Artículo original / Original article / Artigo original

DOI: 10.22507/pml.v13n2a3

Applications of Solar Energy: History, Sociology and last Trends in Investigation[1]

Debrayan Bravo Hidalgo[2] ,Reinier Jiménez Borges[2], Yarelis Valdivia Nodal[3]

Abstract

Introduction: The increase in global energy demand, environmental problems and geopolitical tensions due to the control of finite conventional energy resources; these are reasons that have currently focused the attention of scientists on the applications of solar energy. The **objective** of this contribution is to reflect the trends in research regarding applications of solar energy. The **materials and methods** used in this investigation consisted of a search and bibliometric analysis carried out in the academic directory Scopus. A group of publications was detected under specific search criteria. The information detected was processed with text mining elements in the visualization software and bibliometric map exploration of VOSviewer science. The article dead sections, records of the first applications of solar energy, the social environment of solar energy applications, the first scientific meetings of global connotation in this subject, and bibliometrics of scientific activity focused on the applications of solar energy in the 21st century. As a **result** of the research, a sociological and anthropological vision of the man / energy interaction is exposed; This complements lines of research such as sustainable production and consumption, energy management and climate change. **Conclusions:** The trend in these investigations today, is to growth, and are focused on: heating and cooling of buildings, electric power generation, both in concentrated and distributed forms; and energy conversion for industrial processes.

Keywords: Solar energy, text mining, technology, sociology, anthropology

Aplicaciones de la energía solar

Resumen

Intoducción: el incremento de la demanda energética a escala mundial, la problemática ambiental y las tensiones geopolíticas por el control de los finitos recursos energéticos convencionales, son razones que en la actualidad han focalizado la atención de los científicos en las aplicaciones de la energía solar. El **objetivo** de esta contribución es reflejar las tendencias en investigación en cuanto aplicaciones de la energía solar. Los **métodos** empleados en esta investigación consistieron en una búsqueda y análisis bibliométricos realizados en el directorio académico Scopus. Se detectó un grupo de publicaciones bajo puntuales criterios de búsqueda. La información detectada fue procesada con elementos de minería de textos en el software de visualización y exploración de mapas bibliométricos de la ciencia VOSviewer. El trabajo muestra, entre sus secciones, registros de

1 Artículo original derivado del proyecto investigación denominado Renewable energy resources, energy efficiency and energy transformation systems, financiado por la Universidad San Francisco de Quito (USFQ), Quito, Ecuador a desarrollarse entre los meses enero de 2018 a diciembre de 2022.

2 Máster en Eficiecia Energética, profesor asociado, Universidad San Francisco de Quito (USFQ), Quito, Ecuador. Correo electrónico: dbrayanbh@gmail.com, ORCID: 0000-0003-0428-2263

3 Máster en Eficiecia Energética, profesor asistente, Universidad de Cienfuegos (UCF), Cienfuegos, Cuba. Correo electrónico: rjborges@ucf.edu.cu, ORCID: 0000-0001-6451-8499

4 Máster en Eficiecia Energética, profesor auxiliar, Universidad de Cienfuegos (UCF), Cienfuegos, Cuba. Correo electrónico: yvaldivia@ucf.edu.cu, ORCID: 0000-0003-0775-2160

Autor para la corespondecia Debrayan Bravo Hidalgo. Correo electrónico: dbrayanbh@gmail.com
Artículo recibido: 13/04/2018; Artículo aprobado: 13/12/2018

las primeras aplicaciones de la energía solar, el entorno social de las aplicaciones de energía solar, las primeras reuniones científicas de connotación global en este tema, además de la bibliométrica de la actividad científica centrada en las aplicaciones de la energía solar en el siglo XXI. Como **resultado** de la investigación, se expone una visión sociológica y antropológica de la interacción hombre/energía. Esto complementa líneas de investigación como la producción y consumo sustentable, la gestión energética y el cambio climático. **Conclusiones:** la tendencia en estas investigaciones en la actualidad, es al crecimiento, y están enfocadas a: calefacción y refrigeración de edificios, generación de energía eléctrica, tanto en formas concentrada como distribuida; y conversión de energía para procesos industriales.

