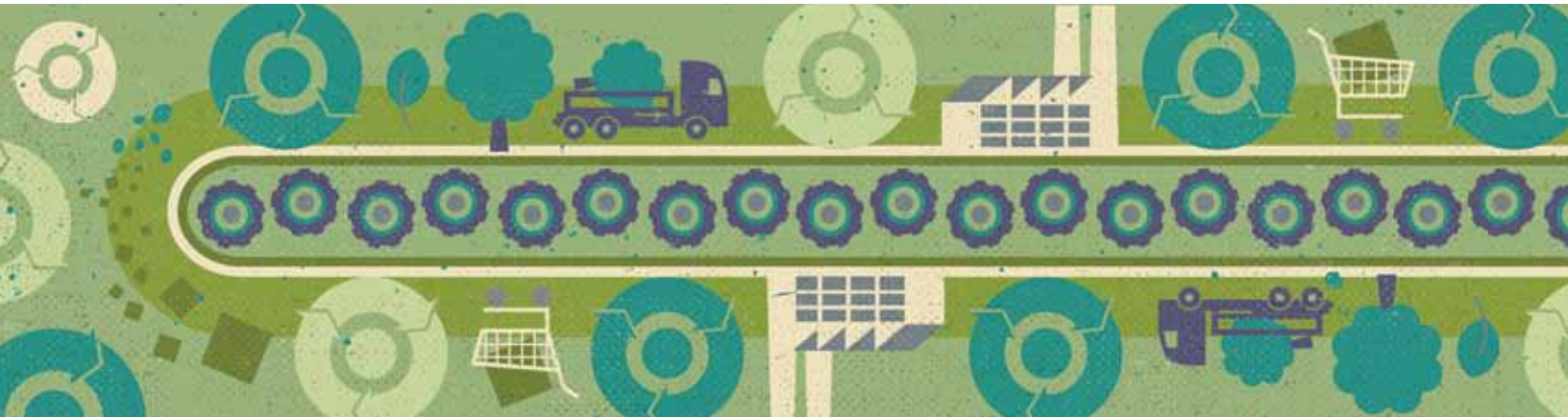




Manufacturing resource productivity

Manufacturers can generate new value, minimize costs, and increase operational stability by focusing on four broad areas: production, product design, value recovery, and supply-circle management.

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Rapid growth in emerging markets is causing a dramatic increase in demand for resources, and supplies of many raw materials have become more difficult to secure. Commodity prices are likely to continue to rise and will remain volatile. Manufacturers are already feeling the effects in their operations and bottom lines, and these challenges will persist, if not intensify.

Consequently, manufacturers' variable costs have increased. Between 2000 and 2010, for instance, the variable costs of one Western steel company rose from 50 to 70 percent of its total production expenses, mainly due to jumps in commodity prices. For one Chinese steel

company, 90 percent of production costs are now variable (Exhibit 1). And for a manufacturer of LCD televisions, energy represents 45 percent of the total cost of production.

But companies that take steps to increase resource productivity could unlock significant value, minimizing costs while establishing greater operational stability. Our experience suggests that manufacturers could reduce the amount of energy they use in production by 20 to 30 percent. They could also design their products to reduce material use by 30 percent while increasing their potential for recycling and reuse.



Indeed, companies could cut their product costs in half by reusing materials and components. Some companies have even begun to pioneer new business models that enable them to retain ownership of the materials used in the products they sell. This can involve establishing mechanisms that prompt customers to return a product to its manufacturer at the end of its consumer utility, enabling the manufacturer to extract additional value from it.

