GEIG Product Description

2015

PRODUCT DESCRIPTION

SYSTEM OVERVIEW

GEI's *X5 Smart Adaptable Fuel Cell Auxiliary Power Unit™* (the "GEI X5") is a "hybrid" system that incorporates the following tightly integrated components:

- High temperature Polymer Exchange Membrane Fuel Cell (HTPEM) operating at 160C-180C.
  - Includes proprietary high temperature PEM stack with internal oil cooling for robust thermal management and high power density.
- High power density 48/96VDC Lithium Polymer energy storage system.
- High efficiency re-configurable power electronics.
- High efficiency architecture for extracting hydrogen from Natural gas and bio-renewable fuels.

Hybrid fuel cell power systems are inherently more fuel efficient and cost effective. Its systems integration topology, robust product design methodology, adaptability, high efficiency, and silent operation, combined with the significant fuel and maintenance savings drives the widespread commercialization of the GEI X5 *architecture*, and allows GEI the opportunity to capture a large share of the multi-billion dollar market for primary stationary, back-up, and on-board power markets, as well as portable APUs (Auxiliary Power Units).

HTPEM SCHEMATIC

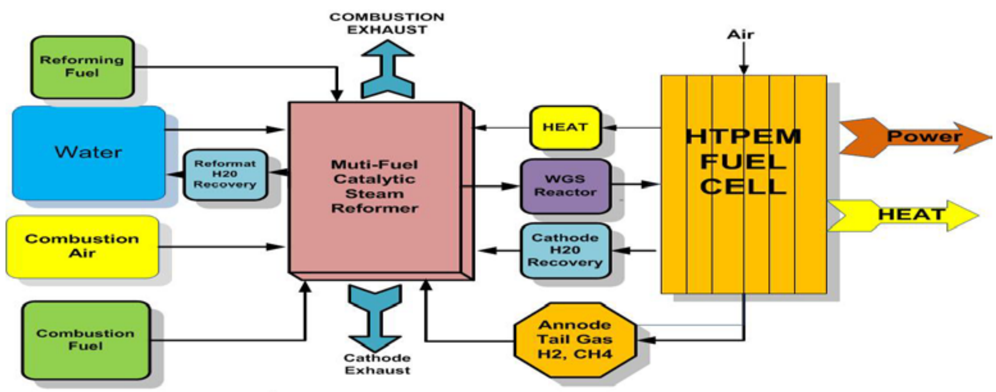
The key to maximize overall system efficiency is to minimize the energy required for extracting hydrogen from the input fuel supply. This hydrogen extraction technology is called '*Steam Reforming'* and provides the purest concentration of hydrogen gas from natural gas of about 80%, as compared to an alternate approach called '*Auto Thermal Reforming'* which provides about 45% hydrogen with very high concentrations of Nitrogen gas as a by-product. There is no Nitrogen gas by-product for Steam Reforming. Although Steam Reforming produces the highest hydrogen concentration, the negative consideration is the extra fuel required to produce the high temperature steam needed which reduces the system operating power generating efficiency (fuel IN to power OUT) to less than 30% and is unacceptable.

GEI recognized in 2012 that the commercialization of fuel cells for global primary residential and commercial power markets for developing nations, required a highly efficient technology for extracting hydrogen from natural gas and bio fuels to ensure the company's success. Toward this critical goal for commercialization, GEI developed the ***HYBRID HIGH TEMPERATURE PEM (HTPEM)***

FUEL CELL electric power generation technology which ensures the maximum possible steam reforming efficiency. Our technology removes the global fuel infrastructure as a commercialization barrier, since hydrogen is not readily available within global fueling markets.

