# Integrated Assessment of Sustainable Methanol Production Processes

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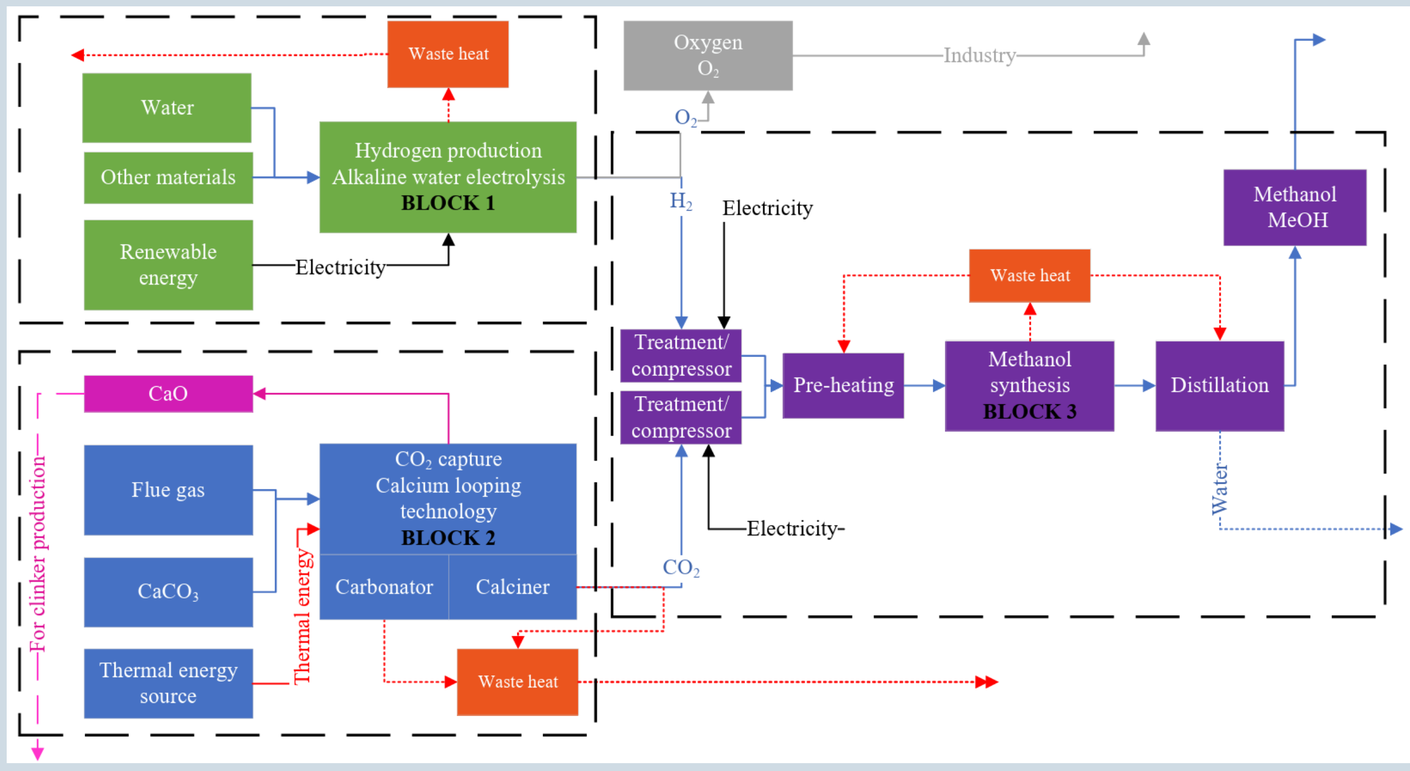
**Methanol ($CH_3OH$) is one of the most widely used chemical commodities globally, with annual demand exceeding 110 million tonnes and European demand around 11.6 million tonnes.**

