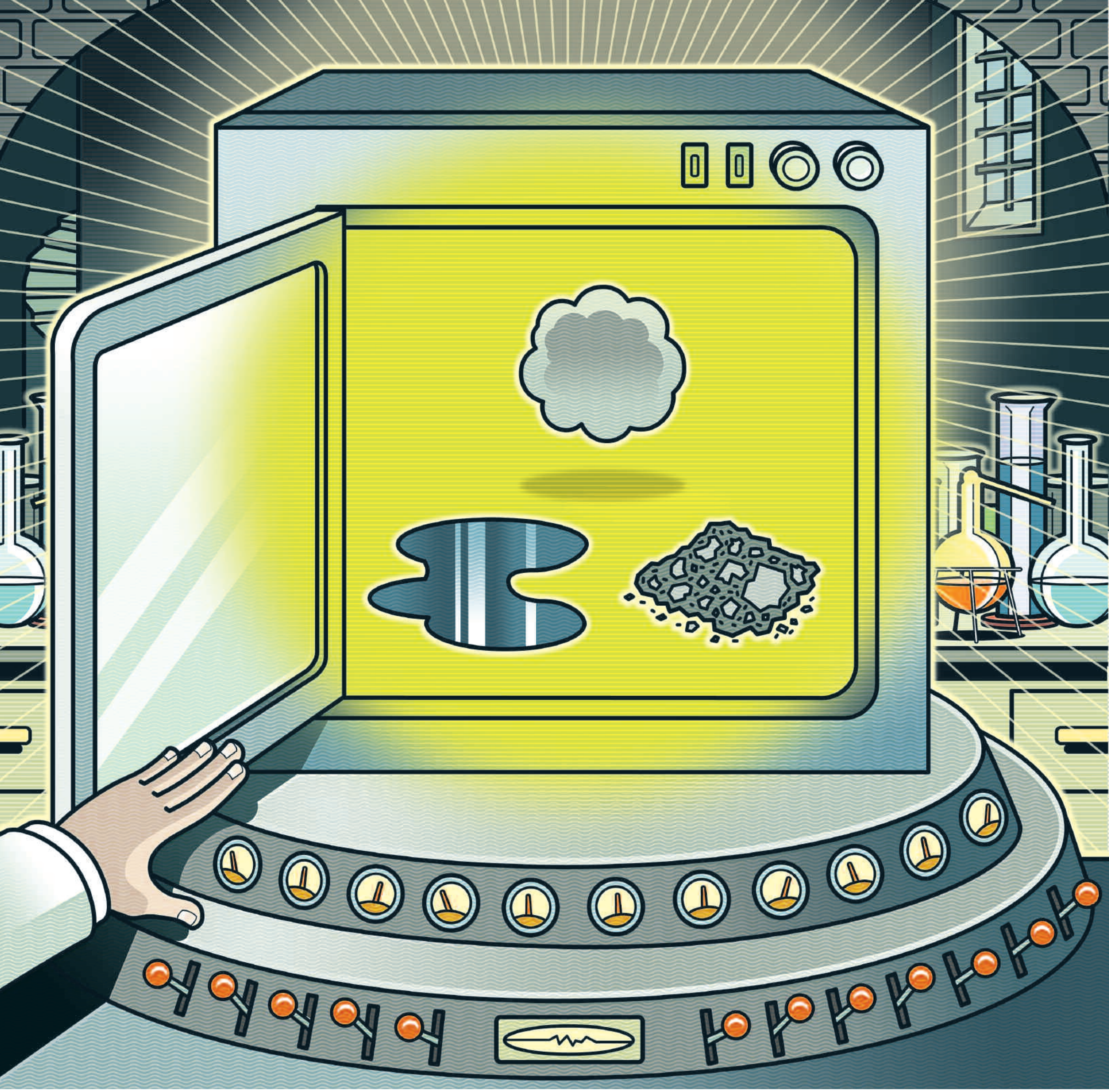

ASR ALCHEMY

MICROWAVES CAN SOLVE THE SHREDDER RESIDUE PROBLEM, ONE COMPANY SAYS, BY CONVERTING THE MATERIAL INTO ALTERNATIVE PETROLEUM PRODUCTS. IN OTHER WORDS, THEY'RE TURNING FLUFF INTO (BLACK) GOLD.