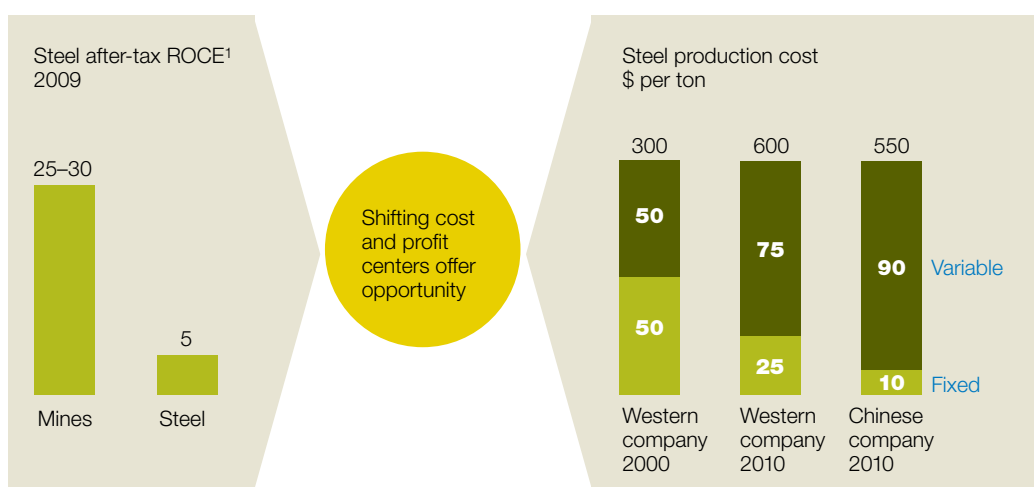
A number of manufacturers have launched resource-productivity initiatives that are already paying dividends. But most efforts focus on operational slivers within the four walls of their business, and classic improvement approaches—such as lean manufacturing and material-and-information-flow analysis—typically fail to fully address energy or resource costs and constraints. Because they lack a systematic approach that

focuses attention on resources throughout the value chain, manufacturers have tended to think narrowly about what is actually a broad landscape of opportunity.

This article offers a practical set of tools to help manufacturers and waste-management companies capture the resource-productivity prize. Manufacturers are likely to achieve the quickest impact if they start by focusing on their areas of core competency. But to secure the full value of their efforts, companies must optimize their operations for resource productivity in four broad areas that cut across their business and industry: production, product design, value recovery, and supply-circle management (Exhibit 2).¹ By taking a comprehensive approach to resource productivity, companies can improve their economics while strengthening their value

Exhibit 1

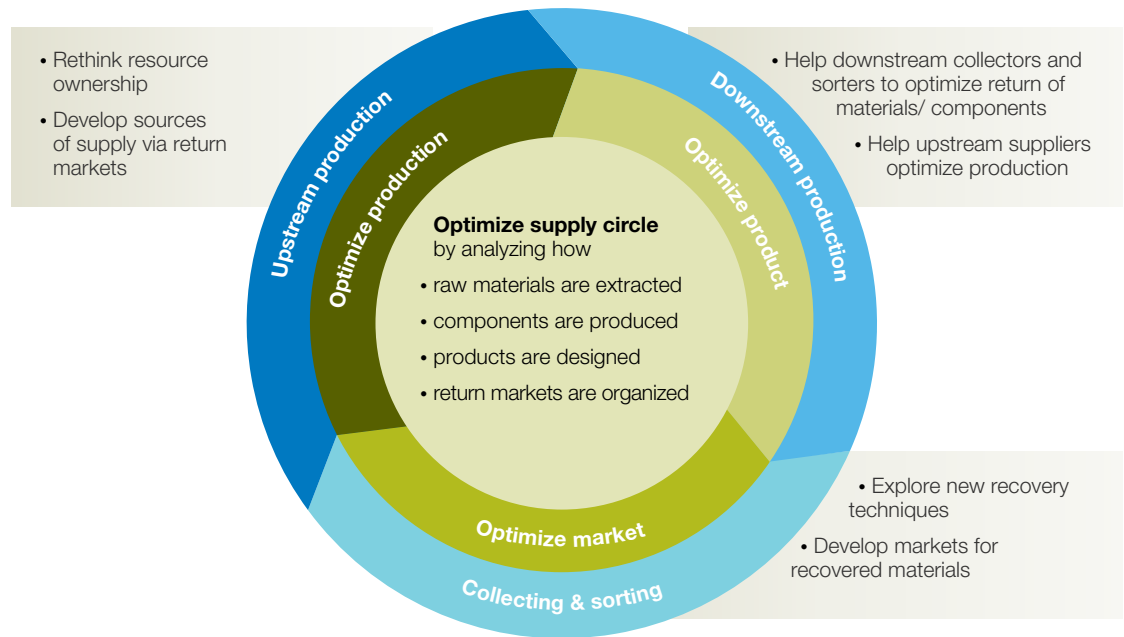
Manufacturers' variable costs have considerably increased.



