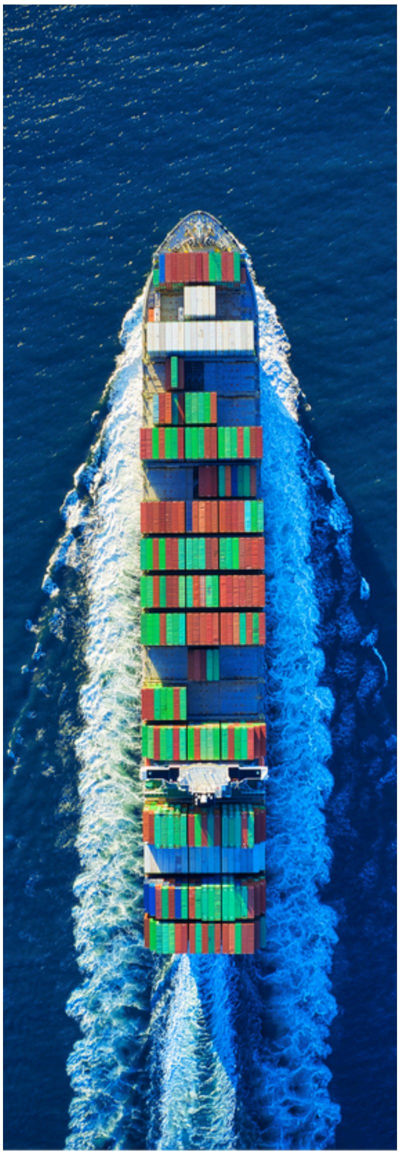
The Biogenic Solution for Maritime Decarbonization

One of the main commitments of the M²ARE project is to **map available biogenic CO_2 sources** to produce methanol as a sustainable alternative to fossil fuels for maritime fuel production. Different factors are fundamental to make a detailed assessment of the biogenic CO_2 sources such as indications on the **points of emission** within the plant, **geographical distribution**, indicative **stream composition/impurities** and the **potential seasonality**.



Biogenic CO_2: A valuable and sustainable alternative to fossil CO_2

The **maritime shipping industry**, a backbone of global trade, is also a significant contributor to climate change, with the **IMO** (International Maritime Organization) attributing approximately **3%** of total global CO_2 emissions to this sector, which overwhelmingly relies on fossil fuels for **propulsion** and **power generation**. Achieving ambitious decarbonization targets necessitates a swift pivot towards **Sustainable Marine Fuels** (SMFs) such as **methanol**, **ammonia**, **liquefied natural gas** (LNG), **hydrogen**, and various biofuels. Among these, methanol is emerging as a critical **low-carbon pathway**; however, its sustainability hinges on its production from non-fossil carbon sources. The EU Horizon project M²ARE is strategically positioned to aim to accelerate this transition by focusing, among others, on the **mapping** and **characterization** of **biogenic CO_2 streams**. This biogenic CO_2, sourced from the **decomposition** or **processing** of biomass (e.g., agricultural waste, forestry residues), is distinct from fossil CO_2 because it is part of the natural short-term carbon cycle, having been recently captured from the atmosphere by plants. By capturing and utilizing this carbon, combined with **renewable hydrogen** (H_2), M²ARE facilitates the production of low-carbon methanol, effectively transforming an existing emission source into a renewable carbon feedstock for the shipping industry, thereby helping to **close the loop** on sustainable fuel production.

