Fuel Cell: A Potential Energy Efficiency Solution for the Telecom Industry

Shalini Jaswal
Green ThinkerZ Society, Mohali, Punjab, India

Abstract— Continuous increase in number of mobile phone users has increased the density of network base stations. This increase has accelerated the need of more reliable, energy efficient and renewable sources of energy. There are number of renewable energy sources available like solar energy, wind energy etc. but they are limited by nature's constraints. Fuel cells are also emerging as a new renewable energy source. These are more reliable than traditional backup solutions and network operators are increasingly showing interest in choosing Fuel Cells as their backup power solutions. The paper explains about Fuel Cells and how Fuels cells are taken into consideration in telecom industry.

Keywords—*Fuel Cell; Telecom Industry; Energy Efficiency; RES*

I. INTRODUCTION

The Telecommunication Industry has been vigorously expanded in the last decade and wireless communication has become the main source of communication. The telecom industry operates on a wide range of mobile phone towers and these towers need constant high voltage electric power supply for their functioning. But the constant supply of electricity remains a challenge for network operators because of human factors, natural disasters or changes in weather conditions. Power loss is a big issue as it causes network downtime. So to avoid the downtime situations network operators uses backup power solutions such as VRLA batteries, diesel generators and propane generators. These traditional fuel based generators are unreliable, pollute environment, maintenance intensive and have spill containment issues. To overcome the limitations of these backup solutions, the fuel cell technology is being taken into consideration by most of the services providers. Fuel cells are more reliable than generators, less noisy, environment friendly and have a wide range of operating temperature.

II. WHAT ARE FUEL CELLS?

Fuel cell is an energy conversion device that produces DC electric current like a battery by converting chemical energy into electrical energy and gives higher conversion efficiencies than any traditional combustion engine. Both Fuel cell and battery generate heat and water as byproducts of the electrochemical reactions. However, a battery contains a closed store of energy inside and as soon as this energy is consumed the battery needs to be disposed of, or recharged by using an external supply of electricity to drive the electrochemical reaction [1]. On the other side, a Fuel Cell continuously produces electric current as long as fuel and oxidant is supplied. Unlike combustion engines a fuel cell has less moving parts therefore has less noisy signature. Fuel cells have wider operating temperature range, -40°C to +50°C, than a battery [2].

III. HOW DOES FUEL CELL WORKS?

Fuel Cells work on the principle of reversal of electrolysis. A Fuel Cell always produces electric energy by using the chemical energy of a fuel and an oxidant. Major components of a Fuel Cell are an ion conducting electrolyte layer, two electrodes - cathode and anode, on either side of electrolyte. Fuel is supplied at anode and oxidant is supplied at cathode. The electrolyte is used to control chemical reactions as it separates cathode and anode and acts as barrier to gas diffusion by preventing direct mixing of fuel and oxidant but let the ions pass through it [3].

A schematic representation of Fuel Cell working is shown in Fig 1 below:

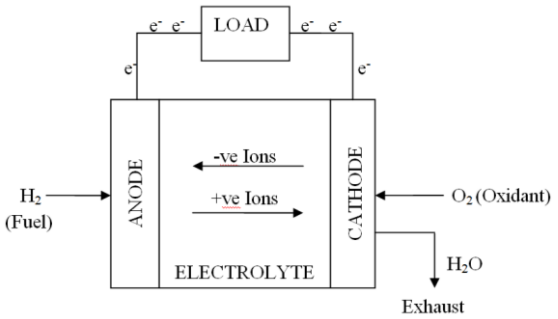


Fig. 1. [4]

The anode is used as –ve electrode, motivated by a catalyst the hydrogen molecules are diffused and the free electrons are conducted to external circuit to supply the power to load connected and the protons passes through the electrolyte to cathode. On the other side, cathode acts as +ve electrode, takes the electrons from external circuit, pass them back to anode through electrolyte. Thus a complete electric circuit is created and water is produced as by-product by combining hydrogen with oxygen either at anode or cathode.

$$\text{At anode: } H_2 \longrightarrow 2H^+ + 2e^-$$

$$\text{At cathode: } \tfrac{1}{2} O_2 + 2H^+ + 2e^- \longrightarrow H_2O$$

The electrolyte can be either solid or liquid and the material used for electrolyte determines the temperature operating range of a fuel cell [4]. A single fuel cell usually generates a very little amount of electric current hence not applicable on commercial basis. Therefore on commercial basis multiple fuel cells are combined into a stack to gain high amount of electric

current. Hydrogen is supplied through either commercial grade hydrogen supply - hydroplus or a methanol and water liquid fuel. The electricity then generated is passed to dc/dc converter to produce high quality regulated current from unregulated DC [2]. In practice most commonly used Fuel cell is Proton Exchange Membrane Fuel Cell (PEMFC).

