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A Study on Bloom Energy

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Abstract: ***Bloom energy is changing the way the world generates and consumes energy. Our unique on site power generation systems utilize an innovative new fuel cell technology with routes in NASAs mars program. It is derived from common sand like powder and leveraging break through advancers in materials science. This technology is able to produce clean, reliable, affordable power practically anywhere from a wide range of renewable or traditional fuels. Bloom energy serves or provides the most efficient energy and the planet providing for significantly reduced electricity cost and dramatically lowers green house gas emissions. Generating power on site, where it is consumed, bloom energy offers increased electrical reliability and improved energy security providing a clear path to energy independence.***

Index-Terms: Bloom; fuel-cell; efficient-power; stack; module; server.

I. 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. Since its entrance into the market in July2008, it has been bought several Fortune 500 firms including Google, Staples, Wal-Mart, FedEx, Coca-Cola, and Bank of America.

WHAT IS BLOOM ENERGY??

Bloom energy is a company which started its production and developed bloom energy servers since 2002 and due to drawbacks after 10 years it is leading through its path now by having some international users like apple, NASA etc…and GOOGLE is the first user of bloom energy in the year 2008 with a capacity of 100kw. It's an environment clean form of energy and is also economical when compared to non-conventional energy sources like solar and wind.

This uses thin white ceramic plates that are made of beach sand. Each plate is coated with a green nickel oxide based ink on one side forming the anode and another black probably lanthanum, strontium and magnetite ink on the cathode side. According to the San Jose Mercury News blooms secret technology apparently lies in the proprietary green ink that acts the cathode. But, in fact these materials are widely known as SOFCs (solid oxide fuel cells).

1.1 SOURCE OF BLOOM ENERGY:

The main source of Bloom Energy is the Bloom box or the bloom server in which it contains a solid oxide fuel cell.

1.2 BLOOM BOX OR BLOOM SERVER:

It is a shiny box with solid oxide fuel cell made by bloom energy of Sunnyvale California. It can use a wide variety of inputs including liquid or gaseous hydro carbons produced by biological sources to generate energy on the site where it will be used.

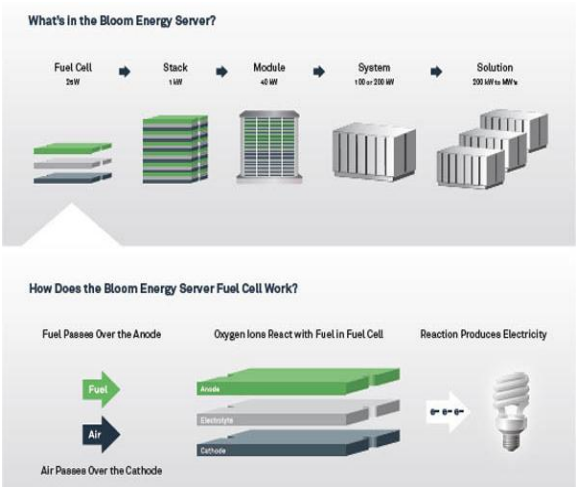

Fig.1. Bloom Box arrangement

It can withstand temperatures up to 1800F (980C). That would cause many other fuel cells to break down or require maintained. It is unlike usual batteries.

It generates electricity using fossil fuels, which works like a battery but has a persistence source of fuel such as natural gas to keep the electricity flowing. It requires only one conversion i.e. from chemical to electrical. Our paper shows how to produce reliable, flexible, less polluting and continuous supply of electric energy from a cheap material i.e. sand which is available in plenty.

Fig.2. Bloom energy server

Starting with its press debut on 60 Minutes in February 2010, Bloom Energy has been publicly promoting their Bloom Energy Server. The Bloom Energy Sever is a solid oxide fuel cell (SOFC) which converts the chemical energy of hydrogen into electrical energy. Bloom's energy servers are built by combining enough single ceramic plates with special inks on each side that serve as the anode and cathode. Each of these plates has been improved to produce about twenty five watts of power ("Alternative energy" 2010). The plates are stacked together until the total power produced is one hundred kilowatts. This means about 4000 plates have to be stacked together. The output from the fuel cell is naturally in the form of direct current (DC), but as most technology is built to run on alternating current (AC). The energy server comes with the necessary conversion to 480 volts three phase AC ("Es-5000 energy server," 2010). 480V is typically delivered on local transmission lines; a 4-to-1 transformer can be used to step down this voltage to 120V with minimal losses if needed. Bloom energy has made several claims regarding their fuel cell design progress that fixes some of the previous issues with fuel cell technology.

