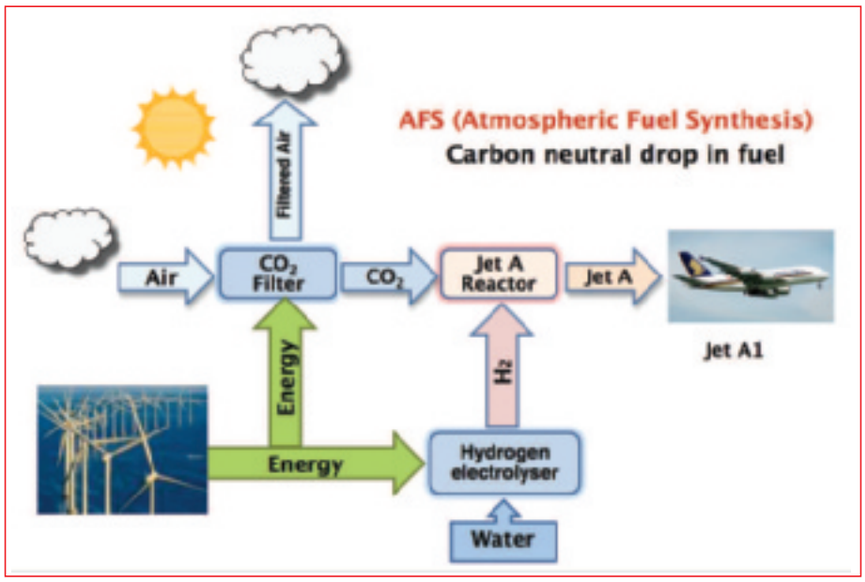
A new way to sustainable aviation fuel

*Renewable energy pioneer **Professor Tony Marmont*** looks at progress towards eco-friendly aviation fuels*

We all know that as fossil fuels become more difficult to extract from the earth and may become available in smaller quantities, that transport fuels and thus aviation fuels are going to become more expensive. Add to that the pressures on aviation in general that some environmentalists are directing at air travel and life for the aviation world as we know it now could become very difficult in the future. And that difficult future may be nearer than we think! So, in common with other parts of the energy market, the search is on for new forms of energy that can be readily available but not add to the levels of carbon dioxide (CO_2) in the atmosphere or otherwise damage the environment. For electricity production, we are familiar with seeing wind turbines around the country and to a lesser extent photo-voltaic panels on buildings, and developments in marine energy from wave devices and the like are under way. But what are the chances for 'green' transport fuels and 'green' aviation fuels in particular?

There is no shortage of potential candidates. The US Air Force has been looking at military avtur derived from coal and a B52 bomber has flown on the coal-based fuel. Airlines have been considering and testing various fuels derived from biomass such as ethanol from sugar and cellulose, and oils from coconut and jatropha seeds. Over the last couple of years there has been great interest in fuels derived from algae, and the latest fuel to be added to the list is isobutanol, currently being championed by Richard Branson. Nuts and seeds can be crushed to give an oil that may be worked up into a suitable fuel composition. Otherwise the coal or biomass is first 'gasified' into a mixture of carbon monoxide and hydrogen called Syn Gas. The Syn Gas is reacted with a catalyst in a 90-year-old process called the Fischer-Tropsch (FT) reaction to turn it into hydrocarbon fuels. The reaction conditions and catalyst may be varied to make petrol or diesel or avtur type fuels. In principle, any carbon containing material can be converted into Syn Gas and then into fuels. Even turkey guts have been used! But there are drawbacks. If coal is used to make the fuels, then CO_2 is still added to the atmosphere when the fuel is burnt. Biomass sourced fuels may have the attraction of being carbon neutral but there are conflicts with the land space currently needed for growing food. So what is wanted is a carbon source that is sustainable and does not use food growing land and yes, one may now be in sight; isn't there a lot of carbon dioxide in the atmosphere?



Top: Prof Tony Marmont explains his fuel process to visitors from the Helicopter Club
Above: Figure 1. Schematic outline of the air fuel synthesis (AFS) route

And this is where I come in. I've been a

prominent proponent of renewable energy for more than 20 years, as evidenced by my letter in the February 2009 issue of GA. On retiring and selling my business interests, I funded the set-up of the Centre for Renewable Energy Systems Technology at Loughborough University, and I have supported similar activities at Nottingham and De Montfort universities. My involvement with renewable energy projects is as extensive as anyone in the UK.

But I also have other interests. I've been a pilot for 40 years and currently own and fly a helicopter. I willingly admit that my helicopter

does not at first sight match with my involvement with renewable energy and my 'green' image, but in my own defence I have worked on producing a biomass fuel derived from grass and straw, and hope to now use the AFS fuel in my helicopter as soon as I can, and my house and farm act as a renewable energy research centre and are entirely run by a range of renewable energy methods. About three years ago, I published a cooperative study with BA, Rolls Royce and Imperial College, investigating the potential for biomass-based aviation fuels in the UK.

