HYDROGENICS
CORPORATION

HySTAT™-A
Energy Station

welcome to the evolution of energy

Changing power
...Powering change

HySTAT™-A Energy Station

About Hydrogenics

Hydrogenics Corporation is a leading global developer of clean energy solutions, advancing the Hydrogen Economy by commercializing hydrogen and fuel cell products.

Through the acquisition of Stuart Energy, Hydrogenics has strengthened its position by gaining over 50 years experience from Stuart's legacy as the global leader in the development, manufacture and integration of multi-use hydrogen infrastructure products.

The combined companies bring together the best available technologies and an experienced team of hydrogen experts. At Hydrogenics we lead by focusing our efforts on offering our customers a full range of hydrogen products. We are positioned as the "Hydrogen Go-To Company", offering a comprehensive suite of products with multiple technology options that meet the needs of both our energy and industrial customers.

Hydrogenics' portfolio of HySTAT™ products provide onsite generation solutions based on proprietary IMET® and PEM electrolyzer technologies. Hydrogenics is also developing hydrogen generation systems based on natural gas reformation.

OUR HYDROGEN FUTURE

A Multi–Purpose Hydrogen Infrastructure Solution

Hydrogenics' proprietary **IMET®** electrolysis based energy station, **HySTAT™-A** is the world's first multi-purpose hydrogen infrastructure product that transforms electricity into stored high value hydrogen energy. The **HySTAT™-A** Energy Station redeploys the stored hydrogen on demand, as high value energy either as fuel for vehicles, or as electricity for peak shaving and backup power, as well as for industrial applications.

The **HySTAT™-A** is comprised of five modules that can be sold as individual modules or combined to form an integrated system.

The modules include:

1. **Hydrogen Generation**
2. **Compression**
3. **Storage**
4. **Fuel Dispenser**
5. **Power Generation**

1. Hydrogen Generation

The **HySTAT™-A** Generator Module is based on emission-free electrolysis technology that generates hydrogen gas on-site, reliably and safely.

2. Compression Module

The Compression Module raises the hydrogen gas to a desired pressure, currently up to 430 bar (6,250 psi).

3. Storage Module

The **HySTAT™** Storage Module available in carbon steel or carbon-fibre composite tanks, is designed to international hydrogen safety standards.

These three modules are the typical **HySTAT™** configuration for many industrial applications including manufacturing semi-conductors, glass and edible oils, as well as for cooling generators at power generation stations.

4. Fuel Dispenser

The **HySTAT™** Dispenser Module can deliver pure hydrogen for fuel cell and hydrogen ICE vehicles, as well as a mixture of hydrogen and natural gas for H_2 Compressed Natural Gas (H_2CNG) vehicle refueling.

5. Power Generator

Adding a Fuel Cell Power Module to a **HySTAT™-A** Energy Station or a hydrogen powered Internal Combustion Engine to generate electrical power, allows the **HyPM®** Fuel Cell Power Module or the Hydrogen ICE (H_2-ICE) to provide backup power, peak shaving and off-grid distributed power generation.

A fully integrated **HySTAT™-A** Energy Station can generate fuel for vehicles and power for back-up purposes.

Scalable Solution

The **HySTAT™-A** product line offers scaleable energy outputs suitable for a range of applications, from small-scale residential power generation to commercial scale fueling and power stations, to large-scale industrial installations.

The concept of the multi-application **HySTAT™-A** offers flexibility to scale down in order to meet the fueling and power needs of a household or small community.

