APRIL 2017

Wharton
University of Pennsylvania

IGEL
INITIATIVE for GLOBAL ENVIRONMENTAL LEADERSHIP

KNOWLEDGE@WHARTON

Special Report

The Circular Economy: From Concept to Business Reality

http://environment.wharton.upenn.edu • http://knowledge.wharton.upenn.edu

INTRODUCTION

The Circular Economy: From Concept to Business Reality

In an ideal world, everything manufactured by people would automatically be either repurposed or reduced to its component parts and recycled for other uses, thus presenting a sustainable, closed loop that wasted no resources. But it's not a perfect world, and the usual destination for our unwanted goods — especially in the U.S. — is the landfill. Can we turn that situation around?

After more than a century of linear thinking about the path products take from cradle to grave, excitement is growing among environmentalists and business leaders about the revolutionary potential of the circular economy — which fights waste by aiming to extract the maximum value from commercial goods. The recent Wharton conference on the subject, co-sponsored by Dow and Wharton's Initiative for Global Environmental Leadership (IGEL), brought together pioneers from industry, academia, and non-profit organizations. This report extends the discussion begun at the conference by looking more in depth at the issue.

CONTENTS

SPONSORS

Wharton's Initiative for Global Environmental Leadership (IGEL) and Dow Chemical have partnered with Knowledge@Wharton to create this special report.

IGEL
INITIATIVE *for* GLOBAL
ENVIRONMENTAL LEADERSHIP

DOW®

Turning Waste Streams into Value Streams

THE FIRST ERA OF SUSTAINABILITY, CALL IT SUSTAINABILITY 1.0, FOCUSED ON CLEANING UP THE PLANET'S GROWING ENVIRONMENTAL MESS. Federal legislation restricted air and water pollution, as well as hazardous waste, and businesses adapted to the new regulations. Sustainability 2.0 took a broader perspective, reducing not just toxic waste, but waste of all kinds. The business community realized that less waste meant less cost and pitched in, often increasing efficiency and boosting profits in the process.

But throughout this era of growing environmentalism, the linear business model, which has dominated the modern world since the industrial revolution, remained fundamentally unchanged. "Take, make and dispose," is what Ken Webster, head of innovation at the Ellen MacArthur Foundation, calls it in his recent book, *The Circular Economy: A Wealth of Flows*.

What Webster and others are now advocating is something far more radical than recent efforts to reduce waste. In its purest form, Sustainability 3.0 — the circular economy — emulates the natural world. Allen Hershkowitz is a veteran recycling advocate at the Natural Resources Defense Council and co-founder/president emeritus of the Green Sports Alliance. He noted in his opening keynote address at the Wharton conference, The Circular Economy: From Concept to Business Reality, "In nature, there is no waste. One organism's waste becomes nutrients for another organism."

In the same way, the circular economy moves past the notion of consumable products, viewing manufactured goods that have outlived their usefulness as "nutrients" that help feed further production. The concept of waste disappears and irreplaceable natural assets are conserved as product lives are extended and new products are generated from the remains of old ones.

Gary Survis, a Wharton lecturer and IGEL fellow, moderated the Circular Economy conference. He noted in his opening remarks that this new approach "represents an incredible opportunity for business." But Survis also pointed out that realizing this potential demands "disruptive innovation" — in technology, manufacturing, supply chains, and business models, as well as in business culture and society at large. "It is early days yet," Survis said. But the momentum is building fast, as major corporations — including Dow Chemical, Caterpillar, H&M and Phillips — eagerly embrace the concept of the circular economy.

> **"In nature, there is no waste. One organism's waste becomes nutrients for another organism"**
>
> —Allen Hershkowitz, Natural Resources Defense Council

PRESERVING THE VALUE OF MANUFACTURED PRODUCTS

At its heart, the circular economy is about preserving value. Traditional recycling reduces waste but salvages only a small fraction of a manufactured product's potential benefit. According to Helga Vanthournout, senior expert with McKinsey & Co.'s Center for Business and the Environment, when you recycle a product after a single use, "You lose all of the value-added — from the energy, labor and assembly — that were added through the manufacturing process."

A 2013 report by the Circular Economy Task Force, "Resource Resilient UK," offers a dramatic example. The study found that a reused iPhone retains around 48% of

its original value whereas recycling its components retains just 0.24%. Less-complex manufactured products offer less dramatic, but still substantial returns. Reusing a ton of textiles, for instance, retains 9.6% of the original value compared to recycling (0.4%).

"A reused iPhone retains around 48% of its original value while recycling its components retains just 0.24%."

—Circular Economy Task Force

Recycling also comes too late in the process to address the environmental harm caused by manufacturing itself. As Hershkowitz notes, "More than 90% of a product's impact happened before you opened the package."

The business community is growing increasingly enthusiastic about the potential benefits of the circular economy, both for the environment and for the bottom line. Instead of limiting their sustainability efforts to increasing efficiency (i.e., reducing waste), more and more companies are focusing on ramping up productivity, the ability to produce more without using up more resources (or incurring more cost). As Survis pointed out, it is early in the process, but already circular-economy pioneers are succeeding on a number of fronts.

