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Households Electricity Consumption Analysis: A Bibliometric Approach

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Abstract: The household electricity consumption ranks in the second position after the industrial electricity consumption, across the globe. This is because of the factors, which include, higher consumer income, electrification, digitalization and advancement in technologies. Moreover, the electricity demand is also depending on household characteristics, non-household characteristics and occupant's behavior. The aim behind this study is to provide insights to researchers on household electricity consumption areas with different aspects, which includes factors affecting them, need of data collection, its approaches and techniques. To know about the research dedicated to the above-mentioned aspects, it is crucial to explore the Scopus database, refer recent patent details, and know the work contributed by eminent authors in this field. For this study various tools like Power BI, VOSviewer, ScienceScape, Microsoft excel and Draw io tools are used for data visualization and interpretation with database obtained from Scopus. This bibliometric analysis is done for 17999 main documents, with emphasis on keywords like electricity, household, energy efficiency. This work would serve as initial step for household electricity consumption analysis research, which would be beneficial for the researchers and government agencies.

Keywords: Bibliometric analysis, Household, Electricity consumption, Scopus, Survey.

1. Introduction

At present, Energy Efficiency (EE) and Energy Conservation (EC) related codes and regulations are essential to address the increased energy demand, power stability and reliability challenges. As per the 2018-year report from International Energy Agency (IEA), there is an increase of 3% in energy-demand from the building sector. This enhanced energy demand is due to the constant increase in electrification, boosted appliance ownership, income level and technological developments. In world, total energy demand from the building sector is around 50%, which contributes to 30% CO_2 emissions. By using non-renewable energy sources and excess energy conservation with less efficiency will lead to higher rate of carbon emission. Hence, policy-makers are focusing more on implementing EE and EC-based programs (Sadeghi et al., 2020).

Now-a-days, many countries are working globally on programs related to smart city and micro-grid development using renewable energy sources for end-users. The European Union (EU) have started implementing concept like nearly Zero Energy Buildings (nZEBs). In addition to this, Energy Performance Certificate (EPC) initiative also supports the nZEBs. Despite the initiatives, EU is facing many obstacles in implementing EE and EC based programs. (Li et al., 2019).

The Household Electricity Consumption (HEC) analysis needs to be considered for both national and international factors. Moreover, in HEC the major loads are from the heating load (HL) and cooling load (CL), which are required for comfort and safety in wavering seasonal conditions (Sadeghi et al., 2020).

Furthermore, the HEC has a significant role in rising greenhouse gas emissions, which leads to the risk of global climate change. The preventive step is to work more on household electricity conservation and efficiency aspects. For this, it is important to answer several open-ended research questions, which include the consumption of electricity by the occupants of the household, their pattern of using the electricity, other affecting parameters on the consumption of electricity, etc. These research questions can be handled by three approaches: one is top-down and bottom-up and the third is a hybrid or combination of the first two approaches (Druckman & Jackson, 2008; Ferna et al., 2011; Jones et al., 2015). The top-down approach is used at nationwide electricity consumption study purposes, which considers aggregated data like national energy statistics, gross domestic product (GDP), population survey statistics, etc. The bottom-up approach is used at demand side and individual house level, which establishes associations between socio-economic, occupant's behaviors and lifestyle, dwelling characteristics and its use (Ã & Yau, 2007;

Baker & Rylatt, 2008; Bedir et al., 2013; Jones et al., 2015; Mcloughlin et al., 2012; Sanquist et al., 2012). The hybrid consumption analysis approach includes aggregated national level dataset and local survey based dataset for the HEC analysis.

Furthermore, household energy load demand is dynamic in nature, as it depends on many factors which are classified in to household and non-household factors. The household based factors include socio- economic, dwelling characteristics, appliances, lifestyle and behavior of occupants. The non-household based factors include national and international regulations and policies, electricity price, macro-economic, calendar events, weather conditioning, culture, psychological (Chunekar & Sreenivas, 2019; Jones et al., 2015). This factors should get addressed through different aspects (top-down, bottom-up or hybrid) for HEC analysis. The socio-economic factors consist of occupant's characteristics, number of family members with their age groups, education level in the household, annual or monthly household income, etc. The dwelling characteristics include household type, number of rooms, heating system type, etc. The appliance factor includes ownership level with its age, size, appliance wattages, frequency usage, etc. Weather conditioning includes various parameters like temperature, humidity, pressure, wind speed, wind direction, rainfall amount, and evaporation (Amasyali & El-Gohary, 2017; Jones et al., 2015). Thus, the proper selection and combination of household and non-household based factor is the significant step for better HEC analysis.

1.1 Previous Work

Moreover, there are three main methods which analyses the impact of diverse factors on domestic electricity consumption. The first method is statistical, the second method is regression analysis and the third method is econometric. The first two methods can be used for top-down and bottom-up electricity consumption approaches with the requirement of huge datasets (Jones et al., 2015). The third method is mostly used for HEC analysis using a socio-economic dataset.

Figure 1 shows the data collection techniques based on HEC analysis as bottom-up aspect. Figure 1 shows nine common data collection techniques namely: personal interviews (Ã & Yau, 2007), phone surveys (Ndiaye & Gabriel, 2011), electricity meter readings from energy service provider company or utility (Bartusch et al., 2012), household electricity monitoring (Ndiaye & Gabriel, 2011), sub-metering of appliances (Parker, 2003), questionnaires (Bartusch et al., 2012), energy audits(Ndiaye & Gabriel, 2011), national household surveys (Wyatt, 2013), and utility bills (Jones et al., 2015; Sanquist et al., 2012).

