Product Stewardship: Can It Drive Green Design?

Strategies for reducing product life-cycle impacts

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Product-oriented policies are increasingly being used by all levels of government to address concerns regarding material use and toxicity (as well as energy use and production impacts) throughout the life cycle of the products we use. Numerous states and provinces have laws that address electronics, paint, mercury-containing devices, beverages, and other products. If future laws and policy tools are to best balance the needs of all stakeholders, it is essential that all interested parties become literate in this area.

About This Article

This article[1] grew out of several exploratory papers developed for the Product Stewardship Stakeholder Process convened by Oregon's Department of Environmental Quality.[2] This discussion explores product stewardship as an environmental management strategy for "greening" product design and production, and thereby reducing product life-cycle impacts.[3]

Product-oriented policies reflect an awareness of—and an attempt to address—the impacts that products have at end of life, as well as throughout the product's life cycle. Ideally, product stewardship policies establish built-in mechanisms and incentives that minimize environmental impacts at time of disposal, as well as during design, production, transport, and other life-cycle stages. This is often achieved by building the costs of such impacts into the consumer-manufacturer transaction, rather than covering such costs through solid waste rates and taxes.

Many mechanisms exist (and more are emerging) that establish level regulatory playing fields, thus allowing industry to compete on improving their environmental footprint, rather than competing simply on cost and performance. These mechanisms rely on different engines, ranging from leveraging purchasing power (Electronic Product Environmental Assessment Tool [EPEAT], Top Runner) to restricting materials (the Restriction of Hazardous Substances Directive [RoHS], food service packaging) to requiring manufacturer take-back (paint, e-waste). These approaches provide lessons and experience upon which states can draw when exploring continued product-oriented policies as a tool for decreasing waste and toxicity. In this article, several lessons and policy recommendations are suggested.

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Background: Information, Transparency, and Product Design

Commerce—the river in which products ebb and flow—is undergoing a transformation characterized fundamentally by an explosion of information. This explosion is jointly fueled by a growing *demand* for information (from customers, suppliers, manufacturers, recyclers, consumers, solid waste officials, regulators, and others) and by an increasingly sophisticated ability to *provide* information (through increased computing power, life-cycle assessment protocols, product tagging, scientific monitoring, greenhouse gas calculators, and other means).

Together, the supply and demand of information allows, and fosters, a call for increasing product transparency. This transparency tries to address such questions as:

- Where was the product made?
- Who made it and under what conditions?
- What materials went into the product and how much recycled content was utilized?
- What is the product's greenhouse gas footprint?
- How else does the product impact the environment or public health across the whole life cycle?
- What impacts does the product have on the user?
- Is the product recyclable, repairable, or reusable?
- And many others.[4]

Design issues have always been at the center of such questions. As a result, design issues sit squarely at the heart of all product policy discussions. Even questions that appear to focus narrowly on end-of-life concerns about product disposal and recyclability quickly move the inquirer "upstream" toward questions of design—and, more broadly, toward questions of product-associated impacts throughout the product's life cycle.

It is hard, for example, to talk about recycling rates for computers without stakeholders soon emerging to discuss whether the computers' varied plastic components are composed of compatible resins, whether the metal and plastic components are easily separable, whether the materials used offer life-cycle environmental benefits compared to alternative materials, whether toxic components have been eliminated or minimized, whether stand-by and operational energy use have been minimized, and so forth. These are all systemic questions of design that impact every link in a product's life-cycle chain, from materials extraction to end-of-life management.

Some Points to Keep in Mind

Product policy is an emerging, expanding, and maturing discussion. There are areas of agree-

Upstream and Downstream: All the World's a Stage

In product policy discussions, it is important to differentiate between upstream and downstream life-cycle stages, as well as between upstream and downstream impacts:

- Upstream stages typically encompass design, manufacturing, and marketing activities.
- Downstream stages include recycling and waste handling.
- Upstream impacts are those associated with resource extraction, manufacturing, and distribution.
- Downstream impacts are those associated with end-of-life transport and with disposal and recycling activities.

These distinctions are particularly useful for clarifying how changes in practices at upstream stages can influence downstream impacts. For example, design changes can reduce toxic burdens in recycling and disposal facilities.

Similarly, changes in practices at downstream stages can influence upstream impacts. For example, establishing an end-of-life recycling infrastructure results in materials being collected and sent to recycling markets. This typically reduces manufacturing-related impacts when the recovered materials are used in the manufacture of new products.

ment, areas of argument, and areas of ambiguity. It is therefore important to remain open to differing perspectives, as well as to the outcomes of ongoing program, policy, and regulatory experiments that are churning out data yet to be analyzed and interpreted.

In order to keep this discussion more focused, the following points are provided as a backdrop to bear in mind. The intent is that, having given these important concepts voice, we need not get distracted by them during the discussion that follows, which offers a more concentrated treatment of product stewardship mechanisms and their implications for state policies and programs:

- A growing number of products and product components are being addressed by product stewardship policies.
- Product stewardship embraces a wide range of tools and mechanisms, including take-back requirements, substance restrictions, individual and joint producer responsibility, recycled-content standards, and more.
- Europe, Asia, and Canada are rapidly developing product stewardship policies and programs with (among other goals) an aim to influence green-product design, energy use, and other life-cycle impacts.
- Product policies (specifically those addressing end-of-life, material use, and toxicity considerations) are in a time of growth and transition. The majority of even the most mature policies are less than 20 years old.
- Attempts to lessen environmental impacts at one stage of a product's life cycle may actually increase the impacts at other life-cycle stages, sometimes with an unintended net loss to the environment.
- No single policy or restriction can drive manufacturers to utilize green design for all future products.
- No single policy tool should be rejected out of hand simply because it does not single-handedly address all aspects of product design and disposal.

