EXPLORING THE TRANSITION OF SMART ELECTRICITY USERS TO GREEN CONSUMERS: AN OPEN KNOWLEDGE MAPS ANALYSIS

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Abstract

The era of technology and smart electricity is a technological advancement for households that use smart electricity. This research aims to discover the potential of smart electricity users to become green consumers. Therefore, we use the Open Knowledge Map platform to find out the behaviour of smart electricity users using cluster visualisation. The data used are research papers from 2013 to 2022. Hence, we found 11 clusters of related articles. The main focus of the research cluster is the social behaviour, construction user, and consumer behaviour cluster, which is related to green consumer behaviour from the behaviour of households using smart electricity. Furthermore, we have confirmed the potential household smart electricity users to become green consumers. Therefore, we have a construction related to the potential of smart electricity user households to become green consumers for further research.

Keywords: Smart Electricity, User, Household, Green Consumers

Introduction

In recent years, the trend of green consumerism has shown significant growth. Green consumers are smart shoppers and agents of change who inspire their communities to live more sustainably. They consider various environmental aspects in every purchase, from raw materials and production processes to product packaging. Their existence shows that environmental responsibility has become integral to modern consumption behaviours.

The presence of technology changes consumer behaviour. (Albarsyah, 2023; Ekawati et al., 2023) Because they know how to use technology and knowledge to fulfil user needs (Alfian et al., 2019; Sa'adah et al., 2022; Subianto, 2017). Energy consumption generally continues to grow. (Klyuev et al., 2022). The highest electricity consumption occurs in China, the United States, India, Russia, and Japan. Accordingly, Indonesia's electricity needs 2050 are estimated at 1,611 TWh, while its production capacity is only slightly above that, around 1,767 TWh.

In such circumstances, efforts are needed to save electricity usage by managing usage at the household level, which is possible through the use of smart forms of electricity. The growth of smart technology continues to develop along with the discovery of electricity-based technology, so using batteries is inseparable from using energy. Electrical energy is one source to be able to operate technology. With unstable or abnormal increases, electricity users will increase in 2021 (Klyuev et al., 2022).

In his research, (Xiang et al., 2019) argue that increasing energy use should be considered abnormal, given that electrical energy is a fundamental need that consistently sees significant growth, particularly with the rise in household appliances. (Harahap R. et.al, 2022), further contend that income and electricity prices are the primary factors driving this increase in consumption. According to (Mutia et al., 2017), efforts to stabilise electricity use necessitate continuous monitoring of electrical energy consumption. Their study also highlights that excessive electricity use and unexpected costs negatively impact household economies (Pasaribu, 2022a). (Purnomo, 2020) posits that the proliferation of new tools designed to facilitate work contributes to higher electricity consumption, a claim supported by research on the development of smart networks (Abi et al., 2014; Herrmann et al., 2018; Lund et al., 2017; Thoma et al., 2018). (Putri & Idris, 2021) reveal that the ease of completing tasks without considering the costs incurred leads to excessive electricity use and the need for both short-term and long-term electricity purchases. These findings collectively suggest that while technological advancements and economic factors drive increased electricity consumption, they also underscore the need for more sustainable consumption practices.

Smart electricity actually has an extraordinary function in the ease of monitoring usage and the amount of load incurred on the use of devices. The results of the publication (Alrawi et al., 2019; Chawla et al., 2020), both explain that the demand for electricity has continued to increase in recent years. Excessive use of electricity will have an impact on depleting available electricity resources. According to research results (Ibrahim et al., 2021), the power plant that produces electricity will run out quickly. In order to maximise electricity use, smart electrical is a priority in controlling excessive energy use, and it is stated by (Alani & Osunmakinde, 2017; Jianyuan et al., 2022), so that it can detect the amount of electricity consumed.

(Klyuev et al., 2022) Electrical energy is produced from several world energy sources, namely 29% from oil, 27% from coal, 24% from natural gas, 10% from biomass. The use of electricity sources triggers an increase in the cost of paying for the energy used. Centralised energy with smart meters allows users to play

an important role in controlling usage. (Rommetveit et al., 2024). (W. Li et al., 2024) A new paradigm takes a more active role in managing their energy consumption. (Pasaribu, 2022b).