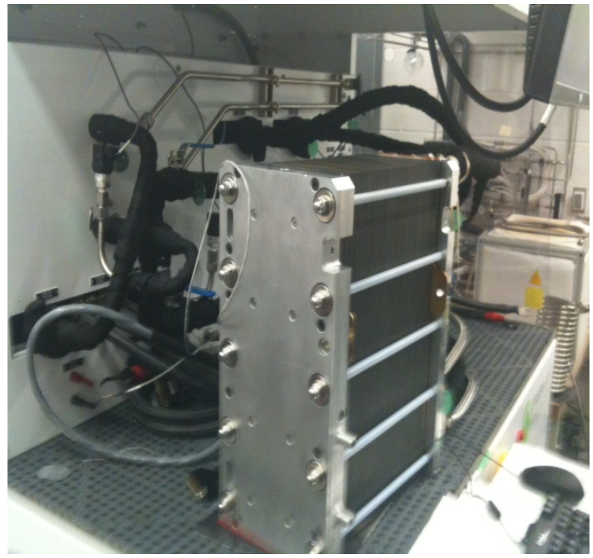
The figure below shows the overall component schematic of a tightly integrated HTPEM/steam reforming system including capturing of thermal energy contained within the fuel cell stack mineral oil coolant for steam generation, water capturing to ensure a near water-neutral system, capturing of the chemical excess energy contained within the fuel cell stack exhaust tail gas for heat recovery which results in decreased fuel consumption.

GEI Global has the only high temperature PEM fuel cell stack with an integrated high capacity mineral oil coolant that removes by-product heat (as a result of fuel cell electricity generation), and subsequently re-captures the excess heat for high purity hydrogen generation via steam reforming with natural gas and bio fuels. The advantage of GEI Global's integrated fuel cell electric power generator for steam reforming of natural gas is an increased overall system efficiency (fuel IN to power OUT) from 22% to 48% and resulting in high concentrations of hydrogen with minimum by-products. Additionally, when operated in a combined heat and power mode results in a thermal efficiency of 91%+.



An important benefit of GEI's HTPEM fuel cell power generation system is an increased tolerance to less pure fuels, resulting in a more robust fuel cell electric power generation system at a cheaper cost and in a smaller fuel processing package.

Summary



The GEI GLOBAL integrated internal fuel cell stack high heat capacity oil coolant system (active cooling) provides for a superior technology for managing thermal gradients and ensuring uniform fuel cell plate-to-plate temperatures. Considering the high dependence on uniform stack temperatures for maximizing stack power, the GEI thermal managing technology provides for a significant competitive advantage for maximizing HTPEM fuel cell stack power density (i.e. kW/Liter). For example, other HTPEM fuel cell providers have adopted either air cooling or intermittent liquid cooling blocks (passive cooling). Both methods are inadequate for managing thermal gradients for high power density HTPEM fuel cell stacks with a large active membrane area. These limitations restrict HTPEM stacks with air and passive cooling technology to operating at low current densities of 150-200 mA/cm^2 while the GEI HTPEM active cooling stack technology allows operation at a 50% higher power density. The higher power density provides for both a higher stack power output with a smaller stack footprint, and at a lower cost. The more uniform plate-to-plate temperatures also extends fuel cell membrane durability, as well as, extends overall fuel cell stack life.

The internal fuel cell stack cooling also serves as a high temperature heat source for the GEI steam reforming technology for extracting hydrogen from natural gas. The GEI systems integration technology allows for the perfect thermal matching of the fuel cell power system with the steam reforming hydrogen extraction system which would normally require consumption of fuel to provide the necessary heat source for steam reforming. Leveraging the fuel cell stack coolant as a high temperature heat source at 160C allows GEI's tightly integrated steam reforming system to operate at a high thermal efficiency of > 90%, which increases the overall system efficiency to > 48%.

FUEL CONSUMPTION

The GEI fuel cell HTPEM technology will have the following natural gas (98% Methane) fuel consumption:

- = 215 liters/ kW-hr
- = 8.5 ft^3/kW-hr
- = 8.5 $x10^3$ BTU/kW-hr
- = 8.5 $x10^{-2}$ Therms/kW-hr

For example, a 25 kW HTPEM fuel cell stack provides 600 kW-hr per day. Thus the natural gas fuel consumption will be 5,100 ft^3 of natural gas per 24 hour day (i.e. 600x8.5). If the cost of natural gas is say \$0.009 per ft^3 (\$9/1000 ft3) for a certain area, the expected operating cost is \$45.9 per day ($600\frac{kW-hr}{day}\bullet\frac{8.5\,ft^3}{kW-hr}\bullet\$0.009/\,ft^3\bullet=\frac{\$45.9}{day}$), or \$0.0765 cents per kW-hr.

