What to do while waiting for the 10X battery.

One clarion call of the CAFE Foundation, for which I write the blog (shameless self-promotion) is the need for a 10X battery that will be 10 times more powerful, and therefore 1/10 as heavy, as today's best lithium batteries. Such a development would make electric airplanes a reality.

Meeting CAFE halfway, the U.S. Department of Energy just announced a program to develop a battery that's five times more powerful, five times cheaper and only five years away. Secretary Chu may have become a bit impatient on the slow progress toward such goals, measured at about an 8% real-world improvement each year. He's putting up $120 million for six national laboratories, five universities and four private firms to reach a goal that might just be attainable with the concentration of brains and talent being put to work.

In the meantime, it might take a while for an uncompromising electric airplane to achieve commercial success, even though innovators are employing their best skills to make that happen.

What's one to do to make flying less expensive and even "greener" while we wait? Homebuilders have an edge here.

Klaus Savier and Speed with Economy

This article cannot begin to examine every vendor or new airplane, so I chose to highlight examples with demonstrated success in saving fuel while not punishing performance.

Klaus Savier, head of Light Speed Engineering, for instance, is long associated with electronic ignition, and more recently, fuel-injection systems. Replacing the standard magneto on an aircraft engine with his ignition system will guarantee 10% fuel savings, Savier says, noting that no customer has argued with the claim.

Beyond that, Savier's Light Speed ignition lowers exhaust temperatures 100° at "normal" cruise at 12,000 feet and 22 inches of manifold pressure. A cooler engine lasts longer, he says. With no magneto maintenance and long-lasting integrated circuits driving the ignition, the savings add up. And with avgas

Panel of Klaus Savier's modified PV O-360 Lycoming-powered Long-EZ Determinator. "Cruising at 17,700 feet, 160 knots indicated, 217 knots true, 50 psi FP. The small airspeed reads a low amount of crank-case pressure. Fuel flow was about 8.2 gph. The gear warning is not recommended!…The Delaminator has the more efficient O-200 from the Cessna 150s. It cruises at the same 17,500 feet at about 195 KTAS and 4.2 gph," Savier said.

Delaminator's 67-inch-diameter, 101-inch-pitch propeller—one element in high-mpg performance.

Dean Sigler

A technical writer for 30 years, Dean has a liberal arts background and a Master's degree in education. He writes the CAFE Foundation blog and has spoken at the last four Electric Aircraft Symposia and at three Experimental Soaring Association workshops. Part of the Perlan Project, he is a private pilot, and hopes to get a sailplane rating soon.

Photos: Dean Sigler, Klaus Savier, Courtesy Serge Pennec

Light Speed's Delaminator VariEze demonstrator at 17,000 feet on a typical cross-country flight.

The PSA Peugeot 106 or Citroen AX engine. This is an aluminum-block engine, dropping weight to 176 pounds (80 kilograms) plus radiator and accessories. Pennec says the engine can be found for €300 in salvage form or €1,300 in exchange form.

averaging around $6 a gallon, Savier estimates that his system pays for itself in 100-200 hours of flying.

Savier's spark plugs go about 100 hours between changes, but they cost only $5 each, and even cleaning aviation-style plugs can be more expensive than that. Aircraft Spruce lists Champion plugs from $27.75 to $63.60 for those with massive center-fire electrodes, to as high as $119.75 for those with fine-wire electrodes. Tempest plugs run from $23.50 to $63.80.

The fine-wire plugs can give 1000 hours of service, and Savier suggests using spark plugs with the smallest possible electrode. (Heat ignites a spark, while massive electrodes quench heat from the spark.) On most systems, the spark needs to start 15-20° before top dead center (BTDC) to obtain maximum peak pressure.

Savier argues that electronic fuel injection and ignition can make significant improvements in aircraft efficiency. He shows this with his VariEze Delaminator and Long-EZ Determinator test beds. His VariEze with a Continental O-200 engine, dual Plasma CDI and a Light Speed prototype electronic fuel-injection system turned 254.89 mph over 500 miles in the 2007 AirVenture Cup, taking first place in the Sprint Class. At Delaminator's speed for best range, at 17,000 feet, the airplane can achieve the magic 100 mpg, burning 1.5 gph at a true airspeed of 150 mph—economical flying indeed.

Another flight from Savier's Santa Paula, California, home field to Panama City, Florida, covered 1985 statute miles in 8 hours, 58 minutes, using 25.8 gallons of fuel of the 29.2 carried in the standard tanks, ending with more than an hour's worth of fuel remaining. He reports, "Average fuel flow for the entire flight was 2.87 gph. Average speed was 220.6

Light Speed's Savier says his plugs with electronic ignition come out this clean every time.

The prototype Dieselis with an Opel (identical to Isuzu equivalent) cast-iron engine. The airplane has well over 800 hours on it now with no difficulties.

mph. Tailwind average was around 30 mph at 17,500 feet. The density altitude was above 19,000 feet. Of course, I was on oxygen for the entire flight."

