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PEST Study of CO_2 Capture Strategy from 2007 to 2018

Daniel Mendoza Casseres[1], Guillermo Eliecer Valencia[2] and Javier Cárdenas Gutiérrez[3]

[1] Industrial Engineering Program, Faculty of Engineering
Universidad del Atlántico, Carrera 30 No 8 – 49, Puerto Colombia, Colombia

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

[3] Civil Engineering Program, Faculty of Engineering
Universidad Francisco de Paula Santander Colombia – Cúcuta, Colombia

Abstract

Currently, CO_2 capture and storage is a method approved by many countries to combat CO_2 emissions, taking power and oil plants as study areas. According to many climate agreements made in the last decade, developed countries have implemented capture and storage projects in several countries, resulting in a reduction of CO_2 emissions and being a key player in reducing global temperatures by 2050 using protocols, research centres and government support for future capture projects. The study conducted research on the countries with the largest number of publications on CO_2 capture, considering the actions taken by different governments on issues related to politics, economics, society and technology with the help of a PEST analysis.

Keywords: CO_2 capture, CO_2 emissions, CAC, PEST analysis

1. Introduction

Carbon dioxide emissions have become a global problem due to their great impact on climate change and the environment, and because of this techniques have been

developed to try to control emissions into the atmosphere [1], one of them is the technique of capturing CO_2, applied in a modern power plant, in which by 2100, it can reduce between 10% and 55% according to the IPCC [2].
Three methods are used for capture and storage, solvent based chemisorption [3], for which studies have been conducted using different solvents, such as a multifunctional acid-base catalyst [4], co-immobilized enzyme/complex [5], and porous polymers [6] to increase capture capacity and assist in the design of catalytic systems for carbon dioxide conversion. Adding to this, for carbonate loop technology, techno-economic studies have been carried out [7],[8] and life cycle assessments [9] in different coal processing plants and thermodynamic studies for the simultaneity of natural gas production and CO_2 capture [10]. The oxyfuel process, which has been investigated for the effectiveness of CO_2 capture in a cement plant [11],[12], as well as research and reviews of different applications, compared to other capture methods [13],[14]. These methods have been used as a way to try to reduce CO_2 emissions in many applications, but using different ways of applying them, such as using ionic liquids to capture and store CO_2 in processes based on monoethanolamine in the combustion gases of a power plant, reducing the energy consumed by up to 30% and reducing CO_2 emissions [15], as well as using an amine impregnated silicic acid compound as an adsorbent for CO_2 capture, obtaining that the desorption activation energy was 335 Kj/mol and the estimated thermal regeneration load for the absorber was 53.29 kJ/mol CO_2 [16],[17], as well as for the study of CO_2 capture by carbontae loop in a 1 MW plant [18], analyzes the influence of crushing on the CO_2 capture yield of CaO derived from natural limestone, for which, depending on the process used to obtain CaO, CaO will have less carbonation and will have greater crystallization or greater carbonation and less crystallinity of Cao, producing more CO_2 emissions [19]. Although the method is very useful for reducing emissions, it is characterized by high energy consumption, with which research was conducted to use a hybrid configuration of the CO_2 capture process after combustion in thermal power plants using aqueous monoethanolamine as a simulated absorbent in Aspen Plus [20]. The main contribution of this study is to understand and show the evolution of CO2 capture in different countries, analyzing the trend and number of publications during 2007 to 2018 using HistCite.

2. Methodology

2.1 Review of the concept: CO_2 Capture.

Many of the human activities and constant use of fuel burning in large power plants, car engines, or industrial processes produce CO_2 emissions. Carbon dioxide capture and storage is one of the techniques they use to reduce CO_2 emissions in power plants, industrial plants and plants where the raw material is fossil fuels and/or coal [21],[22]. For the application of capture and storage systems, a process was initiated from 2015 to 2050 [23] to reduce emissions in industry, starting with gas and bio-fuel processing plants. The implication is that

by 2025 applications such as steel and iron blast furnaces, cement kilns and flue gas cleaning must have the technique fully implemented as shown in Figure 1 [24].

