Servicizing:
The Quiet Transition to Extended Product Responsibility

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Submitted to:
U.S. Environmental Protection Agency
Office of Solid Waste

May 1999

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Acknowledgments

We gratefully acknowledge funding for this project by EPA's Office of Solid Waste under Cooperative Agreement CX-826825-01-0. Special thanks are extended to Clare Lindsay for her guidance and critiques throughout the preparation of this study.

Our case studies would not have been possible without the generous donation of time and insights of our industry colleagues, including: Jan Agri (AB Electrolux), Don Dorsey (Castrol Industrial North America, Inc.), Lee Eilers (Coro, Inc.), Fernand Kaufmann (Dow Chemical), Leigh Hayes (Radian, Inc.), and Dawn Rittenhouse and Jim Dentzer (DuPont, Inc.). Many thanks also to Janet Ranganathan (World Resources Institute) and Bette Fishbein (INFORM) for their valuable comments on an earlier draft of the study.

An earlier version of portions of this report appeared as:

White, Allen and Linda Feng (1998). "Servicizing: The Quiet Transition to EPR," paper presented at the *OECD Workshop on Extended and Shared Responsibility for Products: Economic Efficiency/Environmental Effectiveness*. Washington, DC, 1–3 December.

Any remaining errors of fact or interpretation, of course, are the sole responsibility of the authors.

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Services and the environment

Over the past generation, the economies of the U.S. and other wealthy industrialized states have undergone significant structural changes. Services have attained new prominence, and the relative contribution of traditional manufacturing to these economies have diminished. These changes have created enormous opportunities for entrepreneurs and new national wealth on the one hand — and huge social costs attendant to the decline of traditional industries and challenges for public policy on the other.

Because the human impact on the environment is intimately linked to economic activity, these changes present both challenge and opportunity for environmental policy. The structural changes producing a service and information-led economy is often presented in environmental terms as gradually divorcing economic growth from material and energy throughput and environmental burden. The idea of a *functional* economy — in which the focus of consumption is not goods per se, but the services which those goods deliver — has been associated with the idea of eco-efficiency. In a functional economy, commercial and domestic consumers buy cleaning services instead of washing machines, document services rather than photocopiers, and mobility services rather than cars.

Systematic analysis of the environmental implications of a service and information-led economy is just beginning. *It is clear that the simplest and most optimistic view — a service economy is inherently clean economy — is insufficient and incorrect*. Instead, the service economy is better characterized as a value-added layer resting upon a material-intensive, industrial economy. All else equal, economic growth in services may be less environmentally problematic than growth in manufacturing. But that is not sufficient when society already exceeds environmental limits in a number of crucial ways. *If services are to produce a greener economy, it will be because they change the ways in which products are made, used and disposed of — or because services, in some cases, supplant products altogether*.

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Our focus: product-based services

The idea of services *supplanting* products has received significant attention — for example, the "dematerialization" potential of information technology in reduced travel and transport of physical goods. Clearly, however, all products cannot be dematerialized— not only does the provision of basic needs (e.g., food, shelter, clothing) require the mobilization of an irreducible physical minimum of material and energy, but the information technology which may make dematerialization possible rests upon an extensive, sophisticated manufacturing and maintenance infrastructure.

This study thus focuses on the environmental implications of an emerging class of product-based services, with emphasis on the business-to-business markets. Product-based services include the familiar — warrantees, maintenance agreements — as well as the less familiar — chemical management

services, mobility services, furnishings management.

What these services have in common is that for the consumer, consumption shifts from purchase and use of a product to purchase of a service. For manufacturers and service providers responding to — or driving — these market changes, involvement with the product is extended and/or deepened in phases of the product lifecycle. In some cases, formal property rights may change as a result — for example, a manufacturer may retain ownership of its product through the use phase, via a leasing arrangement. Even if this does not happen, a service orientation necessarily involves a greater involvement with the product in its use phase than does the provision of "product in a box."

Our term for the emergence of this growing class of product-based services, which blurs the distinction between manufacturing and traditional service sector activities, is "servicizing." In a servicizing environment, the notion of straightforward buying and selling softens and diversifies into a spectrum of property rights arrangements, including leasing, pooling, sharing and take-back. Value is increasingly created and measured by the function provided, and for the manufacturer, the product increasingly becomes a means of delivering this function, rather than an end in itself. To date, this "servicizing" phenomenon has been driven largely by business, not environmental, concerns. It can be seen as one aspect of a major shift in how firms think about and approach competitiveness.

Servicizing:
The emergence of product-based services which blur the distinction between manufacturing and traditional service sector activities.

Extended Product Responsibility:
The principle that actors along the product chain share responsibility for the lifecycle environmental impacts of the whole product system. The greater the ability of an actor to affect the impact, the greater the responsibility.

Servicizing and extended product responsibility

What is the potential for environmental gains from servicizing and, in particular what policy initiatives and governmental role might be helpful in realizing these gains? Can servicizing be a driver towards extended product responsibility (EPR)?

EPR is the principle that actors along the product chain or lifecycle share responsibility for the lifecycle environmental impacts of the whole product system, including upstream, production and downstream impacts. The greater the ability of the actor to influence particular environmental impacts within the product lifecycle, the greater the share of responsibility for addressing those impacts should be.

Thus, EPR is a principle whose applications should result in lower lifecycle environmental impacts for products or product systems. Servicizing describes a business strategy which defines and serves a market's needs for speed, convenience, flexibility and other value-added attributes by changing the way in which the function embodied in products is delivered.

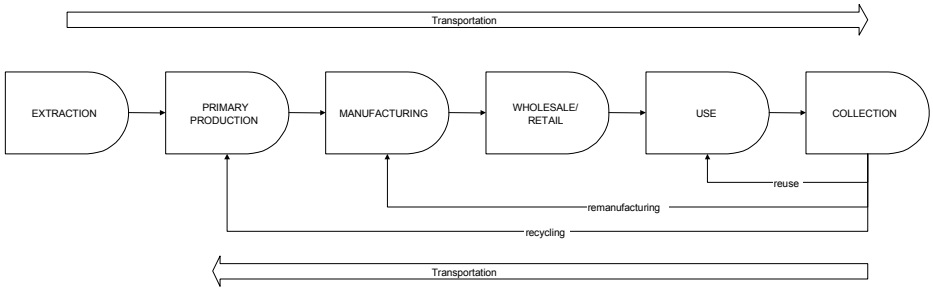


Figure ES-1: The product lifecycle. EPR is a lifecycle-based concept.

The link between servicizing and EPR is that both require manufacturers or service providers to extend their involvement with, and responsibility for, the product to phases of the lifecycle outside the traditional seller-buyer relationship. If servicizing contains within it potential environmental benefits, it is because this altered relationship with the product drives superior environmental performance — in short, because servicizing drives EPR.

Achieving EPR in a non-regulatory context means that the market must act to align environmental responsibility and incentives to improve environmental performance with those actors who have the *ability* to reduce the lifecycle impacts in question. There are three means by which environmental responsibility or incentives might be placed upon the manufacturer or service provider:

- when the business arrangement serves to internalize use or disposal costs;
- when the product in question has significant value at end-of-life;
- when provision of the product is viewed as a cost, rather than a profit, center.

Does servicizing lead to EPR?

EPR is a lifecycle-based concept, and it is appropriate to employ a lifecycle framework explicitly in assessing the linkages between servicizing and EPR. Further, a focus on the *product* lifecycle or the *product system* is appropriate because it highlights the *absolute* environmental impacts associated with the manufacture, use and disposal of a particular product in the economy. If servicizing is to be meaningful as a route to eco-efficiency, it must reduce these absolute impacts — not simply create a larger value-added to spread across the same environmental burden.

Using a lifecycle framework, the potential, generic means by which use and non-use environmental impact reductions may be achieved over any product's lifecycle are set out. The potential for servicizing to achieve each type of reduction is discussed in terms of the three categories of economic incentives. As depicted in Table ES-1 below, servicizing has the *potential* to create situations in which these economic incentives to EPR arise.

***Servicizing has the* potential** *to create situations in which. . .economic incentives to EPR arise. . .{but this] simple picture of "economic stimulus and firm response" is considerably more complicated in the real world.*

An examination of the experiences of seven firms with servicizing, however, shows that the simple picture of "economic stimulus and firm response" which our theoretical, lifecycle-based analysis depicts is significantly more complicated in the real world. These complications are likely to have significant implications for the ability of servicizing to drive EPR:

- Among the case study firms, the relationship between manufacturing and service provision exists on a spectrum from near-total autonomy to near-total integration. Autonomous operations avoid many potential conflicts between traditional sales and manufacturing units on the one hand and service provision on the other. These conflicts tend to arise when servicizing has the effect of decoupling product volume from profits. Autonomy is also, however, likely to diminish the possibility that servicizing will drive environmental gains in product design and manufacturing methods.

Table 1: Possible reductions in environmental impacts derived from servicizing

	Source of impact reductions	Conditions to achieve reductions	Examples (real and hypothetical)
Use Impacts	Via product design	Use related environmental costs are internalized, and these costs may be reduced by better design of product.	A manufacturer provides refrigeration services on a fixed fee basis. As electricity costs are a substantial portion of the costs of providing the service, the manufacturer has incentive to produce a more efficient unit.
	Via increased turnover	Servicizing drives more rapid turnover of product stock in use combined with progressive efficiency improvements in consecutive model years.	A major appliance market becomes servicized under leasing arrangements, concurrent with mandated efficiency improvements. Resale of older, "post-lease" units is prohibited. An energy services company (providing heating services at a fee indexed to outside temperature) replaces a heating system in a commercial building with more energy-efficient/cost-saving equipment.
	Via more optimal operation of existing product (maintenance, training, process efficiency)	• Use-related environmental costs are internalized, and these costs may be reduced by more optimal operation. • Where the product is a cost rather than a profit center, and more optimal operation extends product life/reduces product consumed.	A cleaning services provider absorbs the costs of equipment breakdown and consumable supplies, providing incentive to train operators for more optimal operation of the machines. A chemical management services provider is compensated on the basis of service delivered rather than the volume of chemicals sold. Chemicals become a cost rather than a profit center; the provider has incentive to increase process efficiency in the plant.
Non- Use Impacts	Via reductions in number or volume of product manufactured (increased durability, larger service capacity, more efficient utilization)	The product is a cost rather than a profit center, providing incentives for any of the following: • more durable products • products of a larger service capacity, via the realization of economies of scale • more efficient utilization of products in use	A manufacturer of commercial laundry equipment offers "laundering services" to large customers, guaranteeing machine availability and a given service capacity. The manufacturer thus has an incentive to provide large-capacity, durable machines which reduce maintenance costs.
	Via reductions in the volume of materials mobilized per unit (reclamation activities)	The product has economic value at end-of-life, or where end-of-life costs are internalized — in either case stimulating reclamation activities.	A manufacturer and provider of desktop computing services guarantees a two-year upgrade cycle to its customers, taking back obsolete equipment and incurring responsibility for its disposal. The provider has an incentive to treat this equipment as an asset, minimizing disposal costs and maximizing savings from recycling and reuse of viable components. This reduces virgin material employed in the manufacture of "new units." It also reduces disposal impacts of end-of-life units and may improve environmental performance of primary and product manufacturing.
	Via improved environmental performance of non-use processes. (esp. disposal impacts; reclamation activities)	The product has economic value at end-of-life, or where end-of-life costs are internalized — in either case stimulating reclamation activities.	

If service units have no linkage with manufacturing units, there is no ready mechanism whereby economic incentives arising from service activities can be transmitted to design and manufacturing activities

- The practice of lifecycle design is a complex process requiring close integration across business functions and specialized decision-support tools. Absent this capability within the firm, even the presence of an economic incentive may not lead to effective practice of lifecycle design. This, in turn, will diminish the prospects of realizing the potential environmental gains associated with servicing and, more generally, EPR.

Finally, not every servicizing situation gives rise to the three economic incentives — internalized use or disposal costs, high economic value in the end-of-life good, or the rendering of a product into a cost rather than a profit center.

Experience with servicizing also reveals that, although servicized product offerings may be increasing, market barriers to its successful practice can be significant. From the buyer's perspective, servicized products typically demand closer coordination with, and trust in, suppliers, as well as a more sophisticated understanding of costs than is typical of the conventional seller-buyer relationship. Where technological or regulatory change is rapid, e.g., in telecommunications and electronics, these barriers diminish relative to the customers' needs for specialist services and knowledge which they lack or find increasingly difficult to maintain in-house. Given a relatively stable product technology or business environment, e.g., autos, white goods, servicized products seem to have more difficulty gaining market acceptance

Roles for government

The emergence of product-based services — servicizing — is a phenomenon in which public policy thus far has played little role. However, policy does have a number of roles to maximize the prospects of the potential environmental gains implicit in the emergence of product-based services — and perhaps, in making the servicized product more attractive in markets where acceptance is most difficult.

Explicit environmental policies

Regulatory measures can focus the attention of firms on achieving environmental improvements under servicizing. If one compares Europe to the U.S. from a policy standpoint, it is clear that European initiatives in the areas of EPR and product policy are both older and more aggressive. Though these policies have received their share of criticism, they have undoubtedly focused the attention of firms on providing environmentally beneficial end-of-life services.

While the U.S. seems unlikely to pursue the European approach, at least at the federal level, policies which incorporate the social costs of materials extraction and disposal into the purchase price of products are likely to have two effects: (1) building further market demand for decoupling ownership from product use; and (2) building demand for lifecycle management as an explicit component of service offerings. Such policies include, for example:

- **Removing virgin material subsidies, explicit and inherent.** Any policy that subsidizes virgin materials extraction and use to the disadvantage of reuse, remanufacture, and recycle of secondary materials tends to add net environmental burden. More material throughput means more extraction, and more extraction means more emissions. Thus, as a general statement, government subsidies via below-market concessions on public lands for petroleum, minerals and forestry activities works to

the disadvantage of dematerialization. The converse is also true: policies which remove economic privilege from such activities support materials reclamation. In short, subsidies that reduce the cost of making new "stuff" are inconsistent with efforts to steer the economy away from goods and toward more service-oriented modes of enterprise.

Government and policy roles:

- ***Explicit environmental policies*** *(aside from mandated responsibility, these include removal of virgin material and disposal subsidies, and driving product efficiency improvements.)*
- ***Tax policy*** *which favors producer, not customer, ownership of durable goods.*
- ***Convenor and facilitator***
- ***Documentation***
- ***Research***

- **Remove disposal subsidies.** At the other end of the product cycle are disposal subsidies. Government policy that artificially reduces the cost of product disposal runs counter to extracting environmental gains from servicizing. In lessening the cost of outright product disposal, end-of-life reclamation activities (recycling, remanufacturing, reuse) are placed at a competitive disadvantage. End-of-life reclamation activities are a key means by which environmental gains can be derived from servicizing.
- Driving efficiency improvements is an obvious role for environmental product policy when servicizing drives more rapid turnover of a durable good with high use-related impacts. If coupled with tax schemes which encourage this turnover and policies which incentivize reclamation activities, gains can be maximized.

Taxes

As we have seen, decoupling ownership from product use is a key driver of servicizing. Any tax policy — credit, deductions, accelerated depreciation, for example — that favors commercial or household equipment ownership to the disadvantage of equipment leasing represents an impediment to servicizing products. In contrast, tax policies that favor retention of ownership of durable goods by producers or sellers is supportive of servicized arrangements. These policies give producers the incentive to engage in reclamation activities at the end of product life.

Documentation

This study represents only a start in understanding the full scope of how servicizing is unfolding and what ramifications it holds for environmental benefits. Though rich in insights, the cases we evaluated here are few in number. A valuable government role is support for more documentation of the kind presented here. Questions to be addressed include: Are there other sectors where the service transition is observable? Do the generalizations that emerge from this analysis hold up in these sectors? What are the specific seller -buyer arrangements — including the specific financial and contractual arrangements — that will secure the environmental gains achievable under certain forms of servicizing? How can environmental metrics, fixed management fees and pricing per unit of service (e.g., per painted car, per cleaned circuit board) be mobilized to realize the potential environmental gains of servicizing enterprises? Case studies, model contracts, and more quantitative environmental analyses will inform both policy and private sector decision-making.

Convenor

Potential service providers will benefit from learning and emulating other providers. This

is amply demonstrated in the case of chemical management service (CMS) where workshops organized by the Chemical Strategies Partnership have provided valuable fora for both sellers and buyers in advancing chemical management services. One can envision government playing convenor of such fora for a number of other servicizing sectors. Of course, there are limitations: "first movers" may be reluctant to share strategies aimed at building a strong foothold among customers in an emerging market. Thus, timing and expectations of such initiatives must be carefully managed.

Research

"Functionality" is in the eyes of the customer. This means that the marketing of functionality must occur with a clear sense of how product users perceive and measure functional value. Transforming product owners into non-owner product users is neither easy nor automatic, even when the economics are compelling. Even under the bottom-line mindset of most managers, even equipment leasing may be stigmatized for cultural reasons. In the household sector, it may be relatively easy to envision the behavioral changes necessary to transition from washing machine or refrigerator ownership to washing and cooling services. But what about autos, with their brand equity and prestige factors that accompany ownership? And internal to the enterprise, the changes required to reorient traditional product and sales-driven organizations to a service-based mentality presents an array of research questions. In this sense government can play a valuable role in defining the opportunities and limits for building buyer and business acceptance for servicized offerings.

Finally, while we have focused almost exclusively in this study on the transformation of manufacturing firms to service-oriented organizations, the role for new enterprises formed from the outset as functionality-based businesses should not be overlooked. These are the new breed of car-sharing, computer equipment leasing, home telecommunications, and chemical services firms which were never producers of material goods. Nonetheless, their role as aggregators, marketers, and middlemen merits the attention of researchers and policymakers. Creating favorable business conditions for their formation and success is another vehicle for fostering the product-to-service transition already emergent in manufacturing industries.

1. Services and the Environment

The growing importance of services

Structural economic changes in the U.S. and other advanced industrial economies in the post-war era have been dramatic, particularly since 1970. In the U.S. and Europe, manufacturing's relative position as an economic lead sector has declined and services have risen to new prominence.

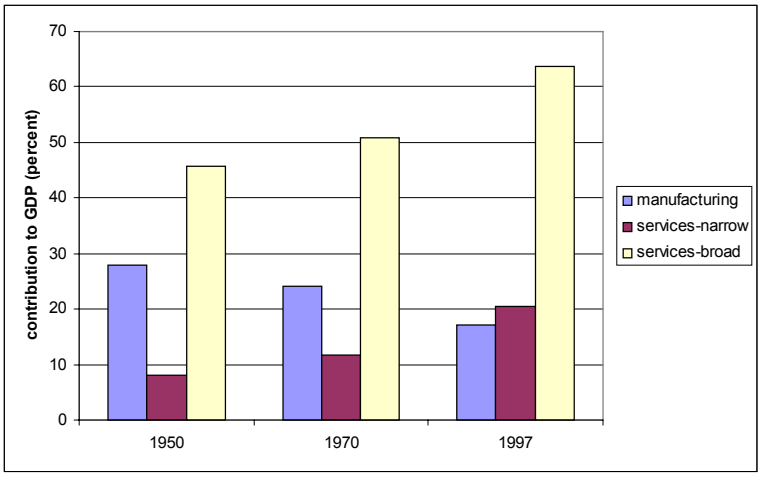
Once called the "tertiary sector," after the primary extractive sector and secondary manufacturing sectors, the service sector is anything but tertiary in the U.S. economy (Figure 1). Narrowly defined, the sector's relative contribution to U.S.GDP has increased by over 200% since 1950. Over the past decade, manufacturing employment has shrunk at an average annual rate of 0.3% while service employment has grown at an annual rate of 4.2%. These changes have created enormous opportunities for entrepreneurs and new national wealth on the one hand — and huge social costs attendant to the decline of traditional industries and challenges for public policy on the other.

Challenges and opportunities for environmental policy

Society's impact on the environment is, of course, intimately linked to economic activity; it is thus of little surprise that this mixture of opportunities and challenges is reflected in the environmental implications of this structural transformation:

- From the standpoint of environmental protection, *any* structural change in the economy is of keen interest and concern. As certain economic activities become more prominent, so too do their environmental impacts. The traditional system of environmental protection heavily focused on the manufacturing sector must be revisited to reflect this growing dominance of the service sector.
- The opportunities for environmental gains seem impressive. In very general terms, the service and information-based economy may be a means to divorce economic growth from growth in material and energy throughput and environmental degradation. Measuring and realizing these potential benefits is a major policy challenge.

Figure 1: Structural change in the U.S. economy



Source: U.S. Bureau of Economic Analysis

In this section, references to services follow the U.S. Bureau of Economic Analysis definitions. Services narrowly defined include economic entities and activities such as hotels and lodging; entertainment; auto repair; membership organizations; and personal, business, legal, educational, and health services. Services broadly defined also include transportation and utilities, wholesale and retail sales, financial services and real estate.

The environmental opportunities presented by a service transition have been the source of much general discussion, but serious analysis is just beginning. At the least, it is fair to say that the simplest, most optimistic view — a service economy is a clean economy — is incorrect. As it now stands, a service economy is better thought of as a value-added layer resting upon a material-based, industrial economy. All else equal, growth in services may be less environmentally problematic than growth in manufacturing. But that is not sufficient when society already exceeds environmental local, regional or global limits. If services are to produce a greener economy, it will be because they change the ways in which products are made, used and disposed of — or because, in some cases, they supplant physical products altogether.

