A Preliminary bibliographic review on Carbon Capture and Utilization

A. Merkoureas – Karras, and M. Loizidou
School of Chemical Engineering, National Technical University of Athens, Iroon Polytechneiou 9, Zografou 157 72, Athens, Greece
(E-mail: alcebiades87@hotmail.com)

Introduction

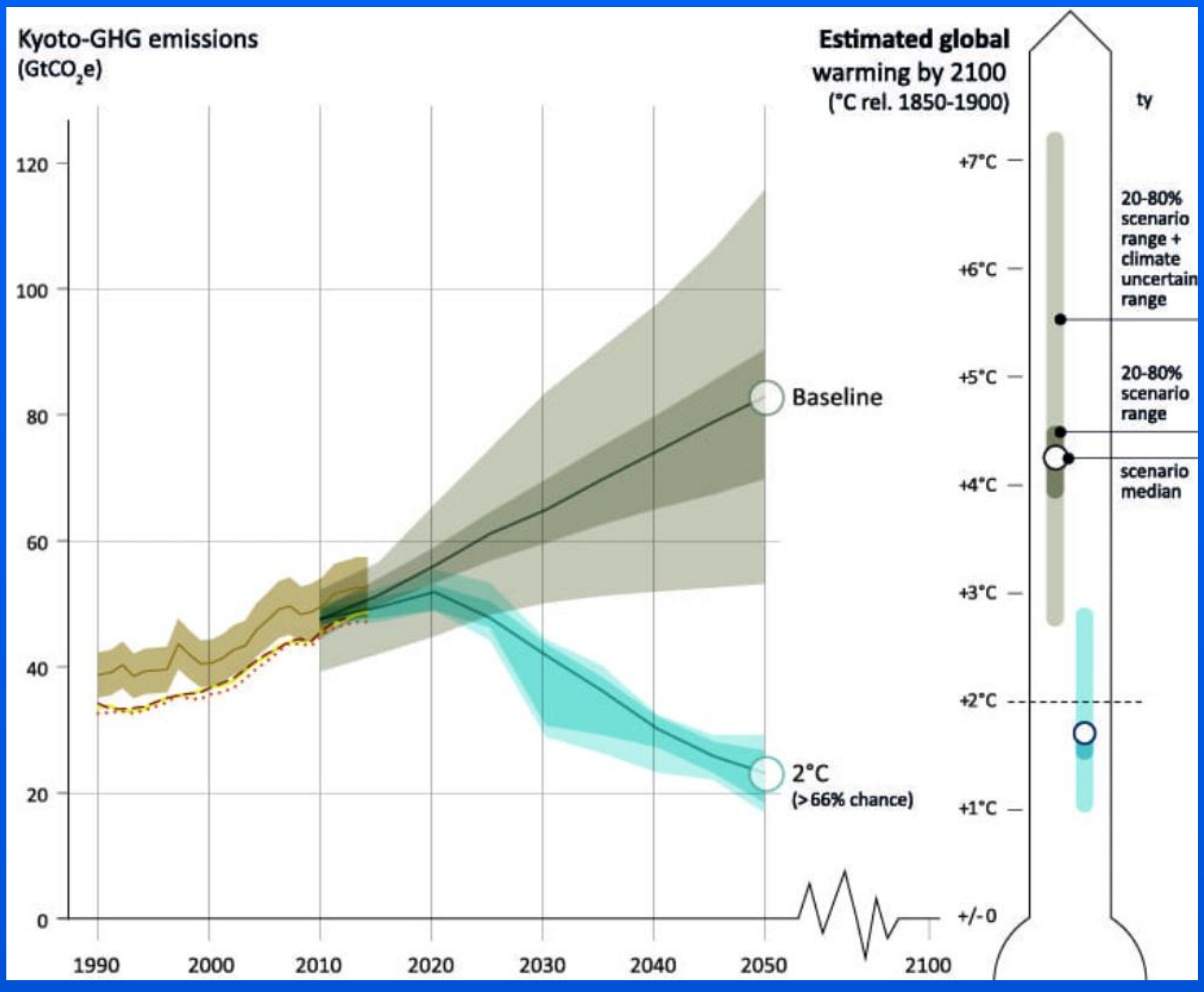

Figure: Historical greenhouse (GHG) emissions and projections until 2050 (Intergovernmental Panel on Climate Change, 5th assessment report)

The current poster paper addresses the recent progress that has been achieved in the wide scientific field of carbon capture storage and utilization. A succinct, yet conclusive review is presented, based on the most highly cited and acclaimed bibliographic sources.
We attempt a general inspection of selected bibliography, in order to identify the most commonly accepted notions that prevail among the scientific community.