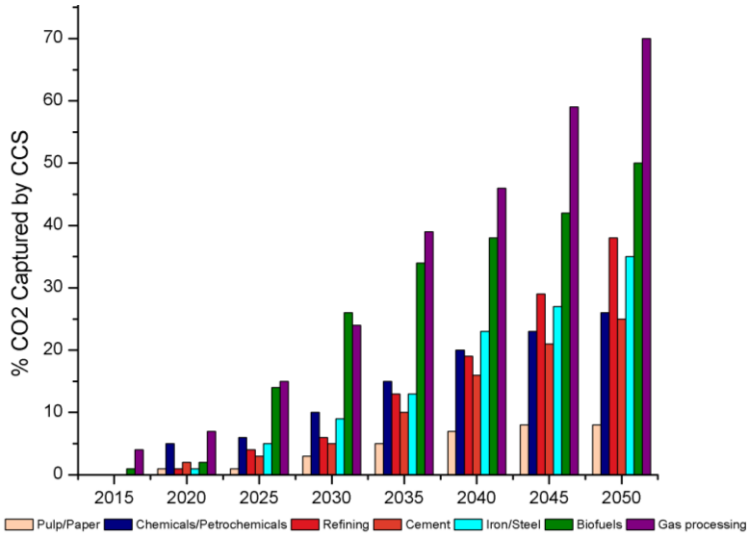

Figure 1. CO_2 captured and stored through CCS in industrial sectors from 2015 to 2050

2.2 CO_2 capture techniques

There are three essential techniques for CO_2 capture and storage, which are widely used in industry: Pre-combustion, which carries out a pre-combustion gasification of fossil fuel H2 and CO_2, thus treating an effluent that is relatively rich in CO_2 and with average pressure conditions that favour capture and post-combustion, which it captures at the end of the entire thermal combustion cycle, with low CO_2 concentration and low pressure, which implies low capture performance; Oxy-combustion, where oxygen is supplied to replace air to prevent nitrogen, reusing CO_2 as inert, reducing the flow of gas to treat and increasing the concentration of CO_2 in it; absorption/adsorption, physicochemical and separation processes, which use amines, ammonia, active carbons, membranes, using regeneration and compression cycles, among others. Figure 2 shows the capture process of each technique, plus where many process reagents are headed.

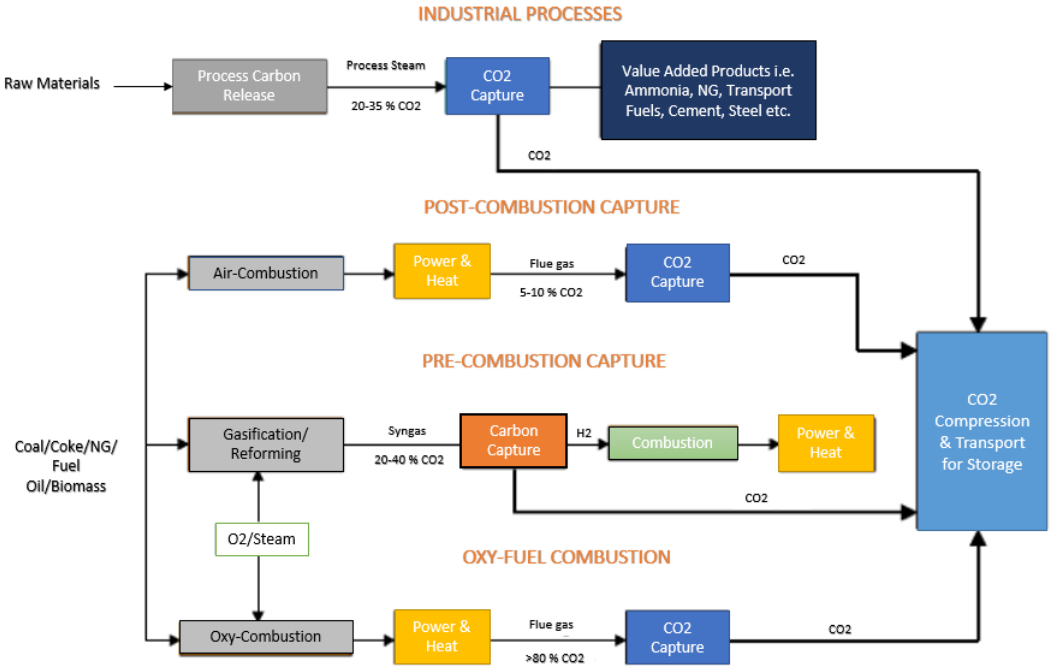

Figure 2. Techniques and technologies for capture, post, pre and oxyfuel combustión.

