BLOOM ENERGY FOR PRODUCING ELECTRICITY

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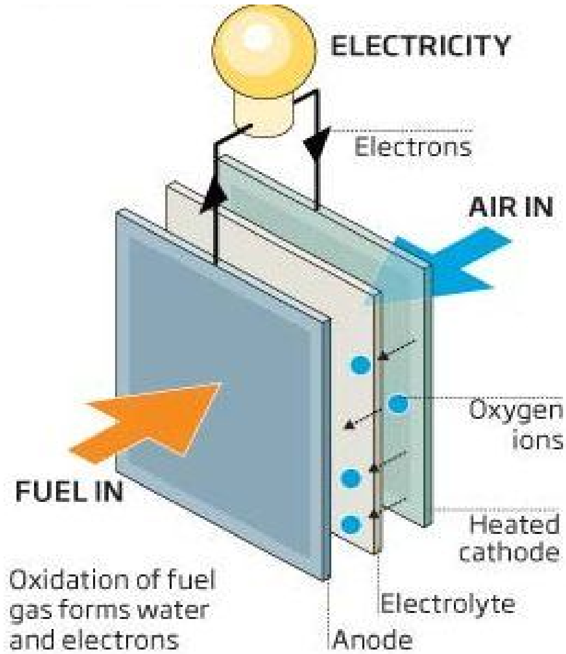
Abstract: The primary purpose of this paper is to examine the technical implications of the Bloom Box fuel cell. Secondly the report evaluates the Bloom Box as a potential electricity source for homes and private businesses based on the economic advantage that it may provide. It also compares the Bloom Box to other off grid electricity options. Lastly, based on the compiled data, the report provides a group opinion of the Bloom Box's potential.

Keywords: *Bloom energy, Bloom box, Bloom box fuel cell, SOFC,*

1. INTRODUCTION

The most prominent modern application of the solid oxide fuel cells is the "Bloom Box" whose history stems from Dr. K. R. Sridhar's research group for the NASA Mars exploration program. The group was looking to develop a sustainable, yet efficient, energy source at the Space Technologies Laboratory at the University of Arizona, but later moved on to form the current company, Bloom Energy in 2001-2002, after securing funding from a few venture capital firms (Bloom Energy Website, 2010). The latest Bloom Box model, the Bloom Energy ES-5000 which can intake natural gas, hydrogen, or even garbage dump gas costs $700,000-800,000 (Bloomberg, 2010). It is capable of generating 100kW, enough electricity for approximately 100 homes. Since its entrance into the market in July 2008, it has been bought several Fortune 500 firms including Google, Staples, Wal-Mart, FedEx, Coca-Cola, and Bank of America. Its proven reliability and economic efficiency has been shown in eBay's decision to use this SOFC fuel source in generating 15% of the electricity consumed in its main San Jose, California headquarters (Christian Science Monitor, 2010). Such widespread use of this product is no mistake as it is highly economical, generating electricity at 8 to 10 cents a kilowatt hour, albeit with subsidies from the state of California, much lower than the usual commercial cost of electricity at 14 cents/kilowatt hour (New York Times, 2010). This seemingly miraculous technology does come with a few disadvantages and hurdles however. Besides the high upfront capital costs, solid oxide fuel cells also relies on extremely high operating temperatures, around 800-1000 degrees Celsius. As a result, Bloom Boxes may be vulnerable to breaking down if not managed and serviced properly. Furthermore, this technology requires a slow start up as it needs to heat up to the high operating temperature before being able to fully run (Scientific American, 2010). Most of the dangers of such a high operating temperature are harnessed, but it still causes some hindrances when it comes to efficient operation.

