Analisis Tekno-Ekonomi Teknologi Penyimpanan Hidrogen Untuk Proses Transportasi = Techno-Economic Analysis of Hydrogen Storage Technologies for Transportation Process

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Abstrak

Industri energi dunia berkontribusi 87% terhadap peningkatan gas rumah kaca di dunia. Untuk mengurangi emisi gas rumah kaca di dunia, hidrogen merupakan alternatif sumber energi dengan densitas energi gravimetrik 120 MJ/kg dan densitas volumetric 0,0824 kg/m3. Tantangan utama hidrogen sebagai energi alternatif adalah densitas volumetriknya yang sanagt rendah, sehingga memerlukan teknologi penyimpanan hidrogen dengan densitas volumetrik yang lebih tinggi. Sistem penyimpanan hidrogen sangat penting dalam siklus supply-chain hidrogen, terutama dari segi keekonomiannya. Sistem penyimpanan hidrogen terdiri dari proses hidrogenasi, transportasi, dan dehidrogenasi. Pada penelitian ini dilakukan analisis tekno-ekonomi dari 5 jenis teknologi penyimpanan hidrogen: compressed hydrogen, liquid Hydrogen, liquid organic hydrogen carrier, metal hydride, and amonia. Penelitian ini menggunakan Aspen Hysys dalam process design, process modeling, dan equipment sizing. Biaya sistem (IDR/kg) ditentukan berdasarkan Capital Expenditure (CapEx) dan Operational Expenditure (OpEx) dari masing-masing proses hidrogenasi dan dehidrogenasi, serta biaya transportasi pada 2000 km. Hasil penelitian menunjukkan bahwa pembawa liquid organic hydrogen carrier memiliki biaya sistem terendah sebesar IDR 40.254/kg, diikuti metal hydride sebesar IDR 45.247/kg, compressed hydrogen sebesar IDR 54.926/kg, amonia sebesar IDR 165.434/kg, dan liquid hydrogen sebesar IDR 189.658/kg. Namun efisiensi penyimpanan liquid organic hydrogen carrier hanya bernilai 8,71%, metal hydride bernilai 7,66%, dan amonia bernilai 33,49%. Hasilnya menunjukkan bahwa baik LOHC ataupun metal hydride memiliki tingkat kematangan teknologi yang baik.
.....The world's energy industries contribute 87% to the increase in global greenhouse gases. To reduce global greenhouse gas emissions, hydrogen as clean energy is an alternative energy source with a gravimetric energy density of 120 MJ/kg and a volumetric density of 0.0824 kg/m3. The main challenge of hydrogen as an energy carrier is its low volumetric density, thus requiring hydrogen storage technology at higher volumetric densities. Hydrogen storage systems are crucial to the hydrogen supply chain process, especially in terms of its economics. The hydrogen storage system consists of hydrogenation, transportation, and dehydrogenation processes. This paper uses the techno-economic analysis of five types of hydrogen storage technologies: compressed hydrogen, liquid Hydrogen, liquid organic hydrogen carrier, metal hydride, and ammonia. Hysys was introduced to help process design, process modeling, and equipment sizing of each technology. System costs (IDR/kg) are determined based on projected Capital Expenditure (CapEx) and Operational expenditure (OpEx) of each hydrogenation and dehydrogenation process, as well as shipping transportation cost at 2000 km. The results show that liquid organic hydrogen carrier had the lowest system cost of IDR 40.254,65/kg, followed by metal hydride at IDR 45.247,35/kg, compressed hydrogen at IDR 54.926,27/kg, ammonia at IDR 165.434,6/kg, and liquid hydrogen at IDR 189.658,25/kg. However, the storage efficiency of liquid organic hydrogen carriers is only 8.71%, metal hydride 7,66%, and ammonia 33,49%. The results show that both LOHC and metal hydride have better technological maturity.