Fuel Cell
A Critical Element for Telecom Site Power Optimization



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Introduction

Operators of telecom sites now have a clean, low cost approach to site power thanks to advanced cooling solutions, outdoor-rated telecom gear, efficient rectifiers and fuel cell backup products featuring low life cycle costs. Both green field and upgrade projects can take advantage of these solutions and benefit from lower power consumption, lower fuel costs, higher reliability and lower maintenance, as well as improved community relationships due to the quiet, low emission operation of the fuel cell systems. Estimated savings of 25% percent or more over five years are achievable by optimizing the site cooling system and power generating solution. This is highly significant considering the cost of base station energy for telecom operators can be as high as 40% of total network operating costs[1]. Additionally, improved reliability of site power contributes directly to higher operator revenue and improved customer satisfaction and retention.

Benefits

Operators, developers, and equipment suppliers are recognizing the high contribution of BTS (base transceiver station) energy consumption, estimated between 10% to 40%, on total network operating costs[1] (OPEX) and the benefits of optimizing these BTS energy requirements. The benefit of reducing BTS energy requirements are substantial; recent programs have demonstrated greater than 60% energy savings by implementing efficient cooling solutions[2,3,4]. These savings result in more funds for the operator to use on service differentiation, network expansion/modernization, improved quality of service, etc.

Additionally, the benefits of optimizing the BTS energy consumption include reduced waste of energy and a smaller resource footprint, lower carbon emissions, stable OPEX costs (reduced vulnerability to volatile fuel prices), and improved corporate sustainability image.

A key to optimizing the site energy requirements is the implementation of innovative fuel cell solutions which have their output power designed specifically for telecom sites, thereby dramatically reducing the site battery bank capacity and the cooling load associated with those batteries. These fuel cell solutions can additionally compound the operator's benefit by further lowering OPEX through reduced maintenance requirements, high reliability, and improved efficiency compared to combustion generators. Furthermore, IdaTech's unique ElectraGen™ ME fuel cell system, Figure 1, operates on HydroPlus™ liquid fuel which offers additional benefits of installation on roof tops and mezzanines due to its light weight and compact size, long autonomy (infrequent refueling = low refueling costs), and installation close to offices and residences due to their low emissions, quiet operation and environmentally-friendly fuel.



Figure 1. ElectraGen™ ME Fuel Cell System

Fuel cell systems can be flexibly deployed to enable the telecom company to reduce OPEX, improve network reliability, and improve community relationships and corporate image.

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Site Optimization

A good understanding of the BTS equipment, environmental conditions, daily network traffic pattern, and equipment power requirements is necessary for optimizing the energy requirements of the site. Data indicate that air conditioning systems for cooling of both batteries and radio gear are typically the largest single energy consumer on a wireless site; consumption of 30% to 60% of total BTS energy is reported[3,5]. Significant gains have been made on improving the efficiency and cooling requirements of radio gear, but the typical large battery banks still require high levels of energy for cooling. Implementing a built for purpose fuel cell system in place of large battery strings and/or combustion generators enables a reduced cooling load and, therefore, a reduction in the entire site load. This is because a fuel cell system only needs a small battery bank, and less batteries equates to a smaller cooling load. Strategies to reduce the cooling load include:

- Implement fuel cell systems. Fuel cell systems start quickly and efficiently follow the site load. Fuel cell systems only need a small battery for startup. Eliminating the large battery banks directly equates to a smaller cooling system requirement.
- Implementing efficient DC powered air conditioners and/or free-air cooling (using ambient air to cool the enclosure) will typically reduce the cooling requirement by 80% or more[4,5,6]. DC powered air conditioning equipment enables efficient operation of the cooling system even during periods when an AC (alternating current) power source is not available, for example during operation by a fuel cell system.
- Raising the temperature set-point of the cabinet/shelter is effective, but must be balanced against possible component lifetime reduction.
- Implementing outdoor rated and efficient telecom equipment to directly decrease the cooling load and reduce transmission losses.

Results from telecoms indicate that implementing free-air cooling reduces energy consumption of each BTS by 3500kW-h per year on average (400W continuous), and raising the temperature set-point of the shelter will save an additional 2750kW-h per year (over 300W continuous)[7]. Combined, over 700W of continuous power demand can easily be saved! Another study indicates savings of 3.6kW in instantaneous cooling load demand[2].

