Inside Eastman’s moonshot goal for endlessly circular plastics

By **Joel Makower**

May 11, 2020

An aerial view of Eastman's Kingsport, Tennessee headquarters facility.

At first glance, the sprawling industrial site, covering roughly 900 acres in Kingsport, Tennessee, appears to be just another chemical manufacturing facility. There are hundreds of buildings and countless miles of pipes, conveyors, distillers, cooling towers, valves, pumps, compressors and controls. It doesn’t exactly look or feel particularly noteworthy.

But something extraordinary is going on at this Eastman chemical plant: two breakthrough processes to turn waste plastics of all kinds back into new plastics, continuously, with no loss of quality.

Last year, the company announced two major initiatives:

- **Carbon renewal technology**, or CRT, which breaks down waste plastic feedstocks to the molecular level before using them as building blocks to produce a wide range of materials and packaging. The company claims this enables waste plastics to be recycled an infinite number of times without degradation of quality.

- **Polyester renewal technology**, or PRT, which involves taking waste polyesters from landfills and other waste streams and transforming them back into a raw material that the company claims is indistinguishable from polyester produced from fossil-fuel feedstocks.

With both CRT and PRT, hard-to-recycle plastics can be cycled an infinite number of times, says Eastman, creating products that can claim high levels of certified recycled content — a true closed loop.

Both technologies are or will be hitting the market, so it is too soon to call them a success. Still, they represent a story about a legacy industrial company seeking to reinvent itself by simultaneously addressing the climate crisis, the scourge of plastic waste and the need to accelerate resource efficiency to meet the material needs of 10 billion people by mid-century.

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Chemical reaction

Eastman, celebrating its centennial this year, was founded by George Eastman, the entrepreneur who, in the late 1880s, started the Eastman Kodak Company. ("Kodak" was a made-up word he appended to his last name.) Along the way, he nearly singlehandedly democratized photography (and spawned countless "Kodak moments") through the company's production of cameras, film, processing chemicals and related goods and services.

In 1920, in the wake of World War I, Eastman's company was suffering a scarcity of raw materials, including photographic paper, optical glass and gelatin, and many chemicals — such as methanol, acetic acid and acetone — needed to produce and process film stock and prints. He determined that ensuring his company's future would require self-reliance. He set out to find a suitable location for a Kodak-owned and operated chemical production facility.

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Kingsport proved to be the right spot, situated in what is known as the Mountain Empire, which spans a portion of southwest Virginia and the mountainous counties in northeastern Tennessee. It had ready access to two key commodities vital to Kodak: wood fiber to make cellulose, the key material in photographic film; and coal, which powered its boilers to make steam and electricity, and later would be used to produce synthetic gas — syngas — to create the acetyl chemicals needed to make films, plastics and textiles.

From those two feedstocks, Eastman Chemical, a subsidiary of Kodak, grew to become an economic powerhouse in the Mountain Empire, expanding into its own empire of more than 50 manufacturing sites worldwide.

The company adapted to, and prospered from, the changing times. By the late 1920s, for example, the demand for home movie film and the growing need for X-ray film led Eastman Chemical to produce acetic anhydride, the base material for photographic emulsions. In the 1930s, the company turned to producing cellulose acetate to make textile fibers. The automobile boom of the 1940s and 1950s led Eastman to produce chemicals and materials critical to automotive design and production. During World War II, the Kingsport site infamously was used to make RDX, a powerful explosive — a million and a half pounds a day, at its peak. By the end of World War II, Eastman was managing a project to produce enriched uranium for the Manhattan Project. After the war, polyester fibers for textiles and other products became, and remain, a significant line of business.

George Eastman didn’t live to see much of the success he catalyzed. He died in 1932 by suicide, a single bullet to the heart.

In the 1990s, Kodak’s photography business darkened with the advent of digital cameras — the company was slow to adapt and got run over by more nimble competitors — and the company spun off its chemical division in 1994 to help pay down debt. (Eastman, the company, has dropped "chemical" from its branding, although not from its legally incorporated name.)

Eastman’s latest innovations, as well as its pivot to make sustainability core to its strategy, has been energized by its current chairman and CEO, Mark Costa. A former management consultant — Eastman was one of his clients — and brandishing degrees from both Berkeley and Harvard, Costa joined the company in 2006 to lead strategy, marketing and business development before ascending to the corner office in 2014. Under his leadership, the company has accelerated its transformation from chemicals to specialty materials.

"When we came out of the great recession in 2009 and were starting to think about our innovation portfolio, we were already thinking about sustainability in a very serious way," Costa told me over lunch in his office in early March, with a sweeping view of a nature preserve and park deeded by Eastman to the city of Kingsport. "We knew that the circular economy and being a lot more efficient with carbon was a good idea."


