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| FUEL CELL INDUSTRY ANALYSIS REPORT |
| 01/01/2015 |

Bambu, the team

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# Introduction

## Intentions

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## History of fuel cells

## Fuel cell as an alternative

## Short industry overview

# Product description

## Introduction

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## Technologies

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### PEMFC

### AFC

### PAFC

### SOFC

### MCFC

### DMFC

### Summary

## Applications

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### Categorisation choices

### Transport

### Portable

### Stationary

## Infrastructure

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### Distribution facilities

#### Delivery

#### Hydrogen storage

### Hydrogen production

#### Introduction

#### Electrolysis

#### Steam reforming

#### Summary

**CHP:**

Combined Heat and Power. The process of generating useful heat and electricity at the same time. Scan the QR below to learn more about CHP.



**FCEV:**

Fuel Cell Electric Vehicle.

A vehicle in which fuel cell is used to power its electric motor.

# Market Perspective

## Introduction

In general, fuel cells are devices capable of combining hydrogen and oxygen thus, obtaining electricity, water and heat in the process. And it differs from batteries because of the fact that it would continually produce electricity as long as hydrogen is being provided to the cells, it also differs from the conventional energy sources due to it does not burn fuel, thus it hold few advantages :

1. The generation process is quiet
2. The process is pollution-free
3. It’s two to three times more efficient than combustion[[1]](#footnote-1)

The markets for fuel cells can be classified into:

1. stationary power: applications where the fuel cells are working at a stationary or fixed location mostly for primary power, CHP or backup power sources;
2. transportation power: applications where fuel cells are used in transportation vehicles like passenger cars, buses and other FCEVs ;
3. and portable power: applications where fuel cells are in portable electronic devices like MP3 players, laptops, mobliephones.

## Investment Cost Reduction

**Do You Know?**

Conventional production of fuel cell involves in using platinum as a catalyst in the manufacturing process, hence, unevitably making the price of fuel cells expensive. Innovations to reduce the quantity of platinum consumed or a complete catalyst replacement would result in cost reduction of fuel cell products.

More about Platinum on Wikipedia:



Figure  : FC Investment Cost Reduction [[2]](#footnote-2)

In the last decade, the cost of fuel cells continued to decline significantly in terms of the average capital needed in order to generate a unit kilowatt of energy using fuel cells, as its is pointed out in the figure above that the cost of fuel cells decreased by fifty percent in a period of five years mainly because R&D departments of many companies attempted and succeeded to some extents in making the fuel cell prices comparable with conventional energy sources. At the same time, it was discovered that durability of the cells has increased by two times in general.[[3]](#footnote-3) The fuel cells cost have then been quite stable for three yoears till now. However, experts projected that the investment cos t will again decrease furthur in the year 2020, due to fuel cells will be actively used in public transportation.[[4]](#footnote-4)

## Intellectual Property

The data in this section is referred from the Clean Energy Patent Growth Index report which keeps tracks of clean energy patents and covered many sectors involved, including fuel cells.[[5]](#footnote-5)

In brief, automakers took most control. Toyata Corporation has once again been receiving most fuel cell patents since it did so in 2012, now with 89 patents. While General Motors Corporation with 89 patents comes as the second highest. Samsung and Honda are in the third and fourth places respectively. The approximate number of patent entities granted is 300. The figures below show the distribution between the top ten assignees and how the patents are distributed geographically.

**Do You Know?**

Most of the patents awarded to the top three assignees in the recent years covers the innovations of fuel cells existing in the automotive industry. Also the R&D department of General Motors Corps invested less in FC technology as a result form the American Recovery and Reinvestment Act.

## Quantity of Fuel Cells shipped

The shipments of the fuel cell systems shipped in terms of individual systems shipped divided in terms of applications namely: stationary power, transportation power and portable power. Transportation power used to be the majority of the shipped system in 2008. However, with the introduction of the CHP units in the market, residential units of CHP were continuously deployed in Japan. And in the year 2013 alone, more than 26,000 units have been shipped to Japan. The shipments of transportation and portable FC have been quite stable and experts forecast that it will remain so at least for a couple of years.

**What makes Japan the biggest market in terms of megawatt shipped:**

Most stationary cells are shipped to Japanese market where the government encourages the usage of CHP, Japan is also the biggest customer to Statinary Fuel Cells.

Form the figure above, we may notice that portable shipments are not visible in the graph this is due to the quantitative value of MW shipped less than 1 MW each year for portable power FC. Majority of stationary FC displayed in this graph is contributed from CHP and telecommunication backup power which require decent amount of power to maintain its operation.