Comparatively, the UTC PureCell 400kW natural gas fuel cell system consumes 9,000 BTU/kW-hr as compared to the GEIG fuel cell power system which consumes 8,500 BTU/kW-hr.

Size

The GEI X5 topology is comprised of the following physical units:

GEI Product Size and Weight				
	5kW		25kW	
COMPONENT	**Size**	**Weight**	**Size**	**Weight**
HTPEM Fuel Cell Stack Power System	48"x36"x36"	300 lbs.	60"x48"x48"	450 lbs.
LIPO Battery Storage	10" x18"x 6"	60 lbs.	10"x18"x12"	80 lbs.
Power Electronics and Controls	12"x12"x6"	40 lbs.	12"x12"x6"	60 lbs.
Fuel Processing	12"x12"x24"	200 lbs.	48"x48"x48"	300 lbs.

VOLTAGE OUTPUT

The GEI HTPEM fuel cell power system provides for multiple power output channels that are programmable through software. The GEI patented high-power DC/DC electronics converter provides for both multiple input with multiple variable-power output channels.

The unregulated voltage output is 48VDC for the 5kW power systems with a maximum current limit of 150 amps. While the unregulated voltage output is 96VDC for the 25kW power system with a maximum current limit of 350 amps. Both systems can be configured with additional pre-programmed constant power output channels for user specific loads and conditions such as external remote DC battery charging and/or regulated AC residential power. The AC power output can be either 120/240 VAC single phase, or 480 VAC three phase.

ENERGY STORAGE

GEI Global has advanced the development of the **L**ithium **P**olymer **H**igh **P**ower **D**ensity (LIPO-HD) battery energy storage module as an energy storage buffer between the fuel cell power system and the external user's load demand. The 4.8 kW 100 Ah (amp-hour) LIPO high density energy storage module provides instant fuel cell system start, instantaneous system load response to any user current spike request, and while protecting the underlying mechanical and sensitive electrical power generation components from unexpected damaging external load spikes.

The table below provides an overview of the GEIG Lithium Polymer battery high density performance characteristics which has the highest performance available on the market.

GEIG Lithium Polymer HD Performance Characteristics				
Capacity (Ah)	Discharge Current (A)	Volts/Cell	Weight (kg/cell)	Power Density (Wh/kg)
40	200	3.7	0.90	164
100	200	3.7	2.07	179
200	400	3.7	4.18	177
240	480	3.7	4.78	186

