

Gas Generation for the Future

VERDE LLC



Summary

- As the Three-Time “Best of Boston” Award Winner, VERDE LLC has extensive experience in designing, manufacturing, building and installing Gas Generation Plants; especially Hydrogen Generation Plants from Electrolysis, NG Reforming, Methanol or Ammonia Decomposition, and several others.
- VERDE LLC is headquartered in Massachusetts, USA.
- VERDE has numerous partnerships, representatives, and Gas Plant Installations in countries around the world.
- Since 2007, VERDE has moved into Renewable Energy, and established strong relationships with the US Department of Energy, National Renewable Energy Laboratory and a number of Renewable Energy institutions.





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VERDE Product Lines



Renewable Energy Market



VERDE Solutions



Business Opportunities

<http://www.verdellc.com>





VERDE Product Lines

Verde LLC delivers a reputable and highly efficient world accepted Gas Product Lines. With the best rates and a highly trained staff, we guarantee to meet your needs and work with you to obtain your project goals with the highest standard of customer satisfaction. Below are some of our customers:

US Army Research Lab
NASA
Sandia National
Laboratories
NIST
NRC-Canada

UC, Berkeley
MIT
UIUC
Duke University
University of Iceland
Los Alamos National Labs

Honeywell
Air Product
CIBA Vision Corporation
Lucent Technologies
Sharp Microelectronics





VERDE LLC. Community

Verde has been bringing forth the latest advancements in all fields of gas generation technology and has recently added the clean energy sector to its industry. Verde was founded by a group of engineers that realized the importance of research and development for the better of mankind. Our dream at Verde is to bring earth to a cleaner, healthier state at rates that everyone can afford.



VERDE Product Lines

■ Hydrogen from Electrolysis



H ₂ capacity	2 - 500 Nm ³ /h
H ₂ purity	> 99.9%
Power consumption (DC)	< 4.5 kw.h/m ³ H ₂
Work pressure	0.5 - 3.0MPa

- Electrolysis is the passage of a direct electric current through an ionic substance that is either molten or dissolved in a suitable solvent, resulting in chemical reactions at the electrodes and separation of materials.

The main components required to achieve electrolysis are:

- An electrolyte: a substance containing free ions which are the carriers of electric current in the electrolyte
- A direct current (DC) supply: provides the energy necessary to create or discharge the ions in the electrolyte
- Two electrodes: an electrical conductor which provides the physical interface between the electrical circuit providing the energy and the electrolyte



VERDE Product Lines

■ Hydrogen from Natural Gas Reforming



H ₂ capacity	50 - 20,000 Nm ³ /h
H ₂ purity %	99 - 99.999%
Work pressure	1.3-2.0MPa

- Prior to pressurization, desulfurization, and mixing with aqueous vapor, natural gas is passed through a special reformer which is packed with a catalyst for cracking and reforming the effluent mixture of hydrogen, carbon dioxide and carbon monoxide. After part of the heat is recovered, hydrogen will be obtained by removing excess carbon monoxide from the reformed effluent. The shift gas is then purified further through pressure swing adsorption (PSA), to obtain pure hydrogen.

Technical Features

- Low operating costs mean your investment is recovered in a short period of time.
- The desorbed gas from PSA can be burned; which can both reduce the fuel consumption and decrease the ventilation of the waste gas.
- Safe and reliable operation
- Highly automated



VERDE Product Lines

■ Hydrogen from Methanol Decomposition



H ₂ capacity	5 - 3,000 Nm ³ /h
H ₂ purity %	99-99.9995%
Work pressure	0.8-2.0MPa

On board methanol reforming has a couple of advantages over other potential fuels:

- Unlike gasoline or diesel fuel, liquid methanol can be readily produced from biomass
- Easily adaptable to the current infrastructure
- Easily transported and stored
- Last but not least, methanol has a high hydrogen density

Technical Features

- Methanol is converted to CO and H₂ with the action of the catalyst
- CO and H₂O are converted to CO₂ and H₂ with the action of the catalyst
- CO₂ and trace CO are separated from the decomposed gases by PSA technology and high purity of H₂ is generated



VERDE Product Lines

■ Hydrogen from Ammonia Decomposition



- VERDE's Hydrogen Generator by Ammonia Decomposition with Purifying System has a very low cost, long service life, simple operation, compact structure, small coverage, and very simple to installation. Liquid ammonia is used as the source for this hydrogen generator.

