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Review Article

Development of design a drop-in hydrogen fueling station to support the early market buildout of hydrogen infrastructure

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ABSTRACT

This paper provides a design of a drop-in hydrogen fueling station. Drop-in stations are expected to be an important factor in the introduction of hydrogen fueling infrastructure. The stations not only allows a streamlined introduction of hydrogen in the vehicle fueling infrastructure, but also, acts as mini pilot plants that can allow for detailed control studies. The effect of the location and availability of utilities, the closeness to residential area, unintended safety concerns, people outlook towards hydrogen, etc. are some of the factors that can be readily studied with such drop-in stations. The proposed design of a drop-in station mainly considers off-the-shelf items and is conceptualized to be implemented at the Missouri University of Science and Technology. The modular design approach, with the off-the-shelf items allows for a design with the capability of mass production, and ease in transport and integration.

Contents

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Introduction

According to the International Energy Outlook 2013, released by the U.S. Energy Information Administration (EIA), worldwide energy-related carbon dioxide emissions will rise from about 31 billion metric tons in 2010 to 36 billion metric tons in 2020. The carbon dioxide emissions will further grow to 45 billion metric tons by 2040, resulting in a total of 46 percent increase [1]. One of the major contributors to the emissions will be in the exhaust gases released from the vehicles. Therefore, it can be said that by employing *zero-carbon print* vehicle fuel a significant change can be observed in the carbon-dioxide emission levels. Research in the area of alternative fuels, renewable and nonrenewable, has demonstrated its applicability in the vehicle power train section, however, in a laboratory environment. With the available research findings, and considering the need of time, steps have to be taken towards the development of a fueling infrastructure. From the available alternative fuels, hydrogen has shown tremendous potential. Hydrogen not only provides cleaner energy, but also, is easy to transport, allowing centralized production, mimicking a gasoline fueling infrastructure [2]. In order to prove the market potential of hydrogen, and test the business case, mobile drop-in units have been an ideal mode of the introduction of hydrogen fueling infrastructure. This paper provides a design of such a drop-in hydrogen fueling station.

Zerta et al. [3] emphasized the importance of hydrogen in changing the global energy landscape. While, solar and wind power solutions maybe considered as an ideal energy resource, their intermittent nature of availability does not assist in fulfilling the continuous power need. Alternatively, the power obtained from solar and wind energy solutions can be utilized to generate hydrogen, using water, through the process of electrolysis. Hydrogen being an energy carrier can be readily stored and utilized to generate electricity, as and when required. Such a flexibility of hydrogen energy, coupled with the improving fuel cell technologies, has launched hydrogen energy as an important factor in the field of alternative energy technology. Currently, most of the hydrogen is produced using natural gas, with almost all of it used at the production facility itself. Utilizing natural gas for further production of hydrogen would, therefore, require an increase in the availability of natural gas. As an alternative researchers have been developing technologies that can utilize locally available feedstock for the production of biogas, which can then be used to produced hydrogen, heat and power with a combined heat, hydrogen and power (CHHP) units [4]. Bartels et al. [5] showed that hydrogen production from biomass is a promising option, even though the current most economical sources of hydrogen come from coal and natural gas units. The authors mention that the hydrogen production from alternative fuels, e.g. biomass, may become economically viable in the future due to the increasing feedstock costs of traditional fossil power plants, technology developments and decreasing cost of alternative energy technology. Ali and Salman [6] provide a comprehensive review of the fuel cell technologies and the current state of the art of the hydrogen energy economy. Becker et al. [7] report that the solid oxide fuel cell (SOFC) combined heat, hydrogen and power (CHHP) systems are capable of an electrical efficiency of 48.4%, and an overall efficiency of 85.2%. This is a significant improvement over the existing technology and has higher energy efficiency and lower emissions for the amount of power generated.

Although hydrogen energy has shown such good potential at the research level, its implementation at the customer end has been rather scarce. Williams and Kurani [8] discuss the commercialization of the light duty hydrogen fuel cell vehicles