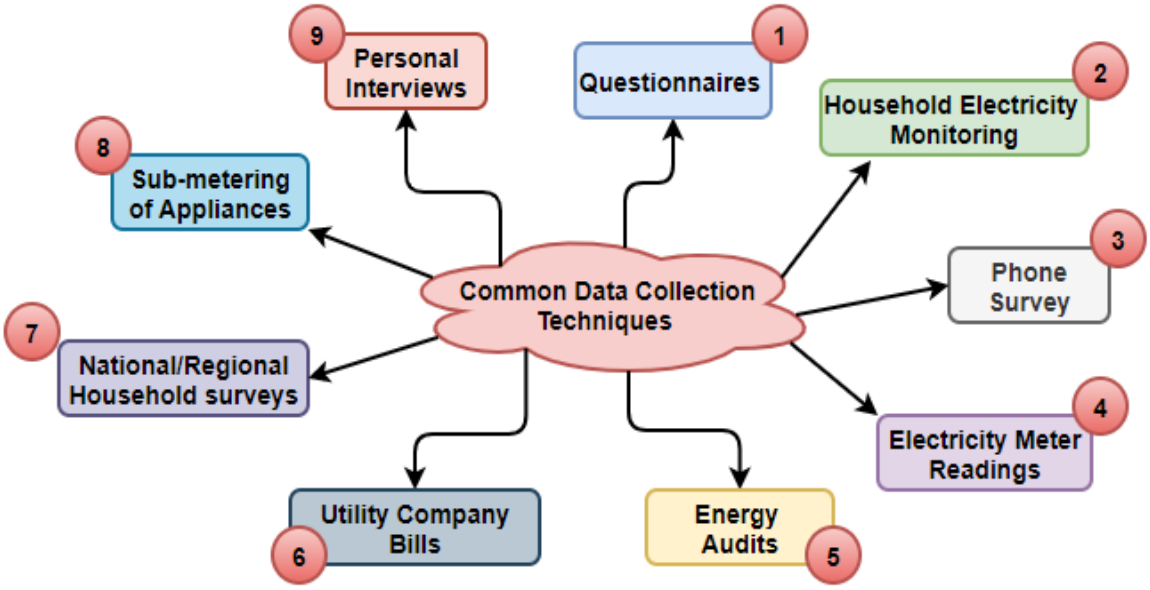

Figure 1. Data collection techniques

A lesser research work has been done in HEC load as compared to commercial and industrial type loads. The main reason is due to lack of sufficient real datasets, which is a consequence of lesser implementations of Advanced Metering Infrastructure(AMI). The sensor-based data collection involves factors like cost and privacy issues. Apart from this, many factors like occupant's lifestyle, uncertainty in the usage of loads and weather conditions creates the complexity in HEC analysis. Although, HEC is having potential and also the needs to work more on this domain (Amasyali & El-Gohary, 2017). Predictive modeling is the one approach which helps to energy providers to manage the demand with power stability. The Demand Side Management (DSM) is an important component in Smart Grid (SG), which also helps in reducing the electricity bill of consumers and Green House Gases (GHGs). Mainly three predictive modes are used in load forecasting namely: engineering, Artificial Intelligence (AI), and hybrid (Amasyali & El-Gohary, 2017; Wang & Srinivasan, 2017; Wen et al., 2020).

1.2 Objectives of Paper

There are four main objectives of this bibliometric study paper. The first objective is to provide insights to researchers on HEC areas with different aspects, which includes bibliometric study, factors affecting them, need of data collection, its approaches and techniques. The second objective is to know about the research dedicated to the above-mentioned aspects, explore the Scopus

database, refer to recent patent details, and know the work contributed by eminent authors in this field. The third objective is to know the various tools like Power BI, VOSviewer, ScienceScape, and Microsoft excel and Draw io used for data visualization and interpretation. The fourth objective is to make the benefit of this bibliometric study to the researchers and government agencies.

The paper consists of four sections. The first section discusses the motivation of the topic in introduction section. The second section discusses the databases, techniques, and methods for bibliometric analysis. The third section deals with detailed bibliometric analysis using the Scopus database, Power BI and VOSviewer tools. Section four is conclusion and future scopes.

2. Data and Methods

The research information is very dynamic and is always updating in a real-time, which should be known to researchers. The researchers will get updated information and knowledge by exploring the publication databases. The widespread publication databases which include Scopus, Clarivate, Crossref, JournalSeek, Semantic Scholar, Mendeley, DBLP, ScienceDirect, Google Scholar, Web of Science, Research Gate, etc. (Chaudhari & Joshi, 2019; Chaudhari & Mulay, 2019; Kuralkar et al., 2020) are used to extract and use the data for analysis. Among all databases, the Scopus database is the widely preferred database in the researcher's literature study. Scopus is the leading abstract and citation database of peer-reviewed research literature in various research domains like science, technology, medicine, social sciences, arts, and humanity. Moreover, the Scopus database also provides the data analysis tool for data visualization (Kuralkar et al., 2020). For extracting the trend of fields from the database, many methods are available namely: webometrics, bibliometric, scientometric, and H- index (Chaudhari & Joshi, 2019; Chaudhari & Mulay, 2019; Sanjeev Kadam,Prabir Kumar Bandyopadhyay, 2016) Among all these methods, the bibliometric analysis method is mostly the preferred method for data extraction purposes. The specialty of bibliometric analysis is that it considers both qualitative and quantitative research work.

Furthermore, the bibliometric analysis includes many aspects namely: patents, publication types, subject domain, available data-based research, yearly publications, journals and publishers, statistical matrices method for analyzing the researches, etc.(Chaudhari & Mulay, 2019). There are two main ways for accessing the public databases: first is free to access (open access) and second is a subscription (paid access)(Sarmiento & Nagi, 1999). Apart from this, one can also

access databases from their university library portals or by approaching separately on individual websites (Sanjeev Kadam,Prabir Kumar Bandyopadhyay, 2016). For this bibliometric paper Symbiosis International Deemed university library portal was used to access the Scopus database. The detailed bibliometric analysis is given in section 3.

3. Bibliometric Analysis

The Scopus database is the base for this bibliometric study related to the HEC research domain. The aim of this bibliometric study is to comprehend the reach of survey-based household's electricity consumption analysis in the world. This Scopus database with bibliometric analysis study would help researchers in their systematic literature survey study, which would lead to find the research gaps of existing literature. The sections which follows discusses the bibliometric analysis. Figure 2 shows the result of all published and article under process documents in Scopus database on 31st December 2020 (Scopus-Database, 2020).

3.1 Documents search using query and fields.

Fixing query as a keyword is the important step to achieve the relevant documents in Scopus database. Initially keywords are provided in search option of documents using basic boolean operators AND, OR by selecting the article title, abstract, and keywords fields related to the HEC research area. It is also possible to limit the publication documents by selecting years. This paper limits the documents by setting the year greater than 2014 as shown in Figure 2.

3.2 Analysis of searched documents

The steps mentioned in the preceding section yields result in terms of three types of documents namely: primary (documents), secondary and patent as shown in Figure 2. The primary document is the main documents, which are presently Scopus indexed. A secondary document is a type of document which has been taken from a Scopus database document reference. Moreover, secondary documents are not directly available in the Scopus database but are available in the Scopus document reference (Scopus-Database, 2020). So, primary documents are more important than secondary documents for further literature study. The patent documents are the legal documents, which are approved by the government for providing a right to make, use and sell an invention for a definite number of years. Table 1 shows the latest top ten granted patents information.

3.2.1 Yearly published documents

The patent documents are around 2.8 times greater than the primary documents. The highest patents are published in the year 2017 (8384 patents).