An active role in managing energy use reduces the negative impact on the environment through consumption choices, reducing pollution and waste in landfills. By using energy and controlling it using technology, there is an effort to create and motivate environmentally friendly consumers. Using energy-efficient devices, energy-efficient lighting, and integrating sustainable principles.

Digital technology facilitates two-way communication between electricity network operators and end users, enabling real-time monitoring and control of electricity use. (Mardini et al., 2020),(H. Li, 2016)Several researchers have realised the enormous potential of data collected by smart grids, which can be used for a variety of applications, including billing calculations, load management research, and customer feedback recorded on smart meters. (Lasch, 2010).

This research critically examines existing studies on smart electricity users to uncover trends and identify key research clusters in the field. By analysing these patterns, we seek to illuminate the most advanced areas of research related to smart electricity users and smart meters. Consequently, we pose several research questions that challenge current understandings and seek to advance the discourse: (RQ1) How are green consumers defined within the context of smart electricity? (RQ2) Which research clusters specifically address the behaviours of smart electricity users? (RQ3) What insights from the Open Knowledge Map reveal the trends in smart electricity research towards fostering green consumers? (RQ4) In what ways does the adoption of smart electricity technologies contribute to the development of green consumers? (RQ5) What future research directions should be pursued to explore the potential of smart electricity users further? By addressing these questions, this study argues for a deeper investigation into how smart electricity can drive sustainable consumer behaviours and pave the way for future innovations.

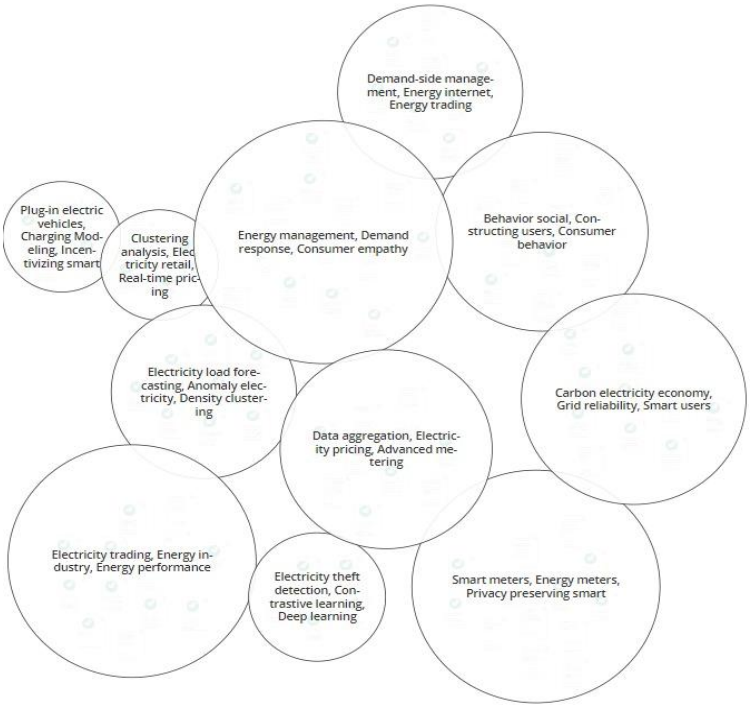
Literature Review

This article searched for literature through data visualisation from the Open Knowledge Maps platform. Open Knowledge Maps is an open-source tool for visually mapping scientific knowledge. It allows users to create concept maps and make connections between materials. (Kraker et al., 2016).

The Open Knowledge Map aims to create a visual link to scientific knowledge worldwide. (Kraker et al., 2016; Tong & Mitra, 2008) explain that each area is positioned closer to each other than to different subjects, making grouping easier and easier to examine.

Open-access documents simplify the analysis process because we can analyse documents in detail. This differs from closed-access documents, which can only be viewed in the abstract. The parameters used in searching for articles begin with determining the keyword "smart electricity user." The double quotation marks ("") aim to get the keywords for smart electricity users that are not separated.