IV. TYPE OF FUEL CELLS

Fuel Cells can be categorized on the basis of electrolyte they use and their operating temperature range. Fuel Cells having low operating temperature usually need pure hydrogen as fuel. Therefore a fuel processor is must to convert the supplied fuel into pure hydrogen and this setup requires extra specialized equipments and consumes relatively extra energy. On the other hand, this additional process is not required in high temperature fuel cells because they can internally produce the fuel at elevated temperatures and therefore doesn't have additional setup costs. Some type of fuel cells work well on stationary power generating plants and some can be useful in small portable applications. Main type of Fuel Cells are:

A. Proton Exchange Membrane Fuel Cell (PEMFC)

Proton Exchange Membrane Fuel Cell or Polymer Electrolyte Fuel Cell (PEFC) uses pure hydrogen as fuel and having operating temperature ranges from 50-100°C and from 122-212°, typically 80°C. Polymer ion exchange membrane is used as electrolyte. It is mostly combined with an expensive catalyst for achieving best resuts and have electrical efficiency ~ 30 to 35 % .

It is best for using in fast start up and shut down applications such as:

- Backup Power
- Portable Power
- Distributed Generation
- Automotive Applications

B. Phosphoric Acid Fuel Cells (PAFC):

Phosphoric Acid Fuel Cells (PAFC) operates on the temperature range of ~ 100 – 220°C and have electricl efficiency ~ 35 to 40 %. These type of Fuel Cells uses pure hydrogen as fuel source and Phosphoric acid soaked in a matrix as electrolyte. Typical stack size is 400 kW-100 kW. The design and power outputs make these fuel cells best to use in buses and large stationary applications.

C. Alkaline Fuel Cells (AFC):

Alkaline Fuel Cells uses Aqueous solution of potassium hydroxide as electrolyte and this gives them an operating temperature range of ~ 150 – 200°C with approxmately 40% electrical efficiency. These fuel cells are best suited for Expensive mission critical applications, such as the USA space programs.

D. Molten Carbonate Fuel Cells (MCFC):

Hydrocarbons are used as fuel source and a combination of high temperature alkali carbonates (sodium or potassium) are used as electrolyte. Operating temperature for these fuel cells is ~ 550 – 700°C and generate electricity with ~ 50 to <70 % efficiency. Best suited for Large stationary power applications.

E. Solid Oxide Fuel Cells (SOFC):

These fuel cells have operating range from ~ 450 – 1,000°C and electrical efficiency from ~ 45 to <70 %. Most hydrocarbons are used as fuel source. Electrolyte: A solid, non-porous ceramic based metal oxide, often Yttria doped Zirconia material. Because these fuel cells operate at high temperature, they offer fuel flexibility without having to specially pre-treat the fuel [5],[6],[7].

SOFC application include:

- Auxiliary power
- Electric utility
- Distributed generation

V. APPLICATIONS OF FUEL CELLS

Depending on their type, Fuel Cells can be used in several applications.

A. Transportation Applications

Transportation applications require quick start-up fuel cells. Because PEM Fuel Cells have low temperature range, they can supply electricity quickly when started. Almost all of the world's leading car manufacture industries have developed fuel cell car prototypes.

Some of them are:

- Adam Opel AG has manufactured a fuel cell car named HydroGen3. It contains a stack of 200 PEM Fuel Cells connected in series which can give electricity output of 129kW with a max power of 60kW.
- A Fuel Cell car "BMW 745h" manufactured by BMW, runs on hydrogen combustion engine and has capacity of 135kW.
- The NECAR(New Electric Car) program was initiated in 1994. Latest of NECAR series is NECAR5 which runs on methanol. It takes hydrogen from an on-board methanol system and has a capacity of 55kW [3].

B. Stationary Applications

Stationary Applications involve generation of combined electricity and heat for commercial & residential buildings. As fuel cells are unaffected by size they can be used in generating output starting from some kW to MW. Stationary Applications of Fuel Cells include:

- Gas treatment module
- Heat exchanger

- Additional power-generating components: expansion turbines, gas turbines or combined gas and steam turbines
- Piping, pumps and compressors required for gas and heat management
- Invertors and transformers [7]

C. Portable Applications

While in transportation applications Fuel Cells are used to replace combustion engines, in portable electronic applications Fuel Cells can be used in place of batteries. While batteries need to be recharged or discharged when they go down, fuel cells can continuously generate electricity over constant supply of fuel.

