THE FUEL SELL

PLASTICS-TO-FUEL COMPANIES SAY THEY PROVIDE AN ALTERNATIVE TO LANDFILLING FOR PLASTICS THAT ARE NOT BEING RECYCLED. BUT CAN THESE TECHNOLOGIES SUCCEED IN THE UNITED STATES ON A COMMERCIAL SCALE?

BY DIANA MOTA

The United States recycled only 8 percent of postconsumer plastics from municipal collections in 2010, according to data from the U.S. Environmental Protection Agency (Washington, D.C.). Despite technological advances, barriers such as contamination, a lack of markets, and recyclers' inability to separate resins in mixed-resin products seem to conspire to keep recycling rates low, according to an April 2011 research project funded by the American Chemistry Council (Washington, D.C.) and prepared by 4R Sustainability (Portland, Ore.). The result is that "about 80 percent of all plastic [in the United States] winds up in the landfill," says Jesse Klinkhamer, CEO of Klean Industries (Vancouver, British Columbia). His company and others see this as a wasted opportunity. "Why are we going to all this trouble to get the oil out of the ground to make products and then send it back into the ground?" he asks. Instead, they propose using a variety of technologies to convert these discarded plastics, either alone or with other unrecyclable material, into fuel.

The idea seems promising, says Craig Cookson, ACC's director of sustainability and recycling. Plastics have a high inherent energy value because about 70 percent of the plastics in the United States are made from natural gas, he explains. When burned for fuel, plastics generate an average of 14,000 British thermal units of heat per pound. That gives them a higher energy value than coal, petroleum coke, wood chips—more than everything but natural gas and crude oil, he says.

In 2012, researchers at the University of Texas at Austin studied one type of fuel made of mechanically processed plastics and fiber—material that could not be recycled from a materials recovery facility. The ACC-funded study, "Residue-Derived Solid Recovered Fuel for Use in Cement Kilns," calls this product, which had

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an energy value of about 12,500 Btu a pound, a viable source of domestic energy for a variety of energy-intensive commercial and industrial operations. If only 5 percent of such MRF materials were diverted from landfills and used as fuel nationwide, it could generate enough energy to power about 700,000 U.S. homes a year, the report states. Further, by replacing coal, this fuel would reduce carbon dioxide emissions equivalent to the removal of a million cars from the nation's roads. The fuel's sulfur dioxide emissions were half those of coal. The report names at least two companies producing solid recovered fuel in the United States from a variety of wastes and recyclable materials. Other companies propose using thermal processes—either pyrolysis or gasification—to turn unrecyclable scrap plastics into gases, oils, or liquid fuel. Scrap processors seem supportive of these technologies, envisioning them as a better destination than the landfill for material that's not economically or technologically feasible to recover. But they're skeptical of the economic viability of the facilities they've seen to date in the United States. Factors such as access to materials, the price of equivalent fuels, and transportation and landfill costs might determine whether these approaches reach their potential, they say.

SOLID FUEL PRIMER

Companies that turn plastics into fuel produce either solid fuel via mechanical processing or liquid fuel via thermal processing—heating—under specific conditions. Manufacturers of solid recovered fuel, or SRF, can engineer their product to meet a customer's specifications by adjusting the proportions of scrap and waste feedstocks, removing undesirable materials such as ferrous metal, then mixing, shredding, and densifying it into pellets or cubes, according to the UT Austin report. "SRF can be used directly in a waste-to-energy facility, co-fired with traditional fuels, or used as feedstock to create higher-quality fuels through gasification or pyrolysis," the report states. Solid fuel technology has not progressed as quickly as plastics to oil, says Jerry Powell, executive editor of *Resource Recycling*, which hosts the annual Plastics Recycling Conference. "Plastics to oil is on the cusp," he says. "I don't see the same investment being put into solid fuel." He attributes the lag, in part, to regulatory requirements that treat the use of solid fuel the same as incineration. That said, Klean Industries' Klinkhamer estimates that 20 to 25 percent of all U.S. waste-to-energy plants use what he calls "refuse-derived fuel."