Next, from the data collected, a selection is made based on the year of publication of the research journal article from 2012 to 2024. Meanwhile, the type of metadata sought is high-quality metadata. In addition, all articles are written in different languages to provide more comprehensive information.



Source: (Open Knowledge Map, 2024)

Figure 1. Review of Research on Smart Electricity Users

From mapping using Open Knowledge Maps, 11 clusters were obtained related to keywords used by smart electricity users, so one of the clusters was taken, which will be developed in this research based on the cluster related to the behaviour of smart electricity users, which will be developed in the literature review.

Methods

This research method uses Open Mind Mapping, which is fundamental to smart electricity users. To obtain this mapping, article mapping was done by accessing Open Knowledge Maps to get information based on research on smart electricity users.

Open Knowledge Maps produces 100 articles related to smart electricity users. Then, an examination of research clusters referring to the behaviour of smart electricity users was carried out. From the selected clusters, mapping was carried out to develop a connection between smart electricity users becoming green consumers when purchasing smart electricity and the energy consumption entered into the smart ammeter.

Discusssion

What are green consumers

Research by (Abeliotis et al., 2010; SuboohYusuf & Zeenat Fatima, 2015), states that a green consumer, also known as an environmentally conscious consumer, considers the environmental impact of a purchase decision for a service or product. Green consumers actively seek to minimise their ecological footprint by choosing products and services that are environmentally friendly, sustainable, and ethically produced.

(Lin & Hsu, 2015) States that green consumer behavior is influenced by personal self-concepts, personal outcome expectations, and social sanctions, while climate change and mass media have no significant impact. Likewise the opinion (Sandu, 2014), green marketing and environmentally friendly products are becoming increasingly popular among green consumers, promoting sustainable development and reducing environmental impact.

Consumers who are environmentally conscious tend to prioritise products and practices in their purchasing decisions. This awareness is reflected in their behaviour, motivations, and challenges, which have been studied extensively and reveal some key insights and trends.

From the insights they have, someone who has an understanding of being environmentally conscious will have a sense of concern for environmental issues and attitudes toward purchasing behaviour, according to research. (Young et al., 2010). (Akenji, 2014) Consumers are motivated to make decisions by using environmentally friendly products systematically. Attitudes toward environmentally friendly behaviour can arise from demographic factors such as age, income, and education. (Abeliotis et al., 2010)Such as in Greece, where young people with high incomes are more involved in environmentally friendly behavioural attitudes.

(Connolly & Prothero, 2008) Consumers who are environmentally conscious are closely related to self-identity and individual responsibility for environmental issues, which can accompany doubts and ineffective decisions. For example, as stated by (Lin & Hsu, 2015), that environmentally friendly consumer behavior has a role in self-efficacy and social influence on environmentally friendly behavior. In this regard, (Shrum et al., 1995) also stated that environmental awareness has increased, along with high environmental costs and scepticism towards environmentally friendly marketing claims.

Varios Cluster

As a result of searching for articles with the keyword Smart Electricity Users, the results of research group clustering were obtained so that there were 11 research clusters. Each cluster shows each research theme of smart electricity users. The results of research theme clustering are displayed in the following table.

Table 1. Open Knowledge Map Cluster Data Tabulation

Cluster	Item	Source
Cluster-1	Energy management, Demand response, Consumer empathy	14
Cluster-2	Electricity trading, Energy industry, Energy performance	13
Cluster-3	Smart meters, Privacy-preserving smart Energy meters	13
Cluster-4	Carbon electricity economy, Gird reliability, Smart users	11
Cluster-5	Behaviour social, Construction users, Consumer Behaviour	10
Cluster-6	Data aggregation, Electricity pricing, Advanced metering	10
Cluster-7	Electricity load forecasting, Anomaly electricity, Density clustering	8
Cluster-8	Demand-side management, Energy internet, energy trading	8
Cluster-9	Electricity theft detection, Contrastive learning, Deep learning	5
Cluster-10	Clustering analysis, Electricity retail, Real-time pricing	4
Cluster-11	Plug-in electricity vehicles, Charging Modeling, Incentivising smart	4

Source: Author, based on Open Knowledge Map

From the results released by the Open Knowledge Map, it was found that the most dominant cluster showed significance in smart electricity users, namely energy management, demand response, and consumer empathy, which consists of 14 articles. Furthermore, the most significant one does not intersect with smart electricity users but is connected to green consumers in the electricity trading, energy industry, and energy performance cluster consisting of 13 articles.

