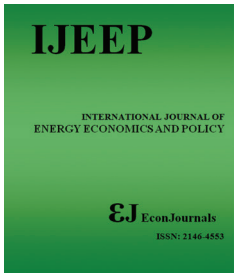

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Mapping Current Trends in Electricity-Saving Behaviour: A Bibliometric Study

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ABSTRACT

This study explored 1,230 publications related to electricity-saving behaviour (ESB), extracted from the Web of Science database. Prior to 2010, research in this field was limited, with fewer than 20 publications per year. The results show that academic interest in the field has risen sharply since 2015, with a peak of over 160 publications in 2021. This growth reflects increasing concern over sustainable energy and climate change, as well as interest in influencing individual and household behaviours related to energy reduction. While the study of ESB is relatively young, it has developed quickly. Analysis of institutional contributions revealed the U.S. Department of Energy, the Beijing Institute of Technology and the University of California to be the top contributors, indicating their significant research accomplishments and a commitment to sustainability research. ESB is a globally important subject with contributions from a range of countries. China was the top contributor with nearly 370 publications, followed by England, Italy, India and Spain. VOSviewer was used to visualise keyword co-occurrence, revealing significant clusters around "behavior," "energy efficiency" and "conservation." The keyword analysis also revealed a significant shift from a focus on technological initiatives, such as "smart meters" and "buildings," to an emphasis on the psychological and environmental components of "habit," "climate" and "residents" in more recent studies. Together, the findings demonstrate the interdisciplinary nature and increasing complexity of ESB research and have significant implications for future research and policy in the field of energy conservation and sustainable development.

Keywords: Electricity Saving Behavior, Bibliometric Analysis, Sustainable Consumption
JEL Classifications: Q40, Q43, Q49

1. INTRODUCTION

Crucial to the survival and growth of all living organisms, energy is generally considered to be a significant contributor to national economies and social advancement (Tripathy et al., 2024). Scholars in the social sciences and humanities – especially in the fields of economics, political science and media studies – are increasingly considering the factors influencing energy policy, such as public discourse and media coverage (Mansoor, 2025). The global transition to more environmentally friendly energy sources has a significant impact on climate change (Masip Macía et al., 2025). Increasing concern over climate change, energy limitations and the necessity of environmentally friendly consumption have led to a greater global emphasis on understanding and promoting electricity-saving behaviours (ESBs) as a component of environmental and energy policy. ESBs are conscious attempts by individuals to lower their electricity usage. These behaviours are motivated by psychological, social, economic, and regulatory components at the national and institutional levels. As ESB aligns with the United Nations' Sustainable Development Goals and green energy strategies, academic interest in this area has increased steadily over the past two decades.

The number of publications and citations on renewable energy entrepreneurship has increased in recent years, reflecting growing interest in the field (Sreenivasan and Suresh, 2024). Technological innovation, supportive government policies and market mechanisms are important drivers of energy transformation and have promoted

the widespread application of renewable energy (Masip Macía et al., 2025). Despite the increasing number of empirical and theoretical studies on ESB, there have been few large-scale, systematic evaluations of these devices. Existing literature surveys are typically narrative or limited to specific ESBs, such as a household's energy consumption, behavioural modifications or the utilisation of smart technology. To date, there have been no studies which thoroughly review global ESB research and identify its core themes, key players or scientific collaboration models. This gap has prevented a comprehensive understanding of the field's development, interdisciplinary connections and practical implications.

Bibliometric analysis is used to gain an in-depth understanding of existing scientific literature (Metli, 2023). This research employs a bibliometric approach to conduct a comprehensive analysis of global trends in ESB. By tracing the evolution of the ESB field and identifying the primary participants (including authors, institutions and countries), as well as the primary research themes, this study provides an organised and empirical depiction of the historical growth of this field. The analysis attempts to identify the prevalent trends, foundational research frameworks and emerging research directions in the literature, with the goal of directing future research efforts.

Bibliometric analysis is a cost-effective and versatile method that can be used to systematically assess a field of research or a specific subject. With proficient data processing abilities, researchers can identify objective trends and priorities in a scientific field (Wang et al., 2024). Various knowledge graph tools such as CiteSpace, HistCite, VOSviewer and Bibliometrix – have been created to conduct network-based and visual analyses of datasets (Xu et al., 2023). These tools can be used to map the conceptual, intellectual and cooperative aspects within a research field. Such analysis can identify current topics, significant works and mainstream approaches, while also highlighting areas which are still developing and may be researched in the future. Analysing how keywords and citations are related to each other can uncover how the scientific research focus is shifting and where research development discussions are taking place.