Eastman CEO Mark Costa (Photo courtesy of Eastman)

"This idea of circularity isn't new to us," he added. "In all of our innovation — I had the responsibility for the innovation portfolio since 2009 — we required everything that we did be tied to a sustainability driver. All the way back then."

Eastman's two new "renewal" technologies are, to some degree, natural extensions of products and services that have long been part of Eastman's toolkit. Now, repurposed and modified for an era of sustainability and circularity, they position the company to address one of the holy grails of the circular economy: turning waste plastic back into new plastic with the same performance and quality characteristics.

Plastic to plastic

The rising attention being paid to the global plastic waste problem has illuminated many serious challenges of collecting, sorting and recycling plastic back into new plastic in a continuously closed loop.

For starters, only a couple kinds of plastics are being regularly collected and recycled, based on available infrastructure and market demand: PET and HDPE — Nos. 1 and 2, respectively, in the SPI resin identification codes developed in the late 1980s by the Society of the Plastics

Industry. Most of the others — SPI Nos. 3 through 7 — are technically possible to recycle but lack both infrastructure and markets in most places.

Worst of all is the growing mountain of packaging that is multi-material — layers upon layers of mixed polymers, papers, laminates and foils — in the form of juice boxes, ketchup packets, toothpaste tubes and countless other things. These Franken-materials are a nonstarter for most modern recycling systems. The best one can hope is that they be downcycled into some durable product — say, artificial turf, plastic furniture or an automobile fan blade — which itself will wear out eventually, ending up as nonrecyclable waste in a landfill. Only a tiny fraction of these plastics ever escape landfills as their final resting place.

Eastman's ability to turn all plastics back into their constituent molecules is a potential game-changer.

Sorting all these plastics is another issue. Even if plastics 3 through 7 were readily recyclable, keeping various polymer types separate from one another is a highly labor-intensive task, assuming the infrastructure was even there to handle it. And given the historically low price of oil, even before the recent market crash, recycled plastic remains uncompetitive to virgin for many applications. Those petrochemicals are just too darn cheap.

So, Eastman's ability to turn all waste plastics back into their constituent molecules and back into productive use is a potential game-changer.

A primer

There are two basic ways to recycle plastics: mechanical and chemical. The former is most commonly used with soda bottles (PET) and milk jugs (HDPE) — plastics 1 and 2, respectively. It involves grinding, washing, separating, drying, regranulating and compounding waste plastic to create new raw materials.

Mechanical recycling can be cost-effective but has limits and disadvantages: The process is heat-intensive — and, therefore, energy- and carbon-intensive — and produces air pollutants. Contamination by food and other foreign materials is another problem that literally gums up the works. And after plastic has been mechanically recycled once, it's rarely suitable for another round of recycling. This means it eventually will end up in waste streams.

And there are physical limits to how recycled plastics produced through mechanical methods can be used in manufacturing. "You can only get up to maybe 50 percent recycled content in a bottle with mechanical, where you really start getting a pretty ugly product and all kinds of other performance issues," Costa explained. "So, there's going to be sort of a quality performance limitation."

An alternative is chemical recycling, a technology that has been around since the 1950s but has become the focus of growing investment and innovation as the circular economy has gained steam. Plastic makers including BP and Dow, and consumer packaged goods companies such as Coca-Cola, Danone and Unilever, are testing or investing tens of millions of dollars in the technology, according to the Wall Street Journal.

In chemical recycling, depolymerization breaks down plastics into their raw materials for conversion back into new polymers. Pyrolysis — heating of an organic material in the absence of oxygen — can turn mixed plastic waste into naphtha, which can be transformed back into petrochemicals and plastics.