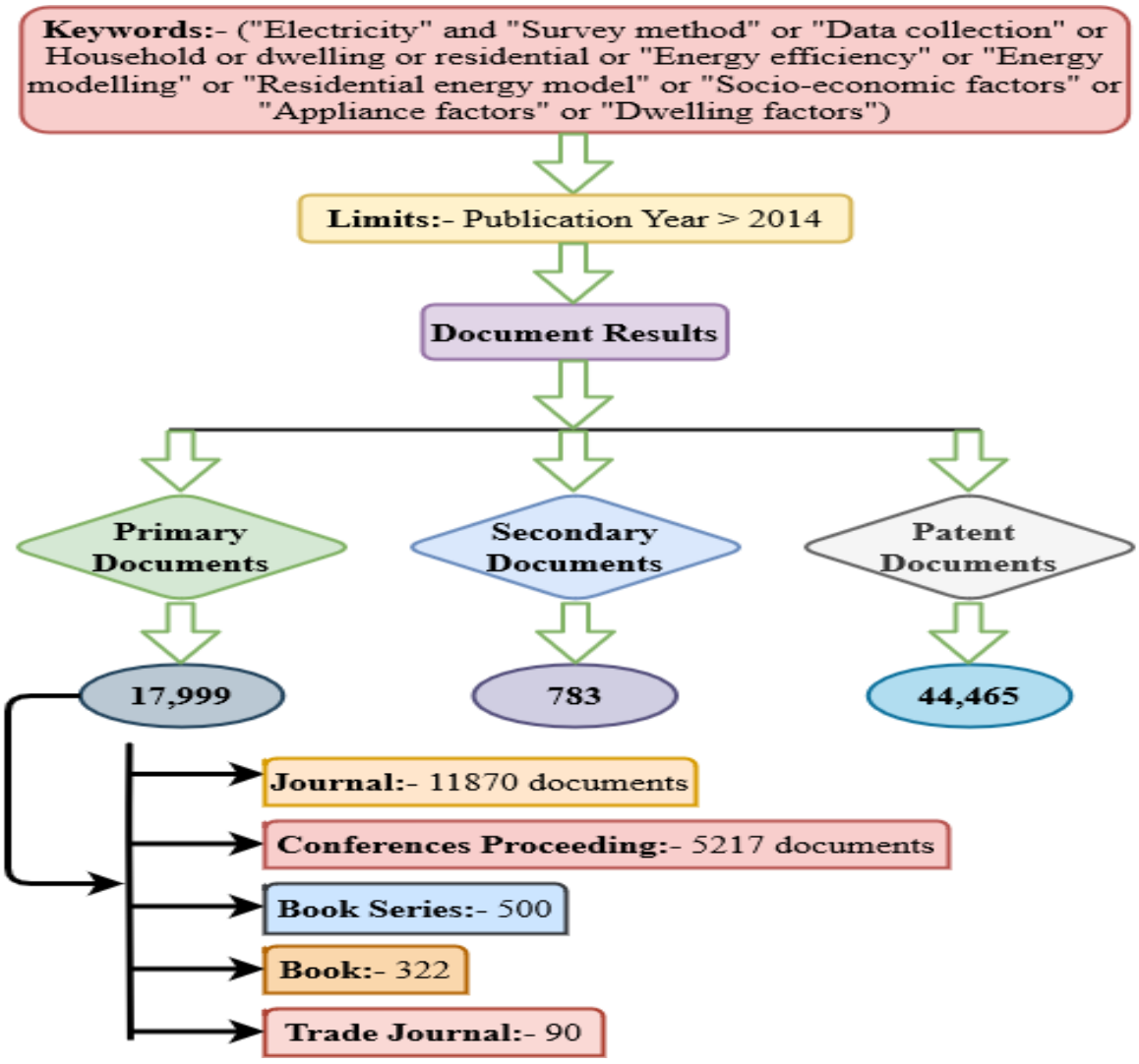

Figure 2. Documents results in Scopus database

For patenting the documents, the same idea should not be published before. Hence authors are giving priority to file the patent and then publish later as documents. Figure 3 shows linearly increasing patents up to the year 2017 and primary documents up to the year 2019. The maximum number of primary document publication is in the year 2019 (3682 documents) related to the HEC area. It is also observed that publication of primary document is decreasing in 2019-2020 year as compared to other years. Also the patent publication shows a decreasing trend in 2017-2019 year.

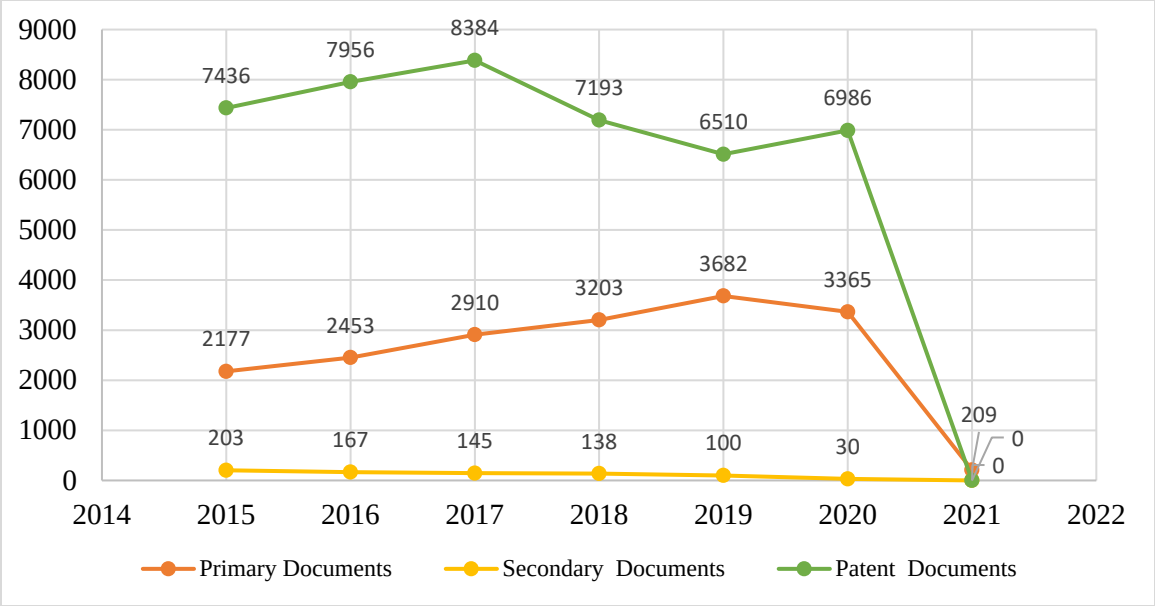

Figure 3. Yearly published Scopus database documents after 2014 year.

Table 1 shows the top ten patent documents during the years 2015-2020. These patents are documented under four main patent office's namely: United States Patent & Trademark, Japan Patent, World Intellectual Property Organization, European Patent and United Kingdom Intellectual Property as given in Table 1. This information will help researchers to file the patent. Furthermore, 17,999 documents are published in different sources namely: journal, conference proceeding, book series, book and trade journal. From primary documents, around 65% of documents are published in different journals. The detailed discussion on the top ten journals for publication is discussed in succeeding sections.

Table 1. Top ten granted patent documents

Sr. No.	Title	Author and Year	Source/ Office	Patent No.
1	Method and Apparatus for Optimizing and Simplifying the Enforcement of Building Energy Efficiency Regulations	Suyeyasu, Daniel; Goodrich, Kimberly., 2016	United States Patent and Trademark Office Granted Patent	US9245066
2	System and method for Managing and Monitoring Lifting Systems and Building Facilities	Chun Ming, Lau, 2019	European Patent Application	EP3470354
3	System, Method and Computer Program For Simulating Vehicle Energy Use	Stevens, Matthew; Mendes, Christopher, 2015	United States Patent and Trademark Office Granted Patent	US9157383

4	System and Related Methods for Global Targeting of Process Utilities Under Varying Conditions	Noureldin, Mahmoud, Bahy; Aseeri, Almed, Saleh; Al-Abdullah, Yacoub, Y. , 2017	European Patent	EP2310965
5	Modeling system for energy systems	Meier, Paul Joseph (Meier, Paul Joseph), 2020	United States Patent and Trademark Office Granted Patent	US10749339
6	Multi-channel video intercom system with access to advanced digital services	José Ignacio García Bort; Jesus Molina Hernandez; Elias García García, Development, S.L.U.) , 2016	United Kingdom Patent Application	GB2539741
7	Multi-channel video intercom systems with access to advanced digital services	García Bort, José Ignacio; Molina Hernandez, Jesus; García García, Elias., 2017	United States Patent and Trademark Office Granted Patent	US9762852
8	Building power management systems	Authors of Document Albonesi, David H.; Chong, Howard; Hencey, Brandon, 2019	United States Patent and Trademark Office Granted Patent	US10371405
9	Heat pump system	Mark Hewitt, 2020	United Kingdom Patent Application	GB2582137
10	Reduction of operational cost using energy storage management and demand response	Asghari, Babak; Sharma, Ratnesh., 2016	United States Patent and Trademark Office Granted Patent	US9367108

3.2.2 Top ten journals analysis

Figure 4 shows the top ten journals based on highest number of published documents related to the HEC study.