The primary goals of this research are to determine the degree to which the international scientific community is involved in the study of ESB, to identify the significant contributions and emerging trends within the field and to identify additional areas for future research. Policymakers, practitioners and those involved in behavioural change can benefit from understanding the major research areas and successful ESB strategies in order to facilitate the development of effective conservation programs. Knowledge of international collaborations and research publications can help define funding priorities and promote productive academic associations. This paper converts academic research into practical knowledge, supporting the larger goal of promoting sustainable energy methods across the globe.

2. THEORETICAL BACKGROUND

The concept of ESB is based on a multidisciplinary approach that integrates perspectives from environmental psychology, behavioural economics, sociology and energy policy. Understanding the motivations behind an individual's behaviours that reduce electricity consumption requires the use of various theoretical approaches to explain how attitudes, social norms and environmental factors influence pro-environmental behaviours.

The theory of planned behaviour (TPB; Ajzen, 1991) is considered paramount to the ESB field. This theory posits that behaviour is derived from behavioural intent, which is influenced by attitude, perceived social pressure from peers and perceived behavioural control. The TPB is frequently utilised to study behaviours associated with energy conservation, as it can be applied to demonstrate how social pressure and the perceived difficulty of behaviours affect an individual's decision to engage in ESB.

Another popular theoretical approach is norm activation theory (NAT; Schwartz, 1977), which focuses on the personal importance of norms and moral responsibility in promoting environmentally responsible behaviour. In the context of ESB, NAT suggests that individuals may lower their energy expenditures due to morality or environmental concerns even without receiving external compensation.

The value–belief–norm (VBN) theory (Stern et al., 1999) combines the ideas of environmental values, beliefs and personal norms into a chain that ultimately results in environmentally friendly behaviour. This model is particularly significant in explaining the habitual, long-term behaviours associated with electricity saving.

From a behavioural economics perspective, concepts such as nudge theory, bounded rationality and loss aversion are also applicable to ESB research. Strategies such as real-time feedback, behavioural framing and energy efficiency standards have demonstrated an ability to influence behaviour without restricting consumer freedom.

Due to the mix of theoretical approaches used, the study of ESB is an interdisciplinary field, but the application of theory lacks uniformity. While the theory–practice frameworks like TPB and VBN are commonly used, newer approaches like systems thinking and practice theory are less frequently applied. Additionally, the measurement of important concepts like motivation, awareness and feedback is inconsistent across investigations and contexts. The variety of proposed theories in the ESB field is indicative of the complexity of behaviours related to energy saving, and highlights the need for a more consistent theoretical approach. This study attempts to use bibliometric analysis to explain the evolution of theories applied to the examination of ESB, tracing the development of knowledge in the field.

3. MATERIALS AND METHODS

The global energy production and consumption pattern is undergoing profound changes (Saundry, 2019). Improving energy efficiency and promoting energy conservation are essential to addressing global energy challenges and promoting sustainable development (Purwanto et al., 2024). Promoting entrepreneurship is widely considered to be an important strategy

for encouraging sustainable energy development in developing countries (Gabriel, 2016).

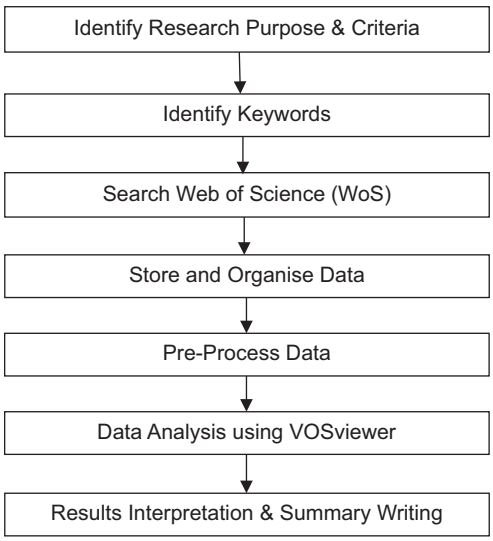
As a quantitative technique, bibliometric analysis can be used to assess the scientific literature by tracking patterns, trends and relationships between publications. Bibliometric research can help increase the depth of analysis of ESB approaches and detect trends, collaborations and the main challenges within the field (Masip Macía et al., 2025). The methodology of the present study, outlined in Figure 1, comprises several main steps, including defining the scope of the study, collecting the required data, pre-processing and preparing the dataset, data analysis with bibliometric tools and interpreting the findings to extract meaningful insights.

