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NextFuel

Sustainable methanol for maritime transport produced through an electrified steam methane reformer

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Introduction

Nowadays, almost 90% of goods are transported by the maritime sector, globally, rendering it a vital facilitator of the global economy.[1] Nevertheless, the sector remains very carbon intense, producing almost 3% of the global greenhouse gas (GHG) emissions. This, along with the stricter FuelEU Maritime regulation that demands a drastic reduction in the GHG emissions[2], has increased the pressure for adopting sustainable fuels. Biomethanol emerges as a promising green fuel, since emissions are significantly reduced, compared to traditional marine fuels.

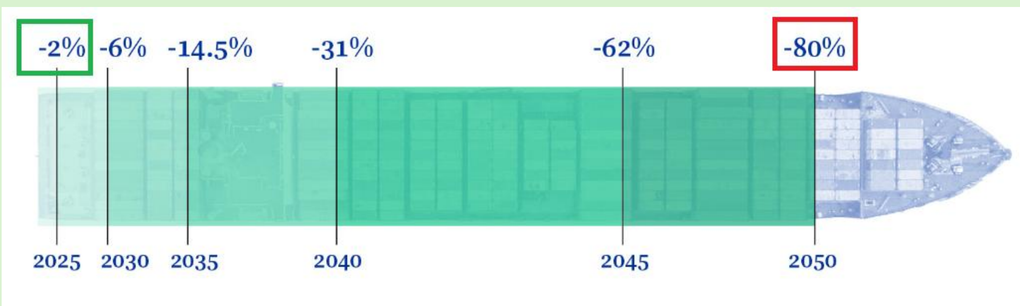

Figure 1. Annual average carbon intensity reduction, according to FuelEU Maritime regulation.

Taking the above into account, the ***NextFuel project*** pioneers a new approach, in which the Steam Methane Reforming (SMR) process is electrified, in order to produce biomethanol more sustainably, while reducing the fossil fuel consumption and CO_2 emissions (carbon footprint). Additionally, by utilizing biogas as the feedstock for methanol synthesis, instead of natural gas, the process can become even more sustainable.

NextFuel's novelty

- The core of the project is the eREACT reactor, which is an innovative electrically heated steam methane reformer that replaces the current conventional fossil-fired reformers.
- By utilizing renewable electricity and innovative reactor designs, it can greatly reduce fossil fuel dependency and CO_2 emissions.
- Integrating onboard carbon capture technology ensures that the maritime industry can move towards a zero-emission future.

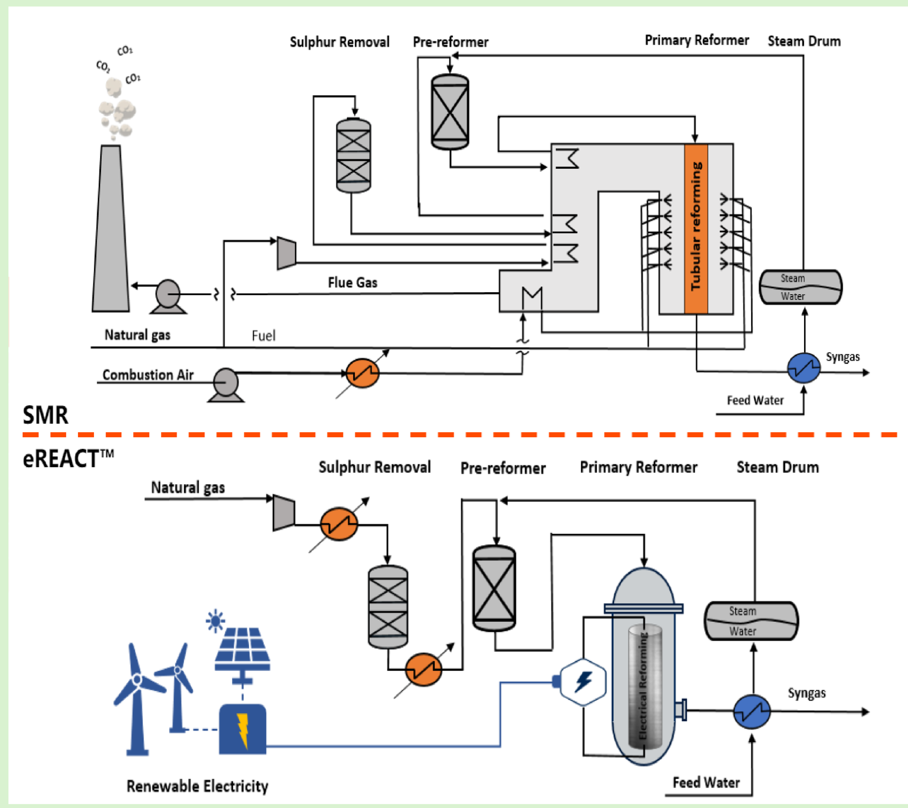

Figure 2. Conventional SMR (top) and electrified SMR (bottom) process flowsheet.[3]

Methodology

Traditional SMR reactors are energy-intensive and they are heavily relying on fossil fuels, in order to drive the strongly endothermic reactions, within the reactor. Thus, substantial CO_2 emissions are generated.

The ***NextFuel project*** introduces an electrified SMR process, aiming to revolutionize biomethanol production, by replacing the large furnace of the conventional SMR reactors with electric resistance heated reactor walls. This method facilitates the integration of renewable electricity to convert biogas into syngas. Furthermore, in this way, the thermal limitations of the traditional SMR reactors are bypassed; while, the catalyst utilization is enhanced, the reactor volume can be reduced up to 100 times and the direct CO_2 emissions are eliminated.