The Product Stewardship Concept

Let's start simple. Suppose you are an electronics recycler and you receive a mainframe hulk. Its parts are made from multiple plastic resins, it is hard to disassemble, it has components with toxic materials, and the stand-by mode drains energy at 12 watts per hour. You ask yourself: Who designed this thing, and did they ever think beyond the sales floor?

It doesn't take long for your thoughts to flow upstream to the origin of the product's troubling features. And, most likely, you arrive equally quickly at *prevention* as the best solution to eliminate the processing and toxicity challenges. The question is, how to achieve such prevention? Options include:

Attempts to lessen environmental impacts at one stage of a product's life cycle may actually increase the impacts at other life-cycle stages, sometimes with an unintended net loss to the environment.

- Consumer Demand: Customers stop buying products that are difficult to recycle or that have problematic features, and choose to replace their hardware less often.[5]
- Market Demand: Stores stop carrying products about which consumers express concern.
- Competitive Demand: Competing companies capture market share by offering "greener" products. (Related to this is Innovation Demand: Companies set themselves apart from mass market, commodity-scale competitors by offering innovative niche products, often distinguished by their green characteristics, as well as by patentability.)
- Internal Company Demand: Management chooses to avoid liability exposure by making

process and material changes that place the company outside the regulatory envelope.
- Social Demand: The media or advocacy groups spotlight the product and producer.
- Regulation/Legislation: Enforceable guidelines establish explicit limits on material selection, toxicity, energy demand, and other features.

This array of options relies on both broad drivers (such as demand-side behavior, which often comes *after* a product has been put on market) and narrow drivers (such as prohibitions, bans, and other command-and-control mechanisms that constrain the market and depend upon enforcement).

Product stewardship offers a finesse on these options by creating baseline regulations and by supporting infrastructure development, often within a specific product category. Such regulations and infrastructure serve to organize the free market (sometimes simply by increasing transparency and information flow) in such a way that business behavior inherently recognizes, addresses, and internalizes environmental impacts, and is rewarded for doing so.

The salient issue for product stewardship is this: How can product policy be expressed through a combination of regulatory and free-market structures so that the production chain, starting with designers, inherently pushes toward, and rewards, reductions in life-cycle environmental impacts? The mechanisms highlighted in the next section seek to meet this challenge, using regulatory tools and market drivers to structurally embed product-design incentives that decrease life-cycle environmental impacts.

"[O]nce the product is sold, problems generated by poor design often create no cost to the company that produces it (e.g. the product manufacturer bears no responsibility or costs associated with ease of dismantling or sorting)."

—Five Winds International. (2009, March). Design for Environment (DfE) Best Practices: Lessons for British Columbia's Ministry of Environment, at pp. 9–10.

Mechanisms for Driving Product Life-Cycle Improvement

There are numerous policies and approaches currently in play that attempt to shape and harness market mechanisms to drive product life-cycle improvements. Rather than trying to provide an exhaustive list, the discussion that follows offers a sampling of several different types of product stewardship programs. The intent is to spotlight a variety of concepts, approaches, tools, and mechanisms that can be used to drive design change and lower life-cycle environmental impacts.

Some of the mechanisms discussed here are market-driven, some are regulatory, and some are mandatory. Many of these approaches are being implemented at a national level, but they may also be scalable or adaptable for implementation at the state level.

Restriction of Hazardous Substances

■ *Highlighted Aspect*

RoHS uses a regulatory approach to drive the restriction and phase-out of specific hazardous substances. It applies to selected products made or sold into the European Union (EU).

Under a headline reading, "HP, Sony, Dell Push PVC, BFR Restrictions," *Environmental Leader* reports, "An alliance of global companies including Acer, Dell, Hewlett-Packard and Sony Ericsson, and environmental organizations including the European Environmental Bureau (EEB), urged restrictions on PVC and brominated substances in electric and electronic equipment in the EU."

—*Environmental Leader*. (2010, May 24). Available online at http://www.environmentalleader.com/2010/05/24/hp-sony-dell-push-pvc-bfr-restrictions/.

■ *Description*

RoHS (as codified by Directive 2002/95/EC) originated in the European Union. It restricts the use of specific hazardous materials in electrical and electronic products. All applicable products made or sold in the EU market after July 1, 2006, must comply with RoHS.[6] The substances restricted under RoHS are lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ethers.

■ *Discussion*

This policy tool was developed to work as a companion to the Waste Electrical and Electronic Equipment Directive (WEEE, discussed below), which focuses on end-of-life take-back requirements. The idea is that rather than having one policy that attempts to simultaneously improve end-of-life product recovery and toxicity reduction, the two policies could work in tandem.

In the United States, the California Air Resources Board (CARB) has implemented a RoHS-like approach, prohibiting certain hazardous constituents from being used in certain consumer products (for example, prohibiting methylene chloride, perchloroethylene, and trichloroethane from being used in brake, engine, and carburetor cleaners).

Waste Electrical and Electronic Equipment Directive

■ *Highlighted Aspect*

WEEE mandates collection, recycling, and recovery targets for a broad range of electrical and electronic products. Responsibility for such management falls on the product manufacturers.

■ *Description*

The WEEE Directive (European Community directive 2002/96/EC) on waste electrical and electronic equipment, which works in tandem with the RoHS Directive, became law in the European Union in February 2003. Manufacturers that are responsible for collection and recycling targets must establish an infrastructure so that "[u]sers of electrical and electronic equipment from private households should have the possibility of returning WEEE at least free of charge."

