FEBRUARY 2014
McKinsey Quarterly

Remaking the industrial economy

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A regenerative economic model—the circular economy—is starting to help companies create more value while reducing their dependence on scarce resources.

The problem

Unprecedented prices and volatility in natural-resource markets are pressuring the traditional "take, make, and dispose" approach to manufacturing.

Why it matters

Creating an industrial system that restores material, energy, and labor inputs would benefit business and society alike. The savings in materials alone could top $1 trillion a year.

What to do about it

Learn how value is created in a circular economy to better design and optimize products for multiple cycles of disassembly and reuse.

Create new relationships with customers to ensure materials are returned.

Focus on the economics and logistics of turning products into materials—not just the other way around.

Cooperate with other companies in the precompetitive sphere in order to create scalable markets for complex materials.

Visualize, for a moment, the industrial economy as a massive system of conveyor belts—one that directs materials and energy from resource-rich countries to manufacturing powerhouses, such as China, and then spirits the resulting products onward to the United States, Europe, and other destinations, where they are used, discarded, and replaced. While this image is an exaggeration, it does capture the essence of the linear, one-way production model that has dominated global manufacturing since the onset of the Industrial Revolution.

Increasingly, however, the linear approach to industrialization has come under strain. Some three billion consumers from the developing world will enter the middle class by 2030. The unprecedented size and impact of this shift is squeezing companies between rising and less predictable commodity prices, on the one hand, and blistering competition and unpredictable demand, on the other. The turn of the millennium marked the point when a rise in the real prices of natural resources began erasing a century's worth of real-price declines. The biggest economic downturn since the Great Depression briefly dampened demand, but since 2009, resource prices have rebounded faster than global economic output (Exhibit 1). Clearly, the era of largely ignoring resource costs is over.

In light of volatile markets for resources, and even worries about their depletion, the call for a new economic model is getting louder. In response, some companies are questioning the assumptions that underpin how they make and sell products. In an effort to keep control over valuable natural resources, these companies are finding novel ways to reuse products and components. Their success provokes bolder questions. Could economic growth be decoupled from resource constraints? Could an industrial system that is regenerative by design—a "circular economy," which restores material, energy, and labor inputs—be good for both society *and* business? If the experience of global automaker Renault is any indicator, the answer appears to be yes.

- Renault's plant in Choisy-le-Roi, near Paris, remanufactures automotive engines, transmissions, injection pumps, and other components for resale. The plant's remanufacturing operations use 80 percent less energy and almost 90 percent less water (as well as generate about 70 percent less oil and detergent waste) than comparable new production does. And the plant delivers higher operating margins than Renault as a whole can boast.

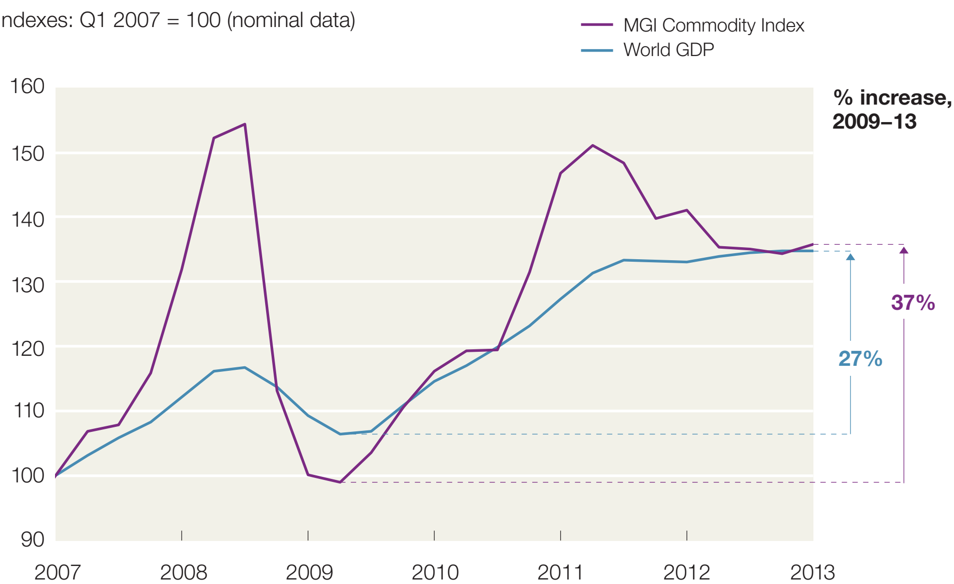
- More broadly, the company redesigns certain components to make them easier to disassemble and use again. It also targets components for closed-loop reuse, essentially converting materials and components from worn-out vehicles into inputs for new ones. To support these efforts, Renault formed joint ventures with a steel recycler and a waste-management company to bring end-of-use expertise into product design. Together, these moves help Renault save money by maintaining tighter control of its raw materials throughout its vehicles' life cycles—or *use cycles*.

