CHAPTER 2
CARBON DIOXIDE CAPTURE USING ADSORPTION

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2.1 INTRODUCTION

The level of global urbanisation has rapidly increased and become an essential aspect along with the continuous development of global industrialisation. This resulted from the growing industrial revolution, where we are confronted with the Fourth Industrial Revolution, or Industry 4.0 (IR 4.0) (Du & Xia, 2018). Consequently, these have increased greenhouse gas (GHG) emissions (Didenko et al., 2017). It is an agreement that the rise of global GHG emissions is usually attributed to five economic sectors: energy, industry, buildings, transport, and AFOLU (agriculture, forestry, and other land use). These were characterised by the Intergovernmental Panel on Climate Change (IPCC) Working Group III (WG3) (Lamb et al., 2021). Among the greenhouse gases, carbon dioxide (CO_2) gas is the most prominent gas that has been emitted into the atmosphere. Considering the sectors that contributed to the release of GHG, the main source of GHG (mainly composed of CO_2) is traced back to fossil fuel utilisation as an energy source (Hanif et al., 2019). The CO_2 composed in the GHG possesses the properties of absorbing and radiating heat. Besides CO_2, other gases are also dangerous and are well known as contributory factors to cause global warming, such as methane (CH_4) and nitrous oxide (N_2O)

(Maucieri et al., 2017). The percentage of gas composition in the GHG emission varies depending on the processing type and fuel sources (coal or petroleum) used. The global fossil fuel CO_2 emission growth rate has been reported to increase from 0.9% per year in the 1990s to 3.0% per year in the 2000s (Peters et al., 2020). Nonetheless, the growth has returned to a slow growth rate of 0.9% per year since 2010 and slowed down more from 2014 to 2016.

Although, at the end of December 2019, the COVID-19 outbreak and pandemic declaration by the World Health Organisation (WHO) on 11 March 2020 significantly altered and transformed global activities, including global supply chains and economic recession (Le Quéré et al., 2020; Vasilii, Gao, & Anna, 2022). Since then, the closing of the international border and home restriction orders have changed the world's transportation and consumption patterns. Thus, the global daily CO_2 emissions were reduced by approximately 17% (11–25% for $\pm 1\sigma$) by early April 2020 compared with the 2019 average (Le Quéré et al., 2020). After two years, a number of countries (high-income countries) are already developing a post-pandemic plan and are now about to enter the endemic phase; during this phase, society is returning to pre-pandemic patterns of behaviour, depending on personal risk tolerance (Gostin, 2022). For instance, China is one of the first countries to recover from this global phenomenon and a set of effective and efficient health security, economic, and social measures, allowing China to restart economic activities in the domestic market and restore foreign trade with its counterparts (Vasilii et al., 2022).

According to Le Quéré et al. (2020), the power economic sector is the largest CO_2 emitter, with about 44.3% from the utilisation of fossil fuels, followed by industry with 22.4%, surface transport (20.6%), public buildings and commerce (4.2%), residential (5.6%) and aviation (2.8%) economic sectors. CO_2 is a greenhouse gas that absorbs less heat per molecule than CH_4 and N_2O; nevertheless, it is the most abundant and is retained in the atmosphere longer (Lindsey, 2023). Therefore, the continuous growth of atmospheric CO_2 concentration will cause about two-thirds of the atmospheric total

heating energy imbalance (Figure 2.1). The continuous cumulative concentration with the long-lived ability to absorb and re-radiate heat of the CO_2 will increase the abundance of heat-trapping gases and amplify the natural greenhouse effect.

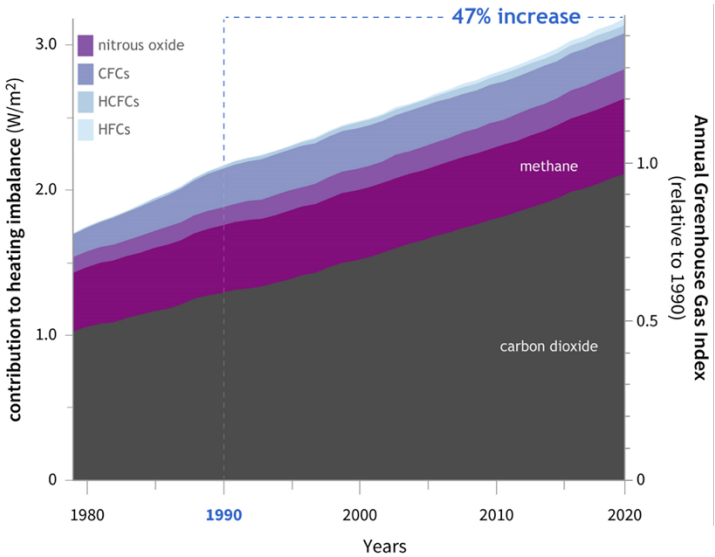

Figure 2.1 The effect of the annual greenhouse gas emission on the heating imbalance (Source: Lindsey, 2022)

Consequently, it increases the Earth's average temperature (Lindsey, 2023). In addition, aside from the effect of the average earth temperature caused by the growth of the atmospheric CO_2 concentration, the increase of anthropogenic CO_2 emissions is also reported to affect the ocean parameters and indirectly interrupt the ocean ecosystem. According to Gattuso et al. (2015), the ocean plays a crucial role in regulating the Earth's climate. Since 1750 and the 1970s, the ocean has absorbed around 28% of the atmospheric CO_2 and about 93% of the Earth's additional heat. This scenario has resulted in the increasing ocean temperature and is affecting the ocean's carbonate system, leading to ocean acidification (Cattano et al., 2018). The term 'ocean acidification' (OA) represents the changing of seawater chemistry, where the reduction of pH has occurred by about 0.4 pH units in the 21st century and the reduction of the