SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Science Writing

Year 9-10

Ella McDermott

St John's Grammar School - Senior School

ROWE SCIENTIFIC PTY. LTD. www.rowe.com.au

Australian Government Department of Defence

Government of South Australia Department for Education

SASTA South Australian Science Teachers Association

Ella McDermott

29 Gloucester Avenue

Belair SA 5052

The Hon. Chris Bowen, MP

MG 60, Parliament House

PO Box 6022, Parliament House

CANBERRA ACT 2600

15/05/23

Subject: Clean Tech – Carbon Capture, Use and Storage

Dear Minister,

I am writing to you in your capacity as Minister for Climate Change and Energy. We have a world crisis at our hands, and we need to take action immediately! We are destroying our home and the idea of doomsday may not be the fantasy it was once made out to be.

The lifestyle of the modern population is causing the release of greenhouse gases into the atmosphere, blanketing the Earth and trapping the Sun's heat in. There are grave consequences to this, such as altered weather patterns and disruptions to the balance of nature[1]. Currently, fossil fuels account for more than 75% of global greenhouse emissions and 90% of total carbon dioxide (CO_2) emissions[2]. Therefore, does it not make sense to target a significant source of this problem, CO_2 released as a fossil fuel emission?

To ensure that Australia upholds its obligations under the Paris Agreement[3], we must tackle these troublesome emissions now. Fortunately, a solution has already been developed to assist with this; carbon capture, usage and storage (CCUS). CCUS is the process of capturing CO_2 emissions, for them to be stored, or used[4]. This method not only allows new CO_2 emissions to be captured from locations such as industrial facilities, but also emissions that are already in the atmosphere[5].

CCUS can considerably decrease our CO_2 emissions, making it significantly easier to keep our promises under the Paris agreement and follow The Government's Climate Change Bill that has now become law[6]. To achieve this, Australia needs to reduce its emissions to 350mt CO_2-e by 2030[7]. For every 200 CCUS facilities, roughly 220Mt of CO_2 can be captured per year[8], showing that CCUS has the potential to play a huge role in helping Australia meet its goals.

The process of CCUS consists of three main stages. First, the CO_2 must be captured through one of several methods. One method is post-combustion, which works by separating CO_2 from flue gas, after the fuel is burnt. This process could take place using a chemical solvent for example[9].

Alternatively, pre-combustion is a process that relies on capturing CO_2 before the burning of fuel. First, coal is partially oxidised in oxygen (O_2) and water (H_2O) steam in a high pressure and temperature environment. This leads to the production of synthetic gas, or syngas, which is comprised of carbon monoxide (CO), CO_2, hydrogen (H_2) and small amounts of other gaseous components. This syngas is then put through the water-gas shift reaction, producing another gaseous mixture, this time made of H_2 and CO_2. The CO_2 is then separated, leaving the H_2 rich mixture for combustion[10].

Oxy-fuel combustion is another method of carbon capture. Although only relatively recently developed, oxy-fuel combustion is highly effective as over 90% of the emitted CO_2 is captured, and the only other by-product is H_2O. The process starts with removing elements such as argon (Ar) and nitrogen (N_2) from air until it has a high concentration of O_2. This air is then combined with fuel, such as coal or natural gas, in a stream of CO_2 inside a combustor. The fuel and O_2 chemically react resulting in CO_2 and H_2O steam, which then pushes a turbine which generates power. This process finishes with H_2O and CO_2 as the only by-products. This means that the CO_2 can be easily captured[11].

Another method, direct air capture or DAC, can be used to capture CO_2 directly from the atmosphere. This process takes place using fans to draw in the air from the atmosphere[12]. This air is then put through either solid or liquid DAC, to separate the CO_2 for collection. Solid DAC involves solid adsorbents operating at ambient to low pressure, such as under a vacuum, and in medium temperature, usually 80°C to 120°C. Alternatively, liquid DAC relies on an aqueous base solution, potassium hydroxide (KOH) for example, separating CO_2 from the air while it passes through a series of units. These units are at extremely high temperatures, anywhere from 300°C to 900°C. Although this method of CCUS still needs some development, it has extremely high potential to greatly decrease the CO_2 in the atmosphere[13].

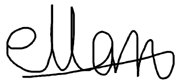
Another method, bioenergy with carbon capture and storage (BECCS) is also available. This process involves capturing carbon from biogenic sources. However, this technology still needs development and at this point in time, would not be particularly effective[14].

