

# Embedding a thermodynamic-property-model for natural gases in a simulation tool for modelling LNG evaporation and liquefaction processes with higher accuracy

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To date natural gas as an energy source of the future is only getting to Germany via pipelines, which run through a multitude of states. In the future Liquefied Natural Gas (LNG) could play a vital role in the energy industry.

The evaporation and the liquefaction are essential processes in the LNG process chain. High expectations concerning the economic efficiency, the product quality and environmental safety result in increasing demands on these processes. This applies both to the design and the operation of a specific system, e.g. to the optimal use of resources while vaporizing LNG. Fundamental contributions to optimisation and operation of a system are expected from the simulation of processes. Therefore, an accurate representation of thermophysical properties and energy balances of the simulated process is essential. Results of process simulations are highly influenced by the property-model used. New highly accurate equations of state for natural gas and LNG represent an unused potential for accurate process-modelling.

GERG-2004<sup>1</sup> is an equation of state model that describes mixtures of arbitrary composition consisting of up to 18 specified components. It covers the gas and liquid phase as well as the overcritical region and the vapour-liquid equilibrium with the highest accuracy possible. It was adopted by the GERG (Groupe Européen de Recherche Gazières) as the new reference equation of state for natural gases. The development of a corresponding ISO standard is proceeding. However, so far the GERG-2004 is not used in commercial, LNG related simulation software.

In order to embed the GERG-2004 into various simulation tools, the software available for GERG-2004 has been adapted to the CAPE-OPEN standard. The thermodynamic property package resulting from the combination of available software for the GERG-2004 model and a new CAPE-OPEN interface allows for a consistent and stable calculation of thermodynamic properties of natural gases in commercial simulation tools.

This paper describes the way in which the GERG-2004 model was integrated into common simulation tools. Compared to simulations based on typical engineering equations of state, significant differences were found, e.g., for liquid volumes and temperatures in the two phase region, close to the saturated vapour line. These differences result in changes for calculated heat exchanger surfaces in the corresponding stages. Results found for the influence of thermodynamic-property-models on the simulation of LNG evaporation and liquefaction processes are discussed. Furthermore, advantages achieved by using the CAPE-OPEN standard will be discussed.

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<sup>1</sup> Kunz, O.; Klimeck, R.; Wagner, W.; Jaeschke, M. The GERG-2004 Wide-Range Reference Equation of State for Natural Gases and Other Mixtures. GERG Technical Monograph 15 (2007). Fortschr.-Ber. VDI, Reihe 6, Nr. 557, VDI Verlag, Düsseldorf, 2007.