Palabras claves: Energía solar, minería de texto, tecnología, sociología, antropología

Aplicaciones de la energía solar

Resumo

Intodução: O aumento da demanda global de energia, problemas ambientais e tensões geopolíticas devido ao controle de recursos energéticos convencionais finitos; Estas são razões que atualmente têm focado a atenção dos cientistas nas aplicações da energia solar. O **objetivo** desta contribuição é refletir as tendências em pesquisa sobre aplicações de energia solar. Os **materiais e métodos** utilizados nesta investigação consistiram em uma pesquisa e análise bibliométrica realizada no diretório acadêmico Scopus. Um grupo de publicações foi detectado sob critérios de pesquisa específicos. As informações detectadas foram processadas com elementos de mineração de texto no software de visualização e exploração do mapa bibliométrico da ciência VOSviewer. Trabalho morto entre suas sessões, registros das primeiras aplicações da energia solar; o ambiente social das aplicações de energia solar; os primeiros encontros científicos de conotação global neste assunto; e bibliometria da atividade científica focada nas aplicações da energia solar no século XXI. Como **resultado** da pesquisa, expõe-se uma visão sociológica e antropológica da interação homem / energia; Isso complementa linhas de pesquisa como produção e consumo sustentáveis, gerenciamento de energia e mudanças climáticas. **Conclusões:** A tendência nessas investigações hoje; é para o crescimento, e estão focados em: aquecimento e arrefecimento de edifícios, geração de energia elétrica, tanto em formas concentradas e distribuídas; e conversão de energia para processos industriais.

Palavras-chave: energia solar, mineração de texto, tecnologia, sociologia, antropología

Introduction

Solar energy is the oldest natural form of energy used by the humanity since times immemorial. It was used mainly for drying various products, mainly food, as well as for its conservation. The first documented application was discovered in the south of France, dated 8 000 B.C, where during the excavations, a bank was found that was used to dry agricultural products. In later times, during the period 5 000-2 000 B.C, several sites were discovered, mainly in the Middle East, in which the drying of different products, such as animal skin and clay plates, destined to the construction of writing boards, took place. In those sites, it was discovered that the Assyrians, for example, used to dry clay writing boards initially in the sun, later completing the process in the shade, using natural ventilation (Bux, Bauer, Mühlbauer, & Conrad, 2001; Deering & Sweeney, 2017; Dhurandher, Sharma, Woungang, & Saini, 2017).

With the direct and indirect use of solar energy, all our energy needs can be met (Donateo, Ficarella, Spedicato, Arista, & Ferraro, 2017; Karthik Reddy & Poondla, 2017). Each square meter of the South and Central America receives, on an annual average, 5 kW / h of solar energy, equivalent to the chemical energy accumulated in a liter of oil (Ahmadi, Toghraie, & Akbari, 2017).

Energy is not an economic sector, although its treatment requires studying its cost, in one way or another the production of goods and services demand energy for its operation. Also, the population demands energy to satisfy their basic comfort needs, among others. That is why energy must be seen as a transcendental aspect for the sustainable development of human activities. Energy consumption can be significantly reduced if the habits and lifestyles related to good practices of efficient use are taught during the educational stage at all levels (Andreas, Burns, & Touza, 2017; Fischhendler, Herman, & Maoz, 2017; Turrini, 2006).

This contribution reflects the trends in research regarding applications of solar energy. Based on a

bibliographic review within the boundaries of the Scopus catalog, and processing this information with text mining practices in the VOSviewer computational tool.

Materials and methods

In the development of this research, the Scopus catalog was used, and many of the scientometric analysis tools that it provides to its subscribers (Burnham, 2006). Under the search criteria Applications of solar energy in the title of the articles, and considering from the first record in 1957 to February 2018, was located within the catalog Scopus 1 144 scientific contributions and 288 524 patents related to these.

