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Weathering of stored Liquefied Natural Gas (LNG) – Modelling approaches

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Abstract- The global energy sector is undergoing unprecedented change as it transitions from its reliance on fossil fuels to renewables. In the environment of increasing world-wide energy consumption, and the need to mitigate the adverse effects of climate change, natural gas has an important role to play in the energy mix for the foreseeable future, because of its competitive cost and lower emissions when compared to other fossil fuels. Currently natural gas can be distributed to users either through pressurized pipelines or as liquefied natural gas (LNG).

LNG is stored in highly insulated storage vessels, which are nevertheless subject to heat ingress driven by the large temperature gradient between the surroundings and stored cryogen. The heat intrusion drives a number of complex transport phenomena within a cryogen, including evaporation, natural convection, thermal stratification and liquid thermal expansion; thus raising engineering, safety, economic and environmental challenges. Of special concern is the weathering of LNG as a result of preferential evaporation of the most volatile components, methane and nitrogen. In order to keep the pressure below a pre-set value the produced vapour is removed as boil-off gas (BOG), resulting in the increase in the concentration of the heavier components in the remaining LNG. For both isobaric and non-isobaric evaporation of LNG, experimental data is scarce and most research work has been focused on developing models.

The talk will focus on elucidating the different modelling approaches, with emphasis on recent developments. The results will be presented demonstrating: (i) the influence of nitrogen on BOG (ii) how superheating of the vapour phase influences the weathering process; (iii) the increase in complexity if the weathering takes place under non-isobaric conditions, present in small and medium sized storage vessels and (iv) how the development of simple models and analytical solutions can complement the development of the CFD models, that are by their nature more complex, computationally more expensive and less yielding to providing the necessary physical insight on the interplay between different mechanisms.