SRF, also called engineered fuel, "burns at a one-to-one replacement rate for coal," producing roughly the same energy per pound, but with lower levels of mercury, sulfur, and other harmful emissions, says Steve Berry, president of Vexor Technology (Medina, Ohio). Vexor uses a batch process to produce engineered fuel, grinding the plastic and other nonrecyclable materials into ¾-inch particles and mixing them with inks, carbon black, and other industrial "waste" products. The resulting fuel gets pneumatically blown into lime and concrete kilns or other combustion furnaces as a coal replacement, Berry says. The fuel, which combusts within 20 seconds, looks like black landscaping mulch, he says. "The amount of plastic [in the fuel] varies, but it is typically 20 to 30 percent by weight of our mix." About 70 percent of Vexor's infeed material comes from single-stream recycling plants. Thus, anything of value to recyclers has been removed. "Our goal is to develop a symbiotic relationship" with recyclers, Berry says. In 2012, the firm's Ohio facility diverted about 15,000 tons of material from landfills and turned it into fuel. With new sites opening in Pennsylvania and Indiana, the company hopes to divert as much as 500,000 tons of material this year, Berry says.

For about a dozen years, Balcones Resources (Austin, Texas) has been making a solid fuel that consists of about 60 percent postindustrial scrap plastic and about 40 percent cellulosic fibers from wood pulp, says Jay Saxton, general manager of the company's Little Rock, Ark., facility, the site of its fuel technology plant. The firm doesn't

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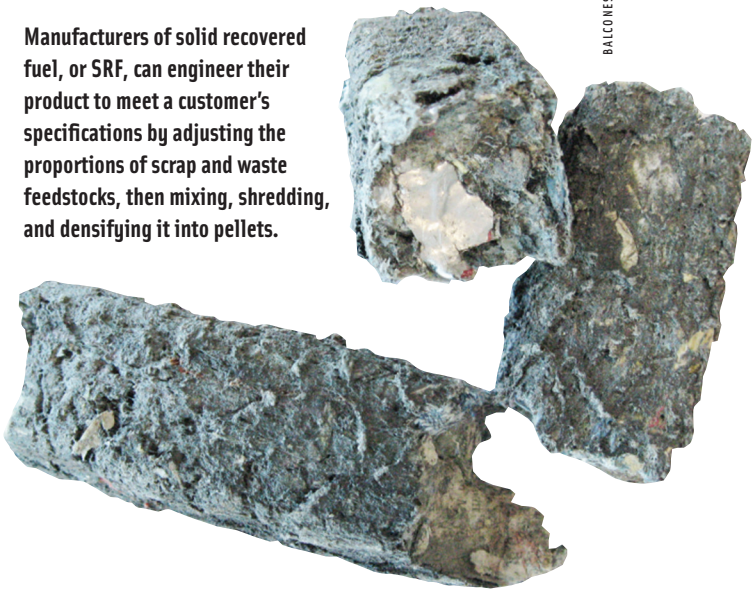

BALCONES RESOURCES

use postconsumer plastics in its fuel because state regulations would then consider use of the fuel incineration, Saxton says. The plant has the capacity to make about 3,000 tons of fuel a month. The process takes in about 14,000 tons of plastic annually, he says, typically material commingled with cellulose-based products such as wood or pulp fiber, backed with paper and adhesives, or contaminated with food. "We target materials that aren't recyclable. It's a landfill alternative." The firm charges the materials' generators or suppliers a tipping fee that's slightly higher than what they would pay at the landfill, Saxton says. This attracts companies that have goals other than the lowest price. For example, "larger, more global companies that want to achieve zero landfill will bring us their material."

The 7/8-inch cubes produce 12,400 to 13,500 Btu of heat per pound, Saxton says. Balcones prices the fuel at or below natural gas prices and sells it primarily to paper mills in Arkansas and Texas. "Paper mills are not going to pay a premium for our fuel if they can buy natural gas cheaper," he explains. Other mills might pay more, but freight costs don't make it worthwhile. "We try to be a cheaper alternative to natural gas with a goal to keep material out of the landfill."

Large-scale, utility-based power plants use the engineered fuel pellets Klean Industries produces to replace coal and petroleum-based fuels, Klinkhamer says. (The company also produces liquid fuel.) The proportion of plastic in the pellets ranges from 20 to 80 percent, depending on the plant that makes them, he says. The commingled plastics in the pellets, which can be no more than 20 percent PET or PVC, come from a variety of sources, such as waste transfer stations, MRFs, and automobile shredders. The pellets also contain biosolids, such as sewage sludge, and other wastes that have little calorific value. About 20 facilities throughout the United States purchase Klean Industries' fuel, Klinkhamer says, including plants in Ames, Iowa; French Island, Wis.; Honolulu; and West Palm Beach, Fla. The company and its partners currently produce more than 500,000 mt a year and expect to increase that to more than 1 million mt a year in the next 24 months, he says.