The first step of bibliometric analysis is to clarify the research objectives and develop screening criteria. To ensure the relevance of data to the research aim of understanding the development of and research trends in the field of ESB, several inclusion criteria were adopted for the study. Only literature published in English was considered. Studies in fields like energy and behavioural sciences were included in the dataset to incorporate viewpoints from different disciplines.

The Web of Science (WoS) database maintains a set of academic works from top journals and global meetings, ensuring that only validated, trusted research is included (Mansoor, 2025). The data for the study were obtained from the WoS Core Collection on 12 June 2025, via a search for the keyword "electricity savings behavior." A specific set of search terms was identified and applied to the retrieved records to determine whether they met the predefined criteria for inclusion in this study. Records that were deemed relevant were downloaded from WoS in a format that was compatible with the full records and referenced material (e.g.txt).

The downloaded documents were placed in structured folders and subfolders to maintain traceability and facilitate handling during the study. Every document had a visible tag. The data were pre-processed to eliminate redundant entries and standardise author names and keywords, as well as to check compatibility with the analysis software. Of the 1,713 records initially obtained, 1,230 met the inclusion criteria and were retained for analysis.

Figure 1: Research workflow



After pre-processing, the cleaned data were imported into the bibliometric software VOSviewer. VOSviewer works well with a large range of dataset sizes and is known for its visually appealing outputs. It can be used to construct co-authorship, bibliographic coupling and co-citation networks, as well as keyword co-occurrence maps on the major themes (Hu et al., 2022). Four specific analyses were carried out in this study. First, collaboration patterns were revealed through a co-authorship analysis between researchers, institutions and countries. Second, analysis of keyword co-occurrence helped identify clusters of themes and emerging issues. Third, citation analysis determined the most influential publications within the field. Finally, bibliographic coupling was used to uncover intellectual linkages and shared references among studies. Thresholds such as minimum keyword occurrence or citation count were adjusted to filter and focus the output on the most significant elements to enhance the interpretability of the resulting visualisations.

4. RESULTS AND ANALYSIS

4.1. Publication Trend Analysis

A total of 1,230 papers relevant to the field of ESB were identified and retrieved from the WoS database. The distribution of the publication of these papers across time indicates a large increase in the level of interest among scholars, beginning in 2015. Prior to 2010, the subject received very little attention, with fewer than 20 articles published each year. The number of publications peaked in 2021 at 160 papers, though the following years had similar outputs. This growing interest in ESB clearly mirrors the increasing global prioritisation of energy conservation and sustainability, and was likely catalysed by swelling awareness of climate change, technological support and energy policies. These results indicate that ESB has become an academic domain with substantial, increasing momentum. A detailed breakdown of the number of publications by year is presented in Figure 2.

4.2. Top Institutional Contributors

Analysing the institutional affiliations of the publications on ESB reveals a broad, international distribution of research activity on the subject. The United States Department of Energy (DOE) is the overall leader, with 33 publications. The Beijing Institute of Technology and the University of California System follow closely behind with 32 and 29 publications, respectively. These figures attest to the institutions' strong research capacity and, more importantly, sustained engagement with studies related to ESB. The remaining institutions reflect the truly global interest and collaborative nature of ESB research, including the Chinese Academy of Sciences, the Ministry of Education of China, the University of London, Tsinghua University, Delft University of Technology, the National University of Singapore and Fraunhofer Gesellschaft. These institutions have between 17 and 26 publications each. A detailed breakdown of institutional contributions is provided in Figure 3.

4.3. Top National Contributors

Several nations are pioneering the field of ESB scholarship. China is paying substantial attention to energy efficiency and sustainability at the national level, with 365 publications on ESB identified in this study. England has approximately 120 publications and is drawing more attention to its already well-established standing in traditional research in environmental and behavioural sciences. Other countries are also making considerably strong contributions. Italy, Spain and India, for example, have each produced between 60 and 100 publications. Countries like Sweden, France, Malaysia, Brazil and Saudi Arabia have also made contributions to the field, though at lower levels than other nations. These data suggest that while ESB research is internationally distributed, it is primarily driven by nations with strong policy frameworks, institutional capacity and targeted funding to support energy sustainability. A specific country-level breakdown of research publications is given in Figure 4.