Once the cooling system has been optimized, the telecom should look to the power generating system, including the backup power system for important, additional OPEX savings. Implementing a fuel cell system, especially a liquid fueled system such as IdaTech's ElectraGen™ ME product, enables the operator to realize savings from operation at higher efficiency, lower cost of fuel, elimination of fuel theft, reduced maintenance costs, and higher reliability.

A 1 kW to 10 kW telecom site will typically employ a 12KVA to 30 KVA diesel generator. Diesel generators for telecom applications are over dimensioned because larger diesel generators have higher reliability, are readily available, are more difficult to steal, and can accommodate higher inrush currents. Peak efficiency of these generators often exceeds 20%, but efficiency quickly drops to less than 10% at power levels below rated output. Therefore, in most telecom applications, the generator will spend a large portion of time operating at low efficiency. In contrast, an ElectraGen™ ME system load follows and operates at over 30% efficiency and, because the output is more closely matched to the load, the system spends a majority of time operating at high efficiency.

Cost of diesel fuel continues to rise, and the volatility in price makes it difficult for telecom operators to predict and control OPEX. In some regions, diesel is currently sold at more than $2.70 per liter (over

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$10 per gallon), and this doesn't include the cost of delivery to the telecom site. IdaTech's ElectraGen™ ME system operates on HydroPlus™ fuel, Figure 2, a blend of methanol and water, which can be blended close to the point of use and in some cases can be produced from renewable sources, thereby enabling carbon neutral power generation. Methanol is primarily produced from natural gas, is one of the most widely distributed chemicals in the world, and is increasingly important as an alternative vehicle fuel. Global methanol manufacturing capacity continues to increase to support these new demands.

An additional benefit of HydroPlus™ fuel is that there are no other significant uses for this product, except as fuel for the ElectraGen™ ME system, and theft is therefore not an issue. In contrast, diesel theft is as much as 40% or more in some regions.



Figure 2. HydroPlus™ Fuel

A significant portion of BTS OPEX is the maintenance requirement of the diesel generator, Figure 3. Frequent oil changes, air, oil, and fuel filter maintenance, cooling system and belt maintenance, and maintaining the condition of the starting battery add significantly to OPEX. Scheduled maintenance of the ElectraGen™ ME system only consists of two cabinet filters, which are washable. Additionally, the simplicity and low number of moving parts in a fuel cell system contribute to high reliability and low levels of vibration transmitted to surrounding structures.

Maintenance Items	Service time				
	Daily	Weekly	Monthly	6 Months	Yearly
Inspection	X				
Check coolant heater	X				
Check coolant level	X				
Check oil level	X				
Check fuel level	X				
Check charge-air piping	X				
Check/clean air cleaner		X			
Check battery charger		X			
Drain fuel filter		X			
Drain water from fuel tank		X			
Check coolant concentration			X		
Check drive belt tension			X		
Drain exhaust condensate			X		
Check starting batteries			X		
Change oil and filter				X	
Change coolant filter				X	
Clean crankcase breather				X	
Change air cleaner element				X	
Check radiator hoses				X	
Change fuel filters				X	
Clean cooling system					X

Figure 3. Typical Diesel Generator Maintenance Schedule (Cummins Power Generation)

Power output of a fuel cell system is direct current and therefore directly compatible with BTS telecom gear and DC air conditioners, avoiding losses from DC to AC inverters. An additional benefit of replacing an AC generator (i.e., a diesel generator) with a fuel cell system is the possibility to decrease both the number of rectifiers and the size of the battery bank because the characteristic power surge from the AC generator is eliminated when the DC fuel cell system generator is implemented, Figure 4.