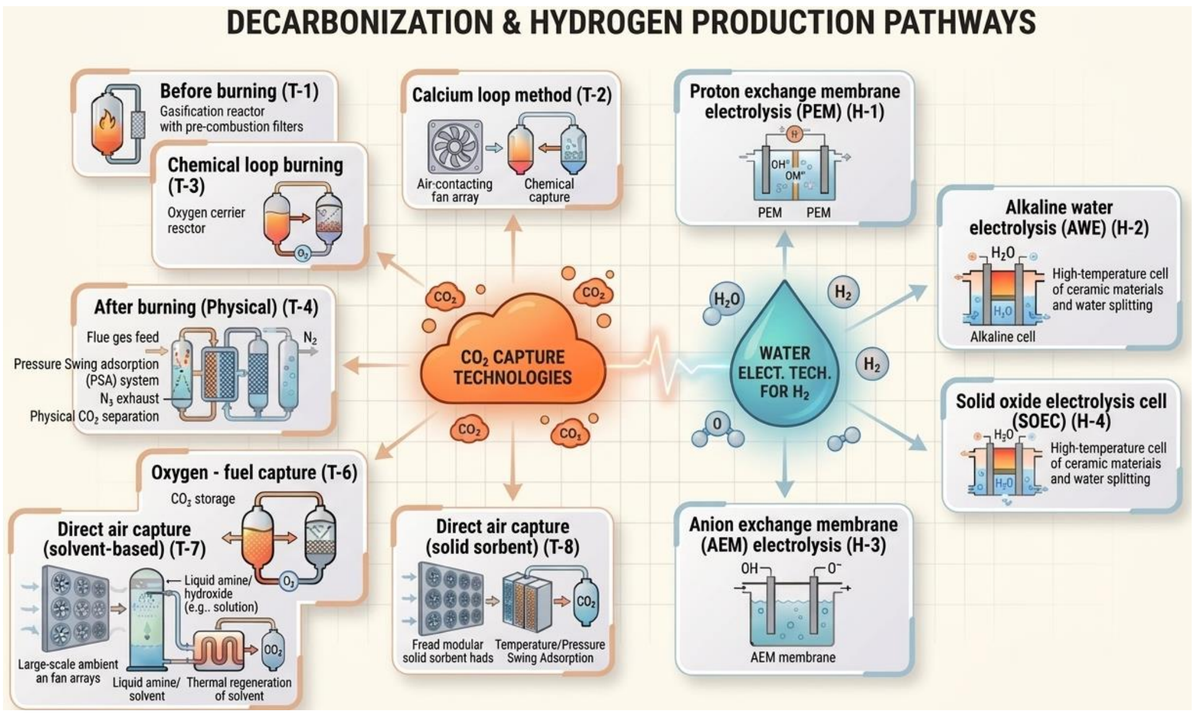
As the need to reduce greenhouse gas emissions in transport and the chemical industry increases, e-methanol is considered an important energy carrier for integrating renewable electricity into the liquid fuel market. The different concepts of e-methanol production, with different electricity supplies, electrolysis technologies and $CO_2$ sources, require the development of a transparent methodology for comparing the technical and environmental performance of production processes.