Figure 2: Number of publications

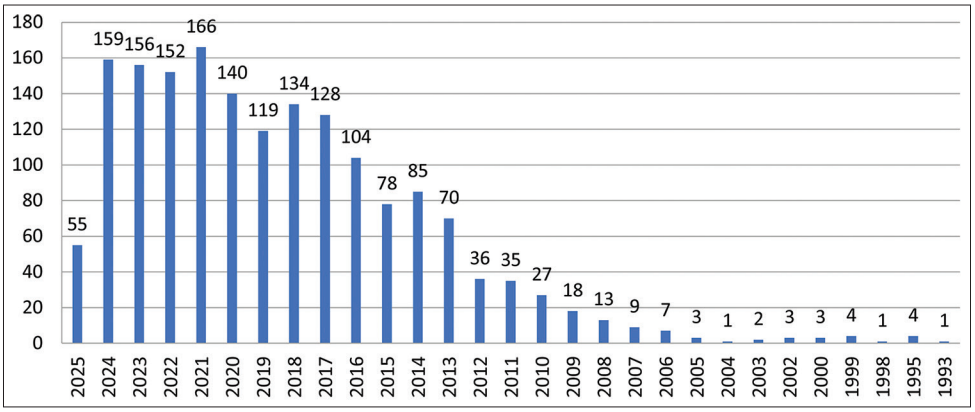


Figure 3: Top 10 institutional affiliations of researchers

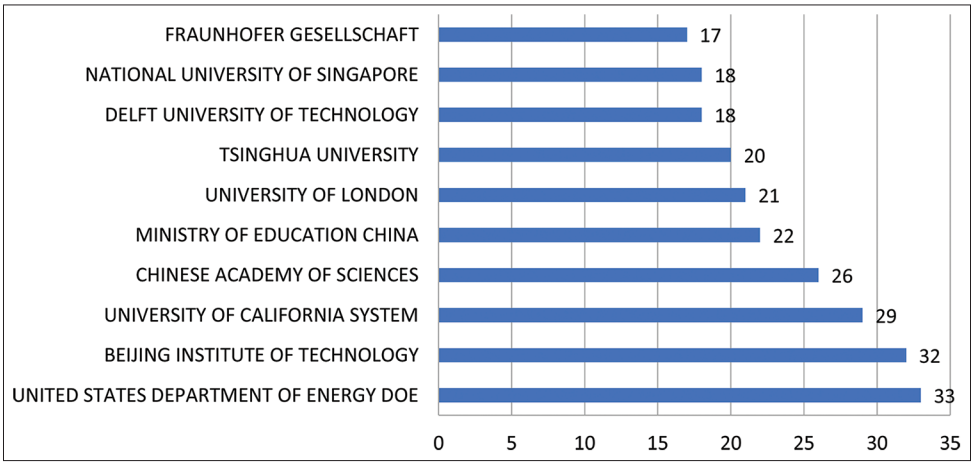
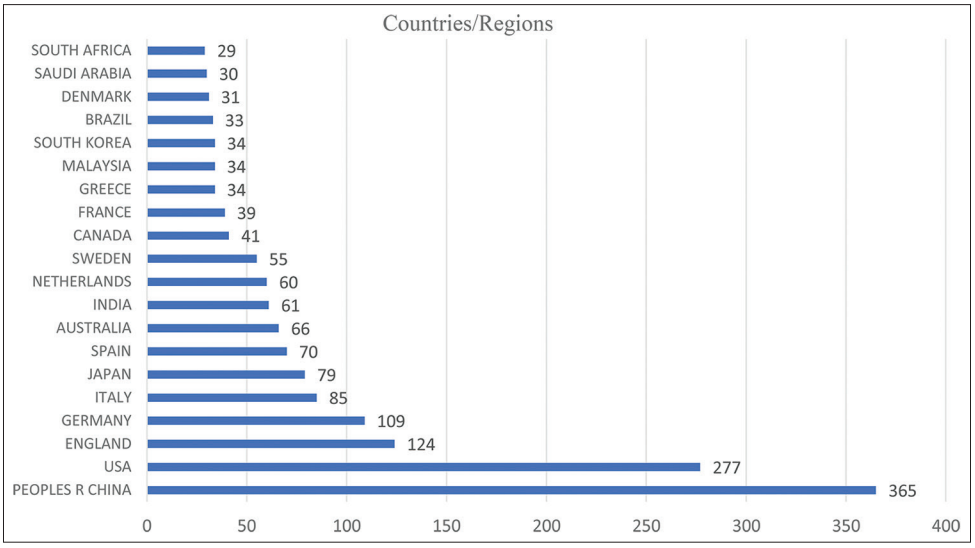


Figure 4: Publications by country



4.4. Keyword Co-occurrence Analysis

VOSviewer was used to conduct a keyword co-occurrence analysis, shown in Figure 5. This visualisation identifies the most frequently used keywords in the ESB literature, revealing the underlying thematic structure of the field. The resulting network map identifies several prominent clusters, each representing a distinct research focus. Central terms such as "behavior," "consumption," "conservation" and "energy efficiency" take dominant places on the map as they form the foundation of ESB studies. Other frequent keywords include "feedback," "determinants," "policy," "planned behaviour" and "pro-environmental behaviour," demonstrating the crucial role of psychological, behavioural, and policy-oriented aspects in electricity conservation.