PLASTICS TO OIL

Companies that convert plastics via gasification or pyrolysis generate products such as synthesis gas, oils, or liquid fuels that, with further processing, can substitute for natural gas, gasoline, or diesel fuels, according to the UT Austin report. What's the difference between the two processes? Gasification typically uses more heat and drives chemical reactions by controlling the amount of oxygen in the system, producing synthesis gas that can be converted into methane, the report explains. Pyrolysis operates at lower temperatures without oxygen, and it requires more steps to turn the resulting material into high-quality fuels. Further, gasification can use a wider variety of feedstocks—including food waste, biomass, and mixed waste streams—whereas "pyrolysis requires a comparably more pure feedstock of only plastics," the report states. Many people confuse processes such as pyrolysis with incineration, says Russell Cooper, vice president of business development for Vadxx Energy (Akron, Ohio). Incineration is burning plastic and other materials to produce heat for generating electricity, whereas pyrolysis is "more akin to melting plastic back into its original [state], which is hydrocarbons," he explains.

The plastics-to-fuel processors typically use unwashed, commingled plastics from a variety of sources, including plastics manufacturers, MRFs, and other recyclers, they say. Some of these companies want shredded material with no more than 10 percent moisture; others, such as Vadxx, say they will shred and dry the material themselves. Though pyrolysis and gasification technologies have existed for a while, ACC's Cookson says, and commercial-scale facilities exist in Europe and Asia, the U.S. facilities that use them to convert plastics into fuel are small-scale or pilot projects, though several companies say they're on the verge of establishing commercial-scale facilities.

■ Vadxx's process can produce four barrels, or 168 gallons, of oil from 4 tons of used polymer, Cooper says. "Ten pounds of MRF residue equates to 1 gallon of synthetic oil." At its pilot plant in Ohio, which has the capacity to handle about 1.5 tons of plastic a day, the company has experimented with difficult-to-recycle materials such as automobile shredder aggregate and electronics plastics. Vadxx plans to break ground on its first commercial-scale plant, which will have the capacity to process up to 50 tons of plastics a day, as soon as its financing is in place, Cooper says. The company reports having business relationships with several recycling companies.

■ The Plastic2Oil system from JBI (Niagara Falls, N.Y.) converts unsorted, unwashed "waste plastic" into ultralow-sulfur fuel. The plant at its

headquarters has the capacity to process 4,000 pounds of material an hour, producing 1 gallon of fuel from each 8.3 pounds of plastic, the company says. "We focus on contaminant streams," says John Bordynuik, company CEO and founder. To date, the feedstock has been primarily postcommercial and postindustrial material. Ideally the supply would consist of high-density polyethylene, low-density polyethylene, polypropylene, or products that contain one or more of those resins, the company says. It cannot process PET, PVC, polystyrene, or Nylon. The fuel products the plastics produce include No. 2 diesel, No. 6 fuel, Naphtha, and carbon black. In 2011 the company signed a 10-year revenue-sharing agreement with paper producer Rock-Tenn Co. (Norcross, Ga.) to convert into fuel the residual plastics from its mills, MRFs, and monofill landfills, according to news reports. The company also has announced signing various agreements in the past two years to supply fuel to several companies. [Editor's note: In January 2012, the U.S. Securities and Exchange Commission filed suit against JBI, Bordynuik, and the company's former chief financial officer for alleged securities and accounting fraud related to the value of media credits the company purchased in 2009.]

■ One of the biggest names in the U.S. plastics-to-oil market, Agilyx (Beaverton, Ore.), declined to comment for this article, but at *Resource Recycling*'s March 2012 Plastics Recycling Conference, Lew Feucht, an Agilyx sales associate, said the company had been operating a commercial-scale facility for more than two years. Future facilities, which will have the capacity to process 30 to 100 tons of material a day, ideally will be constructed near the source of the plastic, such as a MRF, he said. The company has run trials of a variety of materials, including plastics from a "dirty MRF," automobile shredder aggregate, medical waste, agricultural plastics, construction and demolition scrap, carpet with PP backing, hazardous waste, residual plastic from paper recycling, industrial packaging films, e-scrap, and motor oil bottles—"lots of stuff with contamination or [things] that are difficult to recycle." The technology can accept plastics 1-7, though he noted that PET and PVC "don't make much oil."

A February 2012 *Resource Recycling* story described plans by California and Oregon recycling companies to install Agilyx plants at their facilities. Agilyx has since acquired the permit to construct the facility in California. And in November, Oregon's Department of Environmental Quality (Portland) held an informational meeting on the project in that state, which would process unrecyclable material for agricultural plastics recycler Agri-Plas in Salem.