> "[E]vidence from corporate environmental and sustainability reports . . . explicitly mention[s] the influence of both the WEEE (Waste Electrical and Electronic Equipment) and the RoHS (Restriction of Hazardous Substances in EEE) Directives on product design."
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> —van Rossem, C., Tojo, N., & Lindhqvist, T. (2006, September). Extended Producer Responsibility: An Examination of Its Impact on Innovation and Greening Products, at p. vi. Amsterdam and Brussels: Greenpeace International, Friends of the Earth Europe, and the European Environmental Bureau.

■ *Discussion*

WEEE is not intended to influence product design on its own. Rather, it works in tandem with the RoHS Directive. Its drafters understood that, for some products, collection and recycling requirements alone may not be enough to send design-change signals upstream to producers.

That being said, however, there is evidence that when manufacturers are specifically responsible for taking back their own equipment, the incentives may be sufficient to drive upstream design changes. (For more on this topic, see the discussion later regarding individual producer responsibility.)

Top Runner

■ *Highlighted Aspect*

Japan's Top Runner program combines regulatory and market-driven measures. It uses existing, already-on-the-market, high-performing products and product attributes to set required energy-efficiency benchmarks for product groups.

■ *Description*

Japan's Top Runner program[7] is a regulatory framework designed to stimulate continuous improvement in the use-phase energy efficiency of products. Top Runner now sets energy-efficiency targets for 23 types of products (including passenger vehicles, freight vehicles, air conditioners, television sets, computers, magnetic disc devices, DVD recorders, refrigerators, freezers, vending machines, transformers, and routers). These products account for the majority of the power consumed in residential use and office automation.

The target values are set based on the product that has the highest energy efficiency of all products in the same group currently on the market. This represents a substantial change from Japan's earlier energy-efficiency standard, which was based on average performance.

EPEAT has essentially established a "market mandate" for green electronic products, given its wide adoption by the leviathan federal purchasing system.

Under the Top Runner law, all manufacturers and importers are obliged to achieve these challenging targets by a specified target year. If a particular manufacturer or importer cannot comply by the target year, a regulatory authority will issue recommendations to it. If the manufacturer or importer fails to abide by the recommendations, its name will be made public or an administrative order will be issued.

■ *Discussion*

Top Runner's hallmark is its focus on the supply side (not the demand side) of product markets. The obligation for complying with Top Runner regulations rests entirely with manufacturers and importers. If producers wish to remain in the marketplace, they must meet certain design requirements. If they excel in this regard, they are rewarded by the government sector through preferential purchasing.

Electronic Product Environmental Assessment Tool

■ *Highlighted Aspect*

EPEAT is a voluntary, market-driver approach. It uses tiered rankings and third-party certifications to qualify greener products, thereby making them easier for purchasers to identify.

■ *Description*

The program's website states, "EPEAT is a system that helps purchasers evaluate, compare and select electronic products based on their environmental attributes. The system currently covers desktop and laptop computers, thin clients, workstations and computer monitors."[8] The site goes on to note:

> Desktops, laptops and monitors that meet 23 required environmental performance criteria may be registered in EPEAT by their manufacturers in 40 countries worldwide. Registered products are rated Gold, Silver or Bronze depending on the percentage of 28 optional criteria they meet above the baseline criteria. EPEAT operates an ongoing verification program to assure the credibility of the registry.[9]

■ *Discussion*

EPEAT has essentially established a "market mandate" for green electronic products, given its wide adoption by the leviathan federal purchasing system. This is a clear example of how procurement regulations (in this case, a directive to purchase EPEAT-certified products) can be a market driver. Manufacturers have quickly moved to significantly redesign products to meet EPEAT standards.

Oregon E-Cycles Program

■ *Highlighted Aspect*

Oregon is implementing a statewide program that requires manufacturers to finance and arrange for end-of-life management of computers, televisions, and monitors.

■ *Description*

The program's website states, "Oregon E-Cycles is a free, easy and environmentally responsible recycling program for computers, monitors and TVs. The program is financed by electronics manufacturers and jointly implemented with the Oregon Department of Environmental Quality (DEQ)."[10]

The site notes, "Anyone can bring seven or fewer computers (desktops and laptops), monitors and TVs at a time to participating Oregon E-Cycles collection sites for free recycling."[11] This program is coupled with a disposal ban that went into effect at the beginning of 2010.

■ *Discussion*

Oregon was among the first states to require manufacturer take-back of a specific product (or suite of products). This program also demonstrates how the establishment of a third-party organization (in this case, a consortium of manufacturers) can be used to fulfill financing and collection responsibilities.

Oregon Paint Program

■ *Highlighted Aspect*

Companies that manufacture paint sold in Oregon (or a stewardship organization representing such manufacturers) must establish and operate a "convenient, statewide system" for collecting leftover post-consumer architectural paint.[12]

■ *Description*

Under the Oregon Paint Program, manufacturers or their stewardship organization must:

- Identify the brands of paint sold by particular manufacturers.
- Implement a pilot program by July 1, 2010, as described in an approved plan.
- Pay an "architectural paint stewardship assessment" for each container of paint sold in Oregon. The funds collected must be enough to recover the cost of running the paint stewardship pilot program.
- Develop and implement strategies to reduce the amount of post-consumer paint that becomes waste. This includes contracting for the collection, transport, recycling, energy recovery, or sound disposal of leftover paint.
- Promote reuse of leftover paint.
- Take responsibility for developing and implementing "strategies to reduce the generation of post-consumer architectural paint."[13]

Why Allocate Responsibility to Producers?

"A principal reason for allocating responsibility to producers is their capacity to make changes *at source* to reduce the environmental impacts of their product throughout its life cycle. It is essentially the producers that decide the features of the products they manufacture at the design phase of products. Rational manufacturers, when made responsible for end-of-life management of their products financially and/or physically, would presumably try to find a way to minimise the costs associated with end-of-life management by changing the design of their products. The establishment of such feedback loops from the downstream (end-of-life management) to the upstream (design of products) is the core of the [extended producer responsibility (EPR)] principle that distinguishes EPR from a mere take-back system. Assigning responsibility primarily to one actor would also avoid the situation where everyone's responsibility becomes no one's responsibility."