BY THEODORE FISCHER

Ever since the ancient Greeks, people have tried to transform low-value materials into high-value ones, starting with alchemists' attempts to turn lead into gold. Today Global Resource Corp. (West Berlin, N.J.) is putting a 21st-century twist on this endeavor. Instead of lead, the company's source material is automobile shredder residue, or fluff—the lowest-value byproduct of the car shredding process. And it's using microwaves, not magic, to turn that material into alternative petroleum products—natural gas and oil—that today might be more desirable than gold.

ASR is not an imminent problem in the United States, where shredders generate up to 9 million tons annually, most of which ends up in the country's still relatively abundant landfills. But in Europe, where shredders generate 5 million tons of residue, the European Union's 2000 End-of-Life Vehicle Directive mandating 85 percent vehicle recovery—plus individual countries' landfill bans—are driving innovation in residue recycling or recovery.

Global Resource is the latest in a long line of companies that have tried to make fluff valuable—or vaporized. Argonne National Laboratory (Argonne, Ill.) selectively dissolves the fluff and recovers the thermoplastics embedded within. Midwest Associates (Cleveland) developed Skygas, a heat-based conversion process that turns up to 10 tons of ASR an hour into hydrogen and carbon monoxide gas. SiCon (Hilchenbach, Germany) and Salyp (Ypres, Belgium) both devised systems that mechanically separate fluff into constituent salable products: ferrous and nonferrous metals, plastics, fiber, and minerals.

You could call Global Resource's approach separation at the molecular level. When it bombards the ASR with specific frequencies of microwaves, the hydrocarbons in the mix (primarily from plastics and rubber) turn into oils and gases the company can recycle and resell. The company says its process can convert approximately 65 percent of fluff by weight into salable gases and fuels, generating significantly greater yields at a lower cost than existing technologies—and potentially reducing this country's dependence on foreign energy.

"When people talk about alternative or renewable energy, they're usually referring to ethanol [or other] green biofuel products. Until now, renewing hydrocarbons was not part of that discussion," says Jerome Meddick, GRC's director of business development. "We have demonstrated you can recover energy from any hydrocarbon-based product and continue that recovery process indefinitely."

NOT YOUR MOTHER'S MICROWAVE

GRC's patent-pending process employs specific frequencies of microwave radiation to extract oil and other petroleum products from various unconventional hydrocarbon resources. Its first applications were shale deposits, tar sands, and waste oil streams, but more recently it has been used on scrap tires and ASR. In fact, the company stumbled into fluff processing while working on scrap tires.

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"I was going out to one scrap dealer to get a contingency contract for the steel that we would be producing from tires," relates Jay Gill, GRC's national sales manager. "The guy said, 'I wish you could do something with my fluff.' I said, 'What's fluff?' … I told him to give it to me, and we put it in our little system out there, and it's pumping out gas and oil."

GRC operates a small, experimental version of the technology in its New Jersey lab. Two refrigerator-sized microwave units stand side by side, their tops connected by wave guides that conduct microwaves between the machines. But these are not your mother's microwave ovens. "In your home microwave, you have a 2,450-MHz frequency that's taking the water [in food] and heating it by shaking the molecules," says Frank Pringle, GRC's chairman and CEO, the inventor of the process. "This isn't heat-related. We're taking hydrocarbons in a solid state, shaking them, and

ILLUSTRATION BY PETER HOEY

In the Global Resource Corp. laboratory, a few handfuls of automotive shredder residue (left) are placed in a wide-mouthed beaker inside the microwave unit (above) and covered with a bell jar.

splitting them. It's like splitting the atom, in some regards, with heat as a byproduct. We're cracking the carbon chains and heat is generated."

The two units can operate on a wide range of microwave frequencies, employing GRC's patent-pending "recipes" for processing particular materials. "We found about 7,000 frequencies, and we can dial a frequency until we find the best [one]," Pringle says. "Like a guy tuning a piano who keeps hitting his fork until he gets the tension right, we tune in the frequency for a specific hydrocarbon."