***Servicizing**: the emergence of product-based services which blur the traditional distinction between manufacturing and traditional service sector enterprises.*

While the latter case may have received more attention — e.g., the "dematerialization" potential of information technology via reduced travel and transport of physical goods — the case in which services alter the ways products are made, employed, and disposed of is our primary focus. Thus, examine critically the environmental implications of an emerging class of product-based services, the potential they may have for achieving environmental benefits, and the policy changes which may be required to realize these benefits.

Product-Based Services

"Traditional" services include economic activities such as the provision of lodging and entertainment; personal services (e.g., hair care); and legal, business, financial and health care services. These services tend to rest on the provision of labor and expertise, not physical goods. They are typically delivered by enterprises created at the outset as service firms and offered at the site of the service provider. Thus, the infrastructure and goods that supports them typically remains in the hands of the service provider, and their purchase involves relatively little material flow. And indeed, growth in the service sector — and the sustained expansion in the economy at large — has been led by huge growth in information and telecommunications services. These are services which largely fit the traditional model of enterprises delivering value with relatively low material intensity.

Yet, it is increasingly clear that if the traditional model of services was ever an adequate approximation, it is certainly no longer so. With the service sector's growth has come increasing complexity and diversity. An important category of services — and one that appears increasingly prominent — is quite different from the traditional "pure" form. Driven by efforts to define or serve a market's need for speed, convenience, flexibility, or cost savings, many manufacturing firms have begun a process of reinvention that shifts their focus away from product manufacture toward service delivery; that is, their products function either as a vehicle or platform for the service provided.

Some of these product-based services are familiar, e.g., warrantees, maintenance agreements on appliances, autos, and office furniture. Others, such as those depicted in Table 2, are less familiar, more recently arrived in the marketplace. Chemical management services (CMS) — essentially, outsourcing of chemical management in an industrial plant — is a growing example of product-based services. CMS firms promise use *reductions* to their customers, inverting the traditional supplier-customer relationship from one where profits are tied to sales to one where profits are tied to efficiency (Reiskin, White and Johnson, 1998). Xerox — a company built on copier manufacture — now promotes itself as a document services company, focused on the integration of document reproduction and storage with business systems. And IBM's belated aban-

donment of its "mainframe" culture and reinvention as an "e-business" and "information solutions" company is perhaps the most vivid example of this product-to-service transformation. But there are many others that are less dramatic and still in process, but collectively no less significant (Box 1).

For these traditional manufacturers, reengineering as service providers, one effect is to extend and/or deepen their involvement with their product in all phases of the product lifecycle, not just its manufacture. Formal property rights may change as a result — in product-based services, the traditional buyer/seller relationship is softening and diversifying into a spectrum of property rights arrangements, including leasing, pooling, sharing and take-back (James, 1998). For example, a manufacturer may retain ownership of its product through the use phase via a leasing arrangement. But even if this does not happen, a service orientation necessarily involves a greater involvement with the product in its use phase than does provision of the traditional "product-in-a box.".

In all of these examples, the seemingly simple question of whether customers are purchasing a product or a service becomes blurred. A blend of services with products, and vice-versa, is increasingly common commerce and a distinct class of "product services" is emerging, particularly in the business-to-business markets (Box 2). It is this transformation— a phenomenon we call "servicizing" — and particularly its environmental implications that is the focus of this report.

Table 2: Examples of product-based services

Service (Sample provider)	Description
Chemical management services (Castrol Industrial North America)	Manages chemical procurement, delivery, inspection, inventory, storage, labeling and disposal for industrial customers. Seeks process efficiency improvements. Compensation can be based on cost savings delivered, not volume sold.
Document services (Xerox)	Integrates document storage and reproduction technology — Xerox's traditional manufacturing strength — with customer's business systems to produce automated, just-in-time, customized document production.
Mobility Services (Call-a-Car ~ Netherlands)	On-demand car rental. A fleet of cars is owned by a membership organization; subscribers pay fixed costs and per-kilometer/per hour fees. Cars are reserved "on demand" via a central reservation point.
Furnishing services (Interface; DuPont Flooring Systems)	Interface experimented with an "Evergreen Lease" program. Customers leased installed modular carpet, which Interface undertook to maintain to a given appearance standard with selective rotation or replacement (with recycling) of worn tiles. DuPont, in addition to leasing carpets, also provides a series of carpet-related services throughout the carpet's lifecycle.

Source: Case studies, Appendix A; Meijkamp, 1994

Box 1: How extensive are the "new services?"

Quantifying the current value of, and growth in, "servicized product offerings" is difficult. Economic accounting for services is problematic in any case, and the blurred line between products and services which servicizing represents only adds to the difficulty. Beyond the gross and very aggregate figures depicting an increasingly service-oriented economy cited above, a growth trend in servicized product offerings does seem clear anecdotally:

- Our case studies (Appendix A) provide evidence that new varieties of service offerings are available from many industrial sectors whose firms traditionally focused on the provision of "product in a box." This is reinforced by the writings and case-study accounts of a growing literature in the area of "eco-efficient services" (Stahel, 1997; Axt et al., 1994; Hinterberger et al., 1994)
- Outsourcing in the U.S. economy is a decade-long trend; the fact that firms can and do outsource innumerable services formerly performed in-house points to the existence of growing offerings among non-traditional service provides, including firms historically defined principally as component and materials suppliers to manufacturing and service enterprises.

Box 2: What is driving growth in the new services?

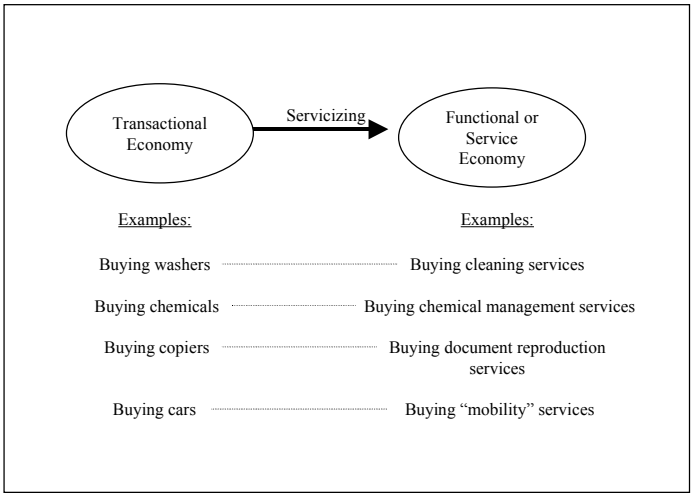
The growth in product-based services can be viewed as one manifestation of an economic transition away from fordist (mass and standardized) modes of production towards flexibility and customization of product offerings. Attendant to this transformation are significant changes which have emerged since the 1970s in the ways U.S. business thinks about creating value and gaining competitive advantage (Sibbet, 1997). The fordist focus of management — how to make more goods more efficiently — has gradually shifted in competitive global markets to include *quality* and *value-added* as well. These management models focus on the organization — on ideas of continuous organizational learning and agility, along with reengineering, outsourcing, supply chain management, and "virtual" organizations. Knowledge, information, and core competencies, rather than physical assets, increasingly define leadership enterprises. Firms are increasingly comfortable looking outside themselves for skills and services that are not their strategic focus — and indeed, may be compelled to do so.

Product-based service offerings fit well with this new competitive model in numerous, often interrelated ways: (Several of these are addressed in greater detail in Section 3):

- *Cost control.* Purchasing a product-based service (e.g., chemical management services) rather than only a product (e.g., chemicals) can be a means of strategic outsourcing, replacing services previously performed in house with those provided by a specialist to whom they are a core competency. Similarly, product leasing rather than purchase can be a means to externalize the costs of capital expenditures, thereby improving the balance sheet of the enterprise.
- *Need for specialist skills*. Rapid change in the information technology underlying business systems, increased requirements for integration of these systems, and increasing complexity in the regulatory and business environment in general increasingly require specialist skills which most firms find difficult to maintain in-house.
- *Product differentiation.* Production is increasingly mobile, but effective service delivery requires local knowledge and infrastructure. Product-based services thus can be used to achieve successful product differentiation and market advantage, even for manufacturers who are not the lowest-cost producer.

Finally, *environmental regulation* in Europe (but not yet in the US) is increasingly fixing responsibility for end-of life treatment of the product upon the manufacturer. In various EC countries, packaging, automobiles, white goods, and electronics are, or may soon be, subject to take-back requirement. These regulations force manufacturers to add end-of-life services to their product offerings, typically implemented through PROs (Producer Responsibility Organizations). In the US, however, environmental regulations have made firms concerned with the need to control potential liabilities, spurring demand for specialist, product-based services in certain areas, such as chemicals.

Figure 2: The Functional Economy



Product-Based Services and the "Functional Economy"

Clearly, the service economy is steadily stretching its boundaries. A useful way to view this growth in services is that of change from the sale of product to the sale of function or utility. (See Box 3 for one taxonomy of different types of services.) It has been suggested that in today's market, where mobility and flexibility are of high value, what the customer ultimately wants is not ownership of products, but the utility or functions provided by the products. (Friend, 1994 & 1996; Pantzar, 1994; Margetta, 1997; Popov and DeSimone, 1997): As Hawken (1993) has observed:

> *"What we want from these products is not ownership per se, but the service the products provide; transportation from our car, cold beer from the refrigerator, news or entertainment from our television."*

One must be careful not to overstate this case. Consumer preference for ownership of certain products, especially those with strong brand signals, is in fact deeply rooted in subjective needs for security, control, prestige and status (See AB Electrolux, Appendix A). But it is certainly true that the objective economic worth of products is based upon the function they deliver. This functional. or utility-based view of product consumption, is finding increasing expression in the business-to-business markets where functionality and cost-effectiveness — not prestige or status— dominate. For example:

- Office equipment customers may want maintenance, repair, upgrade, and operations assistance along with the hardware itself, including computer and computer-related hardware and software.
- Commercial cleaning service firms may want their equipment customized, maintained, upgraded, and removed as their needs change week to week and month to month.
- Industrial firms may want to extract the value of chemicals as cleaners, degreasers, and metal coaters without worry about the procurement, storage, labeling, permitting, and waste disposal associated with chemical use.

This shift in the manufacturer's role from product provision to service provider has been called by other authors "functionalization" or "functional economy" (Stahel 1997; Ayers, 1998) (Figure 2). In this study, we call it "servicizing" in order to emphasize that it is a dynamic state of change from a pure product model toward a more service-oriented business model. By our definition, both enterprises and products may be in the process of servicizing.

The Functional Economy as Green Economy

A functional economy has been equated with the idea of a greener, more eco-efficient economy. Stahel (1997) states this explicitly. He notes that a functional economy is not only one in which customers are users of functions and services rather than consumers of products, but one that

> *". . .optimizes the use (or function) of goods and services and thus the management of existing wealth (goods, knowledge, and nature). The economic objective of the functional economy is to create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible."*

This idea that "eco-efficiency" — extracting more value per unit of material input — can arise or be facilitated by a service transition is increasingly popular. (Popov and DeSimone, 1997; Hinterberger et al., 1994). This view frequently cites the case of the "servicized product" in which the manufacturer retains ownership of the product throughout

its lifecycle, ensuring proper end-of-life management, and driving increased durability, remanufacturing, materials recycling, and more efficient utilization of the product stock.

More generally, the potential for eco-efficiency gains from servicizing lie in the closer alliance between seller and buyer, producer and customer, that is one of the defining elements of the servicizing enterprise. This relationship is the vehicle through which information and knowledge flow between the two parties, typically in two-way fashion. When a firm's product becomes a servant to the solution that its customer seek rather than an end in itself, then changes in the product — in its nature, its design, its disposition — are far more likely. Where less of a product, or a different product altogether, is capable of delivering equal or greater value, the firm which has servicized will make the indicated changes. In this solution-based mindset lies the seeds of dematerialization. As we see later, the extent to which environmental gains are achieved through such dematerialization depend on the nature of the servicized product and the particular set of incentives faced by the buyer and seller.

Analysis of the relation of product-based services to eco-efficiency improvements, however, has largely remained at this level of generality, and policy discussions are equally general. (James, 1998)

"***In "functionalizing" the economy,*** *product-based services have been argued to promote eco-efficiency.*

Thus far, this proposition has been subject to little detailed analysis. There is a clear need to examine the environmental implications of these product-based services, the potential they may have for achieving environmental benefits, and the policy efforts which may be required to realize these benefits.

This study is an effort to begin such an analysis.

Focus and Approach of This Study

Against this background of uncertainty, three points are clear:

- The service transition represents an important and ongoing structural change in the U.S. economy. More than simply growth in traditional services, this transition has increased the diversity and complexity of service offerings, and is beginning to blur the line between "products" and "services."

- The services transition presents important questions to policy-makers. A crucial question regarding the "greening" potential of an increasingly service-based economy is how services may bring about changes in the product environmental lifecycle by affecting their manufacture, use and disposition.

- Precisely because they are product-based, an emerging class of services seems to have particular potential to achieve these changes in the product lifecycle. In "functionalizing" the economy, product-based services have been argued to promote eco-efficiency.

Thus far, this proposition has been subject to little detailed analysis. There is a clear need to examine the environmental implications of these product-based services, the potential they may have for achieving environmental benefits, and the policy efforts which may be required to realize these benefits.

This study is an effort to begin such an analysis, focusing on product-based services in the business-to-business markets. To this end, our approach in this study is as follows:

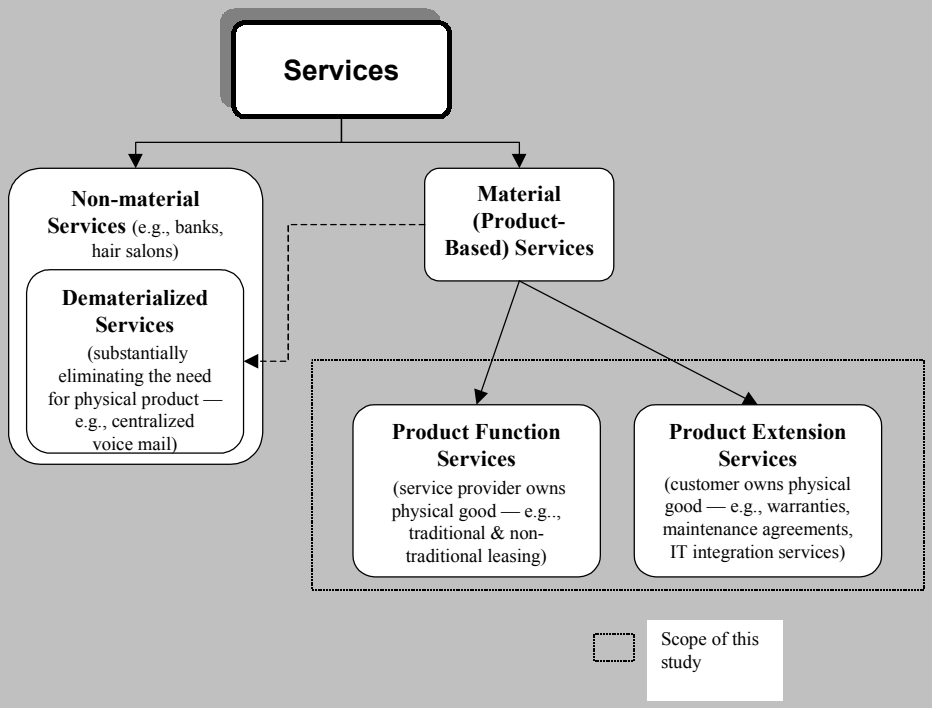
- Section 2 examines at the linkage between servicizing and extended product responsibility (EPR), the emerging no-

tion that reducing product lifecycle impacts is a shared task for all who are involved over the product lifecycle. EPR is the principle that the greater the *ability* of an actor to reduce environmental impacts within any phase of the lifecyle, the greater the *responsibility* to do so.

- Section 3 discusses the drivers, challenges and organizational responses to servicizing, focusing on why firms chose this route and what obstacles must be overcome.
- Section 4 turns to a discussion of environmental impacts of servicizing, using a simple conceptual lifecycle model to explore under what circumstances, and by what means, servicized products may yield environmental gains.
- Finally, in Section 5, we conclude with some thoughts on the policy implications of our study: what options are available for tapping the potential of servicizing to deliver environmental benefits?

All sections are informed by the set of seven case studies of servicizing firms that appear in Appendix A.

Box 3: A Taxonomy of Services



At the most elementary level, it is useful to divide services into two major categories — material (i.e., product-based) and non-material:

A. Non-material services

Non-material services are delivered via a supporting infrastructure and goods that remain in the hands of the service provider. Their value to the customer is totally — or near totally — tied to the information or technology embodied in the transaction. Non-material services include health care, hair salons, insurance and banking – essentially, the whole range of activities normally associated with the tertiary sector of the economy. Many, such health, lifestyle, and financial services, rely on relatively little material input. Others, such as transport and recreation, may be more material-dependent, but still well short of the material inputs associated with product extension and product utility services described earlier.

Non-material services include as a sub-category **dematerialized services**. In these cases, technology has obviated or drastically reduced the need for products altogether. In other words, the function once fulfilled by a product is now fulfilled essentially by information. One example is that of centralized voice mail supplanting answering machines (in which the messaging service once provided by a desktop machine is now provided by a combination of remote hardware and information transmission over the phone line. Compared to desktop answering machines, the hardware requirements are much reduced on a per-user basis.) Another example is the genetically-engineered pest-resistant seed. Here, instead of reliance on physical inputs (pesticides and fungicides) to deliver the desired service (crop protection), genetic information is encoded in the seed itself to defend against insects or disease.

B. Material, or product-based, services,

Material, or product-based, services by contrast, use an established, physical product as the vehicle, or platform, for delivering services related to the product for customers. For example, chemical management services center around the use of chemicals in a plant. Network integration services center around computer and telecom hardware and software systems. Material services incorporate both product-extension and product function services. These are the focus of our work, and are described in more detail on the facing page.

Service taxonomy (cont'd)

B1. Product Extension Services. Product extension services are characterized by customer ownership of the physical good, and thus represent only a minimal departure from a traditional, pure sell-buy arrangement which places full responsibility for the product in the hands of the buyer. Product extension services enhance the utility that ownership of the product delivers to the customer. The most familiar versions of these services include warranties and maintenance agreements.

In the case where the product must integrate into a complex environment, product extension services can mean managing the interface between the product and its work environment, hence maximizing the product's efficiency as well as effectiveness. The case of Xerox's document services, where document management activities beyond stand-alone copying are integrated within a networked and increasingly digital enterprise, is such an example. Another is Herman Miller's Coro commercial furnishings services business; Coro's post-occupancy services manage moves and inventory in customer's high-churn office environments. (See Appendix for case studies)

Characteristics likely to make products particularly suited for this type of servicizing include:

- **Material difficult to handle and/or requiring regular maintenance.** Industrial cleaning and office equipment are examples of items with frequent maintenance and repair requirements.
- **Products requiring extensive networking and/or technological expertise**. Information technology and computer networks demand integration and maintenance that are often more time-consuming and more costly than the initial purchase of the equipment. In such cases, product providers can often create competitive advantage by also providing the integration and maintenance service needs associated with these products; customers can obtain "one-stop-shopping" solutions.

B2. Product Function Services. In this category of services, ownership of goods resides with the service provider. Customers have the use of the product, but maintenance as well as end-of-life disposition are the responsibility of the service provider. Thus, the customer gains the function of the product is provided without ownership. Thus, traditional rental or leasing arrangements fall into this category. Product function services can be seen as a temporary flow or transfer of material goods from the provider to the customer (Graedel, 1997).

Also in this category are non-traditional leasing arrangements. AB Electrolux, for example, is experimenting with a "functional sales" concept, in which customers pay a monthly fee for the guaranteed "function" delivered by a product — e.g., professional kitchen equipment. In contrast to a traditional product lease, the arrangement is monthly, and the fee is for a guaranteed function rather than a particular piece of equipment.

From the customer's perspective, products particularly suited to this kind of servicizing include the following:

- **Product with lifetime greater than average customer use period.** Products such as elevators and office furniture, which often outlive the business or organization that uses them. The Swiss company Schindler AG began to sell "vertical transport" services to take advantage of the longevity of elevators. Its leasing contracts include maintenance and services, and in 1992 accounted for 70% of Schindler's revenues. (Weizsacker, Lovins and Lovins, 1997)
- **Products with low utilization rate and/or heavy infrastructure requirements**. Automobiles, for example, are often inconvenient to own because of cost and/or outright absence of parking space. Traditional car rental is a well-known of example of auto servicizing, wherein the customer is a temporary user who extracts the utility (mobility) value of the product on a temporary basis and is charged on a time and/or distance basis. Leasing, of course, is a variant on this arrangement. Taking traditional arrangements one step farther, the emerging "Mobility Services" enterprise provides the customer with the utility of a vehicle "on demand" without being encumbered with vehicle storage, insurance, maintenance, or repair. Services such as Call-a-Car in the Netherlands and Honda's Intelligent Community Vehicle System are examples of this newer service concept. Because easy accessibility of vehicles is crucial to customer satisfaction, mobility services enterprises require real-time information regarding demand.
- **Products characterized by rapid obsolescence**. Personal computers, for example, can become obsolete so quickly that it often discourages consumer investment. For these and similar products, services where the product supplier will provide periodic upgrades may gain a market advantage. For example, IBM has created a service called SystemCare, which includes an option that allows buyers to upgrade their computers after 24 months (Narisetti 1997).