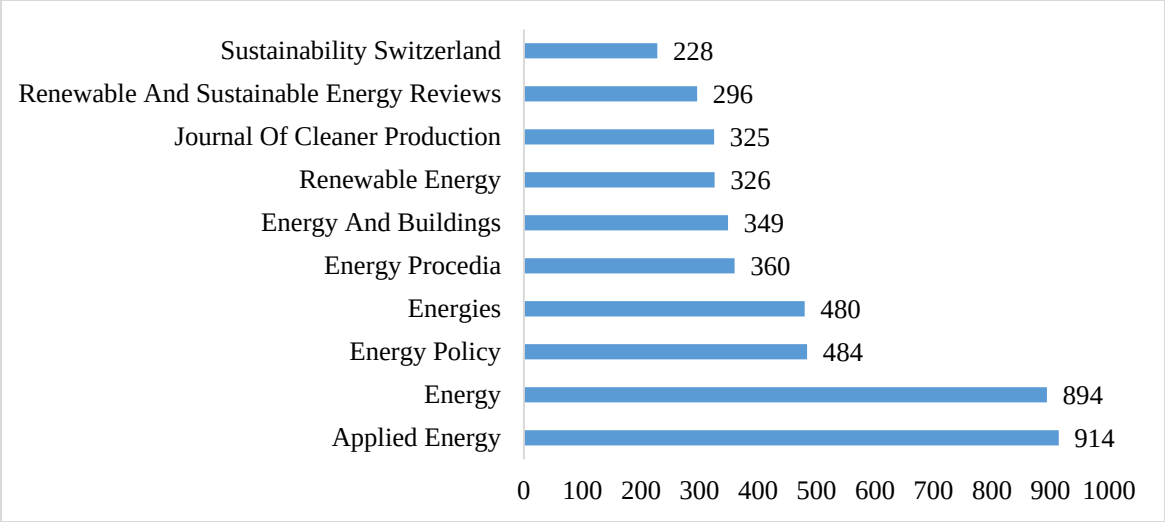

Figure 4. Top ten journals with publications

All these journals contributed 44% of publications from a total of 17999 documents. Applied energy journal published highest 914 documents followed by energy with 894 documents. Table 2 shows the details of the top ten journals with selected parameters. This parameter is important to select the quality journal for publication.

Table 2. Analysis of top ten journals

Journal Name	Publisher	Q	Impact factor	SJR 2019	H index
Applied Energy	Elsevier BV	Q1	8.848	3.19	189
Energy	Elsevier Ltd.	Q1	6.082	2.27	173
Energy Policy	Elsevier BV	Q1	5.042	2.17	197
Energies	MDPI	Q2	2.702	0.64	78
Energy Procedia	Elsevier BV	NA	1.15	0.55	73
Energy And Buildings	Elsevier BV	Q1	4.867	2.06	166
Renewable Energy	Elsevier BV	Q1	6.274	2.05	174
Journal Of Cleaner Production	Elsevier Ltd.	Q1	7.246	1.89	173
Renewable And Sustainable Energy Reviews	Elsevier Ltd.	Q1	12.11	3.63	258
Sustainability Switzerland	MDPI AG	Q2	2.576	0.58	68

The journals are ranked based on values with SJR (SCImago Journal & Country Rank). The ranked journals are classified into four equal groups called as Quartile (Q) which is as statistical term. The Q is divided based on value namely: Q1, Q2, Q3 and Q4. Q1 is the highest value and Q4 is having the lowest value. The Q value indicate the quality of a journal. In the top ten journals, 80% of documents are published by Elsevier BV publisher.

Moreover, all Elsevier BV publishers fall in Q1, has better impact factor and H index except Energy Procedia journal as information on SJR cite is not available. Impact factor and H index are the journal quality measuring parameters in terms of productivity and impact (Scimago Journal & Country Rank, 2020). Among top ten journals, Energy Procedia is having variations in yearly published documents and not having Q in SJR cite. So for such journals author should check Scopus coverage before submitting the manuscript for publication.

Figure 5 shows that Renewable and Sustainable Energy Reviews journal is having the highest impact factor (12.11). Due to the discontinuity in Scopus coverage, Energy Procedia is having the lowest impact factor and also it has published more documents.

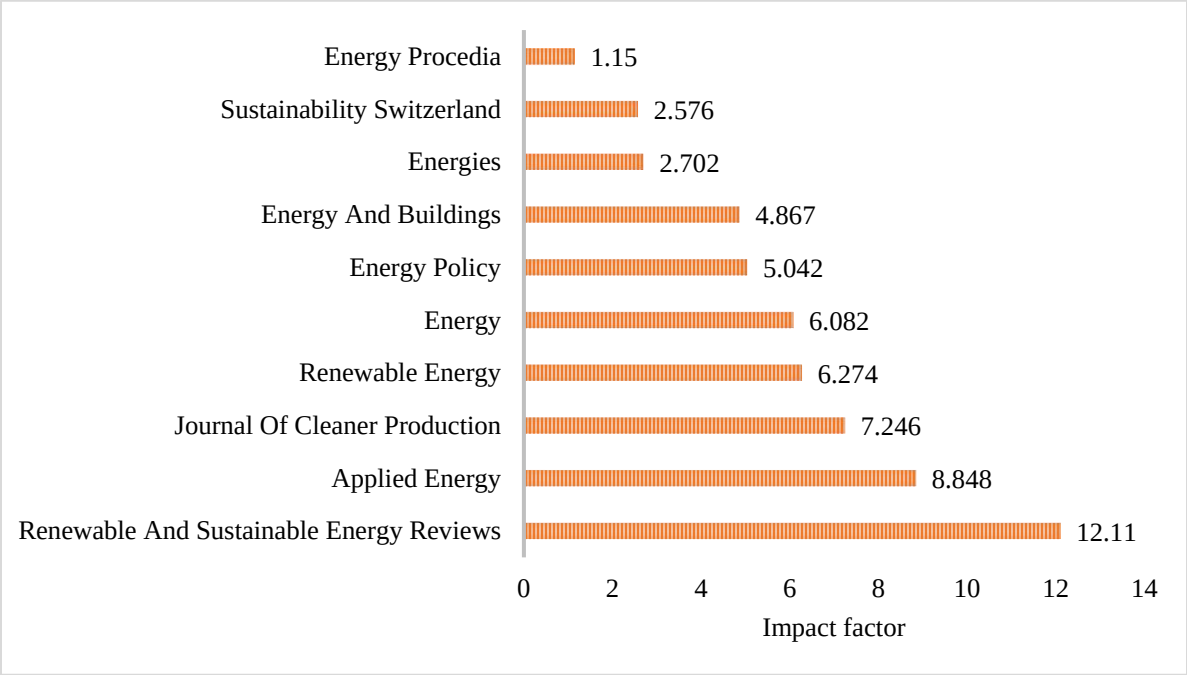

Figure 5. Top ten journal impact factor

3.2.3 Top ten publication type

Among total publications (17999 documents) based on HEC research area, the top ten publication types cover 99.77% published documents. Figure 6 shows that the article and conference-type has the highest publication type among different publication types.