**Why is Portable Application of Fuel Cell invisible in the Graph?**

All of fuel cell products belonging the portable power category normally have low energy efficiency and the power usage by the application is dramatically lower than the other two categories. Hence, the portable application power is semmingly invisible in the graph.

In terms of countries, the US FC shipments remains quite stationary and the growth is stagnant mainly due to the end of federal American Recovery and Reinvestment Act or (ARRA) which leads to the decline in Fuel Cell shipments but the decline is expected to be reversed in the few years. When the act will be re-enacted and this will encourage a number of companies to deploy fuel cells at their warehouses.[[6]](#footnote-6) For fuel cell electric vehicles, the global shipments remains quite low this is because of the major auto manufacturers planned to release their commercial fuel cell electric vehicles starting in the year 2017. The notable company that took initiative in shipping commercial fuel cell vehicles is Hyundai who started the shipment to European Region in the year 2013.[[7]](#footnote-7)

## Company Profiles

Currently the fuel cell market is flourished with many companies developing a variety of different products ranging from small hand held fuel cell mp3 players to big substations used to power backup for vital communications. Our group decided to give introduction to all the aspects of fuel cells, therefore introduction to fuel cell companies from all corners of the world are covered in this chapter. Notice that this is not the complete list of all the manufacturers, since there are many public and private companies in existence but the profiles provided in this chapter should prove significant to give insight to the entire fuel cell industry.

Here is the list of companies included in this IAR in alphabetical order:

* Bloom Energy
* Horizon Fuel Cell Technologies
* Intelligent Energy
* Nedstack
* Panasonic
* Plug Power
* SFC Energy
* Toshiba

### Bloom Energy

**Bloom Energy Website:**



Bloom Box, a bloom energy product is designed to operate under extreme conditions of tempertature, it can withstand the temperature of 1800 Farenhiets!

The company was founded in the year 2001 and is headquartered in Sunnyvale, California. Its first customer was the University of Tennessee, which ordered the company a SOFC product for educational purposes in 2006. Many other university across the United States similarly ordered the same product to conduct field trials. But it wasn’t until July of 2008 that the first commercial version of Bloom Energy’s products were shipped to Google. The company proved to be one of the highest ranked SOFC producers since then some notable customers of this firm includes Adobe, Bank of America, Coca-Cola, eBay, Google, Kaiser Permanente, and Walmart. The Company claimed that their products have already generated more than 100 million kilowatt-hours of clean energy for its customers.[[8]](#footnote-8)

|  |  |
| --- | --- |
| Headquarters | California, USA |
| Fuel Cell Type | SOFC |
| Market | Stationary (Large-Scale) |
| Application | Buildings(commercial, universities, arenas) data centers |

[[9]](#footnote-9)

### Horizon Fuel Cell Technologies

**PEM:**

Proton Exchange Membrane

A proton exchange membrane or polymer electrolyte membrane (PEM) is a semipermeable membrane generally made from ionomers and designed to conduct protons while being impermeable to gases such as oxygen or hydrogen.

More info about PEM on Wikipedia:



Horizon is currently the largest micro fuel cell producer and the largest producer of PEM fuel cell stacks below 1,000 W. Today, the firm produces compact, lightweight PEM fuel cells at various performance levels, and also delivers hydrogen storage and on-site hydrogen generation solutions for multiple applications. The company was founded in 2003 and it currently own five subsidiaries around the globe.[[10]](#footnote-10)

|  |  |
| --- | --- |
| Headquarters | Singapore |
| Fuel Cell Type | PEM |
| Market | Portable, Stationary(backup) |
| Application | Educational, consumer electronics, military, aerospace |



### Intelligent Energy

Intelligent Energy also manufactures back up power in telecom sectors as an alternative to diesel gases.

Intelligent Energy Home Page:



[[11]](#footnote-11)

Intelligent Energy was founded in Loughborough, United Kingdom 2001. Its main focuses are Proton Exchange Membrane type fuel cells. The firm partners with global companies that research on automotive, stationary power, and consumer electronics markets. Very notable accomplishments include collaborating with Suzuki Motor Corporation and built “Burgman” the first fuel cell scooter to achieve European Whole Vehicle Type Approval, and supplying fuel cells to Boeing who used it for the first fuel cell aircraft.[[12]](#footnote-12)

|  |  |
| --- | --- |
| Headquarters | Loughborough, United Kingdoms |
| Fuel Cell Type | PEM |
| Market | Portable, Stationary(backup) |
| Application | Aerospace, defense, generation portable power, automotive |



### Nedstack

NedStack obtains hydrogen partly from Chlorine industry by-product and uses the same hydrogen to generate power for chlorine resulting in a saving of upto 20% on energy consumption of the plant.

