FEASIBILITY OF HYDROGEN ENERGY PRODUCTION THROUGH NATURAL GAS STEAM REFORMATION PROCESS IN UAE

Ayoub Kazim*
United Arab Emirates University
Department of Mechanical Engineering
P.O. Box 17555 Al-Ain, U.A.E.

Introduction

Energy Information Administration, EIA estimated that the natural gas reserves of the United Arab Emirates (UAE) are approximately 224.9 X 10^9 GJ, which is considered world's fourth-largest natural gas reserves After Russia, Iran and Qatar. Over 90% of UAE's reserves of natural gas are in the emirate of Abu Dhabi, which has been supplying Japan most of its liquefied natural gas (LNG) since 1977 [1]. In order to fulfill the rapid demand of natural gas in the energy market, UAE has embarked major NG-intensive projects, specially the multi-billion $US Dollars Dolphin project, which interconnects pipelines between Qatar, UAE and Oman and with possible links to Indian subcontinent [2].

Many scientists and energy policy makers believe that hydrogen energy, which possesses significant characteristics such as being environmentally clean, storable, transportable and inexhaustible, could play a key role in fulfilling the global energy demand and without any negative environmental impacts. Presently, utilization of hydrogen energy to run fuel cells for a clean power generation has gained worldwide attention. Fuel cells especially proton exchange membrane fuel cells (PEMFC) have been playing a significant role in industrial, utilities and transportation sectors of many developed countries. Production of hydrogen can be achieved through either utilizing conventional or renewable resources. However, Hydrogen produced from natural gas steam-reformation process, is considered to be the most common and cost effective hydrogen producing method [3].

The objective of the current study is to conduct a feasibility study of hydrogen energy production through natural gas steam-reformation process in the UAE. The analysis will be performed at various scenarios (%) of natural gas to be used in hydrogen production through steam reforming process. Moreover, the total cost of hydrogen produced by 10% of NG as well as the total amount and cost of carbon emitted by natural gas steam-reformation are to be compared against other fossil fuels and hydrogen producing methods.

Results and discussion

In Figure 1, a cost breakdown was conducted on hydrogen production at NG utilization rate of 10%, 50% and 100% of the country's present NG production. Clearly, the higher the utilization rate of natural gas (%), the more cost effective hydrogen is produced and stored. For instance, at 100% utilization of NG, the capital cost of NG steam reforming plant would be approximately $1.4/GJ, which is 50% less than 10% of utilized NG. Similarly, the operation and maintenance cost (O&M) and compression and storage cost of hydrogen at 100% NG utilization would be $0.265/GJ and $0.45/GJ, respectively. These values are estimated to be 60% and 45% less than hydrogen produced at 10% NG utilization. In general, the total cost of hydrogen produced at 100% NG utilization would be approximately $6.15/GJ, which is 25% less than at 10% NG utilization if an average cost of natural gas is set to be $4/GJ [4].

Cost of hydrogen produced by 10% of NG steam reforming is considered to be more attractive than hydrogen produced by biomass gasification or by solar-hydrogen or wind-hydrogen methods as depicted in Figure 2. However, the capital cost of NG steam-reforming plant is $1.225/GJ more than biomass gasification plant, which is $1.45/GJ. Nevertheless, the capital cost of NG steam-reforming plant is 3 times less than the capital cost of solar-hydrogen or wind-hydrogen plants. Furthermore, utilization of renewable resources (solar and wind) requires electrolysers, which could add more to the total cost of hydrogen. An average cost of solar-PV assisted electrolyser would be about $3.9/GJ of hydrogen produced. And, the average cost of wind-power assisted electrolyser would be about $5.5/GJ of hydrogen produced. The total cost of hydrogen produced by 10% of NG is $8.2/GJ, which is 10% less than hydrogen produced through biomass gasification. Moreover, the total

* Fax +971-3-7623-158 E-mail: akazim@uaeu.ac.ae

cost of hydrogen produced by 10% of NG is 45% and 57% less than solar-hydrogen and wind-hydrogen energy systems, respectively.