The reason that a constant water supply is not required is because a Bloom Box has anode gas recycling. This hydrogen is recycled back into the fuel cell system. The patent claims that without recycling, the fuel cell would only have an efficiency of 45%. If the system recycles 85% of the exhaust and uses 75% of the hydrogen per pass, then the fuel cell would have an AC electrical efficiency of 50% to 60%. However, all evidence available shows that Bloom has been unable to pass about 50% efficiency in the Bloom Box at the time of this report.

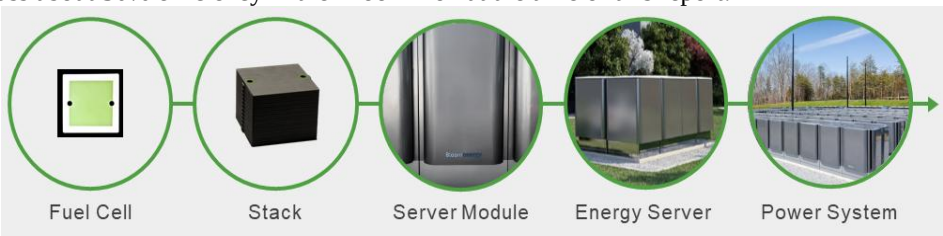

Fig.3. Bloom energy evaluation

Patent 7,704,617 was filed on April 2, 2007 for a Hybrid Reformer for Fuel Flexibility. This is a design for a reformer that has higher concentrations of nickel at one end that gradually reduces along the reformer so that any hydrocarbon can be put in and reformed in the same reformer thereby reducing power consumption and allowing for increased efficiency.An alternate design option listed is to keep the concentration of nickel constant throughout the reformer and instead adjust the concentration of rhodium, opposite of the way the nickel was graded (inlet has a higher concentration of rhodium than the outlet).

Patent 7,705,490 was filed on May 7, 2007 for an Integral Stack Columns. This patent discusses different ways of electrically converting the output to what is needed as fuel cells have a limited current carrying capability. As such these converters are needed to supply a standard electrical connection. The patent describes how Bloom Energy decided to convert the DC power produced by a fuel cell into an AC output that most technology currently runs on. Additionally the DC to AC converters are used to control the current from individual stacks to optimize fuel usage.

1.3 WHAT IS A FUEL CELL??

A fuel cell is an electro chemical cell that converts a source fuel in to an electrical-current. It generates electricity inside a cell through reactions between a fuel and an oxidant, triggered in the presence of an electrolyte. The reactants flow in to the cell, and the reaction product flow out of it. While the electrolyte remains within it. A collection of fuel cells, skinny batteries that use oxygen and fuel to create electricity with no emissions made of sand that is baked in to diskette sized ceramic squares and painted with green and black ink.