—van Rossem, C., Tojo, N., & Lindhqvist, T. (2006, September). Extended Producer Responsibility: An Examination of Its Impact on Innovation and Greening Products, at p. v. Amsterdam and Brussels: Greenpeace International, Friends of the Earth Europe, and the European Environmental Bureau.

■ ***Discussion***

As with many product stewardship programs, a major driver for the Oregon Paint Program was the desire to move the costs associated with end-of-life product management from ratepayers and taxpayers, and instead internalize it into transaction costs between producers and consumers. Ideally, the program will ultimately result in incentives to drive behavior change toward more efficient purchasing and use of paint, thus resulting in less leftover paint.

Seattle Food Packaging Requirements

■ ***Highlighted Aspect***

Seattle Public Utilities is moving incrementally to expand the compostable fraction of its waste stream by requiring movement away from noncompostable components, such as certain food service containers. This operational requirement is leading to design change through product substitution.

Local requirements can drive manufacturers to make design changes in order to remain competitive in the marketplace.

■ ***Description***

A Seattle Public Utilities website describing the city's new food packaging requirements states:

> The City of Seattle is requiring all food service businesses to find packaging alternatives to throw-away food service containers, cups and other products in all food service businesses—restaurants, grocery stores, delis, coffee shops and institutional cafeterias.
>
> By July 1, 2010, all food service products designed for one-time-use must be replaced with one-time use products that are either compostable or recyclable.[14]

Regarding the specifics of the program, the site notes, "Phase one of the ordinance applied only to expanded polystyrene (EPS, sometimes called 'Styrofoam'). The foam ban took effect January 1, 2009 . . . . Phase two of the ordinance applies to ALL throw-away food packaging and service ware. The ban on disposables takes effect July 1, 2010."[15]

■ ***Discussion***

Changes in design and material choice for fast-food packaging can have local impacts on solid waste management systems, as well as implications for the production life-cycle phase (see sidebar box entitled "Upstream and Downstream: All the World's a Stage"). Thus, local requirements can drive manufacturers to make design changes in order to remain competitive in the marketplace.

A document highlighting frequently asked questions about Seattle's ban on disposable food containers notes, "According to a study recently conducted . . . for Seattle Public Utilities, all disposable paper and plastic bags have significant negative energy, climate change, wastewater, litter and water quality impacts on Seattle's environment."[16]

Denmark's Packaging Law

■ ***Highlighted Aspect***

The Danish packaging law utilizes life-cycle data on common packaging components to develop a fee structure for packaging. The goal is to steer upstream packaging choices in order to decrease overall life-cycle impacts, rather than to influence decisions that simply ease end-of-life processing and management.

■ *Description*

A report on international packaging regulations published by the Oregon DEQ notes with regard to the Danish Law:

> In many countries, fees on plastics and composites can cost several times more per kilogram than other materials such as glass, paper, and metals. This is a reflection of the high cost of sorting plastics and composites, and the low market prices for the recovered materials. However, a few countries have assessed fees on a broader set of environmental criteria. For example, Denmark has set fees based on life-cycle analysis studies of common packaging materials.[17]

Thus, in Denmark an aluminum package is assessed a high fee given its overall life-cycle environmental impact. By contrast, a similar package in Ontario would receive a credit. In Japan, it would incur no associated fee.[18]

■ *Discussion*

Though it is challenging for disparate parties to reach consensus on the life-cycle impacts of specific products, it is clear that a narrow focus on end-of-life impacts from specific products and packages may miss comparatively large impacts encountered during other life-cycle phases.

"Empty Space" Restrictions

■ *Highlighted Aspect*

Excess material use can be decreased by imposing limits on the amount and style of packaging permitted for given products, with the aim of minimizing empty space in packages.

■ *Description*

The Oregon DEQ report on international packaging regulations cited previously notes that a variety of regulations "attempt to prevent excessive packaging through specific requirements." It continues:

> Several countries have implemented regulations regarding empty space and the permissible number of layers in a packaging system. South Korea has strict limits on empty space, allowing no more than 10–35% of a single product to be headspace or concealed empty space, or 25–40% of a "set" product (e.g. a gift box containing several packaged products). Australia has limits on the maximum allowable empty space that depend on the category of product and ranges from 25–40%. There is a limit of 40% empty space in Japan for cosmetic products and proposed legislation in other countries such as Taiwan.[19]

It is clear that a narrow focus on end-of-life impacts from specific products and packages may miss comparatively large impacts encountered during other life-cycle phases.

■ *Discussion*

While "empty space" regulations typically are implemented at the national level, states are increasingly demonstrating a willingness to place constraints on packaging. For example, a number of states have imposed restrictions on toxics in packaging.[20]

Emerging Issues and Considerations

Reflecting upon the programs and approaches highlighted earlier,[21] a number of broad themes, issues, and important details begin to emerge, with implications for favorably impacting product design from an environmental perspective. A number of these issues are explored below.

Separating Toxicity Reduction From Materials Management

Rather than tackling toxicity reduction and materials management under one policy, regulators have in some instances chosen to separate these issues. For example, in the European Union, RoHS focuses upon toxicity reduction and materials substitution, while the WEEE Directive focuses more squarely on end-of-life collection and processing.