All this information was extracted from this academic research catalog in CSV format; and it was processed in the VOSviewer bibliometric analysis software. This is a computer program to create, visualize and explore bibliometric maps of science. The extracted information in CSV format, contained: a) Title., b) Keywords, c) Author, d) Years, e) Institution of the authors, f) Nationality, g) Magazine where it was published, h) Appointment index.

VOSviewer was used in text mining and to analyze data from bibliometric networks, collaborative relationships between nations, authors and their impact. In addition, it was used to obtain the relation of coincidence between scientific terms under the search criteria previously exposed.
Finally, through the use of Scopus's bibliometric tools, the most representative journals were detected in the topic Applications of solar energy and the citation index of these journals from 1996 to 2017.

Results

The energy requirement of humanity is continually growing (Bravo Hidalgo, 2015). It is predicted that by the middle of our century the world demand for energy will at least double. These energy conditions, and in the face of real environmental challenges, can only be covered by obtaining electrical energy and thermal energy from renewable energy sources (Testi, Schito, & Conti, 2016).

All forms of energy used in the generation of electricity are derived in one way or another from our nearest star. Oil, coal, natural gas and wood were originally produced through photosynthesis. The wind and the waves are due to the temperature differences created by the sun on the fluids that compose them (Breeze et al., 2009; Oteman, Kooij, & Wiering, 2017; Syed & Safdar, 2017). Throughout history, each form of applied energy contributed to the development of society (Deering & Sweeney, 2017).

First applications of solar energy.

Before entering the historical journey, it is fair to highlight the fundamental role that science and technology have played in the course of history, specifically in the twentieth century. Their role was maximized thanks to access to innovative forms of energy which contributed greatly to the rapid development and complexity of nations, to demographic growth and the production of goods and services, as well as the diversification and specification of emerging groups in the social structure of those times (Allamehzadeh, 2017; Moss, 2017; Perović, 2017). This section has focused on the projection of solar energy in the first steps of documented civilization. Although there is more literature referring to the period of middle age (Allamehzadeh, 2017; Guzmán, 2017).

The earliest report of the use of solar energy is the burning of the Roman fleet in the bay of Syracuse, attributed to Archimedes, a Greek mathematician and philosopher (287-212 B.C), who used flat reflecting surfaces to focus lightning solar on the Roman ships built in wood. This feat remained a subject of controversy and discussion among historians for centuries, since it was later coined as a myth because there was no technology at that time for the manufacture of concave mirrors. In fact, Archimedes used well-polished brass military shields. Regardless of all the theories, it is well known that Archimedes was an expert in optics and is the author of the book called Mirrors or Construction Spheres (Περί κατόπτρων ή Σφαιροποιία) that, unfortunately, was not saved for posterity. The first reference drawn in this event is given by Loukianos (190-120 B.C). During the Byzantine era (514 B.C), Proclus, bishop of Constantinople, repeated this feat by burning the enemy fleet that was besieging Constantinople. Later, once again during Byzantine times, Ioannis Tzetsis (1 100-80 B.C), a Byzantine writer described in his book Chiliades, vol. 3, the burning of Roman ships by Archimedes (Bilgen, 2013; Thomas & Thomas, 2003). Vitelion, a Polish mathematician of the thirteenth century, describes Archimedes 'experiment in detail in his book Optics (Bilgen, 2013): Archimedes' fiery crystal composed of 24 mirrors, which transmitted the sun's rays in a

common focus generating a large bright spot thermal load.

Subsequently, the experiment was repeated once again by the French naturalist and academic G. L. Buffon who experimented in solar energy applications and showed that the Archimedes experiment was achievable.

It should be mentioned here that one of the most important descriptions of the activities of the sun is that of the well-known Greek philosopher and scientist Aristotle (384-322 B.C) who conceived the hydrological cycle (Bilgen, 2013; Thomas & Thomas, 2003; Waddell, 2010). To date, a better explanation of the hydrological cycle has not been drawn. Another evidence of the use of solar heat is the orientation of the houses. During the antiquity, the constructors oriented the facades of the house to take better advantage of the heat of the solar rays. Socrates (469-399 B.C), the Greek philosopher, describes that the optimal use of natural solar radiation is obtained by orienting the main rooms of a building to the south.

