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Political-economical evaluation of CO₂ capture in Australian building sector

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Abstract

CO₂ capturing technologies, despite the fact that they have been introduced a few decades ago, are suffering from a wide implementation across the industries. Governments, after the 2015 Paris climate change agreement had decided to lower the level of carbon emission to a certain degree depending on the region and the countries environmental state. The commitments worth billions of dollars had doomed to accomplish a significant practical advancement. Reports indicate that none of the 22 CO₂ capture proposals across Australia had come to reality. In this article, a precise focus had been placed on the political and economical aspects of these technologies aiming to tackle the barriers exist. Legislations and regulations had been reviewed for political evaluation purposes. Carbon tax levy and its economical benefits, if remained in effect, had been discussed. For the purpose of economical evaluation, the Australian job market had gone under investigation. Data mining techniques had been deployed in order to extract data from the total number of job advertisements and the positions which had been stating environmental assessment as a keyword in their job description had been picked as to be an indication for employability.

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Keywords

CO₂ Capture; Carbon Tax; Data Mining; Employment

Introduction

CO₂ capturing, although so far had been considered mostly for capturing the flue gases emitted from the energy power plants, is now also being considered for implementation in the construction industry particularly in the cement factories. The application in the construction industry can go beyond to steel manufacturing industries as well. If it is to be considered for steel production, care must be taken in order to have a proper control over the structural behaviour of steel frames made mainly due to the possible different crystallization procedure in this case [1, 2]. It is known as a matter of fact that for the production of each ton of cement another ton of CO₂ is being emitted in the atmosphere. From the technological point of view, three major approaches are present for this purpose: post-combustion, pre-combustion, oxyfuel combustion[3, 4]. Although this paper is precisely focusing on the implementation of CO₂ capturing techniques in the concrete/cement industry, the extension of such approach is nevertheless practical in the steel manufacturing as well. Cement industry is one of the best places of investment for CO₂ capture mainly because of the high rate of return as cement factories are one of the major sources of CO₂ emissions. Barker et al. [5] states that pre-combustion method cannot be employed in the cement factories due to the technological barriers exist. This method is designed to capture the fuel-derived emissions and not the larger quantity of CO₂ from decomposition of carbonate minerals. In the same study, the cost of cement production and CO₂ capture were calculated assuming a 10% annual discount rate in constant money value, a 25 year plant life and other incurring expense.

Carbon Dioxide is a naturally occurring gas which occurs in the environment through decomposition of plants/animals, volcanic eruptions and as a waste product through respiration. Carbon Dioxide has always been present in the environment however since the industry revolution in 1760 the amount of CO₂ in the atmosphere has increased by approximately 40%. Since the industrial revolution over 200 years ago the amount of carbon dioxide in the atmosphere has increased dramatically due to the discovery that us humans can use naturally occurring elements such as fossil fuels (coal, oil and natural gas) and hydrocarbon fuels (methane, butane, propane, and hexane) as a fuel source to power machines and vehicles, as a source of electricity, to heat homes and in the power and manufacturing industries. At first the use of fossil and hydrocarbon fuels as a power source was well regarded however as time when on and technology has advanced it is now known that the high carbon emissions are having a severe impact on our environment and is believed to be the main driving force towards climate change. In Australia since the 1960's there have been a few times where the temperature was just above average however as you look further down the chart you can see that since the 1980's the temperature in Australia has been above average and the closer you get to the present time the amount over the average temperature also increases; in the 1960's the temperature was less than half a degree over the mean temperature, in the 1980's the temperature was getting closer to 1 degree above average and now in 2019 the temperature is roughly 1.5 degrees above the average.