2. The Servicizing/EPR Linkage

Extended Product Responsibility

Extended product responsibility (EPR) is the principle that actors along the product chain share responsibility for the lifecycle environmental impacts of the whole product system. The greater the ability of the actor to influence the environmental impacts of the product system, the greater the share of responsibility for addressing those impacts should be (PCSD, 1996).

- Consumers, for example, can affect environmental impacts of product systems in a number of ways: via purchase choices (i.e., choosing greener or more efficient products); via maintenance and environmentally conscious operation of durable goods and appliances (e.g., proper maintenance of automobiles improves fuel efficiency); and via disposal (e.g., recycling to the extent possible).
- *Suppliers* may have significant ability to influence the environmental impacts embodied in the materials and components they provide to product manufacturers. A supplier may have the choice, for example, between obtaining hardwood from a sustainably managed forest, or one subject to destructive forestry practices. Suppliers may apply pollution prevention principles to their own manufacturing operations.
- *Product manufacturers* are situated to reduce lifecycle environmental impacts of their products through their influence on product design, material choices, manufacturing processes, and product delivery (EPA, 1998a). Thus, for manufacturers, EPR is pollution prevention applied across the product lifecycle, extending well beyond the factory gates. Further, it is pollution prevention applied across business functions; application of lifecycle approaches in manufacturing necessarily extends beyond the EHS department to include product designers and production engineers, supply and operations, and product distribution and support (Stoughton et al., 1998).

Extended Product Responsibility: *the principle that actors along the product chain share responsibility for product lifecycle environmental impacts. The greater the ability of an actor to affect the impact, the greater the responsibility.*

Manufacturer Responsibility: US and Europe

Many of the most commonly cited examples of manufacturer EPR involve take-back activities. As the matrix below (Table 3) makes clear, however, manufacturer responsibility is not limited to these end-of-life or take-back activities. What these diverse EPR activities have in common is an extension of responsibility for, and involvement with, the product beyond historical practice, often into phases of the lifecycle in which the manufacturer has traditionally had little or no involvement. This may involve changes in formal property rights.

To date in the US, extensions of manufacturer responsibility are, for the most part, voluntary — albeit often inspired by the lessons learned in dealing with mandates abroad or by the desire to forestall mandates at home. In Europe and elsewhere, take-back and other regulations are assigning responsibility for elements of lifecycle per-

formance to actors in the product lifecycle. This mandating of "extended responsibility" has focused largely on end-of-life impacts and has assigned responsibility primarily to manufacturers. This focus is reflected in the terminology employed — in Europe, EPR stands for "extended *producer* responsibility."

Table 3 summarizes categories of EPR activity by manufacturing firms and provides examples of specific offerings and programs.

Table 3: Examples of Manufacturer Extended Product Responsibility in the U.S.

Corporate or Industry-wide Stewardship Programs	
Voluntary measures addressing environmental management systems and downstream environmental and safety aspects of product use (product stewardship)	• Chemical Manufacturer's Association Responsible Care initiative • User training programs (e.g., Monsanto) and user site audits (e.g., DuPont)
Take-Back or Buy-Back Programs/Initiatives	
Take-back of product, product components, or packaging for reuse, recycling or waste management.	• Product take-back by Nortel, IBM, and Xerox • (European auto and electronics initiatives)
Leasing Systems	
Ownership of (usually durable) materials and products is retained by the manufacturer or supplier	• Interface's carpet leasing program • Emergent leasing systems for PCs and other electronic equipment
Lifecycle Management	
Approaches to product design and development and management which attempt to minimize lifecycle impacts of products, typically including working with suppliers and users, and working to incorporate reused or recycled materials	• IBM's Environmentally Conscious Products Program • Nortel's Design for Environment Initiative • Xerox's Environmental Leadership Program
Partnerships for Recycling/Waste Management	
Cooperation among companies in the product chain to create common systems for recycling and waste management.	• Rechargeable Battery Recycling Corporation (rechargeable battery producers) • Vehicle Recycling Partnership (VRP) (Ford, GM, and Chrysler)

Source: Adapted from *Extended Product Responsibility: A New Principle for Product-Oriented Pollution Prevention*. (Davis and Witt, 1997). For more examples, see case studies, Appendix A.

Environmental benefits of EPR

The environmental benefits deriving from widespread application of EPR potentially include more efficient use of resources, cleaner products and technologies, more efficient manufacturing, reduced environmental hazards associated with storage, shipping, handling and disposal, increased recycling and recovery, and greener consumption (PCSD, 1996).

These benefits arise from the assumption of responsibility for lifecycle impact reductions by those in a position to effect such reductions. The allocation — or internalization— of responsibility in the product chain should lead to greater efficiency in the utilization of resources across the lifecycle, with a concomitant reduction in waste-related environmental impacts at any given level of economic activity.

Often this responsibility was previously unallocated — with manufacturers' responsibility for goods ending at the point of sale, and consumers' responsibility ending when the good is no longer useful. In this case, society bears the externalities represented by waste, pollution, and resource depletion arising across the product lifecycle.

With internalization, the environmental impacts associated with process wastes, product disposal, or in-use impacts will represent real economic costs to actors who have the ability to reduce these costs. In this sense, EPR can be thought of as a means of operationalizing the "polluter pays principle" — a concept well established in Europe. By assigning responsibility according to the *ability* of the actor to bring about environmental improvements, however, EPR goes beyond the polluter pays principle. For example, while consumers may be responsible, strictly speaking, for the use-related impacts of their automobiles, under EPR both consumers and manufacturers share the burden for reducing these impacts — consumers via purchase decisions and driving habits, manufacturers via vehicle and engine design.

Figure 3 depicts an EPR scheme in which the manufacturer accepts (or is assigned) responsibility for (1) costs of breakdown and repair during an extended warranty period,

and (2) disposal at end of life. Effectively, this means that the manufacturer assumes ownership of the good at end of life, a change in typical property rights in which the manufacturer's ownership ends at the point of sale. Because repair and disposal costs are now internalized, the manufacturer has incentives to reduce these costs by increasing product durability, reliability, recyclability and remanufacturability. (This resembles European EPR schemes for durable goods, where take-back obligations are assigned. The scheme could apply to automobiles, replacing the typical warrant associated with auto purchase.

Servicizing and EPR

What, then, is the relationship between servicizing and EPR? Servicizing is a business strategy which defines and serves a market's functional needs for speed, convenience, flexibility, and other value-added attributes. EPR is a principle whose application should result in lower lifecycle environmental impacts for products or product systems. The intersection is that both require manufacturers or service providers to extend their involvement with, and responsibility for, the product to phases in the lifecycle outside the traditional seller-buyer relationship.

If servicizing contains within it potential environmental benefits, it is in large part because this altered relationship with the product drives superior environmental performance — in short, because servicizing drives EPR.

But does servicizing always lead to, or incentivize, EPR? As the following discussion illustrates, there is no simple answer to this question. Rather, the answer seems to be potentially yes, in certain cases.

Potential economic incentives from servicizing that drive environmental improvement

Assuming that actors along the product lifecyle pursue voluntary EPR primarily for economic reasons, then achieving EPR in a non-regulatory context means that the market must align responsibility and incentives to improve environmental performance with those actors who have the *ability* to reduce the lifecycle impacts in question.

Based on the discussion thus far, three situations would appear to position servicizing as a vehicle which leads manufacturers (or service providers) to reduce lifecycle environmental impacts. These are situations in which the servicizing arrangement:

(1) results in internalizing use or disposal costs;

(2) is driven by the economic value of the end-of-life good; or

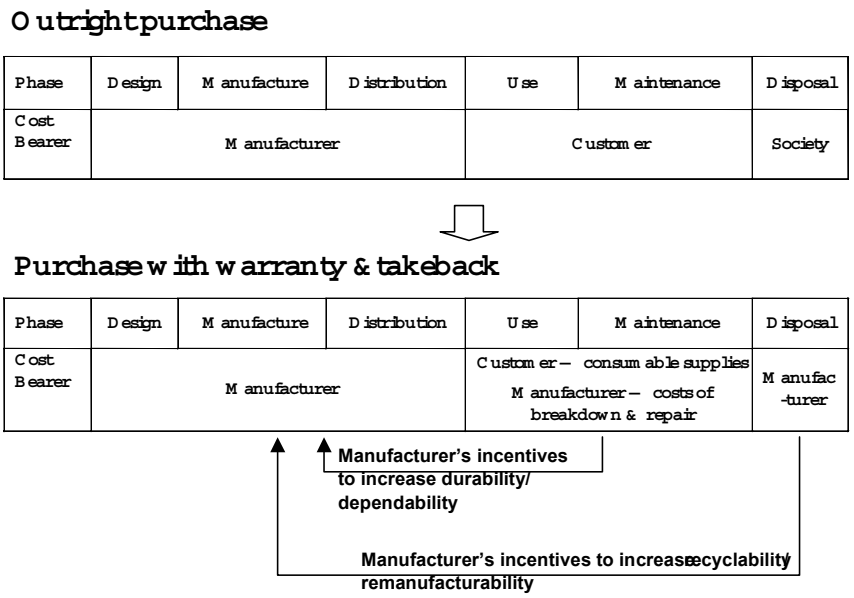
(3) reconstitutes the product as a cost rather than a profit center.

Each of these scenarios is described below. All potentially lead to environmental impact reductions by providing economic incentives to increase the efficiency with which resources are utilized in various phases of the lifecycle.[1]

***If servicizing contains within it potential environmental benefits,** it is in large part because this altered relationship with the product drives superior environmental performance — in short, because servicizing drives EPR.*

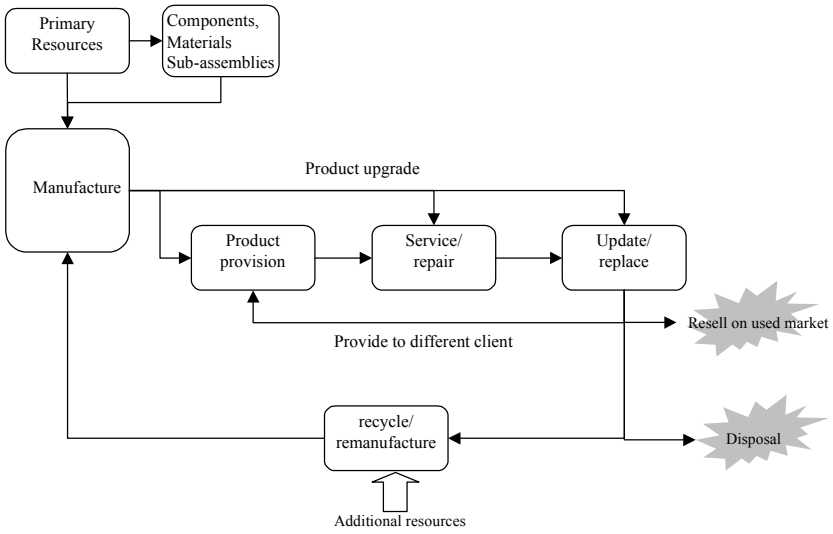
[1] Resource efficiency is a necessary attribute of a more sustainable economy and underlies the "eco-efficiency" concept introduced by the World Business Council on Sustainable Development (Schmidheiny, 1992). Eco-efficiency rests on the proposition that current industrial economies employ resources in extremely inefficient ways. It thus is possible to decrease the environmental burden associated with each unit of economic value created by increasing the efficiency with which resources are utilized.

Figure 3: Servicizing of a durable good: product take-back



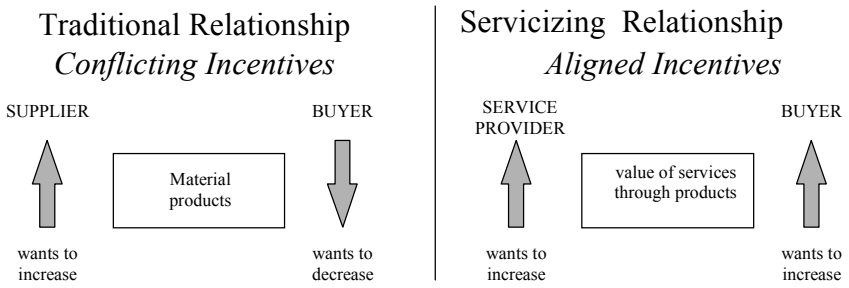
Source: Tellus Institute

Figure 4: Servicized PC Product Offering



Source: Tellus Institute

Figure 5: Incentives in a traditional sales model versus a service model



Source: Reiskin, White and Johnson, 1998.

Consistent with the focus of this work, the discussions focus on servicizing as a business strategy with possible environmental implications, rather than a business strategy pursued, or marketed with, an explicit environmental component.

Internalization of use or disposal costs

Some servicizing arrangements internalize environmental costs associated with use or disposal of the product. In such cases, the manufacturer has an incentive — in theory — to reduce these costs to improve the competitiveness of its product.

- An appliance manufacturer offers a fixed-fee contract to provide commercial laundering services. Laundering consumes significant amounts of water and energy, both of which add to the manufacturer's costs. In a competitive market for such services, the manufacturer will have an incentive to produce machines efficient in both water and energy use. Reduced resource use will lower costs and allow more competitive pricing or higher margins.
- A truck manufacturer leases vehicles at a fixed price per mile and includes all maintenance and repair. Because maintenance and repair are now costs to the manufacturer, an incentive may exist to build a more durable, lower maintenance vehicle.
- If the truck manufacturer also incurs disposal costs, the manufacturer may have an incentive to design a more recyclable/remanufacturable vehicle.

Typically, the costs internalized will not be the full social costs of resources consumed and wastes produced, but rather the direct costs of fuel, electricity or consumable supplies, and the economic costs of disposal. Cost internalization is thus partial, not full. The effectiveness of cost internalization as a driver to minimizing use and disposal impacts is likely to depend on: (1) the size of these costs relative to total costs and (2) whether or not these costs can be passed through to the customer.

Economic value of end-of-life good

Some servicizing activities may be driven in part by the economic value of the end-of-life good. The good may contain reusable components or valuable materials, embodying energy, labor and capital. In such cases, the servicizing activity may be motivated by the opportunity to recover this value by product reclamation activities — recycling, remanufacturing, reuse. All have the effect of reducing end-of-life disposal impacts and reducing the amount of virgin material and energy mobilized to make the good.

***Economic incentives to EPR which* may *arise from servicizing*:**

- ***internalization*** *of use or disposal costs*
- ***recovery of economic value*** *of an end-of-life good*
- ***transformation of the product*** *into a cost rather than a profit center*

This second scenario, of course, relates to the previous one, in which a servicizing arrangement internalizes to the manufacturer the disposal costs of a good. The firm may in this case be driven to examine this end-of-life product as a potential asset, or to make efforts to increase its value. Such efforts might include introducing design for disassembly or upgradability. It should also be noted that the benefit of recovering embodied labor, material, or capital is likely to depend significantly on the costs of a recovery infrastructure. Where an existing infrastructure processes end-of-life goods or can be adapted to this purpose, material or component recovery may be achievable at significantly lower cost than if a manufacturer must create such an infrastructure from scratch.

Figure 4 depicts a servicized product offering for PCs, loosely modeled on IBM's SystemXtra PC leasing program for commercial customers (see IBM case study, Appendix A). The manufacturer retains ownership of the machines throughout the lease period, and has in place a distribution and service system serving the customer on-site. Thus, the reverse logistics arrangements which permit product take-back and reclamation activities are already in place, and the manufacturer has incentive to recover value from post-lease machines — both because they are an owned asset, and because disposal incurs costs.

Product as cost, not profit center

Where the servicizing arrangement means that provision of the product is a cost, rather than a source of profit, the service provider will have incentive to reduce the number of units employed to yield a given quantity of service.

***These incentives highlight* possibilities *for, not assurances of, environmental gains* from servicizing. The situations themselves may not apply to any particular servicized product offering — and if they do, the cause-and-effect relationships they describe (economic stimulus yields firm response) may be insufficiently strong to influence firm behavior.**

- Consider, for example, a chemical management services (CMS) model in which the chemical supplier takes over aspects of chemical management from the chemical user (a manufacturer) (Figure 5). These activities range from procurement, delivery, and inventory control to EH&S reporting and end-of-life management. In a typical supplier-customer relationship, the supplier's revenues are driven by volume sold — an incentive perverse both to the manufacturer's best interests and those of the environment, which would be best served by chemical use reduction.

  If the CMS provider's compensation is based on service provided and gain-sharing from provider-identified efficiency improvements in the manufacturer's processes, supplier and manufacturer incentives become aligned. The supplier's profitability is divorced from volume sold, and in fact increases when chemical use decreases. And the customer enjoys the benefits of higher efficiencies and lower cost. In this model, the supplier-manufacturer relationship becomes an alliance in which each partner exploits their core competency. Such a relationship demands closer coordination and a greater degree of mutual trust than is typical of a standard supplier-customer relationship.[2]

Servicizing does not always generate these incentives

Again, servicizing is a business strategy which *might* move the firm into EPR activity and yield environmental benefits. These benefits derive from reallocation of property rights or responsibility across the product lifecycle and the consequent internalization of environmental costs and benefits.

The existence in a servicizing situation of one or more of the three incentives just discussed would seem, *a priori*, to make achieving these environmental benefits from servicizing much more likely. These incentives define an alignment between economic incentives facing the firm and environmental benefits to society:

- when servicizing has the effect of internalizing use or disposal costs;
- when the product concerned has significant end-of-life value;
- when servicizing renders product provision into a cost rather than a profit center.

[2] For a description of the CMS model, see Johnson, White and Hearne, 1997; Reiskin, White and Johnson, 1998; Votta, et al., 1998.

These incentives highlight possibilities for, not assurances of, environmental gains from servicizing. The three situations may not apply to a particular servicized product offering — and if they do, the cause and effect relationships they describe (economic stimulus yields firm response) may be insufficiently strong to influence firm behavior.

Section 4 looks at this question in detail.

Surmounting organizational barriers

Beyond potentially giving rise to economic incentives which spur the manufacturer or service provider to reduce product lifecycle environmental impacts, servicized product offerings may reduce organizational resistance to EPR.

Organizational resistance to extending involvement with a product beyond point-of-sale and historical practice has been identified as a major barrier to increased manufacturer responsibility in environmental impacts of products (Stoughton et al., 1998). This resistance is rooted in the changes implied by this extended involvement — changes in metrics of performance and human capital requirements, the need for new forms of coordination across business functions, and the need for closer interaction with other actors in the lifecycle chain.

If a firm voluntarily pursues servicizing activities, then this resistance has — *prima facie* — been in some measure overcome by the strength of the market and business analysis which led to the decision to "servicize" the product. A significant barrier to EPR practice — a reluctance to extend producer involvement with the product —in all likelihood has been diminished.

•

As the case studies (Appendix A) and Section 3 make clear, these institutional barriers are surmountable. In certain cases, servicizing is driven by a discrete market opportunity, or simply represents a gradual evolution of existing offerings and engagement with the customer. In other cases (e.g., IBM, Xerox), servicizing is perceived as a survival strategy in the market or, in the case of DuPont, as part of a general innovation-seeking growth strategy in a mature industry, chemical manufacture.

***Servicized** product offerings may reduce organizational resistance to EPR.*

- It is clear, however, that integration of EPR into servicizing activities is by no means automatic, even once the barrier to extended lifecycle involvement has been overcome. Standard business analysis tools are not well-suited to allow firms to assess the business case for EPR activity. Adding environmental considerations to the product development cycle is often seen as lengthening time to market. Environmental and economic gains for the firm from EPR activities may not be reflected in the incentives of individual departments or line businesses (Stoughton et al., 1998

3. Servicizing Drivers, Challenges and Organizational Responses

How does the market environment and nature of the product affect the drivers and challenges of servicizing? How do firms respond and adapt organizationally? How do market and product characteristics and organizational response affect the possibility that servicizing will lead to EPR activity? These are critical questions whose answers must inform any policy design process.

To explore these questions, we examined seven companies spanning a diversity of sectors, engaged in servicizing activity:

- AB Electrolux (Appliances and "functional sales");
- Castrol Industrial North America (Lubricants and metal-working fluids and chemical management services);
- Coro (A Herman Miller business; post-occupancy furniture services);
- DuPont (diversified chemicals and chemical products; car-painting business and carpet services);
- IBM (computer hardware and software and "information solutions");
- Radian International and Dow Chemical (chemical management services and chemical manufacturing); and
- Xerox (document storage and reproduction and "document services.")

Case studies (Appendix A) of the first five companies are based on interviews supplemented with secondary material. The IBM and Xerox studies were based on published articles and literature and company reports.

Seven servicizing case studies:

- AB Electrolux
- Castrol Industrial North America
- Coro
- DuPont
- IBM
- Radian International/Dow Chemical
- Xerox

Drivers and Approaches to Servicizing

What triggers the move toward a servicizing business strategy or a servicized product offering? Our cases reveal several impetuses. In two cases — IBM and Xerox — a decision was made at the CEO level to define service rather than product provision as the center of a new business strategy. The leadership of both companies felt that a service orientation was a survival strategy in their respective markets — and that it was better to lead than to follow.

In IBM's case, the company had accumulated spectacular losses in the early 1990s ($18 billion by 1993), was widely perceived as having lost touch with its customers, and had clearly misjudged the significance of the personal computer and the consequences of desktop computing of its traditional mainframe hardware-and-software business. IBM had protected that business at huge opportunity cost. In the case of Xerox, the company had successfully won back significant market share from competitors — but in defending its core light-lens copier business, the company had failed to capitalize on a number of its own inventions and innovations.