M²ARE

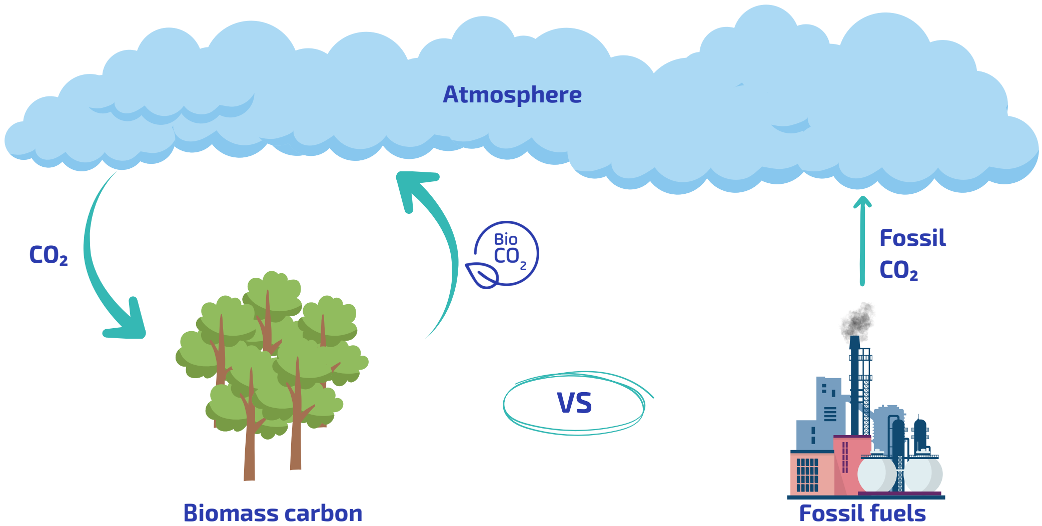


Figure 1. Biogenic and fossil-based carbon cycle

Conversion process of biomass

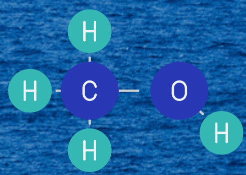
Bio-CO_2 is a by-product deriving from **several processes** of **biomass conversion**. This carbon source often remains unutilized, and it origins from three main biomass conversion technologies:

- **Combustion** (main CO_2 emitting process);
- **Digestion** (production of biogas and digestate);
- **Fermentation** (production of products like bioethanol).

Potential impurities contained in the bio-CO_2 feedstock

A previous assessment on the different biomass feedstocks is fundamental to have an overview of the compounds that could **potentially interfere** with the **catalyst** during the methanol synthesis process, leading to **catalyst poisoning** and deactivation.

Methanol



Methanol is the simplest alcohol, having a great potential in terms of **energy source** and **hydrogen carrier**. It requires relatively small investments to adapt storage, transportation and refueling infrastructure.

- Soluble in water
- Easily degradable
- Liquid at atmospheric conditions
- Easy to store and transport

CO_2 capture and separation techniques

Different states in which CO_2 can be transported include: **gas**, **liquid**, **dense form** and **supercritical fluid**. Each with their own advantages and disadvantages. On-site storage of CO_2 from industrial off-gases typically involves gas holders. The CO_2 is stored in a relatively pure state, but thorough cleaning of the off-gas stream is essential to protect the catalysts used in methanol synthesis. The choice of CO_2 transportation method, whether by pipeline, maritime, or road, depends on factors like **volume**, **cost**, and **geography**. While road transport is suitable for smaller volumes over short distances, pipelines and maritime transport are more feasible for large volumes exceeding one million tons annually. CO_2 can be transported as a liquid via trucks, trains, or ships, or as a supercritical fluid through pipelines.

CO_2 storage and transportation

Three primary technological approaches are currently employed to capture carbon dioxide (CO_2) from industrial and energy-related sources: **post-combustion**, **pre-combustion**, and **oxy-fuel combustion**. The choice among these three methods is not universal, but rather depends heavily on the **specific context** of the industrial facility. Key determinants in selecting the most suitable CO_2 capture technology include the required **purity level of the captured CO_2 product** (which impacts its transport and eventual utilization or storage) and the **thermodynamic conditions** and composition of the original flue or gas stream. For instance, post-combustion capture is often retrofit onto existing power plants, while Pre-combustion is typically integrated into new facilities that use processes like gasification.

M²ARE Project
M²ARE Project
M²ARE.eu
info@M²ARE.eu

The information contained in this factsheet is part of the results obtained in the context of the M²ARE project. Further information can be found in the full paper available at this link.

Coordinator:

Air Liquide

Partners:

Everllence, Sant'Anna, Université de Lorraine, CPERI, LRGP, TU Delft, etaflorence renewable energies

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