The colour gradient of the nodes represents the average year of publication of each keyword, ranging from blue (2017) to yellow (2021). Recent research themes in yellow, with keywords including "extended theory," "habit," "climate' and "residents," reflect a recent swing in examining models of behaviour and their relationship to electricity use within a specific setting. Earlier studies were more centred on technological and intervention-related keywords (e.g. "buildings," "smart meters," "thermal comfort," "feedback"). This shift in keywords provides direct evidence of the changing focus of the field from infrastructure and technology to more human-centred concerns.

4.5. Citation Analysis

Figure 6 displays the citation network identifying the most influential publications within the research field of ESB. In the visualisation, the size of each node corresponds to the number of citations a publication has received. The colour gradient reflects the average publication year, from purple (2016) to yellow (2024), demonstrating the temporal dimension of influence.

Figure 5: Keyword co-occurrence analysis

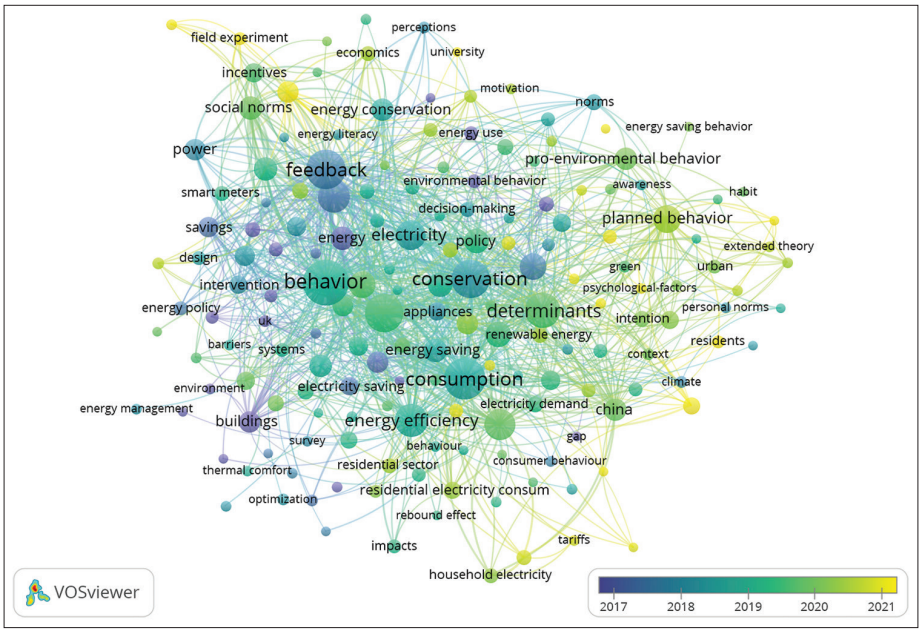
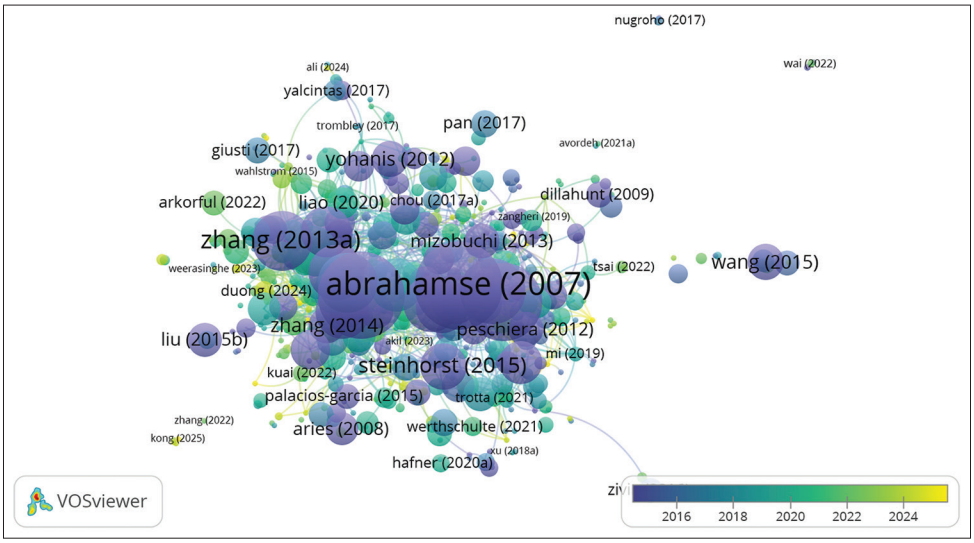