**Process flow diagram of sustainable methanol production**

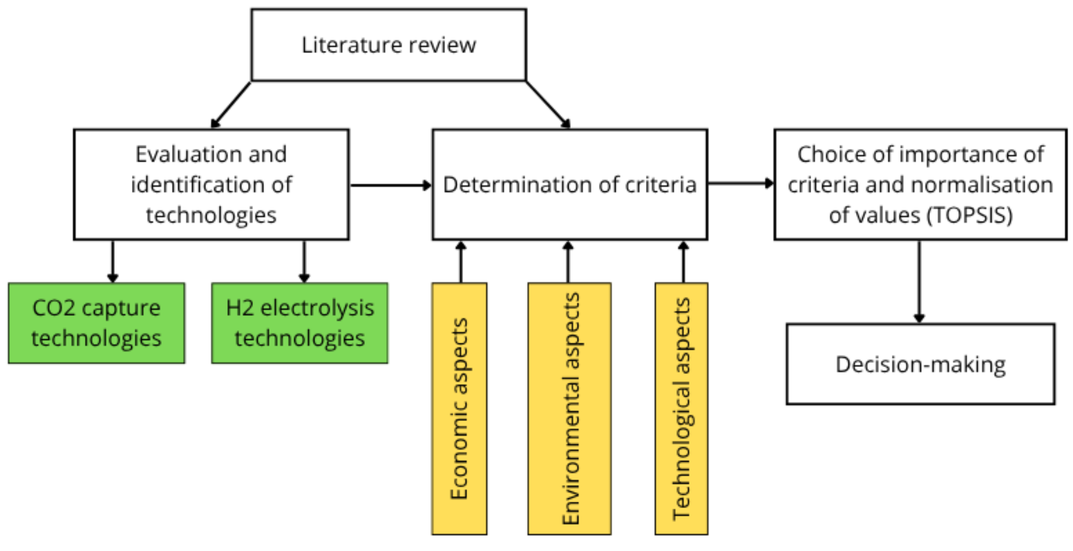
## Introduction

Methanol **serves** both as a **fuel** and as a crucial feedstock for the **chemical** and **pharmaceutical industries**, giving it a pivotal role in multi-sector decarbonisation. In this study, methanol production is analysed in relation to $CO_2$ capture and hydrogen electrolysis.



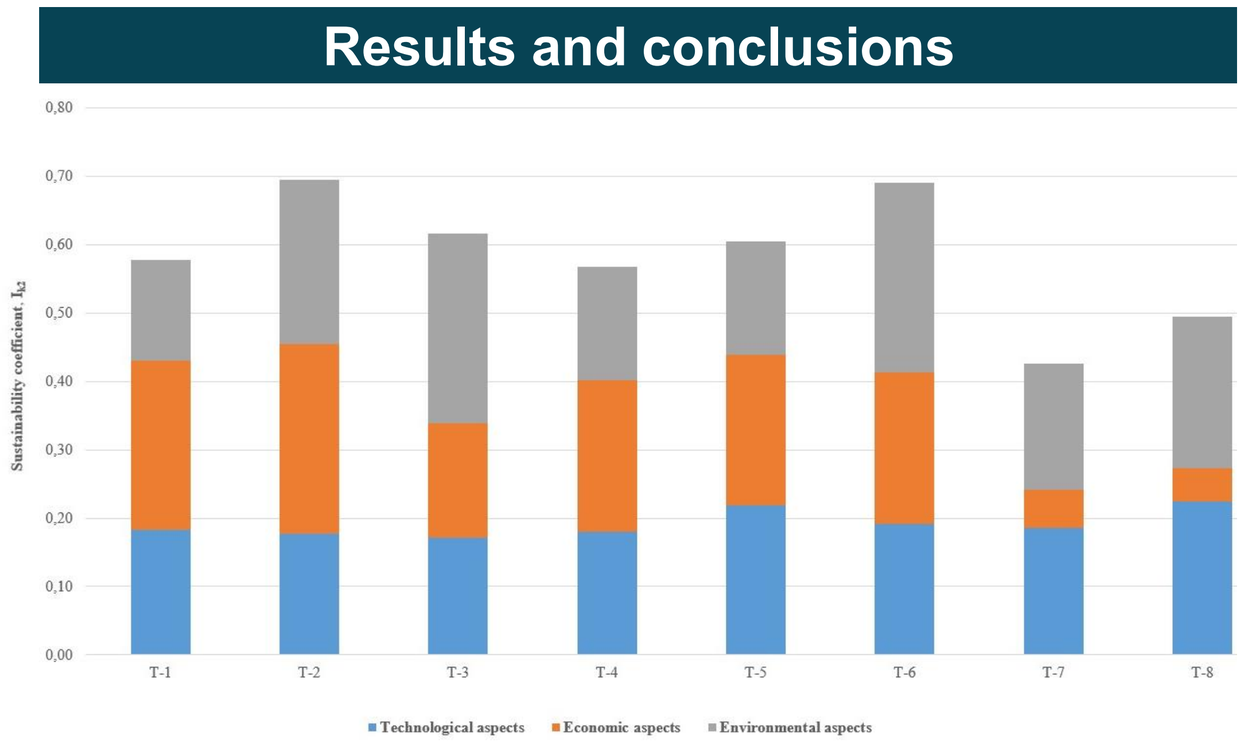

## Methodology

To **develop** and **evaluate** Power-to-Methanol concepts that use renewable electricity, water electrolysis, and captured $CO_2$, assessing their technological feasibility, environmental impact, and economic viability in **achieving carbon reduction targets** and energy system integration.