3. Results and Discussion

3.1 PEST Analysis

The changes that occurred in the different countries with respect to the number of articles published on CO_2 capture and storage are due to the regulations that have been implemented around the world, following global interests, such as the reduction of emissions to reduce the greenhouse effect. The country that had the greatest positive impact in terms of political, social, economic and technological aspects was the United States, due to its research into CO_2 capture techniques used in oil wells, using pure CO_2 acts as a solvent and generates greater extraction of oil. In addition to this, many power plants have tested many carbon dioxide capture and storage systems, reducing CO_2 emissions and taking the lead in developed economies with lower emissions, which has generated the interest of the government to continue implementing, giving incentives to those plants that can acquire these technologies. The second country with the most publications is China, known as the country with the most green technologies, supporting the fight against global warming. China has implemented certain policies together with government support to implement a total of seven CCS projects, in order to contribute to the reduction of its emissions by 35-40% in the coming years. The third most published country is the UK, which has been presenting research projects on CO_2 capture and storage techniques since 2006, and in 2011, imple-

menting a project to support new power and thermal generation plants, with approximately 1 billion euros to implement capture and storage systems, with the expectation of obtaining many jobs for its citizens. Finally, South Korea, has been implemented since 2011, creating the Korea Carbon Capture & Sequestration R&D Center, which has as its base project "Korea CCS 2020", for which more than 600 researchers hope to study the best way to implement CO_2 capture systems, hoping to obtain more than two original CO_2 conversion technologies applicable to large companies, more than four types of original CO_2 capture technologies, among others, with a budget of, approximately, 160,000,000 USD as shown in Table 1.

3.2 Analysis of research trends

The country that has published the most articles during the study period is China with 1223 articles published (24.54%) maintaining a growing linear trend from 2011 to date, followed by the United States with 964 (15.74%), the United Kingdom with 345 (6.57%), South Korea with 288 (5.61%) and Australia with 281 (5.34%). These five countries make up 57.8% of total global publications, showing a greater trend in these countries with the issue of CO2 capture, shown in Figure 3.

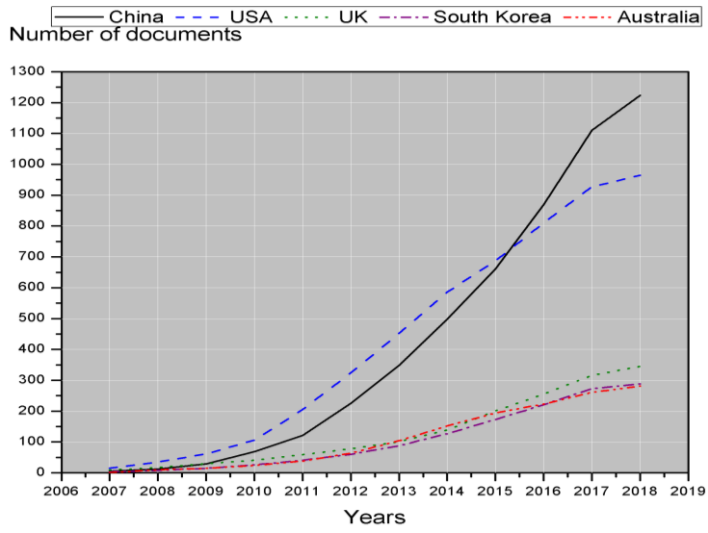

Figure 3. Trends in scientific production for the top 5 conutries from 2007 to 2017.

Figure 4 shows the top 10 countries with the highest number of publications regarding CO_2 capture in percentages. For a better visualization of the data, they were divided into two time intervals, one between a period of time between 2007-2012 and 2013-2018, in order to show the evolution of research on political, economic, social and technological aspects in the number of articles published and thus be able to perform an analysis that can predict behavior.

Table 1. Pest analysis at China, USA, UK and South Korea.

