WINDGAS - What It Is and Why It's Important

October 2011

1) Introduction

Greenpeace Energy was founded in 1999 following a Greenpeace campaign for green energy. The energy cooperative has since established itself as the quality leader on the green power market, counting now 110,000 customers and more than 20,000 cooperative members. It remains our goal to offer products which contribute to an environmentally-friendly energy supply and that are attractive to consumers. For this reason, Greenpeace Energy has introduced in July 2011 the *pro*Windgas product to promote the windgas technology, which we present in detail below.

Our gas price of EUR 0.0675/KWh includes a surcharge of EUR 0.004, which will be used to build electrolysers and to develop other technology for the windgas plan. Since October 1st, 2011, customers are being supplied initially with 100% natural gas. In the course of 2012, an increasing share of windgas will be successively added to the natural gas, and in 2013 we will begin to feed in windgas from our own production plants.

In this way, we are doing all we can to ensure that windgas makes the transition from being a good idea to becoming a reality in energy supply. We will organise power of consumers, build our own facilities, and remain proactive in the political arena in establishing the framework conditions to make windgas a success.

2) What is windgas?

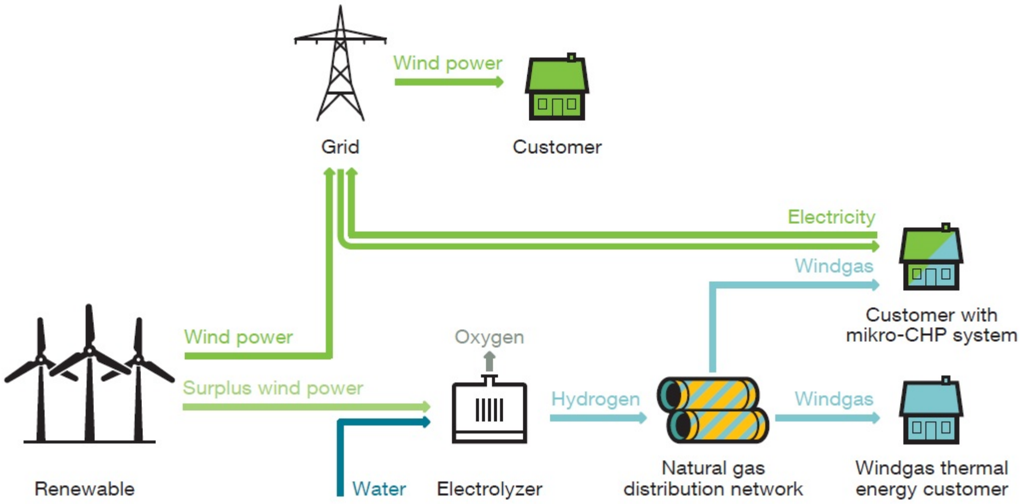
Windgas is our name for gases generated in a process powered by electricity from wind turbines or other renewables. These 'green' gases can be either hydrogen or methane.

When, under favourable conditions, more renewable electricity is generated than can be consumed or transmitted through the power grid, this surplus energy is converted into windgas and fed into the gas grid. It may then be used like conventional natural gas for heating, cooking, running gas-powered cars, for industrial processes, or it may be reconverted to electricity in gas-fired power plants, including mini-cogeneration units.

The generation of windgas is planned to rely solely on renewable energy. This will predominantly be wind power, but the technology is open to other sources; in particular we can easily envisage "solar gas".

In contrast to the power grid, where storage of electricity remains a problem, it is possible to store gases in the gas grid in large quantities and for many months. This is a crucial advantage and explains why windgas is also sometimes referred to as storage gas.

Windgas will be produced in a well-proven chemical process known as electrolysis: Water is split into its elements, hydrogen and oxygen, when an electric current passes through it. The hydrogen is then fed into the gas grid up to a share of five percent by volume. This technical constraint is, however, expected to be eased in the future. But even while the constraint applies, the storage capacity for renewable energy in the gas grid is enormous: 45 times the total capacity of all pumped-storage hydroelectricity in Germany today.



