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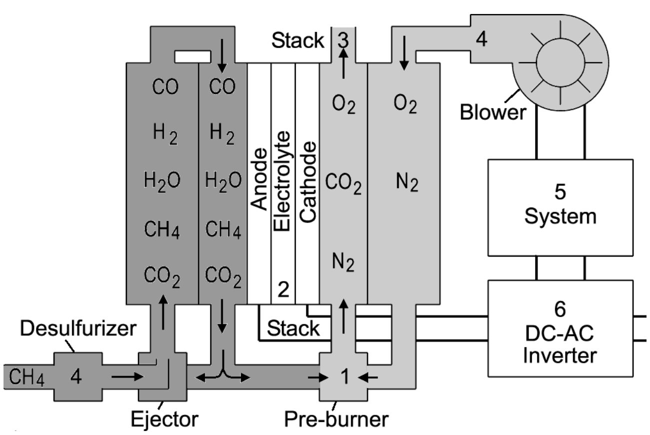
Fuel Cells for Electric Power Production

There is a rapid trend in North America to deregulate the production of electric power. One of the benefits of deregulation is that it will promote CHP (combined heat and power) powerplants. North America will likely generate much of it's electricity by burning fossil fuel at least for the next several decades. CHP will conserve fuel by utilizing the heat that is produced as a result of generating electricity. Because heat can not be piped efficiently for long distances CHP powerplants will generally need to be much smaller than the present ones which are often around 200,000 kw.

Presently new large powerplants generally use gas turbines. Contrary to popular opinion, these gas turbines (with addition of heat exchanging or steam turbines) can be highly efficient in the large sizes and produce little pollution. The latest are 57% efficient in converting fuel to electricity (all efficiencies based on lhv of fuel). In the future, ceramic gas turbines could reach 70% efficiency. Unfortunately very small gas turbines are not nearly as efficient. Present microturbines in the 30 kw range are only about 25% efficient even when heat exchanging is employed though future ceramic microturbines in this size may achieve 35% efficiency.

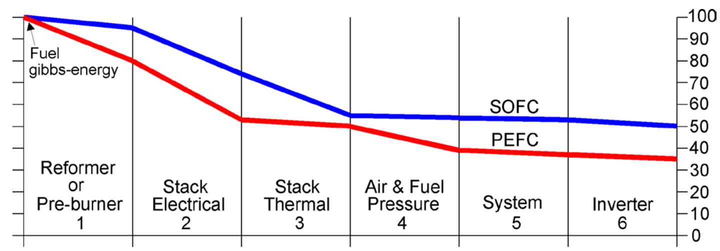
Fuel cells, which can convert chemical energy directly into electricity, will likely be the favored technology of the future for small electric power production. Not only do they produce reasonable efficiencies in 30 kw sizes, they will likely be able to run quietly, need infrequent maintenance, emit little pollution and have high efficiency even at part load conditions. There are two types of fuel cells that will likely be the major contenders in the deregulated marketplace. The first is the polymer electrolyte fuel cell or PEFC and the second is the solid oxide fuel cell or SOFC. Though there are numerous worldwide companies working on both of these technologies, two Canadian companies are in fact doing leading edge development and are proposing to use their fuel cells both for powering automobiles, buses etc. as well as for electric power production. Global Thermoelectric in Calgary Alberta is developing the SOFC and Ballard Technologies of Burnaby BC is developing the PEFC.



Simple type SOFC suitable for 1-30 kw powerplants

The Global SOFC runs at a red hot temperature of 800°C and so must be made of ceramic materials. At this temperature the chemical reactions are good and neither exotic catalysts or air pressurization are required. A liquid cooling system is not required. In fact insulation is required to maintain the cell temperature. The SOFC can readily use many common hydrocarbons fuels such as natural gas, diesel, gasoline, alcohol and coal gas. It can reform these fuels into hydrogen and carbon monoxide inside the cell. Both hydrogen and carbon monoxide are used in the cell. It does not produce any power below 650°C and so a few minutes of fuel burning is required to reach operating temperature. Small 30 kw powerplants will likely be 50% fuel to electricity efficient, 200 kw units 60% and large one's over 70%.

The Ballard PEFC runs at a modest 80°C. It is particular in that only hydrogen fuel can be used in the cell. Hydrocarbon fuels must be reformed carefully. Even small amounts of carbon monoxide in the cell can poison the catalyst permanently. A two stage liquid cooling system using first very pure water, then antifreeze is required. Larger than 1 kw PEFC are generally pressurized to increase the chemical reaction at the low temperatures involved. A catalyst is also required. This type of fuel cell was chosen for automotive applications because the cell produces reasonable power even at ambient temperatures. The reformer requires a few minutes warmup time however. Stored hydrogen can be used in the startup phase. Small 30 kw powerplants will be 35% fuel to electricity efficient, 200 kw units 40% and large one's over 45%.



Exergic-energy loss diagram for 30 kw SOFC vs PEFC powerplants

It appears that the SOFC will be about 1.4 times more efficient than the PEFC. Because electric powerplants run continuously, the savings in fuel compared to the PEFC are considerable. This is why most experts consider the SOFC the most likely contender for the CHP market. The exergy or exergic-energy loss diagram illustrates why the SOFC is generally more efficient than the PEFC when running on hydrocarbon fuel. One reason is that the SOFC has less losses in the reformer. This is because much of the fuel is reformed in the cell. High temperature byproduct thermal-energy of the cell is actually added to the reformed fuel. Because the PEFC has a lower cell temperature this is not possible. Another reason is that the SOFC has less air pressurization losses. It only uses a low pressure blower to drive air through the cell. The PEFC runs at a high air pressure. In a small 30 kw powerplant this pressure-energy can not be readily recovered.

Ben Wiens is an energy consultant in Coquitlam BC. He a former employee of Ballard. Originally there was no intention to promote Global but it should be mentioned that he bought shares in the company during the research for this article. For more information on energy conversion go to www.benwiens.com