Powerstudy

by Felix Jung, *Sustainability & LCA Manager, Liquid Wind*

The shipping industry faces a considerable challenge – one approaching at an increasing speed. Confronted with the International Maritime Organization's (IMO) regulations that require it to reduce its carbon intensity by 40% by 2030, the sector is focussing on short-term efficiencies. Achieving the IMO's targeted 70% reduction by mid-century, shipping looks further ahead to a broader energy transition. Momentum is growing towards the use of renewable fuels. Calculating life-cycle emissions demonstrates that eMethanol can significantly contribute to carbon footprint reduction.

Achieving the first of the above goals will require a process of collaboration and pilot projects that enable the industry to adopt the first generation of alternative fuels. Ticking off the second will require an ample supply of fully sustainable marine fuels. Compliance with the 2030 target will necessitate the progressive adoption of fuels from biogenic and synthetic sources (e-fuels); by 2050, there will need to be a sharp decline in fossil fuel usage and a ramping up of the supply of renewables. How the industry spends the time and where it places its focus between now and 2030 will be critical to a successful outcome.

Swing the balance

The classification society Lloyd's Register notes that the readiness of alternative marine fuels is an interplay between technology, investment, and market readiness. The technology piece is relatively straightforward around how the fuels work; investment reflects the commitment needed in the fuels and infrastructure. The community element stands for the policy required to adopt zero-carbon fuels.

Net-zero carbon ships are technically and operationally possible, but the challenge for the industry is that the bulk of the fuel technology exists outside shipping. Developing a non-fossil fuel is a simple challenge. Setting up the required supply chain and infrastructure is when one must roll up the sleeves. Making it happen requires a partnership between producers and consumers.

Anecdotal evidence suggests that a primary driver of fuel adoption is price; required capital will be higher, but ultimately the total fuel cost lies in its operational expenditure. To help close the competitive gap requires a carbon price – which will emerge once shipping enters the EU Emissions Trading System in 2023.

The key to the green policy framework is how regulators work to make fossil fuels uncompetitive and enable a playing field that supports a clean fuel transition with alternatives available at price parity. Bridging the supply-demand gap with a policy framework that does not penalise first movers is what can be done in the short term. From a practical viewpoint, this involves linking vessel trades and regions to map out and facilitate fuel production and find convergence between the two. These 'green corridor' projects require partnerships between producers and consumers and a strategy that enables both sides of the equation to move in tandem.

Counting emissions – all of them

Shipowners and other stakeholders are already focussing on methanol, specifically how to navigate the pathway from conventional to renewable alternatives. For example, the Green Maritime Methanol initiative based in the Netherlands brings together knowledge centres and companies to provide input and feedback on the transition to sustainable methanol.

The project partners have recognised that making methanol a viable fuel requires the industry's input from the outset, gaining knowledge of regulations, requirements, constraints, and opportunities. The project focuses on transitioning from fossil to biomethanol and from blue to green eMethanol made from renewable resources. The project's Pieter 't Hart sees biomethanol emerging in volume by 2030, followed by a shift to recycled CO_2 and eMethanol, with a gradual process speeding up.

Perhaps the most crucial aspect of this process is the life-cycle assessment of carbon emissions so that all stakeholders can understand the total carbon contribution of their fuel choices in terms of emissions on a well-to-wake basis. Shipping's current carbon intensity measurement is tank-to-wake, counting only the emissions emitted when combusting the fuel. The former measurement enables transparency to capture the entire upstream process from well-to-tank. Using a well-to-wake approach is essential to ensuring that the burden of greenhouse gas emissions (GHG-E) is not shifted upstream. The emissions profile of each fuel needs to be rationally assessed.

About 94% emission reduction

To meet the growing demand for carbon-neutral fuel and the need to reduce GHG-E, Liquid Wind is developing FlagshipONE. This commercial-scale renewable eMethanolfacility will capture