Here’s the link to more info regarding Nedstack:





Nedstack is a PEM fuel cell stack provider for system integrators who delivers energy systems to the telecom, rail, and utilities industries. The company was founded in 1998 when seven engineers took over AkzoNobel’s PEM activities. Right now, over 1,000 Nedstack fuel cells are in operation world-wide mostly as backup power sources.[[13]](#footnote-13)

|  |  |
| --- | --- |
| Headquarters | Amhem, The Netherlands |
| Fuel Cell Type | PEM |
| Market | Transportation, Stationary(backup) |
| Application | Stationary power, telecommunication backup, buses |

[[14]](#footnote-14)

### Panasonic

**DMFC:**

Direct Methanol Fuel Cell

DMFC uses ethanol instead of hydrogen fuels. The efficiency is quite low for these cells. Hence, they are mostly used in portable applications.

Scan the QR code below for more information on DMFC:





The firm was founded in the year 1918, at the moment it was known as Matsushita Electronics, the company now comprises of more than 500 sub companies. The company was the first to manufacture a DMFC laptop which was capable for operating continually on battery for 20 hours and displayed it publicly at the International Consumer Electronics Show, 2006 ’. The firm is also one of the largest global manufacturers for residential CHP, and in recent years, the company managed to miniature and simplify fuel cell’s structures.[[15]](#footnote-15)[[16]](#footnote-16)

|  |  |
| --- | --- |
| Headquarters | Osaka, Japan |
| Fuel Cell Type | DMFC,PEM |
| Market | Stationary, Portable |
| Application | CHP units, Consumer Electronics,DMFC |



Figure - Panasonic Fuel Cell Laptop

[[17]](#footnote-17)

### Plug Power



Plug Power is a major player in the PEM fuel cell material handling equipment market. The company was incorporated the year 1997 as a joint venture between Edison Development Corporation and Mechanical Technology Inc. Right now, the company mainly focuses on GenDrive®, a PEMFC designed for industrial vehicles especially material handling equipment and distribution facilities. The company has deployed over 3,000 GenDrive® units with run times exceeding 8.5 million hours.[[18]](#footnote-18)

|  |  |
| --- | --- |
| Headquarters | Latham, New York |
| Fuel Cell Type | PEM |
| Market | Stationary, Transportation |
| Application | Material Handling Equipment |

[[19]](#footnote-19)

### SFC Energy



The firm produces power generator for mobile homes, yachts and vacation cabins. SFC Energy ally itself with other big companies in different industries and had already shipped more than 30,000 commercial products. The company’s facilities are located mainly in the Netherlands and Romania, its fuel cartridges are manufactured in Germany near Munich where its R&D department is located. SFC Energy also manufactures DMFC for mobile and off-grid power serving leisure, industrial and defense market.[[20]](#footnote-20)

|  |  |
| --- | --- |
| Headquarters | Brunnthal, Germany |
| Fuel Cell Type | DMFC |
| Market | Stationary |
| Application | Leisure, industrial and defense |

[[21]](#footnote-21)

### Toshiba



**CEATEC:**

Combined Exhibition of Advanced Technologies, an annual tradeshow in Japan.

In the year 1984, Toshiba operated an experimental 50 kW fuel cell power plant, the first power plant in Japan. The company actively research on DMFC and PEM technologies for the Japanese market. Among the main products are residential PEM fuel cells and PAFC developed since 1990s. The company also demonstrates its DMFC- powered cell phones and MP3 players at the CEATEC conference which can operate for 320 hours using fuel cell and methanol fuel.[[22]](#footnote-22)

|  |  |
| --- | --- |
| Headquarters | Tokyo, Japan |
| Fuel Cell Type | DMFC, PEM |
| Market | Stationary, Portable |
| Application | Consumer Electronics, Residential |

[[23]](#footnote-23)

# Law and governmental regulations

## Forms of influence

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## Situation in Japan

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## Situation in Germany

## Situation in the USA

# Comparison to other technologies

## Alternative technologies

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### Introduction about different technologies

### Trend of these technologies in different regions

## Advantages and disadvantages of fuel cells

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### Advantages

### Disadvantages

### Challenges

## Different elements of settling a technology

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### alternative elements

### policy as an important element

# Future perspectives

## Opportunities

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## Limitations and risks

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## Forecast

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# Conclusion

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