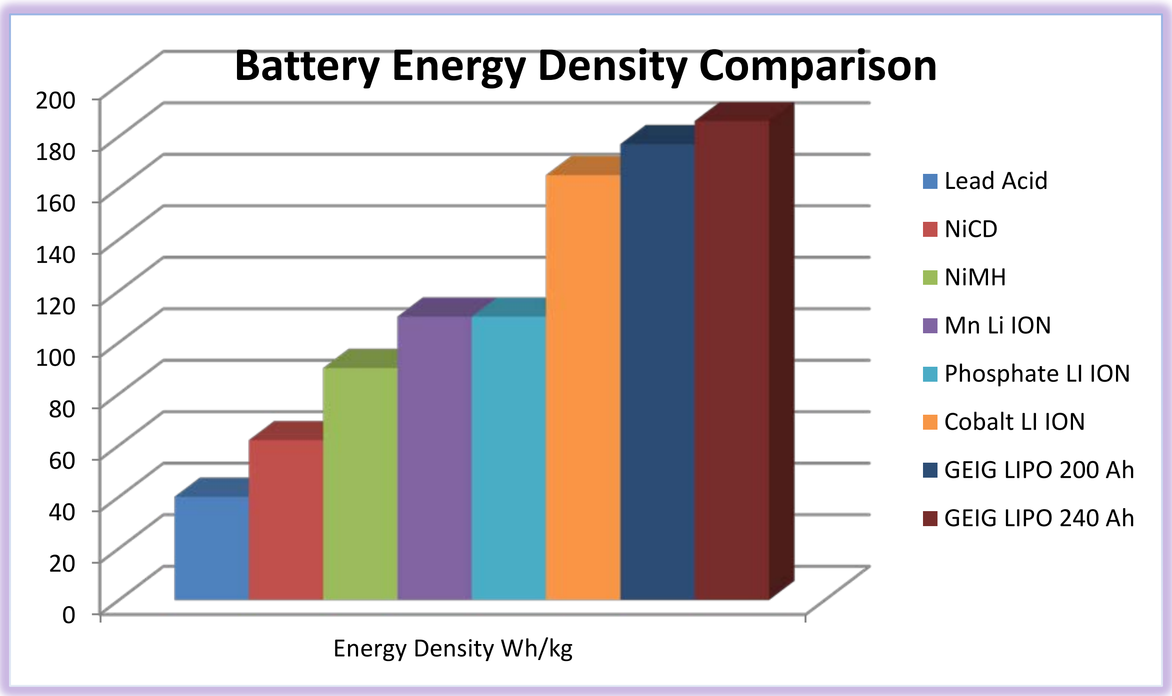
DEFINITION OF ENERGY DENSITY AND POWER DENSITY

Energy Density (Wh/kg) is a measure of how much energy a battery can hold. The higher the energy density, longer runtimes are possible. Typical applications are cell phones, laptops and digital cameras.

Power Density (W/kg) indicates how much power a battery can deliver on demand. The focus is on power bursts, such as drilling through heavy steel, rather than runtime. Batteries with high power density are used for power tools, medical devices and transportation systems.

An analogy between energy and power densities can be made with a water bottle. The size of the bottle is the energy density, while the opening denotes the power density. A large bottle can carry a lot of water, while a large opening can empty the water bottle. The large container with a wide mouth is the best combination.

The chart below is a comparison of various battery chemistry available today for different applications.



The energy density provides a way to compare the performance of different energy storage technologies. GEI Global constantly seeks to advance its' battery technologies to complement our market advantage which is the design innovation and system integration knowledge for high density energy storage, power management, controls and power distribution.

The advantage of the GEIG LIPO high density energy storage module and controller, shown to the right, when integrated with a 24 kWh (8-hour solar day) solar energy residential power plant is an initial reduced cost, continued lower operational cost, as well as, an overall smaller physical footprint than other battery storage technologies. For example, the physical size of the GEIG LIPO energy storage module is 20"x15"x12" and provides 20 kWh per day. Within the size of a small airline carry-on luggage, the GEIG 20kWh LIPO battery module provides sufficient capacity for an average size US home for 24 hours without the electric grid or solar assist.

The 24kWh solar power array provides an average of 8 kWh (8-hour solar day) for normal house hold operations, and 16 kWh (8-hour solar day) for battery charging for non-solar operations. If solar or wind charging is not possible due to non-ideal weather conditions, battery charging is directly from the grid, which serves entirely as backup. But during normal daily operations, the average residual home is completely green and operates off-grid with energy to spare.

Other applications include:

- Energy storage buffer for fuel cell electric power systems,
- Back-up high energy density storage medium for commercial scale solar, wind, and other intermittent renewable energy resources,
- Portable solar AC motor drive systems for 24/7 rural irrigation pumps,
- Earth friendly residential solar and wind homes for the Caribbean islands and Dubai,
- Solar and wind powered electric vehicle charging stations; home and commercial,
- Green LED lighting and agricultural growth
- 24/7 security solar monitoring systems for remote areas, and
- Remote 24/7 solar cell phone tower power systems for developing countries such as Africa and India.

In summary, the GEIG LIPO high density storage medium allows for instantaneous load spikes without impacting the fuel cell stack and balance-of-plant mechanical components, both systems incorporate a high power density Lithium Polymer (LIPO) battery for energy storage. The LIPO energy storage provides a discharge capacity of 100 amp-hours with a maximum current draw of 500 amps for 30 minutes. This strategy allows the GEI fuel cell power system to be load-following and also protects the fuel cell stack for electrical and chemical stresses which extends the fuel cell stack life.

