Backup Power for Telecommunication Applications:
Comparing Fuel Cells to Diesel Generators

ReliOn®

Fuel Cells | Simply Powerful

The options for backup power are varied, but the most often used power source for moderate-sized telecom sites needing extended runtime is a diesel internal combustion generator. This incumbent technology has been the mainstay for years, despite issues with reliability, maintenance costs and environmental cleanliness. As the nation has shifted its focus to the importance of all these issues, fuel cells have become a viable option for more and more locations.

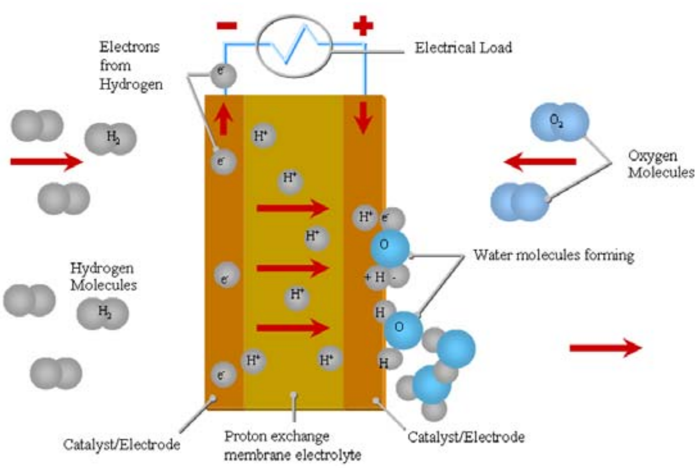
Telecommunications, government communications, security and other markets use fuel cells for backup power in grid-powered locations. Fuel cells are also used in remote and off-grid applications as one component to a hybrid power solution which can involve any of the following other power sources: solar arrays, wind turbines, batteries, and/or generators. Fuel cells are recognized as a clean, green alternative to batteries and combustion engines, capable of passing the most stringent air quality standards.

There are currently more than 1,300 telecommunication sites using fuel cell power solutions in North America alone. While this represents a small percentage as far as total telecom sites, it is clear that fuel cells are a growing solution to the need for reliable energy for sites in locations as diverse as cities, suburbs, rural, off-grid and environmentally sensitive areas.

This paper investigates the case for fuel cells, focusing on the similarities and differences between diesel generators and fuel cells.

Fuel Cell Technology

A fuel cell is a device that converts the chemical energy of a fuel (hydrogen, natural gas, methane, alcohol, gasoline, etc.) and an oxidant (air or oxygen) directly into electricity. While there are a number of fuel cell technologies available, the most common and practical technology for small to medium-sized standby power is the proton exchange membrane, or PEM, fuel cell. Proton Exchange Membrane (PEM) fuel cells generate electricity through an electrochemical reaction using hydrogen and oxygen. This process happens without combustion. A fuel cell operates electrochemically through the use of an electrolyte, just like a battery, but it does not run down or require recharging. It is like a generator in that it operates as long as the fuel is supplied; but unlike an internal combustion generator, it is simple, quiet, clean and has few moving parts.



Proton Exchange Membrane (PEM) Fuel Cell Diagram

Based on technology available today, customer sites can be provisioned with fuel for hundreds of hours of runtime. Refueling allows the system to run continuously as long as needed for extended outages.

Most fuel cells being used for backup power today range from hundreds of Watts to about 20 kilowatts. For sites with these relatively low power loads and outages lasting from hours to days, fuel cells can be the backup power source of choice.

Fuel Cells vs. Diesel Generators
Telecom operators are very familiar with the use of diesel generators to provide backup power at their sites and are growing in their familiarity with fuel cells. In order to have a meaningful comparison of the two options, it is important to address costs, reliability and environmental factors.