An explanation regarding the tabulation results of research clusters in cluster 1 discusses electricity users managing electricity usage by monitoring electricity usage from smart meters and consumers having empathy to manage the costs incurred to enjoy the electrical energy used. This cluster explains the use of smart electricity with smart meters from the consumer side to strive for environmental friendliness of the energy used.

Cluster 3 and cluster 4 group research is based on installed smart meters, raising the consumer's perspective on using energy which appears on the smart meter, recording usage, and inputting energy input to be used. Controlling usage based on smart meter users can control usage and create economic value.

Cluster 5 is an area where the use of electricity with smart meters controls electricity use in terms of consumer behaviour, encourages users to care about the energy they have purchased and used, is concerned about the environment, and cares for other users.

Cluster 6 and Cluster 10 articles in this area are more inclined to examine the price of energy purchased by users and the price of electricity purchased according to current prices, including green consumers. The purchased energy is input into the smart meter in the form of numerical data to distribute electrical energy to the user.

Clusters 9 and 11 articles that fall into this area are more inclined to examine electricity use by turning on electrical devices, charging them, and using smart electricity used by users to monitor the detection of energy used.

For Cluster 2, Cluster 7, and Cluster 8, the articles included in this area research that energy can be purchased anywhere, making it easy for users to buy energy tokens that are used or input into smart meters.

The main focus of this research is cluster 5: social behaviour, construction users, and consumer behaviour. Based on cluster 5, user behaviour in using smart electricity will be developed, and the literature review will focus on green consumers. To provide an overview of the research, a tabulation of previous research will be displayed based on the results of mapping articles produced by the Open Knowledge Map.

Research trends relate to smart electricity users, so this study focuses on users who refer to green behaviour. Green behaviour, one of which is seen in purchasing behaviour (Haba et al., 2023), (Borah et al., 2024).

Table 2. Search Results for Journal Articles

No	Journal / Proceedings	Writer	Amount
1	IEEE Innovative Smart Grid Technologies-Asia	(Horsmanheimo et al., 2013)	1
2	Energy Efficiency springer	(Nyborg & Røpke, 2013)	1
3	IEEE Electrification Magazine	(Dimeas et al., 2014)	1
4	Information Systems Frontiers	(Lukić et al., 2017)	1
5	Power engineering: economics, technique, ecology	(Denysiuk, 2014)	1
6	Energy Economics	(Tsao & Vu, 2019)	1
7	The 17th International Conference of Young Scientists on Energy and Natural Sciences Issues	(D. Stanelytė, 2021)	1
8	i-com - Journal of Interactive Media	(Egert et al., 2021)	1
9	POWER ENGINEERING: Economics, technique, ecology	(В.Ю. Лободзинський, М.П. Бурик, О.В. Петрученко, 2022)	1

The next step is to select articles from the mapping results that do not use English. Then, English articles can be collected as a reference for the next step.

Table 3. Mapping of Research Constructs

No	Potential Users	Writer
1	Controlling electricity usage with cellular communications	(Horsmanheimo et al., 2013)
2	Households control flexible electrical energy.	(Nyborg & Røpke, 2013)
3	Control and monitor smart meters in households.	(Dimeas et al., 2014)
4	Business intelligence for smart grid supply chains	(Lukić et al., 2017)
5	Different pricing and purchasing policies maximise benefits for users	(Tsao & Vu, 2019)
6	Increase system efficiency and smooth loads through flexible generation planning and dynamic pricing.	(D. Stanelytė, 2021)
7	Prosumer involvement motivates people to contribute by adapting their electricity consumption to the needs of the energy grid.	(Egert et al., 2021)

The articles taken were in English, and seven of them met the requirements, as shown in the mapping in Table 3.

Based on the main focus of the research cluster, a search was conducted using Google Scholar to analyse the number of citations of articles from the cluster related to user behaviour, so it was decided that the research article, (Nyborg & Røpke, 2013), obtained 171 citations from articles based on clusters.