Remanufacturing. Companies that manufacture products with high intrinsic value, says Vanthournout, "realize that when a customer is finished with a product for whatever reason, it still has a lot of residual value." She points to Phillips as a good example. "Phillips will take not just outdated, but also faulty or broken parts, and entire products — medical imaging equipment, for instance — restore them to good-as-new-condition, and then redeploy them to the market." These remanufactured products appeal to smaller hospitals that cannot always afford the newest and best equipment but cannot accept anything that is not in good working order.

Caterpillar is another leader in remanufacturing: 65% of the company's costs are generated by materials, giving it a strong incentive to fully embrace the concept. Through its profitable Cat Reman program, Caterpillar incentivizes the return of used parts by sharing the reduction in manufacturing costs with the consumer. Once restored to good-as-new condition, the salvaged parts are either used in manufacturing new equipment or sold as less expensive spare parts, opening up a new market for the company.

Remanufacturing is not only good for the bottom line, of course; it also has enormous benefits for the environment. Caterpillar, for instance, estimated that remanufacturing a cylinder head leads to 61% less greenhouse gases, a 93% reduction in water use, an 86% reduction in energy used, and a 99% reduction in waste sent to landfill.

Cascading. Important in its own right, remanufacturing is also part of a larger circular-economy concept. "Cascading" refers to the successive use of materials, component parts and whole products from one use-cycle to another. While there is typically some loss of value at each stage, over time the overall value extracted from the original product is significantly enhanced.

For instance, an old cotton sweater, instead of being discarded can continue to generate value in secondary or even tertiary markets (thrift shops historically, and more recently eBay and Craigslist). Once the garment is no longer suitable for wearing, experts say, its fibers can be used as fiber-fill in the furniture industry, after which the same fibers can be used yet again in stone wool insulation for construction. Even after that, anaerobic digestion can be used to extract fuel and fertilizer from the old cotton.

There are times when the cascade of uses actually increases the value of the original product in a process known as "upcycling." When fashion company H&M uses polyester recycled from plastic polyethylene terephthalate (PET) bottles to make clothing, for example, it is upcycling the material to a more enduring use, and preventing the use of petroleum hydrocarbons to manufacture the fiber.

New business models. In the linear economy, consumers spend heavily on their own cars, which spend most of their product lives (more than 90%) sitting idle in garages and parking spaces. Uber, Lyft and other sharing economy companies suggest a different approach that, once again, extracts far more value from a single product.

Digital technology and "big data" make the sharing economy possible, and its growth has been dramatic in virtually every industry, most notably, travel, consumer goods, services, taxis, bicycles and car rentals, finance, music, employment and waste reduction. And the rise of this new approach to business may permanently change consumers' attitudes towards ownership. In a recent PwC study, 81% of people familiar with the sharing economy agreed that "it is less expensive to share goods than to own them individually" and 57% agreed with the statement: "Access is the new ownership."

But sharing is just one of the new ownership models embraced by leaders of the circular economy. "Servitization" is another, a new business model that converts traditional

products to services, either in conjunction with the sale of a traditional product or as a kind of leasing arrangement. Phillips, for instance, is now selling lighting as a service. According to the company, customers pay a service fee for a lighting system, while Phillips retains ownership. The company installs, maintains and upgrades the system as needed, and at the end of the agreement, recycles the equipment, sparing the customer the headaches of ownership and reducing energy bills by 55%.

Interface is another pioneer, selling the service of supplying carpet to businesses and households, contracting to replace and recycle worn tiles over time, rather than simply selling floor covering as a one-time disposable product. (The Wharton School now uses Interface carpet in all of its buildings.)

In the aviation industry, Rolls-Royce's TotalCare airplane engine program exemplifies a 21st-century form of renting. Instead of buying an engine for a fixed price, customers pay to use it based on the number of hours the engine is actually powering a plane. But the engine is not all that customers are renting, because Rolls-Royce also monitors the engine remotely and maintains it, modifies it and replaces parts as needed. The engine maker generates more than 50% of its revenue through this program, while maintaining long-term customer commitment and dramatically increasing the lifetime value of the original product.

Renault's electric cars offer yet another approach to servitization. Instead of including the battery in the purchase price of the car, the company leases it to French customers. That allows Renault to replace the battery as needed. The used pack can be re-engineered or recycled to extract more value — without any service delays for the customer.

PRESERVING THE VALUE OF BIOLOGICAL NUTRIENTS

When they wrote their 2002 seminal book, *Cradle to Cradle: Remaking the Way We Make Things*, William McDonough and Michael Braungart talked about technical and biological cycles and nutrients.

Nature, of course, is the model for a circular economy, and as long as the population in certain areas doesn't grow too dense, nature makes good use of biological nutrients. Three hundred years ago, for instance, natural processes kept the water flowing down the Delaware River clean enough to drink, notes Patrick Cairo, retired senior vice president for corporate development at Suez North America. But by the 1960s, he says, "There was so much waste being dumped into the Delaware that bacteria, which grew to attack the organic material, consumed all the oxygen, so you had areas where there was zero oxygen in the water."

