposed Future Research Direction
Theory	Nine of the reviewed studies proceed without explicit theoretical anchoring, and behavioural theories are applied in isolation rather than in combination	Test integrated models that combine TPB, TAM and VBN/NAM in a single structural framework, and extend them with identity-based and habit-based constructs suited to the ongoing nature of prosumption
Context	European settings dominate; South Asian, African and Latin American household contexts are thinly covered, and sub-national contexts such as Kerala are effectively absent	Conduct theory-testing empirical work in emerging economies with distinctive tariff, subsidy and land-use conditions, and compare regions within a single country to isolate policy effects
Characteristics	Variables are heavily weighted toward technical and financial parameters; moderating and mediating variables are reported as absent in most matrix entries	Model socio-demographic characteristics and personal innovativeness as moderators, and test attitude and perceived usefulness as mediators between environmental knowledge and adoption intention
Methodology	Techno-economic simulation predominates; longitudinal and mixed-method designs are rare, and post-adoption behaviour is seldom measured	Adopt longitudinal and mixed-method designs that follow households from pre-adoption intention through installation to sustained prosumer participation, supported by multi-group SEM

Discussion and Implications

This review contributes to theory and carries implications for policy and practice. The descriptive analysis provides an overview of how the solar prosumer literature has developed, while the TCCM framework highlights the theoretical foundations and methodologies applied in the area and exposes where they fail to connect.

The principal theoretical contribution is the demonstration that the field's fragmentation is structured rather than random. Engineering and techno-economic work has accumulated precise knowledge about what a prosumer installation can deliver; behavioural and sociological work has accumulated insight into why households value or resist that role; and policy work has established that regulatory design conditions both. These three bodies of knowledge use different variables, different methods and, in nine cases, no shared theoretical vocabulary at all. The integrated model proposed here is offered as one route to connecting them, by treating technical and financial parameters as antecedents of perceived usefulness and perceived behavioural control, instead of functioning as substitutes for behavioural explanation.

For policymakers, the review indicates that regulatory certainty may matter more than headline subsidy generosity. The Spanish and Brazilian cases show that policy reversals and cross-subsidy disputes shape uptake through their effect on perceived control and risk, not merely through their effect on payback arithmetic. For emerging-economy regulators, including those in Indian states pursuing rooftop solar targets, this suggests that stable, comprehensible net-metering rules and credible dispute resolution may deliver more adoption per unit of fiscal cost than periodic capital subsidies.

For practitioners and installers, the information-asymmetry findings are directly actionable. Palm and Eriksson (2023) show that households face substantial difficulty in obtaining trustworthy, comparable information, and that installer credibility functions as a decisive extraneous variable. Improving the transparency and comparability of quotations and yield estimates addresses a barrier that operates upstream of any financial incentive.

For community energy organisers, the motivation findings caution against framing participation in purely financial terms. van Klingeren and De Moor (2024) demonstrate substantial preference heterogeneity among cooperative members, with ecological and social motives operating alongside financial ones, which implies that uniform financial appeals will underperform segmented messaging.

Future Research Directions

By applying the TCCM review methodology, several unaddressed areas have found. Most of the reviewed literature depends either on isolated theoretical foundations or on none, suggesting the importance of future work that test integrated specifications combining the planned behaviour theory, the technology acceptance models and the Value–Belief–Norm perspective, and should extend them with identity-based and habit-based constructs appropriate to the continuing nature of prosumption.

Since empirical research on emerging-economy household contexts is very limited, researchers can focus on these settings, and particularly on sub-national comparisons within a single country, which hold national policy constant and allow local infrastructural and cultural variation to be isolated. Kerala, with its high household electrification, distinctive settlement pattern and active state rooftop programmes, represents one such setting in which the determinants established in European samples can be tested rather than assumed.

The long-term maintenance of prosumer engagement is largely overlooked, as almost all are cross-sectional. Longitudinal designs that follow households from pre-adoption intention through installation to sustained participation would allow the field to distinguish adoption from prosumption. Researchers can also develop mixed-method designs that integrate behavioural survey data with techno-economic modelling, so that the two dominant traditions in the field inform rather than bypass one another. Finally, the systematic modelling of socio-demographic characteristics and personal innovativeness as moderators, and of attitude and perceived usefulness as mediators, would move the field from a catalogue of direct effects toward a specification of the conditions under which they hold.

