Hydrogen-Wind-Nuclear Plant in Ontario Not Currently Worthwhile, Study Shows

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A recent case study on using hydrogen to store the electricity generated by a mix of wind and nuclear power in Ontario, Canada, has shown that the hydrogen addition won't be worth the cost, at least not at the current state of hydrogen technology development.

Bruce Power – Canada's first private nuclear generating company – is considering including a hydrogen storage and distribution component to go along with a large scale wind farm, all presently sharing the main electrical transmission line in Bruce County, Ontario.

The province's first commercial wind farm, Huron Wind, is located on the shore of Lake Huron. Its five wind turbines provide a maximum output power of 9 MW. Additional large scale wind farms are located close by, using the same transmission lines.

Bruce Power's nuclear power plant, located about 250 km northwest of Toronto, consists of six reactors. Together, the reactors generate a total output power of 4,830 MW, which supplies more than 20% of Ontario's electricity.

Using hydrogen as a storage and distribution method for the electricity generated by the wind farm and nuclear plant from the same region could have several potential benefits. When the cost of electricity is low, for example, the company could store part of its electricity production as hydrogen, and then sell it back to the electricity market when the price increases. Similarly, electricity could be stored as hydrogen when there is not enough line capacity to transfer it all at once. In periods of low winds, hydrogen storage could help make up for the variability and in periods of high winds and constrained transmission capacities, hydrogen could be used to store the electricity. In the future, the hydrogen itself could be sold to a hydrogen market, which could be more profitable than selling it back to the electricity market.

However, costs of the initial investment, production, and operation won't be matched by the profit solely from storing electricity as hydrogen, according to the study by Gregor Taljan and Gregor Verbič from the University of Ljubljana, Slovenia, and Claudio Cañizares and Michael Fowler from the University of Waterloo, Ontario.

Even with an optimistic hydrogen production efficiency of 60% through electrolysis, the researchers' evaluation shows that the electricity stored as hydrogen would need to be sold to the electricity market at a high price that rarely happens in order for the scheme to be profitable. As the researchers demonstrate, the selling price of electricity would need to be about four times the buying electricity price for the hydrogen system to profit from storing electricity.

"This study is very important from the viewpoint of finding synergies between electrical energy and chemical energy stored in hydrogen," Taljan told *PhysOrg.com*. "The study shows that currently, hydrogen is not profitable solely for electricity storage. On the other hand, it might be economically acceptable to produce hydrogen from electricity at advantageous electricity/hydrogen prices. Furthermore, hydrogen is shown to be a highly favorable option when there are electricity transmission constraints in the area, limiting sales of electricity of a power producer."

As the researchers explain, hydrogen storage might be an economically feasible option for storing electricity in times of insufficient electricity transmission line capacities, which would otherwise be dumped. This could be especially true in cases where the upgrade of transmission systems is not an option due to various reasons (such as remote location, resistance of local population, etc.).

The study also showed that a hydrogen sub-system for producing hydrogen could be profitable if there is sufficient hydrogen demand. For instance, transportation applications (such as cars, trains, and planes) could provide a market for buying hydrogen produced by a mixed wind-nuclear plant.

“Hydrogen production might become profitable when the Hydrogen Economy becomes fully mature, i.e. when the demand, and correspondingly prices, for hydrogen increases (expected mainly from the transportation sector),” Taljan said. “This might happen when the prices of fossil fuels rise as a result of many different possible factors (e.g. shrinking reserves, higher demand, political instabilities, CO_2 emissions trading schemes). In this scenario, hydrogen might become a real fossil fuel substitute option which will drive up the hydrogen demand and prices, making the hydrogen production a lucrative business.

“In this context, it is also important that research into hydrogen production, storage, transmission, distribution and consumption components ‘wins the battle’ with the electron economy, where the energy carrier is considered to be electricity. Those two economies compete in many different areas, such as efficiencies, durability, and prices. Currently, hydrogen is advantageous in terms of higher energy density and durability but still lags in efficiencies.”

The team’s investigation into the feasibility of hydrogen is further elaborated in two other recent studies. “Hydrogen storage for mixed wind–nuclear power plants in the context of a Hydrogen Economy,” which is published in the International Journal of Hydrogen Energy, deals with how the excess oxygen and heat utilizations would improve the economics of hydrogen systems primarily designed for storing of electricity.

The second study, "Study of Mixed Wind-Nuclear-Hydrogen Power Plants," which is going to be presented at this year's North American Power Symposium in Calgary, demonstrates that hydrogen is not economically feasible for the sole purpose of storing electricity, in spite of residual heat and oxygen utilization, and based on current hydrogen production and utilization technologies.

More information: Taljan, Gregor; Cañizares, Claudio; Fowler, Michael; and Verbič, Gregor. "The Feasibility of Hydrogen Storage for Mixed Wind-Nuclear Power Plants." *IEEE Transactions on Power Systems*, Vol. 23, Issue 3, August 2008.