To reduce such environmental degradation, cities throughout the world built wastewater treatment plants, which helped reduce pollution, but did little to capture any of the value in the original clean water. Cairo explains that Hyperion, the enormous treatment plant in Los Angeles that receives 80% of the city's wastewater, "for a long time was discharging the effluent into the Pacific."

"Servitization" is a new business model that converts traditional products to services, either in conjunction with the sale of a traditional product or as a kind of leasing arrangement.

Today, about 15% of the wastewater from Hyperion is piped to the nearby West Basin plant, managed by Suez, where the secondary waste stream is treated to five different levels of purity and piped to customers who can use that particular grade of water. In another plant managed by Suez in Edmonton, Canada, biogas is being extracted from the waste that is processed.

Food waste, too, is being reused in numerous ways. At the highest level, uneaten food cascades to people without enough to eat. Elsewhere, compost is taking a growing share of the food waste that used to simply rot in landfills. But according to Nate Morris, founder and CEO of Rubicon Global (a global leader in sustainable waste and recycling solutions), anaerobic digestion, which extracts added value from the organic waste by converting it into energy or fuel, maximizes the use of the material and is "one of the most environmentally sound and energy efficient solutions."

COLLABORATION WITH SUPPLIERS IS KEY

The circular economy is also redefining the traditional relationship among manufacturers, suppliers and consumers. In a circular economy, both consumers who recycle products and distributors who take back used goods become suppliers. And suppliers can sometimes play a key role in remanufacturing. Vanthournout notes that Foxconn, which makes smartphones and other products for Apple and many other companies, "is in a better position than the OEMs to check the [returned] phones for quality, clean them up if necessary, put proper labels on them,

put some software on the chip and put them back on the market."

At its refurbishing plant near Seattle, Phillips offers a concrete example of this kind of close collaboration. One of the company's medical equipment suppliers now works on site at the Phillips facility, helping to refurbish key components. Vanthournout explains: "They found that this model created the best margins for both companies, while maintaining a very high quality level." The arrangement also helps resolve any concern about intellectual property, an issue raised whenever there's collaboration on one company's product.

To make this kind of role realignment and collaboration work along the supply chain, it's important to consider each player's motivation. One approach is to share the value created by remanufacturing with the suppliers who contribute to the effort, while ensuring that the manufacturer initiating the collaboration gets enough of the added value to justify its investment.

Vanthournout used another car manufacturer's experiences as an example of how the right motivation can drive a win-win solution. Renault had been purchasing its cutting oil from a supplier on a volume basis. The more oil the car company used, the more money the supplier made. Renault worked out an agreement with the supplier that shifted maintenance and service involving the oil to the supplier and changed the purchase agreement from volume-based to transaction-based. In this new scheme, the supplier would prosper by making improvements that allowed the oil to be reused multiple times. And that's exactly what happened. By implementing design changes, the supplier dramatically extended the usage period for the oil, and in the process was able to improve its margin by 125%. And Renault's total cost of ownership for cutting fluids fell by about 20%.

THERE'S STILL A LONG WAY TO GO

Rethinking supply chains and business models, forging new collaborative relationships, finding ways to extract value from manufactured and biological materials — none of this is easy, and many of the elements being radically transformed are interconnected. The linear economy is beginning to curve, but there's still a long way to go.

"The reason I say it's early days is because this is so complex," says Survis. But the huge commitment made by major corporations is promising. "It's incredibly powerful," adds Survis, "but it's not like we're now, today, in the circular economy. We talk a lot about it, there's a lot of buzz about it, but we haven't made it yet."

Designing for the Circular Economy

WHAT DO YOU DO WITH A TOASTER WHEN YOU NO LONGER WANT IT? Until recently, no one thought about that question until the toaster was ready for the scrap heap. Today, advocates of the circular economy suggest that the best time to address end-of-life issues is when a product is first being designed. It's at that point that it has the greatest potential for circularity. If the designers of your toaster had thought about it not as a disposable appliance but as a product with value worth preserving, your options would be considerably enhanced.

That, in fact, is what the designers at the London-based Agency of Design (AoD) did. As part of a project that "looked at the end of life of electrical products and designed alternative ways to make the most of the material that they embody," the AoD design team took on the challenge of rethinking the humble toaster. They came up with three different approaches, each of which, says the company, "embodies a different strategy to designing circularity from the outset."

DESIGNING FOR LONGEVITY

AoD began by attacking the planned obsolescence that has dominated product design for so long. Knowing that aluminum recycles "with no loss of its material properties" and that the material is likely to remain valuable to recyclers for the foreseeable future, the design team worked to make every part of the first toaster, known as the Optimist, out of aluminum, "starting off with 100% recycled content and knowing that it can be infinitely recycled into other products at the end of its life."

To maximize the product's longevity, AoD designers looked for a design "so simple that there was nothing to break." The Optimist ended up with very few moving parts and with heating elements — the shortest-lived components in a toaster — that were simple to remove and replace.

The design team also considered the perceived value of the toaster to owners who would relish its longevity. The toaster was given a "rough surface texture, allowing it to grow old gracefully" and its birth date was cast into the aluminum so owners could enjoy celebrating its service year after year. The Optimist even included a simple toast counter so that, "When you hand the toaster down through the generations, your children will know you've enjoyed 55,613 rounds of toast!"