■ Renewable Energy Solutions by Polyflow (Akron, Ohio) is an energy-recovery system that converts mixed-polymer and rubber material into fuels and petrochemicals. According to its website, the company specializes in the "hard-to-handle" categories of plastics, including carpet, plastics with resin codes 3-7, partially filled ink and toner cartridges, contractor buckets with dried paint residue, layered packaging film, and automobile shredder aggregate. It does not accept PVC, says Mike Dungan, director of sales and marketing, though it can handle "rogue" amounts. The system has the capacity to process up to 60 tons of "lightly sorted and unwashed" polymers a day, the company says.

■ E-N-ergy (Seattle) is the distributor in the United States, Canada, and South America for Blest Co. (Yokohama, Japan), which manufactures small-scale commercial machines that use a "hybrid pyrolysis process." The system processes clean, commingled granulated HDPE, LDPE, PP, and PS into a mixed synthetic sweet crude oil that can be used in industrial machinery, incinerators, and other applications that do not require refined gas, says Jackie Ayzenberg, vice president of sales. The oil also can be further refined and separated into gasoline, kerosene, diesel, and heavy oil. Customers that process only PS will produce an oil comprised of styrene monomer, styrene dimer, and styrene trimer, which can be used as an accelerant fuel or in plastic remanufacturing. The machines range in processing capacity from about 22 pounds of plastic an hour, which produces about 2.6 gallons of fuel, to about 220 pounds of plastic an hour, which produces 26 gallons per hour or about 624 gallons per day, which is the equivalent of nearly 15 barrels, she says. "Up to four Blest systems can be combined under a single controller in an array configuration to achieve unlimited processing power," Ayzenberg says. "For instance, we can combine four of the largest, 2.4-ton-per-day units to create a 10-ton system or eight under two controllers to create a 20-ton system [and so on]." The company has installed one North American system to date—in Whitehorse, Yukon—and it has plans to install several units on the U.S. East and West coasts in the first quarter

of 2013. "These installations are right now going through the permitting processes for their respective states," Ayzenberg says.

■ Klean Industries uses Japanese pyrolysis and gasification technologies on a variety of mixed and homogenous feedstocks—including e-scrap and shredder aggregate—to produce an industrial fuel or a chemical product that's used to make new plastic or road-grade diesel, Klinkhamer says. The company has about a dozen projects underway throughout North America, including two flagship facilities with a major chemical and plastic manufacturer, he says, though confidentiality agreements prevent him from providing further details. The plants range in capacity from 20 to 200 mt a day, he adds. Feedstock varies from location to location, but it is primarily polyolefins from MRFs and specific fractions of automobile shredder aggregate.

THE RECYCLERS' PERSPECTIVE

Are plastics recyclers worried that plastics-to-fuel facilities will compete with them for the postindustrial or postconsumer plastics on which they depend? The recyclers interviewed for this story say no. Plastics recyclers are "always interested in markets and outlets for [their] material," says Jonathan Levy, ISRI's director of member services and liaison to ISRI's Plastics Recycling Council. Most plastics-to-fuel producers insist they want material that is not currently being recycled but instead is ending up in landfills or incinerators. "We like to think of ourselves as difficult-to-recycle polymer specialists," says Vadxx's Cooper. At the Plastics Recycling Conference, Agilyx's Feucht took the same perspective. "Don't put recyclable plastic into our system," he said. "If you can't recycle it for economic reasons, [if it's] commingled [or] contaminated … if you're paying to landfill plastic, this is an opportunity."

Tamsin Ettefagh, vice president of sales and purchasing for Envision Plastics (Reidsville, N.C.), points out that plastics recyclers "all have waste from our processes," and converting the material to fuel is an alternative to landfilling it. "Some sort of value should be gotten out of it." ACC's Cookson agrees. "This is about monetizing or extracting value from something that [recyclers] previously couldn't—there's real economic value here," he says. "It shouldn't be seen as competitive but as complementary." He does not expect this approach to replace recycling, he says, because consumers will continue to demand plastic products with recycled content. "We're always going to be recycling, and there will always be opportunities to recycle more and more types and volumes of plastics, but there's always going to be some that can't be recycled or recycled economically."

It all comes down to market demand, Klean Industries' Klinkhamer says. "It's all about what's the highest-value product that can be produced from plastics." Recyclable plastics will always have more value as recyclable material, Cookson says. For example, Envision Plastics primarily handles HDPE, "which would be very attractive as an energy source because of its high Btu value," Ettefagh says. But "our suppliers are getting about seven times [from us] what they would get if they were to sell it to a company that is going to turn it into fuel," she says.

