Feature

Hydrogen: The 'never say die' industry surges again

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New innovations and cost reductions are once again building hype for hydrogen, as new data supports market based solutions. Is this the tipping point in a clean energy revolution? Angstrom Advanced Inc.'s Samuel Sterling gives a new take on an old tale.

A new application of hydrogen is being deployed which is helping solve humanity's ever-evolving energy woes. Traditionally, hydrogen has a large number of non-energy based applications – everything from industrial products to food packaging. Ammonia fertilizer production, which hydrogen is a main component of, amounted to 160 Million tons in 2011.

But while market demand for hydrogen is driven heavily by fertilizer and manufacturing, new demand is emerging for hydrogen in the energy sector.

Power plants in Germany as well as Canada (using wind and natural gas, respectively) are today supplementing their primary electrical generators with advanced configurations of hydrogen technologies. These retrofits help the plants save money by smoothing supply, converting excess electricity generated into storable hydrogen gas, which can be returned to electricity using either a turbine or a fuel cell.

Supply-demand balancing act

For natural gas fired plants, there are huge expenses associated with starting the generators from stop – both from the amount of fuel it takes, and the time it takes to reach generating speed. To mitigate this concern, operators often run their turbines non-stop, regardless of demand for the energy created, and therefore using fuel even though the electricity the plant can generate is more than the plant will be paid for.

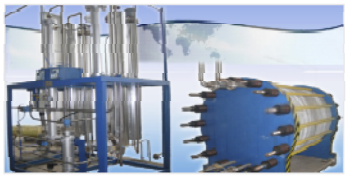
Wind farms face a similar supply-demand problem, but though wind is free – unlike natural gas – the economics are still concerning for wind farm operators. Wind energy is often generated at times when there isn't a demand for the electricity being produced (known as *off-peak*) and therefore there is an abundant supply of low cost, renewable energy that goes unused – *and unpaid for*.

To cut costs and expand margins, the new hydrogen power plant strategy is simple; store extra electricity supply as high energy hydrogen gas, and deliver it as demanded and generating max revenue.

In the last two years there has been increased attention towards hydrogen, and today there are operational hydrogen energy plants reducing carbon intensity and saving money.

Energy carrier

Renewable Hydrogen Generation System, source Angstrom Advanced Inc.



Angstrom Advanced VERDE renewable hydrogen electrolyzer, source Angstrom Advanced Inc.

German Hydrogen Refueling Station , (Image: Fraunhofer ISE)

Fuel cells are being used to power industry and buildings, such as this Sheraton Hotel in San Diego (Image: FuelCell Energy)

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Hydrogenics to provide energy storage for wind-hydrogen installation in Germany
Canadian-based Hydrogenics has been selected by the German city of Herten to supply a wind-

To be clear, hydrogen is an *energy carrier* not a source, as it doesn't actually make energy – it needs the reaction with a catalyst and oxygen to release its contained energy, which often occurs in a fuel cell.

Hydrogen is not naturally occurring anywhere on Earth like, say, oil or coal or even sunlight. Rather, hydrogen must be obtained from processes like electrolysis (running direct current through water to make H2) or reforming natural gas (which contains hydrogen.)

Seeing as the former method demands energy usually derived from fossil fuel, and the latter is derived directly from a fossil fuel, it would seem that hydrogen isn't a clean energy solution after all. Hydrogen produces only pure water when used for energy, but **if it takes carbon intensive fuels to *make* the hydrogen, then why explore it as a source of clean energy at all?**

Well, as there are many crayons in a box, there are also many sources of energy in the world and many aren't fossil fuel based. Indeed, hydrogen can – and has been – created through electrolysis powered by clean energy, and more projects combining renewable energy and hydrogen are being developed right now.

Powering the wind market

In no industry are the benefits of supplemental hydrogen systems more apparent than for wind energy. Diminishing tax credits and subsidies have encouraged developers, operators and owners to explore **new ways to increase margins on current and developing wind projects**. In the wind industry, everyone knows and fears the concept of 'curtailment' – the forced shutdown of renewable energy infrastructure by utilities or other power purchasers.