For the last two years, I have been leading a team that has been examining the feasibility of using carbon dioxide from the air to make hydrocarbon fuels via the Fischer–Tropsch reaction. The key step is finding a way to capture the CO_2 from the air to allow it to be used as a feedstock. In addition to carbon dioxide, hydrogen is required. This also can be readily obtained from the air by condensation of water, followed by electrolysis of the water to make hydrogen and oxygen. Of course, any other readily available source of pure water will be suitable. A chemical reaction is used to convert the carbon dioxide and hydrogen into carbon monoxide and water. The carbon monoxide is then reacted with more hydrogen to make the fuel. The carbon route is cyclical and if the fuel production is driven by renewable energy then the whole process is carbon neutral – welcome to eco-friendly aviation.

The team has named the process air fuel synthesis (AFS) and formed the company Air Fuel Synthesis Ltd to bring the concept to fruition. We have completed the theoretical studies needed and have confirmed the practicality and economic viability of the processes that lead to AFS fuels. We are now seeking funding to build a 5L/day demonstration module. From this demonstration module, Air Fuel Synthesis Ltd will move on to commercial-sized units.

A central advantage of our AFS route is that it is a new application for several existing technologies. Consequently, the R&D effort to integrate these technologies will be minimal and AFS will be a very near-term solution to avtur supplies.

The AFS concept will bring many advantages to aviation, transport in general and the environment, starting with the fact that it will be a 'drop in' fuel that requires no change to the storage and distribution network or modifications to engines.

The raw materials of carbon dioxide and water are in unlimited supply. Hence, unlimited amounts of fuel can be made and you do not need to be an oil company to do this. The UK could thus be self-sufficient in fuel for aviation and for transport in general. It follows of course, that AFS fuels can be made by any country, so the geo-political map of the world's fuel supply will change

For the environment, the overriding advantage comes if AFS is driven by renewable electricity, for then the process is carbon neutral. When fully adopted, aviation will cease to contribute to the CO_2 increase in the atmosphere.

The first AFS fuels for aviation could be on the market within two years if funding can be found. Thereafter, AFS fuels will become ever-increasingly available until a 100% market penetration has been achieved. AFS fuels will be a key to allowing sustainable growth for the aviation industry. Indeed, AFS may tick all the boxes for a sustainable aviation (and general transport) fuel of the future.

To power the AFS fuel production, the AFS scheme will best be an integrated system in which the fuel producer owns his own wind turbines (or other renewable electricity source). There would be no need to be grid connected. This helps the economics of AFS production by utilising the support mechanisms available for renewable electricity in the UK and avoids the expensive grid connection costs.

Now that the team has fully worked out the energy requirements for the AFS process, it is possible to calculate the energy needs to meet all the UK's transport energy requirements. If wind turbines alone were to provide this energy and assuming the turbines are all off-shore, then a block of land in the North Sea 175 by 175 miles would be needed. Restricting the AFS wind requirement to meeting the UK's aviation, military and marine fuels solely, this figure reduces to 72 miles by 72 miles. A ten-year programme of wind turbine construction, with the wind turbines placed either on the sea bed or on floating platforms would solve the UK's transport energy needs once and for all.

The AFS scheme is believed to be unique in the UK but there are others across the world who are working on similar programmes. The Los Alamos laboratory which helped develop the first nuclear weapons, has a scheme called 'Green Freedom' and the US Navy has recently revealed a very similar process in which carbon dioxide is recovered from sea water, enabling aircraft carriers to make their planes' fuel whilst at sea. So, let's hope this is not another idea that the UK has played a part in developing only to see it wasted by lack of interest or funding. If you are an entrepreneur who enjoys flying aircraft and wants to make a good investment, then I would be glad to hear from you!

Top left: Prof Marmont's helicopter, and the hangar for which he won a design award
Left: a B52 bomber has flown on coal-based fuel in the United States

**Prof Tony Marmont founded Beacon Energy 12 years ago to foster the concept of low or zero-carbon lifestyles without going back to cave-dwelling. Having pioneered the second wind turbines in the UK, he established a synergy of photovoltaics and hydro power for his own supply. For the last six years he has been making hydrogen from roof water in times of surplus power, then turning it back into electricity in times of shortage.*

He first flew with the ATC at Castle Donington in 1943 and was a radar operator in the RAF from 1948 to 1950. He learned to fly at Cranfield in 1960 when his instructor was Pam Klein (now Campbell) and his aircraft have included a Meta Sokol L40, a Mooney M20, a Twin Comanche, Cessna Skymaster, Cessna 425, Squirrel B2 and Twin Squirrel. He has logged some 5,000 hours. ■