Energy Delta Institute
Energy Business School

Power to Gas

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Power2Gas

Key concepts

In times of oversupply of renewable energy, the natural gas system can also be used to store the excess energy in the form of (substitute) natural gas (SNG). The basic principle of this 'power to gas' concept is the bidirectional linking of the existing infrastructure units (the electricity system and the gas system) with the goal of establishing a new way of managing loads and generation, which enables high proportions of fluctuating electricity generation from renewable energy sources to be accommodated in the energy system. To date, this link only exists in terms of generating electricity from natural gas (gas to power), but not vice versa (power to gas). The new concept is based on storing electricity which cannot be fed into the system for reasons of grid stability, or cheaply available electricity (e.g. at times when a large amount of wind power is available), in the form of substitute natural gas.

The concept

The concept envisages using electrolysis to convert 'excess' electricity from fluctuating sources into hydrogen, then into substitute natural gas in a subsequent synthesis step with CO_2.

$4\ H_2O \Rightarrow 4\ H_2 + 2\ O_2$ (Equation 1)

Subsequently:

$4\ H_2 + CO_2 \Rightarrow CH_4 + 2\ H_2O(g)$ (Equation 2)

Power to gas can accommodate excess renewable power by initiating electrolysis and can store it temporarily as SNG in the natural gas system. At times when less renewable power is available, or when the demand for electricity is higher, the process can be slowed down, stopped or reversed to produce electricity from gas.

Storage capacity

The power to gas concept is also easy to integrate in the existing energy system. A particular advantage compared to other storage options is the use of the natural gas system with its high storage and transport capacity. While a high voltage direct current transmission line is restricted to outputs below 2 GW, gas pipelines can reach up to 20 GW. High renewable power yields can be stored both seasonally and transported long distances with high energy transmission levels.

Flexibility

Also noteworthy is the particular degree of flexibility regarding utilization of the stored energy, because not only can SNG be converted back into electricity, it can also be used in the heating or fuel market. The latter is of particular interest in the context of the planned increase in the proportion of renewable fuels in transport.

In short, power to gas has the following advantages over other storage options:

- Power to gas permits seasonal storage of renewable energy. For instance, while the storage capacity of the electricity system in Germany is currently only approx. 0.04 TWh – with a storage coverage of less than one hour –, the storage capacity of the gas system in Germany is over 200 TWh with a storage coverage of months.
- Power to gas can provide positive and negative balancing energy to stabilize the electricity grid.
- By expanding renewable energy capacity in the future, high renewable power levels will be available more and more often, which cannot be absorbed fully by the electricity system, but may be stored as SNG in the existing gas system.
- Power to gas can serve as a big step towards the decarbonization of the natural gas industry

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EDIAAL is an Energy Delta Institute programme that aims to gather, edit and make available independent knowledge on the role of gas in the transition to a low carbon economy. The EDIAAL project is partly made possible by a subsidy granted by The Northern Netherlands Provinces (SNN), Koers Noord. EDIAAL is co-financed by the European Union, European Fund for Regional Development and The Ministry of Economic Affairs, Agriculture and Innovation, Peaks in the Delta.

in co-operation with:

Case studies – Power2Gas

Key concepts

Power2Gas is a promising solution of the intermittency problems associated with solar and wind power and there are a number of pilot projects on-going in Europe. In some cases the produced gas is stored on-site and used when necessary to produce power, in other cases it is fed into the natural gas system and used as normal natural gas.

Wind–hydrogen hybrid power plant, located in Prenzlau, Germany

This power plant uses wind power to produce hydrogen gas, and then co-fires the hydrogen with biogas in on-site combined heat and power (CHP) units. The plant generates electricity and heat, as well as fuel for hydrogen vehicles. The project consists of one biogas unit, three 2-megawatt wind turbines, two CHP plants and an electrolysis unit.

When more wind power is available at the site than can be accepted by the network, a series of electrolysers are used to generate hydrogen which is stored on site. This stored energy, effectively acting as renewable base-load energy, is used in a number of ways:

- The hydrogen can be mixed with biogas and fed into cogeneration plants which produce electricity and heat. The electricity can then be fed back into the grid at times when little or no wind is available; the heat is fed into a district heating network, increasing the overall efficiency of the hybrid power plant.
- The hydrogen is also used as a fuel by TOTAL hydrogen refuelling stations in Berlin and Hamburg which support fleets of fuel cell vehicles (1).

MYRTE solar-hydrogen hybrid power plant, located on Corsica

MYRTE contains a 560 kW photovoltaic power plant which has been connected to the Corsican electricity grid since December 2011. The system can provide electricity during the day but, using the electrolysers and AREVA's hydrogen energy storage system, excess electricity can be stored and returned when required using fuel cells.

Early in 2013, in a second phase, the capacity of the hydrogen system will be doubled. The third phase consists of carrying on the operation of the MYRTE platform and improving its performance. Optimisation of operating procedures and improvement in reliability are the main goals for the coming years.

This process of energy storage finds concrete and immediate applications: it constitutes a solution for areas where access to electricity is difficult (lack of electricity line, remote sites) and is particularly adapted to the island context. It also targets markets of energy storage to enhance integration of renewable energies into the grid, the reliability of the national grid and the decentralized energy management such as micro districts (2).

E.ON wind-hydrogen pilot plant, located in Falkenhagen, Germany

E.ON is developing a pilot plant in Falkenhagen to convert power from wind energy into hydrogen which can then be stored in the German gas grid. The company is investing over €5 million on the pilot plant and further research into this innovative technology.

Using power from renewable energy sources, the plant will produce up to 360 m^3 of hydrogen per hour from 2013 onwards through electrolysis. The hydrogen will be fed into the Ontras gas pipeline system and be used like normal natural gas. This makes the gas grid a storage system for power from weather-dependent renewables. At present, up to 5 percent hydrogen can be added to the natural gas grid without any problems, and in the medium term experts expect this proportion to increase to 15 percent. To expand energy storage potential even further, a possible next step could be to convert hydrogen into synthetic gas by methanation; this means that today's entire renewable power output could be stored in the German gas grid (3).

Conclusion

All of these examples are positive steps for the future of Europe's renewable energy sector. The successful integration of variable renewables into electricity grids while avoiding the need for curtailment will be vital to meeting future renewable electricity targets and decarbonising the grid. In addition, the potential for projects like these to provide hydrogen for nascent fuel cell vehicle fleets only adds to their attractiveness and cost effectiveness.

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