Criteria	China	USA	UK	South Korea
Policies	For this Asian country, leader in its continent in capturing CO2 emissions, there are 3 policies implemented in 2007, which regulate emissions by conducting research between 2007 and 2020 for green engineering implementations, including CO2 capture as a key piece to achieve the purpose.	Due to the implementation of CCS in industries, the government, together with the Energy Security and Climate Initiative, supporting the International Energy Agency, presented proposals for the commercialization of CCS in all energy industries, offering discounts for those who are included and a larger budget from the government due to the importance of this challenge for the environmental impact.	In this country, it is required that new coal-fired power plants be required to build a CCS at part of their capacity and that new thermal power plants of more than 300MW must be designed to be ready for carbon sequestration, establishing the legal framework 2009/31/EC of the European Parliament and of the Council.	In this country, there is the KCRC, an institution dedicated to the study of technologies and policies for CCS, where it focuses on strategy planning, complying with the Paris climate agreement and developing a comprehensive plan for the international competitiveness of CCS technologies, proposed in the Korea CCS 2020 project.
Economic Aspects	Due to its large capacity of raw materials with coal and having a large number of coal plants, China has decided to invest in CO2 capture plants, costing $129 million, only the first of seven to build, which will begin to capture more than 40 million tons annually.	Due to the high cost of implementing CCS projects and the increased prices of storing CO2 emissions, as well as the low price of coal and the reduction of Natural Gas prices, studies have been conducted to implement several CCS projects, following many oil companies that use these projects for their work.	Since 2012, a program for the commercialization of CO2 capture and storage projects has been initiated, contributing more than one billion euros to the design and construction of new projects; in addition, by 2020, the government will give more than 20 million euros for projects and new technologies related to CO2 capture and reuse.	With the Korea CCS 2020 project as a standard for international marketing, the South Korean government has invested more than $150 million in the project, with more than 600 researchers.
Technology	As the leading country in green technology, it complements policies with strategic alliances with other countries, and many companies have provided support together with the government to carry out research and implement systems in other countries to complement the green technologies implemented.	At present, not much research has been done on the implementation and innovation of CO2 capture, so the same technologies are still being used, using other catalysts, due to their high cost and lack of government support.	The UK is currently participating in the ERA-NET scheme to accelerate CCS technologies with eight European countries, which is supported by €36.6 million for calls for proposals on the take-off of CCUS in Europe.	Since 2011, the KCRC has developed technologies for the best and constant updating of CCS techniques, to encourage an optimal way to implement it, following one of the objectives of the Korea CCS 2020 project, being the third country with competitive technologies in the world.
Society	China leads the climate change committee, due to its innovations in green technology, to help restore air quality, reduce emissions and meet the Paris agreement not to raise the Earth's temperature by two degrees Celsius by 2050.	With the increase in emissions in the world after the climate agreement signed in Paris and Trump's opposition to this agreement, in the USA there was a decrease in carbon emissions from all developed countries, causing uncertainty as to how the environmental impact will be regulated being outside the climate agreement.	The UK government has stimulated the environmental sector with a value of 50 million euros, part of which is for CCS projects, which could generate more than 100,000 jobs, providing more than 6.5 billion pounds sterling for the country.	The development of the project will bring more jobs to the region, in addition to demonstrating the first technology to integrate capture-transport-storage of ten thousand tons of CO2, reducing emissions caused by the country.

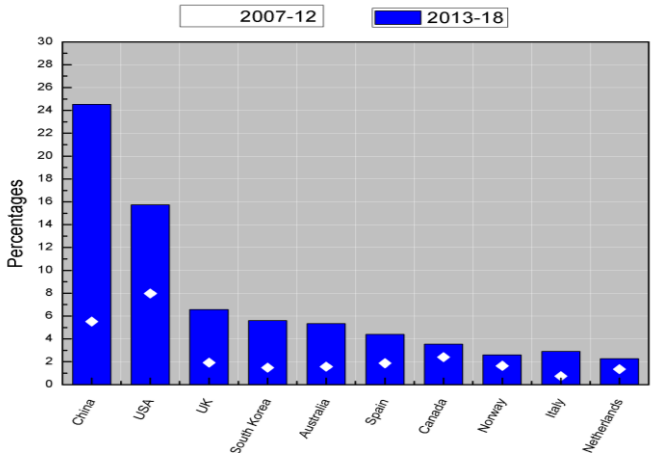

Figure 4. Top 10 countries, share of worldwide reseach production output, 2007-12 and 2013-18.

The figure shows that countries such as South Korea, Australia and Spain have a similar number of publications in both periods, while China and the USA stood out in both periods, with more China contributing for the period 2013-2018.

4. Conclusions

The strategies taken by the countries analyzed have resulted in increased research into CO_2 capture, adding new technologies and techniques to optimize capture in power plants and reduce CO_2 emissions on the planet. The organizations in charge of studying new capture methods and technologies play an important role in complying with climate agreements, in addition to creating green technologies for the preservation of the planet. Countries such as the United States, China and the United Kingdom have the highest number of publications on CO_2 capture and storage methods and technologies, despite their high implementation cost and the constant price of capture storage.

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