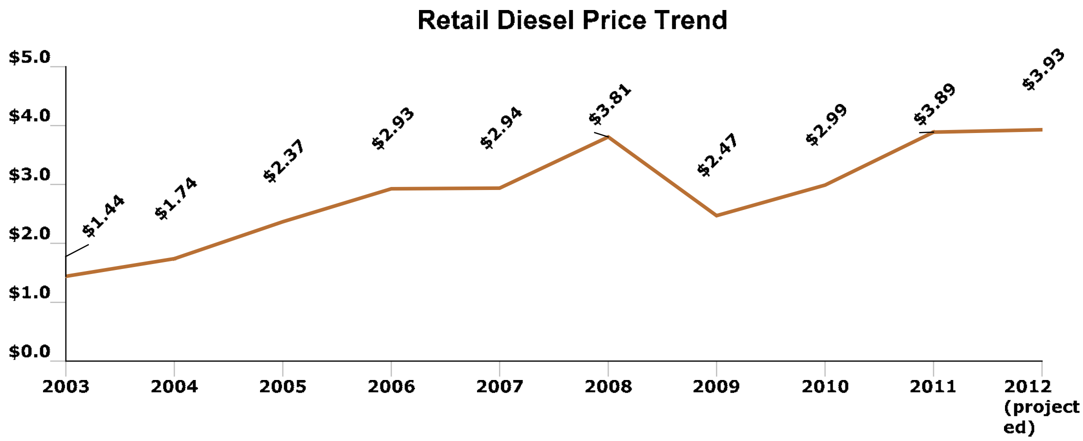
Costs
Traditionally, in addition to being a technology that operators are familiar with, diesel generators have been a lower initial cost power option when compared to fuel cells. However, as fuel cell technology has advanced and come down in price, and further spurred by the federal government and some states offering substantial grants and tax credits, fuel cells are generally on par with generators in terms of first cost. On a lifecycle model, fuel cells offer a reduced operational cost when compared to combustion generators.

Item	Typical Fuel Cell: 10kW system in enclosure with fuel storage	Diesel Generator: 50kW with ATS and fuel storage	Typical Fuel Cell: 10kW system indoor rack-mount with external fuel storage
Capital Cost			
Equipment Cost	50,000	30,000	45,000
Incentives: Treasury Grant / Federal Tax Credit*	-15,000	0	-13,500
Incentives: States**	varies	0	varies
Permitting/Installation	13,500	18,000	13,500
Total First Cost	48,500	48,000	45,000
Operational Costs			
Annual Maintenance & Fuel	700	5000	700
Lifecycle cost after 10 years	55,500	98,000	52,000
Cost comparison after 5 years	52,000	73,000	48,500
Cost comparison after 1 year	49,200	53,000	45,700
* Federal treasury grant / tax credit is $3/W or 30% of the cost of the fuel cell, whichever is less. In this case, $3/W * 10kW = $30,000; 30% of cost is $15,000 (outdoor) or $13,500 (indoor).			
** State tax credits for fuel cells vary where available. California and New Jersey currently offer the best incentives.			

Operating Costs

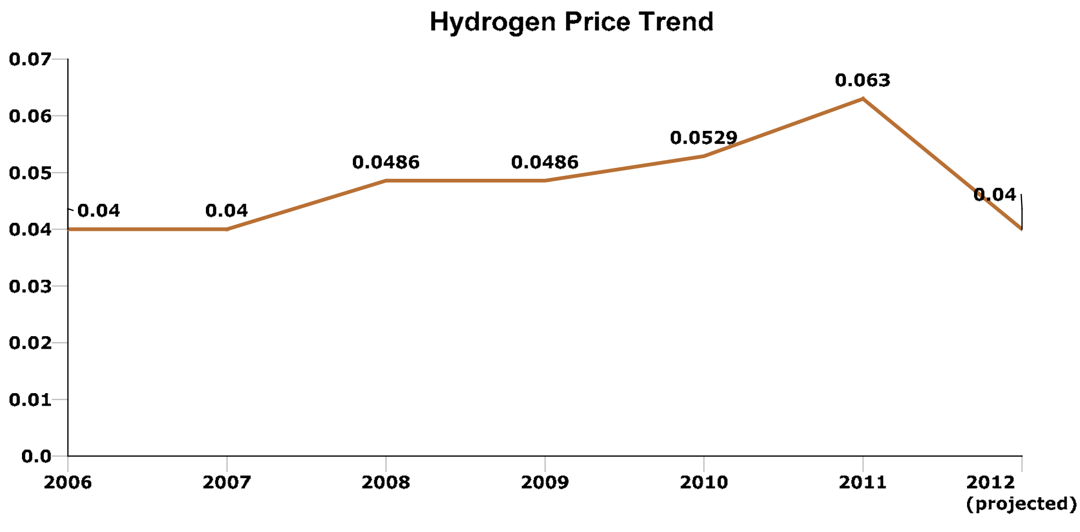
Diesel

The cost of diesel fuel fluctuates, but has risen significantly over time from under $1.50/gallon in 2003 to $4.06/gallon in May of 2011, according to the U.S. Energy Information Administration's (EIA) record keeping. The EIA's short term energy outlook forecasts that on-highway diesel fuel retail prices will average $3.89 per gallon in 2011 and $3.93 per gallon in 2012.[1] From 2009 to 2011, diesel prices have risen 57.5%. While wholesale diesel prices may be somewhat less, the trend is still significant.