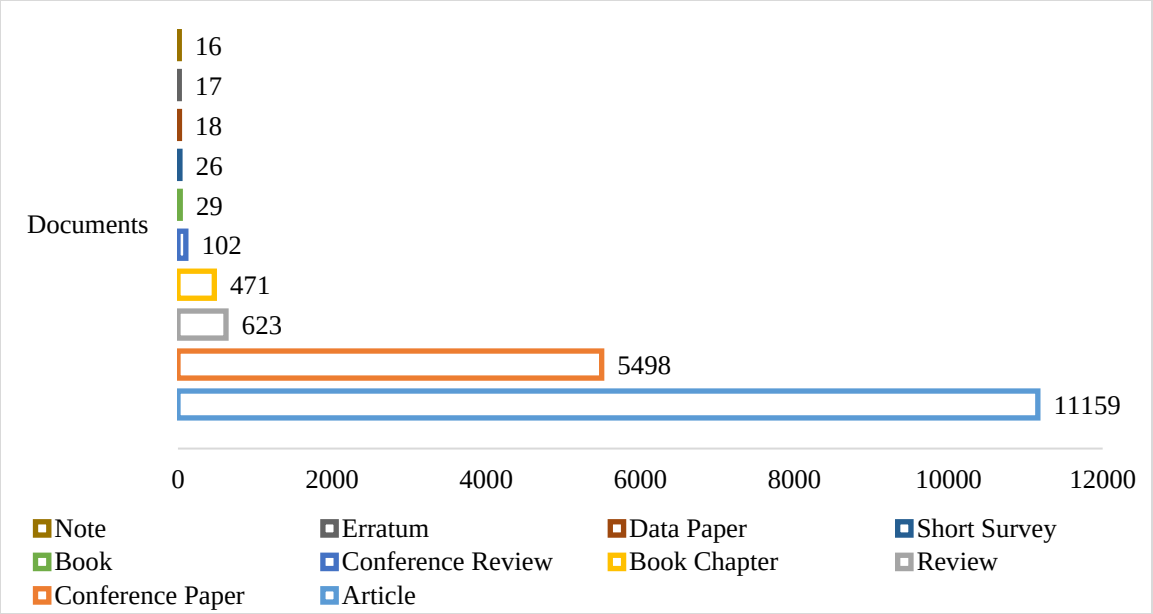

Figure 6. Top ten publication type

3.2.4 Published documents in top ten languages

Table 3 shows that 17469 documents are published in the English language as a global language associated to the HEC analysis.

Table 3. Published documents in major languages

Languages	Documents	Languages	Documents
English	17469	French	24
Chinese	277	Korean	14
Spanish	46	Turkish	10
Japanese	45	Persian	4
Russian	42	Hungarian	3
German	41	Ukrainian	3
Portuguese	37	Romanian	2
Polish	25	Czech	1

Other top five languages are Chines, Spanish, Japanese, Russian and German, which indicates the contributions of different countries to their national language. The language may be a barrier for the reader. Such publications may not be globally readable, and which may have negative impact on citation and H-index matrices.

3.2.5 Top ten countries publications

Figure 7 shows the top ten countries' publications related to the HEC research domain. The highest publications around the world are contributed by the United States (2842 documents) followed by China (2745 documents). The first ten countries published 12255 (68%) documents out of total primary (17999) documents.

Figure 7. Top ten countries publications

3.2.6 Top ten keywords

Figure 8 and Figure 9 belong to keyword based analysis in the Scopus database. Both figures are different based on the dataset. Figure 8 considered the top two thousand Scopus datasets and Figure 9 considered all datasets. ScienceScape tool was used to draw Figure 8, which shows that repeatedly used keyword is energy efficiency followed by energy utilization.

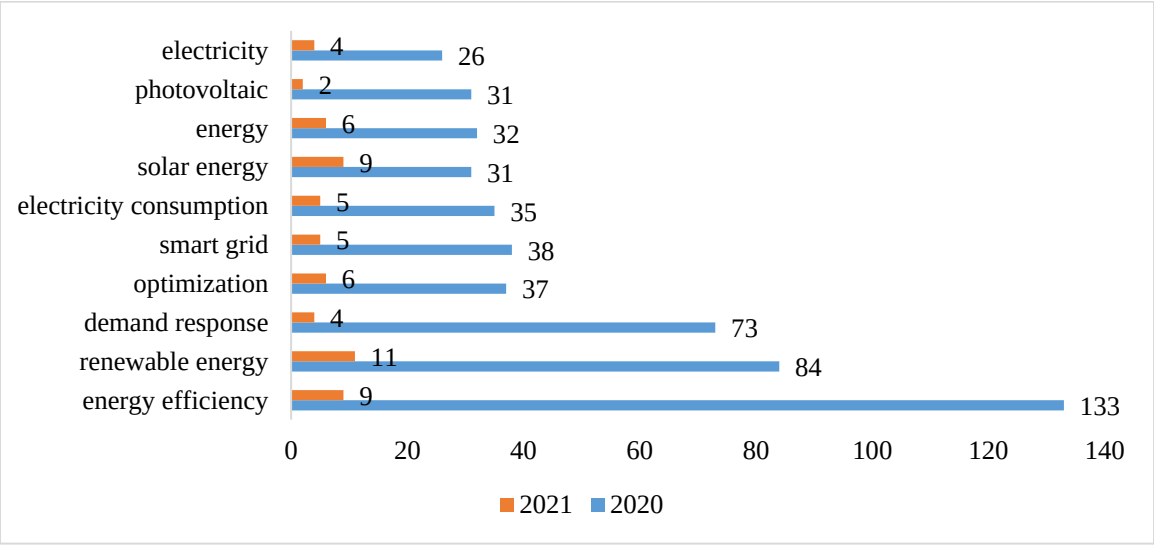

Figure 8. Keywords in top two thousand database

A total of 160 keywords were provided by the Scopus database with 108931 documents published. Figure 9 shows the top ten keywords based on several published documents. The contribution of these ten keywords is around 25%. The list of the top ten keywords is shown in Figure 9. This analysis would help in selecting the keywords for a paper so that the paper may be easily searched by the readers and would increase the citations. The top three keywords used are energy efficiency, energy utilization and housing as shown in Figure 9.

