World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:12, No:01, 2018

Li-Ion Batteries vs. Synthetic Natural Gas: A Life Cycle Analysis Study on Sustainable Mobility

Authors : Guido Lorenzi, Massimo Santarelli, Carlos Augusto Santos Silva

Abstract : The growth of non-dispatchable renewable energy sources in the European electricity generation mix is promoting the research of technically feasible and cost-effective solutions to make use of the excess energy, produced when the demand is low. The increasing intermittent renewable capacity is becoming a challenge to face especially in Europe, where some countries have shares of wind and solar on the total electricity produced in 2015 higher than 20%, with Denmark around 40%. However, other consumption sectors (mainly transportation) are still considerably relying on fossil fuels, with a slow transition to other forms of energy. Among the opportunities for different mobility concepts, electric (EV) and biofuel-powered vehicles (BPV) are the options that currently appear more promising. The EVs are targeting mainly the light duty users because of their zero (Full electric) or reduced (Hybrid) local emissions, while the BPVs encourage the use of alternative resources with the same technologies (thermal engines) used so far. The batteries which are applied to EVs are based on ions of Lithium because of their overall good performance in energy density, safety, cost and temperature performance. Biofuels, instead, can be various and the major difference is in their physical state (liquid or gaseous). In this study gaseous biofuels are considered and, more specifically, Synthetic Natural Gas (SNG) produced through a process of Power-to-Gas consisting in an electrochemical upgrade (with Solid Oxide Electrolyzers) of biogas with CO2 recycling. The latter process combines a first stage of electrolysis, where syngas is produced, and a second stage of methanation in which the product gas is turned into methane and then made available for consumption. A techno-economic comparison between the two alternatives is possible, but it does not capture all the different aspects involved in the two routes for the promotion of a more sustainable mobility. For this reason, a more comprehensive methodology, i.e. Life Cycle Assessment, is adopted to describe the environmental implications of using excess electricity (directly or indirectly) for new vehicle fleets. The functional unit of the study is 1 km and the two options are compared in terms of overall CO2 emissions, both considering Cradle to Gate and Cradle to Grave boundaries. Showing how production and disposal of materials affect the environmental performance of the analyzed routes is useful to broaden the perspective on the impacts that different technologies produce, in addition to what is emitted during the operational life. In particular, this applies to batteries for which the decommissioning phase has a larger impact on the environmental balance compared to electrolyzers. The lower (more than one order of magnitude) energy density of Li-ion batteries compared to SNG implies that for the same amount of energy used, more material resources are needed to obtain the same effect. The comparison is performed in an energy system that simulates the Western European one, in order to assess which of the two solutions is more suitable to lead the de-fossilization of the transport sector with the least resource depletion and the mildest consequences for the ecosystem.

Keywords : electrical energy storage, electric vehicles, power-to-gas, life cycle assessment
Conference Title : ICEIMRE 2018 : International Conference on Energy Industry, Markets and Renewable Energy
Conference Location : Sydney, Australia
Conference Dates : January 29-30, 2018