# CHAPTER I
# INTRODUCTION

Waste gases from combustion of solid, liquid and gaseous fuels in different human activities have significantly contributed to environmental problems, especially in increasing global temperature. Pollutants from electricity generation, cement and fermentation plants, industries, transportation, heating (cooling), cooking, and other activities include not only NOx, SOx but also the greenhouse gases (GHGs) such as $CO_2$ and $CH_4$. The reduction of GHGs emission, particularly $CO_2$, therefore, plays a key role in controlling harmful effects on human beings' life (Halmann *et al.*, 1998; Maroto-Valer *et al.*, 2002).

$CO_2$ is a colorless and odorless gas. A molecule of $CO_2$ consists of two double bonds with one carbon and two oxygen atoms. $CO_2$ serves as an essential source of photosynthesis in plants to produce carbohydrates, lipids, etc. and new oxygen to assist life on Earth (Pierantozzi, 2000). Although the concentration of $CO_2$ is presently 0.038 percent in air (Keeling *et al.*, 2005), the greater amount of $CO_2$ is being emitted to the environment by combustion of carbon-containing substances which are mostly fossil fuels. $CO_2$ is not the most severe GHG, but it is the highest emitted which makes it the most unavoidable anthropogenic GHG (Kangwanwatana *et al.*, 2013). To substantially decrease emissions, recovery and utilization of $CO_2$ from manufacturing plants and natural sources is becoming clearly.

Using captured and recycled $CO_2$ involves the following: (1) directly apply $CO_2$ from concentrated flue gas or rich sources to applications that do not need pure $CO_2$; (2) develop efficient and less-energy processes for $CO_2$ separation for cases requiring pure $CO_2$; (3) search new and high effective compounds as alternate medium or solvent to replace the old ones in existing processes with $CO_2$; (4) use $CO_2$ as supercritical fluid or either solvent or anti-solvent; (5) make use of $CO_2$ along with high 'atom efficiency' such as carboxylation and carbonate synthesis; (6) employ $CO_2$ as a reactant or feedstock to yield applicable chemicals and materials; (7) reduce $CO_2$ emissions by means of sequestration for energy recovery; (8) convert $CO_2$ into fuels and chemicals via renewable energy; (9) use bio-chemical or geologic-formation condition to transform $CO_2$ into "new fossil" energies (Song, 2006). In spite of these promises, in recent years study and research experience have shown that appreciable limitations are linked with $CO_2$ utilization. Those drawbacks encompass: (1) expenses for capturing, separating, purifying and transporting; (2) energy need for converting $CO_2$; (3) restrictions in market size; (4) little interest from manufacturers in recycling and utilizing $CO_2$; (5) the deficiency of socio-economical driving forces (Song, 2006).

Depending on constraints such as location, type of industry, etc., there is no single, universally viable route for $CO_2$ utilization—one or more approaching methods can be taken into account. Additionally, a technique merging various processes may be the most feasible solution for many applications. In this research work, demonstration of converting $CO_2$ into methanol in terms of technology and economy will be presented.