Both CEOs (Xerox's Allaire and IBM's Gerstner) realized that technology was rapidly redefining the markets their firms served — broadly, business management systems. A trend towards increasing integration of previously distinct business systems and hardware would progressively decrease the utility of both firms' stand-alone products. This can been seen as a *technological deepening*, that is, increased technology infrastructure requirements, for these business functions. The specialist skills required to acquire, integrate and service this infrastructure are increasingly difficult for customers to provide in-house. Thus, Xerox began focusing on its document strategy, integrating document storage and reproduction technology with customers' business systems to produce automated, just-in-time, customized document production. IBM began focusing on the hardware and software integration underlying "e-business" (electronic commerce).

- ***Firm approaches to servicizing*** *range from top-down strategic reorientations to gradualist approaches.*
- ***Rapidly changing business environments*** *seem to facilitate market acceptance of servicized product offerings.*
- ***Improving the environmental performance*** *of the firm's product was a significant impetus to servicizing for only one of seven case study firms — AB Electrolux.*

This said, service provision did leverage traditional product strengths in both cases. That is, both firms' products were not abandoned as much as redefined as vehicles to meet customers' functional needs. For IBM, "e-business" exploits the company's traditional strengths in large-scale processing and storage. For Xerox, xerographic reproduction is still a central part in its document strategy. Nonetheless, it is clear that the service reorientation of both firms requires a fundamental shift in corporate culture and market engagement — albeit a shift still ongoing, and one whose ultimate outcome remains uncertain.

In comparison to IBM and Xerox, technological change is considerably slower in the markets served by other firms in the case studies — e.g., appliances, lubricants, process chemicals, diversified chemical-related products, office furnishings. While there is some willingness among customers in these sectors to consider servicized product offerings as outsourcing options, their business environment is not changing so rapidly as to demand specialist services from suppliers. In these markets, servicized product offerings replace services previously carried out in-house. In such cases, the burden seems to be much more on the service provider to prove the economic benefits of their offerings.

Thus, the servicizing approaches of five firms we studied — AB Electrolux, Castrol Industrial, Coro, DuPont, Radian/Dow — may be characterized as more incremental. Their efforts may be viewed as (1) a more gradual evolution of existing lines of business and/or (2) a decision to pursue a specific and relatively narrowly delineated market opportunity as a new addition to existing business.

- DuPont, as a car paint and carpet fiber manufacturer, is now implementing a car painting service and carpet leasing program.
- Coro identified post-occupancy furnishings as an untapped market; this is a stand-alone business pursued independent of manufacturing operations.
- Castrol initiated its chemical management service offerings to leverage the focus of its industrial customers on outsourcing — but this also represented a logical outgrowth of Castrol's historical engagement with the customer.
- Radian, too, is an incrementalist case. The firm entered chemical management services (CMS) as a growth strategy and pursues CMS as a discrete service

offering. CMS builds on Radian's EH&S strengths. It does not, however, represent a radical change in the way in which Radian engages with its customers or the market. Radian has always been a consulting (services) organization, not a manufacturer — notwithstanding its brief alliance with Dow.

A number of the case study firms have a reputation for environmental innovation (e.g., Herman Miller, Xerox) or have engaged in end-of-life, EPR activity in other aspects of their business (e.g., product take-back by Xerox and IBM, Responsible Care at DuPont). However, improving the environmental performance of the firm's product offering has been a significant incentive to servicizing only for Electrolux. In this case, the original planning exercise which produced the functional sales model was organized by Electrolux' corporate environmental affairs division. This, of course, does not mean that servicizing driven from the business case cannot produce environmentally beneficial outcomes; Section 5 takes up the question of how and when this might happen.

Internal Challenges and Responses

Servicizing presents firms with challenges of organizational and cultural change. Transformation from a product-based to a service-based enterprise often encounters internal barriers which take time and resources to resolve. Traditional modes of production and sales may present formidable hurdles.

Internal challenges

For a customer considering a servicized product offering, the incentive is usually the specialist expertise or economies of scale which the service provider can bring to bear. Effective application of this expertise, however, often requires the provider to acquire a deeper (or broader) understanding of customers' business and production processes relative to that required by traditional product sales. This requirement brings with it not only new human resource requirements — often in areas not previously housed within the firm — but the added challenge of closer coordination with the customer. This coordination typically crosses a number of production departments or business functions. Thus, successful servicizing requires the provider to act more as ally and partner than as vendor. This, in turn, requires adjustments on the part of both parties..

***Where** service organizations coexist with traditional sales and distribution organizations and incentive and performance measures are at odds, conflict can result.*

Where one-time product sales (discrete, tangible transactions) are replaced by contracts operating over an extended period of time, traditional incentives and metrics can cease to reflect the real drivers of profit for the firm. This can be difficult for management as well as for line manufacturing businesses to accept. These traditional incentives and metrics focus on the volume of goods sold or the number of contracts signed. When servicizing has the effect of decoupling product volume from profits — and particularly in situations where provision of the product becomes a cost rather than a profit center — this disconnect may become particularly problematic.

Where service organizations coexist with traditional sales and distribution organizations and incentive and performance measures are at odds, conflict can result. Varying degrees of such conflict were observed in the case study firms:

- DuPont, with a highly diverse product line, found that its more traditional products such as carpet fibers are relatively more difficult to adapt to servicizing than products such as electronics parts, which are more accustomed to dematerialization as key to remaining competitive.
- This service-product conflict seems to be largely avoided, however, in the case of Herman Miller. In this instance, service offering (Coro) and product manufacturing and sales (other divisions) are separate and distinct. Servicizing affects product sales only indirectly and positively; the existence of Coro services can be a value-added argument for the furniture sales force.

- ***Organizational arrangements*** *underlying product sales and service exist on a continuum, from complete separation between manufacturing/product provision and service to full integration.*
- ***Most firms*** *adopt an intermediate approach*

- In contrast, chemical management services are typically associated with chemical use reduction. In this case, the service provider may be perceived as (and may, indeed, be) harmful to the profitability and performance of the manufacturing operation and its traditional sales force. Radian believes, for example, that Dow became concerned with potential conflicts between Radian's vision of total chemical management and its own chemical distribution organization.

Firm responses

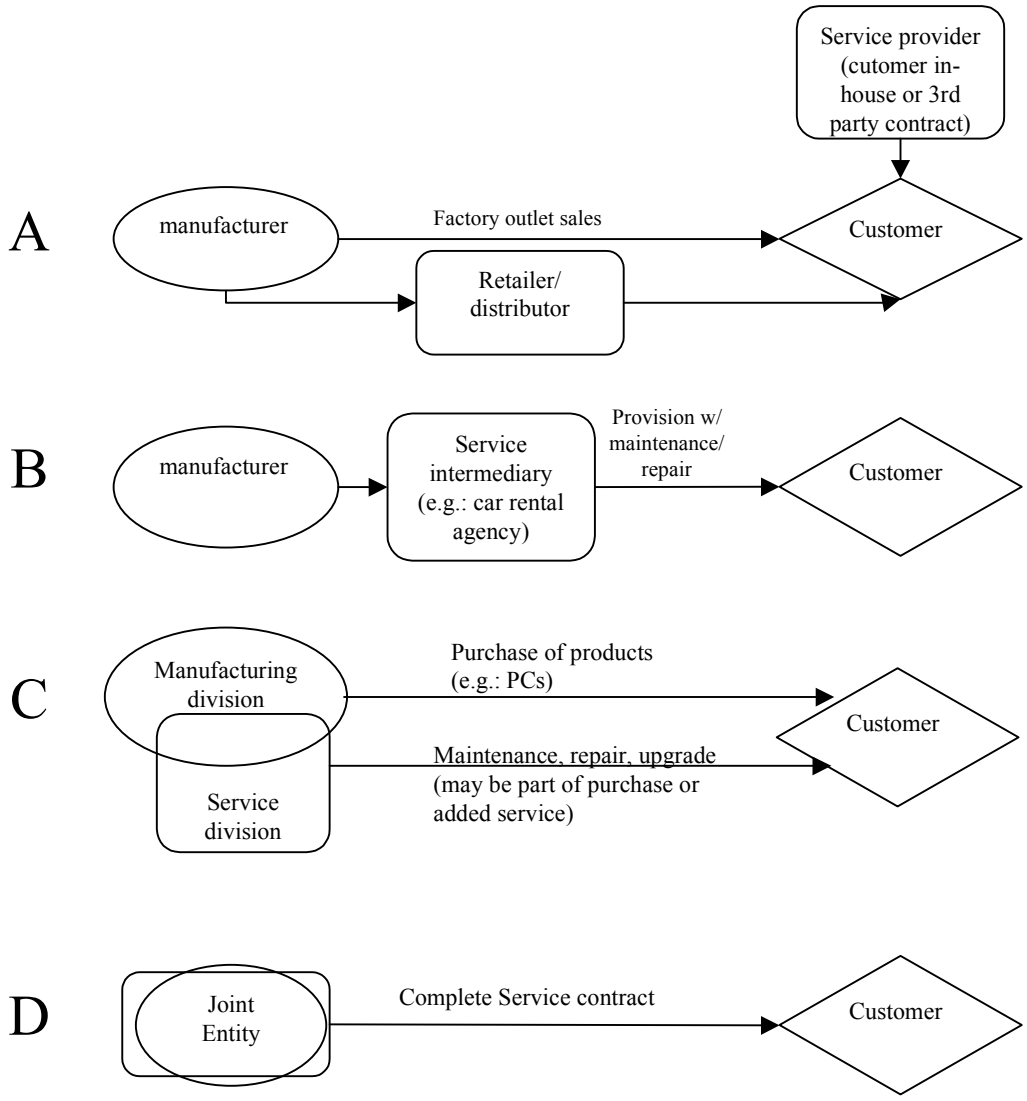
The case study firms differed in their response to this set of challenges. The limited information the companies were willing to disclose on the subject of incentives and metrics suggests that they often are dealt with post hoc, and on an ongoing basis.

By contrast, *organizational* arrangements which have evolved or been made to support servicized product offerings are somewhat more transparent in the case studies. In this area, the simplified framework in Figure 6 provides a tool for distinguishing these arrangements.

Organizational arrangements underlying product sales and service exist on a continuum, from complete separation between manufacturing/product provision and service to full integration, as in Figure 6. In this simplified scheme, most of the firms fell into the middle two characterizations (B and C).

- Radian provides chemical management services as an intermediary between the chemical manufacturer and the chemical customer (scheme B);
- Castrol provides similar services while manufacturing its own products, appearing to fall somewhere between schemes C & D.
- Coro's furniture services are sufficiently separated from Herman Miller's manufacturing operations that interaction between the two businesses is fairly limited. The arrangement shares elements of schemes C and A. Coro is not properly a service intermediary, as in scheme B, as the customer purchases furniture from Herman Miller or other manufacturers' retail networks.) This is also the case for DuPont Flooring Systems, a subsidiary of DuPont which leases carpets and offers carpet-related services.

Figure 6: Service and manufacturing: separation to integration



Source: Tellus Institute

External Barriers and Challenges

Gaining market acceptance

Servicized products must prove themselves to be superior to traditional stand-alone products and in-house services that they replace. As noted above, where technological change is rapid and demands specialist services that customers lack in-house, making the case for the servicized product may be easier. Given stable product technology, however, service providers offering traditional products in untraditional packages are under a significant burden to prove the worth of their offerings. This burden is rooted in a number of different factors:

- Coro notes that double burden posed by the servicizing model. On the one hand, service providers are outside organizations which must coordinate closely with their customer, often across business divisions — an area in which an in-house organization would presumably have a significant advantage. On the other, it is not sufficient to deliver cost savings alone — servicizing for the customer must represent a significant improvement in the level of service compared to the in-house or third-party contract services being supplanted.

- Electrolux notes the barrier to these services posed by customer psychology. To some European customers, both commercial and end-consumer, "leasing" implies both insufficient means to buy the product and the prospect of paying a very high rate of effective interest on the product investment. When (1) the opportunity costs of up-front capital expenditure and (2) the value of guaranteed access to the function provided by the product are not considered, outright purchase and ownership appears to provide the lowest cost alternative.

- The specialized skills, time, and significant costs attached to chemicals management might, *a priori*, seem to make chemical management services a readily embraced strategic outsourcing option. While the CMS model now seems to be gaining momentum, market acceptance for providers such as PPG, Ashland, Olin and Henkel has come only after large, well-known client companies such as General Motors adopted the model. The barriers experienced by the CMS approach, despite the economic arguments in its favor, are testimony to at least two factors: (1) the difficulties of trust — CMS replaces in-house services, engendering worries about loss of control, joint safety standards (a concern for both the supplier and the customer), and excessive reliance on one supplier; and (2) poor understanding of costs — just as deficient chemical cost accounting by industrial firms means they have incomplete understanding of their true chemical costs, much less what the cost savings might be by moving to CMS.

Information requirements

Services, by definition, are more nuanced and more differentiated according to individual customer preference than sales of "product in a box." The coordination requirements of the servicizing model have already been discussed. Both these points highlight the information-intensive nature of services. In a service model, quick response to clients' needs is essential. It is easy to see why: selling a pair of scissors is simple, but selling a haircut using the scissors requires taking into account the customer's style preferences as well as time and budget constraints. These are information elements which reach well beyond the physical goods used to deliver the service. In fact, so inseparable are service and information that almost 80% of information technology is bought and used by the service sector (Re-

jeski, 1997). Where the boundaries between products and services are no longer distinct, it has been suggested that the service content of a product can be seen as the informational content embodied in that product (Allenby, 1998).

Examples of this information-intensivity in the case studies include:

- In the cases of Xerox and IBM, which provide information technology and technology-intensive document services, the goal of servicizing is to integrate increasingly complex hardware and software products with each other in such a way as to serve the individual business needs of clients.
- DuPont, which found that it must find ways to grow beyond the traditional, material- and capital-intensive means, seeks to increase the "knowledge intensity" of its products as a general multi-year growth strategy. This means incorporating information of customers' needs into the products, so as to anticipate customer needs at each stage of the product lifecycle, in effect preemptively designing solutions into them.
- Coro's post-occupancy furniture services include programs such as "move management," office population tracking, and project management. These services are dependent on the successful coordination between Coro, the management of the client firm, its affected employees and the Herman Miller dealers who provide the moving services. Further, Coro is in large part a database manager, maintaining floorplans, furniture inventories, and personnel locations for its clients. Both coordination and the necessary tracking of space, furnishings and personnel are decidedly information-intensive.
- Electrolux sees profitable servicizing in its market — which involves managing an appliance "fleet" — as dependent on detailed information regarding customer use patterns. It is the compilation, monitoring and analysis of such information that is key to adding value and reducing waste — in materials, time, and labor — throughout the appliance system.

Implications for EPR

We have examined some of the drivers of servicizing, as well as a number of the internal and external challenges it presents to firms and their responses. A picture emerges which points to several implications for EPR.

- ***Autonomy** between service and manufacturing units may avoid internal conflict, but is less likely to drive environmentally-based changes in design and product manufacture.*
- ***Servicizing** may help to make the business case for EPR, but it is not sufficient.*
- ***Environmental drivers** in the market may make environmental gains from servicizing more likely.*

Recall that Section 3 offered three situations in which, *a priori*, servicizing might be expected to yield environmental benefits:

- when servicizing has the effect of internalizing use or disposal costs;
- when the product concerned has significant end-of-life value; and
- when servicizing renders product provision into a cost rather than a profit center.

All three situations define an alignment between economic incentives experienced by the firm under servicizing and an environmental benefit accruing to society at large. Though few in number, the cases allow some insights into how the simple picture of "economic stimulus and firm response" may be complicated in the real world of managing the firm.

Transmission of incentives

The organizational arrangements supporting servicized product offerings (Figure 6) illustrate that the relationship between manufacturing and service provision can exist on a spectrum from near-total autonomy to near-total integration. From an organizational perspective, autonomy would seem to avoid many potential problems arising from conflict between traditional sales and manufacturing and service provision. These arise, recall, when service units and quality conflict with traditional volume sales as the basis for supplier compensation.

Autonomy, unfortunately, is an organizational arrangement which seems less likely than integration to drive environmentally beneficial outcomes. This is because a major mechanism by which environmental benefits derive from EPR is changes to product design and manufacturing methods. In a voluntary EPR framework, these changes are driven by the incentives arising from service activities. Thus, tight integration between the service and manufacturing organizations is more likely to permit clear "transmission" of these incentives, allowing service activities to drive manufacturing or design changes. This indicates that the joint service/production entity represented by scheme "D" in Figure 6 has the best potential for a full-fledged EPR outcome.

Finally, it is clear from prior EPR research that incorporating lifecycle considerations into product design and manufacture is a complex process requiring close coordination across business functions and specialized decision-support tools. In general, the presence of an economic incentive to do so is not, by itself, sufficient (Stoughton et al., 1998; Shapiro and White, 1997).

Does servicizing "break ground" for EPR?

We earlier suggested that servicizing could reduce resistance to EPR by demonstrating business benefits for extended involvement in the product lifecycle. Servicized product offerings can (1) drive the firm to consider ways to recover the value embedded in the product and (2) support a reverse logistics infrastructure to support reclamation activities.

The case studies deliver mixed messages regarding these arguments. A reverse logistics infrastructure may ease the way for EPR activity, but a conscious decision to pursue reclamation activities is still required:

- Coro, for example currently accepts furniture trade-in and has many elements of a reverse logistics infrastructure in place. Trade-ins, however, are disposed of on the second-hand market, with a significant amount probably still going to landfills. The company, however, hopes to leverage this reverse logistics infrastructure to offer a "green" lifecycle management program to customers.

- Xerox has practiced product take-back for many years — copiers were originally leased rather than owned. But old product was simply landfilled or warehoused; the company did not pursue a reclamation strategy until recently, well after pursuing reinvention as the "document company."

Of course, the value of reclaimed photocopier components far exceeds that of an office chair or desk. From this perspective, the servicizing-EPR link seems more likely to yield environmental benefits through take-back when high-value materials and components are involved.

Environmental drivers in the market

Clearly, a number of barriers stand between servicizing activities pursued for business strategy reasons and those pursued for environmental gains. Environmental preferences in the market may make such gains more

likely by focusing the attention of firms on environmental outcomes.

Electrolux is the only case study company for which improving the environmental performance of a product was an explicit incentive to a servicized product offering. The European markets which Electrolux serves, of course, are increasingly subject to mandated producer responsibility for end-of-life product management. Further, Northern European markets are in particular widely seen as placing a high premium on the environmental performance of products. In contrast, U.S. markets are less strongly influenced, either by end-of-life regulation or green consumer preferences; producers still view the latter as constituting only small, niche markets.

It is therefore of little surprise that, among the limited sample of companies, indications are mixed regarding the use of environmental performance as a means to promote service offerings in the U.S. market. Neither Castrol, Radian, nor DuPont, for example, stress their service offerings as a means of achieving beyond-compliance environmental performance, though such service models are well-suited to improving chemical management and driving chemical use reductions. On the other hand, Coro believes that tying its service model to a life-cycle management option may be an effective means of differentiating its offering in the future.

4. Environmental Impacts of Servicizing

EPR is a principle for spreading responsibility for product lifecycle impacts across multiple participants. Three situations in which product servicizing can, in some circumstances, drive efforts to reduce these lifecycle impacts by stimulating EPR activity are: cost internalization; economic value at end of life; and treating the product as a cost, not a profit center. All may be characterized as economic drivers to resource efficiency.

In general, understanding the impacts of service activities is in its infancy relative to manufacturing activities (Graedel, 1998). This section uses a lifecycle framework to describe the general means by which environmental impacts may be reduced in the use and non-use stages of the lifecycle. This includes assessment of the conditions under which servicizing may achieve these reductions. This discussion is exploratory. The linkages are complex and situation-specific. Nonetheless, scoping these linkages will help move beyond generalizations and intuition to begin establishing a firmer basis upon which to fashion policy recommendations.

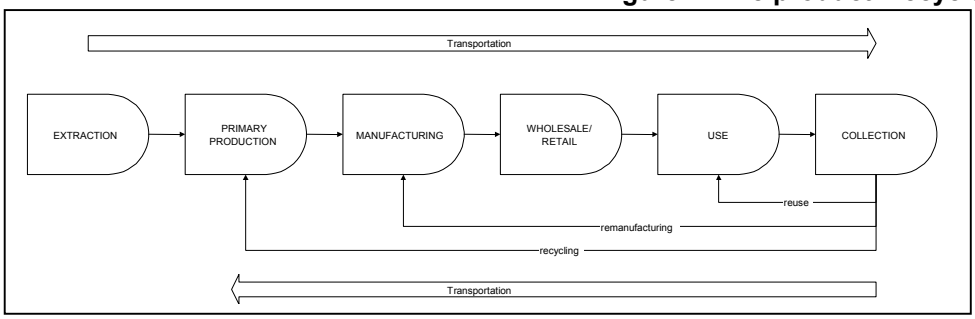
Key Concepts of Lifecycle Analysis for Servicizing

Figure 7 depicts the familiar lifecycle of a product, from raw materials extraction to end-of-life. In most product markets, the reuse, remanufacturing and recycling loops depicted are weak, capturing little of the product throughput.[3] Each stage of the lifecycle generates a set of environmental impacts. The lifecycle environmental impacts of a product or product system, as opposed to a single use, are the aggregate of the impacts in each phase. This framework forms the basis for a high-level assessment of the lifecycle impacts associated with a particular product under a servicized business model.