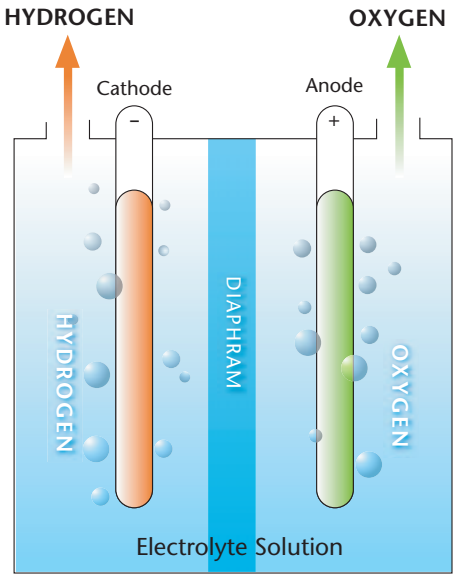
HySTAT™-A Energy Station

Hydrogen Generator Module

The **HySTAT™-A** Hydrogen Generator Module is a water electrolysis based product that generates high-purity hydrogen, and oxygen, for use in a variety of applications.

Electrolysis is an efficient and emission-free method of generating hydrogen. With this process, electricity is used to separate water into its constituent elements, hydrogen and oxygen, by passing an electric current through an alkaline electrolyte solution between positively and negatively charged electrodes. The hydrogen and oxygen are kept separate after the electrolytic reaction by highly efficient inorganic membranes, and then channelled to separate hydrogen and oxygen vessels.

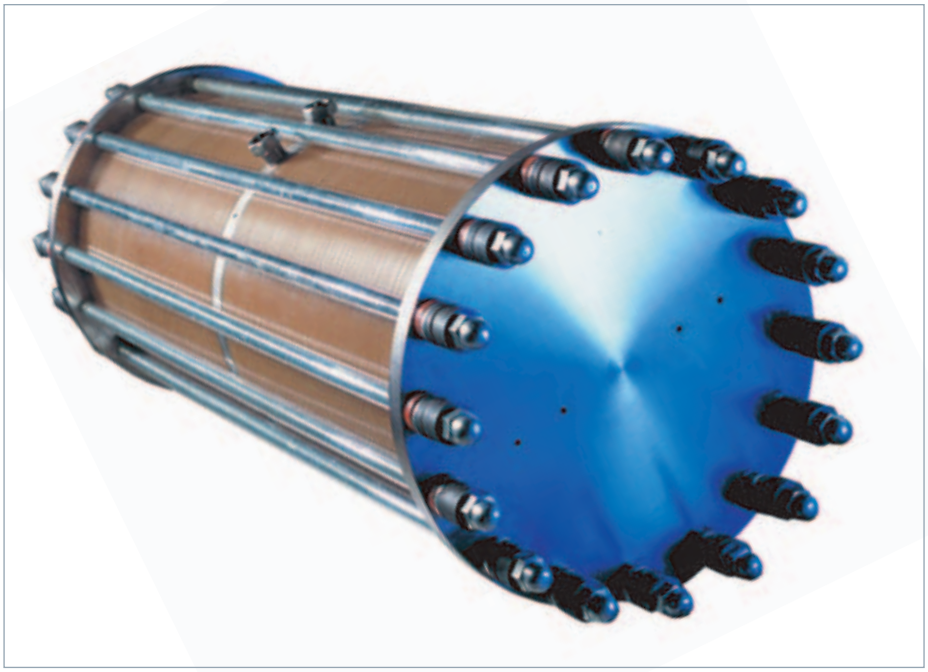
IMET® Technology is a pressurized alkaline electrolyzer that generates high-purity hydrogen at pressures up to 25 bar (363 psi) directly from the electrolyzer. The patented membrane technology, is developed and manufactured in-house, allowing Hydrogenics to maintain a high level of quality control. This proprietary technology simplifies compression and gas handling systems, and is ideally suited for all applications. **IMET®** Technology features electrical connections that automatically ground the unit making the **IMET®** technology one of the safest electrolysers in the market. In addition, this technology is highly efficient with an electrical consumption of 4.2 kWh per Nm^3 of hydrogen produced (at cell stack steady state), and an overall module consumption of 4.8 kWh per Nm^3 of hydrogen produced (including auxiliaries).



The standard **HySTAT™A** hydrogen generator module is configured with our leading edge proprietary **IMET®** Technology.