Technical Features

- VERDE uses high-quality, heat-resistant, corrosion-resistant, stainless steel alloy as the gill of the decomposition furnace to ensure the long-term stable operation of our Hydrogen Generators
- Great efficiency, all of the metal components are equipped with double-fin heat exchanger material to fully enhance the heat transfer area
- The high temperature nickel catalyst allows for a low content of residual ammonia and highly effective decomposition

H ₂ capacity	5 - 500 Nm ³ /h
Impurity Oxygen	≤2ppm
Residual Ammonia	≤3ppm
Work pressure	0.05-0.2MPa



VERDE Product Lines

■ Nitrogen Generation by Pressure Swing Adsorption



N ₂ capacity	1 – 3,000 Nm ³ /h
N ₂ purity %	95 - 99.999%
Work pressure	≤0.8 MPa

- The PSA Nitrogen generator obtains N₂ by using pressure swing adsorption principles at normal temperatures, along with clean compressed air as raw material and a carbon molecular sieve as the adsorbent. This is achieved due to the different rate of adsorption of oxygen and nitrogen on a carbon molecular sieve's surface as well as different diffusion rates through the open/close of the program control valve

Technical Features

- Rapid response: qualified Nitrogen can be produced in 15-30 minutes
- Efficient molecular sieve filling and long service life along with stable and adjustable pressure, purity and flow allows the product to meet many different customer requirements
- Reasonable structure, advanced process, safe and stable with less consumption
- Fully automatic operation



VERDE Product Lines

■ Nitrogen Generation by Membrane Separation



N ₂ capacity	1-1,000 Nm ³ /h
N ₂ purity %	95 - 99.99%
Work pressure	>0.8 MPa

- The compressed air filters through the polymer membrane filters, which separate the gases due to differences in solubility and proliferation rate. According to the characteristics, various gases can be divided into two categories: "rapid gas" and "slow gas." After being compacted and purified (to remove oil, water and dust) the air will enter the membrane separator to obtain nitrogen.
- **Technical Features**
- Simple start-up and shut-down procedure; in less than 2 minutes the system reaches normal and stable gas supply
- No moving parts: minimal maintenance required
- Lightweight, compact structure and small coverage



VERDE Product Lines

■ Liquid Nitrogen Generating Plant



- VERDE Liquid Nitrogen Generators are top of the line systems. Our Generator applications range from 5- 8,000 liters of LN₂ per hour

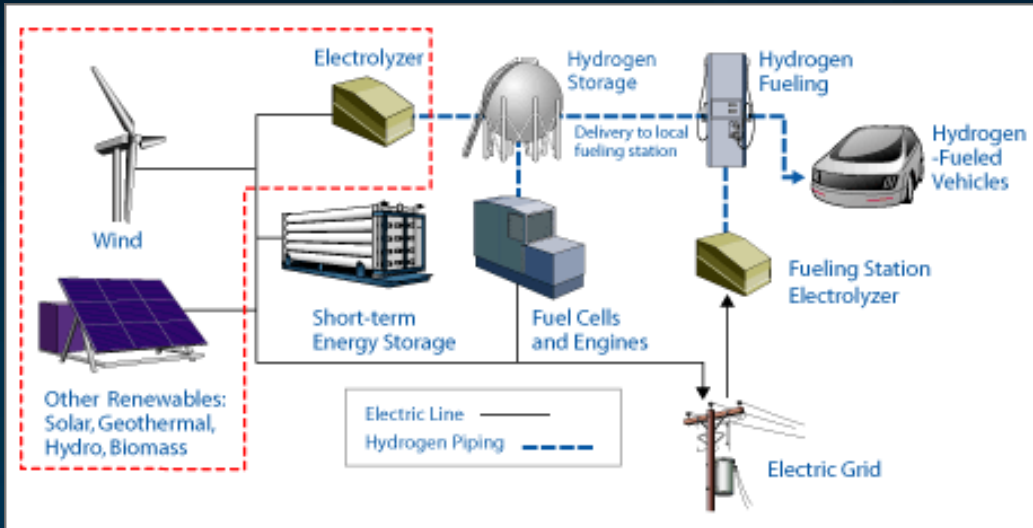
Cryogenic Engine features:

- Fully Automatic cold head with integral controls
- Includes high efficiency frequency drive with water cooling or optional air cooling
- Fully automatic PLC based controls provide many features and modes including auto start, timed run, auto purge, etc

LN ₂ capacity	5 – 5,000 liters/hour
LN ₂ purity %	95 - 99.999%
Work pressure	0 - 2 MPa



Looking into The Future





Renewable Energy Market

-Three significant Problems

1. Lack of infrastructure

- ❖ In the US, \$300 Billion Dollars is needed to connect all potential wind farms

2. Intermittency of renewables

- ❖ In NY state, wind farms have to be disconnected frequently in order to protect Grid Network from over-production.
- ❖ The same problem occurs throughout the US.

3. Other unnecessary losses

- ❖ 8%-15%* loss in the electricity distribution.

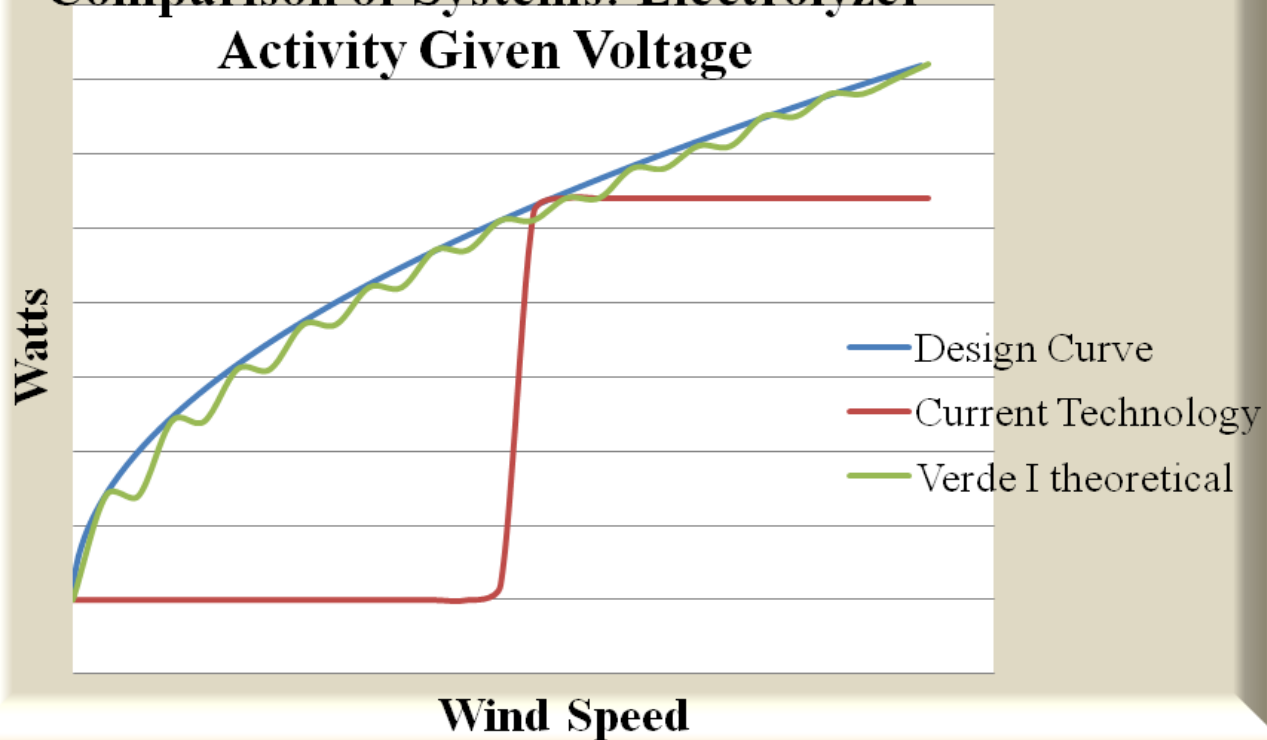
* Source: IEC(International Electrical Commission), 2007-2009, "Efficient Electrical Energy Transmission and Distribution"