The next stage of CCUS is transporting the captured CO_2. This process starts by compressing the CO_2 into a liquid state. The CO_2 is then transported via pipeline, ship, rail or road tanker[15]. In the last stage, the CO_2 is either used, or more commonly, stored. When looking for ideal places to store CO_2, scientists often look for deep geological formations. This allows the CO_2 to be injected into the earth at depth of at least 1 km. Some commonly used locations include depleted oil and gas reservoirs, coalbeds or deep saline aquifers, as the geology is ideal[16]. Alternatively, CO_2 can be used after capture, often for the production of commercially marketable products or services[17]. However, it is yet to be determined if CO_2 usage actually benefits the environment after accounting for external effects, such as the carbon intensity of the energy used for the conversion process or even how long the CO_2 is retained in the product[18]. With further research and development, CO_2 usage could be an effective way to manage CO_2 emissions, while making something useful out of it[19]. Industries that already use captured CO_2 are the fertiliser industry[20], refrigeration[21], food and beverage processing[22], production of synfuels[23] and the oil and gas industries[24].

In addition to the wide variety of processes available, CCUS also has other attributes that make it an effective and superior method to reducing our CO_2 emissions. One benefit of CCUS is that it can be fitted to existing industrial facilities that run on coal, gas, biomass or waste. This allows important but hard-to-abate industries[25], such as power plants and hydrogen[26], steel, iron and chemical production[27] to continue operation in a low emission manner. Keeping these existing industrial facilities will also save Australia having to find new energy solutions or having to shut down these carbon intensive industries altogether. In addition, although the initial capital investment of fitting CCUS on to existing facilities can be high, it is one of the most cost-effective solutions available to decarbonise these hard-to-abate industries. Furthermore, the price is continually reducing as CCUS becomes more mature[28]. CCUS is also a long-term solution as evidence suggests that globally, there is plentiful underground storage that can hold more CO_2 than needed to meet international climate targets[29]. Moreover, CCUS is an environmentally friendly technology as it has a limited land and H_2O footprint[30]. CCUS also has a high efficiency as technology fitted on to industrial facilities can capture roughly 90% of CO_2 present in flue gas and as the technology develops it can become even more effective[31].

With a responsibility to act on climate change, Australia must find an ongoing solution soon. Evidence already indicates that CCUS can be a significant factor in Australia meeting its obligations[32]. With a variety of options available for different types of CCUS and an array of benefits, it only makes sense that Australia implement CCUS across industrial facilities. If we work hard, Australia can position itself as a leader in CCUS[33]. However, we must act now if we want to avoid further consequences from this already devastating climate crisis. The choice is yours; will you fight for a future?

Yours faithfully,



Ella McDermott

Word count: 1,311

Bibliography

- Department of Climate Change, Energy, the Environment and Water. (2022) *The Hon Chris Bowen MP | Minister for Climate Change and Energy.* Available at: https://minister.dcceew.gov.au/Bowen (Accessed 24/04/23)
- UsingEnglish.com. (n.d.) *Format of a Formal Letter.* Available at: https://www.usingenglish.com/resources/letter-writing.php (Accessed 24/04/23)
- Bowen, C. (n.d.) *Minister for Climate Change and Energy & Federal Member for McMahon.* Available at: https://www.chrisbowen.net/contact/ (Accessed 24/04/23)
- St John's Grammar. (n.d.) *St John's Grammar.* Available at: https://www.stjohns.sa.edu.au/contact/ (Accessed 24/04/23)
- Parliament of Australia. (n.d.) *How to address Senators and Members. Available at:* https://www.aph.gov.au/senators_and_members/guidelines_for_contacting_senators_and_members/how_to_address_senators_and_members (Accessed 24/04/23)
- Brander, M. (2012) *Greenhouse Gases, CO2, CO2e, and Carbon: What Do All These Terms Mean?* Available at: https://ecometrica.com/assets/GHGs-CO2-CO2e-and-Carbon-What-Do-These-Mean-v2.1.pdf (Accessed 01/05/23)
- United States Environmental Protection Agency. (n.d.) *CO2e.* Available at: https://www3.epa.gov/carbon-footprint-calculator/tool/definitions/co2e.html#:~:text=Carbon%20dioxide%20equivalent%20or%20CO,in%2040%20CFR%20Part%2098 (Accessed 01/05/23)
- United States Environmental Protection Agency. (2023) *Biogenic Emission Sources.* Available at: https://www.epa.gov/air-emissions-modeling/biogenic-emission-sources#:~:text=Biogenic%20emission%20sources%20are%20emissions,contributors%20to%20background%20air%20chemistry. (Accessed 03/05/23)
- Byju's. (n.d.) *Argon Gas Formula.* Available at: https://byjus.com/argon-gas-formula/#:~:text=The%20molecular%20formula%20of%20Argon%20Gas%20is%20Ar. (Accessed 13/05/23)
- Byju's. (n.d.) *The chemical symbol for nitrogen gas is.* Available at: https://byjus.com/question-answer/the-chemical-symbol-for-nitrogen-gas-is-a-ni-b-n2-c-n-d-n/ (Accessed 13/05/23)
- Byju's. (n.d.) *Why is oxygen written as O_2?*https://byjus.com/question-answer/why-is-oxygen-written-as-o2/ (Accessed 13/05/23)
- https://byjus.com/chemistry/potassium-hydroxide/ (Accessed 13/05/23)