The total cost of solar-hydrogen and wind-hydrogen are considered to be far more than other hydrogen energy producing methods even though they do not contribute any negative-environmental effects as depicted in Figure 3. The total amount and cost of carbon emitted by natural gas steam-reformation are estimated to be 48 kg-CO_2/GJ and \$6.7/GJ, respectively. These figures are regarded to be the least among other fossil fuels and hydrogen producing methods. Conversely, the total amount and cost of carbon emitted by coal gasification to produce synthetic fuels are approximately 145 kg-CO_2/GJ and \$20/GJ, respectively. Definitely, these figures represent the highest among other fossil fuels and hydrogen producing methods. The carbon emission cost presented in our study is based on \$140/tonne-CO_2, which could be set to reach the limit agreed in Kyoto-protocol. This value is more reasonable than the value suggested by the EPA of \$14/tonne-CO_2 [5].

Conclusion

With the country's substantial potential of natural gas reserves, hydrogen could be produced at an economical rate of at least \$6.15/GJ based on 100% of NG utilization. This rate is 25% less than hydrogen produced at a more conservative rate of 10% NG taking into consideration the average cost of natural gas of \$4/GJ. Nevertheless, the cost of hydrogen produced at a 10% of NG is more attractive than any other hydrogen producing methods. Furthermore, the total amount and cost of carbon emitted by natural gas steam-reformation are estimated to be 48 kg-CO_2/GJ and \$6.7/GJ, respectively. These values were considered to be more favorable in comparison with other fossil fuels and hydrogen producing methods.

References

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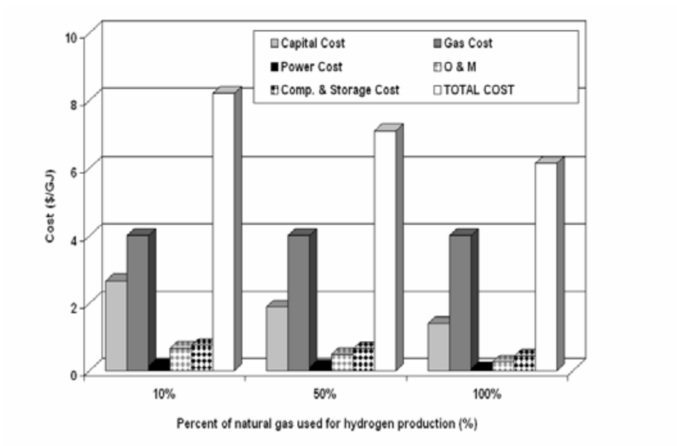

Figure 1: Cost breakdown of hydrogen production at various percentages of current production of natural gas.

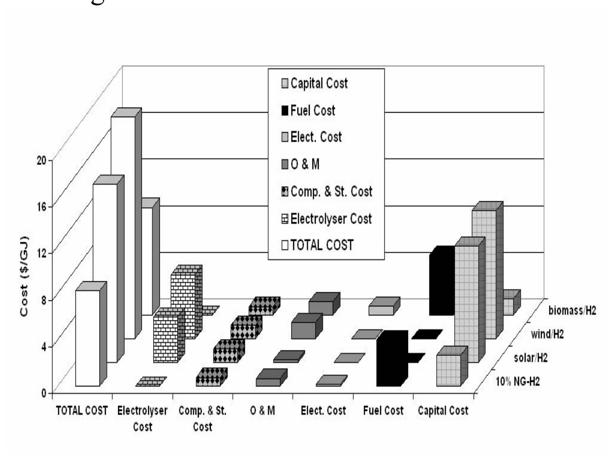

Figure 2: Cost comparison between hydrogen production by 10 % NG at current production and other types of hydrogen producing methods.

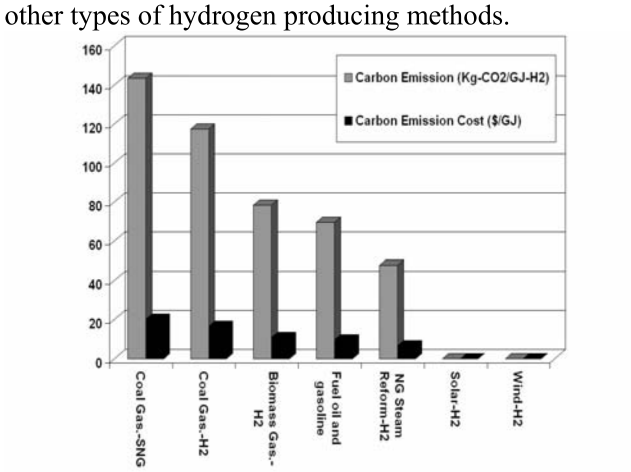

Figure 3: Amount and cost of carbon emission from various types of energy producing methods.