VERDE Solutions

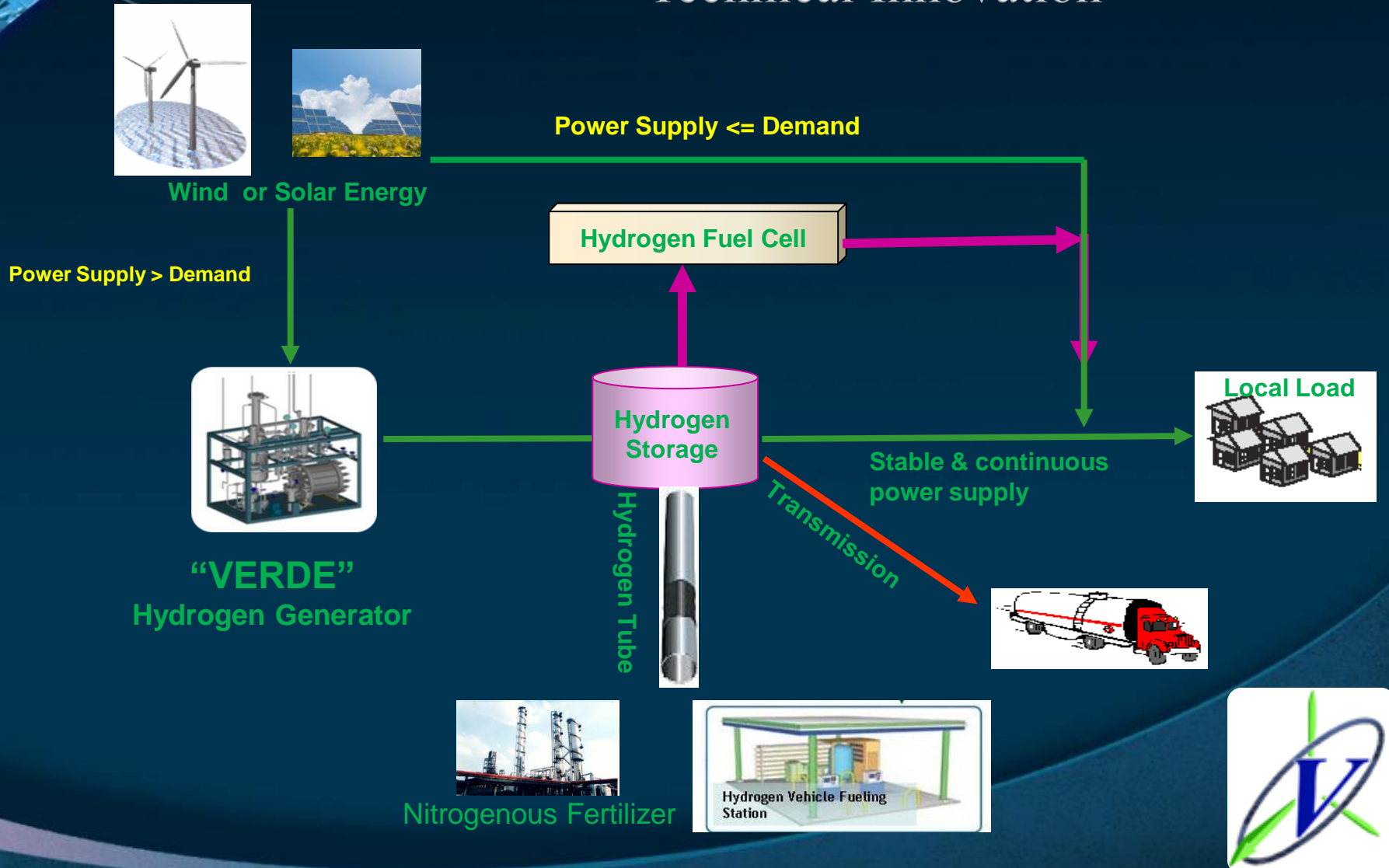
Our Patent*: The Electrolyzer is the *1st* Hydrogen System in the world that is directly driven by Intermittent Renewable Power.

