Contemporary Engineering Sciences, Vol. 11, 2018, no. 71, 3523 - 3530
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/ces.2018.87363

Research Progress on Sustainable Energy:

A Pest Study

Guillermo Valencia Ochoa[1], Jorge Duarte Forero[1] and Luis Obregon Quiñones[2]

[1] Efficient Energy Management Research Group, Universidad del Atlántico
Carrera 30 No 8 – 49, Puerto Colombia, Colombia

[2] Research Group on Sustainable Chemical and Biochemical Processes
Universidad del Atlántico, Carrera 30 No 8 – 49, Puerto Colombia, Colombia

Abstract

In the article, the most influential countries in the field of sustainable energy are taken into account, in order to determine the consequences that external aspects have on the number of research projects on a topic, it was decided to take into account the political, economic, social and technological criteria, summarized in a table. To complement this analysis, a ranking was made with the 5 countries that made the most publications, where the importance of the political role in each country was observed, in the flow of annual publications, where the most noticeable impact was in the country of China, the rest of the countries in the top maintained a stable behavior taking into account this point, USA, the country with the greatest number of publications, has the highest participation rate with 17%, almost double the second country in this ranking.

Keywords: Research progress, sustainable energy, Pest study

1. Introduction

The importance of energy within a country's economy is predominant, which is one of the major reasons why sustainable energy is one of the most researched issues at the global level, given that industry is a major contributor to climate change and growing awareness [1]. Given the current over-exploitation of resources, in addition

to the fact that these resources are considered non-renewable, this poses a challenge for society, which sees the damage to the environment becoming worse each year, and has therefore set itself the goal of reducing the global temperature increase produced by greenhouse gases by at least 1.5 °C [2].
Sustainable energy is considered a very important political driver, given the seriousness of the problem it is aimed at solving, from the economic point of view, it directly or indirectly affects, taking into account the nature of the research, it has been found that when the use of renewable energy increases by 10%, there is an economic growth of 0.27%, while, increasing the same percentage, but for non-renewable energy, there was a growth of 2.11% [3], [4].
Following the Fukushima accident and the Paris agreements, Japan investigated that so many resources were needed to supply these nuclear power plants, which implied an increase of 36% in gas imports and 121% in heavy oil imports, which has a great environmental and economic impact, which is why it was simulated that it is feasible to use 100% renewable energy [5]. The transition between the use of different types of energy involves both socio-technical and justice aspects, but these issues have always been treated as scattered cases, which could lead to inaccurate conclusions, so it is necessary to bridge these aspects in order to have a clearer criterion for future application [6].
Even though the number of organizations that seek to reduce the use of fossil fuels, with the aim of reducing their negative impact on the environment is increasing, research on this issue is quite limited in comparison, especially in countries that do not have this energy culture, especially in southern European countries [7], in order to demonstrate that the political, economic and social issues affect the degree of research on sustainable energy, research is being conducted to find qualitative parameters that allow us to see the proportionality with which these trends are affected [8].
The main contribution of this article is the complementary analysis of the political, economic, social and technological aspects that affect academic indicators in one way or another, bearing in mind that the subject to be dealt with is sustainable energy.

2. Methodology

2.1. Review of concepts

Sustainable energy is capable of supplying the current energy demand, without compromising the integrity of the environment, among the sustainable energies, are the renewable energies, which have taken great importance, taking into account the great impact that fossil energies have on the environment, where in general it is the most used, given the current environmental problems, has tried to exploit the alternatives offered, among the most used renewable energies are solar energy, wind energy, biomass energy, geothermal and hydroelectric energy.
Renewable energy differs from sustainable energy in that renewable energy tries to take advantage of any resource that does not generate damage to the environment,

while sustainable energy proposes the use of any type of energy as long as it can continue to be used in the future, an example of sustainable and non-renewable energy, is nuclear energy, which is not considered renewable given the damage it can generate. Therefore, any type of renewable energy is considered sustainable, but not in the opposite case.

2.2.Main types of sustainable energy

Solar energy: is the energy generated by the sun's rays, which can be extracted by means of solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt salt power plants and artificial photosynthesis. It is currently considered that only solar energy could supply the world's energy demand if the required technology were available, since more energy is produced in one hour than consumed worldwide in one year [9].
Wind energy: is the energy obtained from wind, the kinetic energy produced by wind on a turbine, then converted into useful forms of energy that are more beneficial to human activity, currently its main use is the generation of electricity, has obtained great relevance in the USA as it is the second source of renewable energy in the country and is expected to provide 20% of energy generated [10].
Hydraulic energy: is the source of renewable energy obtained through the flow of water in rivers, it is the conversion of hydraulic power to electricity through the flow that passes through turbines, generators and converters, generally hydroelectric stations are located at the bottom of the river bed, this in order to take advantage of the potential energy of the fluid and convert it into kinetic energy [11].
Nuclear energy: is released spontaneously through the process of nuclear fission, which is the most commonly used method in nuclear power plants [12], although it is an efficient way of obtaining energy, the minimum security conditions are high, and therefore there are few countries capable of using this type of energy commercially. Furthermore, since the Fukushima incident in 2011, many of the countries where it was implemented have decided to stop using it as a source of energy and focus on alternative and sustainable ways [13], [14].

