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How ammonia beats batteries to supply long term firm power from renewables

Not many people know this - yet - but ammonia is looking like being the best means by which wind and solar power can provide 'firm' power - that is ensure continuous supply of energy demand from renewable energy 100 per cent of the time.

Ammonia, in this system, acts as an energy carrier for hydrogen produced from water which has been electrolysed - split into hydrogen and oxygen - by renewable electricity (mainly wind or solar). The hydrogen can be more or less simultaneously combined with nitrogen from the atmosphere to produce ammonia. The ammonia can be stored, and when needed, it can be burned in conventional-style turbines/engines or used in specially designed fuel cells to generate electricity when required.

Currently much conventional wisdom has it that batteries are only the main means of storing renewable energy. Indeed batteries are very good for evening out balances in daily production and consumption of electricity - so peak demand can be reduced and the amount of firm power reduced. But we also need firm power for those days - under a 100 per cent renewable energy system - when there is little wind or sun. This is where ammonia comes in as a potentially better option for providing fim power. It is not a question of either batteries or ammonia, but simply that they can perform different functions providing short term and longer term storage respectively.

Ammonia (used as a hydrogen energy carrier) has a great advantage over hydrogen itself in that it can be stored much more easily than hydrogen. Ammonia is already stored for lengthy periods whereas long term storage of hydrogen requires development of the use of caverns or depleted gas fields.

In brief, there are various studies attesting to the likely practicality of this general type of system. A pilot project demonstrating the green ammonia to firm power concept was concluded last year at the UK's Rutherford Appleton Laboratories (1).

One student led project (at the University of Strathclyde), summed up the advantages of the system by pointing out 'The principle of having the storage tank connected to the National Grid would allow not only surplus wind energy to be stored as ammonia but all excess renewable resources from any power plant in the UK' (2). This project (2) concluded that ammonia would be a much better solution than batteries, owing partly to the fact that so much battery capacity would be required to do the same job, but also because of the value of the renewable energy that would also be wasted when there was excess production compared to electricity demand.

Indeed supplying reserve power through ammonia (or some other storage vector, eg compressed air, biomethane etc) could be very cheap indeed since the storage solution would be generated using 'excess' renewable energy that was virtually, if not actually, zero cost.

One reason why ammonia is likely to emerge as a key part of progress to a 100 per cent renewable energy economy in countries like the UK is simply because ammonia is a very important industrial feedstock. The fertiliser industry, in particular, requires massive quantities of ammonia which are currently derived by a highly energy/carbon intensive process involving the 'reformation' of fossil fuels. The reformation (called the Haber process) releases hydrogen from the fossil fuel (usually natural gas or oil derived) which is then combined with nitrogen to produce the ammonia.

A key point to remember is that the fertiliser industry is going to be under pressure to reduce its carbon footprint by deriving its ammonia from low carbon energy sources. Indeed there is increasing attention being given to the notion of 'green ammonia', and several research and demonstration projects into 'green ammonia' are being conducted around the world. Green ammonia will, in effect, be subsidised by the increasing quantities of otherwise zero cost renewable energy produced when renewable energy is excess compared to demand (this phenomenon becoming more and more common as the proportion of renewable energy of total energy rises). As the fertiliser and other industries source their ammonia as green ammonia in larger quantities then the availability of this will make the possibilities of it being used as a fuel increase.

It is certainly the case that the optimum processes involved in a green ammonia system are yet to be determined. These include, if possible, improving the efficiency of the system. It also involving deciding which strategy is best to minimise nitrogen oxide production when burning the ammonia (this can be done by different techniques, or using the ammonia in adapted fuel cells). However, when compared with the complexities and problems of the rather-more-state-favoured nuclear or carbon capture and storage projects, the challenges facing using green ammonia as firm power seem simple to resolve.

If it is the case that renewable energy can be effectively stored using ammonia to provide firm power (and I think it is the case) then not only can renewables provide firm power on days when there is little wind or sun but also ammonia could potentially be used to power aircraft.

by David Toke November 2019

(1) Green Ammonia, Siemens, https://new.siemens.com/uk/en/company/topic-areas/sustainable-energy/green-ammonia.html

(2) Conclusion, Wind Energy Storage Project, University of Strathclyde, http://www.esru.strath.ac.uk/EandE/Web_sites/17-18/windies/index.html

https://phys.org/news/2019-08-ammonia-fuel-cells.html

https://phys.org/news/2018-01-link-solar-hydrogen-ammonia.html https://www.sciencedirect.com/science/article/pii/S2542435118301788

https://www.solarpaces.org/missing-link-solar-hydrogen-ammonia/

https://www.sciencemag.org/news/2018/07/ammonia-renewable-fuel-made-sun-air-and-water-could-power-globe-without-carbon