Curtailment occurs when the grid is overloaded by electrical supply, and transmission does not accept electricity from wind farms. Therefore, when curtailment occurs, wind turbines and solar panels lay idle providing no energy to the grid even when there is wind or solar resource to be harvested. During curtailment, renewable energy operators' assets generate little or no revenue. **In Texas and Oklahoma, curtailment occurs as often as 50% of generating time.**

Auxiliary hydrogen storage provides operators of wind assets a solution to the issues of:

- curtailment;
- generating during off-peak hours;
- intermittent energy supply.

Hydrogen is a dispatchable form of energy with several applications, including:

- electricity
- fuel
- fertilizer
- power plant coolant
- industrial product

> **The differences in tariff prices written into power purchase agreements (PPAs) are often considerable enough to consider storage, and many inherent characteristics of hydrogen technology make it the front runner for energy storage.**

Power producers can convert energy generated in curtailment or off-peak periods into hydrogen, and return the energy to the grid in higher value on-peak times. As the proliferation of hydrogen fuel cell vehicles continues, **wind farms may be able to sell their off-peak generation as a valuable transportation fuel**.

Further, as many wind farms are sited near (or on top of) agricultural land, wind farms can produce *extremely* valuable fertilizer with a very small amount of upfront capital. The variety of value-producing scenarios that hydrogen offers is just the beginning of the technology's benefits.

Other benefits

Commercially, hydrogen has been gridlocked for years, without much attention in political and business agenda because of the high cost of the technology. Today though, hugely innovative development activity and

> **unique new business models present a strong case for implementing hydrogen paired with renewable energy sources.**

Angstrom Advanced – out of Braintree, MA – has worked with national laboratories, industry giants, and universities to create innovative new electrolysis products that are specifically designed for use with intermittent energy sources. Similarly, fuel cell design has vastly improved and companies are now deploying fuel cells in multiple MW configurations for commercial and utility applications.

hydrogen energy storage solution. The project will allow excess renewable energy to be stored as hydrogen for later use in a fuel cell.

Iberdrola to build 102.85 MW windfarm in Mexico
The construction contract for the 102.85 MW La Venta III windfarm in Mexico has bee awarded to Iberdrola Renovables by the Mexican Federal Electricity Commission (CFE).

Dow manufactures wind energy formulations in China and South Korea
Dow Epoxy Systems (DES) has established a manufacturing facility in China and will start producing blends in a Dow Epoxy site in South Korea to serve composites, wind energy and infrastructure customers in the China and Asia Pacific region.

Updating power grids essential for renewables
Updated European power grids would allow larger amounts of wind and other renewables onto the European energy system, according to the European Wind Energy Association (EWEA).

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A hydrogen economy is proposed to solve some of the negative effects of using hydrocarbon fuels where the carbon is released to the atmosphere. Modern interest in the hydrogen economy can generally be traced to a 1970 technical report by Lawrence W. Jones of the University of Michigan.
In the current hydrocarbon economy, transportation is fueled primarily by petroleum. Burning of hydrocarbon fuels emits carbon dioxide and other pollutants. The supply of economically usable hydrocarbon resources in the world is limited, and the demand for hydrocarbon fuels is increasing, particularly in China, India, and other developing countries.
Proponents of a world-scale hydrogen economy argue that hydrogen can be an environmentally cleaner source of energy to end-users, particularly in transportation applications, without release of pollutants (such as particulate matter) or carbon dioxide at the point of end use.

Fossil fuels represent more than 80% of world consumption, and transport in particular depends 95% on oil. While reserves are diminishing, worldwide demand is constantly increasing, due to the emergence of certain economies. Experts estimate that the global demand for energy could rise by more than 50% between 2009 and 2030 and that oil production will reach a peak around 2020/2030.
Burning fossil fuels generates CO2, a greenhouse gas that is the primary cause of global warming.
It is necessary to develop alternative sources of energy. To meet the specific needs of transport, these energies must be easy to store.
Hydrogen, produced independently of oil and combined with the fuel cell, is one of these alternatives. It can be produced using a variety of sources: natural gas, biomass, water and electricity, and be easily stored in various liquid or gaseous forms. It is easy to store, and refill containers.
In a fuel cell, hydrogen combines with the oxygen in the air to produce electricity and only discharges water. It is the ideal fuel to power cars fitted with an electric engine which produce their own electricity on board and do not pollute.

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