3. Research results

3.1. PEST analysis

In Table 1, an analysis is made taking into account the political, economic, social and technological aspects of the three main countries in sustainable energy, in order to determine the degree of impact that these factors have on academia and how this is reflected in the number of publications produced in each country, where it can be observed that the country with the greatest economic participation in this type of energy is China, being this a country with high energy consumption and one of the most polluting at a global level.

Criteria.	USA.	China.	UK.
Political.	Relevant laws in the field of energy include, the PURPA of 1978, the Energy ACt of 1992, the numerous modifications through the EPAct of 2005 and EISA of 2007. PURPA was the first law to establish tax credits for renewable energy, the Energy Act of 1992 liberalizes the electricity market, while the EPAct and EISA support the use of renewable electricity and biofuel. In 2011, Barack Obama wanted electricity to come from clean sources by 2035, measures that for the most part have been declined by the new US president, Donald Trump.	The Chinese law on sustainable energy is divided into three levels, the first level provides guidelines and guidance on the Chinese government's view of the environment, the second level seeks to standardize the direction and objectives to be followed in accordance with the government's plan, and the third level offers support and economic incentives to encourage the growth of sustainable energy use in the country. In 2001, the SETC proposed a 5-year plan in which one of the objectives is to achieve 13 Mtce of electricity, excluding the use of biomass and hydroelectric power[15].	The basis of the energy policies or the policies they are aimed to achieve is to stimulate the exploitation of alternative forms of energy generation within the UK, to establish and develop options for the future and to encourage UK industry to exploit the domestic and external market, new key objectives were introduced in the future, such as helping the UK to meet global targets for reducing greenhouse gas emissions, helping to provide secure, diverse, sustainable and competitive inputs from which energy can be extracted[16].
Economic.	Since 2010 the price of PV has decreased by up to 70%, the advance of this type of energy has been such that, currently batteries are better and cheaper, thus saving from 100 billion to 280 billion, avoiding investment in new electrical infrastructure between 2010- 2040.	At the beginning of 2017, China announced an investment of 360 billion dollars in renewable energy over a period of 3 years, and China currently invested more than 100 billion dollars in domestic renewable energy, in addition to investing 32 billion more than any other country in this area, in foreign renewable energy[17].	The amount of money invested in sustainable energy by UK businesses increased in the period 2010-2015, but was drastically reduced in 2017, when only $4.8 billion was invested.
Social.	The acceptance of sustainable energy in the USA is such that 91% of the population believes it is necessary to invest in this type of energy to keep it economically competitive and 67% would agree to pay more to the energy supplier if it uses renewable energy.	Comparing rural and urban dwellers within China, urban areas have a greater knowledge of solar energy technologies, while the solar toilet heater (SWH) is more widely accepted than photovoltaic solar energy[18].	The UK's interest in renewable energy has been increasing over time, with the main source of interest being the commitment made in the various intergovernmental agreements to reduce the damage done to the environment.
Technological.	Sustainable energy uses in the United States have a long history, such that in the 1970s a predictive model of wind turbine performance was developed, with nearly 10% of the electricity used in the country coming from biomass, 44% from hydroelectric, 6% from solar and 3% from geothermal sources, a distribution applied to renewable energies. [19]	By 2011, China's energy demand was 70 per cent met by energy produced using coal as fuel, 6 per cent from hydropower, less than 1 per cent from nuclear power and 1 per cent from renewable energy, and by 2050, coal power production is expected to decline by at least 35 per cent.	On the technological front, the United Kingdom has been characterized by a very poor choice of mechanisms for obtaining sustainable energy, where wind energy is the first choice and biomass energy comes second[16].

3.2. Analysis of research trends

As a complement to the PEST analysis and to be able to analyze in greater detail the impact generated on the degree of research on the subject.