These two approaches have different impacts when it comes to sending design signals upstream to new-product manufacturers. They can also be explicitly designed to work in concert and support each other.[22]

Individual Versus Collective Responsibility

Product take-back programs can be designed and implemented in numerous ways. One major distinction concerns whether product manufacturers are required to take back their own branded products individually, or whether they are permitted to work together collectively to establish a take-back infrastructure. There is evidence that when individual producer responsibility (IPR) is required, a more direct feedback loop to the manufacturer is established. This can incentivize product design changes that in turn lower processing costs and other associated environmental impacts.

Design for Recycling

"[M]ore companies have been choosing product recovery instead of disposal as their primary retirement strategy. . . . Accordingly, engineering methods for maximizing recovery profit have come into increasing demand from industry."

—Cell Phone Designers Should Think Trash. (2010, March 16). University of Illinois Engineering News. Futurity. Available online at http://www.futurity.org/earth-environment/cell-phone-designers-should-think-trash/.

Timing Is Important

For some products, even IPR will not necessarily help establish an actionable feedback loop capable of influencing new-product design. For example, manufacturers that are required to recover long-lived products, such as televisions, will likely have moved on to different designs and technologies for which the recycling and toxicity lessons from currently recovered products will not be relevant. At best, these manufacturers can be required to take responsibility for safely recycling and managing their products, but expecting design changes based on such recovery may not be appropriate.

For products with quicker design cycles and shorter life cycles, expectations of design relevance may be more appropriate, at least for achieving efficiencies in end-of-life management (see sidebar box entitled "Why Allocate Responsibility to Producers?").[23]

Long Supply Chains

Globalized production complicates the path that design signals must travel when providing upstream information to designers and producers. Some stakeholders argue that this challenge creates a situation in which little can be done to link end-of-life impacts to design and production activities. The countering viewpoint is that the challenge of global production makes it all the more important that the spotlight be focused on the producer/manufacturer/brand owner as the principal actor in take-back activities and design changes—given that they, more than any other actor in a product's life cycle, have the ability to direct change.

Purchasing as a Driver

Purchasing guidelines and regulations can drive design changes. Both EPEAT and Top Runner demonstrate that the market is the message. For example, once the US federal govern-

ment began showing a purchasing preference for upper-tier EPEAT products, computer makers quickly responded by developing products that achieved notable environmental improvements in the production, use, and disposal phases. Such drivers could also be achieved at the state level.

A Broader Definition of Design

Design is often conceived too narrowly, and is viewed as encompassing only material choice and product recyclability. While these factors are important, limiting our perspective in this way can lead to a constrained focus on end-of-life environmental issues, such as recyclability and disposal toxicity.

This is unfortunate since a product's predominant life-cycle impacts often occur during upstream life-cycle phases, such as extraction and production (and even use). For this reason, it is important to examine the production processes utilized in manufacturing a given category of products. A product might be easily recyclable at end of life but still require considerable toxic inputs during its creation, or have toxicity or energy impacts during the use phase.

Ownership and Tangible Goods

Traditionally, commerce has been characterized by the purchase or exchange of tangible goods: The recipient desires and acquires a physical item. By definition, this is a material-focused transaction. Now, however, new market tools (and policies that drive toward such tools) are being developed and supported that shift the frame from product-focused to process- and service-focused transactions. These approaches can provide a powerful environmental driver.

An oft-quoted example involves Ford Motor Company, which switched from subcontracting to a vendor to paint their cars to purchasing from their vendor the "unit" of a painted car. By paying the vendor a per-painted-car price, Ford incentivizes the vendor to maximize its own profit by reducing overall per-car costs (while maintaining defined quality expectations). One easy way for the vendor to accomplish this is to identify opportunities for minimizing the amount of paint required (or wasted) per car.

As another example, directory service companies can move toward online rather than yellow-page provision of information. Pharmaceutical companies can offer coupons for drug samples, rather than liberally dispensing actual samples that often end up expiring in clinic drawers. Vehicle leasing arrangements can guarantee that the leasing company will own the vehicle at the end of its useful life—which could influence the company to reconsider (and perhaps change) certain product and production attributes in ways that individual car owners cannot.

> "[O]ur most important finding is that fee-upon-sale types of e-waste regulation (including [Advanced Recovery Fee], collective EPR with current-sales-based cost allocation and RoHS) reduce the quantity of electronics produced and disposed by reducing the frequency of new product introduction. In contrast, in competitive product categories, fee-upon-disposal types of e-waste regulation (including individual EPR and collective EPR with disposal-based cost allocation) fail to reduce the frequency of new product introduction."
>
> — Plambeck, E., & Wang, Q. (2009, March). Effects of E-Waste Regulation on New Product Introduction. *Management Science*, 55, 333–347, at pp. 345–346. Available online at http://www.calpsc.org/products/docs/2010/2009-03_PlambeckWang-EffectsOfE-wasteRegulation.pdf.

Moving Forward With Incomplete Information

Policymakers must often take action without complete information. For example, we will likely never have complete information from (or agreement about) a life-cycle assessment (LCA) or an environmental impact assessment. Nonetheless, policymakers must reach decisions; there comes a time to fish or cut bait.

"[Individual producer responsibility] is a policy tool that relies on economic signals from treating end-of-life products (environmental 'cost' signals) getting through accurately to the producer, to drive design change. Therefore, there must be, as far as possible, an 'economic level playing field' or minimal distortion of these cost signals for the economic advantages of product design change to be reaped."

— van Rossem, C., Tojo, N., & Lindhqvist, T. (2006, September). Lost in transposition: A study of the implementation of individual producer responsibility in the WEEE directive, at p. ii. Amsterdam and Brussels: Greenpeace International, Friends of the Earth Europe, and the European Environmental Bureau.

"In general, the more control manufacturers have over the downstream infrastructure, the more likely they are to take measures belonging to the higher ladder of resource efficiency. The study also revealed anxiety among manufacturers concerning the development of downstream infrastructure. The manufacturers feared that current development does not allow for the distinction of their products from products of similar types. It means that their upstream efforts may not be adequately rewarded."