Batteries also present an opportunity to reduce OPEX. The traditional telecom solution is to implement large strings – typically 400 or more amp-hours capacity – of VRLA (valve regulated lead acid) batteries for backup. These large battery strings require air conditioning systems for cooling, and the associated air conditioners consume high amounts of power – typically 40% or more of the entire BTS load is for air conditioning[8]. VRLA batteries have a short life

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time (< 3 years) if not maintained at 25C and are often the target of thefts. For backup power, batteries can be deployed in a stand-alone configuration, or in combination with diesel generators. In a battery - diesel generator solution, a cycle charging scenario is typically employed in an effort to improve average diesel generator efficiency, but this requires even larger strings of batteries – often more than 1000 amp hours capacity – to carry the load while the diesel genset is off line. In contrast, an IdaTech ElectraGen™ fuel cell system starts quickly and operates efficiently while following the load, thereby foregoing the need for a large battery bank. Typically only a relatively small bridging battery of 100 to 150 amp-hour is required to carry the load while the fuel cell system is starting; a 60% or higher reduction in battery capacity. This need for only a small battery creates the possibility to implement advanced chemistry batteries such as lithium-ion which, although higher capital cost, are much more temperature tolerant, thereby reducing or eliminating the need for a cooling system. These batteries also exhibit significantly improved cycle life – 2000 cycles at 100% depth of discharge. And, because they don't "look" like a battery, lithium-ion batteries are less likely to be stolen.