The demonstration almost looks like a stage magician's trick. Pringle puts a wide-mouthed beaker filled to the brim with a hydrocarbon-based substance—sandy-colored oil shale rocks, chopped-up tires, or clumps of fluff—under a bell jar. He inserts the bell jar into the chamber of the larger microwave and slams shut the solid metal door, creating a seal. (To create uniform heat and uniform results, the process must operate in a total vacuum.) He activates the power for about 10 to 15 minutes, depending on the contents. He shuts off the power, opens the door, and presto! The beaker now holds a small heap of blackened ash, and a round-bottomed flask attached to one of the microwave units contains a small quantity of oil.

A chemist extracts a sample of the oil and gas for analysis in a gas chromatography-mass spectrometer—a machine better known to *CSI* fans for its ability to analyze DNA samples. The GC-MS identifies the type of hydrocarbon chain in the sample and indicates its potential use: C4 and above for gases, C5 for vehicle fuel, C10 to C16 for kerosene, and C14 to C20 for diesel fuel.

The company can recycle the oil from some materials with little or no further processing. "Out of a typical 20-pound tire we get about 1.2 gallons of diesel fuel," Pringle says. "I drove my truck on that once during the experiments. I just filtered the particulates out."

The rest of the vanished material turns into natural gas, which the company pumps into a tank and burns off. GRC reports that fluff generates more gas than oil—about 80 percent gas to 20 percent oil. "We used to send our gas samples to an outside lab to determine Btu value, but now we have that provision installed in our GC-MS," Gill says. "Now with ASR we're seeing 1,200 Btu per cubic foot."

Even the blackened residue that remains in the beaker has potential resale value, the company says. The 4-percent ash that remains after tire processing, for example, could be sold as pigment for plastics or printer toner or to remake automobile tires.

The process is dry: It requires no injections of water or any other type of liquid, which sidesteps logistical and environmental issues raised by some other ASR processing techniques. And as a closed-loop system, "there are no emissions other than pre-process air," says Hawk Hogan, GRC's chief engineer—potentially giving the process an environmental edge over the use of ASR as fuel in an energy recovery facility. "You don't have to burn it," Pringle says. "You just have to send [the oil] back to a place that makes plastics, and they can convert it back into plastics."

Will the system work? After witnessing demonstrations at GRC headquarters, Dinesh Agrawal, director of the Microwave Processing and Engineering Center at Pennsylvania State University (University Park, Pa.), notes two innovations that make the process seem promising for recycling ASR or just about anything else containing hydrocarbons. "Using a microwave energy application for recovering oil and gas from tires and other things is not new," he says. "It's already been done in Australia and Japan and other places." What's unique, he says, is "they use, number one, a continuing microwave system with varying frequencies, while others have used only a single frequency which is the same as your kitchen microwave. Second, they use a vacuum."

After the process bombards the shredder fluff with different frequencies of microwaves, the hydrocarbons in the material turn into natural gas—lit for demonstration purposes by Frank Pringle, GRC's chairman and CEO, left—and oil, seen here in its collection flask, above right. A small quantity of black ash, above left, is all that remains.

FROM PROTOTYPE TO PRODUCT

A full-sized GRC microwave reactor system for processing ASR would operate somewhat differently than the prototype, the company explains. It would be a tumbler system, something like a washing machine. A front-end loader would pick up fluff and load it into a cleated hopper elevator that transports it into a double-flat-gate airlock system. "We have to maintain a vacuum, and this is where we begin that part of it," Hogan says.

According to the design, flappers on the airlock system activated by a servo-driven motor open and close and send the fluff into a feed screw. The fluff drops into the feed screw, which feeds it down a chute into a rotating reactor chamber lined with rings to seal in the vacuum. "These rings are the same as the combustion rings in your car," Hogan says. "The combustion engine has rings to maintain pressure in the cylinder when it pumps. We use rings to maintain a seal for our vacuum."

As the reactor drum rotates, flight bars move the fluff forward through it, over the control center and microwave tubes located under the feed screw, and toward microwave antennas at the end of the drum. The antennas emit expanding and extremely animated cone-shaped microwaves. "Microwaves are like Super Balls," Hogan says. "When they hit the side of the stainless steel chamber, or anything in the chamber, they deflect off [it] and bounce in another direction until absorbed. We have a lot of activity going on in here that's basically curing the material at that time."