As the name indicates, the post combustion methods are facilitating the process of CO₂ capture from the flue gas after the fuel had been burned for energy generation purposes. A typical

procedure in this process is as demonstrated in figure 2. The amine treatment of the flue gas is a widely acceptable method in the post combustion capturing method. MEA commercial absorption process constitutes of the removal of the CO₂ from the flue gas in an absorber. MEA

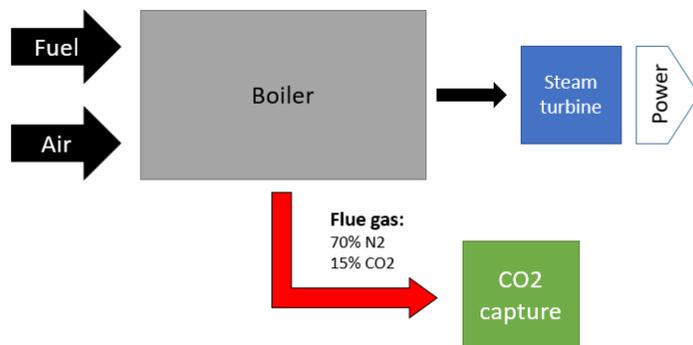


Figure 1 Post combustion carbon capture procedure

reacts with CO₂ in the gas stream to form MEA carbamate. The CO₂-rich MEA solution is then sent to a stripper where it is reheated in order to release the CO₂. The CO₂-free MEA is recycled afterward[6].

Other solvents are also applicable for this process such as hot potassium carbonate, chilled ammonia and ionic liquids[7]. Monoethanolamine is by far the most well-known amine-based absorbent due to its high chemical reactivity and low cost of production. There are number of issues incorporated with the use of MEA in carbon capturing. High enthalpy of reaction, low absorption capacity, oxidative behaviour followed by corrosion and thermal degradation.

The solvent chemistry becomes important once it's realised that the circulation flow rate required for capturing a given amount of CO₂ by having a higher CO₂ absorption capacity. The kinetics data derived from the chemical reactions also allow the determination of the size of the absorber or desorber columns. One of the critical factors to be considered in the design process of absorber or in the selection process of the solvent is the equilibrium solubility of CO₂ in the solvent as a function of temperature and pressure shown in Figure 3. The estimation of heat energy required in the post combustion process can also be obtained from the solubility data. Henni et al. reported that the CO₂ solubility increases in amine-based solvent exposed to higher pressure[8].

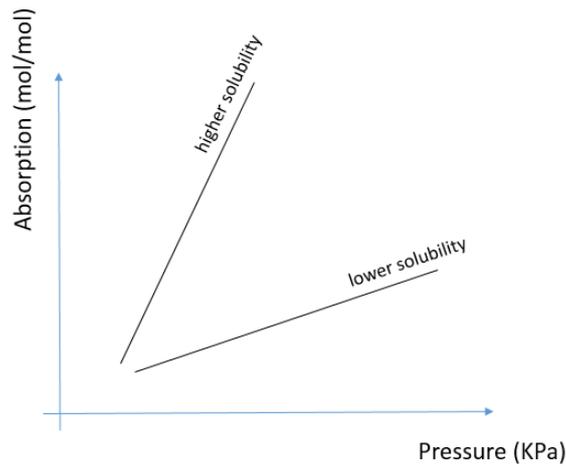
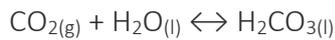


Figure 2 - Correlation of CO₂ solubility in amine-based solvents with pressure

Monoethanolamine overall reaction with CO₂ develops as followed in equation 1 [7]:



Equation 1 Chemical reaction of Monoethanolamine with CO₂ gas.

Since the conventional amine technologies are costly, energy intensive and if implemented would result in large increase in the cost of producing electricity, it is suggested to employ the membrane systems to enhance the efficiency of the conventional MEA (Monoethanolamine) capturing technologies[9]. It has also been reported that the capture of the 90% of the CO₂ in flue gas requires 30% of the power generated by the plant which adds up a cost of \$40-100 for a ton of carbon dioxide. The monoethanolamine absorption would increase the cost of electricity production by 70%. [10, 11]. Another study ran by Paul Feron et al. [12] proposes a