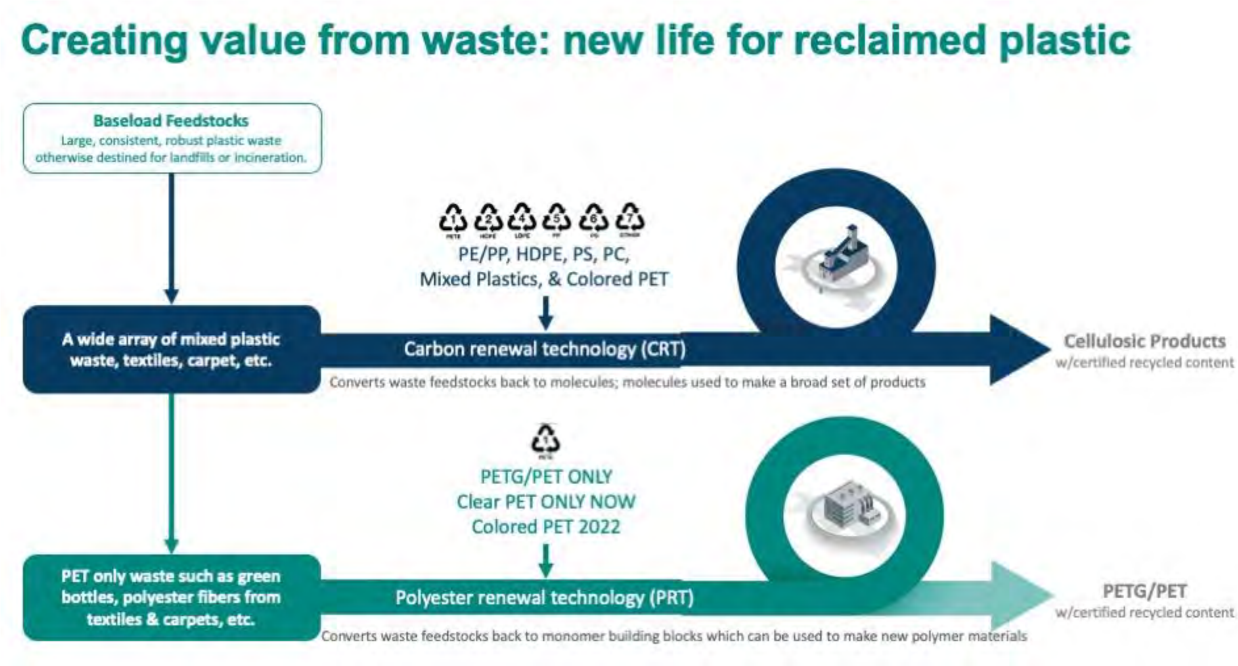
With only about 9 percent of the more than 400 million tons of plastic waste produced globally each year currently being recycled, according to U.N. Environment, that leaves the other 90 percent or so as potential feedstock.

There's big potential here, according to a 2019 report from the American Chemistry Council. It found that if widely adopted, chemical recycling — which it refers to as "advanced plastic recycling and recovery" — could create nearly 40,000 direct and indirect U.S. jobs, as much as $2.2 billion in annual payroll and $9.9 billion in direct and indirect economic output.

Calling on the carpet

Eastman's carbon renewal and polyester renewal technologies are forms of chemical recycling. But they aren't intended simply to displace mechanical recycling. For PET and HDPE plastics, mechanical recycling already is reasonably efficient, creating recycled materials streams that have proven cost-competitive in many markets.

"We don't want to compete with that," Costa said. "Frankly, the value of it is too high. From a sustainability point of view, you shouldn't touch it."



Besides, there's a much bigger opportunity. Eastman's Polyester Renewal Technology is a chemical recycling process specifically for polyester waste, which produces virgin-like materials, even from colored PET, according to the company. The process involves using glycolysis — the breakdown of PET by ethylene glycol — to disassemble waste PET into its fundamental building blocks. Those building blocks then can be reassembled to produce new polyesters with high levels of recycled content.

In its search for waste plastics, Eastman easily can forgo tapping into recycling markets for plastic water and soda bottles. There are plenty of other sources of waste polyester — from carpets, for example.

In one recent initiative, the company partnered with Circular Polymers, a company that reclaims post-consumer products for recycling. Circular Polymers is collecting and densifying the PET it retrieves from waste carpeting. It then converts the PET waste into pellets, which are shipped by railroad from its plant in California to Eastman in Tennessee. Eastman uses its CRT process to turn the pellets into new materials with certified recycled content. Those materials end up in textiles, packaging for cosmetics and personal care products, and eyeglass frames.

Costa says Eastman could divert millions of pounds of carpeting a year through partnerships such as this, although that's still a mere fraction of the more than 3 billion pounds of carpet sent to landfills in 2018, just in the United States, according to Carpet America Recovery Effort, an industry group.

And it's not just polyester. Eastman sees potentially unlimited opportunity in all the other types of plastic waste — especially the stuff that's hard to recycle, from a cost and logistics perspective, including those dreaded Franken-materials. The company's goal is to extract the value of the carbon molecules contained in these waste materials and put them back into productive use as like-new plastics.

Said Costa: "If there's a way to bring carbon back in through products that's better than the fossil-fuel approach of the linear economy, we should do that, right? I mean, this isn't complicated."

Fashion forward

Eastman's goal is to substitute its "carbon renewal" materials for their virgin counterparts wherever they are economically viable. Beyond pure economics, Costa described to me his three criteria for determining when it makes sense, from both a business and ecological perspective, for Eastman to recycle waste plastic. First, the waste has to go back into products — not be incinerated or burned to make energy. Second, the carbon footprint of the recycled material must be better than its fossil-fuel equivalent, based on life-cycle analysis. And third, "Consumers shouldn't give up a lot in their quality of life." That is, few if any tradeoffs in price or performance.