Windgas: The Mechanics

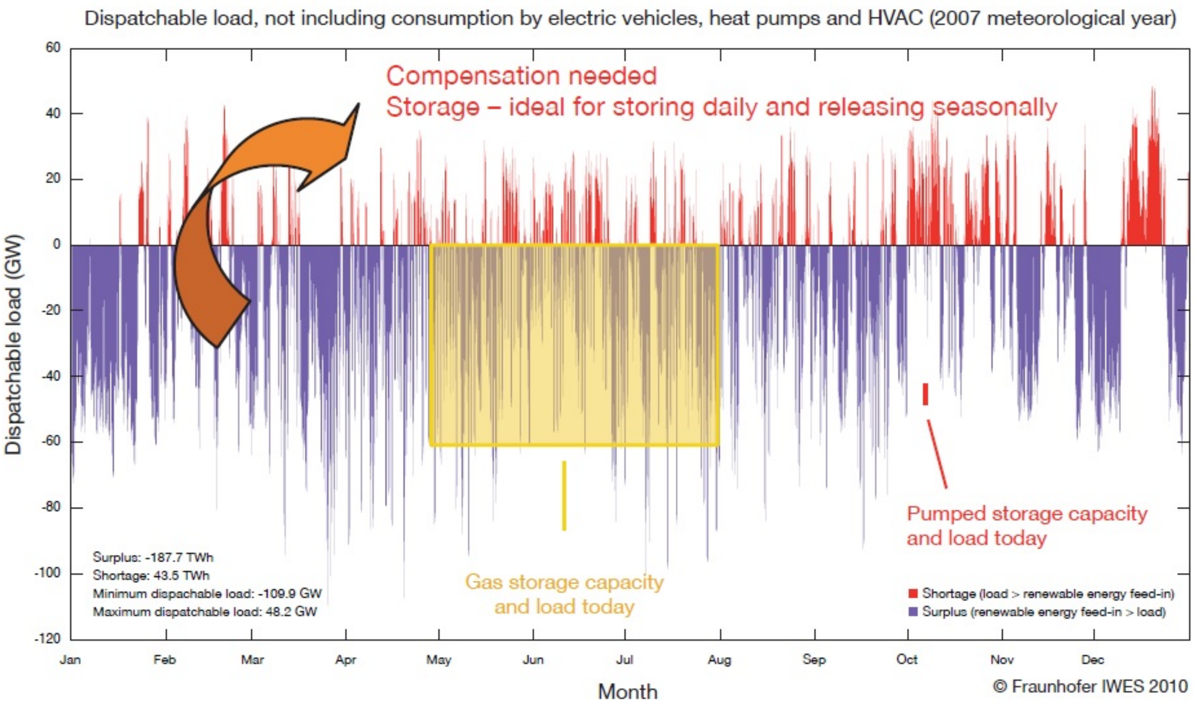
But the potential of windgas is even greater. The addition of carbon dioxide to hydrogen in a further step yields methane. This process is more expensive and slightly less efficient than the production of hydrogen; moreover, we need to rely on an ecologically acceptable source of CO_2. This can be CO_2 gained from production processes (breweries) or environmentally sound biogas plants, or even, in the long run, from the atmosphere. But the major advantage of renewable methane is that there are no limits to its absorption in the gas grid. It could indeed replace natural gas altogether. This would increase the storage capacity to 220 TWh_{th}, equivalent to about 120 TWh_{el} at 55 percent efficiency if the gas is reconverted to electricity – enough to meet Germany's power demand for two or three months if enough gas-fired power plants are in place to support this technology.

3) What are the advantages of windgas?

<u>Windgas makes it possible to store renewable energy</u>. This is of crucial significance in supplying Germany completely from renewable energy sources because weather conditions will cause large fluctuations in the generation of wind and solar power.

The Fraunhofer Institute for Wind Energy and Energy System Technology estimates that annual storage demand for green energy will reach 170 TWh when Germany is fully supplied from renewable sources. This enormous amount of electricity, equivalent to about one third of the country's annual power consumption, must be stored at times of strong winds and/or sun, and then be reconverted to electricity when green power generation falls short of demand. This energy may have to be stored for many months to achieve a balance between windy winters and calm summers.

Alternative energy storage systems, such as pumped-storage hydroelectricity, batteries, compressed air storage or flywheels, also have their merits because they often operate at higher efficiency levels than windgas. The chain of conversion in the windgas scheme (wind power → hydrogen → storage in the gas grid → gas-and-steam power plant → electricity) leads to energy losses of about 45 percent, and more if methanation is added to the process. But none of the alternative technologies exhibit or promise the necessary capacities. Pumped-storage hydroelectricity, the most developed system, currently accounts for only 0.04 TWh of storage capacity in Germany. Norway's huge reserves in pumped-storage are sometimes mentioned as a potential backup for Germany's green energy. But it has lately become clear that Norway's willingness to "rent out" its capacities is quite limited; moreover, even if the capacities were available, they would have to be shared with other European countries. This is not to mention the difficulties of transmitting the power to Norway and back, the necessity to upgrade those power plants, etc. In sum, windgas currently represents the only workable solution with sufficient capacities to support Germany's energy supply from 100% renewable resources. Required infrastructure investments are also comparatively low as the gas grid is already in place.