Hydrogen

Like with diesel, hydrogen prices have risen over time. They are not tracked through the EIA; however, a survey of bulk hydrogen prices per cubic foot offers a perspective on cost trends. From 2009 to 2011, hydrogen prices have increased about 29.6%.



[1] http://www.eia.doe.gov/steo/

Maintenance Costs

Diesel Generator

Generator maintenance consists of a quarterly service call comprised of seven separate system checklists:

- Cooling System
- DC Electrical System
- AC Electrical System
- Air Induction & Exhaust System
- Power Unit
- Lubrication System
- Fuel System

These quarterly maintenance issues, including fuel, cost the customer in the neighborhood of $5,000 annually.

Fuel Cell

A fuel cell maintenance call happens once a year and involves inspection of and possible exchange of a standard air filter. This decrease in maintenance is attributable to the simplicity of fuel cell design and the fact that they have very few moving components. Fuel cell maintenance, including fuel, costs the customer about $700 annually.

Fueling Options

Intrinsic to both fuel cells and diesel generators is the need for fuel in order to operate. Diesel is widely available through a fueling network of “bump trucks”, which arrive at outside plant sites as needed to refuel a large storage tank onsite.

PEM fuel cells use hydrogen in order to supply energy. Traditionally, fuel cells have used hydrogen cylinders to store fuel (packaged gas). The refueling of hydrogen cylinders has been accomplished by the replacement of cylinders onsite. The distribution model consists of a vehicle transporting full cylinders to the site; these cylinders are exchanged and the empties returned to the fuel depot. For many sites, this remains the option of choice.

A second option is bulk hydrogen refueling. ReliOn has worked with existing bulk hydrogen suppliers to establish a refueling model similar to the diesel/propane model. In this model, the cylinders remain on site and the fuel is transported by a fuel truck (bulk refueler). The cylinders are filled on site by the refueler by re-pressurizing the tanks, essentially, topping them off. This development has broadened the market for fuel cells to address higher capacity installations and sites requiring extended run times of several days.

When assessing the suitability of a site to utilize this model, just as with other infrastructure fuels, it is important to address potential issues such as sufficient site access, turning radius, and road conditions that support the weight of the trucks.

A third option for providing fuel for fuel cells is the fuel reformer. In simple terms, this is a mini-refinery deployed with each fuel cell. It takes a hydrogen-rich carbon-based fuel, such as methanol mixed with water and, using heat and catalyst, separates the hydrogen from that fuel in order to deliver it to the fuel cell. Because these fuels tend to be liquid, energy density is better than with gaseous hydrogen, allowing for more runtime to be stored on site in a smaller space. However, reformers introduce additional complexity to the fuel cell system and can reduce the reliability of the system as a whole. Hydrocarbon fuels, because they are not simple hydrogen, also emit pollutants in the reforming process. The amount of pollutants is much less than those emitted by diesel generators; however, fuel cells running on straight hydrogen emit no pollutants.

Reliability

The reason power engineers add backup power to the site design is to increase the reliability of the site, so that the company can continue to provide service to its customers despite events that knock primary power out of service. Thus, the reliability of the backup power equipment is paramount to the goals of the operator.

Diesel generators of the size routinely used at telecommunication outside plant sites have a reliability rating of 88.4%[2].

ReliOn fuel cells have a reliability rating of 99.63%. This was arrived at through third party testing in commercial customer environments over the course of three years.

[2] Survey of Reliability and Availability Information for Power Distribution, Power Generation and HVAC Components for Commercial, Industrial and Utility Installations, Hale/Arno, IEEE Industrial and Commercial Power Systems Technical Conference, 2005

Environmental Issues

Noise

Sensitivity to noise is dependent on the location of the site needing backup power. Sites located in neighborhoods or locations where people congregate will have a lower threshold than remote sites. Diesel generators and fuel cells both have ranges of noise, depending on the product selected and its configuration. A survey of diesel generator and fuel cell specs shows that the average fuel cell is about 10 decibels lower than the average generator.

Toxicity

Fuel toxicity has the potential to add costly cleanup in case of fuel spills. Diesel fuel, being heavier than air, spills directly onto the ground and can lead to significant contamination of the soil if not dealt with promptly. Soil must be excavated and surrounding areas tested for acceptable levels of contaminants. More extensive measures must be taken if contamination reaches ground water and public water supplies.

Hydrogen does not have these issues. Hydrogen is non-toxic and because it is lighter than air, it disperses quickly if leaked.