- Renault also works with suppliers to identify "circular benefits" that distribute value across its supply chain. For example, the company helped its provider of cutting fluids (a coolant and lubricant used in machining) to shift from a sales- to a performance-based model. By changing the relationship's nature and terms, Renault

Exhibit 1

Since 2009, resource prices have rebounded more quickly than global economic output.

Indexes: Q1 2007 = 100 (nominal data)



Source: Food and Agriculture Organization of the United Nations (FAO); International Monetary Fund (IMF); Organisation for Economic Co-operation and Development (OECD); Oxford Economics; World Bank; UN Comtrade database; McKinsey Global Institute (MGI) analysis

> motivated the supplier to redesign the fluid and surrounding processes for greater efficiency. The result was a 90 percent reduction in the volume of waste discharge. This new arrangement benefits both companies: the supplier is moving up the value chain so that it can be more profitable, while Renault's total cost of ownership for cutting fluids fell by about 20 percent.

Renault's experience is just one data point in a growing body of evidence suggesting that the business opportunities in a circular economy are real—and large. In this article, we'll explore the concept of such an economy, examine the arguments and economics underpinning it, and discuss the challenges that must be overcome to make it a reality. The work, which draws on McKinsey's recent collaboration with the Ellen MacArthur Foundation and the World Economic Forum[1] (see sidebar, "An enabler in a big system," on page 8) suggests that in addition to the implicit environmental benefits that a circular economy would bring, there is a significant economic impact. In fact, our research suggests that the savings in materials alone could exceed $1 trillion a year by 2025 and that, under the right conditions, a circular economy could become a tangible driver of global industrial innovation, job creation, and growth for the 21st century.

Circular thinking

A circular economy replaces one assumption—disposability—with another: restoration. At the core, it aims to move away from the "take, make, and dispose" system by designing and optimizing products for multiple cycles of disassembly and reuse.[2] This effort starts with materials, which are viewed as valuable stock to be used again, not as elements that flow through the economy once. For a sense of the scale involved, consider the fast-moving consumer-goods

[1] This work is summarized in three reports: *Towards the Circular Economy: Accelerating the scale-up across global supply chains*, World Economic Forum, January 2014; *Towards the circular economy: Economic and business rationale for an accelerated transition*, Ellen MacArthur Foundation, January 2012; and *Towards the circular economy: Opportunities for the consumer goods sector*, Ellen MacArthur Foundation, January 2013. All are available on ellenmacarthurfoundation.org.

[2] For readers interested in learning more about circular economies and the thinking behind them, we recommend two seminal books: Michael Braungart and William McDonough, *Cradle to Cradle: Remaking the Way We Make Things*, first edition, New York, NY: North Point Press, 2002; and Walter R. Stahel, *The Performance Economy*, second edition, Basingstoke, Hampshire: Palgrave Macmillan, 2010.

industry: about 80 percent of the $3.2 trillion worth of materials it uses each year is not recovered.

The circular economy aims to eradicate waste—not just from manufacturing processes, as lean management aspires to do, but systematically, throughout the various life cycles and uses of products and their components. (Often, what might otherwise be called waste becomes valuable feedstock for successive usage steps.) Indeed, tight component and product cycles of use and reuse, aided by product design, help define the concept of a circular economy and distinguish it from recycling, which loses large amounts of embedded energy and labor.

