Power-to-Gas Technology

Power-to-Gas: Energy Storage System of the Future?

"Power-to-gas" is the name given to an energy process and storage technology which allows electricity to be held in reserve in the megawatt range. Existing network infrastructure can be utilized by linking existing power and natural gas grids. This allows seasonally adjusted storage of significant amounts of power and the provision of CO₂-neutral fuels in the form of the resulting renewable energy source gas.

Power-to-gas represents a complete system solution to the problem of surplus energy reserves on the way to a new renewable energy age. Hydrogen - and methane in a second additional step - is produced from surplus wind energy by a process of electrolyzation. The hydrogen produced can be stored in the existing natural gas network for later use.

The idea of separating water into its individual components of hydrogen and oxygen is not new, but the coupling of the power grid with the natural gas storage network is. Hydrogen production (70 percent energy conversion efficiency level) is just the first step in a process which will ultimately result in the production of synthetic gas (i.e. methane - 55 to 65 percent energy conversion efficiency level) which can replace natural gas on a like-for-like basis.

Existing energy storage technologies like compressed-air energy Storage (CAES) and pumped storage hydroelectricity certainly have a role to play in the future, but alone they are not able to meet the expected surpluses of solar and wind energy or expected energy shortfalls in periods of low sunshine and wind (future renewable energy-based do-
mestic power supply requires a storage capacity between 20 to 40 terawatt hours - current energy storage capacity is approximately 0.04 terawatt hours).

At present, a compensating capacity level of 17GW is already required to maintain domestic supply and demand balance. This figure is set to rise to 28GW in 2025. To date, balancing power has largely been provided by hydro pumped storage and gas power plants. However, hydro pumped storage is dependent on a number of supporting geographical factors and capacity limitations which restrict universal application. Gas storage, on the other hand, is not encumbered by any of the restrictions associated with extant energy storage technologies.

Germany’s Gas Network Infrastructure: The Advantage

Germany’s generous gas network reserves - more than 400,000 km of pipeline connecting natural gas reservoirs with a total storage volume of 23.5 billion cubic meters and a further 15.2 billion cubic meters in planning - allow for provision of approximately one sixth of annual domestic electricity generation.

Put another way, Germany’s extant gas network provides energy storage capacity of approximately 220 terawatt hours - or a three thousandfold capacity increase on Germany’s current pumped storage levels (assuming a base efficiency level of 55 percent).

As such, power-to-gas represents a major energy storage opportunity, as the gas network’s current storage capacity of around 210 terawatt hours allows it to serve both a renewable energy storage and distribution function in the future while discharging the burden on the power network and making the recovery of CO$_2$ from fossil fuel sources for material use possible.

Power-to-gas also contributes to the stabilization of the power system by providing negative and positive regulating energy through targeted on-off switching. Germany is unique in the fact that hydrogen can be fed into the in-situ gas grid in significant quantities (up to 30 percent grid capacity in some regions).

Germany enjoys another unique advantage: the presence of salt caves in wind-intensive regions which are already being used for natural gas storage purposes.
Model Commercialization Projects in Germany
POWER-TO-GAS TECHNOLOGY

Center for Solar Energy and Hydrogen Research Baden-Wuerttemberg (ZSW), SolarFuel GmbH and Fraunhofer Institute for Wind Energy (IWES)

The Center for Solar Energy and Hydrogen Research Baden-Wuerttemberg (ZSW), in partnership with SolarFuel GmbH and the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) has been operating a 25 kilowatt power-to-gas pilot plant since 2009 (a second research facility, with 250 KW of electric power, is scheduled for completion by the end of 2012).

The demonstration facility produces standard certified substitute natural gas. The consortium received the German gas industry’s innovation and climate protection prize in 2010 for its pioneering power-to-gas work. SolarFuel GmbH and IWES are ZSW cooperation partners, with IWES overseeing grid connection and control while ZSW is responsible for process development and SolarFuel enjoying commercialization responsibilities.

Greenpeace Energy

Greenpeace Energy will be the first German energy supplier to provide its customers with “green hydrogen” energy created in regenerative and climate-neutral fashion from wind power. The wind energy provider operates a pilot electrolysis plant in Brandenburg. The “proWind gas” generated can be used for conventional domestic heating and cooking purposes and even as a fuel for vehicles.