Benefits of IMET® Technology

Virtually maintenance-free	Pumpless electrolyte circulation; minimal moving parts.
On-site and on-demand production	Variable hydrogen production from 25 - 100% of capacity.
Reliable supply, and efficient delivery of hydrogen	> 98% availability; efficiently manage hydrogen inventories.
Flexibility to meet a customer's specific needs	IMET® is scalable producing from 1 Nm^3/h to 60 Nm^3/h (optional up to 120 Nm^3/h) of hydrogen.
Multi-use system	IMET® generates argon and oil-free oxygen. Additional purification packages can be provided.
Easy to install	Delivered in plug & play packaging for indoor or outdoor use; minimal commissioning time; uses readily available water and electricity.
Safe operation	Asbestos-free; meets international codes and standards (PED, TÜV, ASME, CE, GOST, UL, AUS/NLZ).
Easy to use	Remote monitoring available; fully automated operation.



IMET® Technology 1000 series cell stack

Standard Purity

The **HySTAT™-A** Generator Module can also be supplied with a standard deoxo-drier purification package for "fuel cell grade" hydrogen.

The deoxo vessel removes entrained oxygen through a catalytic reaction, and the drier removes humidity remaining in the gas by a molecular sieve adsorption system.

Our standard purity after standard compression and purification is as follows:
(Total parts per million = ppm)

Nitrogen	12 ppm
Oxygen	5 ppm
Water	5 ppm*
Hydrocarbon	<1 ppm
CO_2/CO	<1 ppm

Max Impurities	< 23 ppm
Purity Level	> 99.9987 %

**-65°C atm dew point*

Optional High Purity Applications
Even higher levels of hydrogen purity, up to a maximum purity of 99.9995%, can be achieved with additional equipment including nitrogen removal down to 2 ppm.

HySTAT™ Energy Station

Hydrogen Production

HySTAT™ SPECIFICATIONS

Hydrogen Output	Nm^3/h (scfh)	1-3 (38-114)	4-15 (152-570)	16-30 (608-1140)	31-45 (1178-1710)	46-60* (1748-2280)
Cell Stack Technology		**IMET® 300 Series**	**IMET®1000 Series**			
Number of Cell Stacks	—	1	1	2	3	4
Maximum Pressure	bar (psi)	25 (363)	10 or 25* (145 or 363)			
Cell Surface Area	cm^2 (in^2)	300 (46.5)	1000 (155)			
Standard Purity	%	99.9**	99.9***			
Power Consumption (Electrolysis)	kWh/Nm^3 (kWh/100scf)	4.2 (11.0)	4.2 (11.0)			
Power Consumption (inc. rectifier and auxiliaries)	kWh/Nm^3 (kWh/100scf)	4.9 (12.9)	4.8 (12.6)			
Power Supply	—	380 - 600 VAC / 50 - 60 Hz, 3 phase				
Packaging	—	Indoor or outdoor operation - Alucobond enclosure Optional steel containers or ISO container (10', 20', 40')				

Data is normalised to 0°C (32°F) and is for marketing purposes only. ** Larger systems available upon request.*
*** 25 bar max. pressure option - possible only up to 30 Nm^3h.* **** Up to 99.9995% purity can be achieved with purification packages*

Compression Module

Using **IMET®** the **HySTAT™-A** Hydrogen Generator Module delivers hydrogen at pressures up to 25 bar (363 psi); however, higher pressures are frequently required for transportation and power applications. The **HySTAT™** Compression Module currently raises the pressure up to 430 bar (6250 psi).

Our Compression Module is offered with a diaphragm compressor. Other compressors, including reciprocating compressors, can be integrated into the module, as part of an optional package.