Moreover, a circular system introduces a strict differentiation between a product's consumable and durable components. Manufacturers in a traditional economy often don't distinguish between the two. In a circular economy, the goal for consumables is to use non-toxic and pure components, so they can eventually be returned to the biosphere, where they could have a replenishing effect. The goal for durable components (metals and most plastics, for instance) is to reuse or upgrade them for other productive applications through as many cycles as possible (Exhibit 2). This approach contrasts sharply with the mind-set embedded in most of today's industrial operations, where even the terminology—value chain, supply chain, end user—expresses a linear view.

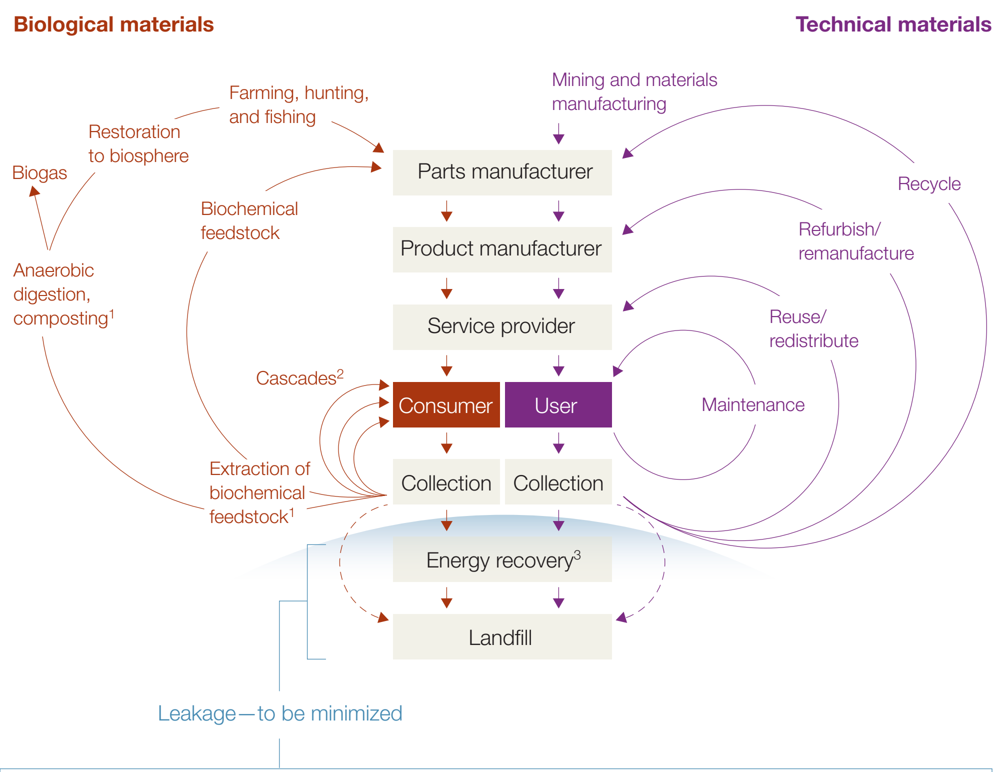
Since restoration is the default assumption in a circular economy, the role of consumer is replaced by that of user. For companies, this change requires a different way of thinking about their implicit contract with customers. For example, in a buy-and-consume economy, the goal is to sell the product. In a circular economy, the aspiration might be to rent it out to ensure that its materials were returned for reuse. When products must be sold, companies would create incentives to guarantee their return and reuse. While all this might sound rather utopian, a number of companies are starting to pull four (often mutually reinforcing) levers to convert theory into hard-hitting practice.

1. The power of the inner circle

Ricoh, a global maker of office machines, designed its GreenLine brand of office copiers and printers to maximize the reusability of

Exhibit 2

In a circular economy, products are designed to enable cycles of disassembly and reuse, thus reducing or eliminating waste.



Leakage of biological materials defined as:

- loss of opportunities to maximize reuse before returning nutrients to soil
- inability to restore to soil because of contamination

Leakage of technical materials defined as:

- loss of materials, energy, and labor when products, components, and raw materials cannot be reused, refurbished, or recycled

[1]Can take both postharvest and postconsumer waste as an input.
[2]Diversifying reuse across value streams—eg, cotton clothing reused as secondhand clothing, as fiber fill for upholstery, and as insulatation for construction.
[3]Can reduce opportunities for reuse of materials. For example, excess capacity of incinerators could set up competition between their operators and recyclers for end-of-use materials.