This publication should be considered as preliminary to a fully comprehensive review that will be published in the near future. In response to the ever-worsening phenomenon of Climate Change, almost exclusively caused by the soaring quantities of carbon dioxide in the atmosphere, since 1970, strategies and technologies have been developed, aiming at the abatement of Global Warming, which is the most menacing aspect of Climate Change. The main strategies followed, can be by and large separated to (1) Capture and storage/sequestration (CCS); (2) Capture and utilization (CCU)

Context

It is important to identify crucial factors that define the political and technical context within which all relevant technologies are adjusted to.

The main limiting factors have been ascertained, as follows :

(1) The commitments of Paris Agreement (2015). The most important goals set by the treaty are (a) to reduce the CO_2 emissions that derive from human activity (e.g. industry, transportation) by 50% until 2030, with reference point the total CO_2 emissions of 2020. (b) to achieve net-zero emissions by 2050. It has been estimated that these measures will be sufficient enough to keep the increase of mean global temperature well below 2°C, in comparison to pre-industrial levels; ideally a rise of only 1.5°C could be achieved, keeping the ecosystem in a safe state of balance [1].

(2) The extremely high consensus rate that is recorded among members of the scientific community, with regards to the identification of human activity as the main driver of global warming. A high level of similar consensus has been also measured, among modern citizens throughout the world. It is therefore understood that there is imminent urge for changes in a global scale.

(3) The physical and chemical properties of the CO_2 molecule itself. It is characterized by high thermodynamic stability [2], therefore the conversion to other less oxidized and more useful products (alcohols, carboxylic acids, etc.) requires the devotion of significant amounts of energy. The energy demand is the most important of the various limiting factors of CCS/CCU technologies.

Technologies

The initial technologies developed for the purpose of limiting CO_2 emissions were focused in capture methods, and later, storage. While the CCS technologies are of great worth, it became evident that new technologies of CO_2 treatment had to be developed. As a consequence of this conclusion, a more advanced rationale, according to which CO_2 should be utilized as raw feedstock, started to develop.

The most important technologies that are included withing the field of CCU, include mainly **(1)** the mixture of CO_2 with renewable-derived H2 for the production of methanol and dimethylether (hydrogenation reaction), **(2)** the use of Fischer-Tropsch reaction for the production of synthetic liquid fuels, **(3)** electrochemical conversion for the production of less oxidized valuable products such as formic acid and methane, **(4)** mineralization, which is a method that can be used to produce building materials or generally carbonate salts from alkaline species (including industrial residues), via the neutralization reaction, **(5)** the use of algal cultures for the conversion of CO_2 into lipids, carbohydrates, and other biomolecules.

All these technologies – among other less significant – are mainly assessed in terms of technological readiness level (TRL). TRL is the main marker of the maturity of a certain method/technology.

Conclusions

Taking into consideration all the various aspects that comprise the CCU scientific and technical framework, we can present succinctly the most important and substantial conclusions, to which this preliminary study lead to.

- Carbon utilization technologies are complementary to CCS. The newest technologies combine both CCS and CCU frameworks. The CCU component of the CCS-CCU integrated systems is less developed, yet has great potential for advancement, while CCS has mostly matured.
- Regarding the associated costs of these systems, there is agreement about the complexity of developing cost-effective technologies with significant output. However, the LCA tool seems to be of great value, in the successful regulation of complex systems, so as to be efficient.
- The CO_2 removal capacity of these systems is in the order of magnitude of dozens of Mt CO_2/year, while the emissions are ~37 Gt CO_2/y
- The soaring prices of CO_2 (EU permits have escalated to ~95€/tn) are regarded as a major driver towards a CO_2-neutral economy [3].

References

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