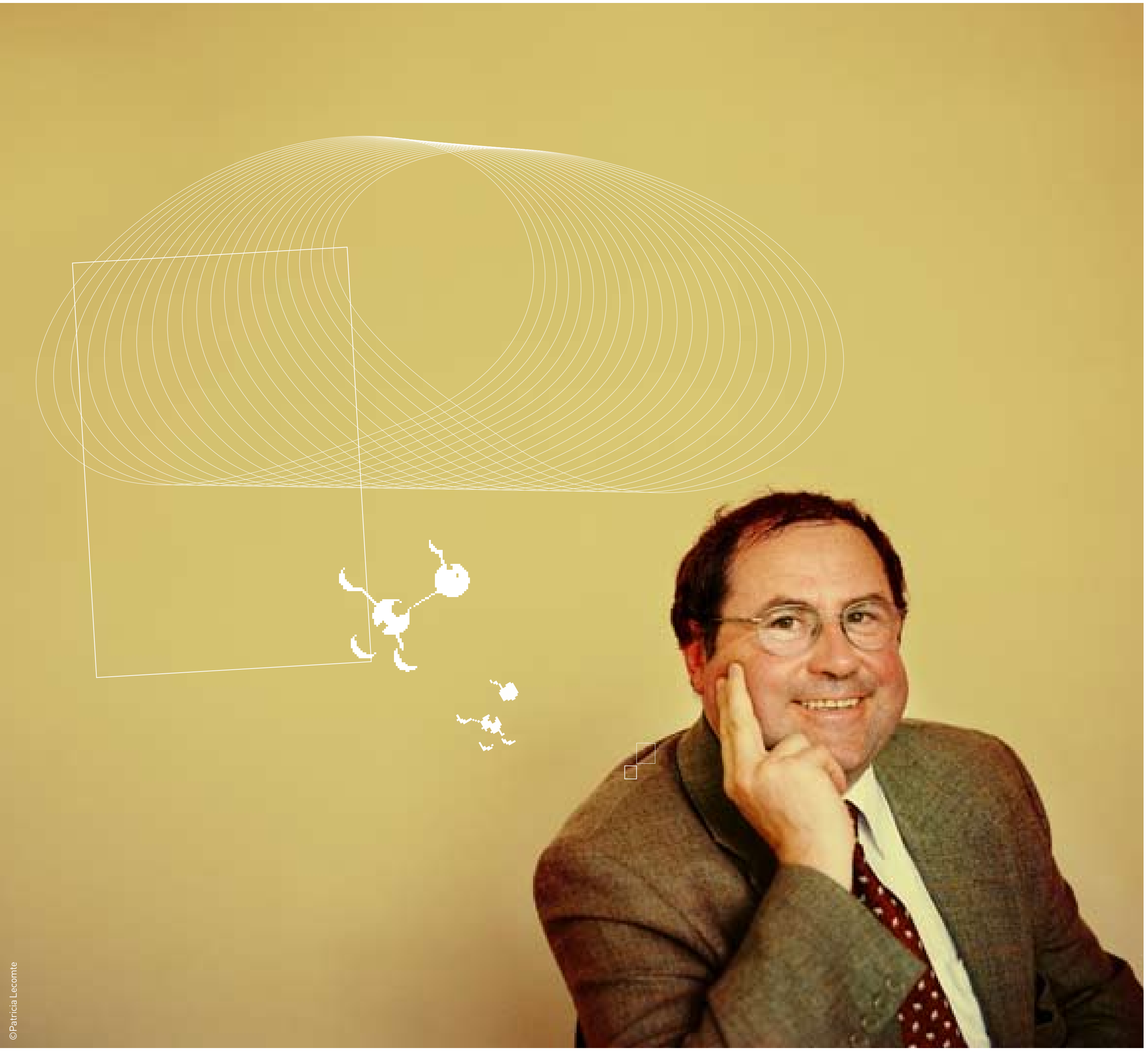
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Face to face with Xavier Montagne
Head of the fuels-lubricants-emissions department of *Institut Français du Pétrole.*

BIOGRAPHY	1983	1986	1998	2002
	CHEMICAL ENGINEERING DEGREE.	Ph.D IN PETROLEUM SCIENCES.	NAMED HEAD OF THE FUELS-LUBRICANTS-EMISSIONS DEPARTMENT.	NAMED TO THE SCIENTIFIC MANAGEMENT BOARD OF IFP.

New fuels for tomorrow's airplanes?