Source: *Towards the Circular Economy: Accelerating the scale-up across global supply chains*, World Economic Forum, January 2014

products and components, while minimizing the use of virgin materials. Products returning from their leasing contracts are inspected, dismantled, and taken through an extensive refurbishing process that includes replacing components and updating software before the machines reenter the market. By designing the components to be reused or recycled in Ricoh facilities, the company reduces the need for new materials in production and creates a tight “inner circle” of use that allows it to employ less material, labor, energy, and capital. GreenLine products are now offered in six major European markets, where they account for 10 to 20 percent of Ricoh’s sales by volume and earn margins that are as much as two times higher than those of the company’s comparable new products—without a reduction in quality.

For products that can’t be remanufactured, refurbished, or upgraded, Ricoh harvests the components and recycles them at local facilities. The company is currently considering a plan to return some recycled materials to its manufacturing plants in Asia for use in making new components. After factoring in the price differences between virgin and recycled materials (polypropylene, for example) and the cost of Asia-bound container shipping, Ricoh estimates it could save up to 30 percent on the cost of materials for these components. Overall, the company says, it’s on track to reduce the input of new resources in its products by 25 percent below their 2007 levels no later than 2020.

2. The power of circling longer

A closely related way companies can benefit from a circular economy is to maximize the number of consecutive product cycles (cycles of reuse, repair, or remanufacture), the time products spend in each of them, or both. If designed appropriately, each additional cycle eliminates some measure of the net material, energy, and labor costs of creating a new product or component. For example, Renault leases batteries for electric cars, in large part to recover them more easily so they can be reengineered or recycled for additional duty. Keeping close control over the process helps ensure the product’s quality and gives Renault a chance to strengthen its ties to customers.

Leasing isn’t new in the automotive industry, of course: tire-maker Michelin leased automobile tires in the 1920s. In 2011, Michelin Fleet Solutions had 290,000 vehicles under contract in more than 20 European countries. The group offers tire upgrades, maintenance, and replacement to optimize the performance of trucking fleets and to lower their total cost of ownership. By maintaining control over the tires, Michelin can collect them when they wear out and can extend their technical utility by retreading or regrooving them for resale. The company estimates that retreads, for example, require half of the raw materials new tires do but deliver up to 90 percent of the performance.

An enabler in a big system

Dame Ellen MacArthur made history in 2005, when she became the fastest solo sailor to circumnavigate the globe. She now leads the Ellen MacArthur Foundation, an organization that works with businesses, universities, and governments to accelerate the transition to a circular economy.

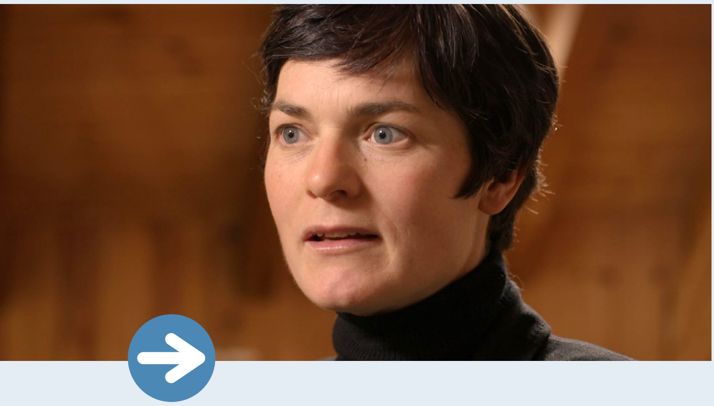
When you set off around the world on a boat, you know that you only have so much food, so much diesel. And you become incredibly connected to those resources. As you watch those resources go down, you understand just what "finite" means because you're two and a half thousand miles from the nearest town. I realized that our global economy is no different—powered by resources that are ultimately finite—and that there is a much greater challenge out there than sailing around the world. Our global economic system relies on taking something out of the ground and making it into something else, and the material or the product it's made into ultimately gets thrown away. In the long term, that just can't work. When you finish a round-the-world journey on a boat, you can restock and do it again. But we're not able to do that on a global economic scale.