Service units as a basis for comparison

In broadest terms, servicizing describes changes in the way that the services, or utility, provided by products are delivered to customers. Comparing lifecycle impacts of alternative means of service provision requires a measure of service that is independent of the means by which the service is delivered. For example, rather than "loads of laundry" or "washer cycles" being the measure of utility, "pounds of clothes cleaned" would be preferable.

Figure 7: The product lifecycle



Source: Tellus Institute

[3] Exceptions in which these reclamation loops are strong in the U.S. include: automobiles (75% recycling by weight, with substantial markets for used and remanufactured components) (Das et al., 1995), and aluminum cans (63.5% reclamation rate) (EPA, 1998b).

Box 4: Environmental performance improvements associated with reclamation activities

Obviously, the environmental performance of reclamation activities varies by material and by product. However, environmental gains from recycling (the reclamation activity which salvages the least energy, labor and processing embedded in the end-of-life good) carries significant environmental gains across a wide range of materials. The table below gives reductions in *production* impacts for several common materials. Avoided disposal impacts are not assessed; if included, environmental gains from recycling would be greater. While the study quoted did not assess plastics recycling, it does document that a significant portion of environmental impacts in plastics manufacture is due to petroleum extraction, refining and feedstock production. Environmental gains from recycling would therefore be expected to be significant. Environmental gains would in general be expected to be higher for higher-level reclamation.

	Impact reduction (increase) represented by recycled production compared to virgin production						
Material	Energy (MMBTU/ton)	CO (lbs/ton)	NOx (lbs/ton)	Particulates (lbs/ton)	Sox (lbs/ton)	VOCs (lbs/ton)	Toxics (lbs/ton**)
Paper*	35%	96%	(176%)	92%	(75%)	56%	83%
Aluminum	96%	96%	98%	50%	99%	98%	99.6%
Glass	26%	54%	38%	68%	54%	1%	89.9%
Steel**	15%	6%	3%	7%	(19%)	9%	6%

*average of linerboard and boxboard; **Basic oxygen furnace production only; electric arc production for recycled steel not assessed.
** weighted by relative health Impacts

Source: Tellus , 1992

Expressing in-use environmental impacts

In-use impacts associated with a stock of products functioning in the economy (e.g., the use-related environmental impacts associated with U.S. refrigerators) can be expressed in simplest terms as:

$$total\_impacts\_in\_use = \sum_i service\_units_i \times impacts\_per\_service\_unit$$

Where

i is each product in the stock,

service_units$_i$ denote the amount of service delivered by each product in the stock in a given year, and

impacts_per_service_unit$_i$ denote the environmental impacts per unit of service. Environmental impacts may be characterized by a single metric, or by several. If environmental impacts are characterized by several metrics — for example, emissions of CO_2 and criteria air pollutants — both impacts per service unit and total impacts in use become vectors. Further maintenance, repair and upgrade affect impacts per service unit.

Expressing non-use environmental impacts

Non-use impacts are those that arise from all other elements of the product lifecycle: raw materials extraction, primary production and production of components and intermediate goods, manufacturing, wholesale/retail, and end-of-life. In very simple terms, these can be expressed as:

$$non\_use\_impacts = \sum_p n \times impacts\_per\_product_p$$

Where

- *n* identical products (or units of product, as in the case of chemicals) are manufactured
- *p* are non-use phases of the lifecycle
- *impacts_per_product*$_p$ are the impacts incurred by one product in a single phase of the lifecycle.

Defining service units can be difficult. For example, a subway and a private vehicle may provide the same objective service — moving a person from point A to point B. But subjective factors such as convenience, flexibility and privacy must enter the comparison. For this exploratory assessment, the problem is simplified. By examining "product-based services," we assume that services are delivered by the same products as under a conventional purchase arrangement. What is changed are the property rights and/or the additional services provided by the manufacturer or intermediary. This limited case is a starting point for further research of alternative and/or more complex model.

Use vs. non-use impacts

The distinction between use and non-use impacts is essential to assessing the lifecycle environmental issues associated with servicizing. The determinants of use and non-use impacts tend to be different — a key distinction for effective policy design which must intervene at specific points in the lifecycle. Impact reductions in one category may increase impacts in the other. What, then, distinguishes use from non-use impacts? Generally, we can say that:

- All else equal, impacts in all categories *except use* scale with the number of products produced. Non-use impacts also depend on the environmental performance of the processes in each non-use stage.
- Impacts in *use* scale with the number of service units delivered *and* the efficiency of the product. Efficiency in some cases is strongly contingent not just on product design, but on maintenance and operator training (this is, for example, less true of home electronics, but more true of automobiles and industrial equipment).

  Most products produce few impacts when not actively utilized. A washing machine creates impacts when clothes are washed, not when turned off. An auto creates few impacts while parked at the curb, with the notable exception of congestion if parked in a public right-of-way[4]

- ***The service unit*** *— a measure of utility — must be the means of comparing lifecycle impacts of alternative means of delivering the same function or utility.*
- ***Reclamation activities*** *(recycling, remanufacturing, reuse) do generate environmental impacts, but these are generally less than those generated by the use of virgin materials.*

Effects of reclamation activities

- Reclamation activities (recycling, remanufacturing, and reuse) reduce end-of-life, extraction, primary production and often manufacturing impacts. This occurs because, in recapturing some of the material and energy embodied in the original product, reclamation activities reduce the amount of material extracted and disposed of over the lifecycle of a given number of products.
- Reclamation operations do generate their own environmental impacts, in transportation and in the processes used to remanufacture or recycle products, components and materials. Typically, however, these impacts — especially in the case of remanufacturing — are strongly offset by impact reductions in extraction, primary production, manufacturing and end-of-life. (See Box 4).

[4] The consumption of "standby" electrical power by many electronic goods, even when turned "off," is an exception.

Reducing Use and Non-Use Impacts Under Servicizing

Reducing in-use impacts

Reducing in-use impacts requires either reducing the number of service units delivered, or reducing the impacts per service unit.

There is little reason to believe that the types of servicizing with which this study is concerned will, in general, reduce the number of service units consumed. Such reductions are a function of broader trends in consumer behavior and intentional policy interventions aimed at altering consumption trends. Under this assumption, if servicizing has an effect on in-use impacts, it must do so by reducing the environmental impacts created per unit of service.

***Use impacts** associated with a product may be reduced by:*

- *changes in product design;*
- *increased turnover when consecutive product years are characterized by increased efficiency;*
- *enhanced or more optimal operation, e.g., better maintenance, operator training, process optimization.*

Impacts per unit of service, in turn, depend on the following factors: product design; age or cumulative service units delivered (where performance degrades over time); and, often, maintenance and operator training. Each of these factors may, in theory, be leveraged to achieve in use-reductions. Note again that this simplified analysis assumes product-based servicizing — that is, that services continue to be delivered by essentially the same products.

Reduced use impacts through product design

Designing products to be more efficient or less polluting in use has been a strategy widely employed in legislation and voluntary standards to reduce in-use impacts. Examples in the U.S. include mandated fleet average fuel economy for automobiles (CAFÉ standards), as well as auto emission limits for CO, SOx and NOx; mandated energy efficiency standards for major appliances (e.g., refrigerators); mandated water efficiency standards for household fixtures; and voluntary energy efficiency standards such as the Energy Star label for office equipment.

Servicizing is likely to provide an incentive to manufacturers for more efficient product design only when the terms of service provision internalize use-related environmental costs. For example, if a manufacturer provides refrigeration services to an industrial or commercial establishment on a fixed-fee basis, the costs of energy used by the refrigerators are borne by the manufacturer rather than the client. Where these costs are a significant fraction of the total costs of service provision, and where the market is competitive for this type of service, reducing use-related environmental costs will allow the manufacturer to price its service more competitively in the marketplace.

Reduced impacts via increased turnover

For durable or semi-durable goods, the stock of products in use is generally composed of a distribution of vintages, or product ages. *Where consecutive product years are characterized by increasing efficiency*, or where product performance degrades with time or cumulative use cycles, the impacts associated with the use of the overall stock of products will decrease as older vintages are retired and new models come into use, assuming that the number of products in use remains constant.[5]

[5] This may not be the case if servicizing itself induces larger markets for a given service unit. For example, P.C. leasing could make PCs

If the average age of products in use can be reduced, the impacts of the total product stock would decrease. Average age can be reduced by increasing the rate of turnover, or by selectively removing the oldest products from use — as in the case of accelerated retirement of older and highly polluting vehicles. (Note that this does not fall into any of the three previously identified situations in which servicizing may yield environmental benefits.)

Is servicizing likely to have this effect? In leasing a durable or semi-durable good, consumers typically expect relatively new units (e.g., cars, computers). Widespread servicizing of a product market might reduce the average product age. Most such leasing markets, however, rely on the used product market to absorb products whose useful leasing life has expired. Examples in the U.S. include sales of used fleet cars by car rental companies, absorption of used office equipment by second-hand dealers, and, with the emergence of servicized PC markets, perhaps significant resales of older computer equipment.

Reduced impacts via enhanced operation

For many durable and semi-durable goods, maintenance, operator training, and/or process optimization has a significant effect on in-use environmental impacts. A prominent example of this type is the automobile; but it also applies in general to complex mechanical equipment.[6]

Where more optimal operation can reduce in-use environmental impacts, there are two situations in which a servicized product offering might lead to such reduction:

- Where servicizing internalizes use-related environmental costs, service providers may be incentivized to improve operation and reduce these costs. A cleaning services supplier, for example, who absorbs the cost of consumable supplies has an incentive to train operators in more optimal operation of the equipment.

***Non-use impacts** associated with a product may be reduced by:*

- *reducing the number or volume of product manufactured;*
- *reducing material and energy throughput per unit;*
- *improved environmental performance in non-use processes.*

- Where provision of the product is treated as a cost rather than a profit center, and improved operation and maintenance extends product life and/or reduces the quantity of product required to deliver the service, environmental benefits are achievable. As in the cases of Castrol, Radian, and others, a CMS provider might be compensated on the basis of service delivered (e.g., coating, cleaning) rather than on the volume of chemicals sold. In this case, the provider has an incentive to increase process efficiency and reduce waste.

Reducing non-use impacts

Non-use impacts are those that arise from all other elements of the product lifecycle: raw materials extraction, primary production and production of components and intermediate goods, manufacturing, wholesale/retail, and end-of-life.

Reducing non-use impacts requires either (1) reducing the number of units manufactured, or (2) reducing per-unit impacts in

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available to lower income households for which current costs are prohibitive.

[6] Operator training can significantly lower the in-use impacts associated with cleaning equipment, for example (Agri et al, 1999).

one or more phases of the lifecycle (see Box 4 "expressing non-use environmental impact").

Again for simplicity, assume that the number of service units delivered is constant, i.e., demand does not change. Then the number of products manufactured depends on the lifetime/durability of the product, and the number/volume of products required to deliver a given quantity of service.

Impacts per unit over each phase of the lifecycle, in turn, depend (1) on the environmental performance of the operations in each phase, per product unit, and (2) on the nature and volume of materials mobilized in each phase to produce one product unit (i.e., material and energy throughput).

***Reducing the number or volume of products manufactured** thus depends on increasing one or more of the following: product durability, service capacity, or efficiency of use. . .*

***In certain situations**, servicizing could provide incentives for manufacturers to take these actions.*

Each of these factors can *in theory* be leveraged to achieve non-use impact reductions. The potential of servicizing to achieve this leverage is discussed below.

Non-use reductions by reducing the number or volume of product manufactured:

The number (or volume) of products required to deliver a given number of service units depends on the durability of the product (or design lifetime) and, in some cases, on the efficiency with which the product is employed or its service capacity (that is, the number of service units which one product can deliver).

Durable or semi-durable goods typically have a design lifetime which can be expressed as a number of operating cycles (e.g., hours on a power plant or compressor, cumulative pages on a copier, wash cycles in a washing machine). In the long run, more intensive utilization of the product of unchanged durability and service capacity will not reduce the number of products manufactured. Rather, each individual product will simply have a shorter calendar life.

Reducing the number or volume of products manufactured thus depends on increasing one or more of the following: product durability, service capacity, or efficiency of use:

- More durable products will last through more use cycles and fewer will need to be manufactured[7] — assuming that the more durable product is not technically obsolete before its design life ends.
- Products of a larger service capacity will, in general, realize economies of material scale. That is, the goods and energy employed to produce 10 large industrial washing machines are likely less than those employed to produce 30 smaller domestic units whose aggregate capacity is the same.
- In some cases, the *efficiency* with which a product is used determines the quantity needed to produce a given level of service. This is particularly true of chemicals. E.g., the quantity of paint or solvent used in a manufacturing process,can vary widely with the operator and equipment configuration.

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[7] More durable products are in general heavier and more robustly built than less durable ones. Thus, all else equal, for each unit of a more durable good manufactured, more materials and energy are mobilized, and non-use impacts are higher than for less durable goods. In *general*, the reduction in products manufactured will offset these increased per-unit impacts. Consider, for example, a small electric appliance such as a toaster oven, with an average life of four years. Making an oven which would last twice as long would mean a heavier product — thicker metal, more robust hinges, heavier electrical connections. But these impacts are likely to be far less than those incurred by manufacturing a second, less durable oven to replace the one disposed after four years of operation..

In certain situations, servicizing could provide incentives for manufacturers to take these actions and reduce the number (or volume) of products manufactured. This would occur when provision of the product is a cost rather than a profit center; that is, the product becomes a cost of doing business (like labor and capital), not a profit maker. Incentives are provided to reduce cost of this provision by:

- Increasing product durability or extending product life, through design changes or better maintenance and operation;
- Producing products of a larger service capacity to realize economies of scale;
- Utilizing products more efficiently, to reduce the number or volume of product required.

A service provider who bears the costs of breakdown and unscheduled downtime, for example, has an incentive to practice better maintenance. Examples might include an energy service provider responsible for a boiler in an apartment building or a car sharing or leasing company for which regular and preventive maintenance means fewer car purchases over time.

Non-use reductions by reducing material and energy throughput per unit

The materials and energy mobilized to produce a product are a significant source of environmental impacts. Each pound of plastic or metals employed has a large ecological footprint — energy used and pollution generated in extraction and refining, ecosystem degradation in extraction operations, and so forth. Turning these materials into components and intermediate goods requires further resources and generates additional wastes. Thus, reducing the material and energy throughput per product necessarily reduces per-unit, non-use impacts across the lifecycle.

The various reclamation paths depicted in the product lifecycle (Figure 7) — recycling, remanufacturing, reuse — all have the effect of reducing material and energy throughput per product produced. Recycling extracts basic materials — metals, plastics, fibers — for reuse. Remanufacturing refurbishes used components or assemblies for incorporation into new units — or refurbishes whole products for resale.

- By reducing the amount of virgin materials required to make one product unit, all reclamation activities reduce extraction impacts. By diverting material from landfill or other end-of-life disposition (e.g., incineration), reclamation activities also reduce disposal impacts.[8]
- Remanufacturing and reuse additionally reduce the energy and resources required to transform raw materials (or components) into finished product. Thus, these types of reclamation reduce manufacturing impacts.

***The materials and energy** mobilized to produce a product are a significant source of environmental impacts. . . reducing the material and energy throughput per product necessarily reduces per-unit, non-use impacts across the lifecycle.*

Recycling, remanufacturing and reuse do create environmental impacts not present in a linear product life ending in disposal. Recycling and remanufacturing processes can be pollution-intensive. All require reverse logistics systems more elaborate than send-

[8] In some cases, embodied energy, for example, may be partially recovered in incineration, thereby reducing net impacts associated with new product creation. Of course, incineration can have other undesirable environmental impacts, such as metals emissions to air and solid residuals.

ing material to the landfill, with consequent transport-related impacts. However, these reclamation-associated impacts are in general significantly less than those incurred by the use of virgin materials. This is especially true when remanufacturing is compared to the impacts of new product manufacture.

While the use of reclaimed materials and components forces a number of changes in manufacturing processes, there is no particular reason to believe that servicizing in and of itself creates a commitment to pollution prevention (which generally requires more efficient use of materials) on the part of the manufacturer. This issue is addressed below. Nor is there reason to suspect that servicizing automatically leads to "lightweighting" of products (reducing weight per unit), another potential source of throughput reduction. In fact, servicizing may drive increases in durability and product life, as product manufacturers seek to stretch the longevity of product to avoid the cost of early replacement.

Non-use reductions by improved environmental performance in non-use processes

As discussed above, the volume of materials and energy mobilized to produce one product unit affect non-use environmental impacts of processes employed in manufacturing, distribution and retailing, and end-of-life. These impacts also depend, however, on the choices made in these processes and the manner in which they are carried out — that is, on the extent to which pollution prevention principles (or at least pollution control) are applied in each phase. E.g., a manufacturer may choose between two solvents, one environmentally preferable to the other. A supplier may have the choice of hardwood from sustainably managed forests, or those subject to destructive forestry practices. Such decisions have direct repercussions for non-use lifecycle impacts.

In general, there is no particular reason to anticipate that servicizing will cause product manufacturers or their upstream suppliers to more rigorously apply pollution prevention principles to their operations — unless the servicized product offering was marketed specifically on the basis of environmental characteristics. This said, servicizing might, in certain circumstances, stimulate *reclamation activities* (see above). In addition to reducing per-unit material and energy throughput, reclamation activities would be expected to improve the environmental performance of non-use processes in two ways:

- The use of recycled materials or remanufactured components would generally be expected to reduce the environmental impacts of manufacturing operations. In a reinforcing mechanism, servicizing which gives the manufacturer end-of-life ownership may prompt changes in manufacturing operations (e.g., encouraging design for disassembly and the use of recyclable materials).
- Reclamation activities reduce the volume of end-of-life material and, in general, increase the likelihood that these materials will be more properly disposed of. Both effects improve the environmental performance of end-of-life processes.

As above, reclamation activities are likely to arise from servicizing when (1) the product has economic value at end of life, or (2) the effect of servicizing is to internalize for the manufacturer the cost of disposal.

Summary

Table 4 summarizes the means by which servicizing may achieve lifecycle impact reductions. The picture that emerges is one of complexity and nuance, not easy wins. First for use stage impacts and then for non—use impacts, Table 4 depicts the possible source of impact reductions, the conditions necessary to realize reductions, and examples, both real and hypothetical, of cases where such reductions occur. It is clear that while opportunities for achieving environmental gains exist, they will not occur either automatically or for all servicized products. Shaping effective policy strategies mush focus on creating and for accelerating those conditions in which servicizing does, in fact, drive such social benefits. Section 5 outlines a number of approaches aimed at these objectives.

Table 4: Summary matrix: Possible reductions in environmental impacts derived from servicizing

	Source of impact reductions	Conditions to achieve reductions	Examples (real and hypothetical)
Use Impacts	Via product design	Use-related environmental costs are internalized, and these costs may be reduced by better design of products.	A manufacturer provides refrigeration services on a fixed fee basis. As electricity costs are a substantial portion of the costs of providing the service, the manufacturer has incentive to produce a more efficient unit.
	Via increased turnover	Servicizing drives more rapid turnover of product stock in use combined with progressive efficiency improvements in consecutive model years.	A major appliance market becomes servicized under leasing arrangements, concurrent with mandated efficiency improvements. Resale of older, "post-lease" units is prohibited. An energy services company (providing heating services at a fee indexed to outside temperature) replaces a heating system in a commercial building with more energy-efficient/cost-saving equipment.
	Via more optimal operation of existing product (maintenance, training, process efficiency)	• Use-related environmental costs are internalized, and these costs may be reduced by more optimal operation. • Where the product is a cost rather than a profit center, and more optimal operation extends product life/reduces product consumed.	A cleaning services provider absorbs the costs of equipment breakdown and consumable supplies, providing incentive to train operators for more optimal operation of the machines. A chemical management services provider is compensated on the basis of service delivered rather than the volume of chemicals sold. Chemicals become a cost rather than a profit center; the provider has incentive to increase process efficiency in the plant.
Non- Use Impacts	Via reductions in number or volume of product manufactured (increased durability, larger service capacity, more efficient utilization)	The product is a cost rather than a profit center, providing incentives for any of the following: • More durable products • Products of a larger service capacity, via the realization of economies of scale • More efficient utilization of products in use	A manufacturer of commercial laundry equipment offers "laundering services" to large customers, guaranteeing machine availability and a given service capacity. The manufacturer thus has an incentive to provide large-capacity, durable machines which reduce maintenance costs.
	Via reductions in the volume of materials mobilized per unit (reclamation activities)	The product has economic value at end-of-life, or where end-of-life costs are internalized — in either case stimulating reclamation activities.	A manufacturer and provider of desktop computing services guarantees a two-year upgrade cycle to its customers, taking back obsolete equipment and incurring responsibility for its disposal. The provider has an incentive to treat this equipment as an asset, minimizing disposal costs and maximizing savings from recycling and reuse of viable components. This reduces virgin material employed in the manufacture of "new units." It also reduces disposal impacts of end-of-life units and may improve environmental performance of primary and product manufacturing.
	Via improved environmental performance of non-use processes. (esp. disposal impacts; reclamation activities)	The product has economic value at end-of-life, or where end-of-life costs are internalized — in either case stimulating reclamation activities.	

Turnover, vintage and use impacts

One tension which arises from the various environmental impact reduction summarized in Table 4 deserves further scrutiny:

- Potentially, reduction in use-related environmental impacts associated with a product can result from increased turnover of the product stock, accompanied by progressive efficiency improvements in new product over time.
- Increased turnover, however, means that a greater number of products are manufactured, with a commensurate increase in non-use related impacts.