The world's oil consumption is growing. With airlines feeling the impact of spiraling prices and environmental requirements, the burning issue is to find a replacement for jet fuel.

The steep rise in fuel prices throughout 2005 caused tremors in the aviation industry. The price of jet fuel, which accounts for 20% of airline operating costs, shot skyward, and doesn't look ready to come back to earth any time soon. In fact, the main question isn't so much the price of fuel, but rather the quantity of reserves still to be tapped – estimated at only 40 years of oil, versus 70 years of gas and 230 years of coal.

In short, reserves are being depleted, while consumption continues to climb. From 1992 to 2002 the consumption of jet fuel grew 21%, as passenger traffic jumped 53%. While jet aircraft have reduced their fuel burn by nearly 70% since the 1960s, current conditions more than ever demand the invention of a fuel to replace the trusty old Jet A-1, derived from crude oil. Another key question is environmental protection. In fact, the European Parliament has passed a very clear resolution concerning the reduction of aviation's impact on climate change (INI/2005/2249): "The Parliament (…) strongly encourages (…) efforts to introduce biofuels in aviation, as a contribution to reducing impact on climate change."

A complex problem

There is a clear acknowledgement of the need to replace jet fuel, but the problem is not that easy to resolve. In fact, it's a very effective fuel, combining excellent chemical and physical properties (viscosity, freezing point) with good energy density[1] and thermal stability. Furthermore, there are a number of barriers to the replacement of jet fuel. Civil aviation is obviously an international industry, which means that any basic product must be available anywhere in the world – which leaves little room for special fuels. If a replacement synthetic fuel is indeed developed, it will have to offer the same characteristics as jet fuel, and be mixable with it. Given the

> "Civil aviation is an international industry, which means that any basic product must be available anywhere in the world, leaving little room for special fuels." Xavier Montagne

lifespan of aircraft in service, jet fuel will obviously be the primary solution for the next 30 years.

The next issue, and far from the least, is one of safety. Because of the complicated certification process, it takes a lot of time – at least 15 to 20 years – to develop a new fuel and have it approved by international aviation authorities.

For a closer look at this subject, we spoke with Xavier Montagne, head of the fuels-lubricants-emissions department of *IFP* (Institut Français du Pétrole).

Safran Magazine: How does an expert like yourself tackle the question of replacement fuels?

Xavier Montagne: Replacement fuels already exist, despite the obstacles along the road. These are not traditional products, but rather made from raw materials other than petroleum, primarily coal and natural gas. The manufacturing processes for these fuels involve an intermediate stage that produces a synthesis gas (mixture of carbon monoxide and hydrogen). From this point, two different methods can be used: direct production of hydrocarbons using the Fischer-Tropsch technique [a process invented in the 1920s, later widely used in South Africa due to embargos against the country]; or a process based on methanol, which will subsequently be converted into gas.

Why haven't these processes been developed more widely?

Because in most cases they require technologies still under development. However the Fischer-Tropsch process can be used to produce synthetic jet fuel from natural gas, biomass or coal. Global coal reserves are estimated at more than two centuries, but this technology goes hand in hand with significant emissions of carbon dioxide (CO_2). Therefore, the industrial production of this type of fuel must be implemented in conjunction with the deployment of CO_2 recovery systems at the production site. On the contrary, with biomass as the raw material, the overall CO_2 budget becomes much better.

And yet, these replacement fuels have already taken a major step forward...

Yes, an equal mixture of jet fuel and synthetic fuels has already been approved. Use of a "pure" synthetic fuel is even highly likely. At the same time, aircraft and engine manufacturers, plus the IFP, are thinking about other solutions that would reduce emissions. For example, through collaborative programs such as Calin, Alfa-bird and Dream, *Institut Français du Pétrole* is working closely with Snecma and the Safran Group. We provide the knowledge needed for chemical formulations and the choice of appropriate molecules, and Snecma contributes its expertise as engine manufacturer.

What areas are you currently studying?

Raw materials are extremely important. Depending on the products, the different processes are positioned very differently. When we have to make our final decisions, it is the total CO_2 budget[2] "from well to wing" that will prove decisive. Biomass already offers decisive advantages. Its budget is much more satisfactory than that offered by GTL (gas to liquids) or CTL (coal to liquids). As a raw material, coal is saddled with a poor CO_2 budget.

No matter what happens, Safran and IFP are playing pivotal roles in solving this problem. Joint programs allow us to study the impact of these new fuels, and design the industrial systems that will subsequently be deployed. ■

P. FRANÇOIS

(1) Quantity of energy in relation to the volume of fuel.