So far, CRT and PRT processes are finding their way into several of Eastman's many brands of polymers, including Trēva, a cellulose-based thermoplastic made from trees, used in automotive, packaging and electronics applications; CDA, a bio-derived material, used in injection-molded applications, such as ophthalmic frames and tool handles; Cristal, designed and engineered specifically for high-end cosmetics packaging applications; and Tritan, a durable clear plastic used to make Camelbak and Nalgene water bottles, and Rubbermaid food storage containers.

And then there is Naia, a fiber made from certified sustainably managed pine and eucalyptus plantations, widely used in the fashion industry. It is essentially cellulose acetate, the same material used in photographic film, being made by Eastman in Kingsport for about 100 years. In this case, it is spun into a yarn that is used to make fabric.

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Naia is made in a closed-loop process, in which chemical inputs — acetic acid and acetone — continuously are recycled. According to company marketing materials, it compares favorably to silk, cotton, viscose filaments and polyester in terms of environmental impacts — water usage, climate emissions, ecosystem disruption — and feel. Its yarn can be knitted or woven and easily blended with other fibers. Garments made with Naia are easy to home-launder compared with many fashion-forward fabrics, which require dry cleaning, says Eastman. The company claims that Naia produces no microfibers when washed.

There's one big challenge from a sustainability perspective, however: the fossil fuels used as a feedstock to produce the syngas to make one of the principal ingredients for Naia.

Eastman's Naia textile yarn for fashion. (Photo courtesy of Eastman)

Eastman is developing the technology to eliminate the fossil fuels from Naia production, replacing them with gases derived from breaking down waste plastics, a process called reforming, a carbon renewal technology. The resulting product, Naia Renew, is being launched this fall. The company describes it as "a cellulosic yarn sourced from 100 percent circular content, produced from 60 percent certified wood fibers and 40 percent recycle waste plastics."

Used textiles are another potential feedstock for Naia, creating a virtuous cycle that turns no-longer-wearable garments back into new ones. Eastman is in discussions with leading fashion brands about the potential of take-back programs in the future, Steve Crawford, the company's chief technology and sustainability officer, told me during my visit. "They could collect the garments, send them to us, and we could make them back into the same fiber to make new garments."

Mining landfills?

There's yet another disruptive opportunity here: mining landfills to cull plastic waste to be "renewed" through Eastman's processes.

The company says it is working closely with waste management companies to evaluate how to create the availability of such feedstock. "As part of our work, there's a lot of focus on how we partner, how we collaborate with the parties in this space," explained Cathy Combs, Eastman’s director of sustainability. "How do we create an infrastructure that will be able to supply chemical recycling?"

"We’ve demonstrated that the new Eastman recycling technologies are capable of utilizing a broad array of waste plastics, including plastics that aren’t currently utilized in mechanical recycling," Crawford added. "But we’ll need to partner with key players in both the waste collection and waste management systems, and key end-use value chains. We also need brands to help create demand for these materials to become valuable sources of feedstocks for these new technologies."

Of course, all of this innovation is taking place amid a pandemic, not to mention what appears to be a global recession. The textiles sector, like most others, has taken a hit from COVID-19, with a dramatic slowdown in global retail sales resulting in global supply-chain disruption, furloughs throughout the value chain and mounting inventories and liquidity challenges. But industry participants and influencers believe the textiles industry will emerge with an increased emphasis on sustainability as the industry rebuilds, said Jon Woods, Eastman's general manager of textiles and nonwovens.

Mark Costa, for his part, remains bullish on his company’s future, including on the impact Eastman could have both locally and globally — particularly in the economic development that come from mining plastics from local waste streams.

"I think there's going to be real economic opportunity and a lot of small-business job creation — which is great for this country as well as in Europe — who are going to jump into this," he told me. "I mean, the waste management guys will do it, and they'll be big and at scale. But there's also a lot of opportunity for local, small businesses to work with municipalities on how to do that. And just like we saw with carpet and the way they densified it, people are going to get creative. Once there's policy and economic incentive, that's when America does great."

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Costa believes that technologies such as CRT and PRT can give new life to plastics recycling if they can dramatically improve its economics. "The aluminum guys would have never succeeded if they could only take 10 to 20 percent of the aluminum and had to throw away 80 percent. I doubt you'd have high aluminum recycling rates because you just couldn’t justify the effort."

And, he added, some of Eastman’s sustainability and circular ingenuity just might rub off on the beleaguered chemical sector.

"Everyone wants to focus on the things that are negative about the chemical industry, and we have lots of room for improvement. So, how do we collaborate to take this seriously, which I think the industry very much does right now, and solve the next set of solutions to make the environment better at the same time as you're improving quality of life? That's our ultimate goal. That's what we get up every day trying to focus on doing."