A feasibility study of the Superwind concept; Integrating wind turbines with internal reforming fuel cells for hydrogen and power co-production

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It is well known that renewable energy sources, especially wind energy (and solar energy) have a fluctuating character, which makes it difficult to match with practical demand. The often proposed solution for this problem is the conversion of the surplus of wind energy into hydrogen by means of electrolysis. The Superwind concept offers a more efficient alternative for integrating wind energy into the grid. It consists in the integration of a wind turbine with an internal-reforming fuel cell (MCFC or SOFC). The fuel cell is fueled by natural gas or preferably biogas for increased sustainability of the total concept. The fuel cell can convert that gas internally into hydrogen for its own consumption – the electrochemical conversion of hydrogen into electric power -, while simultaneously a controllable amount of surplus hydrogen can be delivered to the output.
The main advantage of this multi-source multi output system lies in its high degree of flexibility. Peaks in wind energy production can be compensated by a decrease in electricity production from the fuel cell. It should be emphasized that in the Superwind concept no wind energy is converted into hydrogen. But instead all electricity from the wind turbine is directly supplied to the grid more or less complemented by electricity (and hydrogen and heat) from the fuel cell.
Contrary to other electricity production units the fuel cell does not stand idle when compensating for peaks in wind energy, but instead will be producing hydrogen. Moreover, this system is also been considered as a tool towards the development of a hydrogen infrastructure.

In this paper we will evaluate the feasibility of the Superwind concept. To do so the technical feasibility of both SOFC and MCFC is being investigated using flow sheet calculations. The economic feasibility of the concept is limited by the high cost of the fuel cell installation. In this paper we will thus present conditions under which the system would become economically attractive. These are dependent on hydrogen price, natural gas (or biogas) price, use of waste heat, cost of the fuel cell installation, the specific market strategy/contracts of the wind turbine owner, and governmental policies. Moreover, the proof-of-concept demonstration which is momentarily being developed in Nij Bosma Zathe, the Netherlands, is also discussed.

Finally, the paper also discusses the opportunities, conditions, current innovation, and social dynamics for initiating and facilitating such strategic niche experiments in the Netherlands.