Transcript: Turning Pond Scum Into Fuel

Reported by Lisa Raffensperger

Lisa Raffensperger: Welcome to the oilfields of the future.

Phil Savage: Well this is our algae farm.

Lisa Raffensperger: We're in a small, cluttered laboratory. Along the counter, glass beakers are lined up under growing lamps. They're bright green.

Phil Savage: It's where we grow the algae and create the biomass which we, you know, then later subject to this liquefaction process.

Lisa Raffensperger: So, to me, this is bubbling vats of green …

Phil Savage: Oh, that's your gasoline in a few years.

Lisa Raffensperger: Gasoline out of liquefied algae. That's the future Phil Savage and a team of other engineers at the University of Michigan are creating. Algae have long been attractive as a source of renewable fuel. For one thing, they live in water. All the other "biofuel feedstocks," as they're called, are land based--and a huge hindrance to making enough biofuel is that there's just not enough spare land. Algae don't even require good water. In fact, they could be grown on treated sewage, using the waste as their nutrients. The other benefit is, algae are voracious growers--as anyone who's ever owned a fish tank can tell you. In scientific terms, that's because they're so efficient at converting sunlight into biomass--much more so than land plants, says PhD student Bobby Levine.

Bobby Levine: Typically, in America, we make biodiesel out of soybeans and we get something on the order of 50 gallons of biodiesel per acre per year from soy. With algae, the estimates range very widely, but you can get anywhere from between 1,000 to 5,000 gallons of bio-oil per acre per year.

Lisa Raffensperger: This productivity is already being exploited. Scores of companies have sprouted up around the country, working on developing algae fuels. But, almost exclusively, what they're trying to make is algae biodiesel. And if biodiesel is like squeezing the juice out of an apple … What Savage's lab hopes to do is put the whole apple in a blender.

Bobby Levine: Okay, here we go, let's try to get something green in here.

Lisa Raffensperger: Here's the first difference. Levine fills a tiny metal cylinder with a squirt of algae--and water. Conventional biodiesel requires the algae to be dried, which takes a huge amount of energy. That drying process is the biggest hurdle to making algae fuels cheap enough to replace petroleum. But, Savage's team intends to use water to their advantage.

Bobby Levine: So, once we load the reactor, we then seal it and react it in a hot sand bath for about an hour, typically.

Lisa Raffensperger: A “hot” sand bath is an understatement--it’s nearly three times boiling temperature. But because the mixture is under lots of pressure, it doesn’t boil. Instead, it drives chemical reactions in the algae that break down all the cell’s components. And that’s the second big difference from biodiesel--it’s using all the cell’s components. For biodiesel, you’d extract just the oil from the algae. But that leaves behind the other stuff in a cell, like sugars and proteins. Which, the researchers say, they can use.

Phil Savage: We use more of what's there. You know, with the biodiesel process, people are excited if they have an algae that's 50 percent oil, but then right away they're only using 50 percent of the mass, of the biomass. With our approach, we’d like to be able to liquefy, you know, 100 percent.

Lisa Raffensperger: What comes out of the superheated reactor is filtered, and what remains is the coveted bio-oil. It’s still not gasoline--more like the crude oil we drill out of the ground now. It needs refining. It shouldn’t be surprising, though, that algae under lots of heat and pressure becomes similar to crude oil--in fact, that’s precisely the way petroleum crude was formed long ago.

Bobby Levine: So, we’re trying to do in the lab what nature took millions of years to accomplish.

Lisa Raffensperger: And the end products, to the naked eye look--well, like gasoline.

Phil Savage: These are samples of some of the different types of crude bio-oil that we've made from the microalgae, and we can get oil with different characteristics depending on how we process it.

Lisa Raffensperger: That’s what Savage and his students are working on--testing different growing and processing conditions to get the most gasoline-like end results.

Phil Savage: It's just one of the knobs as an engineer we have turn is, you know, how we do the processing that influences the product that we get out.

Lisa Raffensperger: When Dr. Savage’s lab is done turning knobs, though, is when his colleagues take over. The two main outputs--the bio-oil and the stuff filtered off--head different directions. The bio-oil goes to chemical engineer Suljo Linic’s lab. This is the “refinery” step. This is what turns crude bio-oil into algae gasoline. Here, researchers are working on building molecules called catalysts, which will …

Suljo Linic: … rearrange these molecules that are part of this algae bio-oil in a way that they resemble something that can be used in a combustion engine.

Lisa Raffensperger: This is the step that will transform test tubes of oil into gasoline as we know it today.

Suljo Linic: So what you really want to do is you want to go from these large molecules that nature has created in the form of this algae, and you want to change its composition in a very selective way to obtain something that’s useful with the least possible amount of energy loss.

Lisa Raffensperger: Conserving energy is also the main focus for chemical engineer Nina Lin’s lab, which will process all the non-bio-oil stuff--the waste, basically. But the waste is still rich in carbon, and carbon equals energy.

Nina Lin: So, what my group is going to help with is, we're going to harness the power of microbes to do some biological upgrade and recycling.

Lisa Raffensperger: Her philosophy?

Nina Lin: Squeeze every carbon, if possible.

Lisa Raffensperger: They'll be genetically modifying microbes like E. coli to digest the waste. Ideally, the waste will also be converted into useful fuel. It's just one more way to "close the loop," as these researchers say. To minimize energy input and reduce carbon emissions. It's environmental engineer Greg Keoleian's job to judge, in the end, how successful they are.

Greg Keoleian: As engineers sometimes in working on technology, we're very, you know, focused on a particular process and trying to optimize it. I am taking the helicopter view of the system to see how impacts are distributed and try to come up with an overall carbon footprint of the system.

Lisa Raffensperger: Keoleian will tally up all the resources, like energy, water, and land, that go into the fuel. Those can then be compared to petroleum and to other biofuels--to see, in the end, how "green" algae gasoline is. He'll put every step of the process into his computer models--from growing the algae, to refining the oil, to recycling the waste carbons, to, ultimately--this.

Will Northrop: So, I'm just going to get the engine, the test cell set up here.

Lisa Raffensperger: They'll be running the fuel in a real engine. The algae gasoline isn't far enough along to do this yet. For now, mechanical engineer Will Northrop tests other biofuels, measuring their emissions, their efficiency, and how they behave in an engine. Eventually they'll test algae gasoline.

Will Northrop: So, we're ready to go. You want to try it? Okay, we've got to go to the other room.

Lisa Raffensperger: He flips some switches and the engine in his lab roars to life.

Will Northrop: So yeah, this is the engine running. It's as if you were kind of cruising down the road in your neighborhood.

Lisa Raffensperger: Cruising, someday, on just a tank full of algae and a smile. I'm Lisa Raffensperger, in Ann Arbor, Michigan.