Ever since the term "planned obsolescence" was coined during the Great Depression, the U.S. and much of the world's economies have relied on the disposal and replacement of products with defined lifespans.

The greatest challenge to making such a long-lived product is coming up with a workable business plan. Ever since the term "planned obsolescence" was coined during the Great Depression, the U.S. and much of the world's economies have relied on the disposal and replacement of products with defined lifespans. As author Giles Slade notes in *Made to Break*, planned obsolescence has become "a touchstone of the American consciousness."

The lighting industry has been grappling with this question since the long-lived L.E.D. bulb was first introduced into the residential market in 2008. According to J.B. MacKinnon in his *New Yorker* article, "The L.E.D. Quandary: Why There's No Such Thing as 'Built to Last'," the answers so far have been less than inspiring. Some companies are returning to planned obsolescence by creating ever-cheaper lightbulbs with ever-shorter lifespans, while

others got out of the residential lighting business. In October of 2015, for example, MacKinnon notes that General Electric "broke up G.E. Lighting to leave behind a rump firm — the light-bulb division, essentially — that would be easy to sell off."

While there are still some markets left for lighting with built-in obsolescence — most notably the automotive sector — the industry is actively pursuing other ways to make longevity pay. A shift is already underway, at Phillips for instance, from selling lights as a product to selling lighting as a service. It's a growing trend, according to the recent Navigant Consulting "Third-Party Management of Lighting Systems in Commercial Buildings: Global Market Analysis and Forecasts" report.

A shift is already underway from selling lights as a product to selling lighting as a service.

Companies are also looking to build in smart technology that distinguishes their L.E.D. product from others and offers opportunities for continuing updates. In the commercial realm, G.E., for example, is developing streetlights that alert authorities whenever a built-in sensor detects gunshots in the area. As for the residential market, MacKinnon quotes Philip Smallwood, the director of L.E.D. and lighting research for Silicon Valley-based Strategies Unlimited: "Lighting is the perfect medium for you to insert the other connectivity products to fill the house, because you use light everywhere."

Regulation may also help pave the way for business models based on long-lived products. Tim Cooper, a design professor at Nottingham Trent University and editor of the book *Longer-Lasting Products*, sees possible solutions in government regulations that penalize obsolescence or reward longevity. But as Cooper recognizes, regulations follow culture, and the throw-away culture has been notoriously slow to change.

MODULAR DESIGN: REPLACING PARTS, NOT PRODUCTS

Another way of extending product life is to use a modular approach that allows owners to replace parts without having to replace the entire unit. This was the second strategy AoD took to rethinking the toaster. The Pragmatist model was designed with modular toasting slots that could be joined together to make any sized toaster a customer wanted. The modular design also made it possible to unclip a faulty toasting slot so it could be exchanged without interrupting the owner's ability to keep making toast. And AoD designed these modules to be "thin enough to fit through a letterbox, making the return process as easy as possible for the consumer."

The Ellen MacArthur Foundation highlights another example of modular design where performance is far more critical. Noting that ambulances were being sold at auction after just a few years, DLL, a global provider of asset-based financial solutions, investigated and found that it was the high cost of maintaining chassis components, such as the engine and gearbox, that led owners to return the vehicles.

The most valuable part of the ambulance, the large box that housed all the medical equipment and carried the patient, was generally in fine condition. DLL reduced customer costs by 20% and doubled the useful life of the vehicles by designing a patient-care module that could be easily removed and remounted on a new chassis.

DESIGN FOR DISASSEMBLY

Modular construction allows for disassembly by the individual, but is of little use to a company looking to extract value from products in volume. For their third toaster design, the AoD designers set out to create an inexpensive toaster that could be quickly and easily disassembled without degrading the component parts or mixing their materials. The solution was a toaster put together with snap-fit joints that contained small pellets. Placed in a vacuum chamber ("a cheap piece of capital equipment," says AoD), the pellets expand, pop open all the joints, and leave a disassembled product.

The AoD strategy is similar to a concept known as Active Disassembly using Smart Materials (ADSM), pioneered by Joseph Chiodo of Active Disassembly Research. Using "memory materials," which hold a shape until they reach a trigger temperature (either hotter or colder than normally encountered), Chiodo created screws and other kinds of connectors.

Once the product is heated or cooled to the trigger temperature, all of the screws lose their threads and the product falls apart without any damage to the component parts. Temperature is not the only means of triggering the change. As with the toaster, a change in pressure can work, or disassembly can be triggered by "microwave, infrared, sound, computer and robotic control, electric current or magnetic fields," according to the Active Disassembly website.

PLASTICS FOR A CIRCULAR ECONOMY

Plastic poses one of the biggest challenges to the circular economy. It is ubiquitous, made from petroleum and takes hundreds of years to decompose. According to a 2016 report by the World Economic Forum, "The New Plastics Economy: Rethinking the Future of Plastics," plastic packaging is of particular concern. "After a short first-use cycle, 95% of plastic packaging material value, or $80 billion to $120 billion annually, is lost to the economy. A staggering 32% of plastic packaging escapes collection systems, generating significant economic costs." In fact, says the report, "The cost of such after-use externalities for plastic packaging, plus the cost associated with greenhouse gas emissions from its production, is conservatively estimated at $40 billion annually — exceeding the plastic packaging industry's total profits."