metal mediated electrochemical process to harvest the CO₂ absorption enthalpy into electric power to compensate the capture energy consumption. It was reported by the same author that *the energy output of 4.1kJ/mol CO₂ was achieved experimentally at the studied conditions, resulting in an enthalpy-to-electricity conversion efficiency of 6.4%*. Modularity and the compactness of the membrane units are from the benefits of utilizing membranes as the sequestration method. Membrane technology is a non-dispersive contacting system that the flue gas does not interact chemically with the membrane. Membrane systems brings 30 times more interfacial area than the liquid phase gas absorption methods [13]. Compared to the issues encountered with the use of liquid absorption such as corrosion and foaming, utilization of membrane technology in post combustion carbon capture, benefits the whole process by cost savings reported as 38-42%, equipment weight reduction of 34-40%, as few significant advantageous reported by Falk-Pedersen et al[14]. One of the limitation to the application of membranes is the capital and energy cost of pressure equipment. Sufficient level of pressure plays an important role in the membrane capturing process as it affects the flue gas flow rate.

Oxyfuel combustion technology separates the oxygen from the air prior to combustion and produces a nearly sequestration-ready CO₂ effluent. In this case as pictured in Figure 5, the coal is burned exposed to a nearly pure oxygen and emits a high concentration of CO₂ which is almost ready for sequestration.

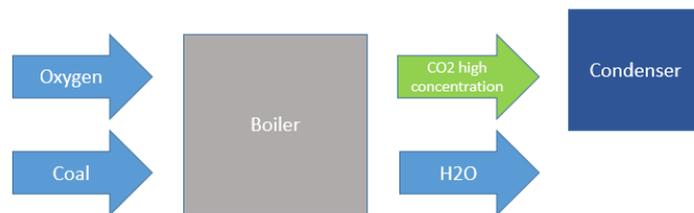


Figure 3 Oxy-fuel carbon capturing method procedure

The by-product of this process contains a high volume of H₂O which is cooled down in order to separate the CO₂ properly.

The novelty of this study, relies in the flowchart shown in figure []. Carbon tax is the main source of government income for running an environmental construction economy. A comprehensive and effective taxation system can be distributed in the sector in such a way that increases the employment rate and also brings an internationally competitive technology.

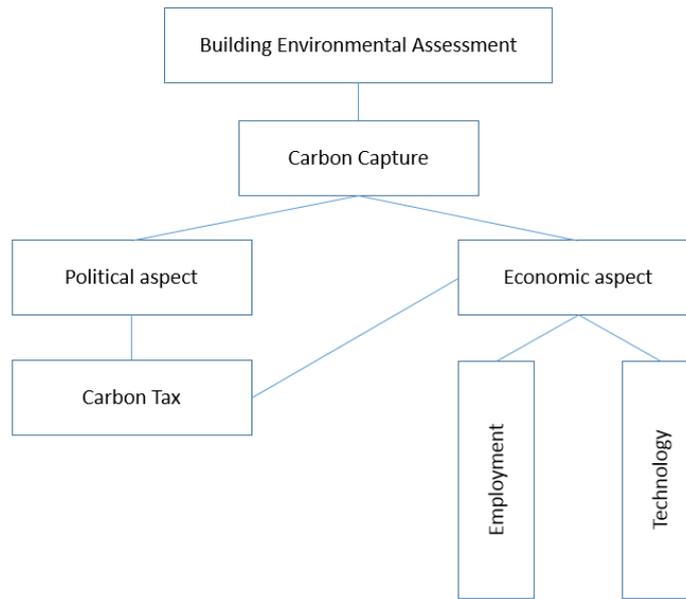


Figure 4 - The current research methodology

Data Mining

A chrome based data mining protocol had been used for extracting data in a timely manner from the total number of job ads categorized in the construction sector. 153 jobs listed in seek.com with average income of \$70,000 had been analysed. This concludes a total value of about \$10M as per wages in the construction industry. Seek.com as the main source for those who are looking for jobs in Australia had been selected. This is good measure in accordance to the official definition of “work force” recognized by the government which constitutes the economical evaluation of employment: “*Total number of a country’s population employed, plus those unemployed people who are actively seeking paying work*”. The scraper computer program had gone through the job descriptions looking for keywords namely *environmental*, *environment*, and *life cycle assessment*. Amazingly, no keywords had been found in the job descriptions. With a rough approximation it can be said that employers in the construction job market does not appreciate the importance of environmental conservation in their practice. In other words, the construction work force is not urged to consider environmental impact of building projects. Amongst these roles are some high level job titles that, by the indication of literature, are supposed to consider environmental impact of construction projects. These are:

- Compliance manager
- Construction manager
- Permits and compliance officer
- Construction supervisor
- Project co-ordinator
- Building contractor
- Contract manager

Political Aspect

Several Australian legislation and regulation had been adopted so far in order to facilitate the conservation of natural resources and capping the greenhouse gas emissions. To name a few most effective ones, *Environmental Planning and Assessment Act (EPA)*, *Clean Energy Act*, *Protection of the Environment Operation Act* [15-17]. EPA is the foundation to the development projects and is enforced by the state department of planning and its subsidiary councils. In the same Act, the utilization of BASIX as an environmental impact assessment tool is promoted. Building certifiers in some instances are urged to refer to the BASIX certificate for imposing conditions and certifying a development activity. For example, Part 6, Division 1 of the Environmental Planning and Assessment Regulation eases the certification process if an application had been accompanied with a BASIX certificate.

The Carbon Tax scheme in effect in the Julia Gillard's government, was another effective policy for coordinating the built environment to a more sustainable ecological system. It has been stated that people tend to use less of a product, in this case carbon, once it comes with a price.

On Economics of CO₂ Capture

One of the well-recognised reasons that CO₂ capturing techniques had not shown a significant practical improvement across the industries is the high initial capital investment required. Nevertheless, it can be said that the construction industry is one of the slowest industries in relation to the embracement of new technologies[18-23]. This fact sets back the research and development organizations from taking steps forward towards a wider implementation of these techniques. Especially since these technologies are new and associated with a high risk, few investors will take the risk to adopt. In 2011 the federal government of Australia had introduced a taxation scheme called "Carbon Tax" which allows the distribution of funds in a direction that allows a higher chance of success for green technologies such as carbon capture.

The purpose of levying carbon tax is to allow the consideration of carbon emission and its irreversible effects on the built environment. As stated by Metcalf & Weisbach carbon tax refers to as "*internalizing the externalities associated with anthropogenic climate change*" [24]. Revenue and distribution are amongst the top challenges that governments are facing. A well-structured taxation system, also, is needed to ensure the long-term implementation of sustainable development in the construction industry. This includes: i. The tax rate, ii. The tax base (offsets and credits), iii. International trade concerns. Green Building Council of Australia (GBCA) and other regulatory bodies had developed a rating system for buildings. Although seemingly comprehensive, the financial aspect relating to this rating measure is still missing.

As the data mining results suggest, the green employment rate is relatively low in the construction sector. The implementation of carbon tax can be used in such a way to create more jobs in this sector. Cooperative game theory on the other hand, proposes a method to distribute the generated wealth amongst the stakeholders in a fair manner[25]. That can also

be extended to the entrepreneurial activities[26]. Several research funding expenditures had been introduced in the past decade, despite the lack of relevant employment opportunity. The universities education modules are also equipped with the knowledge of environmental construction practices which indicates the sufficient presence of skills in the market after the students' graduation. Focusing only on the job market from the economic aspect of carbon capture technologies, the Keynesian general theory suggests that the government expenditure increases the demand of a particular.

Conclusion

Many considerable improvements had been made in Australia in regards to the implementation of green technologies such as carbon capture. However, the high risk of investment and lack of government expenditure leads a low employment rate for those who are equipped with the knowledge and skill of environmental conservation specially in the construction sector. Data mining results had revealed the fact that some important and high ranked positions available in the market have not any indication of environmental conservation. Carbon tax as an effective measure can be the possible way of introducing more jobs in the market.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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