China has also had its own share in solar energy applications. As reported by Kemper (1977), during the Han Dynasty (220-201 B.C), the Chinese used concave mirrors made of brass, tin alloy. The mirrors were used to light the torches of "solar fire" for religious rituals.

Social environment of solar energy applications.

The historical relationship between the areas that are the subject of our analysis, solar energy technology and society, has been a constant. Making an effort to highlight the continuous interrelation that has taken place between these dimensions and the dynamics of human change and development, as well as highlighting the profound meaning and repercussions that solar energy has had on our history, is the purpose of this contribution (Szabó, 2017). In the eyes of historians and anthropologists, solar energy has always been linked to human activity and cultural evolution. This has been transformed to the extent that man has been able to access alternate ways of solar energy, which have allowed the efficient use of it and expand the range of operation possibilities. In the scientific contribution of White (1982) is used: cultural evolution is given to the extent that man has been able, both to access and to implement, energy as a resource to perform more efficiently and through technological innovation a job and thus enable the maximization of favors that the environment provides. For anthropologists (Aguirre, 1982; Paul, 1987; White, 1982), the relationship between man and nature is mediated by several factors such as the human organism, the environment, the energy linked by man to the productive process, the means and ways in which said energy; and the satisfaction of needs and services, as consequences of the use of energy.

Therefore, the cultural products resulting from the application of energy and the efficiency of its use, according to the authors (Hubert, 1990; Troc, 2014), depend on the amount of energy used in the task, the technological means that allow its realization and the result of the work as such.

So, efficiency depends on the knowledge and skills of the subject or group, as well as the technological means with which it counts. These elements would ultimately stipulate the growth or evolution of a human group and its cultural products (Hawthorn, 1995; Hubert, 1990). A number of arguments support the presented criteria, and from a historical perspective, they show the contribution of energy to cultural evolution and its sharp correlation with technological development (Póth & Kistelegdi, 2013).

Humanly speaking, the link with solar energy in all its manifestations, and regardless of the organic or physiological level, has been a catalyst that has allowed the development of man as a some specie in various areas, which has finally allowed society to constitute itself as such. and develop what we call culture.

Considering the above, an investigation from the sociological and anthropological perspective of the human / energy interaction could yield results that would complement lines of research such as sustainable production and consumption, energy management, climate change, among others.

First scientific meetings of global connotation, around the applications of solar energy.

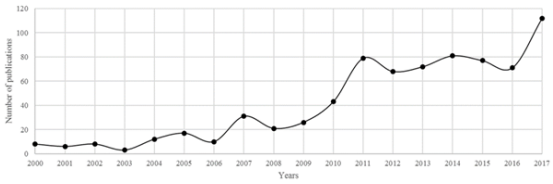
Unlike the formal configuration of the scientific conventions that take place today, the discussions used to take place unofficially, so many of these events were not reported or recorded. With regard to solar energy, in particular, the first symposium was held at MIT, Cambridge, Massachusetts, in 1950, and referred to heating indoor spaces with solar thermal energy. It was organized by the American Academy of Arts and Sciences, and 20 papers were presented (Jensen, 1959). The event was chaired by H. C. Hotel.

In 1953 a meeting was held on the use of solar energy in which the president was Farington Daniels. It was a meeting of 40 participants, held at the University of Wisconsin under the auspices of the National Science Foundation. The procedures were published by F. Daniels and J. A. Duffie in 1955. Duffie added a chapter that reviewed all patents related to solar energy up to that time (Jensen, 1959). The next solar energy congress was held in New Delhi, India, in 1954, under the auspices of UNESCO, and included wind energy.