IF product efficiency improvements can be continuously achieved:

- ➢ *increased turnover (shorter use life) may reduce use-related impacts;*
- ➢ *but non-use impacts increase as more products are manufactured.*

Table 5: Rough lifecycle impact data for two durable goods

impact (Unit)	AUTO (a)		REFRIGERATOR	
	Manfr. & upstream impacts	Use phase impacts (b)	Manfr. & upstream impacts	Use phase impacts (c)
Energy (MMBTU)	113.6	984	7.6 (i)	78
TRI (lbs)	85.0	69.74 (d)	2.75 (e)	
CO (lbs)		5436.2		3.9
HC (lbs)		710.82		1.33
NOx (lbs)		545.6		4.60
Sox (lbs)		28.6		39.78
PM10 (lbs)		70.4		2.34 (f)
CO2 (tons)	ap 23 (h)	182.6	ap 1.5 (h)	16.4 (g)

Auto assumptions: 1990 Taurus, lifetime = 13.74 yrs/143K miles, 21.8 mpg over lifetime, 3000 lbs

Refrigerator assumptions: 200 lb refrigerator, of which 70% steel, 30% plastic, 12 year lifetime, 650 kwh/yr **TABLE SOURCES: SEE ENDNOTE**

To date, EPR discussions focus heavily on end-of-life issues — reducing waste streams, increasing recycling, and ensuring proper disposal. Attention to in-use impacts has been minimal. Further, where these discussions have moved beyond the solid waste stream, they typically have focused on issues of reduced throughput in the product system — thus, product life extension and increased durability are both assumed to be environmentally beneficial.

The tradeoff between use and non-use impacts discussed above, however, suggests that this is not necessarily so. In cases where use impacts are a large portion of lifecycle impacts, servicizing which *increases* the turnover of the product stock may be beneficial in reducing aggregate lifecycle impacts. Analysis showing such a result is depicted in Box 5.

A strategy to accelerate turnover only makes environmental sense for products whose use-related impacts are large compared to their manufacturing impacts.

Products meeting this description will likely share the following general characteristics:

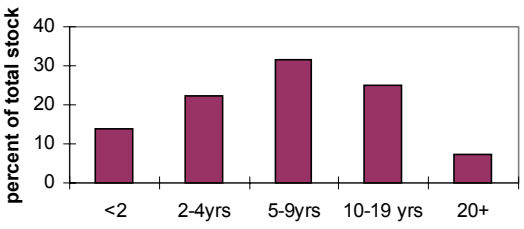
- Goods that are relatively durable and long-lived;
- Goods with high impacts in use (includes goods which are large consumers of energy and/or process chemicals, and goods requiring material-intensive maintenance).

Rough lifecycle data for two products meeting these criteria — automobiles and refrigerators — are presented in Table 5. (Note that end-of-life impacts are not included.) In both cases, energy-associated impacts are far greater in the use phase than in the manufacturing phase. In the case of toxic emissions for autos, manufacturing impacts are greater than use impacts, unless all auto hydrocarbon emissions are considered toxic.

Box 5: How does increased turnover relate to reductions in use-related environmental impacts?

For any durable or semi-durable good in wide use in the economy, the stock of products in use will be characterized by a distribution of vintages — some products will be new, others a few years old, others five years old, and so forth. Consider, for example, the vintage distribution of refrigerators in use in the U.S. depicted in the plot at right:

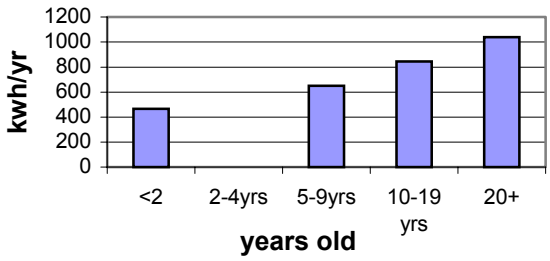
A: Vintages of U.S. Refrigerators



Source: Energy Information Administration (1997 Residential Energy Consumption Survey)

For a number of durable or semi-durable goods, significant efficiency improvements have occurred historically, with further reductions believed to be technologically attainable. In many cases (e.g., cars, appliances, lighting), these improvements have been driven by regulation. Consider the energy efficiency of refrigerators in use in the U.S. by vintage (B):

B: Energy use of an average refrigerator



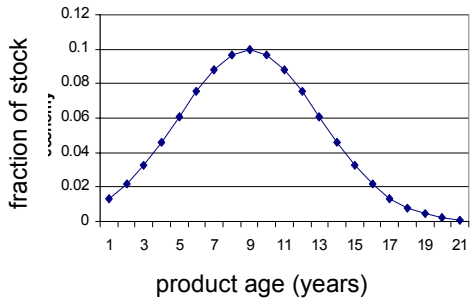
Source: Energy Information Administration (1997 Residential Energy Consumption Survey)

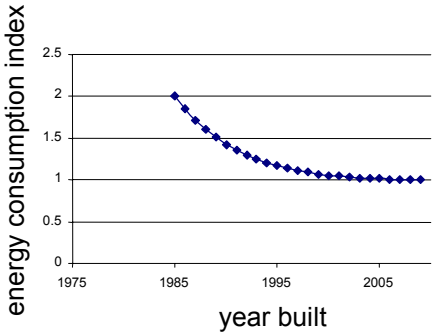
Efficiency improvements in consecutive model years mean more efficient models gradually supplant older, less efficient ones. Assuming a constant number of products in use, the total use-related environmental burden of these products will decline. If, via increased turnover, the vintage distribution can be biased towards younger products, this process will be accelerated. Simplified calculations demonstrate this point:

First, the discrete vintage and efficiency distributions depicted in A and B are given idealized forms (C):

These distributions allow calculation of the average per-unit energy consumption of all refrigerators in the economy, both for the original vintage distribution and one biased towards younger products (D, facing page). The average consumption decreases over time as more efficient products are introduced into the product stock and less efficient ones are retired. Because the rate of efficiency improvement is assumed to slow over time, efficiency gains of the entire product stock also become smaller over time. A younger vintage distribution introduces these gains more quickly. This vintaging effect has been widely discussed, for example, in assessments of automobile emissions, in which it is clear that a small group of older vehicles on the road contributes disproportionately to air pollution.

C: Idealized vintage and efficiency distributions





Lifecycle data for a small electronic device (e.g., a cellular phone) would reveal a different balance between impacts over use and non-use phases of the lifecycle. Power consumption for such a product is lower and lifetime is typically less, driving down use-related impacts. At the same time, their manufacture is chemical-intensive per unit of product weight, as they are composed largely of plastic and electronic components. In the case of such a product, the environmental problem it poses is precisely the combination of toxics-intensive manufacturing, short lifetime, and disposability. Increased product durability, upgradability, and reclamation are indicated from an environmental gain perspective.

For the durable products in Table 5, however, an increased turnover approach may well have beneficial environmental effects — *if* continuous efficiency improvements can be introduced. Increased toxics emissions in the manufacturing stage which would accompany such a strategy could be offset *if* turnover was accompanied by increased remanufacturing and recycling.[9]

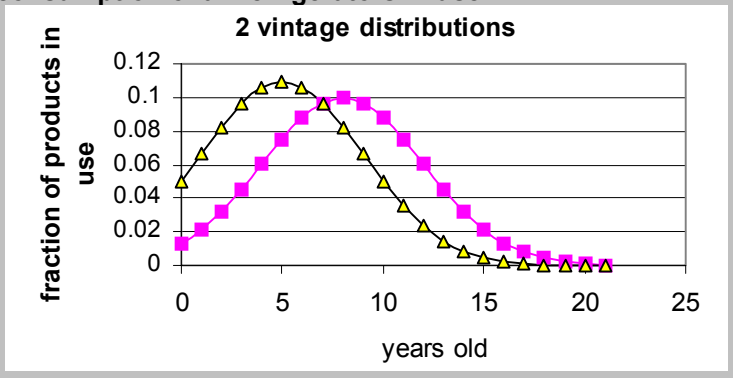
Ideally, increased turnover with continuous efficiency improvements represents a quid-pro-quo arrangement beneficial to both manufacturers and the environment. Manufacturers are presumably forced to invest more in R&D, retooling, reverse logistics, and reclamation-oriented design and manufacturing practices. In return, product throughput increases in the often saturated markets which characterize durable goods. Environmental benefits arise from a cleaner stock of product. Consumer costs which would normally arise from more frequent capital purchases (e.g., buying a car every 5 years rather than every 8 or 10) are offset by a leasing arrangement which effectively externalizes the up-front costs of capital investment.

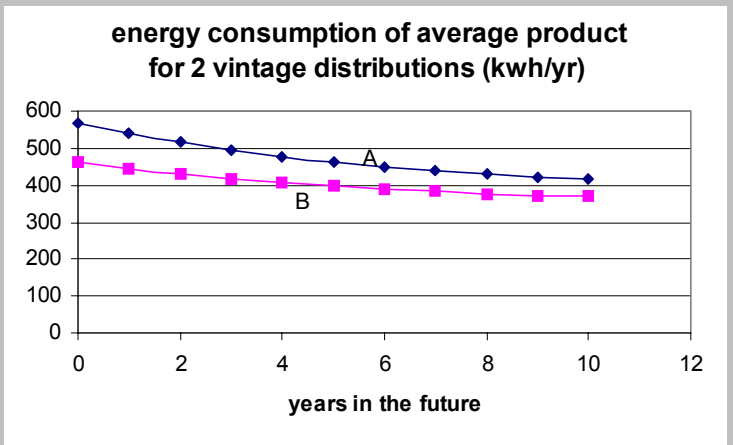
In the context of this scenario, several points must be raised:

- Driving continuous improvement is often politically difficult, even where technologically possible.
- Policies which shorten lifetime tend to shunt products to a second-hand market, whether inside or outside national borders (e.g., in Japan, ownership of a car becomes progressively more expensive after several years, providing an incentive to consumers to purchase new vehicles. The large number of used but

Box 5: (Continued)

D: 2 vintage distributions and average energy consumption of all refrigerators in use





[9] The majority of toxic emissions associated with automobile manufacture are in fact attributable to upstream activities — extraction, primary processing, and part production. For the LCA cited in Table 5 (Maclean and Lave), 75 pounds of TRI emissions/auto are generated by suppliers and upstream activity, and 11.4 pounds are generated by vehicle manufacturers. Reclamation operations, by eliminating pollution-intensive extraction, primary processing and first-stage manufacture operations would be expected to significantly reduce toxics loading associated with the manufacture and upstream stages.

functional cars which result from this policy are largely sold in developing country markets in Asia.

ENDNOTE: SOURCES FOR TABLE 5

(a) Auto data is from Maclean and Lave, 1998.

(b) Includes maintenance and upstream impacts of fuel extraction, refining and distribution.

(c) For average coal power plant emissions only. Does not include fuel extraction and other impacts.

(d) Acetaldehyde, benzene, formaldehyde, 1,3-butadiene.

(e) Based on 1996 TRI emissions for refrigerator/freezer manufacturing facilities (2.8 mn pounds, EPA), 1996 U.S. refrigerators shipped (11 mn, U.S. Bureau of Census) & raw steel and plastics production lifecycle data (TRI emissions in lb/net ton produced = 0.5 for steel, ap. 80 for generalized plastic, *Tellus Packaging Study*).

(f) Figure for total suspended particulates.

(g) Average coal CO_2 emission factor of ap. 210 lbs CO_2/MBTU (US EIA, Hong and Slatick).

(h) CO_2 emissions only from energy use; assumes emission factor between coal and oil.

(i) Scaled by weight from auto manufacture figure.

5. Roles for Public Policy

The Emergence of Servicized Products

Our research highlights the emergence of servicized products in a number of sectors, offered by firms historically defined as product and materials suppliers. Particularly in the US, virtually all of these industrial transformations have occurred with little or no explicit policy intervention, much less interventions of an environmental nature. The changes witnessed at IBM, Xerox, and other firms had little to do with either government mandates or incentives. Instead, they reflected fundamental and rapid changes in technology and markets that spurred both companies to reinvent themselves with new business strategy and product/service offerings.

The many other examples we have referred to, and some we have not, tell a similar story. Monsanto's transformation into a life sciences organization, Dow's experiment with chemical management services, and Coro, Herman Miller's furnishings services unit, all exemplify the creation of information-based enterprise and the subordination of product to service delivery. Dupont is a telling case of this trend. The company has repositioned its corporate strategy from essentially a material producer (chemicals, fibers, electronic materials) to an enterprise whose strategy is to deliver shareholder value through knowledge and information-based services: automotive painting services (versus paints), carpet services (in addition to carpet fibers).

None of these transitions are quick, complete or easy. Old ways of doing business die hard. Weaning managers from the notion that more is better while rebuilding corporate culture around an information/knowledge-based enterprise is a formidable challenge. But it is happening, and not only in the technology businesses such as computers and electronics, but in mature manufacturing sectors such as chemicals and automotive.

- ***In the US, servicizing has been driven by business, not environmental considerations.***
- ***Servicizing does hold potential environmental gains, BUT…***
- ***Realizing these gains is not automatic.***

Potential Environmental Gains. . .

Product-to-service transitions are part of a larger service transition in the economy. Insofar as a service-dominated economy generally is characterized by less environmental loading per unit of output than a manufacturing economy, this could bode well for the environment. However, the real question — and the one that motivated this study — is how services might affect the manufacture, use and disposal of products in environmentally beneficial ways. If a servicized product simply adds economic value to a traditional product, but does nothing to reduce its lifecycle environmental impacts, then the service cannot truly be called "eco-efficient."

Our analysis shows that lifecycle environmental gains *can* derive from servicizing in many, but not all, circumstances:

- Servicizing helps to overcome a major institutional barrier to EPR activity by extending or deepening manufacturers' involvement with a product to phases of the lifecycle in which involvement was previously peripheral or non-existent.

- Servicizing can bring about the development of reverse logistics infrastructures, which may be employed in reclamation activities (recycling, remanufacturing, reuse).

Sources of potential environmental gains from servicizing:

- *Servicizing **may** create economic incentives that encourage manufacturers or service providers to reduce use and non-use impacts.*
- *Servicizing **may** help to overcome organizational or institutional barriers to EPR by deepening or extending firm involvement with a product beyond the traditional manufacture-and-sales model.*
- *Servicizing **may** create reverse logistics infrastructures which can be employed in reclamation activities (recycling, remanufacturing, reuse).*

- Servicizing can create economic incentives that, in theory, drive reductions in environmental impacts in the use and non-use stages of the lifecycle. These economic incentives are created when (1) servicizing internalizes use or disposal costs to the manufacturer/service provider; (2) servicizing is driven by the economic value of the end-of-life good; and (3) servicizing renders provision of the product into a cost, not a profit center.

Servicizing may, for example, reduce material and energy throughput via more durable materials and designs and thus extended product life. It may reduce use impacts by optimizing product utilization via improved maintenance or operation, or by driving more efficient design. It may reduce end-of-life, extraction and manufacturing impacts via take-back and reclamation activities.

Realizing Environmental Gains is Not Automatic

However, our analysis also shows that achieving environmental gains is not automatic:

- The economic incentives described above do not characterize every servicizing situation.
- Where clear economic incentives to achieve lifecycle impact reductions do exist, their ability to influence product design and production depends in substantial degree on the degree of integration between the service unit and the manufacturing entity.
- Even when integration is close, the practice of lifecycle design is a complex process requiring close coordination across business functions and specialized decision-support tools; the presence of an economic incentive itself is not necessarily sufficient.
- Likewise, the existence of a reverse logistics infrastructure may ease the way for producer reclamation activities, but a conscious decision to pursue reclamation activities is still required.

Further, the mechanisms by which gains can be derived under servicizing vary by product characteristics. Until now, EPR has been discussed largely in terms of its potential for reducing end-of-life impacts. Likewise, the idea of eco-efficient services has been discussed largely in terms of reducing material and energy embodied in a product per unit of economic value. Our lifecycle framework for analysis indicates, however, that for durable goods whose use impacts are large compared to manufacturing impacts (e.g., automobiles, heavy appliances), servicizing which achieves greater turnover of the product stock and introduces newer, more efficient/cleaner products more quickly can be environmentally beneficial. While servicizing — particularly leasing arrangements — does seem intrinsically suited to achieving greater turnover of

the product stock, product efficiency gains have historically not been achieved without policy intervention.

A Role for Government

Servicizing to date is a phenomenon in which public policy has played little role. However, policy does have a number of roles to play in achieving the potential environmental gains associated with product-based services — and perhaps, in making the servicized product more attractive in markets where acceptance seems most difficult.[10]

Explicit environmental policies

Our case studies indicate that green product markets and certain regulatory measures can focus the attention of firms on achieving environmental improvements under servicizing. If one compares Europe to the U.S. from a policy standpoint, it is clear that European initiatives in the areas of EPR and product policy are both older and more aggressive. Though these policies have received their share of criticism, they have undoubtedly focused the attention of firms on providing environmentally beneficial end-of-life services.

While the U.S. seems unlikely to pursue the European approach, at least at the federal level, policies which incorporate the social costs of materials extraction and disposal into the purchase price of products are likely to have two effects: (1) building further market demand for decoupling ownership from product use; and (2) building demand for lifecycle management as an explicit component of service offerings. Such policies include, for example:

- **Removing virgin material subsidies, explicit and inherent.** Any policy that subsidizes virgin materials extraction and use to the disadvantage of reuse, remanufacture, and recycle of secondary materials tends to add net environmental burden. More material throughput means more extraction, and more extraction means more emissions. Thus, as a general statement, government subsidies via below-market concessions on public lands for petroleum, minerals and forestry activities work to the disadvantage of dematerialization. The converse is also true: policies which remove economic privilege from such activities support materials reclamation. In short, subsidies that reduce the cost of making new "stuff" are inconsistent with efforts to steer the economy away from goods toward more service-oriented modes of enterprise.
- **Remove disposal subsidies.** At the other end of product cycle are disposal subsidies. Government policy that artificially reduces the cost of product disposal runs counter to extracting environmental gains from servicizing. In lessening the cost of outright product disposal, reclamation actvitities are placed at a competitive disadvantage. Product and material reclamation are a key means by which servicizing may deliver environmental benefits.
- **Driving efficiency improvements** is an obvious role for environmental product policy when servicizing drives more rapid turnover of a durable good with high use-related impacts. If coupled with tax schemes which encourage this turnover and policies which incentivize reclamation activities, gains can be maximized.

Taxes

As we have seen, decoupling ownership from product use is a key driver of servicizing. Any tax policy — credits, deductions, accelerated

[10] As noted in Section 3, servicized products may have more difficulty finding market acceptance in markets where product technology is stable, and customers are not required to continuously acquire new skills and competencies to utilize the product efficiently or in compliance with regulations.

depreciation, for example — that favors commercial or household equipment ownership to the disadvantage of equipment leasing represents an impediment to servicizing products. In contrast, tax policies that favor retention of ownership of durable goods by producers or sellers is supportive of servicized arrangements. These policies give producers the incentive to engage in reclamation activities at the end of product life.

Government and policy roles:

- ***Explicit environmental policies*** *(aside from mandated responsibility, these include removal of virgin material and disposal subsidies, and driving product efficiency improvements).*
- ***Tax policy*** *which favors producer, not customer, ownership of durable goods.*
- ***Convenor and facilitator***
- ***Documentation***
- ***Research***

Documentation

This study represents only a start in understanding the full scope of how servicizing is unfolding and what ramifications it holds for environmental benefits. Though rich in insights, the cases we evaluated here are few in number. A valuable government role is support for more documentation. Questions to be addressed include: Are there other sectors, beyond those identified here, where the service transition is observable? Do the generalizations we offer here hold up in these sectors? What are the specific seller-buyer arrangements — including the specific financial and contractual arrangements — that will secure the environmental gains achievable under certain forms of servicizing? How can environmental metrics, fixed management fees and pricing per unit of service (e.g., per painted car, per cleaned circuit board) be mobilized to achieve the potential environmental gains of servicizing enterprises? Case studies, model contracts, and more quantitative environmental analyses will inform both policy and the private sector.

Convenor

Potential service providers will benefit from learning and emulating other providers. This is amply demonstrated in the case of chemical management service (CMS) where workshops organized by the Chemical Strategies Partnership (www.chemicalstrategies.org) have provided valuable fora for both sellers and buyers in advancing chemical management services. One can envision government playing convenor of such fora for a number of other servicizing sectors. Of course, there are limitations: "first movers" may be reluctant to share strategies aimed at building a strong foothold among customers in an emerging market. Thus, timing and expectations of such initiatives must be carefully managed.

Research

"Functionality" is in the eyes of the customer. This means that the marketing of functionality must occur with a clear sense of how product users perceive and measure functional value. Transforming product owners into non-owner product users (or leasees) is neither easy nor automatic, even when the economics are compelling. Even under the bottom-line mindset of most managers, even equipment leasing may be stigmatized for cultural reasons. In the household sector, it may be relatively easy to envision the behavioral changes necessary to achieve a transition from washing machine or refrigerator ownership to washing and cooling services. But what about autos, with the brand equity and prestige factors that accompany ownership? And internal to the enterprise, the changes required to reorient traditional product and sales-driven organizations to a service-based mentality presents an array of research questions. In this sense government can play a valuable role in defining the opportunities and limits for building buyer and business acceptance for servicized offerings based on behavioral research findings.