(2) CO_2 budget: the sum of CO_2 emissions, from production of the fuel (including extraction, refining and transport of fossil fuels), to consumption. For vegetal-based fuels, the CO_2 absorbed by the plant during growth is subtracted from the CO_2 emitted during production, transportation and utilization.


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Fuels made from biomass offer very convincing advantages, and a good CO_2 budget, but they're still expensive to produce.

GLOSSARY

ALTERNATE JET FUELS

› **CTL (*coal to liquids*)**
Jet fuel made from coal, using the Fischer-Tropsch synthesis process. Enables producing jet fuel from a source other than oil, but would not improve CO_2 emissions, and even less so the CO_2 budget.

› **GTL (*gas to liquids*)**
Fuel produced by converting natural gas into a liquid fuel (jet fuel, as well as diesel). No sulfur emissions.

› **BTL (*biomass to liquids*)**
There are two types of biofuels: first generation fuels, including bio-ethanol, ETBE (ethyl-tertio-butyl-ether) and EMHV and EHV (made from vegetable oils or fatty acids). These fuels do not offer the properties enabling them to replace jet fuel. Second-generation biofuels, called BTL (biomass to liquids), are produced from vegetable matter such as wood and straw. These bio-jet fuels provide better thermal stability and include very few aromatics (reduced soot emissions). They offer greater supply capacity and reduced CO_2, along with the total absence of sulfur in emissions. But BTL production costs are very high, and the availability of biomass remains uncertain. Huge investments will be needed to produce the vast volumes needed.

THE LONG HAUL TOWARD "BIO-JET FUEL"

Snecma is taking an active role in research aimed at the production of jet fuel from biomass

MICHEL DESAULTY
SILVERCREST BRAND MANAGER AT SNECMA (SAFRAN GROUP)


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Jet fuel is of course used to propel the aircraft itself, but it also fulfills several other functions, including cooling the engine oil and being used as a hydraulic fluid in certain systems. In other words, in addition to its energy capacity, a jet fuel has to have other properties, such as stability at high temperature (150°C) and fluidity down to -50°C. It also has to be compatible with the materials used in aircraft construction. So-called first-generation biofuels are already been used, but they offer certain drawbacks. "Ethanol's caloric power is far less than jet fuel, about 40% less; and while EMHV* is roughly equivalent, it's a thermally unstable product: in other words it decomposes as soon as it's heated, leaving deposits in lines and injectors," explains Michel Desaulty, Silvercrest brand manager and formerly head of the combustor and afterbody department at Snecma (Safran Group). "So we're turning to new products made using biochemical or thermal processes."

Snecma is already participating in a joint research program called Calin with both industry and research organizations, including INRA, Onera, Cerfacs, CNRS, IFP, MMP and Airbus. Their work should culminate in the laboratory fabrication of a biofuel, followed by tests designed to check its physical and chemical properties, including during combustion. Once this phase is completed, tests will be performed at an industrial scale to ensure that the fuel is compatible with aircraft and engine systems. Lastly, performance will be checked, first on the ground then in flight tests.

Other, complementary projects are now being developed in Europe, within the scope of the 7th PCRD framework R&D program: Alfa-bird (Airbus, Snecma, Rolls-Royce, MTU, Avio, IFP, etc.), also focuses on second-generation fuels, and a project dubbed "Dream", which will include testing on a turbomachine.

So when can we expect to take an airplane using bio-jet fuel? "The production process is the main question," responds Desaulty. "Just meeting the specifications for jet fuel is not enough to demonstrate the fuel's compatibility. We will have to validate the entire system, including the product and its entire production process, to make sure that the properties and performance measured in research programs such as Calin are in fact reproducible."

In the meantime, there is one major argument in favor of biofuels: environmental protection. Unlike cars, aircraft cannot treat exhaust gases. Controlling the efficiency of combustion, by improving fuel properties and developing new combustion chambers, is the only means of reducing polluting emissions, such as nitrogen oxides, unburned hydrocarbons and particles. For instance, aircraft are accused of producing high-altitude cirrus clouds because of the particles emitted by jet engines, and these clouds increase air transport's impact on the greenhouse effect. Biofuels may help resolve this problem, since they contain no sulfur, and very few aromatic polycyclic chemical species (soot precursor). But biomass production is limited, and will not be able to satisfy all requirements. Various energy scenarios are therefore being studied to come up with a solution.

* see Glossary opposite