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Thermodynamic modelling of liquid hydrogen tank warm-up at low fill levels

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The export of liquid hydrogen (LH2) offers a carbon neutral replacement for liquefied natural gas (LNG). However, among the key challenges in the storage and transport LH2 is the requirement for significantly insulated tanks due to the low storage temperatures required when compared to LNG. During the return voyage, tanks may carry a small amount of liquid (heel) to maintain low temperatures in the tank, as a warm tank may lead to excessive vapour generation during loading, which must be handled by the terminal. However, a higher fill level during the return voyage reduces the effectively carrying capacity of the carrier. To evaluate the effect of fill level on boil-off losses and tank heat gain, a lumped-mass analytical liquid-vapour model was developed in Matlab with a discretized 2D axisymmetric tank and insulation model. The effects of insulation type, wall material and fill level within the vessel were considered, and different methods for tank chill-down during the voyage were assessed across different storage durations. The model points to frequent intermittent spraying of the tank walls as a preferable option, highlighting key differences with the operation of large LH2 carriers compared to existing LNG transport procedures.

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