The great impulse was provided by the World Symposium on Applied Solar Energy, in 1955, in Phoenix, Arizona, and the subsequent one was also held in the same city in 1958 on the use of solar energy and its scientific basis. These two meetings were organized by the Association of Applied Solar Energy, which was later renamed as the well-known International Society of Solar Energy, for its acronym (ISES). ISES continues to organize international and local conferences on solar energy. In 2005, Böer published the 50-year history of ISES in two volumes (Böer, 2005).

Bibliometric of scientific activity focused on the applications of solar energy in the 21st century.
Under the criteria and search conditions highlighted in the methods section of this contribution, and the subsequent analysis of the information extracted from the Scopus catalog. figure N° 1 was obtained. This figure shows the behavior of contributions from the 2000s. There is a clear tendency to growth in research related to this field.

Figure N° 1. Distribution of contributions detected in the last decades
Source: own elaboration. (Made in Scopus)

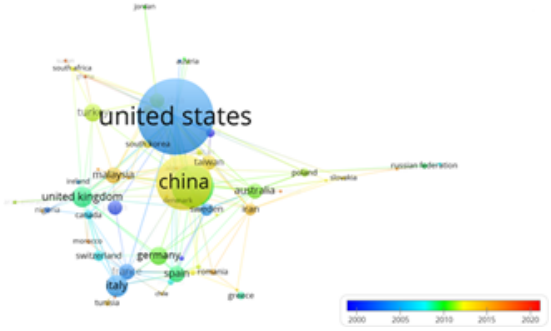


55.1% of the contributions that have been detected under the previously established search criteria are scientific articles, while another 33% belong to session documents (Conference papers), and only 4.1% represent the review articles. These are the most significant percentage values in the distribution of the different types of documents.

The lines of research most represented by this topic are: energy with 41% of documents detected, while engineering reports 34.9%, followed by the area or line of research, materials science, which supports 19.4%. These are the most developed lines of research in the innovations of processes of capture, accumulation and use of solar energy.

The leading nations in terms of published scientific results, detected under the established search criteria are United States and China, with 187 and 125 documents respectively. The powers of the world economic axis see in the applications of solar energy an optimal, efficient and safe outlet to the current energy demands. Figure N° 2 attests to the declared. This figure shows the intensity (in resignation of the circumference) of publications by nations as a function of years (years represented by the color scale). In addition, it shows the cooperation network of these nations in regards to the research of solar energy applications. It is observed how the People's Republic of China intensifies its results in this research area around 2015, with Malacia being the nation with the most cooperation.

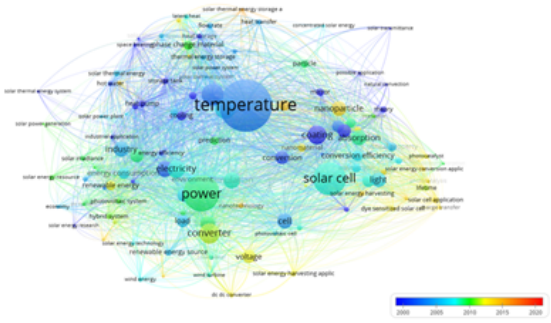
Figure N° 2. Cooperation network among countries in terms of solar energy research and its application, and intensity of published results
Source: own elaboration. (Made in VOSviewer).



To develop the map of terms shown in figure N° 3, of the file exported in CSV formats; the intensity and correlation of terms defined for titles and keywords in each of the works contained under the search criteria mentioned in the methods section was analyzed using the VOSviewer tool. It can be seen in the figure "Temperature" is the term of greatest intensity of occurrence, because this is the physical magnitude of relevant utility in the most diverse forms of application of solar energy. Contemplating the displacement of the range of colors in this graph, it can be seen that these terms have been changing over the years, given that the

application practices of solar energy have been displaced to the production of electrical energy. The applications of solar energy nowadays are not only limited to energy services such as thermal comfort, sanitary hot water or steam service; but, the generation of electrical energy, both concentrated and distributed, is being represented by this practice. The latter is evidenced by the second term of greater concurrence "Power".