Exhaust

Diesel generators are notorious for their pollutants. States such as California have set limits to the number of hours a generator can be run in non-emergency situations in order to address the emissions issue.[3] Federal guidelines limit the amount of emissions allowed by generators[4]. The 50kW diesel generator in our example falls under Tier 2 standards and is allowed 5 grams of carbon monoxide per kilowatt-hour, 7.5 grams of NOx per kilowatt-hour and 0.4 grams of particulate matter per kilowatt-hour. When one extrapolates to 1,000 generators providing 150 hours of runtime per year each for 5 years, the environmental impact becomes very clear.

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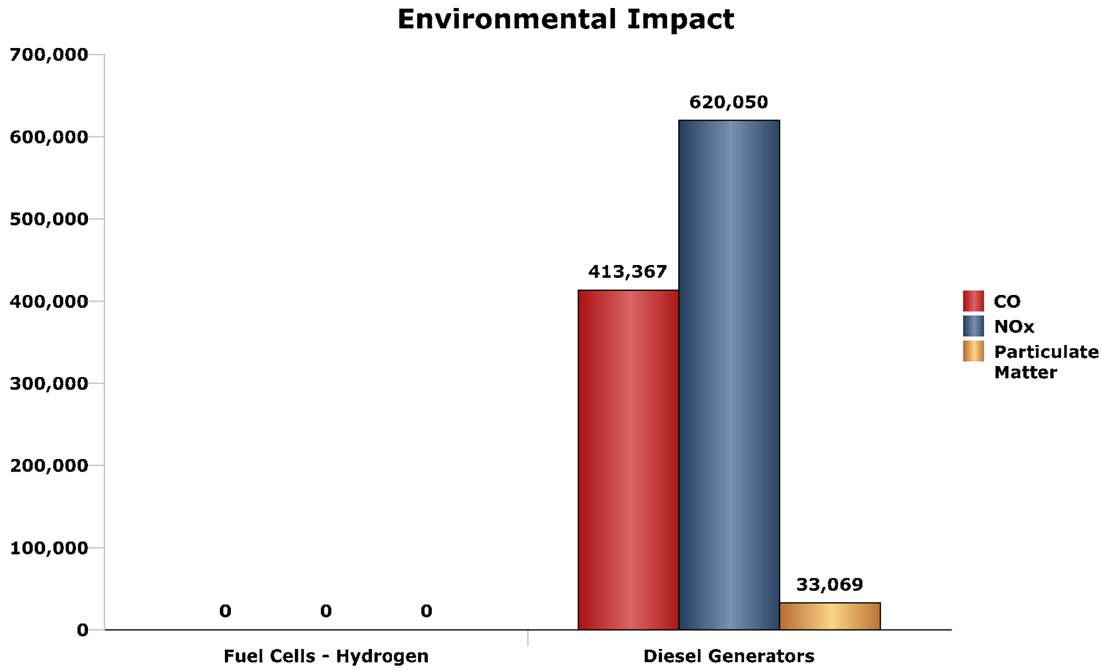
[3] http://www.dieselserviceandsupply.com/generator_engine_emissions_explained.aspx

[4] http://www.dieselnet.com/standards/us/nonroad.php#tier3

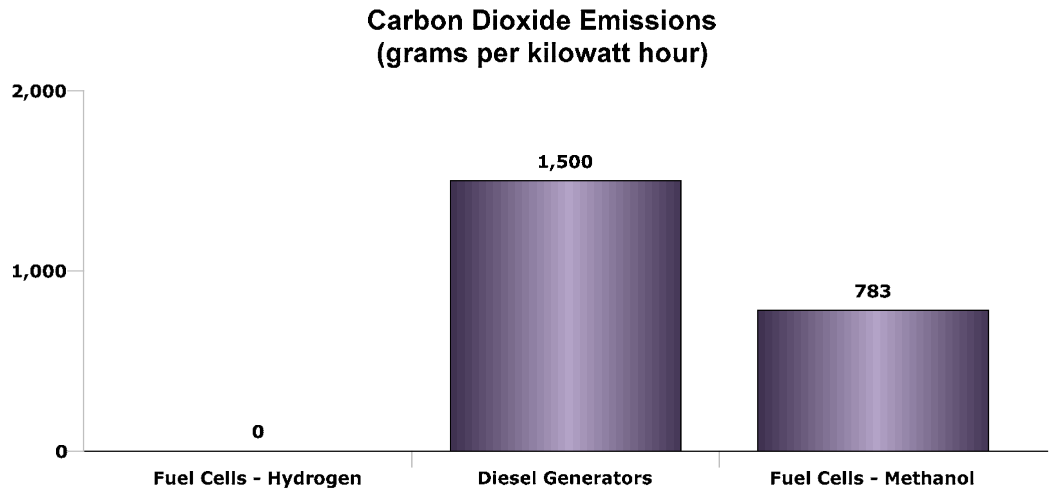


Assumptions:
1,000 sites
50kW diesel generator / 10kW fuel cell
150 hours runtime per year
5 years