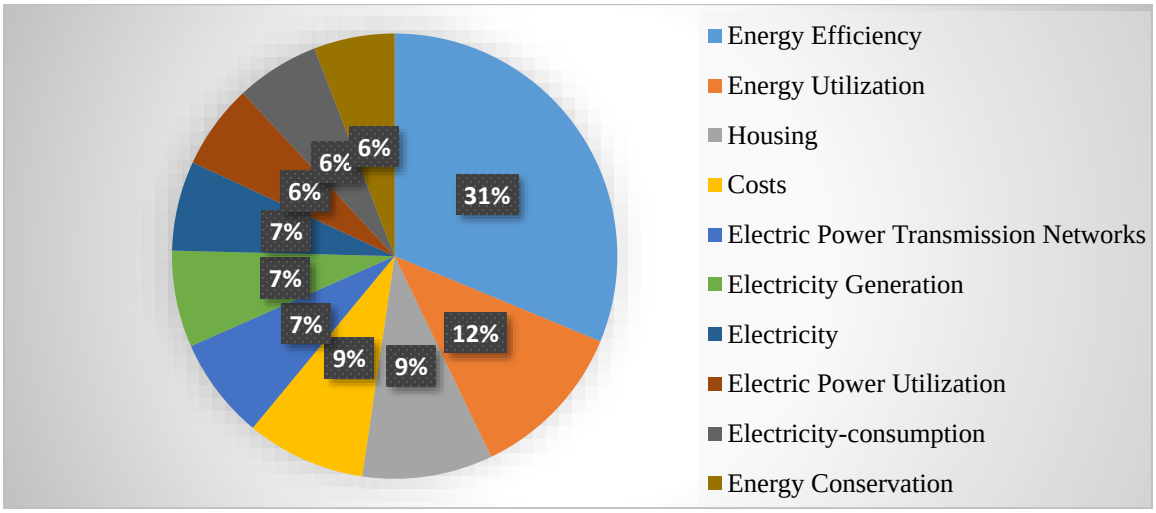

Figure 9. Top ten keywords

3.2.7 Top ten authors publications and Lotka's Law

Lotka's Law is the bibliometric law to determine the productivity patterns for a specific time-period literature. It not only about the authors, but also the journals, institutions and authors keywords related to any given field. This law is active since 1926 by author, demographer and statistician Alfred James Lotka, who published a paper titled "The Frequency Distribution of Scientific Productivity". The mathematical expression of Lotka's Law is as; $X^n \cdot Y = C$, where X is the number of contribution of papers, Y is the number of authors publishing X contribution of papers, n is exponential, which generally ranging between 1.2 to 3.5, and C is constant and depends on number of authors contributing one paper each in specific literature. Moreover, this law concludes that, in a scientific literature study, around 60% of authors contributing one paper, 15% of authors contributing two papers, 7% of authors contributing three papers and so on. Despite this, Lotka's Law is not applicable to all fields of knowledge. For such cases, it is advisable to adjust the n parameter value and validate the author's productivity using Lotka's law (Ahmed & Shuva, 2009; Andreo-martínez et al., 2020).

In this Scopus-based bibliometric literature study, a total of 17999 documents are obtained as results. Scopus allows downloading paper details up to the first two thousand documents, which leads to the difficulty in tracking the total number of published papers (specially one paper each author) by different authors in the concerned field. Thus, this paper focuses on the top ten publications, but lacks in justifying the productivity of the author by using Lotka's Law.

Figure 10 shows the top ten eminent authors who contributed towards the total publication related to the household electricity research domain. Author Javaid N has published 102 documents followed by author Dancer I with 62 Scopus indexed published documents.

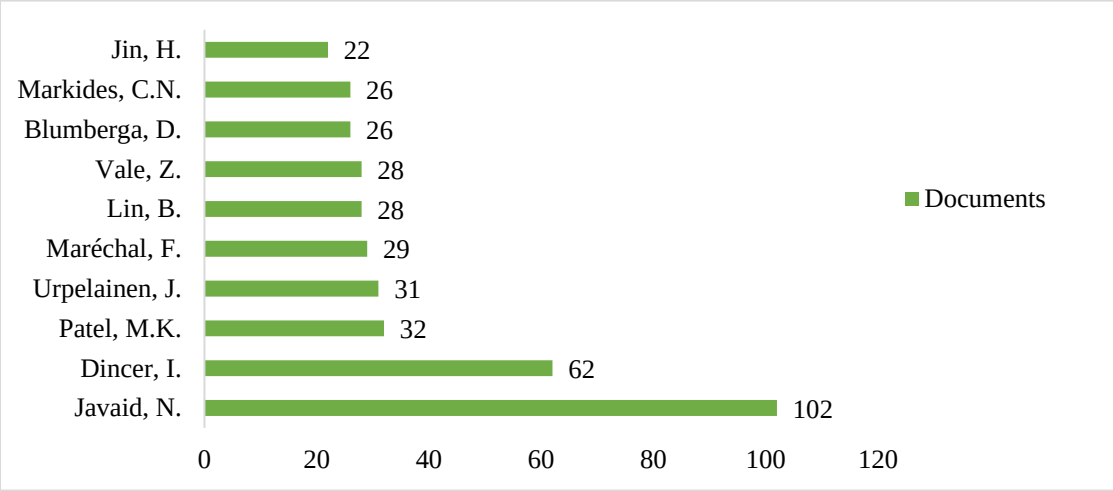

Figure 10. Top ten authors with publications

Figure 11 shows author and co-authorship in top two thousand dataset who have published papers on the household electricity concept.

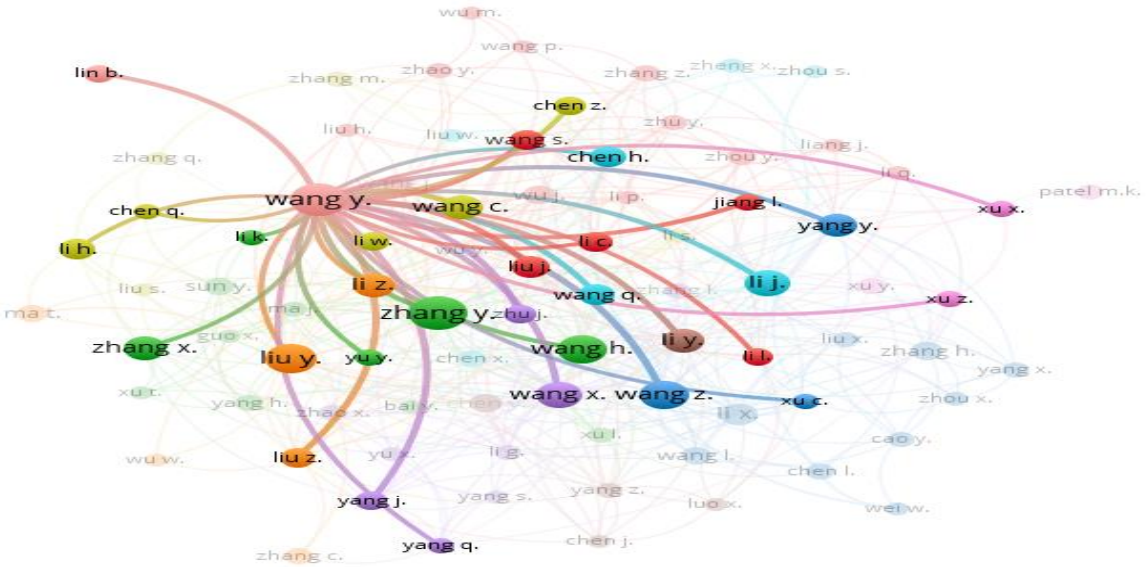

Figure 11. Author and co-authorship in top two thousand dataset

This Figure 11 is interpreting the author and co-authorship for publications using nodes and edges. These graphs will also give information like how many publications are done with a single author, two authors and more and their collaborations with another country, etc. This graph is drawn using VOSviwer tool (VOSviewer, 2020).

