Transportation of Natural Gas Using Liquid Carriers at Ambient Temperature

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Executive Summary

The purpose of this report is to determine whether an existing method of natural gas storage could be used as a transportation method across oceans. This analysis is compared to the Liquefied Natural Gas (LNG) transportation method in order to evaluate whether it could compete as a valid method. The search for a competing method of natural gas transportation was the driving force behind this research. Additional initial research into the lack of ASME codes for carbon fiber reinforced piping, use of additives to increase methane dissolution in propane, the use of other solvents as liquid carriers, and the costs associated with loading and unloading of the mixture was performed.

The analysis used information from the patent "High-Energy Density Storage of Natural Gas at Moderate Temperatures" developed by Dr. Roger G. Mallinson, Dr. Kenneth E. Starling, and Dr. Jeffrey H. Harwell at the University of Oklahoma. This patent details the storage of natural gas in pressurized liquid hydrocarbons at ambient temperature. The idea behind this analysis assumed temperatures of 80 ºF as a threshold to what may be expected during ocean transport and a pressure of 1500 psi to rival compressed natural gas (CNG) transportation. It also investigated several storage architectures for the storage of this mixture on board ocean tankers. The project was done with research into the maximum storage capability of this mixture on large ocean tankers. After determining this it was possible to find the profitability of this method based on shipping costs, operation costs, and depreciation.

The results of the project showed that this method of transport could not compete with LNG as a valid transportation method. Along with the costs required for constructing loading and unloading stations in locations competing with LNG, the operating costs were high and the lack of available transport vessels keep this method from being viable. The operating costs were calculated to be upwards of $65 million for capacities starting at 1 million tons per annum. The fixed capital investment at these capacities calculated to be upwards of $246 million compared to an FCI of $349 million for LNG transport. This was the only respect that cost less than LNG due to the higher density of LNG. The net income based on a gross profit of gas shipped at various distances starting at 1000 miles showed that even at a gas price of $100/ton method was not profitable. Increasing the price of gas would only improve LNG profits so again this method cannot overtake LNG.

This method of transport is concluded to be uneconomical. The cost required for shipment of the same amount of natural gas per year as LNG is almost 4 times as large. The only way to compete with LNG would be to improve the shipping methods to reduce the cost, but these improvements would likely extend to LNG tankers as well. Also, the exploration into natural gas additives that could increase dissolution of methane gas into liquid propane may improve this method if the increase is substantial. The search for a new solvent for storing the methane gas proved that only at pressures above 3000 psi could a 50/50 mol % methane mixture be achieved at ambient temperature so there is no need to investigate this further. The error in profitability proved to be only 2.0% when varying the thermodynamic equations of state for analysis.