One of the reasons plastic recycling rates are so low is because two or more incompatible types of material are often combined together to achieve the qualities needed for specific packages. According to Jeff Wooster, global sustainability director at Dow, the plastic pouches used for everything from frozen food to laundry detergent pods, offer a good example.

They are traditionally made of polyethylene terephthalate (PET), laminated to a film made of polyethylene. Using these two different plastics gives the pouches both "a nice glossy look, and stiffness that lets it stand up on the shelf," says Wooster, and "the ability to run at high speeds on packaging machines." It also makes the pouches impossible to recycle.

To solve this problem, Dow scientists came up with a new packaging structure that meets all the product design specifications but is made not of PET but of two types of polyethylene instead. "By combining different types of polyethylene that are compatible with each other," explains Wooster, Dow created a stand-up pouch that can be recycled in supermarket bins along with plastic shopping bags. One of the first applications of the innovative material was as the pouch for Seventh Generation dishwasher pods. The primary uses for the recycled polyethylene are new shopping bags, which retain much of the product's original value, and wood-plastic composite lumber, which effectively puts the plastic back to good use for at least 50 years.

The stand-up pouch is far from Dow's only contribution to the circular economy. Another innovation announced in the fall of 2016 is a product made of polypropylene-based olefin block copolymers. In the past, post-consumer streams that included polypropylene and polyethylene were difficult to recycle. Dow's innovation makes it possible to combine these two commonly used resins into a host of products — including rigid containers and drums, household containers, industrial tanks, kayaks, and flexible packaging — all of which "offer upcycling opportunities for recyclers and brand owners," according to the company.

PRODUCTS THAT TRACK THEMSELVES

A surprisingly simple idea is driving still more innovation that supports the circular economy: keeping track of what you own. Digital technology, including the "internet of things," is making it possible for companies to design "intelligent assets" that can report back their location, availability and condition. The ability to channel, accumulate, and process this information as "big data" is enabling companies to maximize the value of these assets over time.

Using on-board sensors that monitor equipment in the field allows Caterpillar to move from repair-after-failure to repair-before-failure.

Caterpillar, for instance, is using on-board sensors that monitor its equipment in the field, combined with predictive diagnostics, to extend the life of its products. The technology allows the company to move from repair-after-failure to repair-before-failure and to improve maintenance based on how a machine is being used — all of which saves customers downtime and expense.

IBM has used similar technology to develop a comprehensive analytics asset called the Reuse Selection Tool, to help product managers choose the next optimal use for a product. Now in prototype, the tool ingests a vast range of granular data — including information about the equipment's modularity and reuse potential, regulations, market price, cost of remanufacturing, and supply and demand — enabling the product manager to decide on a per-unit basis whether to remanufacture, recycle, or scrap. It is also exploring the possibility of using cognitive computing, pioneered by the Watson system, to help interpret the data.

A new business-to-business sharing platform, FLOOW2, takes a simpler approach. Instead of relying on intelligent assets that keep track of themselves, it has created a Craigslist-type marketplace where companies can advertise

equipment, facilities, and make them available for rent rather than purchase. Such collaborative consumption is already powering the sharing economy at the consumer level. FLOOW2's innovation is to extend the idea to the business world.

DESIGNING PRODUCTS THAT USE CO_2

One of the primary goals of the circular economy is to prevent the average global temperature from rising 2°C above preindustrial levels. According to the International Energy Agency, achieving this goal will require an investment in renewable energy and energy efficiency of $1 trillion a year for the next 34 years, a three-fold increase in the current level of investment. "It's not happening," says Bernard David, senior fellow at IGEL and chairman of CO_2 Sciences, Inc. Even with all the activities on the horizon, the amount of carbon dioxide staying in the atmosphere will mean an unacceptable increase in global warming.

One potential solution to this problem is carbon capture and sequestration (CCS), which buries the greenhouse gas underground. But the strategy is not yet technically feasible. "Most current CCS techniques are uneconomic because they consume too much energy to sequester the carbon, so they have yet to be deployed at scale," reports a recent GreenBiz article, "Seven Companies to Watch in Carbon Capture and Storage."

The Global CO_2 Initiative, also a brainchild of Bernard David, takes a different approach. Instead of simply burying the gas as a destructive waste product, the initiative aims to transform the global economy through new inventions and investments to use as much as 10% of global CO_2 to make useful, profitable products at scale. A market assessment by McKinsey & Co. identified 25 potential products, representing a market that could reach $1 trillion by 2030. Each of these products is at a different level of readiness, which the initiative grades on a nine-point scale. "In order to have a meaningful impact," says David, "you have to get all these things to a level 9."

