The ultimate solution for maintaining your nationwide generator network

Hydrogen Fueled Engines for Generator Systems

1.0 Introduction:

Hydrogen is the universe's most abundant element and widely known for its combustion and lighter than air properties. However, unlike coal, petroleum, and methane the fuel sources that have been predominately used since the start of the industrial revolution, it is rarely found in its natural state. Hydrogen must be extracted from chemical compounds, of which methane and water are commonest sources. One feature of hydrogen that is again, thrusting it into the lime-light, is its ability to burn with water as the by-product of combustion, unlike traditional fuel sources where a high bi-product of combustion is carbon-based compounds such as carbon dioxide. Hydrogen for many years has been used as a fuel to improve combustion and more recently used as a primary fuel source on some large engine driven generator systems

This information sheet discusses the advantages of using hydrogen for power generation, the difference between blue and green hydrogen, and the technology to deliver and store hydrogen economically.

Types of Hydrogen & Hydrogen / Renewable Energy Micro Grid Systems

Blue Hydrogen Produced From Methane with CO2 Produced in the Process

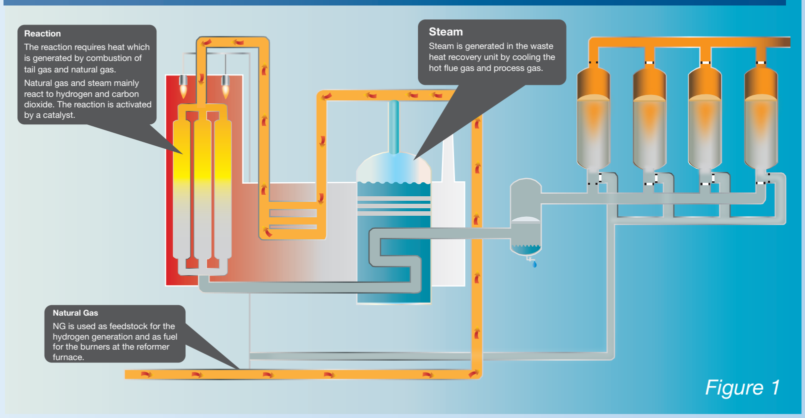

Figure 1

Green Hydrogen with Zero Carbon Using Electrolysis & Renewable Energy

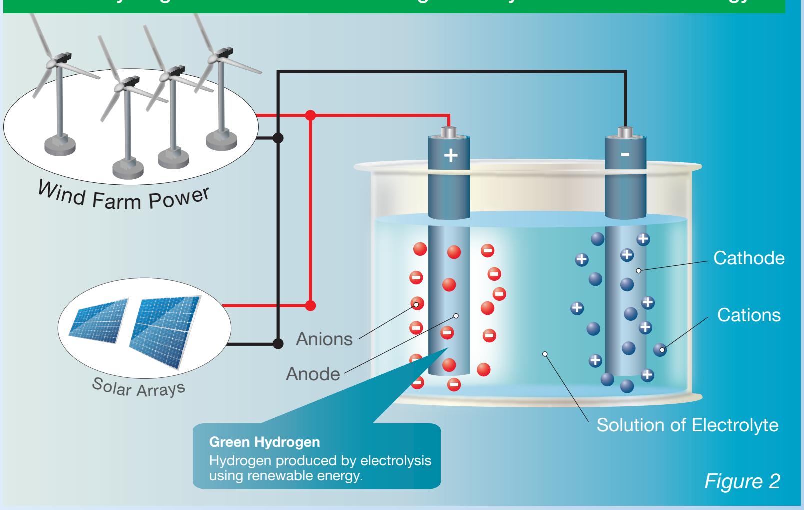

Figure 2

Typical Micro Grid System with Zero Carbon

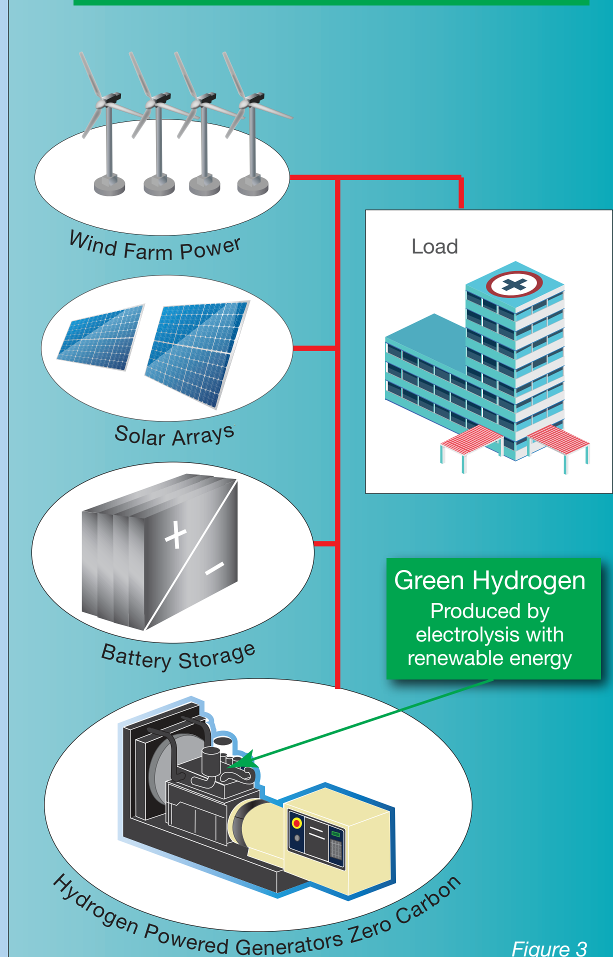

Figure 3

To fulfill our commitment to be the leading network service provider in the Power Generation Industry, the USA, Inc. team maintains up-to-date technology and information standards on Power Industry changes, regulations and trends. As a service, our **Information Sheets** are circulated on a regular basis, to existing and potential Power Customers to maintain awareness of changes and developments in engineering standards, electrical codes, and technology impacting the Power Generation Industry.