Customers connected to the ordinary gas network have been able to take advantage of the “proWindgas” tariff since October 2011. A 0.4 eurocent proWindgas premium is reinvested in further developing the wind-gas technology. The Hamburg-based concern plans to build its own electrolysis plant in order to gradually increase wind-gas energy production share. The company signed a delivery contract with European electricity-from-renewable sources specialist ENERTRAG in January 2012.

Audi - Balanced Mobility

Auto manufacturer Audi has joined forces with energy providers EWE and SolarFuel GmbH in a project which will see the construction of an industrial pilot facility for the production of renewable gas (renamed “e-gas” as part of Audi’s “Balanced Mobility” goal to guarantee climate-neutral mobility) from renewable energy surpluses.

The project represents a major step towards the commercialization of the power-to-gas technology. Located in Werlte near Oldenburg, the world’s first large scale “e-gas” facility will be operational from the third quarter of 2013. Around four thousand cubic meters of renewable methane in natural gas quality will be produced daily for a connected load of 6.3 megawatts, fueling 1,500 turbo-compressed natural gas (TCNG) Audi A3 vehicles for a year. Audi will begin serial production of the TCNG vehicle model range in 2013.

ENERTRAG

ENERTRAG is a European sustainable energy supplier that specializes in generating electricity solely from renewable sources (predominantly wind energy). The company’s “hybrid power station” - which transforms wind energy into hydrogen - is the first of its kind in the world.

Wind power generated in Prenzlau (Brandenburg) is helping heat and power homes as well as finding its way to gas pumps to fuel CO₂-free mobility in Berlin. The company has already successfully deployed its energy storage solution at the world’s first CO₂-neutral filling station, and at the new Berlin International Airport scheduled to open in summer 2012. Project partners to date include the Brandenburg University of Technology Cottbus, Vattenfall, TOTAL Deutschland and the Deutsche Bahn.

CO2RRECT

Bayer, RWE and Siemens have joined forces with a number of academic partners to research ways of transforming climate-damaging CO₂ into useful base chemicals using renewable energy sources. The focal point of the CO2RRECT
(CO$_2$-Reaction using Regenerative Energies and Catalytic Technologies) project is the long-term use of fluctuating energy from renewable sources for CO$_2$ conversion.

The initiative bundles collective academic and industry know-how to identify ways of deploying surplus energy reserves for chemical production. As well as this, innovative technologies which allow the recovery of quantities of energy for the material use of CO$_2$ as a carbon building block for chemical by-products (carbon monoxide and formic acid) are being researched. The project represents a new model of interaction between the energy and chemical sectors.
Power-to-Gas Strategy Platform
The Deutsche Energie-Agentur (dena - "German Energy Agency") has set up the Power-to-Gas Strategy Platform in partnership with industry and research stakeholders to develop this new energy storage technology.

Working closely with research and industry partners, dena will assess the contribution the natural gas grid can make to integrating renewable energy sources into the energy mix and how best make power-to-gas practicable. A cross-sectoral and institutional dialogue involving relevant actors and stakeholders will see policy and economy-based recommendations submitted by June 2012.

An online portal (www.powertogas.info) has been created to provide further information about the Power-to-Gas Strategy Platform and the discussions surrounding the energy storage technology.

**Project Partners**

- BDEW e.V. – German Association of Energy and Water Industries
- BTU - Brandenburg University of Technology Cottbus
- DVGW e.V. - German Technical and Scientific Association for Gas and Water
- EnBW - Energie Baden-Württemberg AG
- E.ON AG
- EWE AG
- Fraunhofer IWES - Fraunhofer Institute for Wind Energy and Energy System Technology
- GAZPROM Germania GmbH
- GDF SUEZ Energie Deutschland AG
- Ludwig-Bölkow-Systemtechnik GmbH
- RWE Deutschland AG
- Siemens AG
- STEAG GmbH
- Thüga AG
- Verbundnetz Gas AG
- Viessmann Werke GmbH & Co. KG
- Volkswagen AG
- ZSW - Center for Solar Energy and Hydrogen Research Baden-Württemberg