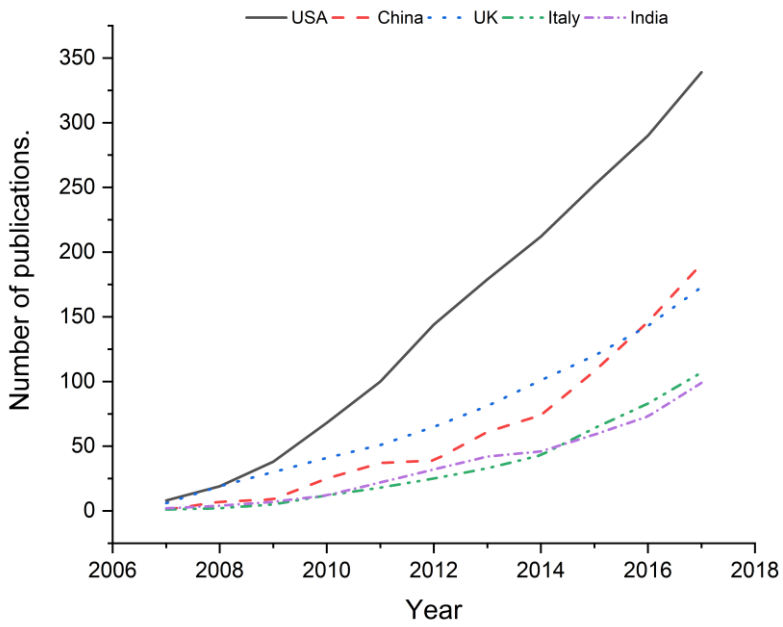

Figure 1. Accumulative number of publications.

Figure 1 shows the cumulative behavior of the number of publications by country of the top 5 countries with the highest number of articles in the period from 2007 to 2017, since these countries are considered the most relevant to take into account in terms of sustainable energy, where it can be seen that the USA, the country with the most publications, has a trend that shows a straight line, with a gradual growth and without drastic changes, which can be observed, that external factors did not play an important role in the publications made in this country, which suggests that the USA is a country that promotes all types of research, while China is a particular case, where there is no clear pattern, despite the fact that by 2007 it was one of the countries with the least published research, it was constantly increasing to the point of surpassing the UK, which was in second place taking into account this rating criterion.

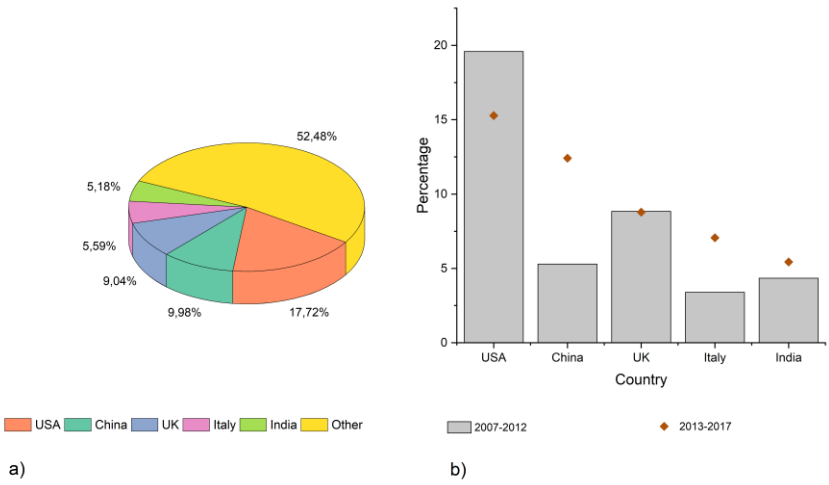

Figure 2. Results, a) Percentage of publications from the first 5 countries. b) Percentages by publication period.

Taking into account that the publication patterns are variable over time and it is difficult to predict how they will behave, Figure 2 (a) shows the percentage of contribution of the first 5 countries, where it can be seen that these countries comply almost entirely with the publications made by the rest of the world, Figure 2 (b) shows the percentage of contribution of these countries with respect to the total number of publications at the global level, in order to see more clearly the change in said behavior, where it is more detailed, that for the period from 2013 to 2017 there was an increase in the participation rate of 4 of the 5 countries in the top, with respect to the previous period, being the USA the only exception in the ranking.

4. Conclusions

The use of sustainable energies has been increasing over time, due to the rise in world energy demand and the fact that the use of fossil fuels for energy generation produces a corrosive effect on the environment, in addition to the finite life they have, it is necessary to explore alternatives that not only allow the current demand for energy to be met, but also ensure that the resources implemented for energy generation are maintained over time, avoiding a future large-scale energy crisis. In order to mitigate both problems, various international treaties have been signed in order to reduce the negative environmental impact. As a result, China, one of the countries with the highest world energy demand, in addition to being one of the most polluting, has increased investment in this type of energy, which is not only reflected in an economic way, it also had an influence on the number of publications, where although the USA was the only country in the top that decreased its contribution at a global level, it still maintained first place, where the

United Kingdom maintained a constant behavior in this aspect, despite being overtaken by China in the second period of analysis.