ENVIRONMENTAL EMISSIONS

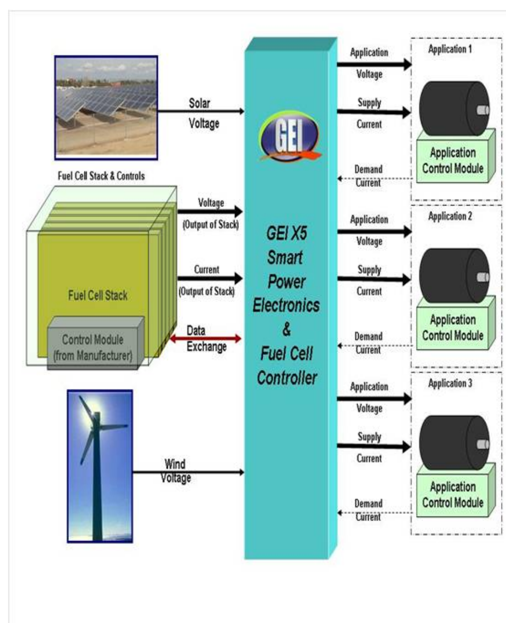
Due to re-capturing of the fuel cell stack exhaust and due to close monitoring of the steam reforming exhaust, the oxygen-to-fuel mixture is carefully controlled to minimize harmful by-products. The table below provides a summary of the expected system emission components.

Emission Data	
Component	Lb/MW-hr
NOx	0.02
CO	0.02
VOC	0.01
CO2	800

Additionally, considering that GEI's steam reforming technology leverages the fuel cell stack coolant for steam generation, there is inherently fewer combustion by-products by design.

SOLAR INTEGRATION

There also exists the option to integrate the GEI ***HTPEM Fuel Cell Power Systems*** with an auxiliary solar grid due to the 'Hybrid' configuration of the GEI power generation technology. In this operational mode, the GEI fuel cell system is designed to integrate seamlessly with other alternative energy systems such as solar and wind and would reduce the use of natural gas, depending upon environmental conditions and the size of the solar grid, to 3-4 cents per kW-hr. The system would operate 24-7 and represents the optimum in power generation efficiency.



Although there is much interest in solar and wind and possible solutions to our energy shortages, most fail to understand the impact to the electric grid of variable output energy sources. The electric grid must be viewed as a very large system with high public expectations for reliability and precise operational requirements to maintain power quality. Wind and solar generators can change output quickly, and accuracy in forecasting output is limited, raising two expensive operational problems.

First, the grid requires fast responsive energy reserves to compensate and stabilize the flow of electricity as these wind and solar renewable sources vary. Typically, electricity systems are constructed with 15% reserves to respond to fossil fuel or nuclear outages. Wind and solar, however, must be backed by 80%-90% reserves. Consequently, a 2nd backup generator must be installed and maintained on immediate standby. The true installed cost of of wind and solar resources is far higher than the cost of the renewable generator itself.

Second, moment-to-moment changes in wind and solar isolation mean that the compensating fossil fuel generators are not operated at a constant optimum design point resulting in higher fuel and maintenance cost, and emissions, per unit of electricity. Therefore, on a systems basis, any claim that renewable energy delivers free and totally clean energy is somewhat misleading as a base load resource. In addition to these operational considerations, the best sites for wind and solar generators are typically far from load centers and requires an installed transmission infrastructure. However, a distribution infrastructure is not required for efficient fuel cells operating on local infrastructure fuel sources.

The global energy demand is expected to increase by 1/3 between 2010 and 2035, and the GEIG power generation technology represents the energy bridge infrastructure that optimizes the use of solar, wind, and fuel cells to provide renewable energy stability while minimizes the use of infrastructure fuels. Without a bold change in policy direction, the world will lock itself into an insecure, inefficient, high-carbon energy system. The GEI ***HTPEM Fuel Cell Power Systems*** represents an advanced hybrid fuel cell technology designed for high efficiency, fuel flexibility, application adaptability, and concurrently reducing the global carbon footprint. Future expansion can also be as large as several kW due to the scalable nature of the GEI fuel cell power systems *architecture*.

SUMMARY

Our future vision of GEI GLOBAL is a global supplier of energy solutions to meet the world's desperate need for efficient, near zero emissions, and multi-fuel power systems. GEI will leverage its market superiority in advanced high temperature PEM fuel cell power systems technology combined with manufacturing scalability to ensure this reality.

In addition, GEI GLOBAL will provide fuel cell energy solutions for developing countries that leverage renewable energy sources such as wind, solar, tidal, and bio fuels. By utilizing renewable energy sources, fuel cells can become an economical source of power, heat, and water, and can contribute rapidly toward the improvement of economic, health, agricultural, and social conditions for the 60% of the world's population without affordable and plentiful power.