One of the most striking things I learned from talking to analysts and investors is that a century of real declines in commodity prices was erased in just ten years. That increase in, and growing volatility of, raw-materials prices means that the conversation with businesses quickly turns to efficiency and the need to use less energy in manufacturing. Businesses are receptive because they understand that there will be further pressure on commodity prices as three billion new middle-class consumers are created in emerging

Meanwhile, in a few stores, the UK-based retailer B&Q is piloting a take-back program for its power tools. Customers can exchange used ones either for cash or a charity donation. The company plans to refurbish the tools it collects in Europe for resale locally or to recycle them and thus recover raw materials that could be used to make new power tools in the company's facilities in China. Our research suggests that the margin-improvement potential, primarily resulting from savings in the cost of materials, could be as high as ten percentage points.

3. The power of cascaded use

Another source of value creation is to take a product or component and diversify its reuse more widely across the value chain, redistributing the materials so they can substitute for inflows of



For the full video interview, see "Navigating the circular economy: A conversation with Dame Ellen MacArthur," on mckinsey.com.

markets. It's not just about tweaking the system—it's about rethinking how the economy can run in the long term.

When we set up the foundation, in 2010, our goal was, first, to demonstrate the economics through analysis. Second, to work with business, we created the Circular Economy 100 platform, bringing together corporations such as Coca-Cola, H&M, and Unilever; emerging innovators and small businesses; and regions. Finally, we are working with universities in Europe, the United States, and India, and next year will be adding universities in China and Brazil. We see ourselves as an enabler in a big system. In the first three years, we have seen the "circular economy" move from a phrase that was barely used to something that is becoming mainstream, and we're glad to have helped this framework become credible. Now we're into a phase where companies need to take this on and unlock more value. And the faster that happens, the faster everyone else will be chasing. This isn't something that needs to take 50 years, though. It can happen a lot more quickly.

This commentary is adapted from an interview with **Tim Dickson,** a member of McKinsey Publishing who is based in the London office.

virgin ones somewhere else. For example, the Australian property and infrastructure company Lend Lease uses scrapped-wood chips from timber mills to create cross-laminated timber panels for construction.

Global apparel retailer H&M launched an in-store collection program encouraging customers to bring in old clothes in exchange for discount vouchers on new H&M clothing. The company partners with I:CO, a reverse-logistics provider, to sort the clothes for a range of subsequent "cascaded" uses.[3] The majority of items collected are dispatched to the global secondhand-apparel market. Clothes that are no longer suitable to wear are used as substitutes for virgin

[3]Cascading is the process of putting materials and components to use, across value streams and industries, after their end of life.

materials in other applications—for example, as cleaning cloths and textile yarns or as inputs for damping and insulation materials in the auto industry or for pipe insulation in the construction industry. When all other options are exhausted, the remaining textiles (1 to 3 percent, according to I:CO estimates) become fuel to produce electricity.

H&M executives view the program as a way to increase in-store traffic and customer loyalty. It is also the first step in the company's longer-term goal of recycling all of its textile fibers for additional purposes and using yarns made from collected textiles in its new products—a move that would bring greater arbitrage opportunities.

4. The power of pure inputs

The final way companies can benefit from the principles of a circular economy is by designing products and components so they are easier to separate into consumable and durable elements later on, thus helping to ensure the purity and nontoxicity of materials along the manufacturing process. Greater ease of separation also increases the efficiency of collection and redistribution while maintaining the quality of the materials—a crucial economic consideration and often a substantial challenge. In the United States, for example, less than one-third of the rubble generated during the construction and demolition of buildings is recycled or reused, though it contains high concentrations of recyclable steel, wood, and concrete.[4] Even in paper recycling (where the inputs are generally considered "pure" and recycling rates approach 80 percent in Europe), the difficulty of removing inks, fillers, and coatings from paper without degrading it results in a loss of materials worth $32 billion a year.