In fact, some plastics-to-fuel companies charge to take the material or accept it free from suppliers—they don't buy it. At the Plastics Recycling Conference, Vadxx's Cooper confirmed that his company can't compete with recyclers on price. "We can't go for good, healthy [scrap] streams," he said. Instead, the company seeks material others can't or won't recycle, especially material that, when kept out of a landfill, has "a positive community impact," such as regulated hospital waste. Agilyx says it works with suppliers that generally do not pay for the plastic feedstock.

Ettefagh believes plastics-to-fuel producers haven't quite proven the economic viability of their operations. She has yet to see one that can make a profit on the value of the fuel alone, she says. "To date, everything I've seen charges a tipping fee" on the plastic supply. One company she spoke with charges a tipping fee and has a government subsidy as well. "If it wasn't for the subsidy, it wouldn't be very plausible." Whether it makes sense for recyclers to turn over their nonrecycled plastics to these companies will depend on whether their tipping fees are lower than landfill tipping fees, she says. Sandy Rosen, CEO of Great Lakes Recycling (Roseville, Mich.), agrees. "Although our first choice would be to try and sell the plastic," he says, "if all things are equal," the company would rather see the material turned into fuel than put in a landfill. But if "we had to spend more, plus [pay the] freight to get it there, it wouldn't be worth it." The price of oil also factors into the profit equation. For it to work, "oil pricing has to be $75 per barrel or

better," Ettefagh says, though several presenters at the plastics-to-oil session at the Plastics Recycling Conference said $45 a barrel is the break-even point.

The larger the company, the larger the challenge of managing nonrecyclable plastic streams. OmniSource Corp. (Fort Wayne, Ind.), one of the largest U.S. recycling companies, has worked with several plastics-to-fuel companies to find an alternative destination for plastics it generates, including automobile shredder aggregate, from its 11 shredding locations and two granulators. "We've probably been approached about six times a year over the past three years," says Scott Gibble, executive vice president of Midwest operations. "We've supplied small quantities of [shredder aggregate] or granulator tailings—in many cases only a baggie or 5-gallon bucket—for trial runs."

When evaluating these potential business partners, "we inquire where they are in the process [of development] and whether we can see what they're doing," he says. In some cases, "they have literally nothing to show you. They have an idea, they've written it on a piece of paper, they're just starting out, and they want a lot of money." In other cases, "they have either a desktop prototype or a small, extremely low-volume prototype," he says. "They're playing around with it; they're trying to perfect it." With the few firms that have larger production plants, "the question becomes, are they profitable business models?"

OmniSource hasn't made any investments or formed any partnerships with plastics-to-fuel companies yet, Gibble says. "We view it more as a future opportunity. We have an interest in understanding the technology, who the players are, where they are at in the process, and how it could benefit us as far as addressing some of our waste streams." For the company to get more involved, he says, "we want to see the process commercialized at the volumes of what we produce, and we would need to evaluate what our investment would be versus the return." For now, OmniSource keeps the issue on its radar screen. "Someone will come up with something that makes sense for us," Gibble says. "I just haven't seen it yet."

Though these technologies show potential, they can't do everything recyclers might want. Several processors point out that PVC is either undesirable or not accepted in these systems, for example. Further, "some of the technology can't handle the mixture of residue and plastics that we have," Ettefagh says. "We have a lot of glass and metals in our residue, which hasn't been attractive to some of the plastics-to-fuel plants." She hopes the technologies will improve "so we can get to zero waste and capture the energy that we're currently landfilling." But she believes that "plastics to fuel will only catch on if landfill costs go up or fuel costs go up, or both. In today's current conditions, it's a marginal business at best and subsidized to stay alive." For now, "the value is still in recycling what you can," Ettefagh says. "The plastic is worth more" as plastic than as fuel.

She makes one more point: The technologies for recycling plastics are improving, too, and as they do, "we will be able to recycle more." This could mean less plastic for the plastics-to-fuel industry. For example, if virgin resin producers put markers into their resins to improve their sorting, those plastics will have more value as recycled plastics, she says. "New technologies allow more materials to be recovered and new value created from those materials."

Theoretically, plastics that are landfilled now could be recycled later, when processing techniques improve. That might be why some recyclers say they don't like the idea of turning plastics into fuel. "It isn't really recycling if you recover it and then send it off to be burned," says Mark Lewon, president of operations for Utah Metal Works (Salt Lake City) and ISRI vice chair. "It's being reused [just] once—you can't get it back." ■

Diana Mota is associate editor of Scrap.