Advantages of HTPEMFC over LTPEMFC

The HTPEMFC system developed by Serenergy is the first commercially available, low pressure, air-cooled HTPEMFC system in the world. There are 8 major advantages of Serenergy's HTPEMFC versus commonly available LTPEMFC:

1) **No humidifier.** There is no need for a humidifier due to the composition of the Membrane Electrode Assembly (MEA) which results in a simpler, cheaper and more reliable system.

2) **No compressor.** There is no liquid water in a HTPEM MEA and therefore there is no need for a compressor. This further reduces system complexity, cost and noise level while greatly increasing system efficiency.

3) **No radiator.** Due to the high operating temperature, heat can easily be removed from the system. There is no need for a liquid cooling loop. Assuming an ambient temperature of 40°C, a LTPEMFC operating temperature of 70°C and a HTPEMFC operating temperature of 160°C, then one has a Δt of 30°C for the LTPEM system compared to a Δt of 120°C for the HTPEMFC. The Δt of a HTPEMFC is therefore 400% more than for the LTPEMFC. The result is that there is no need for a complicated, bulky and expensive liquid cooling system. A simple, small and inexpensive fan can be used for cooling instead. The parasitic loss from the fan reaches a maximum of 3.5 %.

4) **Patented bipolar plates.** The flow-field patent (DK200701063, WO2009010067) ensures minimal temperature difference over the bipolar plate (<15°C). This relatively homogeneous temperature distribution results in prolonged lifetime, higher efficiency, greater power density and an easily controllable system. Moreover, it significantly reduces cathode/cooling pressure loss, directly reducing parasitic power consumption from the blowers.

5) **High system efficiency.** As a result of points 1–4 a very simple fuel cell system has been developed. The Serenergy system uses less than 4% for this base purpose, making this the system with the lowest parasitic power consumption searchable. We term it The Power of Simplicity. Partly due to the low parasitic losses we have achieved system efficiencies of up to 57%. Most fuel cell systems have an energy usage of approximately 10-20% of the output, just to achieve operational status. The best LTPEMFC systems have parasitic losses of 6– 8%, but parasitic loss exceeding 10% are common.

6) **Low system cost.** As a result of point 1 – 4 the systems are built using a very simple internal architecture reducing the Balance Of Plants (BOP) cost to approximately 25% of the fuel cell stack cost. This is achieved by eliminating a number of traditionally used components such as humidifiers, pumps, compressors and radiators. The fuel cell itself only requires a single air-fan, similar to those used to cool CPUs in computers. For LTPEMFC BOP components may cost up to 200% of fuel cell stack costs.

7) **Easier to control.** Since HTPEMFC can be operated over a broader operating window temperature-wise (compared to LTPEMFC) it is far easier to control than a LTPEMFC.

8) **Easier to utilize the heat.** In order to utilize waste-heat two requirements must be met:

a) The waste-heat needs to be of high quality, (meaning that is has to be hot). Waste-heat from a HT-PEMFC (~155 °C) is by definition of a higher quality than waste-heat from a LTPEMFC (~ 70 °C).

b) The waste heat needs to be concentrated in a usable directional stream. In Serenergy's case more than 90 % of the waste-heat leaves the system through the exhaust-pipe and is therefore easy to utilize.

Since the waste heat in Serenergy's systems is of a high quality and is contained in a usable directional stream it is easy, cheap and simple to recover some, or most, of the waste-heat using air-to-air or air-to-liquid heat exchangers.

There are 2 major advantages of Serenergy's HTPEMFC versus commonly available LTPEMFC with respect to fuel:

9) **Highly tolerant to CO.** Due to the higher temperatures, hydrogen with a high CO concentration can be used. This makes it possible to directly use hydrogen reformate, originating from cheap, and easy to handle energy-carriers such as methanol, ethanol, diesel etc. The HTPEMFC can tolerate up to 3 % (30,000 ppm) CO and up to 20 ppm of sulphur without permanent degradation. In comparison, LTPEMFC normally can tolerate less than 30 ppm CO and less than 1 ppm of Sulphur. This is a factor of 1,000 difference in CO tolerance. Because of the high operating temperature, a PrOx reactor is normally not necessary. PrOx reactors are expensive, bulky and significantly lower the system efficiency. The result is that very simple, lightweight and inexpensive reformers can be used to produce hydrogen from a broad range of energy-carriers including the choices listed above.

10) **Fuel evaporation.** The waste-heat from the fuel cell can be employed to evaporate liquid-energy-carriers which boil at a temperature lower than the operating temperature of the fuel cell. Ensuring tight integration between endo- and exothermal processes greatly increases overall system efficiency.