In some cases, companies work with their supply partners to create ecosystems that support circular product designs. For example, Desso, a Dutch manufacturer of carpets, operates a take-back program that collects end-of-use carpet tiles to recover their materials for further production or for sale to secondary materials suppliers. The carpet-backing material can be fully recycled in the company's own production processes; Desso's supplier, Aquafil, converts the Nylon 6–based top yarn back into new yarn. Because the nylon inputs are pure, they can be reused over and over again without degradation. In general, designing a product to use the purest

[4] *Buildings and Their Impact on the Environment: A Statistical Summary*, revised April 22, 2009, US Environmental Protection Agency, epa.gov.

materials possible helps maintain their residual value and supports recycling and reuse.

Squaring the circle

Given the potential of the circular economy to replace untapped value through resource arbitrage, why isn't it taking off faster? Three barriers have slowed the realization of that potential; each holds clues about moves companies can make to convert themselves from linear to circular economics.

Geographic dispersion

The most tangible barrier for corporate decision makers is all around them, in the extensive supply and manufacturing footprints that companies have created to thrive in the linear economy. This problem is evident even in seemingly simple products. For example, B&Q estimates that its cordless drills contain up to 80 components derived from 14 raw materials sourced in as many as seven countries. A product such as a car is significantly more complex. Understandably, closing product and component loops for most products is difficult, despite attractive arbitrage opportunities.

Moreover, good standards for reusable materials require global support, which is not always present. Whether companies attempt to create closed global loops (like Ricoh) or geographically open cascades (as H&M and I:CO are attempting to do in the apparel industry), there is always a risk that an efficient and effective collection, reuse, and recycling process will break down. That is particularly true in developing countries, where the collection and recycling of valuable end-of-use materials frequently falls to the informal sector. In China, for example, the formal sector covers only about 20 percent of the "e-waste" collected.[5] Without adequate standards, reprocessing is inefficient and, worse, creates health and safety hazards for the workers involved.

To get a handle on the challenge of geographic dispersion, senior executives must start thinking as hard about reverse-network activities (moving from products to components to materials) as they do about the traditional inbound ones. They will have to deal with a

[5] Euromonitor; expert interviews.

host of thorny trade-offs. Should refurbishment take place in the region of manufacture or of usage? When is it more economical to reduce components to their constituent materials and sell them on global markets? How cost effective would it be to establish postusage loops with business partners as opposed to making new components with virgin materials?

Developing a clear picture of the economics will be crucial, as will the ability to create "win–win" partnerships. For example, in exchange for lower prices and guaranteed access to supplies, Philips Healthcare returns used components to its suppliers and lets them decide whether to reuse the components for new builds and service parts or to sell them to raw-materials suppliers as high-quality, recyclable (or even ready-to-use) feedstock. (See "Toward a circular economy: Philips CEO Frans van Houten," available on mckinsey.com, on February 7.)

Reverse-logistics skills (such as collection, sorting, remanufacturing, and refurbishment) will be critical. One of the success factors in Ricoh's GreenLine operations is the company's "take-back" system, which optimizes supply and demand for remanufactured machines. This system requires sophisticated reverse-network-management capabilities, such as tracking the location and condition of used devices and components, as well as storing bill-of-materials information.

Complex materials

The second point of leakage involves the sheer complexity and proliferation of modern product formulations, which are rarely labeled or made public and are therefore devilishly difficult to identify after the fact, even for manufacturers. In the world of plastics, for example, companies have broadened the spectrum of materials used, in creative and complex ways. Most innovations in polymer-materials science have come courtesy of new additives that act, for example, as heat stabilizers, flame retardants, pigments, or antimicrobial agents.

In addition, the proliferation of materials can come from sheer habit or even management inattention. Companies, for example, often add materials to cut costs or innovate and then later fail to revisit these decisions; in their purchasing practices, say, they might introduce 16 plastics, where 4 would cover all functional specifications and application needs. These problems have exponentially increased the complexity of materials, while making it hard to classify and collect them on the scale required to create arbitrage opportunities or to demonstrate the returns needed to attract investors.

Moreover, companies often have no cost-efficient way of using chemical or physical processes to extract embedded raw materials without degrading the product, so most of the original value is lost in current, smelter-based recycling processes. For example, only $3 worth of gold, silver, and palladium can currently be extracted from a mobile phone that, when new, contains $16 worth of raw materials.

