SUCCESS STORY

LEC GETS
LEC Green Energy and Transportation Systems

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CARBON CAPTURE AS AN EFFICIENT SOLUTION FOR DECARBONIZATION OF SHIP PROPULSION SYSTEMS

BASED ON AN OVERALL SYSTEMS APPROACH, LEC EVALUATES THE EFFICIENCY OF CARBON CAPTURE TECHNOLOGIES ON BOARD OF DIFFERENT TYPES OF SHIPS WITH THE AIM OF REALIZING CO_2-NEUTRAL SHIP PROPULSION SYSTEMS.

Shipping is currently the most efficient way of transportation, but is responsible for around 3% of global greenhouse gas emissions. In order to achieve the goal of climate neutrality by 2050, measures to sustainably avoid CO_2 emissions from the fuels used are required in addition to operational measures. Due to the restrictions on mass and volume on board, purely battery-electric drives are often not expedient. Therefore, CO_2-neutral liquid fuels, for example fuels based on renewable hydrogen, such as ammonia or methanol, or biofuels, will continue to be the preferred energy sources for use on ships in the future. In the coming decades, however, these fuels will be very expensive and only available in very limited quantities. As ships are generally used for a very long time, but the transformation of propulsion technologies to climate neutrality must take place quickly, retrofit solutions, such as carbon capture systems will be a decisive building block on the way to climate neutrality. In addition, carbon capture systems can also continue to be operated in the future with regeneratively produced fuels as part of a carbon cycle or, together with biofuels, enable negative emission scenarios.

Comprehensive techno-economic comparison of different carbon capture technologies

There exist currently a large number of carbon capture technologies with different degrees of maturity and a wide range of requirements for the respective application. Both, technologies for capturing CO_2 from the exhaust gas (e.g., amine absorption, membrane) and technologies that remove carbon or CO_2 from the fuel before combustion (e.g., membrane reformer) are possible. The impact of carbon capture systems on the energy systems on board of ships can be considerable, as the technologies usually require significant amounts of heat or electricity. For this reason, comprehensive system simulations were carried out using the LEC ENERsim system optimization

framework to determine which technologies make technically and economically most sense for which application. For this purpose, the relevant system components were modeled with all energy and mass flows, and central boundary conditions for compliance with a specified carbon capture rate and for meeting the real operating profiles, which can be very different for different ship types, were taken into account. The relevant characteristic curves and techno-economic parameters were assigned to each model component. With the fully parameterized model, it was also possible to optimize the required sizes and performance parameters of the individual components. As a result, in addition to the cost-optimized design and the optimal operating strategy, the key performance indicators like additional fuel consumption, avoided CO_2 and CO_2 avoidance costs were also determined for each ship type and use case (see Fig. 1 for an example).

Key messages of the study

- Carbon capture systems on board of ships have the potential to significantly reduce greenhouse gas emissions from the shipping sector both in the short and long term.
- The challenges lie in the technological integration on the ship, the increased energy requirements and the resulting additional costs.
- The ship's energy system, in particular the heat demand on board and the usable waste heat from the propulsion system, has a major impact on the energy efficiency of the carbon capture technology.
- With efficient use of waste heat and complete thermal integration, CO_2 avoidance costs can be minimized.
- A prerequisite for the establishment of carbon capture is also the availability of appropriate port infrastructure for CO_2 storage and transport.

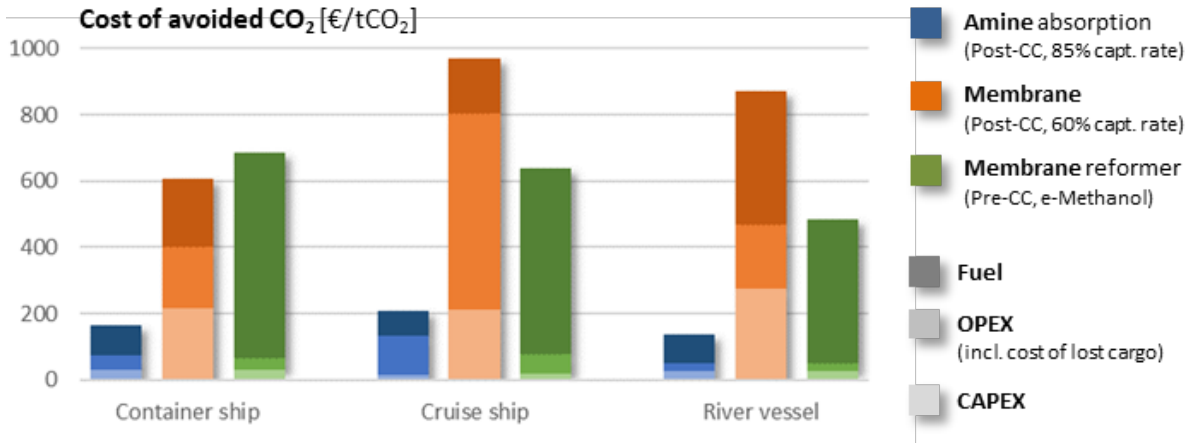

Fig. 1 Comparison of CO_2 avoidance costs for three carbon capture technologies on three different ship types. © LEC GmbH

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