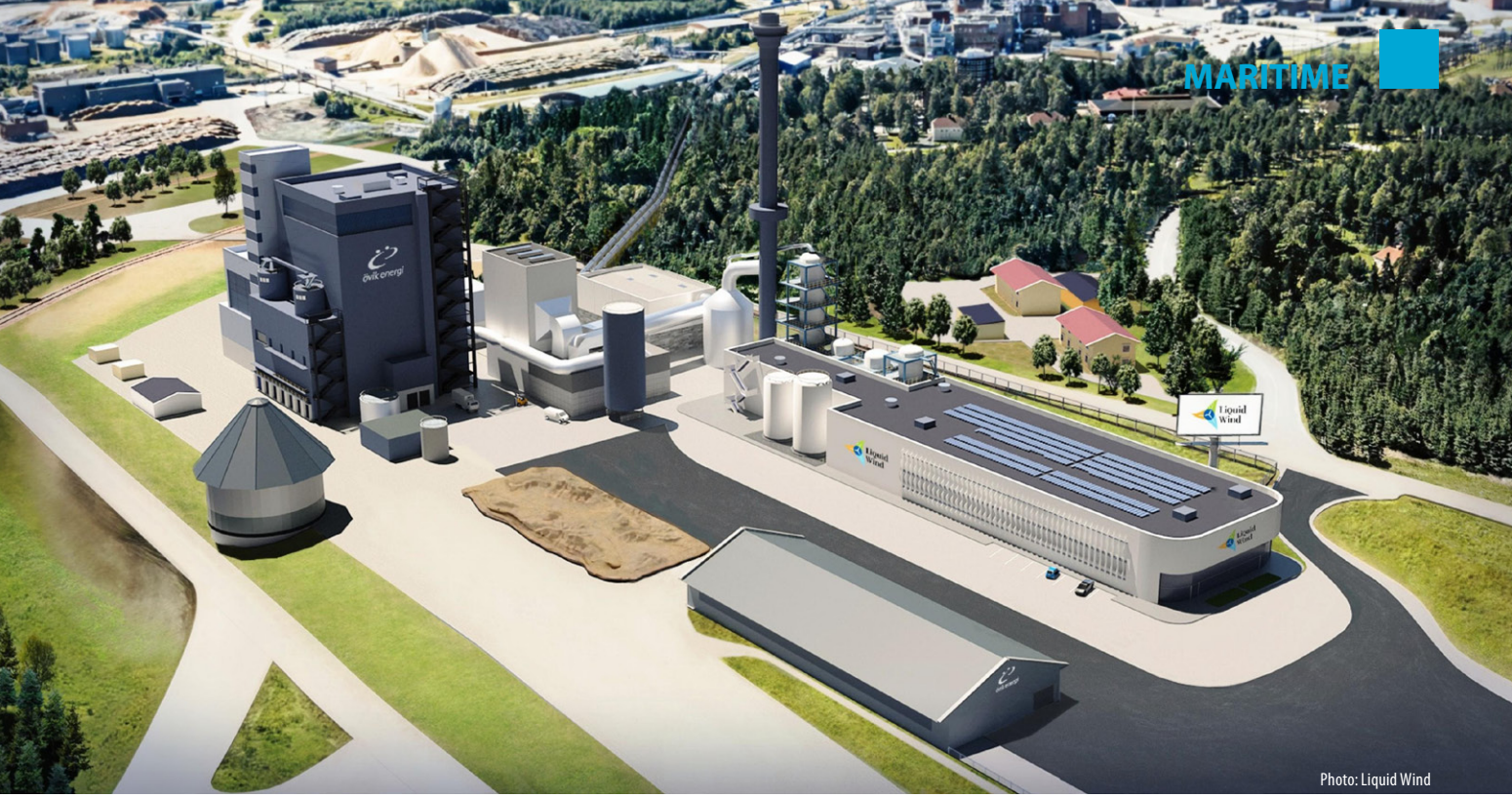

Photo: Liquid Wind

CO_2 emissions from a biomass combined heat and power plant.

Liquid Wind will start constructing FlagshipONE in the Swedish Örnsköldsvik during 2022 and plans to have ten renewable methanol production facilities onstream by 2030. The production pathway for Liquid Wind's methanol will combine green hydrogen generated from wind energy with the CO_2 recycled from biogenic sources. The Danish energy company Ørsted and Liquid Wind AB have reached an agreement, under which Ørsted acquired a 45 % ownership share of Liquid Wind AB's FlagshipONE eMethanol project.

To understand the full carbon contribution of its renewable eMethanol, Liquid Wind undertook a life-cycle analysis to determine and compare the entire environmental impact of its eMethanol, evaluating the production process to understand where it can make improvements.

To calculate the life-cycle emissions of the produced renewable methanol, Liquid Wind evaluated carbon emissions per megajoule (MJ) of energy versus a range of alternative fuels. This required understanding its environmental impact pre-combustion, using inventory analysis, an impact assessment, and subsequent interpretation to make a meaningful comparison.

Using material energy flow analysis, Liquid Wind measured each module of the new facility to record grams of CO_2 per MJ emitted, assigning GHG-E to each material and energy flow for every module. The calculations included assumptions on carbon emissions for wind power as well as negative carbon credits for CO_2 capture but ignored 'embodied' emissions from the manufacturing process.

The research found that methanol is a carbon sink before combustion, i.e., on a well-to-tank basis. Yet, by expanding this to a well-to-wake basis, Liquid Wind found that the company's renewable methanol has a minor net-positive carbon contribution.

The well-to-gate emissions of FlagshipONE's eMethanol (life-cycle emission when leaving the production facility) are relatively small, at around -1.3kg CO_{2eq} per kg of eMethanol produced. About -1.4kg of CO_2 is from capturing the carbon and is credited as negative emissions. When the scope is expanded to include the 'use phase,' well-to-wake, the emissions of transport and combustion are considered. The captured CO_2 is re-emitted, which results in a net-positive climate change potential of about 5g CO_{2eq}/MJ.

A further evaluation against other fuels provided increased transparency of upstream carbon emissions, enabling measurement of sustainable development criteria. Fossil fuels emit around 85-90g CO_{2eq}/MJ on a life-cycle emission basis. Liquid Wind's analysis found that replacing fossil fuels with renewable methanol results in a carbon emission reduction of about 94% (well-to-wake emissions of eMethanol are compared to other marine fuel alternatives based on data provided in **Brynolf et al**. [2014]).

Liquid Wind's research also concluded that the production of low-carbon eMethanol depends on the sourcing of green electricity. For instance, the use of typical grid electricity would increase life-cycle emissions three times.

Clearer light

Well-to-wake accounting of carbon emission equivalence is critical for a successful transition by the shipping industry towards net-zero operations, as it can help avoid burden shift and minimises reputational risk. It also increases control by enabling more accurate comparison and benchmarking and, therefore, more accurate emissions accounting for future trading and market-based levies. In the long run, it helps put shipping's carbon emissions in a clearer light – providing an incentive for sustainable innovation along the supply chain. ■

Liquid Wind

Liquid Wind is a power-to-fuel development company committed to reducing carbon emissions. The company develops, finances, builds, and manages replicable facilities for the production of eMethanol to accelerate the transition to carbon-neutral shipping and transportation. The facilities will produce green electro-fuel, so Liquid Wind can offer customers the opportunity to reach their sustainability goals quickly. In 2021, StartUs Insights included Liquid Wind in the Top 5 Energy Start-ups globally. For more information, please visit **liquidwind.se** and follow the company on **LinkedIn** and **Twitter**.