Despite the difficulties, some companies are making progress. Veolia's Magpie materials-sorting system, for example, uses infrared and laser technologies to sort some plastics quickly. The company's facility in Rainham, in the United Kingdom, can separate nine grades of plastics while processing 50,000 metric tons of them a year. Nonetheless, current technologies still depend on accurate (and often manual) presorting, which must meet minimum purity requirements to ensure an economically viable yield.

As Veolia's example suggests, tackling the problem of complex materials will ultimately come down to extracting them at scale, so that they have a marketable value. This will in turn require companies to cooperate in the precompetitive sphere. Arbitrage opportunities already exist across the value chain—from raw-materials suppliers to product manufacturers, players in end-of-use management, and suppliers of the enabling information technologies. Successful first movers could capture significant economic benefits, including an outsized influence on global standards or on the design of products and supply chains.

The curse of the status quo

The final barrier against a circular economy is the sheer difficulty of breaking ingrained habits. Many aspects of the current system reflect decisions made long ago. While some are relatively innocuous (for instance, QWERTY keyboards and the shape of power plugs), others incur higher costs.

Misaligned incentives dot the industrial landscape, making it hard to create, capture, and redistribute value. Customers, for instance, are used to evaluating the expense of products only at the point of sale, even if costlier but longer-lasting products would be more economical in the long term. Leasing models are unheard of in many industries, though they would benefit both customers and companies. Research from the Ellen MacArthur Foundation suggests, for example, that leasing high-end home washing machines would lower the cost of use for customers by one-third over five years. During that time, manufacturers would earn roughly one-third more in profits because they could lease their fleets of machines multiple times before refurbishment.[6]

Ingrained habits within companies also thwart change. Senior executives rightly worry about the higher levels of capital needed to change products, as well as the friction of moving from familiar sales- to usage-based approaches. One of the biggest concerns for Ricoh's executives before launching GreenLine, for example, was that it might cannibalize new products. Only after creating a control plan to monitor sales of GreenLine and other offerings was the company confident that it could guarantee strong coverage across different customer segments while not cannibalizing its products.

Misaligned incentives also exist between companies. Dividing the gains from optimized designs of more circular products or processes is tricky given the different motivations involved. For example, in the European beer industry, the closed-loop model for returnable bottles is well established. Yet in some markets, the share of bottles completing the circle back to the manufacturer dropped to one-third, from one-half, between 2007 and 2012. The reason: store owners preferred to dispose of the empty bottles themselves because that maximized the sales space available to promote new products. Addressing such challenges requires companies to develop profit-sharing models across their value chains. They should also learn how to spot "moments of truth" when it might be easier to break with the status quo—for example, when companies enter new markets, renegotiate agreements with suppliers and service providers, or face choices about big capital investments.

Toward a circular economy

Ultimately, the systemic nature of the barriers means that individual corporate actions, while necessary, won't suffice to create a circular economy at scale. The real payoff will come only when

[6]For more, see *Towards the circular economy: Economic and business rationale for an accelerated transition*, Ellen MacArthur Foundation, January 2012, ellenmacarthurfoundation.org.

multiple players across the business and research communities, supported by policy makers and investors, come together to reconceive key manufacturing processes and flows of materials and products. Should that happen, our research finds, the benefits would be huge. They include:

- Net materials savings. On a global scale, the net savings from materials could reach $1 trillion a year. In the European Union alone, the annual savings for durable products with moderate lifespans could reach $630 billion. The benefits would be highest in the automotive sector ($200 billion a year), followed by machinery and equipment.

- Mitigated supply risks. If applied to steel consumption in the automotive, machining, and transport sectors, a circular transformation could achieve global net materials savings equivalent to between 110 million and 170 million metric tons of iron ore a year in 2025. Such a shift could reduce demand-driven volatility in these industries.

- Innovation potential. Redesigning materials, systems, and products for circular use is a fundamental requirement of a circular economy and therefore represents a giant opportunity for companies, even in product categories that aren't normally considered innovative, such as the carpet industry.

- Job creation. By some estimates, the remanufacturing and recycling industries already account for about one million jobs in Europe and the United States.[7] The effects of a more circular industrial model on the structure and vitality of labor markets still need to be explored. Yet we see signs that a circular economy would—under the right circumstances—increase local employment, especially in entry-level and semiskilled jobs, thus addressing a serious issue facing many developed countries. Ricoh's remanufacturing plant, for instance, employs more than 300 people.