References

[1] N. Vidadili, E. Suleymanov, C. Bulut and C. Mahmudlu, Transition to renewable energy and sustainable energy development in Azerbaijan, *Renew. Sustain. Energy Rev.*, **80** (2017), 1153–1161. https://doi.org/10.1016/j.rser.2017.05.168

[2] M. Child, O. Koskinen, L. Linnanen and C. Breyer, Sustainability guardrails for energy scenarios of the global energy transition, *Renew. Sustain. Energy Rev.*, **91** (2018), 321–334. https://doi.org/10.1016/j.rser.2018.03.079

[3] S. Adams, E. K. M. Klobodu and A. Apio, Renewable and non-renewable energy, regime type and economic growth, *Renew. Energy*, **125** (2018), 755–767. https://doi.org/10.1016/j.renene.2018.02.135

[4] J. Benedek, T. T. Sebestyén and B. Bartók, Evaluation of renewable energy sources in peripheral areas and renewable energy-based rural development, *Renew. Sustain. Energy Rev.*, **90** (2018), 516–535. https://doi.org/10.1016/j.rser.2018.03.020

[5] M. Esteban, Joana Portugal-Pereira, B. Mclellan, J. Bricker, H. Farzaneh, N. Djalilova, K. Ishihara, H. Takagi, V. Roeber, 100% renewable energy system in Japan: Smoothening and ancillary services, *Appl. Energy*, **224** (2018), 698–707. https://doi.org/10.1016/j.apenergy.2018.04.067

[6] S. Sareen and H. Haarstad, Bridging socio-technical and justice aspects of sustainable energy transitions, *Appl. Energy*, **228** (2018), 624–632. https://doi.org/10.1016/j.apenergy.2018.06.104

[7] I. Heras-Saizarbitoria, L. Sáez, E. Allur and J. Morandeira, The emergence of renewable energy cooperatives in Spain: A review, *Renew. Sustain. Energy Rev.*, **94** (2018), 1036–1043. https://doi.org/10.1016/j.rser.2018.06.049

[8] B. A. G. Bossink, Demonstrating sustainable energy: A review based model of sustainable energy demonstration projects, *Renew. Sustain. Energy Rev.*, **77** (2017), 1349–1362. https://doi.org/10.1016/j.rser.2017.02.002

[9] E. Kabir, P. Kumar, S. Kumar, A. A. Adelodun and K. H. Kim, Solar energy: Potential and future prospects, *Renew. Sustain. Energy Rev.*, **82** (2018), 894–900. https://doi.org/10.1016/j.rser.2017.09.094

[10] D. J. Willis, C. Niezrecki, D. Kuchma, E. Hines, S.R. Arwade, R.J. Barthelmie, M. DiPaola, P.J. Drane, C.J. Hansen, M. Inalpolat, J.H. Mack, A.T. Myers, M. Rotea, Wind energy research: State-of-the-art and future research directions, *Renew. Energy*, **125** (2018), 133–154. https://doi.org/10.1016/j.renene.2018.02.049

[11] Z. Şen, 3.7 Hydro Energy Production, in *Comprehensive Energy Systems*, Elsevier, Vol. 3, 2018, 304-334. https://doi.org/10.1016/b978-0-12-809597-3.00314-x

[12] S. Şahin and H. Mehmet Şahin, 1.20 Nuclear Energy, in *Comprehensive Energy* Systems, Elsevier, Vol. 1, 2018, 795-849. https://doi.org/10.1016/b978-0-12-809597-3.00122-x

[13] V. Knapp and D. Pevec, Promises and limitations of nuclear fission energy in combating climate change, *Energy Policy*, **120** (2018), 94–99. https://doi.org/10.1016/j.enpol.2018.05.027

[14] A. S. Bisconti, Changing public attitudes toward nuclear energy, *Prog. Nucl. Energy*, **102** (2018), 103–113. https://doi.org/10.1016/j.pnucene.2017.07.002

[15] Energy Research Institute, Renewable Energy Policy in China: Overview, 2, 2014.

[16] P. Connor, UK renewable energy policy: a review, *Renew. Sustain. Energy Rev.*, **7** (2003), no. 1, 65–82. https://doi.org/10.1016/s1364-0321(02)00054-0

[17] H. Ma, L. Oxley, J. Gibson and W. Li, A survey of China's renewable energy economy, *Renew. Sustain. Energy Rev.*, **14** (2010), no. 1, 438–445. https://doi.org/10.1016/j.rser.2009.07.029

[18] X. Yuan, J. Zuo and C. Ma, Social acceptance of solar energy technologies in China-End users' perspective, *Energy Policy*, 39 (2011), no. 3, 1031–1036. https://doi.org/10.1016/j.enpol.2011.01.003

[19] Jan Wittry, Wind Energy Research Reaps Rewards, *NASA*. https://www.nasa.gov/vision/earth/technologies/wind_turbines.html

Received: August 14, 2018; Published: August 31, 2018