Figure 6: Citation analysis



The analysis identified Abrahamse et al. (2007) as the most cited publication of the dataset. This work has played a pivotal role in laying down foundational theories and methodologies associated with ESB research. Lasting links between this work and later ESB studies clearly indicate its perennial impacts. Other highly cited and influential publications like Steinhorst et al. (2015), Zhang et al. (2013a, 2014), Mizobuchi and Takeuchi (2013), and Wang and Li (2015) have greatly strengthened the theoretical and empirical advancement of the discipline.

Along with those seminal works, newer writings by researchers such as Liao et al. (2020), Duong (2024), Kong et al. (2025) and Ali et al. (2024) are gaining increasing citations, showing that new research paths and wider concept frameworks are developing in the ESB field. These changes are representative of a lively and growing research environment with new studies continuing to add depth and breadth to the basic literature.

4.6. Co-citation Analysis

Figure 7 shows the co-citation network of main publications in the field of ESB. This network indicates the frequency with which pairs of publications are cited together, depicting the intellectual structure and major thematic orientations of the field. Three main clusters are identified in this figure, each corresponding to different theoretical and methodological traditions.

The red cluster is based on core behavioural theories and fundamental social–psychological frameworks, especially the works of Ajzen (1991) and Stern (2000). The TPB and VBN theory hold the most prominence in this cluster, forming the theoretical core of a substantial portion of ESB literature. This cluster explores individual decision-making processes and normative influences on actions and intentions to save electricity.

The green cluster contains key empirical studies by Abrahamse et al. (2005, 2007), Abrahamse and Steg (2009) and Poortinga et al. (2004). These works are within the field of environmental psychology, concentrating on intervention strategies, behavioural feedback and household energy use. This cluster focuses on understanding how informational and contextual factors affect ESB in a residential setting.

The blue cluster is economically and politically oriented, with works by Allcott (2011), Allcott and Rogers (2014) and Delmas et al. (2013). It explores random selection control trials, pricing interventions, social norms and energy policies as mechanisms through which consumer behaviour can be influenced. The integration of behavioural economics and field experiments helps provide concrete evidence on the effectiveness of big interventions.

The tight links within as well as between clusters stress the hybrid theoretical approach used in ESB studies, linking behavioural science, economics and energy policy. This co-citation guide provides a clear depiction of the main works driving the growth of the field.

