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Proton Exchange Membrane Fuel Cell Systems – A Techno Economic Analysis

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Summary

The problems of toxic emission and resource depletion caused by economic activity are leading to technology changes which will affect the industry energetically and logistically. The power industry has efficiently lowered the dependence from oil by diversifying its fuels : nuclear energy and renewable sources. Traditionally a public industry, utilities are today undergoing structural changes, enhanced by legislative de-regulation but also by stringent emissions and efficiency targets. The car industry is much more oil-captive. Efforts to reduce the emissions are the major driver of research for alternative vehicles – e.g. gas, hybrid and electric. National, regional and municipal emission monitoring are leading to the establishment of programs for pollution reduction, an exemple is the California Air Resource Board (CARB) mandate requiring Zero Emission Vehicles (ZEV) in the coming years. Besides the possibility of powering electric vehicles, the Fuel Cell (FC) technology is also relevant for the energy sector, whereas the commercialisation of silent, high-efficiency packaged power stations (below the MW_{el} size) has begun. The FC are Ultra Low Emission electrochemical engines when they operate on fossil fuels and Zero Emission when pure hydrogen is fed, so that in the case of hydrogen produced through renewable energy sources, i.e. solar, hydroelectric, biomass, there is no emission on the whole fuel cycle. The particular features of the Proton Exchance Membrane Fuel Cell (PEMFC), reported in the study, are likely to enable this FC technology to enter both the electricity and transportation markets. This requires industrial synergies to overcome technological and economical (mostly logistical) bottlenecks. There are three tasks of the present study : a) literature review about hydrogen energy development and more specifically assess the PEMFC status, this is the primary objective of the present work ; b) technical analysis of PEMFC systems to identify the commercialisation pre-requisites, which demanded an interdisciplinary approach to englobe the different domains of the FC technology and solve the major problem : system integration ; c) economic estimates for the subsystem components (fuel processor, H_2 purifier, FC, inverter) : while some are at the laboratory stage, needing to be perfected, others, even if reliable, are practically hand-made. These characteristics of a technology in a pre-commercialisation stage are quantified to expected capital investment and electricity cost for two PEMFC systems. The study results indicate that although the cost of electricity is still too high to compete with conventional systems, i.e. motors and turbines, in the small Combined Heath and Power (CHP) market segment, the PEMFC are expected to advance very fastly on their learning courve and the world's major companies involvement in the technology - reported in detail – is proof of it.