Storage demand – Surplus and shortage of green power supply in a 100 percent renewables scenario

Windgas utilises all wind power – even in times of grid overload. Until the grid has been optimally upgraded, it will – and already does - happen that turbines (and increasingly, photovoltaic plants) have to be shut down because the grid cannot transmit the power they generate. A good 100 GWh of valuable green energy was thus lost in 2010, regardless of the fact that consumers had to pay for it. Forecasts by the Fraunhofer Institute for Wind Energy and

Energy System Technology predict that these losses could grow to 40 TWh by 2020 and 80 TWh by 2030, depending on grid expansion.

Merging the power grid and the gas grid into a single energy transportation system, the windgas plan can reduce the need for additional power lines. No longer will the capacity of the power grid alone have to suffice to absorb the peaks of wind power.

Windgas is an ecologically sensible alternative to biogas. Biogas is so far the only alternative to conventional natural gas for environmentally-aware consumers. Unfortunately, the substrates for biogas production far too often derive from industrial livestock farming and intensive agriculture.

This doesn't mean that biogas is altogether unacceptable from our point of view. It does make sense to use waste and residues from food processing and landscape conservation, dung and liquid manure from livestock farms which have adequate space for animals, from crop production residues and catch crops, as well as biomass which is cultivated in line with ecological standards and is not in competition with food production or nature conservation concerns, such as sewage sludge and landfill gas. However, the amount of such biogas available today is insufficient to have much impact on the energy supply. We therefore do not currently consider supplying biogas, especially because our support for windgas is a much more effective signal to energy policy.

4) Is windgas economically viable?

The production of hydrogen in electrolysers is a proven and mature technology whose application is, however, so far mostly limited to industry. The novelty lies in linking this technology with renewable and fluctuating energy sources. Rough estimates currently put the cost of investment in a standardized industrial electrolyser at about EUR 1.2 million per megawatt of installed capacity. Other investments need to be made in infrastructure, especially for feeding hydrogen into the gas grid. These costs will vary by location, depending for example on the distance to the gas lines and the prevailing levels of pressure in the grid, so that no general statements on costs can be made. According to the latest regulations in Germany's Energy Industry Act and the implementation of downstream regulations, the energy supplier bears 25 percent of costs or a maximum of EUR 0.25 million for grid connections, including gas lines up to 10 kilometres in length. The remaining connection costs are borne by the grid operator and are apportioned to the network charges. Other infrastructure investments, such as intermediate storage, are to be borne solely by the energy supplier.

The volume of hydrogen produced will depend on the electrolyser's number of full-load operating hours. The fact that the electrolysers will run on fluctuating wind and solar power will reduce the number of full-load hours (load-dependent mode of operation). We expect modes of operation at the first facilities to exhibit a higher number of operating hours than the pure load-dependent mode of operation of wind turbines. If we start with a figure of about 5,000 full-load hours, costs will be about EUR 0.30/kWh_{th}, about 10 times the current average price of natural gas. In load-dependent operation, these costs will be higher. However, anticipating a learning curve and economies of scale in the mass production of electrolysers, we may expect the cost of this technology, and thereby the unit cost of windgas, to decline sharply.

The price of the wind power to be used in the production of windgas is of course the most important variable in assessing the economic viability of the scheme. Under the current regime of the German Renewable Energy Act, wind power would have to be bought at the feed-in tariff, about EUR 0.09/KWh. By contrast, under the economically reasonable operating scenario, the electrolysers will run on wind energy that would otherwise be lost due to grid overload. Thus any price above the marginal cost of wind power production, which is almost zero, makes economic sense. Power rates as low as EUR 0.01/KWh would dramatically reduce the price of windgas and ensure its commercial viability. The efficient use of excess wind power in electrolysers therefore necessitates a significant shift in renewable energy legislation.

Our idea is to build a large number of standardised electrolysers either along the gas grid or near wind farms. In the same way that substations are efficiently sited close to wind farms, electrolysers can become standard components of wind farms or may be located in wind farm regions. There are several options for transporting hydrogen, one of which is to feed it directly into the gas grid where a practical and inexpensive connection exists. But systems are also imaginable in which hydrogen is collected in trucks and fed into the gas grid at a central entry point. The more efficient and standardized the plan for developing a windgas system becomes, the lower the unit costs will be.

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