Comparison of Systems: Electrolyzer Activity Given Voltage



VERDE Solutions

- Technical Innovation



Business Application

- Residential System



Public Acknowledgement

Fuel from Thin Air

OCT 22, 2012

You can't just make valuable resources such as fertilizer and fuel out of thin air. Or can you? Several companies are looking into innovative solutions that sound like they were ripped from the pages of a sci-fi novel.

For example, **Massachusetts-based Angetrom Advanced** has a project in late-stage development that produces liquid ammonia by pulling from resources readily available in the atmosphere.

"We manufacture hydrogen electrolyzers that are optimized for running on the intermittent electricity produced by wind turbines," says business developer Sam Sterling with Angetrom Advanced. "Hydrogen is the primary component in ammonia, so we can pair this product with a small ammonia converter so farmers or communities with wind turbines can create their own fertilizer at minimal expense."

Users also need a nitrogen pressure swing absorption device, a small piece of equipment that sits next to the ammonia reactor. This device pulls nitrogen straight from the surrounding air. The size of each batch depends on several factors, but Sterling says a production rate of 1,000 to 10,000 tons of compressed liquid fertilizer per year is possible.

Meanwhile, a British company is **testing a device it says can create synthetic petrol** by pulling carbon dioxide out of the air, purifying it and mixing it with hydrogen to produce methanol. This mixture is passed through a gasoline fuel reactor, and presto changeo - you have petrol.

These projects would dramatically affect the global fuel landscape if they are proven to work on a large scale and not just in these small-batch scenarios. So consider it a compliment when I say I hope their projects are full of a lot of hot air.

Comments (0)

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The Path to Hydrogen: Producing clean, storable fuel from biomass

By Samuel Sterling

New methods of hydrogen production are being pioneered, which are helping increase the efficiency of biomass facilities, creating high value, clean energy from sources of waste. Biomass, one natural, renewable hydrogen source, is the core of many energy sources—from the gas that powers our cars, to the gas that powers the majority of our cars.

Thanks to older, dependable technologies that are simply being used in new, unconventional ways, biomass gas now exists for conversion to hydrogen. This means that in large-scale anaerobic digesters and other biogas plants (or hydrolysis plants), it's possible to maximize the value of natural gas products by converting to high-purity hydrogen fuel in modern, specific plants, operators will effectively be able to use biomass and gas to create a rich, carbon-neutral fuel source.

Hydrogen from anaerobically digested biomass
Early stage development of several plants in the Midwestern United States shows a growing interest in generating more advanced fuels from renewable resources using a staff from and crop products from feeds to produce biogas in an anaerobic digester, farmers now have the primary fuel stock for creating hydrogen, using steam reformer (SRM) technology.

The process looks like this: through an anaerobic digester, methane is created from biologically treated biomass material like a staff, wood chips, trimmings, dung, biomass garbage, etc. Then, using steam-methane reforming equipment, the methane is purified to become high-purity hydrogen fuel, which is a rich, clean, high-energy fuel.

The benefit of producing hydrogen is contained in the differences in heating value between hydrocarbon gases. Found in natural gas, and the much purer hydrogen fuel product, whereas natural gas has a relatively low heating value as far as fuels are concerned—methane contains about 23,000 BTU and is the primary component of most natural gas feedstocks—hydrogen fuel contains nearly three times that value within the same mass.

Whether planning to produce electric, heating, or chemical from a biomass facility, hydrogen is inherently more productive than methane and other hydrocarbon gases.

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Contact Information

Dear Customers,

At Verde LLC, we are committed to placing our customers first by combining quality products with the latest technology, ensuring top performance and flawless results with every application. Our knowledgeable staff along with our meticulously engineered manufacturing and specifications allow Verde LLC to keep this commitment. As we continue to grow, we look forward to confidently supporting our customers needs and ideas today and throughout the future.

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