Diaphragm Compressor Option:

- Superior life cycle cost
- High purity hydrogen gas does not come into contact with lubricants
- Highly reliable design for longer maintenance intervals
- Flexible capacity range
- Can accept inlet pressure

Reciprocating Compressor Option:

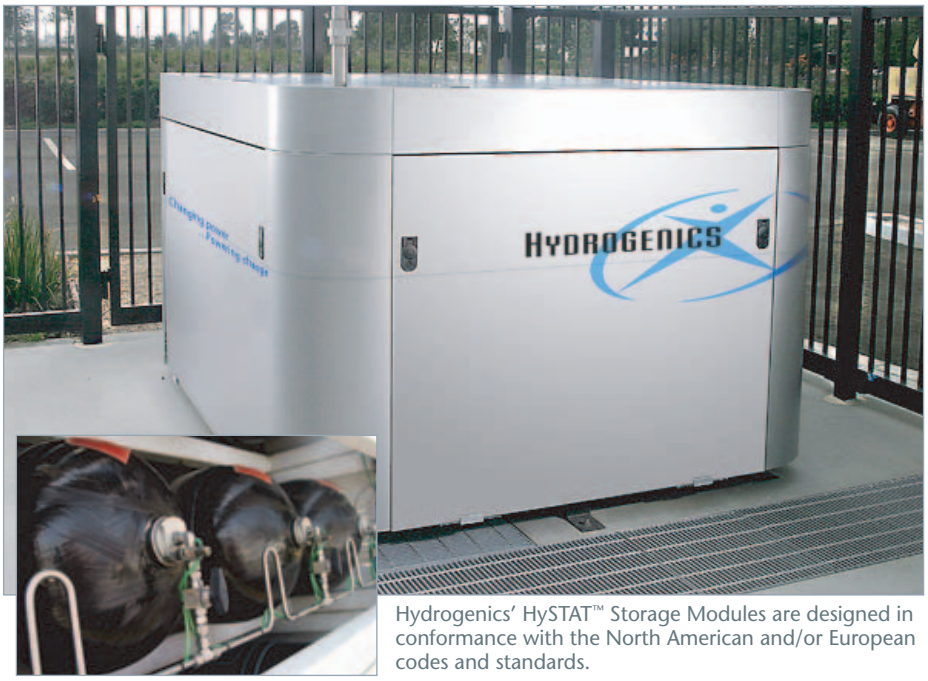
- High levels of compression achieved with low power consumption

Different pressures can be achieved using the same Compression Module. Development of compression technology is currently under way to attain 700 bar (>10,000 psi).

To minimize footprint and maximize efficiency, the Compression Module is housed in one unit with the **HySTAT™-A** Generator Module.

Storage Module

Hydrogenics' HySTAT™ Storage Module is composed of a series of storage tanks mechanically connected and electronically controlled by proprietary software. The Storage Module receives hydrogen directly from the Hydrogen Generation/ Compression Modules. When hydrogen is required, the flow is managed according to customer requirements. The **HySTAT™** Storage Module is available in two types of tanks, steel and composite. Both options are available in two configurations, buffer or cascade storage, depending on the customer's specific requirements.



Hydrogenics' HySTAT™ Storage Modules are designed in conformance with the North American and/or European codes and standards.

Buffer Storage

A buffer storage system stores the required amount of hydrogen using a simple configuration consisting of a series of interconnected tanks that are filled and emptied as if they were one large tank. Hydrogen enters the system via a single control valve, and is delivered from the rack through another control valve.

During delivery, the pressure inside all the tanks drops simultaneously. This means that to attain a certain desired pressure, the initial pressure in the tanks must be higher than the desired delivered pressure, or that the fill is assisted by simultaneous operation of a booster compressor.

- Versatile; suitable for a wide range of applications
- Simple design
- Lower capital cost
- Scalable pressures dispensed per customer requirements
- Simple to use and easy to maintain

Cascade Storage

The cascade system consists of storage tanks arranged in a series of "banks" managed by a control system that determines which bank is able to receive or deliver hydrogen. When hydrogen is required, the first bank delivers hydrogen until the pressure inside this bank equals that of the receiving tank.