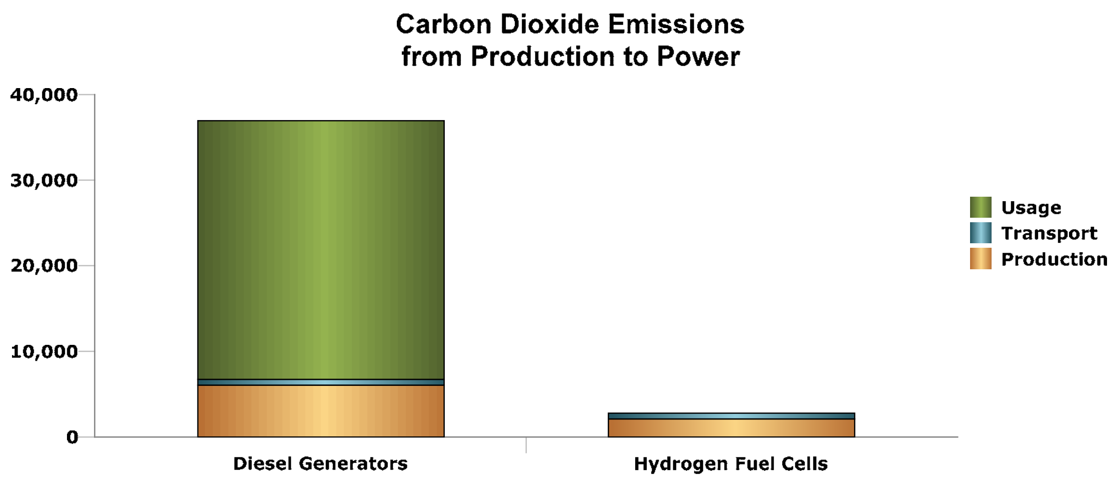
A fuel cell operating on reformed methanol has significantly lower emissions than the diesel generator, with 0.007 g/kWh of NOx, 0.17 g/kWh of CO and 0 g/kWh of particulate matter.

Comparatively, fuel cells running on hydrogen emit no pollutants. This makes them an ideal solution for locations where air quality is an issue. Hydrogen fuel cell emissions are comprised entirely of a small amount of heat and a little water.

When comparing the carbon dioxide emissions of diesel generators and hydrogen fuel cells, the further disparity between the solutions is evident. While the diesel generator emits 1,500 grams of CO_2 per kilowatt hour, the fuel cell running on hydrogen has no emissions at the point of use. Conversely, fuel cells running on reformed methanol emit 783 grams of CO_2 per kilowatt hour; more than half what the diesel generator emits. While the fuel cell using reformed methanol is certainly cleaner than a diesel generator, it is clear that the hydrogen-fueled fuel cell remains the cleanest option.



In the conversation about different types of fuel, it is important to address the amount of carbon dioxide released from the point of fuel production through the production of energy at the customer site. The following figure shows the difference in CO_2 between diesel and hydrogen. Diesel production includes extraction of petroleum from the well and refinement into diesel fuel at the refinery. This process emits roughly 6,050 kg/year of CO_2 in the making of fuel that would be used to provide 300W of power 24/7 for a year. Hydrogen is most often steam reformed from natural gas. This process, including extraction of natural gas and the reforming process, emits roughly 2,100 kg/year in the making of fuel for the same 300W of power. Transportation for both diesel fuel and hydrogen to the customer site are a wash, emitting the same 690 kg/year of CO_2. Finally, while the diesel generator emits 30,200 kg/year of CO_2 at the point of use to provide its 300W of power, the fuel cell emits none.[5]



[5] WTW analysis JRC EUCAR CONCAWE

Conclusions

Certainly, one can argue that diesel generators have a much longer history of use at telecommunication sites than do fuel cells. However, based on costs, reliability data and environmental factors, it is evident that fuel cells are able to provide much more highly reliable backup power at a cost that saves the telecommunications provider money while helping to address sustainability objectives. The telecom industry prides itself on innovation. Shifting to a greater use of fuel cells at communication sites has already happened and is another way telecom is improving the experience of the end user while addressing the bottom line.