3.2.8 Citation Impact

Citation statistics analysis is important to understand the productivity of the author, source title, or journal for the particular title of the paper. Figure 12 shows the top ten citation analysis with respect to source title and authors in the HEC study using Power BI data visualization tool. The top ten cited articles are published in five different journals namely: Science (62.84%), Applied Energy (13.53%), Nature (9.38%), Renewable and Sustainable Energy Reviews (8.1) and IEEE Communications Surveys and Tutorials (6.14%).

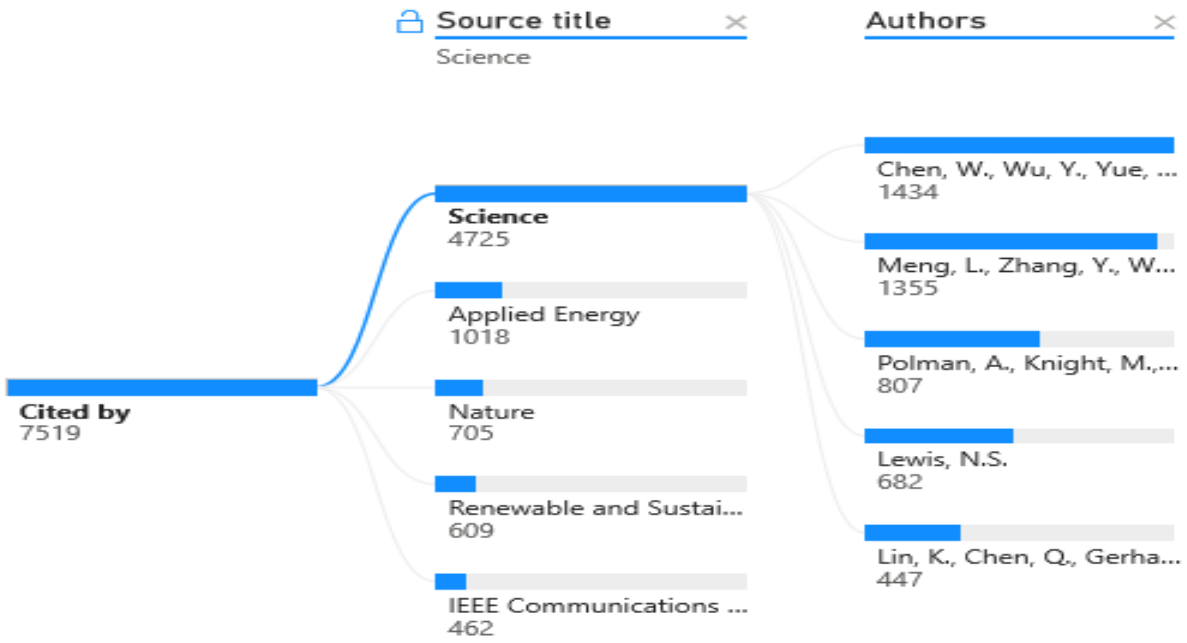

Figure 12. top ten citation study with source title and authors

Table 4 shows the top ten cited papers detailed citation statistics including author names, the title of the paper, published journal name, year of publication and number of times cited the paper. In the top ten papers, mostly cited papers are of review or survey types. Among ten papers, the largest citation rate for the paper entitled “Organic and solution-processed tandem solar cells with 17.3% efficiency” is 1355. Figure 12 and Table 4 is drawn based on the Scopus database which was accessed on 4th February 2021.

Table 4. Top ten highly cited papers analysis

Authors	Title	Source title	Year	Cited by
Chen, W., Wu, Y., et al.	Efficient and stable large-area perovskite solar cells with inorganic charge extraction layers	Science	2015	1434
Meng, L., Zhang, Y., et al.	Organic and solution-processed tandem solar cells with 17.3% efficiency	Science	2018	1355
Polman, A., Knight, M., et al.	Photovoltaic materials: Present efficiencies and future challenges	Science	2016	807
Li, Q., Chen, L., et al..	Flexible higher nature dielectric materials from polymer nanocomposites	Nature	2015	705
Lewis, N.S.	Research opportunities to advance solar energy utilization	Science	2016	682
Nejat, P., et al.	A global review of energy consumption, CO_2 emissions and policy in the residential sector (with an overview of the top ten CO_2 emitting countries)	Renewable and ustainable Energy Reviews	2015	609
Aneke, M., Wang, M.	Energy storage technologies and real life applications – A state of the art review	Applied Energy	2016	591
Vardakas, J.S., Zorba, N., et al.	A Survey on Demand Response Programs in Smart Grids: Pricing Methods and Optimization Algorithms	IEEE Communications Surveys and Tutorials	2015	462
Lin, K., Chen, Q., et al.	Alkaline quinone flow battery	Science	2015	447
Luthander, R., Widén, J., et al.	Photovoltaic self-consumption in buildings: A review	Applied Energy	2015	427

3.2.8 Top ten affiliations

Table 5 provides details of the top ten affiliations with its highest publications. The affiliation and its published documents provide information about the available research centers in the HEC area. These affiliation details are important to do collaborative work with other research centers.

Table 5. Top ten affiliations in publications

Affiliation	Country/Territory	Publication
Chinese Academy of Sciences	China	220
North China Electric Power University	China	218
Tsinghua University	China	217
Ministry of Education China	China	201
COMSATS University Islamabad	Islamabad	136
The Royal Institute of Technology KTH	Sweden	124
ETH Zurich	Switzerland	123
Aalborg University	Denmark	120
University of California, Berkeley	United States	118
Danmarks Tekniske Universitet	Danmark	117

Table 5 shows that the maximum affiliations are from China with 856 published documents. The Chinese Academy of Sciences is having the highest publications (220 publications) followed by North China Electric Power University (218 publications).

3.2.9 Top ten funding agencies

Table 6 shows the top ten funding agencies which have provided maximum research funding for HEC research work. China has contributed maximum funds for up to 1509 documents.

Table 6. Top ten funding agencies in publications

Funding Agency	Country/Territory	Publication
National Natural Science Foundation of China	China	1124
National Science Foundation	United States	351
Engineering and Physical Sciences Research Council	United Kingdom	300
Fundamental Research Funds for the Central Universities	China	250
European Commission	European Union	230
U.S. Department of Energy	United States	218
European Regional Development Fund	European Union	199
Horizon 2020 Framework Programme	Switzerland	165
National Basic Research Program of China (973 Program)	China	135
National Research Foundation of Korea	Korea	120

4. Scope and Limitations

The HEC research topic has huge potential on EE and EC to achieve the social welfare maximization (SWM) model. Under the SWM model, there is a win-win situation for all end-users, utility companies and environments. Most of the literatures consider household factors like physical characteristics of the dwelling, appliance ownership and socio-economic parameter, but has excluded other parameters which includes weather conditioning factor, appliance age, size, power rating, operating hours, occupant's behaviors and lifestyle which may lead for better prediction modeling and its analysis.

The first limitation of this paper is only considered Scopus database for bibliometric analysis. The second limitation of is the Scopus database is allowing to download only first two thousand documents. This has lead to the inability of calculating the author's productivity and its justification by implementing the Lotka’s law in HEC bibliometric study. So for the Lotka’s Law implementations, need to frame the specific keywords, time-periods and filter the other fields

documents. A further enhancement in the analysis can be done by using different data visualization tools to analyze the databases.