As the pressure equalizes, the next bank begins to deliver its store of hydrogen, and so on. By automatically sequencing the banks in this manner, some hydrogen is always kept at a higher pressure so that more complete vehicle fills can be obtained from the same volume of hydrogen storage.

- Suitable for intermittent fast-fill vehicle fueling
- Minimizes on-site hydrogen storage
- Scalable pressures dispensed per customer requirements
- Simple to use and easy to maintain

HySTAT™ Energy Station

Fuel Dispenser Module

Hydrogenics' **HySTAT**™ Fuel Dispenser Module is available with a variety of options that meet the personal or commercial fueling needs of any customer. The Fuel Dispenser Module consists of a hose and nozzle, and a system that controls the operation of the dispenser and the flow of hydrogen or hydrogen natural gas mixture to a vehicle.

The experience of using a **HySTAT**™ Fuel Dispenser is very similar to that of using a conventional natural gas dispenser. A customer selects the proper fill pressure from the user-friendly interface and attaches the hose to their vehicle's refueling receptacle. Hydrogenics' proprietary system manages the rest of the fueling process. The system determines when the tank is full and automatically stops dispensing hydrogen. After disconnecting the nozzle, the customer simply drives away.

Dispenser Safety Features

Many of the features and options of the **HySTAT**™ Fuel Dispenser are designed to make the fueling of a hydrogen-powered vehicle familiar, comfortable and safe for customers.

- Hydrogenics uses "hydrogen-only" nozzles that are designed specifically for hydrogen vehicles; and come with a standard in-line break-away safety feature.

- "Captured Vent" technology eliminates the release of gas when the nozzle is disconnected from the vehicle.

- The arrangement of the dispenser components ensures that hydrogen will vent and dissipate into the air well away from the user – in the event of a system leak.

- The hose and nozzle are designed to electrically ground the vehicle automatically.

Hydrogen itself has some inherent properties that make it a safe fuel:

- 14.5 times lighter than air and will disperse quickly if released.

- Non-toxic if leaked or spilled.

As with all fuels, hydrogen must be treated with respect. Safety precautions similar to those used at conventional gasoline stations also apply to hydrogen fueling stations.

Fuel Dispenser Module Options

Fuel Type	Hydrogen
	Hydrogen & Natural Gas
Dispensing Pressure	250 and 350 bar (3,600 and 5,000 psi) Dual Pressure option
	250 bar (3,600 psi) 350 bar (5,000 psi) Single Pressures
Dispensing Type	Fast-Fill
	Slow-Fill
Customer Interface	Personal Identification Number (PIN)
	Swipe Card
	Credit Card
Additional Options	Flow Metering
	Data Display
	Data Capture

* Customized packaging options available upon request

Fuel Type

Customers have the option to dispense pure hydrogen or a blend of hydrogen and natural gas to be used in vehicles with natural gas engines. The **HySTAT**™ Fuel Dispenser Module is offered in two dispensing configurations: (1) pure hydrogen or (2) hydrogen and blended hydrogen/natural gas.

Dispensing

The Fuel Dispenser Module is also available with various dispensing pressure options, typically 250 bar (3,600 psi), 350 bar (5,000 psi), or both 250 and 350 bar. 700 bar (10,000 psi) is available upon request.

Customers also have the option for a fast-fill design (fueling a passenger vehicle in as little as 2-3 minutes or a bus in 15 minutes); or a slow-fill design (fueling a vehicle or bus gradually over a longer period of time).

Customer Interface

The **HySTAT**™ Fuel Dispenser Module is available with a personal identification number (PIN), a swipe card or credit card customer interface for fleet and retail fueling applications.

Customers typically require dispensers with flow metering, and the data display option that shows the amount of fuel dispensed during use. As well, the data capture option is particularly useful for fleet managers wishing to monitor and optimize their fleet's fuel efficiency.