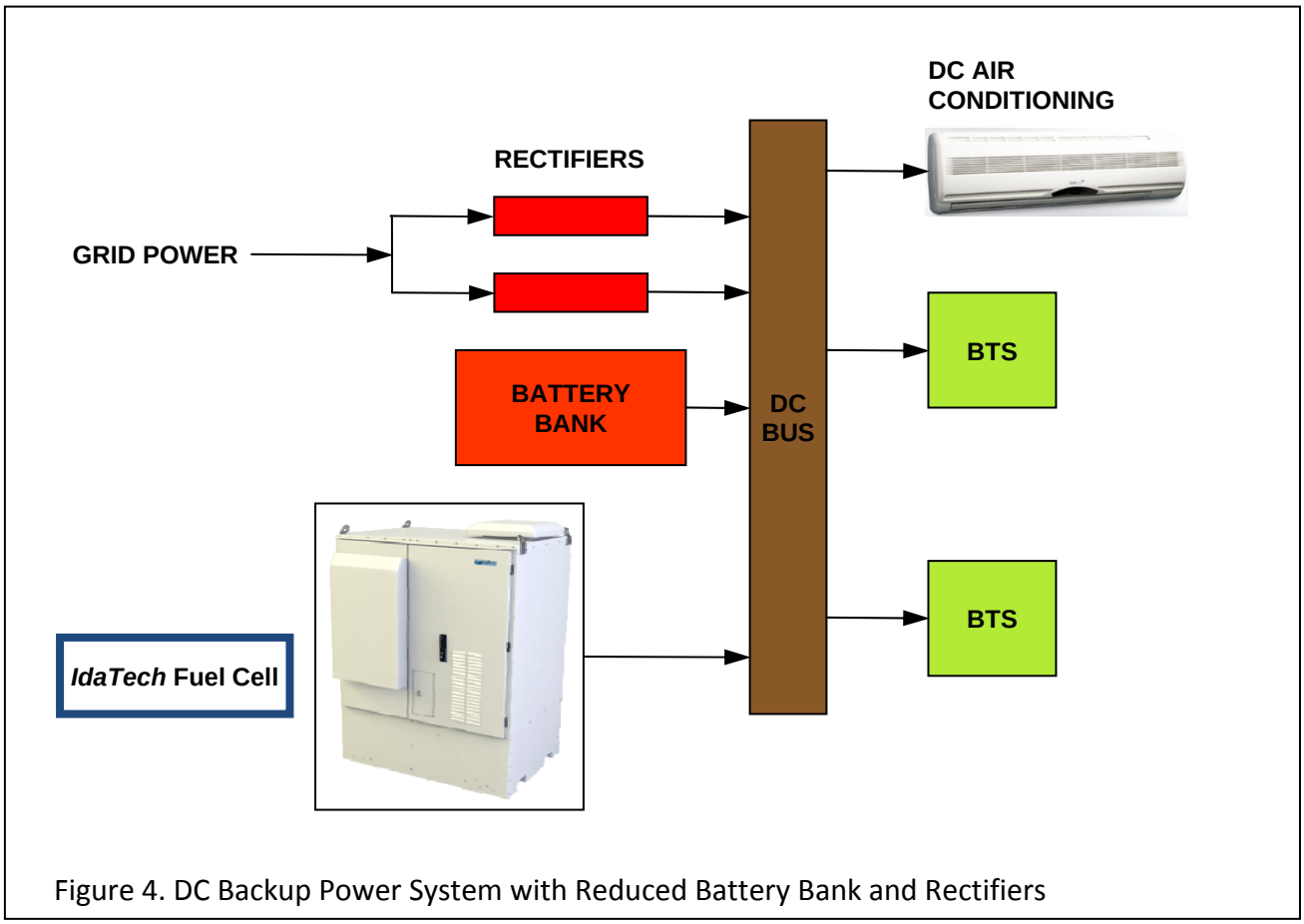


Figure 4. DC Backup Power System with Reduced Battery Bank and Rectifiers

The fuel cell system enables the following site improvements:

Fuel Cell	Benefit
Only a small battery for start up of the fuel cell system is required.	Reduced cooling requirement.
Fuel Cell is a DC Generator.	Replace traditional VAC (alternating current) aircon units with DC cooling solution and reduce site power consumption.
Possibility to use lithium ion battery.	Eliminate battery air conditioning system entirely. Extended lifetime battery – thousands of cycles possible.
Designed for telecom application with load following and efficient operation over power range.	Efficient operation and lower OPEX. Reduced rectifiers since power surge from AC generator is eliminated.
No market for the fuel, and fuel cell system only works for telecom applications.	Not an object of theft - reduced OPEX.
Light weight, low vibration, low emissions.	Easy to site on roof tops, near residences and businesses, environmentally friendly.

Examples

Among other tools, IdaTech utilizes a TCO (total cost of ownership) approach for evaluating whether the ElectraGen™ products are suitable for each application. These TCO analysis include capital and operating costs of all relevant site equipment including generators, batteries, and cooling equipment, as well as an evaluation of the total site energy requirement, including BTS, air conditioning, and lighting. In this way, the costs and benefits of an optimized cooling system, batteries, and fuel cell solution can be compared to traditional approaches (large batteries, diesel generators, cycle charging, etc.) for various operational scenarios. Output from a typical TCO for the Southeast Asia region is shown in Figure 5; note that this TCO does not include the benefit of the power saved by optimizing the site power. Even still, the estimated savings with an ElectraGen™ ME system over 5 years is nearly $13,000USD.

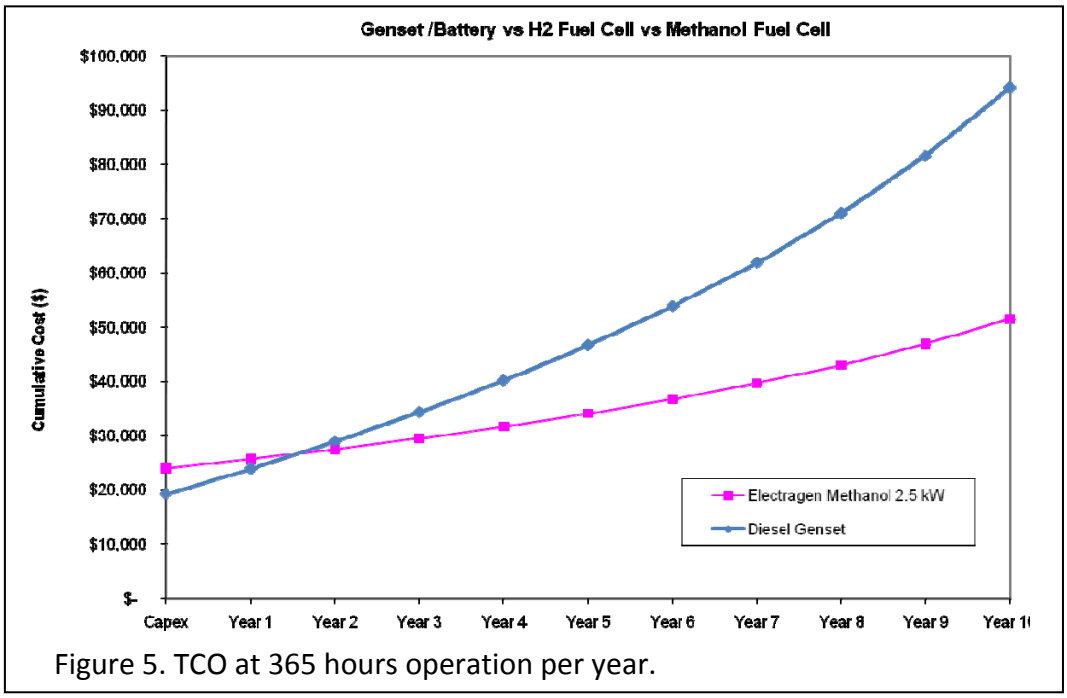


Figure 5. TCO at 365 hours operation per year.