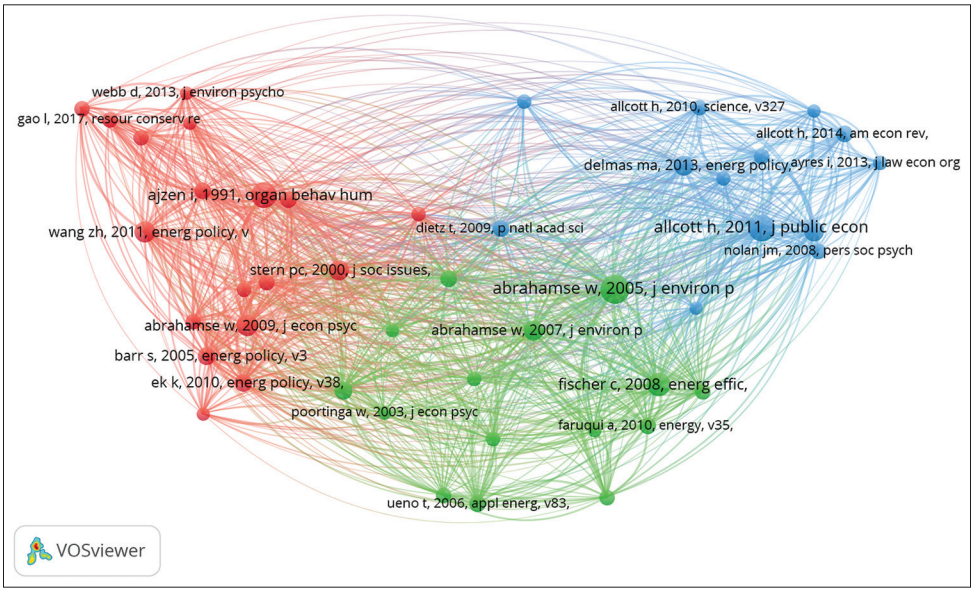
5. DISCUSSION AND CONCLUSIONS

5.1. Discussion

The analysis of 1,230 articles retrieved from the WoS database reveals a steep increase in academic interest in ESB, beginning in 2015. There was minimal scholarly focus on the domain prior to 2010, with fewer than 20 publications per year. A distinct increase in research output started in 2015, spiking to a maximum of 166 publications in 2021. Similarly high numbers of publications were also released in the years following 2021, reflecting a rising international interest in matters of energy efficiency, climate change and sustainability. This upward trend is on track to continue through 2025, suggesting that ESB will remain relevant in scholarly research and in policymaking.

Figure 5 provided a useful visualisation of the thematic evolution in ESB research. Terms like “behavior,” “energy efficiency,”

Figure 7: Co-citation network



"consumption" and "conservation" are at the centre of the figure, revealing their importance in the field. Other key terms in the network, such as "feedback," "policy," "planned behavior," "pro-environmental behaviour" and "determinants," show strong links to other disciplines like psychology, behavioural science and public policy. The colour-coding in the figure helps depict the shift in research priorities over time; earlier studies (in blue) focused more on technical and infrastructural solutions, with keywords such as "smart meters," "thermal comfort" and "buildings'. Later studies (in yellow) had a greater focus on the social, behavioural and contextual dimensions of ESG, emphasising terms such as "habit," "climate," "residents" and "extended theory." This change indicates a shift from technology-based to behaviour-based research methodologies and represents an indirect acknowledgement of the complex psychological and cultural conditions related to electricity saving.

As demonstrated in the citation network shown in Figure 6, Abrahamse (2007) can be considered the most central and influential work in the domain of ESB. It serves as an important reference link to a large number of subsequent studies. Other key works, including Steinhorst et al. (2015), Zhang (2013a, 2014), Mizobuchi and Takeuchi (2013), and Wang (2015), have also made a significant contribution to the development of the scholarly discourse on ESG. Newer works with growing scholarly interest include Liao et al. (2020), Duong (2024), Kong et al. (2025) and Ali (2024). These scholars are providing new insights and changing the thematic directions of ESB research.

The co-citation network shown in Figure 7 explains the intellectual roots of the ESB field, revealing three distinct thematic clusters. The first focus is basic theories of behaviour, in which TPB (Ajzen, 1991) and VBN theory (Stern, 2000) have become cornerstone frameworks in the study of pro-environmental behaviour. The second cluster comprises empirical studies in the field of environmental psychology, placing greater focus on intervention-based research and household-level energy behaviour. The final theme is economic and policy-oriented work, which explores ESB through methods like randomised control trials, pricing strategies and social norms. Together, these clusters reflect the interdisciplinary nature of the field, integrating psychological, empirical and economic-policy perspectives.

Research on ESB has evolved into an extremely interdisciplinary and dynamic field that draws on perspectives from behavioural psychology, public policy, and economics to shed light on how individuals and households consume electricity. A significant increase in publications in recent years is indicative of growing global concern about sustainable energy, catalysed by the demands of climate change and governmental policies demanding energy efficiency. Current studies show a trend towards more holistic and contextual approaches. Rather than considering only the technical aspects of ESB, recent studies are also taking into account social, cognitive and policy dimensions of ESB. The terms 'habit', 'planned behavior', 'feedback' and 'pro-environmental behavior' often appear together in more recent research, showing increasing attention towards the psychology of drivers and strategies for behavioural change.

The ESB field has evolved from primarily focusing on infrastructure and technology interventions to something much more sophisticated: an exploration of human behaviour. The work in this growing and diverse body of literature can help inform effective policy, practice and research interventions for promoting sustainable electricity use and larger ambitions regarding environmental sustainability and climate resilience.