Paul Lucas and Serge Pennec's Dieselis

Paul Lucas and Serge Pennec in France took the route of eliminating ignition systems altogether, putting an Opel Diesel engine in their Dieselis two-seat light plane. They boasted, on their inelegantly translated web site, "Fuel consumption: Boy, is it cheap!"

They also claimed an hourly fuel cost four times less than that of the MC-100 (a popular French two-seater), a low aerodynamic drag craft. "This means that in computing operating costs, the specific fuel efficiency of the engine and the cost of the fuel count a lot more than the aerodynamic performance of the airframe."

With specific fuel consumption for comparable automotive gasoline engines at 186 grams per horsepower hour up to 3000 rpm, direct-injection diesel engines compare favorably at about 165 grams per horsepower hour, the designers note. According to Michel Colomban, designer of the MC-100 and the Cri-Cri, Rotax 912 engines consume 215-295 gr/hp-h depending on speed setting. Pennec and Lucas say, "This big difference explains why the Dieselis, despite the handicap of more aerodynamic drag than the MC-100, doesn't use more fuel at the same speed (9.5 l/h at 210 km/h at 8000 feet)."

Dieselis followed the model of the American Pietenpol of the 1930s: light airframe, heavy engine. The installed Opel Corsa engine added 297 pounds (135 kilograms) to the plane's empty weight, significantly more than the 132 pounds (60 kilograms) for a Rotax 912 or the 165 pounds (75 kilos) of a VW conversion. A Model "A" engine on the Pietenpol weighed 244 pounds, its radiator another 21, and the 6-foot, 6-inch prop another 15-21; 280-286 pounds total for a claimed 35-40 hp. The empty weight of 685 pounds and loaded weight of 1100 pounds is close to specifications for Dieselis and similar to modern LSA.

Because the Pietenpol cruised at 1600 rpm, fuel burn was somewhere around 3 gph. Dieselis burns a mere 1.6 gallons (6 liters) per hour at 99.2 mph (160 km/hr), about 62.5 mpg. That caught my attention 10 years ago, and a newer, better French Diesel aircraft is now available, a direct descendant of Dieselis. Dieselis was also economical to build, costing about $7,000, including the used engine and homemade reduction drive.

A pair of Gaz'ailes in tight formation flight.

Serge Pennec's Gaz'aile

Gaz'aile (meaning gas wing, a lovely pun in at least two languages) would seem like a smaller, cleaner, better-performing version of Dieselis, and its LSA-equivalent performance and low fuel burn make it an attractive possibility for homebuilders. Many are flying in France, but none are even under construction in America or Canada.

Gaz'ailes can accept a range of diesel or gasoline-fueled engines. This is a PSA 1400cc unit.

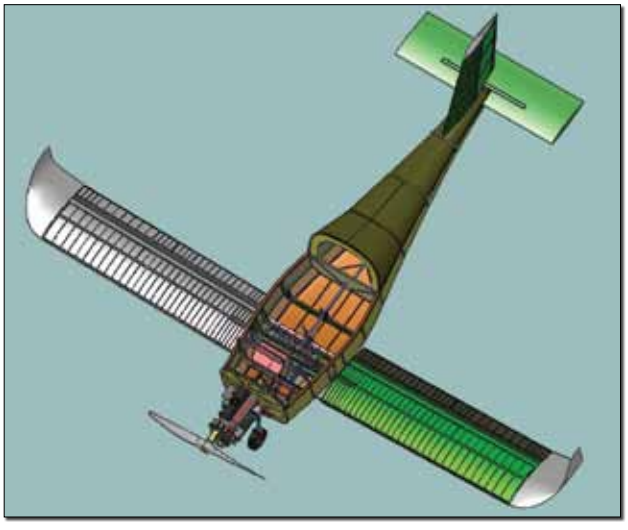
The gasoline engine works well in Gaz'aile, too, giving 124-mph cruise and burning only 3.44 gallons (9.2 liters) per hour, giving 36 mpg.

Gaz'aile can be built with a torquey little turbocharged diesel, or an equivalent petrol-charged engine. Diesels in Europe have several advantages outside of lower fuel burn. Pennec calculates about a 30% fuel savings with the diesel engine, but a big advantage is the basic cost of the fuel. European avgas costs about $8.89 a gallon (€1.8 per liter), while diesel costs $3.46 a gallon (€0.7 per liter). The immediate savings on a fill-up is obvious. Pennec explains that running small at high rpm allows better fuel use than using a larger, slow-turning engine.

For the same power output, Pennec says that the gasoline engine consumes about 30% more. The economics would change for U.S. builders, with 100LL averaging around $6 a gallon and Jet-A around $5.50. Even turning to truck stops to fill up would average about $3.99 a gallon, with a countrywide low of $3.58 and a high of $5.32. The 100LL may become a moot point, with refiners reluctant to continue with the low volumes of what is becoming a specialty fuel and many states and municipalities trying to ban its use.

Theoretically, a person could use biodiesel or even make his own, converting a few hundred gallons of used cooking oil into cheap go-juice batches for a car and/or airplane. I'm reluctant to recommend even trying this on an experimental basis, having been a poor chemistry student and being wary of online recipes for such agents, though it might be a tempting project for someone living near a fast-food gulch.