Finally, while we have focused almost exclusively in this study on the transformation of manufacturing firms to service-oriented organizations, the role for new enterprises formed from the outset as functionality-based businesses should not be overlooked. These are the new breed of car-sharing, computer equipment leasing, home telecommunications, and chemical services firms which were never producers of material goods. Nonetheless, their role as aggregators, marketers, and middlemen merits the attention of researchers and policymakers. Creating favorable business conditions for their formation and success is another vehicle for fostering the product-to-service transition emergent in manufacturing industries.

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Appendix A: Case Studies

AB Electrolux

Castrol Industrial North America

Coro

DuPont

IBM

Radian/Dow

Xerox

AB Electrolux

Company Profile

Electrolux, based in Stockholm, Sweden, manufactures and sells 55 million products annually. It is the world's largest producer of white goods, with sales in over 100 countries. Its major product lines include:

- Household appliances, 72% of 1997 net sales (White goods such as refrigerators, freezers, cookers, washing machines and dishwashers, floor care products, leisure products).
- Professional appliances, 10% of 1997 net sales (mainly for restaurants and institutions and professional laundries, including food service products and laundry, refrigeration and cleaning equipment).
- Outdoor Products, 16% of 1997 net sales (includes garden equipment and forestry products such as chainsaws).

Electrolux has 110,000 employees worldwide, and its net sales in 1997 were SEK 113 billion.

In North America, which accounted for 31.6% of 1997 sales and 24,000 employees, Frigidaire Home Products is the Electrolux Group's major appliance company. Frigidaire sells products under eight of its own brands (as well as manufacturing products for other nameplates) and it has 13 manufacturing facilities in North America.

The evolution of "servicized" products offerings

"Servicizing," or the provision of products as services, at Electrolux grew out of a strategic, environment-oriented planning exercise at Electrolux Euroclean[11], then Electrolux's professional cleaning equipment division. Developed by Electrolux's corporate environmental affairs division, the exercise was intended to identify strategic business opportunities and issues arising from emergent end-of-life and product stewardship regulation and market preferences for environmentally superior products. The exercise identified a potential, service-oriented business model which could offer competitive advantages and reduced environmental impacts in the use phase of the product. The idea was to sell product function, not the product itself, while guaranteeing responsible end-of-life management, including reuse and recycling.

The business model was inspired in part by the experience of Electrolux's former subsidiary, Jonsereds Godsskydd. This business rented tarpaulins and other protective products to construction companies. The tarpaulins were made of PVC. In investigating the environmental concerns surrounding PVCs, the company found that maintaining control (ownership) of the product throughout its use phase was important in resolving those concerns. Ownership made possible the extension of tarpaulin life through improved maintenance and repair, and gave the subsidiary control over disposal. The Xerox copier leasing model — in which copiers were leased, with service provision, on a per-copy pricing system —also contributed to this function-selling model.

Today, the Electrolux Professional Appliances divisions have started to adopt this service concept under the title of "Functional Sales." The functional sales concept combines the sale of a function or solution with the take-back and reuse of end-of-life hardware. Customers do not purchase hardware, but pay a monthly fee for the "function" provided — which usually means rental of equipment, training of staff, supplies, and maintenance. In this vision of a servicized product offering, the customer pays for a process (e.g., the function of cleaning) rather than for the tangible result of that process (e.g., clean floors).

[11] The business manufactured and sold vacuum cleaners, wet and dry vacuums, carpet extractors, burnishers, polishers, scrubber driers, and sweepers. The business is no longer part of Electrolux after sale to Nilfisk Corporation (Denmark) in October, 1998.

In concept, functional sales can reduce the user's cost of obtaining the service by eliminating the need for capital investment, and through better maintenance and operator training, while giving Electrolux control of product at the end of life, when it still retains considerable economic value.

AB Electrolux Euroclean promoted a functional sales service for some of its professional cleaning equipment, which included consultation on selecting appropriate equipment and methods and training programs on using machines optimally, as well as maintenance and repair services. The professional cleaning companies paid a monthly fee for the service (Rocchi, 1997).

The Euroclean subsidiary was divested in 1998; Electrolux is now experimenting with food-related "functional sales" endeavors in refrigeration and cooking. In particular, a program exists for restaurants which falls between operational lease and functional sales of professional food service equipment. Jan Agri, business developer in Electrolux's environmental affairs office, believes that top management interest in this servicizing model is strong, particularly in the Professional Appliances and European White Goods divisions. At this time, however, Electrolux has no fully implemented functional sales programs.

As Electrolux sells most of its products through trade and does not interact with product end-users[12], it is commercial users, rather than households, that are likely to be targeted as its primary market for "servicized" products.

Regulatory and market drivers

The strategic planning exercise which led to the functional sales concept was motivated in part by environmental regulatory trends in the European market. Particularly, the exercise was motivated by the growing tendency to require producers to assume responsibility for end-of-life management of their products. For example, the Swedish government has discussed, though has not yet implemented, a plan to ban landfilling of electronics. Under this plan, producers would bear responsibility for equipment at end-of-life. In Italy, a waste management decree has been in force since 1996 which mandates take-back for refrigerators, washing machines, TVs, and computers free of charge to end user upon purchase of new products.(Cutter, 1998). A much more ambitions EU draft on electronic equipment was circulated in April 1998 and included products from white goods to communications equipment as well as clocks, toys, and other goods. In this draft, take-back would be free to households, but with the costs built into the price of new products.

In the U.S., by contrast, no federal mandates exist or are in serious discussion. There are, however, landfill disposal bans on white goods in 16 states.

In its European markets, Electrolux believes that green product characteristics can be an important means to achieve brand differentiation and improve market share — not simply among domestic consumers, but among commercial customers as well. Further, the service-fee model fits well with the current and emergent focus of European firms on cost control — echoing the focus of U.S. firms in the 1980s. Paying a monthly fee for guaranteed function in effect externalizes the capital cost of equipment for the customer of the servicized product.

Barriers and Challenges

Compared to straightforward product sales, servicizing adds another dimension of challenge to understanding the market and assessing the business case. It requires assessing whether and how people might become interested in a servicized product offering, and determining under what conditions servicizing can offer economic savings, to both the company and customers.

In some European consumer, small business, public and large corporate markets, negative perceptions of leasing can also be a significant barrier to the success of servicized product offerings. To some customers, "leasing" implies both insufficient means to buy the product and

[12] Electrolux divested its direct-selling subsidiary in 1998.

the prospect of paying a very high rate of effective interest on the product investment. Agri notes that when the opportunity costs of up-front capital expenditure are not considered, and the value of guaranteed access to the function provided by the product are not considered, outright purchase and ownership appears to provide the lowest cost alternative.[13]

Additionally, internal incentives must be aligned correctly and based on proper metrics if services are to be successful profit centers. Under traditional incentive structures, for example, salespeople are driven to maximize the number of contracts signed. Under servicized product offerings, the number of contracts may not be the sole determinant of profits for the firm. Instead, factors such as cost of repair, refurbishment, idle time and total machine life enter into the profit equation. Thus, issues of incentives and metrics include a range of factors from proper measurement of productivity (for purposes of strategic planning and performance assessment) to the question of commissions for sales staff.[14] Servicized products also require a continuing commitment of administrative resources and tracking not required for provision of "product in a box." In the case of Electrolux, functional sales are at too early a stage to discern what organizational and human resource changes may become necessary.

Environmental Dimensions of Servicizing

Electrolux's servicized product offerings have been driven in part by explicit environmental considerations. The company conducted a lifecycle analysis of a servicized floor cleaning machine, and found that servicizing had good potential to reduce in-use impacts (via better maintenance and optimal utilization), as well as material and energy throughput in the product system — via life extension, part reuse, and recycling.

Use stage reduction is particularly important, as the use stage of the lifecycle incurs the largest environmental impact in cleaning, laundering and kitchen equipment. This is particularly true for Electrolux's professional appliances. The lifecycle economic cost for resource inputs, principally energy and water, during the use of an appliance often exceeds the initial product price. For domestic white goods appliances, Electrolux estimates that 80% of a product's environmental impact occurs during the in-use phase and the remaining 20% is from the manufacturing phase. Because newer appliances are on average 50% more energy efficient, if all of the approximately 150 million EU households replaced their appliances with newer comparable products, the resulting electricity and CO_2 savings would represent 25% of the greenhouse emissions savings proposed by the Kyoto Protocol for the years 2008 and 2012. (1997 CER)

While environmental gains are not the dominant business driver, Electrolux views "functional sales" as a business strategy which can serve to reduce lifecycle environmental impacts.

Future Directions

The pace and success of servicizing will depend on a number of regulatory and technological trends. Agri believes, for example, that deregulation of electricity will in large meas-

[13] In part for these reasons, Electrolux employs terms such as "functional purchase" or "functional hire" in place of "leasing." This also serves to underscore the distinction between "functional offers" and traditional financial or operational leasing: A supplier offering a functional sale provides a combination of physical products, consumables and services in order to ensure that a customer can benefit from the function of the physical product without having to own, maintain, repair or dispose of the product. The customer pays according to the sophistication of the function as long as his need remains, as a running expense. In contrast to operational leasing, the supplier may use any combination of old or new products to provide the agreed-upon function.

[14] For example, in making a "functional sale" to a cleaning company, Electrolux encountered questions regarding sales commission for its sales force, since profits as well as the proper commission from a 5-year customer contract are not immediately obvious as compared to conventional product sales.

ure determine whether refrigeration services will be viable or not as a servicized product offering. Deregulation would force electricity suppliers to innovate, looking more to services electricity provides rather than simply provision of electricity as a commodity.

In Europe, customers, not appliance vendors, are generally expected to bear the cost of increasingly limited resources such as water. (1997 CER) The awareness of the cost of resources to operate appliances is driving the designs of more efficient models. Servicizing may benefit from this trend if it provides a means for consumers to minimize the costs-in-use of appliances without the repeated capital investments required to purchase ever-more efficient models.

Another regulatory determinant of the future marketability of servicized products is the relative tax treatment of leased versus owned equipment. Because appliances are taxable property, leasing will reduce net property value and thus tax burden. In the U.S., for example, leasing is a well-known tool for companies to strengthen their balance sheets by removing debt.

Lastly, Agri notes, information technology can be another potential impetus for servicizing. Profitable servicizing depends on detailed information about user patterns and requirements. Evolving IT will permit remote monitoring and mapping, allowing functional service providers to construct appropriate pricing structures and more effectively match products to user needs.

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Castrol Industrial North America, Inc.

Company Profile

Founded in 1899, Castrol International is a leading provider of specialty lubricants and related services. A $4.5 billion company, Castrol employs 20,000 people in manufacturing, distribution, research and development facilities in more than 50 countries. Castrol International is the principal company in the lubricants division of Burmah Castrol PLC, a UK-based international manufacturer and marketer of specialized lubricants and chemicals. 1997 lubricant division pre-tax profits were £216.3 million on sales of £1.927 billion.

Located in Downers Grove, IL, Castrol Industrial North America is the industrial product and services division of Castrol International. It manufactures and markets a broad line of industrial products, organized into four businesses — Metalworking, Performance Lubricants, Specialty Products and International:

- Metalworking manufactures cutting and grinding fluids, industrial cleaners, corrosion preventives, hydraulic fluids, industrial lubricants, heat treatment chemicals, and metalforming and forging products. This division offers a number of services and includes the *Castrol+Plus*® business unit, the company's chemical management service
- Performance Lubricants markets high performance industrial lubricants, and associated services.
- Specialty Products are used for lubrication in the automotive, aerospace, nuclear power, robotics or refrigeration industries.
- International sells the products and services of the Metalworking, Performance Lubricants and Specialty Products divisions worldwide (including sales to Castrol affiliates).

These products are marketed to a variety of industries including automotive, aerospace, cement, glass, mining, printing, pulp and paper, refrigeration, textile and wood products.

Service orientation and offerings

Castrol Industrial North America markets itself as a lubrication service and expertise provider, rather than simply a vendor of product-in-a-drum:

> *"Most lubricant companies sell oil. What arrives in the drum is essentially their offering. Castrol Industrial North America Inc.'s offering goes beyond the lubricant. Our proposition to industry is performance lubricants expertise that goes beyond the lubricant. Our proposition to industry is performance lubricants expertise that results in quantifiable cost reductions and improved productivity."*[15] *(Castrol Industrial North America, Performance lubricants)*

> *"Castrol's goal is to establish successful, long-term partnerships with customers. Our sales engineers thoroughly analyze equipment, materials and processes to make the best product recommendations. We then provide on-site monitoring and performance analysis" (Castrol Industrial North America, Metalworking)*[16]

As described by Castrol Industrial North America, the formulation and implementation of a typical lubrication services package from the Performance Lubricants Division would have the following elements (normal customer service would also incorporate many of these elements):

[15] Castrol Industrial North America website "Our lubrication approach."

[16] Castrol Industrial, NA Website, "Metalworking division."

- *Preliminary information exchange* (lubrication needs assessment and identification of performance metrics);
- *Site survey* (benchmarking costs and productivity);
- *Proposal* (recommended package of products and services);
- *Implementation* (procedures training and equipment changeover, managed by a Castrol field representative);
- *Documentation* (regular performance assessments);
- *Continuous Improvement* (opportunities identification).

Castrol+Plus® is the Metalworking Division's chemical management program, a service offering which manages manufacturers' in-plant chemical systems. Extending beyond lubricants, the program partners with customers to monitor and control their in-plant chemical systems and the costs associated with the purchase, handling, use and disposal of chemicals. The goal is to achieve reductions in the customer's net total operating costs.

Services include precise product selection, procurement, materials and maintenance management, process engineering, waste minimization, environmental compliance assistance, health and safety education, laboratory services and continuous improvement. Aimed at reducing customers' net total operating costs, more than half of the documented cost saving for customers comes from improvements in processes. Castrol's profits come both from fees and, in some cases, gain sharing derived from cost reductions.

Castrol+Plus® programs range in size from several hundred thousand to millions of dollars per year and operate in a number of industries. A long-standing *Castrol+Plus*® program is with the Navistar International engine plant in Illinois, which combines a fixed-fee contract with gain sharing. Over the course of the program, coolant use has been reduced by 50+% and coolant waste reduced by 90+%.

Additional service offerings include Castrol Care™ (also in the metalworking division) and Castrol Reprocessing Services™ (a service offering of Castrol Industrial North America). Castrol Care™ provides services for the management of spent, water-diluted, metalworking fluid wastes —including on-site reprocessing, waste minimization and cleaning services. The program is designed for smaller manufacturing operations. Castrol Reprocessing Services™ reprocesses used oils onsite into regenerated lubricants via mobile and fixed-site units.

Servicizing: history, drivers and challenges.

Castrol+Plus®'s chemical management service offerings have evolved over the last 14 years. In principle, the service provision model fit well with a widespread manufacturer focus on outsourcing and cost-control which emerged in the late 1980s. During this period, many heavy manufacturing facilities, for example, cut back on internal chemical engineers and technicians and looked to suppliers for services. Castrol initiated service offerings with the intent of leveraging this trend, receiving wide recognition and credibility after the service model was implemented by a few large companies such as General Motors. Since then, the evolution of service offerings has been both customer-driven and proactively pursued by Castrol.

In principle, the service model was not only a good fit with an emerging management model — outsourcing — but also with the nature of Castrol's product. Chemicals (including lubricants and metalworking fluids) are particularly amenable to servicizing for two key reasons (Reiskin, White and Johnson, 1998):

- Manufacturer's in-plant tooling, waste handling, and other chemical management costs may exceed their chemical purchase costs by a factor of 5–10; these costs are often not appreciated by the manufacturer and provide opportunities for cost savings and efficiency improvements when addressed by a specialist chemical services provider.

- The specialized nature of chemicals and the regulatory requirements attendant to their use and disposal demand attention and expertise throughout their lifecycle — including procurement, delivery, inspection, inventory, storage, labeling, and safety precautions, not to mention the many required resources for training, tracking, legal liabilities and disposal. These are in many cases more efficiently addressed by a specialist provider

The market potential of the service model and the servicizable nature of the product aside, however, servicizing did present challenges to the Castrol organization.

- For Castrol, nearly a century of operations had built a strong culture/identity centered around manufacture and marketing of specialty lubricants. Chemical management demanded a different view — and redefinition — of core capabilities.

- The very different nature of a service business — with profits derived from fees rather than product sales, for example — was initially a new concept for top management to understand.

- Further, "servicizing" demands changes in human resources (skills) and in the measurement of performance. Under servicizing, profitability is decoupled from volume of products sold, and discrete, tangible transactions (sales) are replaced by service contracts operating over an extended period of time.

In response to new human resource requirements and to provide a stronger, dedicated resource and point of contact for the customer, Castrol created a dedicated business unit in the early 1990s (now *Castrol+Plus*™) to consolidate and house skills and human resources needed for service offerings. These particularly included engineering and technical expertise in customer manufacturing operations.

Future developments

The future for chemical management involves customers' continuing drive for yearly cost savings, along with expansion in the scope of services. Additional services can include items such as maintenance, procurement, logistics, environmental reporting, and recycling. For new operations, chemical management may involve coolant and lubricant system design, storage design, and initial product specification, as well as chemical handling training.

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Coro, Inc. (Herman Miller)

Company profile

Coro is a fully owned subsidiary of Herman Miller, a Michigan-based manufacturer of furniture systems and furniture products for offices, health-care facilities, and residential environments. Established in 1994, Coro provides post-occupancy (post-sale) furniture services for large customers — principally planning, managing and carrying out internal moves. Coro accounts for 3–5% of total Herman Miller revenues; its growth target is a minimum of 15% a year for the next several years.

Herman Miller operates seven U.S.-based subsidiaries, including Coro. Including licensees, sales operations are based in approximately 60 countries, with manufacturing operations in the U.S., Mexico, and the U.K.. 1997 net income was $74.4 million on sales of $1.5 billion. The company is publicly held, with approximately 16% of stock under employee ownership.

Service Offerings

As a service business, Coro manufactures no products. Rather, it services customers who have purchased furniture products from Herman Miller and other manufacturers**.** Its mission is to "ensure that the customer. . . receives the highest value from [their furniture purchases] throughout their economic life" (Eilers, 1999). Coro's service offerings are focused on large organizations (Fortune 1000 or 2000 firms) which typically have a large amount of internal movement, relocation and reorganization of individuals, staff and offices over the course of any year. These internal rearrangements necessitate a commensurate rearrangement of physical space and movement of furniture and office contents between locations, and in and out of warehoused inventory. Coro's services are targeted at managing this movement for customers, and have five components:

- *Move management*. Planning, coordination and scheduling of internal moves, working with management and affected employees.
- *Churn management*. The actual work of moving furniture and office contents, reconfiguring furniture, and moving items in and out of warehoused inventory.
- *Inventory management*. Coro stores surplus furniture on behalf of customers and tracks this inventory, drawing first on this resource to satisfy needs of the new office arrangement.
- *Population Tracking*. Ongoing CAD-based documentation of the disposition of space, individuals, and furniture. Provides the information necessary for planning and costing moves.
- *Project Management*. Provides a single point of contact for large new (Herman Miller) product installations, which often occur at multiple sites for large commercial customers.

Coro manages the engagement with the customer; Herman Miller's national dealer network carries out the actual movements of furniture and office contents.

Servicizing history: drivers, barriers and challenges

Coro was founded to fill a recognized gap in Herman Miller's offerings which market research had shown to have significant potential. The industry of which Herman Miller is a part — business and institutional furniture manufacturing — is focused on selling and installing product, but far less on providing post-occupancy services related to move planning and execution, and inventory management. The company estimates that business spending on these services in any year equals spending on new furniture (about $11 billion/year in each category). Thus, while all manufacturers in the industry have a service organization handling delivery and installation, Herman Miller currently is the

only one focused on post-occupancy support as an integrated part of its customer engagement strategy.

> *"We believe that [point of sale] is where the long-term relationship should begin. We have a wonderful opportunity to maximize the long-run relationship by providing this service on the customer's site." (Lee Eilers, Coro President)*

Coro's founder, Michael Volkema, is now CEO of Herman Miller. Thus, there has been strong support for Coro's service concept from the top. The business model has still encountered some challenges from within the Herman Miller organization, however — notably from the distribution network, who can see Coro's activities as infringing on their own. (Herman Miller employs a network of owned and contracted dealers and distributors.)

Conflict with the traditional sales force, however, has not been a significant issue, as is sometimes the case in a servicizing unit of a larger manufacturing company. Coro does not lease furniture currently, but rather manages furniture owned by customers. (Coro does have a relationship with a third- party furniture leasing firm.) Thus, Coro's existence can be a value-added argument for the sales force, who can use the services offerings to differentiate Herman Miller from competitors. Educating the sales force about Coro's offerings has been an area of focus. Establishing credibility with the dealer network has also been essential. Dealers do derive revenue from the provision of the moving services; however, if a customer has a negative experience with Coro, the dealer who promoted the service is unlikely to win repeat business.

The business model itself also presents significant challenges — relocation is a stressful event for most workers, which sets a high standard for satisfactory service. This service, in turn, depends on successful execution of a complex coordination function between Coro, the firm, the workers affected, and Herman Miller's dealers who provide much of the moving and product services.

Environmental dimensions

Lee Eilers, Coro's president, believes that Coro's service model has the potential to support lifecycle management efforts of its customers, and that this can be turned into a significant market strength. Most often, companies dispose of used/end-of-life furniture through a used furniture broker, and its disposition is highly uncertain — with large amounts of recyclable materials in all probability simply being landfilled.