Finally, this research on individual ESB supports businesses seeking to develop and build electricity-saving policies by optimising the user experience. Firms are increasingly trying to promote ESB in more natural way through gamification that turns energy saving into an attractive activity with rewards and social competition (Hamari et al., 2014), promoting environmentally friendly choices as a default setting (Thaler and Sunstein, 2008), and personalised feedback on energy consumption which allows users to be more aware of their behaviours and make timely adjustments (Fischer, 2008). Integrating ESB into circular business models is also a key strategic direction for practitioners. The development of the sharing economy and collaborative consumption help reduce the number of high-energy-consuming products needed, optimising resource use (Frenken and Schor, 2017). This model focuses on reducing direct consumption and aims to redesign the value chain to reduce overall energy demand and encourage energy efficiency and sustainability. Although these activities primarily take place at the organisational level, they create an environment in which individual ESB behaviours are integrated into a more comprehensive and sustainable energy ecosystem. Insights into individual ESBs can help companies develop more effective, user-centric energy conservation strategies. Unlike traditional information-based approaches, future approaches can enhance user engagement by incorporating intuitive user experience elements such as eco-defaults and personalised, real-time feedback to encourage sustainable actions in a more natural and engaging way. These techniques will not only facilitate timely and efficient decision-making, but are also closely tied to overall sustainability goals. While these efforts begin at the organisational level, they will ultimately integrate individual energy-saving habits into a broader, more sustainable energy philosophy.

5.2. Conclusions

This study conducted a wide bibliometric review of 1,230 academic papers on ESB, revealing increasing relevance and important academic and practical applications. Research activity has grown rapidly since 2015, with publication volumes hitting their peak in 2021 and remaining high in the years that followed. Co-occurrence and citation network results demonstrate that ESB is a multidisciplinary field integrating the behavioural sciences, psychology, economics and public policy. The shift in key themes from technical and infrastructural interventions to informed behavioural and context-sensitive applications reflects an increasing orientation towards the human component of energy use. This study helps scholars understand the ESB literature by mapping publication trends, conceptual bases and its thematic evolution. It identifies the primary authors, works and new inquiry groups, giving scholars and practitioners a strategic view of the field's landscape.

The findings point to the need for further research in understanding the socio-cultural drivers of ESB, aiming to better understand the motivating forces of behaviour. Context-specific interventions are needed for different settings, as a nudge in one case could be taking those already performing into an even more constructive practice of sustained energy-saving actions. Policymakers and practitioners should apply the insights to encourage more efficient energy use and also look beyond technology. Additionally, a study of the role community technology and climate information play in altering electricity use is long overdue. Future research should include longitudinal studies that enable actual changes in behaviour to be measured over time and region-to-region comparisons to test the generalisability of approaches. Including big data and AI in research could help develop adaptive, real-time energy conservation strategies.

6. LIMITATIONS AND DIRECTIONS FOR FUTURE STUDY

Though it offers valuable insights into the evolution and intellectual structure of ESB research, this study is not without limitations. First, because the dataset was collected only from publications in the WoS database, it is possible that some significant contributions available in other academic databases like Scopus, Google Scholar or IEEE Xplore may have been overlooked. The use of a single database may have constricted the study and not included the full breadth of ESB scholarship from around the world.

Second, the bibliometric approach emphasises quantitative indicators, such as publication volume, citation counts and keyword co-occurrence. While these data points are effective in identifying broad trends and influential actors, they do not provide insight into the qualitative richness, theoretical depth or methodological rigour of individual studies.

Third, the interpretation of keyword clusters and thematic patterns relies on co-occurrence and co-citation algorithms. Though these approaches are generally accepted as producing clear maps, there is a possibility that critical connections might have been lost, especially emerging themes that cut across disciplines and may be better expressed in the vocabulary of one discipline over another. Certain nuanced or context-specific areas of inquiry may be underrepresented or misclassified in the analysis.

Finally, this study did not evaluate the real-world impact or practical effectiveness of electricity-saving interventions, which would be directly beneficial to practitioners and policymakers seeking to design and implement behaviour-based energy conservation programs.

To correct these shortfalls, a diversified methodological approach should be adopted by future research. Data collection should be extended to include significant databases other than the WoS, such as Scopus, Google Scholar, IEEE Xplore and ScienceDirect. Such expansion could produce a larger set of contributions and other types of sources not included in the present research, including conference proceedings and important interdisciplinary works. Doing so would provide a more general and holistic understanding of the global scholarship on ESB.

In parallel, using qualitative content analysis would enable researchers to take a deeper look into the theoretical foundations, conceptual models and methodological approaches underpinning the ESB literature. It could help identify implicit patterns and meanings which quantitative bibliometric tools might overlook.

Finally, evaluating the outcomes of practical interventions on electricity savings requires real-world case studies. Case-based insights would close a knowledge gap by helping practitioners and decision-makers understand academic findings and implement them in policies or programs intended to encourage behavioural change. By integrating these methods, future research can take a more comprehensive, more nuanced exploration of ESB, leading to the design of increasingly targeted, evidence-informed and impactful strategies for promoting sustainable energy use.

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