---

[1] United Nations. (n.d.) *Causes and Effects of Climate Change*. Available at: https://www.un.org/en/climatechange/science/causes-effects-climate-change (Accessed 27/04/23)

[2] Ibid 1

[3] Department of Climate Change, Energy, the Environment and Water. (2023) *International Climate* Action. Available at: https://www.dcceew.gov.au/climate-change/international-commitments (Accessed 29/04/23)

[4] softtek. (2023) *CleanTech trends.* Available at: https://blog.softtek.com/en/cleantech-trends#:~:text=The%20main%20clean%20technology%20trends,operations%20cleaner%20and%20more%20sustainable (Accessed 13/04/23)

[5] Serin, E. (2023) *What is carbon capture, usage and storage (CCUS) and what role can it play in tackling climate change?* Available at: https://www.lse.ac.uk/granthaminstitute/explainers/what-is-carbon-capture-and-storage-and-what-role-can-it-play-in-tackling-climate-change/#:~:text=What%20is%20carbon%20capture%2C%20usage%20and%20storage%20(CCUS)%3F,CO2%20from%20the%20atmosphere. (Accessed 19/04/23)

[6] Australian Office of Financial Management. (2022) *Australian Government Climate Change commitments, policies and programs. Available at:* https://www.aofm.gov.au/sites/default/files/2022-11-28/Aust%20Govt%20CC%20Actions%20Update%20November%202022_1.pdf (Accessed 29/04/23)

[7] Ibid 6
[8] International Energy Agency. (n.d.) *Carbon capture, utilisation and storage.* Available at: https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage (Accessed 19/04/23)
[9] Ibid 5
[10] Integrated Flow Solutions. (2022) *Pre-Combustion vs. Post-Combustion Carbon Capture Technologies.* Available at: https://ifsolutions.com/pre-combustion-vs-post-combustion-carbon-capture/#:~:text=Pre%2DCombustion%20Carbon%20Capture&text=Operators%20typically%20apply%20this%20carbon,synthetic%20gas%20(or%20syngas) (Accessed 02/05/23)
[11] Southwest Research Institute. (n.d.) *Oxy-Fuel Combustion.* Available at: https://www.swri.org/industry/advanced-power-systems-conventional-power-generation/oxy-fuel-combustion#:~:text=Oxy%2Dfuel%20combustion%20is%20a,CO2)%20inside%20a%20combustor. (Accessed 03/05/23)
[12] Ibid 5
[13] Budinis, S. (2022) *Direct Air Capture.* Available at: https://www.iea.org/reports/direct-air-capture (Accessed 03/05/23)
[14] Pour, N. Fajardy, M. (2022) *Bioenergy with Carbon Capture and Storage.* Available at: https://www.iea.org/reports/bioenergy-with-carbon-capture-and-storage (Accessed 03/05/23)
[15] Ibid 5
[16] Ibid 5
[17] Ibid 5
[18] Ibid 8
[19] Ibid 5
[20] Ibid 18
[21] Ibid 11
[22] Ibid 13
[23] Ibid 8
[24] Ibid 11
[25] Ibid 5
[26] Ibid 3
[27] Ibid 5
[28] Ibid 5
[29] Ibid 5
[30] Ibid 13
[31] Ibid 5
[32] Ibid 5
[33] Srinivasan, V. (2023) *CO2 Utilisation Roadmap. Available at:* https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/CSIRO-futures/Energy-and-Resources/CO2-Utilisation-Roadmap (Accessed 24/04/23)