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C2Or3B-01: Small-Scale Industrial Hydrogen Liquefaction

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Liquid hydrogen (LH2) production has predominantly been performed in the past by large gas separation facilities primarily to take advantage of economies of scale and available utilities and commodities such as liquid nitrogen for pre-cooling. With the expanding hydrogen economy, the increased need for LH2 production and storage will drive industry toward smaller liquefaction plants where localized production, storage and use can be realized. A one tonne per day (1TPD) hydrogen liquefaction plant (HLP) has been designed to achieve localized, efficient LH2 production, on-demand, in remote locations or any location advantageous for use in transportation, where complicated logistics, with its associated costs and evaporative losses in transporting LH2 are eliminated or minimized. The chief advantages of the HLP are safety, reliability, modularity, low cost, lack of restrictions on site location, and ability to make practical use of renewable energy. At the heart of the 1 TPD HLP is the liquefier which utilizes a closed-loop helium brayton cycle where temperatures well below the H2 liquefaction temperature can be realized. LH2 is then stored and maintained at zero loss or densified with a helium side stream taken from the refrigeration cycle. The system utilizes helium at low pressure, making the HLP inherently safer than most other H2 liquefaction cycles currently in use. The liquefier is relatively small with few major components/equipment housed inside the vacuum vessel. Therefore, the simplicity of the system increases reliability, affords a high degree of automation, and facilitates ease of maintenance in order to reduce potential downtime. The HLP is also scalable to provide either higher or lower production capacities per unit or multiple units can be placed in parallel or used to cool mega-scale LH2 storage tanks. Without the LN2 pre-cooling, the HLP can be located in remote areas wherever there is available electricity or where local electricity production capacity exists, such as in natural gas fields. The LH2 produced by the HLP can be used across various markets, including car, truck, aircraft, and rail refueling as well as shipboard bunkering applications, many of which are best serviced by use of local LH2 production and storage. The HLP is designed for either liquid-to-gas applications, such as that used for many cars and trucks, or can be operated in liqud-to-liquid transfer as required for future vehicles using onboard LH2 tanks or to dispense to tanker trucks. Lastly, a significant advantage of small-scale LH2 production is due to the relatively low energy requirement and the economical use of renewable energy, feeding back electrical power to the grid during times of low hydrogen production.

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