¹Return on capital employed.

Exhibit 2

To realize the full resource productivity opportunity, companies need to work across the full ‘supply circle.’

**How to do it?**

Exercise influence in the supply circle where there is no direct control—both upstream and downstream.

Consider new business models—for example, lease rather than sell to retain ownership of materials embedded in products.

propositions to customers and benefiting society as a whole.

Prioritize areas of high impact

Companies should first focus on activities within their operations, where they can exercise the most control; they can turn their attention later to activities that require the cooperation of other organizations, customers, or other stakeholders. Specifically, companies should prioritize the activities that offer the greatest potential for impact given their position on the production circle.

Upstream manufacturers. Companies that are focused primarily on transforming materials

into inputs used by other companies should start by optimizing production for resource productivity. Such companies have the most to gain by reducing the amount of material or energy they use in production. Indeed, the operations of mining companies are often as much as 10 times more energy intensive than the operations of companies that use their products. As a second step, manufacturers should prioritize waste recovery, which can enable them to secure access to materials through activities such as recycling and reuse.

Downstream manufacturers. Companies focused primarily on making components or final

products should start by optimizing their products in order to use materials more efficiently. These companies will gain most by designing products to reduce material requirements, minimize energy consumed while using them, and ensure they are optimized to be recycled or reused at the end of their life cycle. Downstream companies can also benefit from reducing the energy required to manufacture their products, but this may be a second priority, since the operations of downstream players are not as energy intensive as those of upstream players.

Waste-management companies. Companies that handle waste materials—including those that collect, process, and manage waste—should start by optimizing processes and developing new markets for material reuse. They should develop the sorting and collection technologies and capabilities necessary to mine the highest-value materials from the general waste stream at the lowest possible cost. They should also develop business models to help other companies with their material-sourcing and reuse strategies.

Optimize for resource productivity

Depending on where they are located on the production circle, companies should prioritize four broad areas for resource productivity: production, product design, value recovery, and supply-circle management.

Production

Most manufacturers have already made tremendous gains by implementing programs to improve labor and capital productivity (for example, through lean manufacturing). Such efforts can improve resource productivity if they are adapted to include criteria for reducing the consumption of energy and raw materials.

Here we focus on energy—a particular concern for upstream manufacturers, since energy costs can account for as much as 20 percent of their overall production costs. Manufacturers can take four steps to increase energy productivity.

First, companies can adapt the methodology for lean-value-add identification to map energy consumption at every step of their operating processes. This will enable them to calculate the thermodynamically minimum energy required and evaluate actual consumption relative to this theoretical limit (an approach known as “pinch analysis”). The analysis reveals where energy is wasted and how losses can be avoided.

One US surfactant maker that conducted a heat-value-add analysis found that only 10 percent of its steam-heat inputs were thermodynamically required to make its products; 90 percent were wasted. The manufacturer implemented about 20 measures and captured steam savings worth 30 percent of its baseline energy costs, enabling it to recoup what it invested to launch the effort within three years. One measure, which involved implementing a new software algorithm to control the company’s heating and cooling control loop, enabled it to reduce its need for steam by 5 percent. Another company, a car manufacturer, reduced the amount of energy it used in assembly by 15 percent by optimizing ventilation processes.

Second, moving beyond pinch analysis, companies can extend their lean programs to improve energy efficiency by optimizing energy integration in heating and cooling operations. For instance, one chemical company changed its process to release heat more quickly during polymerization, allowing evaporation to start sooner, thus

reducing the energy it used in the subsequent drying stage by 10 percent.

Third, companies can use lean approaches to identify process-design and equipment changes that can deliver greater energy efficiency. One Chinese steel mill saved 8 million renminbi (about \$1.2 million) annually by lowering the leveling bar in a coke furnace an extra few centimeters, which reduced the mill's total energy cost by 0.4 percent. The mill achieved an additional 5 million renminbi (\$0.73 million) in annual savings by adding an insulation layer to ladles used in steelmaking.

Fourth, lean-energy approaches can eliminate waste and capture savings by optimizing the interface between producers—for example, steam-boiler operators, cooling-water-unit operators, and power suppliers—and consumers. One chemical plant managed to avoid a \$2 million investment to increase its boiler capacity by improving consumption planning—specifically, ensuring that demand would not pass the threshold that triggered pressure drops during demand spikes.