Figure N° 3. Map of correlation between terms referring to research in solar energy applications
Source: own elaboration. (Made in VOSviewer)



Therefore, the trends in the applications of solar energy at the beginning of this century, are focused on: a) Heating and cooling of buildings, b) Electric power generation, in both concentrated and distributed forms, c) Energy conversion for industrial processes.

The international scientific community has aroused great interest in this energy practice. Figure N° 4 shows the diversity of scholars who converge in this type of research since 2010.

Figure N° 4. Map of correlation between authors of publications in the field of solar energy applications
Source: own elaboration. (Made in VOSviewer).

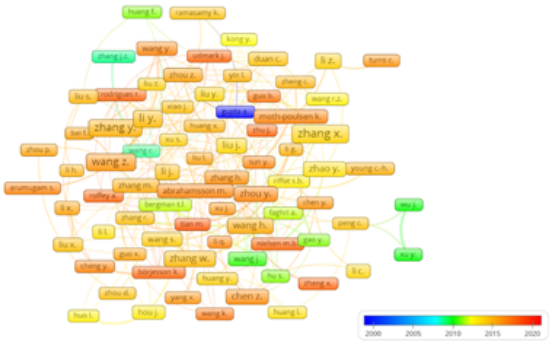
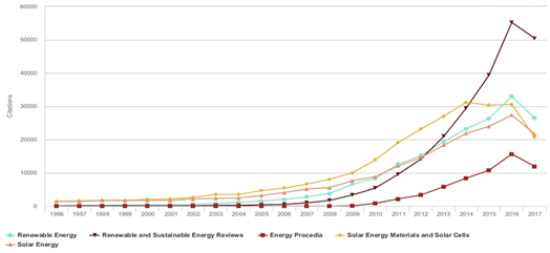


Figure N° 5 shows the performance in terms of citations of the five journals that most socialize this topic in Scopus. This is considered a period that covers from 1996 to September 2017. It shows a significant increase in the index of citations from the year 2010. New environmental conditions at the global level, as well as geopolitical conflicts over the dominance of each more finite energy reserves, have led to the growing interest in energy practices activated with the incidence of the sun. To our days, the path of the sun becomes a viable alternative to the energy and environmental problems facing our civilization.

Figure N° 5. Index of citation index of the journals that most represent this topic within this catalog
Source: own elaboration. (Made in Scopus)



Discussion

The ephemeral historical representation reflected so far, has the purpose of attesting that the extensive and laborious way by which that conception of solar energy and its use has been transformed by the world and has been mobilizing it in turn. It is evident that not only solar energy knowledge and technologies have been modified, but that, taking into account the social nature of innovations, each human group has put its stamp on this evolution. While religious entities have emerged, political and civil among others, whose performance has had a preponderant role in the decisive role that the energetic power has played in the progress, change and crisis of our civilization (Katsaprakakis et al., 2017; Lenton, Pichler, & Weisz, 2016).

The conversion of the different manifestations of solar energy refers to the use of the surrounding environment as a source of energy. The beginning of all economic activity from the most elementary organisms to the most advanced civilizations, is the conversion of solar energy, (Hall & Raumplaner, 1998; Sun, Fong, & Liu, 2017; Swart, 2015). Solar radiation, together with the inherent characteristics of the planet's atmosphere, allow the conversion of the first one into various

energetic forms that are essential for vital sustenance, (Chilipirea, Petre, & Dobre, 2013; Hamakawa, 2002).

Knowledge and technique have defined the social groups that have made the decisions, relying on the criterion that the mastery of nature through the tools created and the use of resources is the goal to achieve well-being and the possibility of a dignified and pleasant life. The passing of the years and consequently of the centuries, in the pilgrimage of man over the kingdom of this world, shows that the man-energy relationship is not so simple and that a sociological and historical explanation of the phenomenon may well contribute to a better and more broad understanding of the subject, which could challenge that traditional view of linearity and unlimited ascendancy of civilization (Hanel & Hård, 2015; Majumdar, Setter, Dobbs, Hencey, & Albonesi, 2015).