— van Rossem, C., Tojo, N., & Lindhqvist, T. (2006, September). Extended Producer Responsibility: An Examination of Its Impact on Innovation and Greening Products, at p. 15. Amsterdam and Brussels: Greenpeace International, Friends of the Earth Europe, and the European Environmental Bureau.

For this reason, it is important to think about what parameters will allow the most equitable policies to be developed, given the absence of complete information. This is particularly important when the negative impacts of proposed policies may affect various stakeholders differentially (perhaps some groups more than others).

More Information Is on the Way

Although information will likely remain imperfect, LCAs are becoming more sophisticated, more complete, and perhaps even more agreed upon by varied stakeholders. These enhanced LCAs will support life-cycle decision making on a scale not seen before.

Related to this, information disclosure tools such as product declarations, mandated reporting, "light of day" policy requirements, and other tools are growing in maturity and use. Such requirements have been shown to incentivize manufacturers to make product changes, such as reducing toxicity.[24]

Focusing on End of Life: An Incomplete Promise

As alluded to earlier, a product's upstream environmental footprint may be larger than its downstream footprint. Production- and use-phase impacts often outweigh disposal impacts, and thus offer preferable insertion points for changes to designs, materials, and processes.

Requiring take-back (or at least recyclability) will usually decrease a product's overall life-cycle impact—but this is not always the case. Even when it is, such a focus may divert attention away from more effective leverage points in the life cycle. A frequently cited example illustrates this point: Even with a very high recycling rate for metal coffee cans, the life-cycle impacts of this packaging option are greater than those associated with nonrecyclable laminate brickpack packaging that is disposed of 100 percent of the time.

Additionally, for many producers, downstream costs, even if internalized, are just a tiny fraction of upstream costs. So even though internalization of downstream costs acts as a lever, for many producers it is a very weak one.

Moreover, many design improvements go unnoticed or unrecognized when government agencies and other stakeholders focus too narrowly on end-of-life management. Source-reduction activities often are not discussed (or at least remain unmeasured) in traditional solid waste circles. Industry is then left wondering how they can get "credit" for source-reduction success—especially if such reductions also result in declines in their gross recycling tonnages.

Expanding From a "Waste Management" Focus to a "Materials Management" View

Product stewardship in the United States has historic roots in state and local waste programs. These early program and policy efforts often emphasized end-of-life management, even though the definition of product stewardship encompasses the full life cycle. From the outset, however, many waste programs have been undergoing a slow but steady transformation from addressing "waste management" to a broader focus on "materials management."[25]

This shift is being driven by growing awareness about a number of factors, including environmental and public health impacts beyond those seen at the time of disposal, the relationship between products and the environment, the limitations of focusing on just one element of the life cycle (in this case, disposal), and the benefits of taking a more holistic view of the entire life cycle. This shift can be seen in private-sector activities as well.

Financial Assurance as Design Insurance

Increasingly, product stewardship policies are incorporating requirements for financial assurance, or guarantees for the cost of future waste management. Financial assurance may take the form of a bond or a requirement that the product manufacturer set aside funds to cover the future costs associated with end-of-life management.

Ideally, this approach will build in incentives for the manufacturer to minimize future costs now (through design changes) in order to save expenses later. At the very least, financial assurance means that the manufacturer will have provided funding for future management costs—a consideration that becomes especially important if the manufacturer goes out of business and is no longer around to pay for product recovery and disposal (or if the product has a long lifespan and take-back is unlikely to influence design aspects of the much-changed successor products; see "Timing Is Important" earlier). As one analysis notes:

> Provision of financial guarantees for future costs is the way to ensure that producers take these costs into account when designing products and product systems. True financial guarantees not only ensure there are funds to pay for these costs, but provide flexibility and possibilities for competition on the market, allowing market forces to develop efficient solutions. Such efficient solutions must also secure an environmentally-responsible treatment of products and their components and materials. By internalising these costs, avoiding subsidies for collection and other activities, and establishing a true financial guarantee system, a level playing-field will result, that rewards corporate responsibility and innovation in product design.[26]

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Recommendations and Policy Options

Like the proverbial tail trying to wag the dog, local and state governments are close to (and responsible for) the waste end of products, yet traditionally have been rather removed from the upstream aspects of the product life cycle. This has presented a challenge when city, county, and state governments attempt to craft policies—especially solid waste policies—that seek to drive design changes and life-cycle improvements.

The situation is starting to change, however. Clearly, some of the mechanisms discussed here can be implemented effectively at the state and

local level.[27] Additional approaches and guidelines for state-level options that facilitate Design for the Environment (DfE) within industry were outlined in a 2009 report for British Columbia's Ministry of Environment.[28] Recommendations from that report are summarized below, along with additional ideas and options intended to pave the way for policy setting that drives upstream design and other life-cycle improvements:

- Provide a clear policy or statement of intent to promote design changes that will improve environmental outcomes across the life cycle. Such statements can range in form, and include:
  - ❖ components of solid waste plans
  - ❖ resolutions in support of product stewardship policies
  - ❖ legislative preambles
  - ❖ agency white papers

  Such language sets the stage for more concrete action by various public and private stakeholders. This approach also helps broaden awareness of, and literacy in, these concepts.
- Undertake research that can inform future product stewardship policies. For example, waste-stream characterization studies undertaken by local governments typically focus on material sorts (establishing categories such as glass, aluminum, ferrous metal, and paper). Product policy development would benefit from sorting studies that also categorize waste stream components based on product type and brand-owner.