From various stages of the search, it becomes evident that the behaviour of smart electricity users is quite diverse. To gain more detailed insights, we filtered the data to focus specifically on households using smart ampere meters. However, this approach alone is insufficient. Further analysis is required to understand the potential of these smart electricity consumers to transition into smart-friendly users.

Smart electricity users and green consumers

In the context between smart electricity users and green consumers, as seen from the behaviour that occurs today, consumer lifestyles continue to develop along with emerging technology alongside daily activities. Research trends are related to smart electricity users, so this study focuses on users who refer to green behaviour. Green behaviour is seen in purchasing behaviour. Smart grids rely on active consumer engagement to efficiently balance energy supply and demand and proactive consumer engagement, such as adjusting consumption.

As smart electricity users, according to (Perri et al., 2020) is to adopt smart energy consumption behaviour positively. Attitudes, subjective norms, and perceived behavioural control become factors influencing intention. In line with the opinion (Raihanian Mashhadi & Behdad, 2018) using smart electricity is closely related to intelligent feedback so that it can improve energy conservation behaviour and reduce total electricity consumption applied, especially in households, by up to 20%.

Likewise, the opinion of (Alkawsi et al., 2020) increase the knowledge of consumers who understand how to save electricity and have a sense of environmental concern regarding the theory of acceptance and use of integrated technology, resulting in a significant increase in green consumers.

Reasons to be green consumers?

Using electrical energy to fulfil daily needs is fundamental to saving electricity usage. (Palety & Mahalakshmi, 2022). Using electrical energy to fulfil daily needs is fundamental to saving electricity usage, which has the potential for electricity to be used all the time, even during busy times (Ur Rashid et al., 2020).

Smart electricity users in households have the potential to see the behaviour of smart electricity usage where (Pasaribu, 2022a). The involvement of electricity in the process is an initial and sustainable step towards green users. Users can purchase electricity independently by inputting it into the installed smart ammeter and monitoring electricity usage when connected to the mobile application (Horsmanheimo et al., 2013).

Behaviour that is carried out independently and reduces significant environmental impacts can directly affect green consumer efforts. Efforts to become a green consumer begin with changes in behaviour and control over the resources used, striving for the energy used according to needs. Utilizing energy according to needs, of course, provides energy sustainability efforts. Energy sustainability occurs from the efforts of consumers who are aware of the environment, energy sources come from the environment that is processed to create energy that is utilized by all groups.

What research can be developed on smart electricity users?

Based on seven articles discussing the potential for using smart electricity for consumers to be green consumers, no paper analyses intense household empathy in using electricity for other users, still implementing the concept of using smart electricity according to existing needs. Thus, from the Open Knowledge Map analysis, discussing the behaviour of household smart electricity users, only one article discusses that smart electricity users can resell electricity using cellular networks (Horsmanheimo et al., 2013). Apart from that, consumer friendliness towards the environment can function as mediation or moderation in the context of further research.

From various stages of the search, it becomes evident that the behaviour of smart electricity users is quite diverse. We filtered the data to focus specifically on households using smart ampere meters to gain more detailed insights. However, this approach alone is insufficient. Further analysis is required to understand how these smart electricity consumers can transition into green consumers—households that use electricity efficiently and adopt sustainable practices and renewable energy sources. The goal is to identify strategies that encourage households to minimize their environmental impact and embrace a more sustainable lifestyle.

Conclusion

The results of visual mapping using an open knowledge map obtained 11 clusters related to smart electricity users. From these clusters, cluster 5, which includes social behaviour, construction users, and consumer behaviour, was chosen to find potential smart electricity users and green consumers. Seven articles were selected using English from several articles based on these clusters.

Green consumers are created from their daily behaviour to buy smart electricity. Smart electricity monitors energy purchased independently by users, especially households, using smart electricity and input into smart ammeters. Users can monitor and record usage via applications connected to the smart network and the behaviour of green consumers. Smart electricity users control flexible usage according to the number of electronics used in the household, so household costs vary. Purchasing decisions and costs vary according to each household's policy for using smart electricity and contributing to other energy uses.

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