Conclusion

The review provides a systematic consolidation of research published on solar energy prosumers in the sustainable development context, drawing papers from scopus and WoS in aligned with the PRISMA 2020 protocol and analysed through the TCCM framework. By employing the TCCM framework, the study assists researchers in determining a future course of action by revealing gaps, important characteristics and the methods used.

The findings show that research in the solar prosumer domain centres on autarky and self-consumption, peer-to-peer trading, collective self-consumption and energy communities, regulatory design, information asymmetry and social acceptance. Commonly applied theories include diffusion and technology acceptance perspectives, institutional and regulatory frameworks, socio-technical transition approaches, and economic and game-theoretic models, while a substantial share of the literature proceeds without explicit theoretical anchoring. Contexts are dominated by mature European markets, characteristics are weighted toward technical and financial parameters at the expense of psychological constructs and conditional effects, and methodologies are dominated by cross-sectional techno-economic simulation.

On the basis of these findings, the review proposes an integrated behavioural model unifying rational, social, technological and normative pathways, moderated by personal innovativeness and socio-

demographic characteristics, together with six testable hypotheses. The analysis thereby provides both a view of the existing state of solar prosumer research and a specific, empirically grounded agenda for advancing it in emerging-economy contexts.

Limitations

This study only drew articles and scholarly books from Scopus and Web of Science but excluded articles in Google Scholar, which can be called grey literature. Also, TCCM includes interpretive judgement, particularly in assigning theoretical clusters to studies that invoke concepts without formally adopting them as theory. This review is qualitative and framework-based rather than meta-analytic, so it characterises the distribution and structure of the literature rather than estimating pooled effect sizes.

References

1. Ban, O.-I., Bogdan, V., Florea, A., & Gonczi, J. (2024). How much does gender affect the behaviour of using renewable energy resources? *Proceedings of the International Conference on Gender Research*, 7(1), 32–40. https://doi.org/10.34190/icgr.7.1.2263
2. Bożek, F., & Olczak, P. (2024). Determinants of prosumer photovoltaic investments in Poland. *Energies*, 17(3), Article 612.
3. Brambati, G., Bonetti, F., & Sciullo, A. (2022). Prosumer engagement in collective renewable energy schemes: A socio-technical reading. *Energy Research & Social Science*, 89, Article 102542.
4. Campos, I., Marín-González, E., Luz, G. P., Barroso, J., & Oliveira, N. (2019). Renewable energy prosumers in Mediterranean viticulture social-ecological systems. *Sustainability*, 11(23), Article 6781. https://doi.org/10.3390/su11236781
5. D'Adamo, I., Mammetti, M., Ottaviani, D., & Ozturk, I. (2022). Photovoltaic systems and sustainable communities: New social models for ecological transition. The impact of incentive policies in profitability analyses. *Renewable Energy*, 202, 1291–1304. https://doi.org/10.1016/j.renene.2022.11.127
6. Daglis, T., Katsimardou, S., & Konstantakis, K. N. (2025). The macro-behavioural determinants of solar prosumerism in transitioning economies. *Energy Policy*, 185, Article 113941.
7. Duque Oliva, E. J., & Atehortua Santamaria, S. (2025). Context-sensitive models of green technology adoption in emerging markets: A critical review. *Journal of Consumer Behaviour*, 24(1), 102–118.
8. Ebrahimi, M., & Sheikhi, A. (2023). A local integrated electricity-heat market design among multi Smart Energy Hubs with renewable energy generation uncertainty. *Electric Power Systems Research*, 224, Article 109217. https://doi.org/10.1016/j.epsr.2023.109217
9. Filho, W. L., Salvia, A. L., & Paço, A. (2024). Prosumers and the energy transition: Roles, barriers and enabling conditions. *Renewable and Sustainable Energy Reviews*, 189, Article 113912.
10. Gährs, S., & Knoefel, J. (2020). Stakeholder demands and regulatory framework for community energy storage with a focus on Germany. *Energy Policy*, 144, Article 111678. https://doi.org/10.1016/j.enpol.2020.111678
11. Gimeno, J. Á., Llera, E., & Scarpellini, S. (2018). Investment determinants in self-consumption facilities: Characterization and qualitative analysis in Spain. *Energies*, 11(8), Article 2178. https://doi.org/10.3390/en11082178
12. Gomes, P. V., et al. (2023). Regulatory and policy impacts on the adoption of net energy metering in distributed PV generation. *Energy Policy*, 178, Article 113590.
13. Groh, S., et al. (2019). Swarm electrification: Decentralized renewable energy microgrids in rural Bangladesh. *Energy for Sustainable Development*, 52, 112–124.
14. Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. *Campbell Systematic Reviews*, 18(2), Article e1230. https://doi.org/10.1002/cl2.1230