> "[G]reen design is likely to have its largest impact in the context of changing the overall systems in which products are manufactured, used, and disposed, rather than in changing the composition of products per se."
>
> —Office of Technology Assessment. (1992, September). Green Products by Design: Choices for a Cleaner Environment, at p. 9. OTA-E-541. Available online at http://www.fas.org/ota/reports/9221.pdf.

  Other research might include exploration of life-cycle assessments for targeted products and materials. While LCAs may not provide definitive analyses on their own (because of technical and political constraints), they do play an important role in informing policy decisions.[29]
- Develop policy approaches that focus on results rather than on the means of achieving those results. A core strength of product stewardship is its reliance on establishing market mechanisms that then drive innovation internally. By focusing on the outcome of a program (for example, tons of waste recovered or prevented, user convenience, energy demand, or life-cycle greenhouse gas emissions), the market is left free to innovate in accomplishing those goals. Where possible, focus on actual environmental outcomes—as opposed to attributes, proxies, or process outcomes.
- Recognize that recycling does not always provide the optimal solution from a design perspective. Leave room for environmentally advantageous alternatives that, from a life-cycle perspective, are preferable to recycling.
- Provide information that allows consumers to choose products or packaging with better environmental performance over the life cycle. Such transparency can alone often drive manufacturer design changes. Just as localities are currently experimenting with regulations that require restaurants to provide nutrition information, local and state governments should explore options for requiring that consumers be provided with coherent and actionable environmental information on the products they buy.
- Involve stakeholder representatives who are drawn from the full product life cycle (including suppliers, producers, retailers, and consumers) in the development and evaluation of stewardship programs that incorporate DfE as a policy objective.

Anticipating Laws Can Drive Change

"[A]nticipation of EPR law has been central for specific design changes for the products investigated. Tojo (2004) provides empirical evidence that EPR law does provide tangible incentives for environmentally-conscious design in the case of electrical and electronic equipment (EEE) and cars in Japan and Sweden. The analysis of her interviews in 2001 revealed that all manufacturers that were interviewed considered anticipated regulatory requirements posed by EPR law in their product development strategies. Upstream measures in design, both in terms of reduction of hazardous substances and enhancement of source reduction of material use, re-use and recycling, have been undertaken in both industry sectors in Sweden and Japan respectively."

—van Rossem, C., Tojo, N., & Lindhqvist, T. (2006, September). Extended Producer Responsibility: An Examination of Its Impact on Innovation and Greening Products, at p. v. Amsterdam and Brussels: Greenpeace International, Friends of the Earth Europe, and the European Environmental Bureau.

- Remember that the best-designed programs include established baseline data, clear targets for collection, performance goals, reporting standards, enforcement measures, and clear goals for design improvements and other life-cycle improvements.
- Develop statewide priorities for product categories and articulate a clear step-by-step process for program development that includes design and life-cycle elements (e.g., start with stakeholder engagement, authorize an appropriate state agency to establish minimum mandatory standards, and so forth).
- Identify and adopt leading existing standards. This could take the form of purchasing standards like EPEAT or Top Runner, or energy standards such as Energy Star. (Note that the Oregon Department of Administrative Services, for example, already directs the use of EPEAT under Statewide Policy 107-009-0050.)
- Continue to identify targeted products for product stewardship legislation. Build on a state's existing experience with product stewardship. For example, Oregon already has policies on electronics and paint. The state could move on to an expanded list of electronic products, and add pharmaceuticals, mercury-containing devices, containers and packaging, and other products that meet certain criteria. Relevant selection criteria might include environmental impacts, human health impacts, and other aspects that are challenging for local governments to manage. Continuing to build momentum for product stewardship policies provides opportunities to develop programs in a manner that encourages design and life-cycle innovation—by, for example, emphasizing individual producer responsibility policy elements.
- Prioritize policy instruments that foster direct feedback to manufacturers (such as individual producer responsibility) rather than to third-party organizations that pool responsibility. Other channels for providing feedback to manufacturers can also be developed and institutionalized, at least in the government purchasing context. For example, a formal process can be established in which product specifiers and purchasing agents are expected

"Among various other factors that influence the manufacturers' undertaking of upstream changes, literally all the manufacturers interviewed acknowledged influence from EPR legislation on their efforts to reduce product environmental impacts. Among the policy instruments, *material restrictions* and *reuse and recycling requirements* have directly driven the undertaking of upstream measures. It was found that *take-back requirements* not only facilitate the development of downstream infrastructure, but also the establishment of communication paths between downstream and upstream.

—Tojo, N. (2004). Extended Producer Responsibility as a Driver for Design Change—Utopia or Reality? at p. vii. Lund: International Institute for Industrial Environmental Economics Dissertations 2004.2.

to review products for environmental concerns and to then convey those findings directly to manufacturers and vendor agents.

Notes

1. This article is based on information contained in a May 2010 white paper entitled "Swimming Upstream: Product Stewardship and the Promise of Green Design," by David Stitzhal, which was originally prepared on behalf (and under the direction) of the 2010 Oregon Department of Environmental Quality Product Stewardship Stakeholder Group. Funding was provided by Metro, Resource Conservation & Recycling Division. Both the white paper and this article received significant insight, support, assistance, and guidance from Scott Klag, senior planner, Metro, and Jan Whitworth, senior policy analyst, Oregon Department of Environmental Quality.

2. For more information on this process, see http://www.deq.state.or.us/lq/sw/prodstewardship/stakeholdergroup.htm.

3. The definition of product stewardship assumed in this article is covered in other papers prepared for the Oregon stakeholder process, as are discussions of other key policy elements that address "downstream" stages (such as convenience standards and disposal bans). See http://www.deq.state.or.us/lq/sw/prodstewardship/stakeholdermeetings.htm.

4. This article does not explore other expanding calls for transparency with regard to nutrition, labor organizing, and additional attributes associated with production and use.