HySTAT™-A Energy Station

Power Module

One of the key value propositions of the **HySTAT™-A** Energy station, when integrated with a power module – be it based on a fuel cell or Internal Combustion Engine (ICE) - is its ability to effectively store electricity as hydrogen for later deployment. This is particularly useful with intermittent renewable energy sources such as wind and solar.

Hydrogenics manufactures a line of fuel cell powered modules, the **HyPM®*** ranging in output from 7-65 kW; and can arrange for the supply of power modules designed with a hydrogen powered internal combustion engine. These hydrogen ICEs are suitable for applications requiring power from 125kW.

A typical ICE power module is based on a Hydrogen fueled ICE connected to an electrical generator. These Hydrogen ICE gen-sets convert hydrogen into electricity for backup power, supplemental power, and peak shaving or remote off-grid primary power.

The Hydrogen ICE is designed for quick start-up to provide critical back up power in the event of a grid power disruption and can ramp up from standard mode to full load operation. The Hydrogen ICE is scalable with the versatility to generate power ranging from a few kilowatts of electricity to a megawatt.

* For more information on the HyPM® range of products refer to our website: www.hydrogenics.com

The Hydrogen ICE is integrated with the generator to produce electricity. The entire Hydrogen Power Module is protected by a sound-attenuated weather-proof enclosure.

Renewable source of electricity

125 kW Power Module:
Hydrogen ICE

- 6.8 L Ford Triton engine modified to run on hydrogen
- Operates at 3,000 rpm
- "Lean burn" fuel-oxygen ratio to virtually eliminate NO emissions

The Generator

- Standard 125 kW of power (higher outputs available)
- Available in 50 and 60 Hz, in a wide range of voltages

Sample HySTAT™ Installations

Toyota & the National Fuel Cell Centre at the University of California Irvine

Hydrogenics opened a small scale **HySTAT™-A*** Refueling Station for vehicle fueling in June 2005. This **HySTAT™-A** Refueler has been installed at the National Fuel Cell Research Center (NFCRC) at the University of California, Irvine. The refueler will provide clean Hydrogen fuel to the Toyota Fuel Cell Hybrid Vehicles (FCHV) managed by the NFCRC.

* Formerly known to as Stuart Energy Station (SES-f)

Vehicle Fueling

Hydrogenics' **HySTAT™-A** Refueling Station installed at the U.S.A. headquarters of Toyota Motor Sales in Torrance, California, generates enough hydrogen to fuel Toyota's fleet of vehicles. Features of this station include:

- Generation capacity of 12 Nm/h of hydrogen
- Up to 414 bar (6000 psi) compression
- 49 kg of hydrogen stored in a cascade storage configuration
- Dual pressure dispensing 250 and 350 bar (3,600 and 5,000 psi)
- Personal identification number (PIN) customer interface
- Installed in December 2002

Industrial Hydrogen

Hydrogenics has installed over 1,100 hydrogen generating systems for industrial applications in almost 100 countries.

For more information on our industrial products please contact one of our sales representatives (contact information on back).

HySTAT™-A Energy Station

welcome to the evolution of energy

The Power of Hydrogen™

Clean - Hydrogen is an environmentally friendly fuel that can meet the world's energy needs. Water electrolysis produces hydrogen with no on-site emissions, and when renewable sources of electricity are used (wind, hydro, solar), the entire cycle from electricity generation to hydrogen production is zero-emission. The environmental benefits of hydrogen continue when used in an internal combustion engine or a fuel cell.

Secure - Hydrogen energy is both regional and global. Any nation, region, or neighbourhood in the world with local sources of electricity and water can produce their own hydrogen. This allows countries, organizations and individuals to become energy independent, self-sufficient and free from the limitations of relying on external sources of energy.

Distributed Energy - Both individual consumers and large organizations can generate their own hydrogen energy, on site and on demand, wherever there is electricity and water. Hydrogen can be used in a variety of applications including manufacturing industrial products, fueling vehicles, and powering buildings, homes and appliances. Hydrogen is an excellent energy vector that can efficiently meet many customers' needs.

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