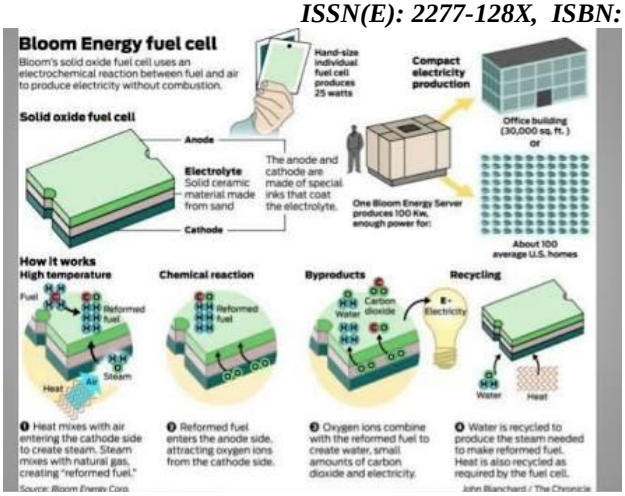

Fig:4. Fuel Cell Arrangement

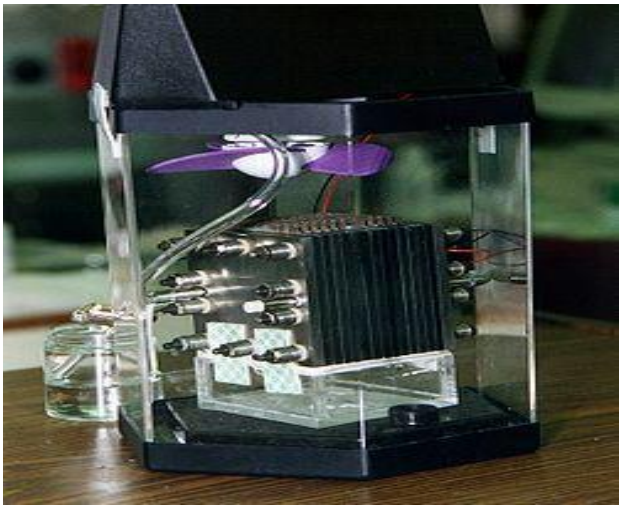
Fig: 5 Stack of cells providing power

II. CELL DESINGNING AND WORKING


Fig : 6. Coated Ceramic Plates

2.1 CELL DESIGNING:

The fuel cell design come in many varieties however, they all work in the same manner. They are made up of three segments which are sandwiched together: the anode, the electrolyte and the cathode. Two chemical reactions occur at the interfaces of the three different segments. The net result of the two reactions is that fuel is consumed, water or carbon dioxide is created and the freed electrons travel through a wire creating the electrical current which can be used to power electrical devices. Chemical reactions in fuel cell: for methanol fuel cells below are the chemical equations for the reaction.

Cathode Reaction:

$$\rightarrow \quad 3/2\ O_2+6H^+ +6e^- \quad 3H_2O$$

Anode Reaction:

$$\rightarrow \quad CH_3OH+H20 \quad CO_2+6H^+ +6e^-$$

Overall reaction:

$$\rightarrow \quad CH_3OH+(3/2)O_2 \quad CO_2+2H_2O+\text{Electrical energy}$$

Many combinations of fuels and oxidants are possible. A hydrogen fuel cell uses hydrogen as its fuel and oxygen as its oxidant. Other fuels include hydrocarbons and alcohols.

2.2 WORKING:

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 Zirconium

(ScSZr). 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 those 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.

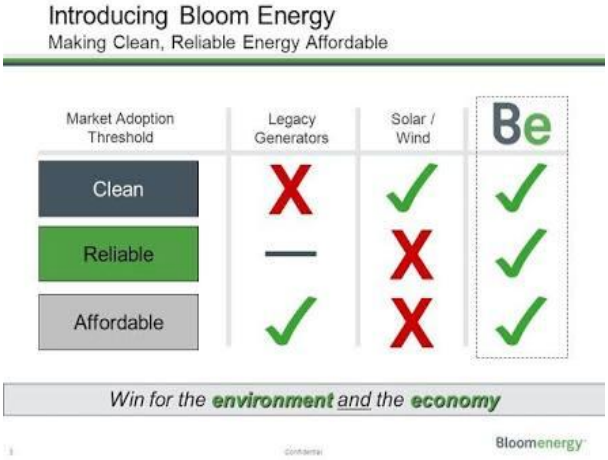

Fig:7. Better Use of Bloom Energy

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.

ADVANTAGES:

- **Carbon Sequestration:** The electrochemical reaction occurring within Bloom Energy systems generates electricity, heat, some H_2O, and pure CO_2. Traditionally, the most costly aspect of carbon sequestration is separating the CO_2 from the other effluents. The pure CO_2 emission allows for easy and cost-effective carbon sequestration from the Bloom systems.
- **Reverse Backup:** Businesses often purchase generators, uninterruptible power supplies and other expensive backup applications that sit idle 99% of the time, while they purchase their electricity from the grid as their primary source. Increased asset utilization leads to dramatically improved ROI for Bloom Energy's customers.
- **Time to Power:** The ease of placing Bloom Energy Servers across a broad variety of geographies and customer segments allows systems to be installed quickly, on demand, without the added complexity of cumbersome combined heat and power applications or large space requirements of solar. Fast installation simply requires a concrete pad, a fuel source, and an internet connection.
- **DC Power**:
  Bloom systems natively produce DC power, which provides an elegant solution to efficiently power DC data centres and/or be the plug-and-play provider for DC charging stations for electric vehicles.
- **Hydrogen Production:** Bloom's technology, with its NASA roots, can be used to generate electricity and hydrogen. Coupled with intermittent renewable resources like solar or wind, Bloom's future systems will produce and store hydrogen to enable a 24 hour renewable solution and provide a distributed hydrogen fuel-in infrastructure for hydrogen powered vehicles.

Bloom is proud to deliver one of the most robust and dynamic energy platforms on the market today.

APPLICATIONS OF BLOOM ENERGY:

- Bloom Energy can be used where the onsite generation of electricity is used.
- It can be used as a plug and play type of electricity.
- It can be used for all purposes like domestic and industrial.
- It is presently used by GOOGLE, WAL-MART, eBay etc…,.

III. CONCLUSION

The costs should come down over time to the point where Bloom boxes really can be used in homes. 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. Additionally it needs to be compared to other equivalent renewable technologies. 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.. The cost of a 100 kW Bloom Box has been previously stated to be between $700,000 and $800,000. 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. 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 much profitable.

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