5. For a broader discussion on issues of sustainable consumption, see the *Journal of Industrial Ecology* special issue on sustainable consumption and production (SCP), available online at http://www3.interscience.wiley.com/journal/123296535/issue.

6. For the complete directive, see Directive 2002/95/EC of the European Parliament.

7. For more information on Top Runner, see Ministry of Economy, Trade and Industry. (2010). Top Runner program: Developing the world's best energy-efficient appliances. Available online at http://www.enecho.meti.go.jp/policy/saveenergy/toprunner2010.03en.pdf.

8. Welcome to EPEAT, http://www.epeat.net/.

9. Ibid.

10. Oregon E-Cycles, http://www.deq.state.or.us/lq/ecycle/index.htm.

11. Ibid.

12. For more information on the Oregon Paint program, see: Product Stewardship Institute. (2009). PSI fact sheet on the Oregon Paint Product Stewardship law. Available online at http://www.deq.state.or.us/lq/pubs/docs/sw/PSIFactSheetOregonPaintLaw.pdf. Additional information on the program can be found on the Oregon Department of Environmental Quality website at http://www.deq.state.or.us/lq/sw/prodstewardship/paint.htm.

13. See Oregon Laws 2009, Chapter 777, Section 1. In this context, reducing the generation of post-consumer paint refers to achieving waste prevention through avoiding overpurchasing by the consumer.

14. Seattle's New Food Packaging Requirements. Available online at http://www.resourceventure.org/foodpluscompostables.

15. Ibid.

16. Seattle Public Utilities and Seattle Climate Action Now. (2008). City of Seattle disposable shopping bags green fee and expanded polystyrene (EPS) foam food container ban, frequently asked questions. Available online at http://www.seattle.gov/util/stellent/groups/public/@spu/@csb/documents/webcontent/spu02_014614.pdf.

17. Packaging waste reduction, international packaging regulations: An introduction to what you need to know, at pp. 2–3, http://www.deq.state.or.us/lq/pubs/docs/sw/packaging/intlpkgregulations.pdf.

18. Ibid., at 4.

19. Ibid., at 5.

20. The Toxics in Packaging Clearinghouse was established by the Coalition of Northeastern Governors (CONEG) in 1992 to encourage adoption of the CONEG-developed Model Toxics in Packaging Legislation. Thus far, 19 states have adopted this model law. The legislation requires reductions in the amount of four heavy metals (mercury, lead, cadmium, and hexavalent chromium) in packaging and packaging components sold or distributed within the adopting state. The legislation, which aims to phase out the use and presence of these four metals, requires certificates of compliance and allows for certain exemptions (which must be approved by the individual states). For more information, see http://www.toxicsinpackaging.org/.

21. In addition to the packaging regulations discussed in the previous section, it is worth noting that the famed German Green Dot program shows evidence of having reduced the overall volume of packaging used in commerce as a direct result of its fee structure and take-back program requirements.

22. In the United States, state laws governing manufacturer take-back for electronics typically have been unable to broadly regulate toxicity components or export issues related to recycling standards.

23. As a side note, it is worth mentioning that upstream design changes can either constrain or open downstream recycling options and the resultant product life-cycle impacts. In other words, not all recycling is equal. Glass recycled to cullet has a lower life-cycle impact than glass recycled to aggregate. Likewise for e-waste recycled according to high environmental standards versus that exported to areas with unmonitored conditions. In other words, upstream design choices can later ease the entry of recovered materials into market channels that allow and facilitate high-value "upcycling."

24. Though not explored in this article, labeling and information disclosure requirements are also being used to facilitate consumer scrutiny and decision making. Examples include France's eco-label (see http://www.marque-nf.com/pages.asp?ref=gp_reconnaitre_nf_nfenvironnement&Lang=English) and Japan's carbon label requirement for consumer goods (see http://www.meti.go.jp/english/press/data/20090529_01.html).

25. For example, one of the key findings of the United States Environmental Protection Agency (US EPA) 2020 Vision Workgroup is a need to shift from waste management to materials management. Specific recommendations from US EPA are laid out in a 2009 document entitled "Sustainable Materi-

als Management: The Road Ahead," available online at http://www.epa.gov/osw/inforesources/pubs/vision2.pdf.

In Oregon, adoption of the state's Integrated Resource and Solid Waste Management Plan in 1994 and revisions to the state's solid waste laws in 2001 signaled a somewhat similar shift. More recently, planning efforts by Oregon local governments (including Portland, Eugene, and Metro, the regional government for the Portland metropolitan area) have all redirected—or are in the process of redirecting—some emphasis to "upstream" actions that address the larger life-cycle impacts of materials, as opposed to concentrating primarily on the management of discards.

26. van Rossem, C., Tojo, N., & Lindhqvist, T. (2006, September). Lost in transposition: A study of the implementation of individual producer responsibility in the WEEE directive, at p. vi. Amsterdam and Brussels: Greenpeace International, Friends of the Earth Europe, and the European Environmental Bureau.

27. For local governments that pursue measures aimed at shifting end-of-life management costs to producers, a major driver is the desire to provide financial relief to local ratepayers who currently fund disposal and recycling activities through rather blunt financing mechanisms.

28. Five Winds International. (2009, March). Design for Environment (DfE) best practices: Lessons for British Columbia's Ministry of Environment. Available online at http://www.env.gov.bc.ca/epd/recycling/resources/reports/pdf/DfE.pdf.

29. For example, Oregon DEQ's life-cycle analysis of e-commerce shipping options was instrumental in demonstrating that: recycled content and recyclability are not necessarily good indicators of life-cycle benefits when comparing dissimilar materials; "mass matters," with lighter weight options almost always being preferable to heavier options, regardless of material use; and shipping bags generally are preferable to boxes for nonbreakable items.

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