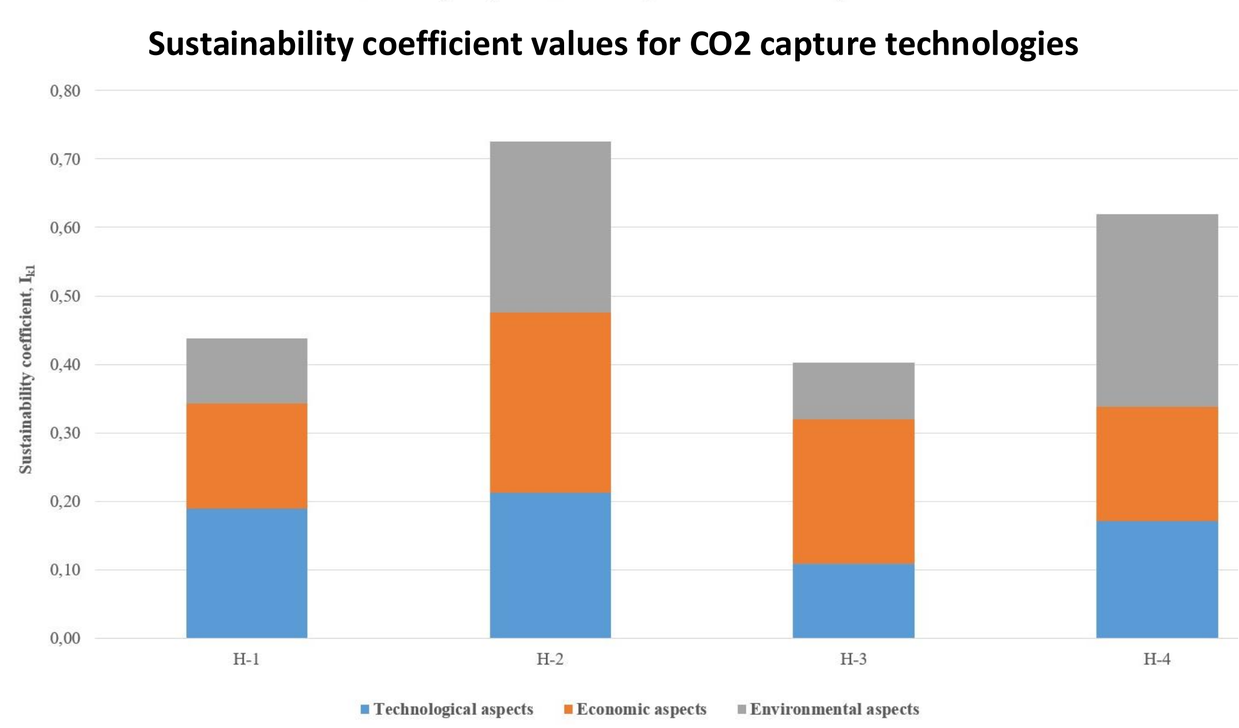



**Key stages of multi-criteria analysis**

## Results and conclusions




**Sustainability coefficient values for CO2 capture technologies**




**Sustainability coefficient values for green H2 production electrolysis technologies**

The sustainability analysis identified **Alkaline water electrolysis** (**H-2**, coefficient **0.73**) and **Calcium loop $CO_2$ capture** technology (**T-2**, coefficient **0.70**) as optimal, outperforming alternatives across technological, economic, and environmental criteria.

These technologies were selected for the sustainable **methanol production process flow diagram** due to their superior technical maturity, cost-effectiveness, and environmental performance.