The technology behind our approach lies in the eSMR lab prototype built by our partner Topsoe. Within the ***NextFuel project,*** we aim to apply this approach and offer a novel and world-first industrial production of biomethanol, creating a scalable and cost-competitive pathway for renewable methanol production in Europe, directly supporting the maritime decarbonisation objectives.

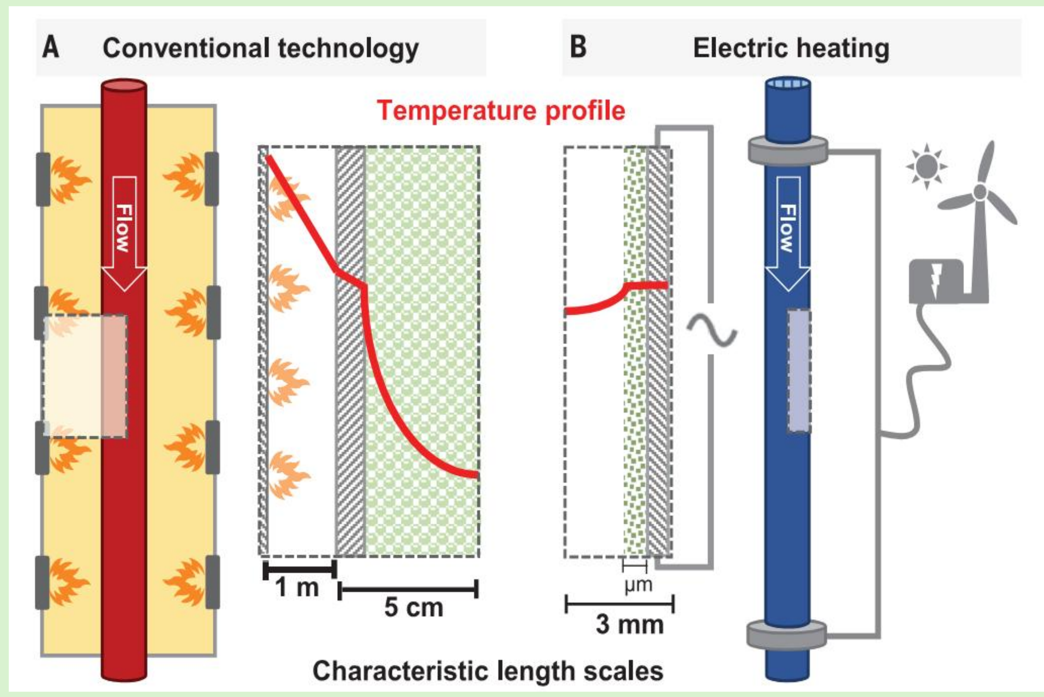

Figure 3. Heating principles of (A) Conventional SMR and (B) Electrified SMR.[4]

Assessment Framework

We have developed the simulation framework for the Life Cycle Assessment (LCA), Life Cycle Costing (LCC), resource availability, logistics and business models. LCA simulations took place using the SimaPro Craft LCA software.

We have identified the case studies examined: plant sizes, locations (Southern & Northern Europe) and the parameters affected. The utilization of by-products and its potential contribution to improving the overall performance is also evaluated. LCA calculations have been carried out for the small and medium sized plants in Greece & Norway, and for the large plant in Norway, for the different cases.

So far, 3 main scenarios, differentiated by the plant's size, have been investigated:

- Scenario I: Small plant size, with daily capacity of 50 MTPD
- Scenario II: Medium plant size, with daily capacity of 150 MTPD
- Scenario III: Large plant size, with daily capacity of 750 MTPD

Additionally, different feedstocks have also been examined, including:

- Raw biogas → for the small plant
- Biomethane (and carbon dioxide) → for the medium and large plants

1. Goal and scope definition

- **Functional Unit & System Boundaries**: e.g. 1 ton of produced biomethanol, cradle-to-gate

2. Inventory Analysis

- **Data collection (Primary & Secondary data)**: e.g. energy, materials, emissions, waste flows

3. Life Cycle Impact Assessment

- **Method:** Environmental Footprint (EF 3.1)
- **Impact categories:** Climate change, acidification, ecotoxicity, human toxicity, etc.

4. Interpretation

- Contribution analysis
- Sensitivity analysis

Figure 4. The LCA framework created and used.

Results and Discussion

LCA results:

- ✓ The analysis indicated that for the small plant in Greece, electricity demand was by far the dominant contributor across all impact categories, while feedstock was the second one.
- ✓ Also, in cases where the excess heat was recovered, there was a great environmental benefit, leading to a reduction of the total environmental impacts, along with economic benefits.
- ✓ In the cases of the small and medium plants in Norway, feedstock was found to be the primary driver of environmental impacts, while the electricity consumption contributed less compared with the scenarios in Greece.

Conclusions and Future Research

- ✓ Preliminary economic and environmental analysis indicate that the electrification of the SMR process provides a transformative approach to sustainable biomethanol production.
- ✓ The LCA and LCC frameworks designed within ***NextFuel project*** are flexible, since they will be continuously updated as more detailed data become available, during the lifecycle of the project.
- ✓ Future work will also focus on the comparison of biomethanol with alternative marine fuels, in order to determine its relative advantages and limitations.

References

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Acknowledgements

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