References

Aguirre, Á. (1982). Conceptos clave de la antropología cultural: Daimon.

Ahmadi, G., Toghraie, D., & Akbari, O. A. (2017). Efficiency improvement of a steam power plant through solar repowering. International Journal of Exergy, 22(2), 158-182. doi:10.1504/IJEX.2017.083015

Allamehzadeh, H. (2017). Wind energy history, technology and control. Paper presented at the 4th IEEE Conference on Technologies for Sustainability, SusTech 2016.

Andreas, J. J., Burns, C., & Touza, J. (2017). Renewable Energy as a Luxury? A Qualitative Comparative Analysis of the Role of the Economy in the EU's Renewable Energy Transitions During the 'Double Crisis'. Ecological Economics, 142, 81-90. doi:10.1016/j.ecolecon.2017.06.011

Bilgen, E. (2013). Intersol Eighty Five: Proceedings of the Ninth Biennial Congress of the International Solar Energy Society: Elsevier.

Böer, K. W. (2005). The Fifty-year history of the International Solar Energy Society and its national sections (Vol. 2): American Solar Energy Society.

Bravo Hidalgo, D. (2015). Energía y desarrollo sostenible en Cuba. Centro Azúcar, 42(4), 14-25.

Breeze, P., Vieira da Rosa, A., Doble, M., Gupta, H., Kalogirou, S., Maegaard, P., . . . Kruthiventi, A. (2009). Renewable energy focus handbook. San Diego, CA, USA: AP & Elsevier.

Burnham, J. F. (2006). Scopus database: a review. Biomedical digital libraries, 3(1), 1.

Bux, M., Bauer, K., Mühlbauer, W., & Conrad, T. (2001). Solar-assisted drying of timber at industrial scale. The Southern African Forestry Journal, 192(1), 73-78.

Chilipirea, C., Petre, A. C., & Dobre, C. (2013). Energy-aware social-based routing in opportunistic networks.

Deering, D., & Sweeney, G. (2017). Understanding the scope: Brief history of energy industry cyberattacks. Pipeline and Gas Journal, 244(5).

Dhurandher, S. K., Sharma, D. K., Woungang, I., & Saini, A. (2017). An energy-efficient history-based routing scheme for opportunistic networks. International Journal of Communication Systems, 30(7). doi:10.1002/dac.2989

Donateo, T., Ficarella, A., Spedicato, L., Arista, A., & Ferraro, M. (2017). A new approach to calculating endurance in electric flight and comparing fuel cells and batteries. Applied Energy, 187, 807-819. doi:10.1016/j.apenergy.2016.11.100

Fischhendler, I., Herman, L., & Maoz, N. (2017). The political economy of energy sanctions: Insights from a global outlook 1938–2017. Energy Research and Social Science, 34, 62-71. doi:10.1016/j.erss.2017.05.008

Guzmán, R. (2017). Science, technology and society in the XIX century: The concept of energy, its history and its cultural meanings. Revista de Humanidades(36), 145-178.

Hall, P. G., & Raumplaner, S. (1998). Cities in civilization. 167-189.

Hamakawa, Y. (2002). Solar PV energy conversion and the 21st century's civilization. Solar Energy Materials and Solar Cells, 74(1-4), 13-23. doi:10.1016/S0927-0248(02)00043-0

Hanel, T., & Hård, M. (2015). Inventing traditions: interests, parables and nostalgia in the history of nuclear energy. History and Technology, 31(2), 84-107. doi:10.1080/07341512.2015.1101837

Hawthorn, G. (1995). Mundos plausibles, mundos alternativos: posibilidad y comprensión en la historia y en las ciencias sociales (Vol. 4): Ediciones AKAL.

Hubert, A. (1990). Diet, environment and society: Cultural

and social aspects of diet in nutritional anthropology.

Jensen, J. S. (1959). Applied solar energy research: a directory of world activities and bibliography of significant literature.