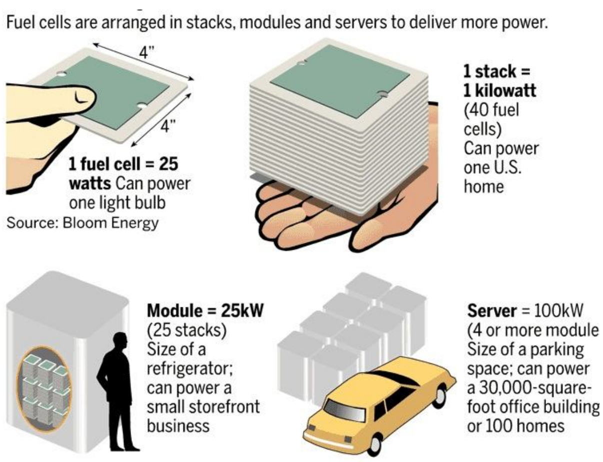


Fuel cells are devices that convert fuel into electricity through a clean electro-chemical process without any combustion. This conversion technique gives much higher conversion efficiencies than conventional thermo-mechanical methods. The operating principles of fuel cells are similar to those of batteries; i.e., includes an electro-chemical combination of reactants to generate electricity—a combination of a gaseous fuel (hydrogen) and an oxidant gas (oxygen from the air) through electrodes and via an ion-conducting electrolyte. However, unlike a battery, a fuel cell does not run down or require recharging. A fuel cell operates as long as both fuel and oxidant are supplied to the electrodes, and the influence it exerts on the surrounding environment is negligible.

2. SOLID OXCIDE FUEL CELL

A SOFC is a type of fuel cell valued for its potential market competitiveness, with high efficiency in fuel input and electricity output. A SOFC is like a rechargeable battery that always runs. It consists of three parts: an electrolyte, an anode, and a cathode. In Bloom's SOFC, the electrolyte is a solid ceramic square made from a common sand-like "powder.‖ According to Bloom's patent description, these thin white ceramic plates are Scandia stabilized Zirconia (ScSZ). The anode and cathode are made from special inks that coat the electrolyte on each side. One side of the ceramic electrolyte plate is coated with a green nickel oxide-based ink that works as an anode; the other side, which works as a cathode, is coated with black ink (most probably Lanthanum Strontium Manganite—a non-radioactive substance). The Bloom server does not require chemicals, such as the corrosive acids used in conventional fuel cells. Instead, it uses inexpensive metal alloy plates for electric conductance between the two ceramic fast-ion conductor plates, as opposed to the use of costly precious metals like Gold or Platinum that are used for high conductance in other fuel cells.

The electro-chemical process within SOFC requires a high operating temperature (600-10000C) for its reactions to take place. At a high temperature, warm air enters the cathode side of the fuel cell. The resulting steam mixes with the fuel to produce reformed fuel; this reformed fuel enters the anode side, and a chemical reaction takes place. As the reformed fuel crosses the anode side, it attracts oxygen ions from the cathode. Oxygen ions combine with the reformed fuel to produce electricity, water, and a small amount of carbon dioxide gas. Water is recycled into the cell to produce steam to generate reformed fuel, and this process also generates the heat required for the functioning of fuel cells. The continuous supply of fuel, air, and heat constantly generates the electricity from the cell.



Each Bloom Energy fuel cell is capable of producing about 25W of energy, which is enough to power a light bulb. For more power, multiple cells are mounted together, along with metal interconnect plates, to form a fuel cell stack. A few stacks together (about the size of a loaf of bread) are enough to power an average U.S. home. In an Energy Server multiple stacks are aggregated into a "power module"; and multiple power modules, along with a common fuel input and electrical output, are assembled as a complete system. When more power is required—for example, for commercial or industrial sites—multiple Energy Serve systems can be deployed side by side. The current Energy Server in the market has the capacity to generate 100kW of electricity, which would power a 30,000 sq. ft. office building or 100 average-sized U.S. homes.

3. CONCLUSIONS

The costs should come down over time to the point where Bloom boxes really can be used in homes. One potentially disruptive feature of the technology is that it works both ways: fuel can produce electricity, but it can also go the other way so that electricity produces fuel. Sridhar foresees the killer app for his technology becoming practical in about a decade: a Bloom home energy server combined with solar panels or some other renewable energy. The electricity from the solar panels could produce fuel, which can be used to produce electricity to power the house or even to gas up your (modified) car.