Cement is the lowest hanging fruit. One process, already in use, promises to reduce the industry's CO_2 emissions by 70%, both by capturing the gas in the cement and by dramatically reducing emissions during curing. Since cement manufacturing accounts for 7% of CO_2, David says, "Potentially, with that one industry, we can reduce CO_2 emissions by 5% annually."

The initiative, which was launched in January 2016, is working to build "a whole ecosystem to create at scale CO_2-based products," David explains. It's a monumental task, but in October 2017, less than a year after it began, the initiative released a draft "Roadmap of the Global Commercialization Potential of Carbon Capture and Utilization Technologies through 2030." A full roadmap was released in Marrakesh, Morocco, in November 2016 at the Conference of Parties meeting held to advance the Paris Agreement on Climate Change.

As the initiative roadmap suggests, the way forward is paved with possibilities. There will undoubtedly be potholes and detours as companies rethink product design with circularity in mind. But thanks to the design strategies mentioned above, and others not yet imagined, the journey towards a circular economy is off to a strong start.

The Producer Pays

IN RECENT YEARS, THE CONCEPT OF EXTENDED PRODUCER RESPONSIBILITY (EPR) HAS CAUGHT ON, FIRST IN EUROPE in the 1990s and since then in the rest of the world, including the U.S. The concept is relatively simple: Companies that make consumer goods are given responsibility for managing their products and packaging at their end of life. The concept, as the *Journal of Cleaner Production* points out, is to turn what was formerly waste "into the 'food' for industry and the next generation of products."

According to the Maine-based Upstream policy group, EPR is ushering in a new generation of products that have the cost of redesign, reuse, recycling, composting, and disposal (including packaging) included in the retail price. "The proper environmental management of the product and its package for their highest and best use becomes part of the costs of doing business, like R&D, marketing, and logistics," Upstream said.

BEGINNING IN GERMANY WITH A FOCUS ON PACKAGING

Germany enacted the first countrywide law to put the "producer pays" concept into practice in 1991, focusing on packaging. Its goal was the reduction of landfill volume, and a shifting of responsibilities for packaging recovery. Manufacturers under the nonprofit Duales System Deutschland GmbH (Dual System of Germany), a nonprofit organization, were required to set up a system for collecting, sorting, and recycling packaging after consumers were done with it.

The law created a significant incentive for companies to make it easier to recycle their products, and offer them with far less packaging. That goal was soon evident on store shelves. For instance, toothpaste that was sold in a paper box now stood upright on its flat cap. The so-called Green Dot (Der Grüne Punkt) law was influential, and in 1994 it went regional with the European Union Packaging Directive.

Soon, 22 European Union member states were putting a green dot on product packaging, and more than 170,000 licensees were using the Green Dot trademark. Around the world, more than 460 billion packages are Green Dot-labeled every year, and there are coordinating operations in the U.K. and Canada.

> **"The proper environmental management of the product and its package for their highest and best use becomes part of the costs of doing business, like R&D, marketing, and logistics."**
>
> —Upstream

The concept — moving well beyond packaging to include electronics, batteries, cars and other end-of-life goods — spread into Asia as well, to Japan, South Korea, Taiwan and China. Japan, for instance, legislated the Basic Law for a Recycling-Based Society beginning in 1998, and both the Home Appliance Recycling Law and the wide-ranging Law for Promotion of Effective Utilization of Resources in 2001.

FORAYS INTO THE U.S.

The next frontier was the U.S., where EPR has proved a harder sell. According to Reid J. Lifset, associate director of the industrial environmental management program at Yale and editor of the *Journal of Industrial Ecology*, an EPR bill was introduced by Senator Max Baucus (D-MT), then chairman of the Senate Environment and Public Works Environmental Protection Subcommittee, in 1992, but

it faced stiff industry opposition and was never enacted. There is still no national EPR law, and no immediate prospects for one.

There are also no state EPR laws yet on packaging (despite the prominence of those mandates in Europe and Asia), although Jamie Rhodes, Upstream's program director, said he would be "surprised" if a state did not pass a packaging law within the next five years. Several states have shown interest already. In September 2016, CalRecycle Deputy Director Howard Levenson sent a memo to the agency's director, Scott Smithline, recommending establishment of "a mandatory comprehensive, statewide packaging program." The motivation: packaging amounts to eight million tons to landfills annually, approximately 25% of the state's total waste stream.

EPR packaging bills have also been proposed in Rhode Island, and Connecticut's environmental agency is studying packaging EPR.

"EPR does not simply shift costs from the public sector to the private sector; it seems to minimize costs through economies of scale, product design and other market forces."

—Connecticut's 2016 Comprehensive Materials Management Strategy report

While EPR laws on packaging in the U.S. have yet to take hold at the state level, there are already more than 95 state and municipal EPR laws in 12 different product categories, from electronics (25 laws) to thermostats (13 laws) and paint (nine laws), according to Scott Cassel, CEO of the Product Stewardship Institute (PSI). Other categories include auto switches, carpet, cell phones, fluorescent lighting, pesticide containers and pharmaceuticals.

In the absence of federal legislation, PSI has developed many state legislative models that have gained some traction around the U.S.