Generally, these analysis demonstrate that the ROI (return on investment) for the ElectraGen™ ME system is within 2 years and is most sensitive to annual hours of operation. Typically operation of 300 or more hours per year will produce these favorable ROI results, Figure 6. If the benefits from improved BTS availability due to the high reliability of the ElectraGen™ ME system are included in the analysis, the ROI will typically be only 6 to 12 months.

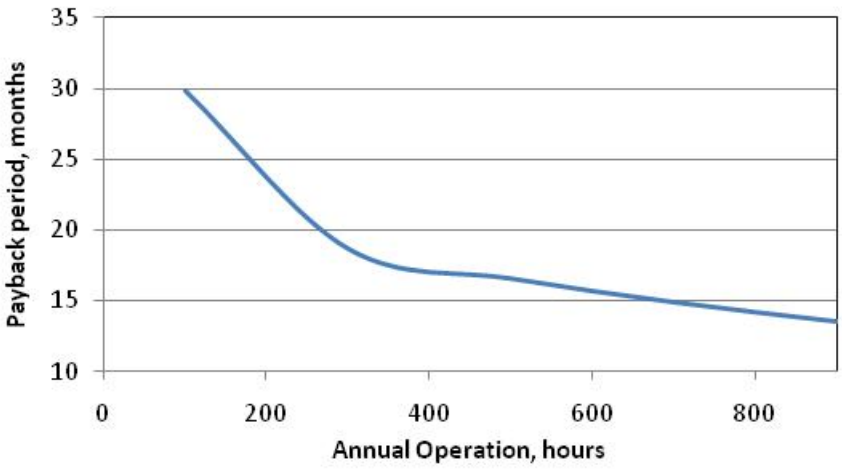


Figure 6. Payback period for ElectraGen™ ME System.

Conclusion

Telecom sites can be optimized for power use. Special attention should be paid to cooling systems, as these consume up to 60% of the total site power. Addition of a fuel cell system in place of the traditional battery and diesel genset solutions enables a 60% or more reduction in battery bank capacity, which similarly reduces the cooling load and even offers the possibility to implement advanced battery types which do not require any cooling. The combination of a fuel cell system and efficient cooling system can yield significant cost savings for the telecom in terms of reduced OPEX. This study has shown that the higher capital cost of a fuel cell system is typically paid back in less than two years and, if the benefits of improved site reliability are included, the payback period is accelerated.

In addition to the OPEX cost savings of low maintenance and high efficiency, the use of fuel cell systems as backup power solution will induce additional indirect savings:

- Improve site availability: increase revenues generated by site.
- Space saving: the foot print of the ElectraGen™ ME is less than the genset and fuel tank.
- Weight saving: ElectraGen™ ME is <500kG with fuel; considerably less than large battery banks or genset; no requirement for special reinforcement for roof top installation.
- Noise enclosure saving: low noise emission fuel cell system will not require noise enclosure and enables locating the system close to offices or residential neighborhoods.
- Rectifier redundancy saving: since fuel cell is a standalone DC power system it will not only back-up the grid supply but also rectifier in case of failure.
- Reduced number of rectifiers: since the current surge from the diesel generator is eliminated.

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- ATS cost saving: Fuel cell system does not required the use of costly and unreliable automatic transfer switches.
- Battery recharging cost: Power consumption cost to recharge battery and maintain the floating voltage is eliminated.
- Battery theft saving; using a small rack mountable Lithium battery to bridge the starting of the fuel cell will reduce cost associated with VRLA battery thefts.

The use of fuel cell system instead of standby diesel generators at telecom site will also improve relationships with local communities (less noise; vibration; pollution…) and will show commitment of the telecom to reduce its carbon footprint and emission level.

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