To determine the implications of the Bloom Energy Server as a whole, the individual aspects of the technical, economic, and social implications must be considered together. Additionally it needs to be compared to other equivalent renewable technologies.

From a technical standpoint the Bloom Box appears to perform as claimed. It contains some improvements to the basic SOFC design, and can achieve efficiencies higher than typical coal and natural gas power plants. As stated in the technical information section, Bloom Energy has some advantages over other fuel cell companies, primarily that they have been increasing their production rate over the past two years, and have a method to guarantee a continuous level of performance as the fuel cell ages. Going forward, other companies could easily have a better product than Bloom Energy.

When similar technologies are competing one variable that can determine the value of one product compared to another is the price. Price can not only be a determining factor in what product people buy but also who the product is available to. The cost of a 100 kW Bloom Box has been previously stated to be between $700,000 and $800,000. This initial price is much higher than that for an equivalent wind turbine installed which from one distributer costs 495 thousand dollars. This price is comparable to an equivalent installation of solar panels, which in 2005 cost the city of Oakland roughly 800 thousand dollar to have installed before any federal or state incentives. It is important to remember that a Bloom Box is able to produce constant electricity twenty four hours a day, seven days a week, unlike either solar or wind technologies. Although the Bloom Box costs significantly more, depending on a customer's particular needs it could certainly be a wiser investment than either 100 kW of wind or solar power.

On the other hand, a Bloom Box requires a constant supply of fuel, meaning it not only has a higher initial cost than wind, it also has an operating cost that is not present in either wind or solar electricity generation systems. In order to take this into account, the return on investment in each technology was considered. As previously discussed, the average ROI of an unsubsidized Bloom Box in California is slightly sooner than a wind turbine if run on natural gas, but much longer if it is being run on directed biogas. In both cases the unsubsidized Bloom Box has a better ROI than solar power. From a strictly monetary point of view, a Bloom Box appears to be the best option for commercial customers seeking to reduce their carbon footprint.

Another important economic aspect to consider when analyzing energy technologies is federal and state government subsidies. Applied subsidies can greatly reduce initial costs to the consumer allowing for much quicker ROI. As previously stated, subsidies allow a Bloom Box in California run on directed biogas to quickly save a customer money compared to all other analyzed technologies.

Since the Bloom Energy Corporation only sells their servers within the state of California and has not announced any plans to change this, it is rather difficult to suggest the Bloom Box monetarily to any companies outside of California. Companies that operate within the state of California, however, appear to have a product worth considering; assuming current subsidy levels remain in place.

Overall the Bloom Box has potential as an alternative energy source for businesses as long as the current levels of subsidies remain in place. Additionally the Bloom Electrons Service is an extremely beneficial program for consumers, but the economics of the current system do not seem profitable over the long term for Bloom Electrons, although it is providing Bloom Energy with an immediate profit. From a technical standpoint a Bloom Box seems to have an advantage over traditional generators if cost is not considered. It produces less noise and fewer pollutants than a traditional generator due to the fact that it operates at a higher efficiency. It has some advantages over alternative systems such as solar and wind generators, and in some cases is preferable to solar or wind systems. Although the Bloom Box still produces emissions when run on natural gas, it still appears advantageous over solar and wind systems in place. The carbon neutral nature of running a Bloom Box on biogas cannot be taken into account because of the current availability of biogas. The major question is if Bloom Energy can reduce the cost of a Bloom Box to a reasonable amount without the government subsidizing over 67% of the cost, which in turn is passed on to electricity companies (who pass the cost on to customers) and taxpayers. However considering the cost has remained static for the past two years despite improvements in production, and the recent suspension of state subsidies in California, the Bloom Box does not seem to be likely to have a significant impact without additional improvements to the technology.

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