The leading states, with up to eight laws, are California, Vermont, and Maine. Connecticut, another leader, has EPR programs for electronics, paint, mattresses, and mercury thermostats, and is studying packaging. The state's 2016 Comprehensive Materials Management Strategy states that "EPR does not simply shift costs from the public sector to the private sector; it seems to minimize costs through economies of scale, product design and other market forces."

According to Lee Sawyer, a policy advisor to Connecticut's environmental agency, EPR for packaging "is certainly on the table. We're taking time to study programs elsewhere in the world, and have discussions with stakeholders. We have EPR for other products, and packaging is the next big item to tackle." Sawyer noted that EPR laws are more successful if undertaken regionally in tandem with other states, which is possible if Rhode Island also passes an EPR packaging bill.

Municipal governments, too, are showing interest in EPR legislation. "Some municipal governments are fine with it," Yale's Lifset said, "because in cases like electronic e-waste and household hazardous waste collection and processing, it tends to be costly and difficult to manage. Local governments are finding it difficult to recycle at high levels, and EPR is a way to make that feasible. The collecting and sorting is then done outside the municipal realm."

These activities suggest that EPR is likely to advance, perhaps quickly, on the state and municipal level, but the prospects for it nationally are not good. Gary Survis, a lecturer at the Wharton School and a senior fellow of IGEL, points out that the last meaningful environmental legislation was passed by Congress in the 1990s, and the current climate would make it very difficult for a national EPR law.

"There has been a generational shift in what the government's role is, and what industry's role is," Survis said. "In part because of the overarching political gridlock, there's been pressure put on business to pick up the slack and lead. It's a very different role than we've seen previously, when Congress was passing heavy regulation. The coalition necessary to pass that kind of environmental legislation isn't there now."

With little prospect of "a consistent national system," says Cassel, U.S. companies are likely to face a "patchwork" of state and local laws. Mark Weick, lead director of sustainability at Dow, points out that such a patchwork of state EPR laws is less desirable than "smart federal legislation," because the local legislation is likely to vary considerably, creating a compliance burden for producers. That same concern about meeting the requirements of many different laws is what led auto manufacturers to the table with the Obama Administration to agree on a national vehicle fleet average of 54.5 mpg by 2025.

When industry works with the states on a template, the "patchwork" problem is dramatically lessened. Arguably,

nine states having separate EPR laws for paint would create the problem industry is trying to avoid. While there are minor differences, the laws are all based on the model that was jointly developed by industry and stakeholders. And Upstream's Jamie Rhodes said that few operational problems have arisen. "The differences aren't that large," he said.

In the case of electronics EPR, however, the stakeholders failed to reach consensus, so the 25 state laws are indeed quite different and became a compliance problem for manufacturers. That example offers a cautionary tale about the importance of working together to draft model legislation.

EPR GRAPPLES WITH BUSINESS REALITIES

"EPR has had an enormous effect in Europe, creating a case for collecting and recycling a variety of products," said Helga Vanthournout, a senior expert with McKinsey & Co.'s Center for Business and the Environment. "The challenge is that many EPR laws were put in with the status-quo technology of those days in mind. And because of technological progression and a slump in commodity markets, there is actually no commercial case for taking products back. The law simply said if you didn't do it voluntarily, you'd be forced to comply. With electronics, there's more of a case to be made for taking back products."

Even in electronics, changes in technology have caused problems. With the rise of flat screens, noted Patrick Cairo, recently retired senior vice president for corporate development at Suez North America, there's "no commercial opportunity for CRTs." That's one big reason Best Buy announced in early 2016 that it would now charge $25 to take back the computer monitors it had been recycling for free. "Our goal has always been to simply break even on our recycling program, and we're not there today," Best Buy spokeswoman Laura Bishop said.

But Cassel points out that EPR works very well when, coordinating with industry, it focuses on specific products that have ready markets. In 2004, he said, PSI worked closely with office supplies giant Staples on the first U.S. computer takeback program, and since then, 162 million pounds of electronics have been recycled. "It was a pilot program, but it's now permanent and still in place today," he said.

EPR and PSI scored a considerable multi-stakeholder victory in a collaboration with the paint industry, beginning with talks in 2002 that led to two memoranda of understanding in 2005 and 2007. "We came to agreement on the problems created by leftover paint, as well as joint solutions needed to increase paint reuse and recycling, and create a sustainable financing system," Cassel said. At the conference, he added, "Now the paint industry is taking responsibility for managing 65 million gallons of unused paint every year." There are nine laws in place that follow the PSI model, resulting in the collection of more than 16 million gallons (over two thirds of which is recycled into new paint), generating savings of more than $69 million and creating at least 200 new jobs.

PSI worked closely with office supplies giant Staples on the first U.S. computer takeback program, and since [2004], 162 million pounds of electronics have been recycled.

A new frontier is carpet recycling. According to Cassel at the conference, PSI has a strategic approach to ensuring a high recycling rate for a product that now mostly ends up in landfills (3.9 million tons annually in the U.S., with only 7.5% recycled). "We get all the key stakeholders to recognize the problem and define it together," he said. "Then we move on to developing joint goals, and to identifying barriers to achieving gains, which could be regulatory, or it could be a lack of education or infrastructure." California passed the first mandatory EPR law for carpet in 2010.