Karthik Reddy, B. S., & Poondla, A. (2017). Performance analysis of solar powered Unmanned Aerial Vehicle. Renewable Energy, 104, 20-29. doi:10.1016/j.renene.2016.12.008

Katsaprakakis, D. A., Georgila, K., Zidianakis, G., Michopoulos, A., Psarras, N., Christakis, D. G., . . . Kanouras, S. (2017). Energy upgrading of buildings. A holistic approach for the Natural History Museum of Crete, Greece. Renewable Energy, 114, 1306-1332. doi:10.1016/j.renene.2017.08.021

Kemper, J. (1977). Pictorial history of solar energy use. Sunworld, 5, 17-32.

Lenton, T. M., Pichler, P. P., & Weisz, H. (2016). Revolutions in energy input and material cycling in Earth history and human history. Earth System Dynamics, 7(2), 353-370. doi:10.5194/esd-7-353-2016

Majumdar, A., Setter, J. L., Dobbs, J. R., Hencey, B. M., & Albonesi, D. H. (2015). Energy-comfort optimization using discomfort history and probabilistic occupancy prediction. Paper presented at the 2014 International Green Computing Conference, IGCC 2014.

Moss, T. (2017). The Rise, fall and resurrection of waste-to-energy technologies in Berlin's infrastructure history Urban Sustainability Transitions (pp. 159-171): Taylor and Francis.

Oteman, M., Kooij, H. J., & Wiering, M. A. (2017). Pioneering renewable energy in an economic energy policy system: The history and development of dutch grassroots initiatives. Sustainability (Switzerland), 9(4). doi:10.3390/su9040550

Paul, R. A. (1987). The Individual and Society in Biological and Cultural Anthropology. Cultural Anthropology, 2(1), 80-93. doi:10.1525/can.1987.2.1.02a00080

Perović, J. (2017). The Soviet Union's rise as an international energy power: A short history Cold War Energy: A Transnational History of Soviet Oil and Gas (pp. 1-43): Springer International Publishing.

Póth, B., & Kistelegdi, I. (2013). The history of the energy and climate concept of the szentágothai research center. Pollack Periodica, 8(3), 3-14. doi:10.1556/Pollack.8.2013.3.1

Sun, G., Fong, D., & Liu, Y. (2017). The comparison between China and UK of the construction of city community sports service system in the scope of eco-civilization. Revista de la Facultad de Ingenieria, 32(9), 500-506.

Swart, P. (2015). The dawn of a civilisation pre bagan urban cities in myanmar. Arts of Asia, 45(2), 106-117.

Syed, T. S., & Safdar, G. A. (2017). History-Assisted Energy-Efficient Spectrum Sensing for Infrastructure-Based Cognitive Radio Networks. IEEE Transactions on Vehicular Technology, 66(3), 2462-2473. doi:10.1109/TVT.2016.2585763

Szabó, L. (2017). The history of using solar energy. Paper presented at the 7th International Conference on Modern Power Systems, MPS 2017.

Testi, D., Schito, E., & Conti, P. (2016). Cost-optimal Sizing of Solar Thermal and Photovoltaic Systems for the Heating and Cooling Needs of a Nearly Zero-Energy Building: The Case Study of a Farm Hostel in Italy. Paper presented at the 4th International Conference on Solar Heating and Cooling for Buildings and Industry, SHC 2015.

Thomas, K. W., & Thomas, A. T. (2003). Commentary on Aristotle's Physics (Vol. 1): A&C Black.

Troc, G. (2014). Opening address of the 11th annual conference of the romanian society for social and cultural anthropology "Modes of appropriation and social resistance". Studia Universitatis Babes-Bolyai Sociologia, 2014(2), 5-8.

Turrini, E. (2006). El camino del sol, un desafío para la humanidad del tercer milenio, una esperanza para los países de sur. Editorial Cubasolar, Ciudad de la Habana, Cuba

Waddell, W. J. (2010). History of dose response. The Journal of toxicological sciences, 35(1), 1-8.

White, L. A. (1982). La ciencia de la cultura: un estudio sobre el hombre y la civilización (Vol. 9): Grupo Planeta (GBS).