Portable applications of fuel cells include:

- Power supply for small devices such as Laptops, Cell Phones, Video Cameras, Computer chips.
- Supplying power to telecommunications satellites, replacing solar panels.
- Supply power to biological applications such as hearing aids and pacemakers [8].

VI. FUEL CELLS IN WIRELESS TELECOM INDUSTRY

Most of the telecommunication companies are trying to provide their customers an energy-efficient experience by developing energy-efficient handsets and networks.

A. Motorola

Motorola is involved in researching fuel cells for mobile networks, mobile devices and replacement of mobile phone batteries with rechargeable fuel cells. Motorola has conducted an experiment to power up TETRA Networks with Fuel Cells. These TETRA(TErrestrial TRunked RAdio) networks are used public safety communications and other Private Mobile Radio networks. Figure 2 is the set up for a trial to use fuel cells to power TErrestrial TRunked RAdio (TETRA).Motorola has tied up with various companies for the research and development of various technologies such as:

- Hybrid fuel cell technologies for radios
- A hydrogen generator as a miniature fuel-cell power source
- Improving PEM fuel cell performance, durability, and manufacturability using single wall carbon- nanotubes (SWNTs) [9]

Fig. 2 –TETRA Fuel Cell Experiment

B. Vodafone

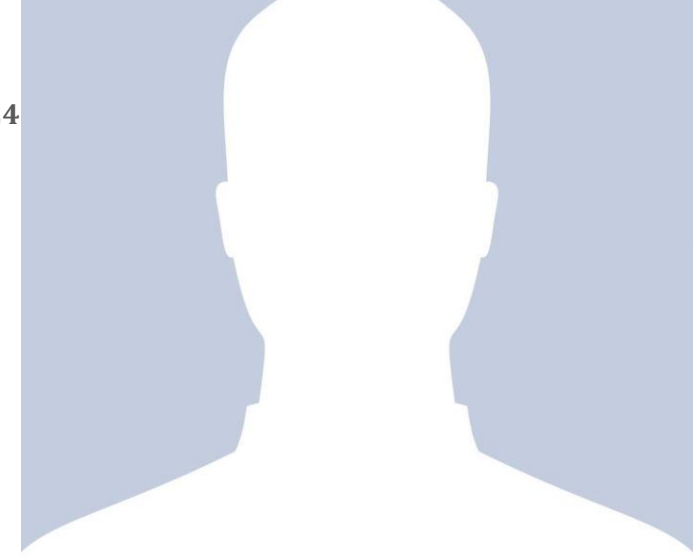
"We have set ourselves a tough challenge to halve our CO2e emissions by 2020, from the 2006/07 baseline... This Group reduction target applies to all of our local operating companies that were active for a full year in 2006/07; and to their CO2e emissions from all energy sources except business flights and other greenhouse gases[7]."

C. Ericsson

"In 2008, Ericsson set a new group-level target to reduce its life-cycle carbon footprint by 40% over the next five years, starting with a 10% reduction in 2009. The footprint will include total CO2 emissions from: in- house activities, such as production, transport, sites and business air travel, and the lifetime energy use of the products sold by Ericsson during the year (portfolio energy-efficiency improvement)[7]."

VII. CONCLUSION

With the rapid growth in telecommunication industry, network providers are seeking ways to provide non-stop services to their customers without any network downtime. Most of the downtimes occur due to failure of constant power supply to mobile base stations. Thus network providers need more reliable ways for continuous power supply other than current electric grids. Fuel Cells has been emerging as a new reliable power supply sources. They can continuously generate electricity as long as fuel is supplied to them. Fuel cells are more energy-efficient, less noisy, have wide range of operating temperatures and are environment friendly (no harmful byproducts & renewable energy source). Network operators are choosing Fuel Cells as their backup power solutions because they have low-cost, need lower maintenance and are more reliable.



VIII. REFERENCES

[1] R.K. Shah,"Introduction to fuel cells," [Online] Available: http://web.iitd.ac.in/~sbasu/L5.pdf

[2] B.J. Holland,J.G. Zhu,L. Jame,"Fuel cell applications," [Online] Available: http://educypedia.karadimov.info/library/AUPEC01_111.pdf

[3] Sossina M. Haile, "Fuel Cell Mats & Comps corr," [Online] Available: http://addis.caltech.edu/publications/Fuel%20Cell%20Mats%20%26%20Comps%20corr.pdf

[4] Different.types.of.Fuel.Cells [Online] Available: http://www.cfcl.com.au/Assets/Files/(EN).3.Different.types.of.Fuel.Cells.Dec-11.pdf