Product design

By incorporating energy and materials parameters into their product-design approaches, companies could reduce the use of materials that are hazardous, nonrenewable, difficult to source, or expensive. Changes to product design could increase opportunities for recycling and reusing components and materials at the end of a product's life cycle. And designers could prioritize the incorporation of sustainable features into their products to reduce the impact products have on the environment. These principles constitute a philosophy known as

“circular design,” which extends beyond products to systems and business models.

Companies that take these steps could reduce costs and facilitate compliance with regulations while bolstering their reputation and building relationships with consumers and other stakeholders. Additionally, they can often expand existing “design to cost” methodologies to quantify the financial or brand impact of incorporating sustainable features in their products.

Several approaches touch on product design: for example, companies can conduct product teardowns, disassembling and analyzing competitors' products to identify opportunities to increase resource productivity; they can use linear performance pricing, which enables comparisons among product attributes that provide different levels of performance for users; or they can pursue “design for manufacturing,” which involves optimizing product design to minimize the resources needed during manufacturing and assembly.

One manufacturer, for example, redesigned its shampoo bottles so that they were thinner—but still met strength specifications—and reduced material consumption by 30 percent. The bottle's new shape enabled higher packing density during shipping, and with a flat “hat,” it could be stored upside down, allowing customers to more easily extract all of its contents before disposal. The cap was redesigned to use the same material as the rest of the bottle, thus eliminating the need to separate materials before they could be recycled. The manufacturer also optimized the bottle's production process to reduce cycle time by 10 percent.

In another example, a vehicle manufacturer redesigned its forklifts to reduce fuel consumption and total cost of ownership for customers. Analysis showed that it could either redesign the power train or reduce the weight of the forklift to achieve its goal, but the power-train option was costly and complex. To reduce the weight of the forklift, the company increased the leverage of the cast-iron counterweight used to provide stability during lifting. This removed 200 kilograms (almost 450 pounds) of cast iron with no sacrifice in stability, which in turn allowed the manufacturer to reduce fuel requirements by 4 percent and cut material costs by \$200 per vehicle.

And a home-appliance manufacturer analyzed its competitors' coffee makers and discovered an opportunity to improve heating efficiency by adjusting the insulation of hot pipes and optimizing the flow of water. It also changed the mounting of the heating system, using springs rather than screws, to make it easier to separate materials during recycling. Combined, these adaptations resulted in a product with an improved footprint at a lower production cost; such “win win” opportunities are not uncommon when focusing on resource productivity.

Value recovery

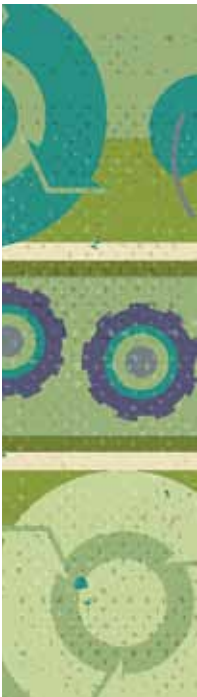
Companies may find they can satisfy their resource needs by recycling and reusing materials historically discarded as waste. Those involved in waste management have an opportunity to pave the way by developing services that allow manufacturers to capture value from materials left over after production or after a product has reached the end of its life cycle.

Great technological advances have been achieved in recycling, organics processing, and waste-to-energy conversion, and these have revealed opportunities in material and component recovery. Modern facilities recover much more material than was possible using manual systems, and they produce recyclates of a quality well above that required by most recycling protocols. These facilities can sort large volumes of varied waste, separating the valuable materials from those of less worth. They can also adjust sorting criteria to optimize selection based on scrap values in the spot market.

Waste-collection operators and recyclers should focus on building new business models by working with manufacturers to identify and develop opportunities for value recovery. This could involve helping manufacturers design products and production processes to facilitate material reuse; it could also involve helping develop logistical solutions that allow manufacturers to incorporate recovered material in their production cycle. Companies such as Veolia Environnement and SUEZ ENVIRONNEMENT have already begun to transform themselves from waste operators into raw-materials and energy suppliers, in part by advising other companies on how to design products that can more readily be recycled and reused.

