Carbon Capture for marine and offshore industries

Carbon Capture is a potential supplemental solution for reducing a vessel or offshore unit's overall carbon footprint says the American Bureau of Shipping (ABS) in an article as part of its Offshore Thought Leadership Series.

Unless a vessel or offshore unit is combusting zero carbon content fuels such as ammonia and hydrogen, other carbon-based fuels such as liquefied natural gas, liquefied petroleum gas, methanol, bio or renewable diesel and dimethyl ether will produce CO2 as a by-product after combustion.

If the carbon-based fuel is produced renewably, the overall carbon footprint might be reduced, or even become net zero. CCS for shipboard application refers to a set of technologies that can be used to capture CO2 from vessel or offshore unit exhaust gas and store it for subsequent disposal or use.

Over the last 20 years many research groups around the world have explored carbon capture technologies to increase efficiency and reduce the size and cost of the system.

CO2 has been safely transported and used in many industries for decades and can be moved by ship, truck or pipeline.

The majority of carbon capture systems have been designed and demonstrated in electric power plants. However, it is possible to deploy CCS technologies onboard vessels or offshore units to capture, store and transfer CO2 ashore for use. Maritime deployment of CCS is now being researched and piloted by multiple firms.

Capture methods

There are three major types of CO2 capture systems: post-combustion, pre-combustion, and oxyfuel combustion. Pre-combustion and oxy-fuel combustion remove carbon from the fuel prior to combustion and produce hydrogen and oxygen, respectively, for combustion. Consequently, the pre-combustion and oxy-fuel combustion carbon capture systems require integration into the fuel supply and power generation systems and calls for a total redesign.

Post-combustion process captures CO2 from flue gas produced after the combustion and therefore can be added to the conventional design with minimal alteration to the engine. Retrofit to vessels or offshore units as a standalone system is relatively straightforward.

In the most-conventional capture based on solutions of liquid amines, there are two steps to separate CO2 from the emission: capture (sorption) followed by thermal or pressure-swing desorption, also termed regeneration.

In capture, the CO2 is absorbed into a liquid or solid by contacting the CO2 source with the absorber. In the desorption/regeneration step, CO2 is selectively desorbed from the absorber, resulting in a flow of pure CO2 gas, with the original amine sorbent regenerated for further use.

Regulatory Requirements and Current Standards

In general, regulations and policies for carbon capture are mostly in development, with Europe being a notable early adopter. The European Union's carbon capture directive on Geological Storage of Carbon dioxide came into force in 2009, providing regulatory requirements for storage.

The United Kingdom's (U.K.) Department of Energy and Climate Change also has projects in motion to support the relatively new technologies. In the United States the Environmental Protective Agency is working on developing regulations to track national carbon capture activity and ensure safe practices.

The 2005 IPCC Special Report on Carbon Dioxide Capture and Storage covers maritime considerations for carbon capture and storage in Chapter 4 including considerations for design, construction, operation, risk, safety, and costs.

Onboard Considerations

The challenge in marine and offshore environment is the handling and storage of captured CO2. The process requires significant power to liquefy or solidify the captured CO2 for storage. Storing CO2 in gaseous form onboard is not a viable option due to space requirements.

CO2 transforms from gas to solid directly when cooled at ambient pressure and solidifies at -78 °C. It can also be solidified by interaction with other chemicals.

To transport CO2 in a liquid state it needs to be contained at 0.7 MPa and -50 °C. If the liquefied CO2 is to be stored onboard, the storage space should be considered based on the expected capture during voyage; 1 ton of liquified CO2 occupies about 1 m3 volume.

Current Research

Offshore CCS projects offer CO2 storage opportunities through use of existing or plugged/abandoned wells. Research projects in partnership with the Bureau of Ocean Energy Management are collecting data on key offshore storage complexes along the US Mid-Atlantic, Southeast and Gulf of Mexico.

These projects and assessment efforts use 3D flow and geo-mechanical modeling and investigate sites with potential to store millions of metric tons of CO2.

Mitsubishi Heavy Industries (MHI) recently conducted a concept study focused on installing a carbon capture and storage unit on a very large crude carrier. The system was comprised of four towers for cooling the exhaust, absorbing CO2, treating the exhaust, and regenerating the CO2, in addition to the required liquefaction and storage facilities.

The objective of the project was to investigate onboard production of methane or methanol by combining hydrogen from water electrolysis with the captured CO_2. MHI reported the CO_2 capture rate at about 86%, and a 20-year rate of return due to the high CAPEX and OPEX.

The U.K.'s Department for Transport recently funded a project by PMW Technology with an A3C carbon capture process, partnered with a naval architect company, Houlder Ltd. to study the potential for using carbon capture technology in shipping. They will use their A3C carbon capture process to extract CO_2 from exhaust gases by freezing, then subliming the CO_2. The CO_2 will then be liquified and stored in tanks onboard the ship.

Presently, carbon capture technology is facing technical and economic challenges for marine and offshore applications. However, it still has potential to be an effective method of reducing GHG emissions for future vessels and offshore units, especially in conjunction with low-carbon fuels. Further technical advances are expected to reduce the scale, cost and complexity of the carbon capture technology.

Role of ABS

Decarbonization is a major component of sustainability. However, sustainability also means sustaining businesses in challenging times beyond environmental aspects including items such as alternative energy sources for lower carbon footprint, new approaches to vessel/asset design to enhance performance, digital solutions to optimize asset management and additional strategies that impact safety, security and the environment.

Through the Offshore Sustainability Online Resource Center, ABS addresses topics of operational sustainability, environmental sustainability, and digital sustainability.

These services are in addition to typical Classification services such as operational safety of production units and unmanned offshore installations, offshore compliance and regulatory issues, and industry research that examine emerging sustainability issues in the offshore industry.

ABS is also working with the Massachusetts Institute of Technology on maritime carbon capture strategies for emissions reduction and CO_2 mitigation technologies.

The studies are taking into consideration the relative sizing for potential onboard systems as well as the modeling of system performance for exhaust flow, efficiency, and CO_2 reduction potential of multiple vessel sizes and profiles.

More information

For more information, visit the ABS Sustainability portal at:
ww2.eagle.org/en/Products-and-Services/Sustainability.html