ALTERNATIVES TO MANDATORY EPR

There's still some doubt about the benefits of EPR. Bob Lilienfeld is director of communications at the American Institute for Packaging and the Environment (AMERIPEN), whose members include Dow, Procter & Gamble, General Mills and Tetra Pak. "AMERIPEN is not against EPR," he said. "We're in favor of efficient recovery. If it can be shown scientifically that EPR does a better job than the alternatives, then it would be seriously on the table." He identified the alternatives that can increase packaging recovery as landfill bans, pay-as-you-throw laws, and recycling mandates.

Cassel counters that Canadian and European EPR packaging laws usually include the three regulatory programs that Lilienfeld cited. "No one except the U.S. brand owners are looking at these approaches as separate from EPR," he said. "And there is no evidence I have seen that says these three programs alone are better than EPR."

Nestlé Waters North America has been one of the few companies supporting EPR for packaging since 2011. "This model can better meet the needs of the American marketplace by increasing recycling rates, reducing government spending, and using private-sector efficiencies to reduce the overall cost of recycling," the company said. In fact, the company set a goal of joining with other companies in an effort to double the U.S. recycling rate for PET beverage containers to 60% or better through EPR programs.

In the absence of legislation, however, Nestlé Waters is acting on its own. In a recent interview with *Packaging World* magazine, for instance, the chief sustainability officer for Nestlé Waters, Nelson Switzer, noted, "We have increased greatly the percentage of recycled PET in our bottles. This has created a demand for PET, helping encourage suppliers to produce the material. This has had a knock-on effect where the demand for post-consumer PET has increased, and recycling programs were encouraged to ensure the supply of high-quality PET meets Nestlé's standards for bottling water."

Voluntary efforts have also been tried in the carpeting industry, but they have had limited results. A coalition of carpet and fiber companies, the U.S. EPA, recyclers, and state and local regulators signed a memorandum of understanding in 2002, calling for a 20% to 25% recycling rate by 2012. But the rate reached only 4% of post-consumer carpet as late as 2014.

Upstream executive director Matt Prindiville is supportive of these efforts, but he describes them as "a drop in the bucket to what's really needed to boost recycling in the U.S." And Rhodes said that voluntary programs "aren't enough," because they are reliant on public infrastructure, rather than producer responsibility. "There wouldn't be a need for these recycling systems were it not for the products that companies make, and the packaging they chose to use with it," Rhodes said.

Nonetheless, companies, acting on their own and in coalitions, have made impressive gains in handling their waste. According to its 2015 sustainability report, the Dow Chemical Company set the goal of reusing 300 million pounds of byproducts between 2005 and 2015, and actually achieved 364 million pounds (the equivalent of 8,200 truckloads). "Knowing where our materials go is something we talk about all the time, and emphasize in discussions," said Rich Helling, a lifecycle analysis manager at Dow. "'Byproduct synergy' is a concept we've worked on for 10 years or more. We take waste and low-value byproducts and find local partners that can use them."

Whether at the national or local level, mandatory or voluntary, "EPR is definitely gaining steam in the U.S. every year," said Cassel. "When PSI launched in 2000, people didn't know about product stewardship or EPR, but now everybody talks about it. And producers understand the need for taking greater responsibility, because they're hearing about it from their customers."

According to Robert Giegengack, professor of earth and environmental science at the University of Pennsylvania (where his students included Scott Cassel): "A human society that imagines itself as moving toward a sustainable configuration will have to recycle products that today we consider waste, and to keep those products from contaminating other resources on which we depend. … If recycling strategies can be built into the industries that today use our key resources, that's a clear example of a pathway to a future that is less unsustainable than the pathway we are on."

Special Report

The Circular Economy: From Concept to Business Reality

IGEL
INITIATIVE *for* GLOBAL ENVIRONMENTAL LEADERSHIP

About IGEL

The Wharton-led, Penn-wide **Initiative for Global Environmental Leadership (IGEL)** promotes knowledge for business sustainability through world-class research, transformative teaching and constructive dialogue between top alumni, academic, corporate, government, and non-government organizations. IGEL is a hub for business and sustainability, connecting and leveraging academic capital at Penn to help business leaders of today and tomorrow create more sustainable industries.

For more information, please visit https://igel.wharton.upenn.edu

KNOWLEDGE@WHARTON

About Knowledge@Wharton

Knowledge@Wharton is the online business analysis journal of the Wharton School of the University of Pennsylvania. The site, which is free, captures relevant knowledge generated at Wharton and beyond by offering articles, podcasts and videos based on research, conferences, speakers, books and interviews with faculty and other experts on global business topics.

For more information, please visit knowledge.wharton.upenn.edu

DOW®

Eric Orts
Faculty Director
Initiative for Global Environmental Leadership (IGEL)
The Wharton School, University of Pennsylvania
ortse@wharton.upenn.edu

Joanne Spigonardo
Senior Associate Director of Business Development
Initiative for Global Environmental Leadership (IGEL)
The Wharton School, University of Pennsylvania
spigonaj@wharton.upenn.edu