Supply-circle management

Many of the activities that affect resource productivity and sustainability—such as acquiring and transporting raw materials, assembling parts used in the manufacturing process, and using and disposing of final products—take place outside the walls of manufacturers' facilities. Although companies do not have exclusive control over these activities, they can exercise





their influence to increase the productivity of their supply chains.

To that end, companies could transform their supply chains into supply circles. Whereas the phrase “supply chain” may evoke an image in which materials are collected in one place and ultimately disposed of in another, the phrase “supply circles” emphasizes that materials can be looped back into the production process after they have fulfilled their utility over the life of a product.

Companies looking to make this shift should first develop a complete understanding of their supply footprint. This involves considering not only which materials are used and in what volumes, but also how much energy is required to use them and what impact they have on the environment. The analysis enables companies to identify areas for improvement in internal, as well as supplier, operations. Companies can use the analysis to manage suppliers, reduce costs, and mitigate the risks posed by potential regulatory changes, supply scarcity, and volatile commodity prices—and to help initiate conversations with suppliers that could result in strategic relationships that enhance the capabilities of each party.

In most cases, a footprint analysis will reveal “hot spots” for manufacturers to prioritize to achieve environmental and economic impact. For example, one beverage producer realized that more than 35 percent of the carbon dioxide emissions generated to produce a half-gallon container of juice came from producing and applying fertilizer to groves where the fruit was grown. It became clear that working with farmers to reduce fertilizer use was one

of the most important steps to take to minimize the company’s carbon footprint.

Companies will benefit from adopting tools to monitor and manage their supply circles. Supplier scorecards and environmental profit and loss (EP&L) statements can be used to place a monetary value on environmental impact. Puma, for instance, developed an EP&L statement and pledged that by 2015, half its international product lines would be manufactured according to its sustainability standard. One objective is to ensure that its suppliers use more sustainable materials, such as recycled polyester. Desso, a European carpet manufacturer, substantially increased its market share and profits after it received Cradle to Cradle Certification for its entire product line.

In a resource-constrained world, value creation moves toward the owners of the resources. Companies should therefore consider developing new business models that enable them to retain ownership of the materials used in their products so that they can recycle or reuse the product at the end of its life cycle. This could enable companies to reduce supply risks while creating high-margin profit centers. The Ellen MacArthur Foundation championed this approach in a recent report, calling on companies to evolve from selling products to selling the services those products provide.² Chemical-catalyst manufacturers have done this for decades, essentially selling the functionality of catalysts to customers without transferring ownership of the materials themselves.

One lead-acid-battery manufacturer built a competitive cost advantage by controlling not only battery production but also post-use

collection, disassembly, and reprocessing of batteries; control of the lead cycle gives the company access to a low-cost source of raw materials. To take an example from another industry, European manufacturers of household appliances and furniture are shifting their business models from customer ownership to lease agreements.³

Upstream extraction and processing companies could play the same game. Steel mills could retain ownership of the steel they sell and thereby reduce their exposure to prices for iron ore and coal. And waste-management companies may have opportunities to form joint ventures with manufacturers to retain ownership of the materials they sell back into the supply circle.



Over the past decade, supplies of various natural resources have become scarcer, and thus more expensive and subject to price volatility, increasing manufacturers' costs and risks. Nevertheless, the changing resource landscape also creates opportunities. To capture them, companies must embark on a journey to transform their operations and dramatically increase resource productivity. They will have to

dedicate as much effort to optimizing resources in the future as they did to lean and other improvement initiatives in the past, while at the same time rethinking their business models to capture the value residing in resource ownership. If they get it right, the effort will enable them to increase the stability of supply and manage their costs while developing new products—and even lines of business—that generate sustainable bottom-line value. ○

¹ We use the phrase “supply circle” in place of “supply chain” because it more accurately reflects the closed-circle, end-to-end shifts in manufacturing processes and objectives that will be necessary to realize value in a resource-constrained world.

² *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*, Ellen MacArthur Foundation, January 2012 (www.thecirculareconomy.org).

³ In the United States, a rental and rent-to-own industry already exists, though it is largely independent of manufacturers and not part of their supply circles.