Focusing a collective effort on the leverage points that would have a systemic impact is the key to unlocking this potential. Our research suggests that the place to start is materials flows, as they represent the most universal industrial assets. The ultimate objective is to

[7] According to the Automotive Parts Remanufacturers Association (United States) and SITA (the waste-management arm of Suez Environnement).

close materials loops on a global level and to achieve tipping points that would bring major streams of materials back into the system, at high volume and quality levels, through established markets. Creating pure-materials stocks for companies would help jump-start that process while giving companies strong incentives to innovate.

The ubiquitous PET[8] provides a useful analogy for how this could happen. The polymer's strong adoption as the basic input for bottles in the beverage industry created a recycled-PET market that extended beyond bottles. This in turn created a stable platform for beverage companies to use PET for their own innovative purposes. Innovation therefore shifted from materials (new additives harder to isolate and later remove) and toward products and processes (for example, novel shapes for sports-drink bottles, new process innovations that allow hot drinks to be injected into bottles, and thinner-walled water bottles requiring lower amounts of materials to create).

Establishing de-facto standards for other materials would act as a catalyst for further action. Our research identified four types of materials, each at a different stage of maturity in its evolution toward the circular economy. These four thus represent realistic starting points where pilot projects would make the greatest difference right away (Exhibit 3).

Mobilizing multiple stakeholders is always challenging, of course, and could take several forms, including industry partnerships and consortia. Nonprofits and nongovernmental organizations will also play a vital convening role.[9] Regardless of the route companies choose, by joining forces they can begin using existing science to develop the projects and enabling mechanisms that could trigger a self-reinforcing virtuous cycle. That would in turn ultimately benefit stakeholders on every level—customers, businesses, and society as a whole.

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The "take, make, and dispose" model of production has long relied on cheap resources to maintain growth and stability. That world no

[8]Polyethylene terephthalate.

[9]For example, the Ellen MacArthur Foundation's Circular Economy 100 program aims to bring companies and innovators together across regions to help develop and accelerate various commercial opportunities. Similarly, the World Economic Forum has created a number of initiatives focused on circular-economy issues.

Exhibit 3

A large-scale transformation would focus on four types of materials at different stages of maturity.

	Current level of maturity of reverse cycle[2]	Triggers for future development
Golden oldies are well-established recyclates—eg, glass, metals, paper, PET[1]	• High volume and collection rate • Moderately good quality of recovered materials • Emerging technologies for sorting and recovering high-quality materials; able to scale up quickly	• Enhanced purity of recovered materials
High potentials—eg, PP, PE,[1] and other polymers—currently don't have systematic reuse solutions	• High-volume, moderate collection rate; low quality of recovered materials • Emerging technologies for sorting and recovering high-quality materials; able to scale up quickly	• Enhanced purity of recovered materials • Improved collection rates
Rough diamonds are by-products of manufacturing processes—eg, carbon dioxide, concrete, food waste	• Emerging technologies for sorting and recovering high-quality materials; able to scale up quickly	• Scaled-up technologies and applications • Reverse system in place[3]
Future blockbusters—eg, bio-based materials and 3-D printing—are innovative materials that support fully restorative usage cycles	• Available technologies that could be scaled up	• Standardized emerging materials • Scaled-up technologies and applications • Reverse system in place[3]

[1]PET = polyethylene terephthalate; PP = polypropylene; PE = polyethylene.
[2]Reverse cycle = postconsumption flow of raw materials through cycles of reuse to disposal or restoration.
[3]Logistics, infrastructure, and technologies are set up for sorting and treatment.

Source: Ellen MacArthur Foundation; World Economic Forum; McKinsey analysis

longer exists. By applying the principles of a circular economy—a system that is regenerative by design—forward-looking companies can seize growth opportunities while laying the groundwork for a new industrial era that benefits companies and economies alike. Capitalizing on the opportunities will require new ways of working, but the benefits are well worth the cost.

The authors wish to thank Tomas Nauclér, Jeremy Oppenheim, Ken Somers, Fraser Thompson, and Helga Vanthournout for their contributions to this article.

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