5. Conclusion

Energy conservation and energy efficiency based policy designing is the global demand for limiting greenhouse gas emissions. For designing a robust and realistic policy, there is a need to understand the household energy consumption pattern, factors affecting energy consumption and occupant's behavioral aspect of purchasing appliances and their use. This bibliometric analysis used keyword based searching method to explore the Scopus database data on HEC analysis. The keywords used were Electricity, Survey method, Data collection, Household, dwelling, residential, Energy efficiency, Energy modelling, Residential energy model, Socio-economic factors, Appliance factors, and Dwelling factors. The publications year greater than year 2014 was set and database was extracted. These search settings resulted in 17999 main documents, 783 secondary documents, and 44465 patents documents. The following observations were made. Among the main documents, highest 65% documents are published in journals followed by 29% documents published in conferences. The better quality journal based on impact factor (12.11) and H (258) index is found to be Renewable and Sustainable Energy Reviews. In the top ten journals, 80% of documents are published by Elsevier BV publisher in Q1 journal except Energy Procedia journal. The important keywords used by the authors are Energy Efficiency, Energy Utilization, Housing, Costs etc. Javaid N is the eminent author who has published 102 documents followed by Dancer I with 62 documents. According to country or territory, highest publication has been done from United States (2842 documents), followed by China (2745 documents). This bibliometric analysis used different tools namely: Power BI, VOSviewer, ScienceScape, Microsoft excel and Draw io for data visualization and interpretation of Scopus database.

References:

Ã, G. K. F. T., & Yau, K. K. W. (2007). *Predicting electricity energy consumption : A comparison of regression analysis , decision tree and neural networks*. *32*, 1761–1768. https://doi.org/10.1016/j.energy.2006.11.010

Ahmed, S. M. Z., & Shuva, N. Z. (2009). *Author productivity in Library and Information Science (LIS) research of Bangladesh : Testing Lotka ' s law and related phenomena Author productivity in Library and Information Science (LIS) research of Bangladesh : January*.

Amasyali, K., & El-Gohary, N. M. (2017). A review of data-driven building energy consumption

prediction studies. *Renewable and Sustainable Energy Reviews*, *81*(January 2016), 1192–1205. https://doi.org/10.1016/j.rser.2017.04.095

Andreo-martínez, P., Ortiz-martínez, V. M., & García-martínez, N. (2020). Production of biodiesel under supercritical conditions : State of the art and bibliometric analysis. *Applied Energy*, *264*(March), 114753. https://doi.org/10.1016/j.apenergy.2020.114753

Baker, K. J., & Rylatt, R. M. (2008). *APPLIED Improving the prediction of UK domestic energy-demand using annual consumption-data*. *85*, 475–482. https://doi.org/10.1016/j.apenergy.2007.09.004

Bartusch, C., Odlare, M., Wallin, F., & Wester, L. (2012). Exploring variance in residential electricity consumption: Household features and building properties. *Applied Energy*, *92*, 637–643. https://doi.org/10.1016/j.apenergy.2011.04.034

Bedir, M., Hasselaar, E., & Itard, L. (2013). Determinants of electricity consumption in Dutch dwellings. *Energy & Buildings*, *58*, 194–207. https://doi.org/10.1016/j.enbuild.2012.10.016

Chaudhari, A., & Joshi, R. (2019). *Bibliometric Survey on Incremental Clustering Algorithms Smart Meter Data Analysis View project Distributed Incremental Data Clustering View project*. *September*. https://www.researchgate.net/publication/335856503

Chaudhari, A., & Mulay, P. (2019). A bibliometric survey on incremental clustering algorithm for electricity smart meter data analysis. *Iran Journal of Computer Science*, *2*(4), 197–206. https://doi.org/10.1007/s42044-019-00043-0

Chunekar, A., & Sreenivas, A. (2019). Towards an understanding of residential electricity consumption in India. *Building Research and Information*, *47*(1), 75–90. https://doi.org/10.1080/09613218.2018.1489476

Druckman, A. Ã., & Jackson, T. (2008). *Household energy consumption in the UK : A highly geographically and socio-economically disaggregated model*. *36*(March 2005), 3177–3192. https://doi.org/10.1016/j.enpol.2008.03.021

Ferna, J. E., Wiesmann, D., & Ferr, P. (2011). *Residential electricity consumption in Portugal : Findings from top-down and bottom-up models*. *39*, 2772–2779. https://doi.org/10.1016/j.enpol.2011.02.047

Jones, R. V., Fuertes, A., & Lomas, K. J. (2015). The socio-economic, dwelling and appliance related factors affecting electricity consumption in domestic buildings. *Renewable and Sustainable Energy Reviews*, *43*, 901–917. https://doi.org/10.1016/j.rser.2014.11.084

Kuralkar, S., Mulay, P., & Chaudhari, A. (2020). Smart Energy Meter: Applications, Bibliometric Reviews and Future Research Directions. *Science and Technology Libraries*, *39*(2), 165–188. https://doi.org/10.1080/0194262X.2020.1750081

Li, Y., Kubicki, S., Guerriero, A., & Rezgui, Y. (2019). Review of building energy performance certification schemes towards future improvement. *Renewable and Sustainable Energy Reviews*, *113*(June). https://doi.org/10.1016/j.rser.2019.109244

Mcloughlin, F., Duffy, A., & Conlon, M. (2012). Characterising domestic electricity consumption patterns by dwelling and occupant socio-economic variables : An Irish case study. *Energy & Buildings*, *48*(July 2009), 240–248. https://doi.org/10.1016/j.enbuild.2012.01.037

Ndiaye, D., & Gabriel, K. (2011). *Principal component analysis of the electricity consumption in residential dwellings*. *43*, 446–453. https://doi.org/10.1016/j.enbuild.2010.10.008

Parker, D. S. (2003). Research highlights from a large scale residential monitoring study in a hot climate. *Energy and Buildings*, *35*(9), 863–876. https://doi.org/10.1016/S0378-7788(02)00244-X

Sadeghi, A., Sinaki, R. Y., Young, W. A., & Weckman, G. R. (2020). An intelligent model to predict energy performances of residential buildings based on deep neural networks. *Energies*, *13*(3). https://doi.org/10.3390/en13030571

Sanjeev Kadam,Prabir Kumar Bandyopadhyay, Y. P. (2016). *Mapping the field through bibliometric analysis of passenger centric railway transportation Sanjeev Kadam, Prabir Kumar Bandyopadhyay Yogesh Patil*. *2*(4), 349–368.

Sanquist, T. F., Orr, H., Shui, B., & Bittner, A. C. (2012). Lifestyle factors in U . S . residential electricity consumption. *Energy Policy*, *42*, 354–364. https://doi.org/10.1016/j.enpol.2011.11.092

Sarmiento, A. N. A. M., & Nagi, R. (1999). A review of integrated analysis of production-distribution systems. *IIE Transactions*, *31*, 1061–1074.

Scimago Journal & Country Rank. (2020). *Retrieved from,*. https://www.scimagojr.com

Scopus-Database. (2020). *Retrieved from,* htttp://www.scopus.com

VOSviewer. (2020). *Retrieved from,* https://www.vosviewer.com

Wyatt, P. (2013). A dwelling-level investigation into the physical and socio-economic drivers of domestic energy consumption in England. *Energy Policy*, *60*, 540–549. https://doi.org/10.1016/j.enpol.2013.05.037