One builder, Jean-Jacques Ballot, constructor and pilot of a Gaz'aile 2, made a coast-to-coast flight of his own, from



Numerous ribs almost form the foam core in the Gaz'aile's wings.

The Gaz'aile's fuselage is almost all wood. The wings are wood, foam and carbon fiber.

Ouessant on the northwest coast of France to Propriano on the isle of Corsica, 873 miles (1409 kilometers), using only 14.27 gallons (54 liters) of fuel. On the trip home, he used only 13.47 gallons (51 liters) of fuel. His trip to Corsica took 7 hours, 57 minutes, the return 7 hours, 28 minutes.

Builders uniformly take three to three and a half years to complete Gaz'ailes and spend around $12,400-$18,600 (€10,000-€15,000). Small turbo diesels and gas engines are inexpensive in European salvage yards.

Arnold Ebneter's E-1

Michael Friend, Boeing technology director, recently shared a picture of himself in his Silent Twister, a lovely elliptical-wing, retractable-gear single-seater, flying in close formation with Arnold Ebneter in his homebuilt E-1 over the Cascade Mountains in western Washington state. Friend noted, somewhat ruefully perhaps, "Here is a picture of me and Arnold Ebneter playing around in the Cascades. Believe it or not, my sleek looking Twister is a few knots slower than Arnold's somewhat, errrr, rectilinear, airplane!"

Ebneter recalls challenging Friend to a race shortly after the impressive picture (see Page 62) was taken. They pulled alongside one another and slowly advanced throttles until Friend was at full power, and then Ebneter used the 30% he had left to walk away from the Twister. Making it an apples-to-apples comparison, both aircraft have Jabiru 2200cc 80-horsepower engines, though the Twister is 550 pounds empty and weighs 910 pounds loaded in the normal category, and the E-1, close to the same empty weight, totals 1102 pounds for Federation Aeronautique Internationale (FAI) record challenges.

The somewhat rectilinear craft has managed some impressive flying, thanks to Ebneter's careful design. After he served 15 years as a fighter pilot, in the 1950s the Air Force sent him to U.S.A.F. College, where he obtained a bachelor's degree in aeronautical engineering. He was then sent to Texas A&M, where his master's degree paper qualified as an AIAA student competition entry and eventually led to the design for the E-1. Ending his Air Force service as a lieutenant colonel, he worked for 17 years at Boeing before retiring almost 20 years ago. In case you're wondering, he is 84 years old.

The E-1 cockpit reflects Ebneter's 20,200 hours of experience and military background. Note the open and readable fuel-transfer selector. (Photo: Arnold Ebneter)

The E-1 as configured for record efficiency flight, with Sensenich ground-adjustable prop, a new spinner and a mixture control, as well as simple wheel fairings. (Photo: Arnold Ebneter)

Mike Friend was surprised that Arnold Ebneter's rectilinear E-1 could outspeed his curvaceous Silent Twister. (Photo: Sherwin Eng, Courtesy Mike Friend)

As a civilian, Ebneter worked for more than 20 years constructing the E-1, frequently finding materials at the sprawling Boeing surplus yard in Kent, Washington. This led to his selecting 7075 aluminum for the upper spar caps on his airplane, availability and low prices guiding him as Boeing discarded pieces too small for its 737s. The 7075's higher compression strength worked well here, and Ebneter chose the more normal 2024 for the lower spar caps.

The wings are wet out to the end bay, where the dry area allows installation of running lights. The wet wings hold 74 gallons, but Ebneter used only 58.5 gallons to start his July 25, 2010, flight to Fredericksburg, Virginia. He flew 2327 miles in 18 hours, 27 minutes, averaging 127 mph and about 3 gph, setting an FAI distance record for airplanes weighing 1100 pounds or less. A more recent record attempt, for overall airplane efficiency, claims 20.74 miles (33.38 kilometers) per 2.2 pounds (1 kilogram) of fuel use. Ebneter squeezed this economy from E-1 on a trip from Harvey Field in Snohomish, Washington, to Spokane, and then to Pendleton, Oregon, and a return to Snohomish, while the plane used only 62 pounds of fuel and gave 55 mpg.

Conclusions

We'll have more examples soon of aircraft that give excellent performance and mileage. All are relatively small and carry close to their empty weight or better. They are also totally practical airplanes, with no hint of extreme engineering or exotic materials. With technology such as electronic fuel injection and ignition systems saving fuel, the more flying we can do, all other factors being equal (a big supposition). Besides, increased speed, range and endurance are beneficial performance factors that make flying safer and more enjoyable. Light, clean aircraft work well with electric power too. When that technology becomes even more of an economic reality, planes such as these will be ready for conversion. ✚

RESOURCES

Dieselis (Serge Pennec, Paul Lucas)
www.membres.multimania.fr/dieselis/gb2.htm

E-1 (Arnold Ebneter)
www.eaa.org/news/2010/2010-08-19_ebneter.asp

Gaz'aile (Serge Pennec)
gazaile2.free.fr/indexAnglais.php

Light Speed Engineering
www.lightspeedengineering.com