2.0 Why Consider Hydrogen for Power Generation:

Since the turn of the last century, hydrogen fuel technology had been established as a method to generate electrical power either as the fuel source for an internal combustion engine or the fuel for fuel cells. Other fuels proved to be more convenient and economical, resulting in most engine driven generator systems using fossil fuels for Spark Ignition (SI) or Compression Ignition (CI). With fossil fuels, carbon is a primary product of combustion when there is a global push to obtain zero carbon emissions. Since bodies such as the EPA in the US have started to regulate exhaust emissions, there has been a renewed interest in hydrogen as a fuel for the following reasons

2.1 Low to Zero Carbon Exhaust Content – When hydrogen burns on a power stroke two atoms of hydrogen combine with one atom of oxygen in the inlet air to form water, H_2O. The result is a fuel source that is carbon zero. Even with huge advances in engine combustion and developments in exhaust aftertreatment technology, most internal SI and CI combustion engines are not carbon zero emitters. Adapting engines to run on Hydrogen would reduce the need for exhaust aftertreatment systems.

2.2 Fuel Efficiency – Hydrogen burns 10-times faster than diesel. The amount of energy produced by hydrogen, per unit weight of fuel, is about three times the energy contained in an equal weight of gasoline and nearly seven times that of coal.
Hydrogen has a wide flammability range in comparison with all other fuels. As a result, hydrogen can be combusted in an internal combustion engine over a wide range of fuel-air mixtures. A significant advantage of this is that hydrogen can run on a lean mixture. Hydrogen has very low ignition energy.

3.0 The Disadvantages of Using Hydrogen:

There are two major hurdles to the wider adoption of hydrogen as a fuel, producing it and delivery/storage.

3.1 Producing Hydrogen – The two primary sources of hydrogen are methane and water.

- **Methane -** The chemical formula is CH_4. Methane reacts with steam H_2O under pressure to produce hydrogen, carbon monoxide CO and a small amount of carbon dioxide CO_2, see ***figure 1***. This method produces carbon as a bi-product and while hydrogen may burn carbon zero, as a fuel if this method is used to produce it there is no net reduction in carbon emissions. This hydrogen is called blue hydrogen. A similar process is used to make hydrogen from coal, and that is called Gray hydrogen. Blue and Gray hydrogen are not seen as climate friendly.

  Hydrogen can also be produced by the catalytic decomposition of methane at very high temperatures called methane cracking with zero harmful emissions. As this technology develops it may be a viable source of hydrogen.

- **Electrolysis of Water -** Electrolysis of water is the process of using electricity to decompose water into oxygen and hydrogen gas by a process called electrolysis, see ***figure 2***. An electrical current passed through two electrodes inserted into water to separate hydrogen from the water.

  How much carbon is produced in the electrolysis process depends on how the electricity to produce electrolysis is generated. If it was the product of a coal or natural gas power station, it would be classified as blue hydrogen. However, if renewable energy sources such as wind or solar were used it would be considered green hydrogen.

3.2 Delivering and Storing Hydrogen – The unique qualities of hydrogen present challenges for delivering and storing the hydrogen to fuel the prime mover.

- **Delivery -** Generator systems have fuel delivered and stored as a liquid (Diesel, LPG and Gasoline) or compressed (Natural gas). Currently there is not a delivery system set up to manage large scale distribution of Hydrogen. Hydrogen will be delivered to site by trucks equipped to manage storage and delivery of Hydrogen.
- **Storage -** Storage of hydrogen as a liquid requires cryogenic temperatures because the boiling point of hydrogen at one atmosphere pressure is −252.8°C. Hydrogen can also be stored on the surfaces of solids (by adsorption) or within solids (by absorption). If using it as a direct fuel to a vehicle it must be stored on board and must be pressurized (in some cases to five or ten-thousand psi) or liquefied to have an appropriate driving range.

4.0 Where Hydrogen is Currently Used in Power Generation:

Several engine manufacturers in the world, including those in the US, have already adapted some of their engines to run on full or partial hydrogen. Engine types vary depending on the original ignition system:

4.1 Diesel Engine Adaptation – Hydrogen can ignite through compression ignition (CI). Early adaptations of hydrogen was using it as an additional fuel to diesel to improve efficiency, lower carbon emissions, and improved power.

4.2 Gaseous Engine Adaptation – Hydrogen can replace carbon fueled engines designed for spark ignition (SI). Some components must be changed due to the embrittling effect of hydrogen on some metals. Again, engines to date have two versions:

- **Partial Hydrogen -** Several engine manufacturers offer the option to have fuels, such as methane and bi-gas, be supplemented with hydrogen. Typical installations include waste-water treatment centers.
- **Total Hydrogen -** Some manufacturers of larger engine generator systems, 1MW and above, already offer generator systems where the prime mover runs totally on hydrogen for zero carbon emissions.

5.0 Micro Grid Systems Employing Hydrogen Fueled Generator Systems:

To be zero carbon a system must be self contained and away from the current grid system. A growing number of applications are being installed as Micro Grid systems. This is where all power provided is generated locally with no connection to the usual utility grid, see ***figure 3.*** Applications include data centers, island communities, new independent developments, secure locations, and smaller towns.

In a micro grid system, as illustrated in ***figure 3***, hydrogen could be created on-site using electrolysis generated by renewable energy, an application as illustrated would have zero carbon as related to power required for all electrical loads.

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