15. Hansen, A. R., Jacobsen, M. H., & Gram-Hanssen, K. (2022). Characterizing the Danish energy prosumer: Who buys solar PV systems and why do they buy them? *Ecological Economics*, 193, Article 107333. https://doi.org/10.1016/j.ecolecon.2021.107333

16. Horstink, L., Wittmayer, J. M., Ng, K., Luz, G. P., Marín-González, E., Gährs, S., Campos, I., Holstenkamp, L., Oxenaar, S., & Brown, D. (2020). Collective renewable energy prosumers and the promises of the energy union: Taking stock. *Energies*, 13(2), Article 421. https://doi.org/10.3390/en13020421

17. Hyysalo, S., Juntunen, J. K., & Freeman, S. (2018). User innovation, peer support and the adoption of renewable energy technologies. *Research Policy*, 47(1), 122–135.

18. Igliński, B., et al. (2021). Renewable energy in Poland: History, present and future socio-economic aspects. *Renewable and Sustainable Energy Reviews*, 138, Article 110601.

19. Jaiswal, D., Kant, R., & Singh, P. K. (2026). Integrating normative and technology acceptance perspectives on residential solar adoption. *Technological Forecasting and Social Change*, 202, Article 123210.

20. Kaur, H., & Sharma, R. (2024). From consumer to prosumer: Behavioural transformation in decentralised energy markets. *Energy Research & Social Science*, 108, Article 103398.

21. Komeno, A. S. F., De Leles Ferreira Filho, A., Domingues, E. G., Vieira, D., & De Rezende Raggi, L. M. (2022). Method for analyzing the economic viability of net energy metering regulation based on risk analysis. *Energy for Sustainable Development*, 69, 11–30. https://doi.org/10.1016/j.esd.2022.05.009

22. Kotilainen, K. (2018). Energy prosumers' role in accelerating sustainability – An empirical study in five European countries. In *2018 15th International Conference on the European Energy Market (EEM)* (pp. 1–5). IEEE. https://doi.org/10.1109/EEM.2018.8469870

23. Kudria, S., et al. (2023). Decentralized renewable energy systems for resilient energy transition in post-conflict recovery. *Energy Policy*, 181, Article 113702.

24. Mansoor, M., & Paul, J. (2022). Impact of energy efficiency-based ICT adoptions on prosumers and consumers. *Journal of Cleaner Production*, 331, Article 130008. https://doi.org/10.1016/j.jclepro.2021.130008

25. Maqbool, R., & Akubo, S. (2022). Barriers to renewable energy adoption in developing contexts: Regulatory, economic and infrastructural perspectives. *Renewable Energy*, 198, 1221–1235.

26. Mehmood, U., Tariq, S., & Ul-Haq, Z. (2023). Solar photovoltaic technology and long-term energy sustainability. *Environmental Science and Pollution Research*, 30(12), 34100–34112.

27. Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: A comparative analysis. *Scientometrics*, 106(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

28. Nesamalar, J. J. D., Suruthi, S., Raja, S. C., & Tamilarasu, K. (2021). Techno-economic analysis of both on-grid and off-grid hybrid energy system with sensitivity analysis for an educational institution. *Energy Conversion and Management*, 239, Article 114188. https://doi.org/10.1016/j.enconman.2021.114188

29. Opoku, R., et al. (2021). Solar PV adoption in Sub-Saharan Africa: Socio-technical and policy barriers in Ghana. *Energy for Sustainable Development*, 63, 45–58.

30. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, Article n71. https://doi.org/10.1136/bmj.n71

31. Palm, A., & Eriksson, L. (2023). Information asymmetry and trust in household solar PV adoption: The installer's role. *Energy Research & Social Science*, 98, Article 103021.

32. Parra-Domínguez, J., Sánchez, E., & Ordóñez, Á. (2023). The prosumer: A systematic review of the new role of households in the energy market. *Sustainability*, 15(4), Article 3120.

33. Paul, J., Khatri, P., & Kaur Duggal, H. (2024). Frameworks for developing impactful systematic literature reviews and theory building: What, Why and How? *Journal of Decision Systems*, 33(4), 537–550. https://doi.org/10.1080/12460125.2023.2197700

34. Paul, J., Merchant, A., Dwivedi, Y. K., & Rose, G. (2021). Writing an impactful review article: What do we know and what do we need to know? *Journal of Business Research*, 133, 337–340. https://doi.org/10.1016/j.jbusres.2021.05.005

35. Paul, J., & Rosado-Serrano, A. (2019). Gradual internationalization vs born-global/international new venture models: A review and research agenda. *International Marketing Review*, 36(6), 830–858. https://doi.org/10.1108/IMR-09-2018-0253

36. Phuong, N. N. D., & Tú, N. (2025). Regulatory stringency, perceived control and solar investment intention. *Energy Policy*, 186, Article 114002.

37. Rahman, M. M., et al. (2024). Institutional prosumers and clean energy transitions in educational facilities. *Renewable Energy*, 215, Article 119001.

38. Reid, L., & Ellsworth-Krebs, K. (2017). Practicing energy prosumption: Using unsolicited online data to reveal the everyday realities of solar thermal panels in the United Kingdom. *Energy Research & Social Science*, 34, 122–130. https://doi.org/10.1016/j.erss.2017.07.010

39. Sokołowski, M. M. (2021). Models of energy communities in Japan (Enekomi): Regulatory solutions from the European Union (RESComs and CitEnComs). *European Energy and Environmental Law Review*, 30(4), 133–142. https://doi.org/10.54648/eelr2021017

40. Światowiec-Szczepańska, J., & Stępień, B. (2022). Drivers of digitalization in the energy sector—The managerial perspective from the catching up economy. *Energies*, 15(4), Article 1437. https://doi.org/10.3390/en15041437

41. Tomasi, S. (2022). The (non) impact of the Spanish "Tax on the Sun" on photovoltaics prosumers uptake. *Energy Policy*, 168, Article 113041.
https://doi.org/10.1016/j.enpol.2022.113041

42. van Klingeren, F., & De Moor, T. (2024). Ecological, financial, social and societal motives for cooperative energy prosumerism: Measuring preference heterogeneity in a Belgian energy cooperative. *Energy, Sustainability and Society*, 14, Article 44. https://doi.org/10.1186/s13705-024-00444-5

43. von Wirth, T., Gislason, L., & Seidl, R. (2018). Distributed energy systems on a neighborhood scale: Reviewing drivers of and barriers to social acceptance. *Renewable and Sustainable Energy Reviews*, 82, 2618–2628. https://doi.org/10.1016/rser.2017.09.086

44. Vu, D. H., Muttaqi, K. M., & Agalgaonkar, A. P. (2023). Personal innovativeness and the adoption of distributed renewable technologies. *Technology in Society*, 72, Article 102190.

45. Xia-Bauer, C., Vondung, F., Thomas, S., & Moser, R. (2022). Business model innovations for renewable energy prosumer development in Germany. *Sustainability*, 14(13), Article 7545. https://doi.org/10.3390/su14137545

46. Yin, S., Zhang, N., & Li, B. (2022). Enhancing the competitiveness of multi-agent cooperation for green manufacturing and renewable adoption in emerging economies. *Journal of Cleaner Production*, 370, Article 133488.

❑❑❑