Once the specific frequencies begin to crack the hydrocarbons, a piping system sucks the gas out to a storage system or direct-coupled generator. Customers "can decide whether they want to condense it or maintain [it as] a gas—however they see fit, we provide for them," Hogan says. The company can supply a condenser or customers can buy their own; a 25,000-gallon tank with an internal condenser is optional equipment.

The residue moves forward to a discharge feed screw, the closed system still emitting no hydrocarbons into the air. As the drum rotates, the residue discharges onto a right-angle feed screw where the vacuum is released and onto a conveyor belt that could feed into an eddy-current separator to capture minute amounts of metals.

The diameter of the infeed and discharge screws and the length and diameter of the drums determine the system's capacity. GRC plans to offer systems sized to process 5, 10, 15, or 20 tons of ASR an hour. The 10-ton-per-hour unit would be about 20 feet long, 5 feet in diameter, and 8 feet high. A facility would need high ceilings to accommodate a 20-ton system, but the reactors will be made of stainless steel so they also can be safely installed outside. "We're going to have to draw the line at 20 tons [an hour] because the system's getting way too big," Hogan says. "If [customers] need 40, they might as well buy two 20s."

On the other end, there's no benefit to producing a system smaller than 5 tons' capacity, Hogan says, because it would not reduce the cost. "The most expensive things here are microwave components," he says. "The klystron microwave tubes and special

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patent-pending devices and software make up about 75 percent of the cost of this system."

PROFIT POTENTIAL

GRC recently submitted a proposal to a major recycler for six 20-ton-capacity machines. Each machine would cost about $5 million, or approximately $30 million total. With estimated energy costs at $15 per ton of processed material, annual operating costs would be $4.5 million a year for those six machines.

The company estimates that, if run at full capacity, the machines could produce an estimated $30 million worth of gas annually, depending on product process arrangement, and they could generate landfill savings (based on landfill costs of $45 a ton) of $6 million a year. "When we calculate all of these numbers, the company is looking at a payback [in], roughly, under two years," Gill says. "After that, you're in the black." Once the company receives a purchase order, it says it can have a reactor up and running on site in about six months.

Every oil company represents a potential customer for the oil the process produces. Combustible gas can be sold to cement kilns, pulp and paper processing mills, cogeneration stations that produce electricity—"Anything that's using a lot of coal to run their turbines can use our gas," Gill says. An eddy-current separator at the end of the reactor can even retrieve resalable copper. "Because that carbon black, that ash, is so powdery, it will separate the copper and some precious metals and throw them into another container," he says.

Of course, before any of this can happen, GRC has to prove its process works as well in a scrapyard as it does in the lab. "On [the] laboratory scale the application is very good, very impressive. We have done it here in our lab and it works," Penn State's Agrawal says. "The only thing is, how can you scale it up? Microwave in other areas has been very successful in laboratories, but when it comes to real commercialization there are so many things involved. And that is what these people are trying to resolve."

The company is getting an opportunity to prove itself in the ASR arena this fall: In May it announced that Gershow Recycling (Medford, N.Y.) is installing its HAWK 10 technology, for processing 10 tons of fluff an hour, at one of its Long Island, N.Y., yards. The company hopes to have the HAWK 10 operational within six to 12 months, says Kevin Gershowitz, the company's executive vice president, but he's realistic about the challenges. "This is brand-new technology," he says, thus some of the variables are still unknown, such as how long it will take to manufacture and install the machinery and how many workers will operate it.

So why take the risk? "The scrap industry is changing rapidly" in terms of technology, Gershowitz says, so the question for any company is "Do you have the technology to compete effectively?

"Fifty years ago, a magnet crane and a baler were considered high tech," Gershowitz says. "Today we have to get the last oink out of the pig—we have to take every opportunity to get the last fraction of value from the metal stream. … We want to be ahead of the curve" or at least just on the curve, when it comes to technology, he says. "We are a progressive, forward-looking company looking to enhance the value of our products."

Once the machine is fully operational, it should reduce the company's landfill tipping fees by about 65 percent, increase its metal recovery, and garner alternative energy tax credits, GRC says. "We expect Gershow Recycling to capture a full return on [its] investment within one year of use," Pringle says. Gershowitz is more conservative in his predictions. "We hope it will reduce disposal costs and recover more metal units, and we hope the fuel it will create will have value," he says. S

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