According to Eilers, Coro is hoping to position itself to offer environmentally responsible end-of-life options to its customers. The company already has nearly all the necessary elements of a reverse-logistics system in place, including furniture take-backs and trade-ins. (Most trade-in furniture which Coro or Herman Miller accepts is currently brokered to the second-hand market.) Marketing a lifecycle management service to customers would require adding reclamation and recycling to this reverse logistics system. If feasible, the desirable model is a "closed loop" manufacturing system — manufacture, sell (or lease), take-back, remanufacture.

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DuPont Case Study

Company Profile

In 1998, DuPont was the 15th largest U.S. industrial/service corporation, with products concentrated in chemicals, fibers and plastics. Net income in 1998 was $1.6 billion on revenues of $24.8 billion. With 101,000 employees worldwide, DuPont has about 165 manufacturing and processing facilities in approximately 65 countries, including 140 chemicals and specialties plants. It also has more than 40 research and development and customer service labs in the U.S., and more than 35 labs in 11 other countries. 48% of its 1998 sales were outside the US, and the company was one of the largest US exporters, selling $4 billion in domestically produced products overseas.

DuPont's products serve various applications in the aerospace, agriculture, apparel, automotive, construction, packaging, pharmaceuticals, and safety industries. Some of DuPont's best-known brand names include: Teflon® resins, Lycra® brand spandex fiber, Stainmaster® carpet, Mylar® polyester films, and Coolmax® and Cordura® textile fibers. DuPont is divided into the following business segments:

- **Agriculture and Nutrition:** Crop Protection Products and the Nutrition and Health segments
- **Nylon Enterprise:** Industrial and Fibers
- **Performance Coatings:** Engineering Polymers, Performance Coatings, and DuPont Dow Elastomers
- **Pharmaceuticals:**
- **Pigments and Chemicals:** White Pigments and Mineral Products which include titanium dioxide products, Specialty Chemicals (a range of chemical intermediates) and Fluorochemicals (refrigerants)
- **Polyester Enterprise:** DuPont Dacron®, Polyester Films, and Polyester Resins and Intermediates
- **Specialty Fibers:** DuPont Lycra®, Nonwovens, and Advanced Fiber systems
- **Specialty Polymers:** Photopolymer and Electronic Materials, Packaging and Industrial Polymers, Fluoropolymers (Teflon®), and Corian®

Servicized Product Offerings

DuPont principally produces intermediate goods employed by other manufacturers. In servicizing its products, DuPont is currently offering several functional services built upon, or extended from, their existing product lines.

- **Car Painting Program With Ford**. DuPont is working with Ford UK in its painting operations. Compensation would be on a per-car basis instead of on the basis of per gallon of paint sold. Effectively, this transforms DuPont from a paint supplier to a provider of car painting services. This program is part of DuPont's growth strategy to increase the information intensity of its products -- that is, adding value through complementing products with expertise on their handling, application, reclamation and disposal. The program in theory would benefit both partners, since DuPont, with more product expertise, can perform the painting operation more efficiently and cost-effectively than Ford.
- **Comprehensive Carpet Services**. As a manufacturer of carpet and fibers such as the Antron fiber and Stainmaster Carpet, DuPont introduced DuPont Flooring Systems. This program offers design consultants to assist in product selection, as well as a menu of post-purchase services which range from in-

stallation to maintenance and carpet reclamation. These offerings provide customers with single-source accountability for varying needs and solutions. Offered as stand-alone carpet-related services, they are also offered in service packages such as the DuPont Answers [SM] Assurance program which covers installation and maintenance-related issues, product performance, and appearance retention for the life of the carpet.

DuPont's installation services include a TacFast system using a simple hook-and-loop technology to attach carpet to any sub-floor and the Liftman® Furniture lift system aimed to reduce business disruption by lifting furniture to install carpet instead of disassembling and rebuilding an entire modular office setup. Its maintenance service includes spill and stain removal, professional carpet cleaning, and consultation and recommendations for cleaning products and techniques.

A first in the carpet industry, DuPont Carpet Reclamation Program is a recycling initiative that includes a complete working infrastructure. By providing reclamation sites in most major U.S. cities, it guarantees that whenever DuPont Flooring Systems removes and replaces commercial carpet, the old carpet—regardless of manufacturer, fiber type or construction—does not end up in a landfill provided that this old carpet was designed with DuPont's Reclamation Specification. The fibers from reclaimed carpet are then used to make products such as new auto parts and sound insulation. As part of this service, for which a fee is charged to the clients equivalent to a would-be landfill fee for the same material, DuPont provides the client companies with certification demonstrating environmental consciousness of the client companies.

- **Carpet Leasing Options**. Urging prospective customers to gain flexibility for their changing business needs, to "match long-term assets with long-term liabilities," and to help customers conserve cash for other investments, DuPont Flooring Systems offer two- to five-year flooring leasing options nationwide. The lease gives customers the option of partial leasing, the ability to upgrade to higher-quality flooring, and either a 10% or $1.00 buyout at the end of the contract.

Other Service Offerings

- **Engineered Consulting Services.** DuPont's Engineered Services began with the Maintenance Painting Consulting System, which assesses customers' painting needs to design a multi-year plan to help minimize costs for budgeting, scheduling, applying, and maintaining protective coatings on infrastructures. The program was then expanded to include the Thermal Insulation System, which helps commercial customers identify and repair damaged thermal insulation, and maintains it to prevent future damage, even though DuPont is not a direct manufacturer of plastics. Features of both Engineered Services include Annual Operational Plans, Quality Assurance and Productivity Programs, Environmental Compliance Programs to minimize any potential environmental exposure, Safety Programs tailored for painting and insulation activities, and Project Management Training to prepare customers for coatings and insulation project management. As a manufacturer of paint, DuPont, by offering this service, is extending its product with product know-how and hence offering a value-added to products which are otherwise sold unaccompanied.

- **Safety and Emergency Response Services**. DuPont also provides Safety and Environmental Management Services, which helps customers improve

their safety performance via consultations, on-site seminars and training, and safety meeting materials. This service builds on DuPont's longstanding "culture" and leadership, transforming internal systems and standards into a marketable, value-adding business line for both traditional and new customers. In addition, Integrated Emergency Response helps industries and communities handle hazardous materials and dangerous goods and prepare for effective early response to chemical incidents. This service provides a framework for using the closest corporate regional resources for responses to chemical emergencies, and by facilitating the sharing of resources to satisfy local and regional chemical emergency response obligations. A comparable program, Farmcare® is available in the agricultural business. Customers of DuPont can also contract for Farmcare which helps farmers become more successful through access to farm safety programs, business management programs, and assistance in working with local communities.

Growth Strategy In A Changing Industry

While Dupont considers itself a science-based manufacturing company, it remains sensitive to the dynamic restructuring and recombination of businesses in the chemical industry worldwide, faced with increasing competition from burgeoning chemicals production in Asia and the Middle East. In this changing industry, growth cannot continue via the traditional, capital- and energy-intensive means. New means of growth are needed. Spearheaded by top-level management and supported by shareholders, company-wide transformations targeted at adapting to market changes has been of high priority for DuPont in order to secure market leadership.

To remain competitive and nimble, DuPont downsized by over 50,000 employees over the past 10 years. In order to focus on new science-based businesses while reducing vulnerability to industry cycles, DuPont exited the energy business this year by selling Conoco, its energy unit. The sale of Conoco, which in 1997 was DuPont's largest sales segment, positioned the company for new acquisitions. An $1.89 billion acquisition of Germany's Herberts auto paint maker, was completed in March of this year, made DuPont the world's largest automotive paint business. DuPont plans to continue expanding its life sciences division, which its CEO Charles Holliday hopes to see account for 30% of DuPont's business by 2002. The focus of this segment is to use biotechnology to strengthen pharmaceutical and agricultural products with better "output traits," e.g., crop nutrition value. Pharmaceuticals have been expanded by the $2.6 billion acquisition of the joint pharmaceutical venture with Merck Co., and the Food and Nutrition business will be expanded by the $7.7 billion acquisition of Pioneer Seed which will focus on improved output traits.

DuPont has three growth strategies of varying scope and time horizons:

1) The first category, with time horizons of 0-2 years, focuses on profitability, and narrowly-defined eco-efficiency and productivity.

2) The second category, of time horizons between 2-6 years, focuses on increasing the "knowledge intensity" of products. Knowledge intensity means knowing what customers need, anticipating any problems a product might create for customers and preemptively resolving those problems. In carpet fiber products, for example, dying is often an additional step in the carpet production process which adds both cost and environmental impacts at the carpet mill. DuPont offers pre-dyed fibers, which, when dyed by DuPont through a different process than that of the carpet producers, creates less environmental impact. In DuPont's electronics (parts)

business, knowledge intensity means understanding all costs/wastes for customers, and then figuring out how to integrate those costs into product design and manufacture.

3) The third category, with time horizons of more than six years, includes "massive projects" aimed at transforming the industry itself. Its components include Food and Nutrition, and safety management businesses. In the former, DuPont is striving to improve the quality and quantity of nutrition per acre (e.g., corn with phosphorous in a form digestible to chickens or with a higher oil content) through biotechnology, while still maintaining DuPont's traditional agricultural businesses. In the latter, DuPont is aiming to manage hazards around the world and create a $2 billion safety services business.

The last two categories of growth strategies are consistent with moving toward "servicized" product offerings, in two ways: (1) they involve appending more value-added to existing products; (2) they build additional value into new products from the design phase. In the latter case, designing knowledge-intensive product offerings requires a high level of understanding of customer operations and the operation of the customers' suppliers. Such knowledge can be obtained through Life Cycle Assessment work, and by examining endusers, markets and locations. Increasing products' knowledge intensity is achieved through an internal, ongoing, Continuing Business Improvement program aimed to cull best practices within the category.

Servicizing Drivers:

Servicizing products, or increasing the value offerings of products, is a change driven both by business strategy and environmental goals. In the Ford UK painting operations partnership, environmental benefit is part of - although not the primary - customer expectation, although no specific environmental metrics are actively involved. Such programs are driven from the business case, but with an understanding of achieving environment benefits, as well. Where business and environment co-benefits do not exist, the decision to proceed is then handled on a case-by-case basis.

Servicizing Challenges and Barriers

DuPont's experience in the auto painting with Ford demonstrates one recurrent theme: to achieve business and environmental gains through servicizing transformations, partnerships with customers are fundamental. Coordination becomes important when sharing the factory floor, for example, because both companies must agree on standards of practice such as personnel safety. An additional challenge for the car painting program is costing and compensation. Agreeing on a service fee requires acquiring an understanding of all the operational costs; this is a challenge because cost data on painting single cars is lacking.

In making products more knowledge-intensive, DuPont, like other firms, has experienced some internal tensions between service and product provision. It is, however, trying to improve internal receptivity to focus on generating more value, not more pounds of products. It is a challenging process to overcome institutional inertia, as DuPont businesses have traditionally been judged by the amount of product made and sold. Reconciliation of the product-service mindsets can occur in a variety of ways. In car painting, for example, a thinner paint capable of delivering at an equal or higher grade may lead to reduced product volume in the short term but larger market share in the longer term. Similarly, thinner Polyester Films may meet new higher performing standards in electronics and thinner denier fibers may add value to new fabrics.

One other difference -- and source of potential tension -- between servicized products and traditional products is that service businesses tend to invest more in R&D, while traditional business invests more on capital, and consequently focuses on using the capital to its full capacity. This may pose a future challenge to the company in making difficult resource allocation decisions.

From an organizational change standpoint, adding service to products is more difficult of a transformation for "traditional" business products, such as fibers. In contrast, servicizing of products such as electronics parts is likely to proceed more quickly because of historical trends toward downsizing and dematerializing. The idea that "less is better" already has currency. Another such case is DuPont's agricultural business, which as early as the 1980's had been transformed from a volume- to value-based enterprise.

Conclusions

Facing growing competition and rapid technological changes, DuPont is re-examining its core business while building toward information and knowledge-based enterprises. It, like most other manufacturers, sees a future less in its traditional products than in product-linked services. DuPont's longer-term growth strategies, in embracing product knowledge-intensity and large-scale transformations, exemplify a servicizing strategy common to many specialty chemical operations. In DuPont's case, however, the potential for concurrently achieving business and environmental gains can be particularly compelling in view of the scale and diversity of its operations.

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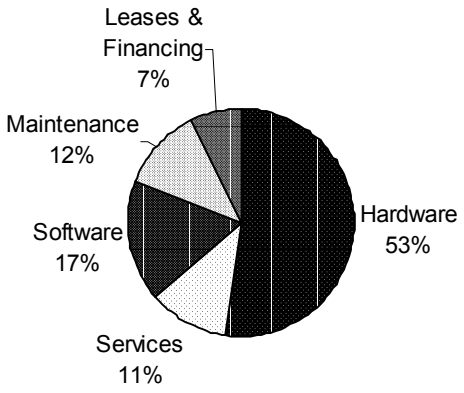
IBM

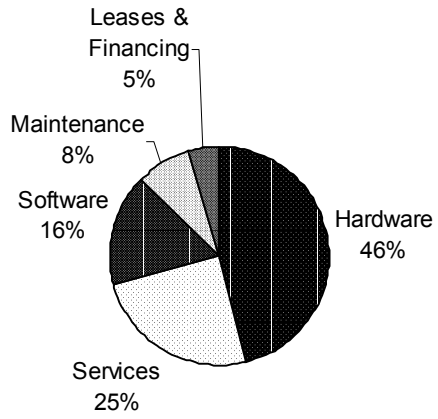
Company Profile

IBM (International Business Machines Corporation) develops and sells advanced information processing products, including computers, microelectronic technology, data storage devices, software, networking, and related services. Headquartered in Armonk, NY, IBM employs nearly 270,000 worldwide and operates 33 manufacturing, hardware development and research sites in 14 countries. 1997 net earnings were $6.09 billion on revenue of $78.5 billion. Over the 1990s, distributions of revenues and profits have evolved as shown below[17]:

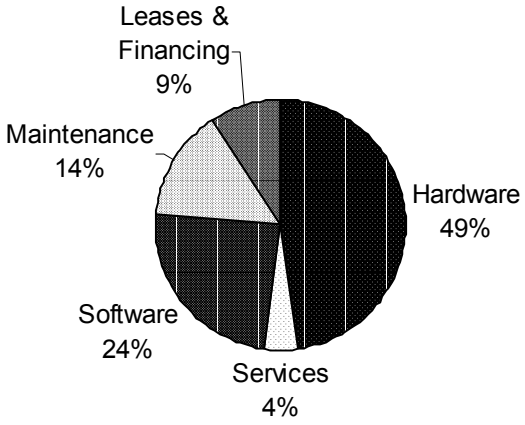
1992 Revenue distribution



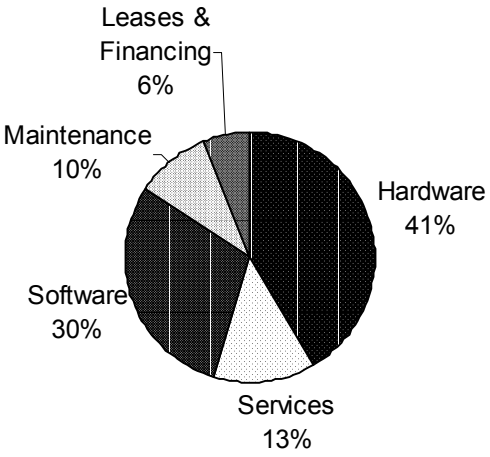
1997 Revenue distribution



1992 Sources of gross profits



1997 Sources of gross profits



The dominant mainframe provider flounders as the PC comes of age

Up through the 1970s, IBM dominated computer hardware and software sales to such an extent that it was a nearly unremitting target for anti-trust actions. This dominance was based in the provision of large mainframe computers and software systems, serving the large-scale data processing needs of government, corporations, and financial institutions.

By the early 1990s, however, IBM was seen as a company in collapse. The company had

[17] From Annual Reports.

recorded $18 billion in losses in the first three years of the decade; the CEO at the time (John Akers) had set upon the extreme remedy of splitting IBM into autonomous operating divisions — a prelude to wholesale dismantling and sale of individual business units. Analysts attributed these problems to several, related factors:

- The company was widely perceived as having lost touch with its customers (traditionally a strength), shifting to a strategy that emphasized pushing hardware rather than addressing a client's business problems (Sager, 1996).
- IBM also had clearly misjudged the significance of the personal computer and the consequences of desktop computing for IBM's traditional mainframe hardware-and-software business, and of protecting that business at a huge opportunity cost. In general, IBM was seen as uninterested in the innovations produced by its own R&D apparatus, which were then exploited by competitors.
- The company was "a byword for stifling bureaucracy and convoluted sign-off procedures," with more than 400,000 employees, and a bloated cost structure. (Economist, 1998).

A service-driven recovery

IBM's recovery over the past several years under CEO Louis Gerstner (hired in 1993) is widely attributed — both by the company and by analysts — to the success of Gerstner's service-oriented vision for IBM.

Gerstner has emphasized a close focus on customers and on providing integrated solutions to business' information technology (IT) needs. He reasons that these IT needs are being driven increasingly by the expansion of networked computing and (particularly internet-based) transactions. This transformation of the business environment presents a number of challenges to the firm, of which hardware purchasing decisions are only the beginning. Firms must achieve broad and transparent integration of a number of different platforms and company systems, and manage a virtual "front door" while preserving internal and transaction security. Systems integration and operation requires a combination of hardware and software expertise both difficult and expensive to maintain internally. Thus, the demands of the networked business environment are at once a source of tremendous confusion for many firms, and a necessarily critical area for strategic focus.

This "e-business" environment (IBM's term) creates soaring demand for "big servers with five-nines reliability (IBM-speak for being available 99.999% of the time), huge storage capability, bullet-proof databases, massive processing power, expert systems integration and strategic planning" (*Economist*, 1998) — all traditional strengths for IBM. Gerstner's belief that IBM's diversity and size would enable it to be a one-stop service provider in all these areas — and that having such status would confer a considerable competitive advantage — led him to keep the company together and aggressively expand its service offerings: Doing so, however, required several critical changes from past practice, notable among them embracing open software and communications standards (e.g., Java and LotusNotes)— in essence, a willingness to support non-IBM platforms.

IBM has, in fact, built the world's largest computer-services business (*Economist*, 1998). In 1995, the company formed its Global Services (GS) division, consolidating service units which had previously been autonomously managed in different geographic regions.(Gerber, 1996). This move brought the IBM brand name to its Integrated Systems Solution Corporation (ISSC), previously barred from using the IBM name in its business under the terms of a 1956 consent decree (CRN, 1997). GS has been the vehicle for strategic implementation of aggressive services growth. Services revenue is larger by nearly an order of magnitude than in 1990, and service revenue growth has been largely driving earnings

growth, with per annum increases greater than 20 percent.[18]

The success of Gerstner's vision to date rests both on successful implementation and on the vision's successful "bet" regarding technology and market trends in the 1990s. Embrace of open standards and double-digit service growth aside, however, the degree to which IBM's core business has changed from selling "big iron" (mainframe computers) to IT "solutions" is a source of debate. IBM argues that the processing power, stability, security and storage of its mid and upper-range servers are a good fit with sophisticated, large-scale e-commerce, and key to its ability to provide "total solutions." Whether mainframes will in the long run be the technology underpinning "e-business," however, is an open question. If services truly drive mainframe sales (rather than vice-versa), IBM would presumably be willing to move away from this traditional core business. IBM's continued dependence on mainframe sales (see charts) and its actions to defend this market during the 1980s, however, call into question the firm's willingness to take this action, if needed.

Environmental implications

In its vision and strategy statements, IBM represents its drive towards service provision and business "solutions" as market-, not environmentally, driven. Several "servicized" product offerings, however, have moved IBM into the practice of extended product responsibility. For example, IBM offers two configurable service packages for commercial PC customers — "SystemCare™" (available through IBM PC resellers) and "SystemXtra™." Both programs offer services such as network support and management in addition to hardware. They are marketed as outsourcing options which allows customers to maintain up-to-date and well-functioning PC and e-business networks without recurring, major capital expenditures.

Both programs feature PC leasing rather than ownership, and permit flat-fee upgrading 24 months into a 36-month lease. The trend toward leasing necessarily increases product take-back (PTB), facilitating (or driving) in turn a higher degree of reuse and materials recycling. PTB programs began in Europe in 1989, and were extended to U.S. commercial customers in 1997 with the announcement of the IBM Credit Corporation (ICC) PELM Service Offering. Currently, IBM has thirteen PTB programs operating world wide to take-back end-of-life computer equipment from external customers. Most of these programs are supported in the local country by an IBM Materials Recovery/Recycling Center (MRC) for the collection and processing of EOL equipment. In addition to these PTB programs, IBM has a network of approximately thirty MRCs world wide for the processing and/or collection of IBM owned EOL equipment. In addition to end-of-lease returns, this equipment is generated from field returns, local manufacturing plant obsolete and surplus, and replacement of IBM personnel equipment. Higher PTB levels will, though IBM's network of materials recovery/recycling centers, enable the company to meet its recycled content standards for new products..

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[18] Service offerings include Business Intelligence Services; Business Management Services/ERP (SAP, PeopleSoft, etc.); Business Recovery Services; Consulting; e-business Services; Education and Training Services; EMU Transition Services; Global Transformation 2000 Services; Hardware and Software Support Services; Industry Solutions; Managed Data Network Services; Managed Electronic Transaction Services; Managed Internet and Intranet Services; Managed Messaging and Collaborative Services; Network Outsourcing Services; Site and Connectivity Services; Small and Medium Business Leadership Solutions; Strategic Outsourcing Services; Systems Integration Services; Systems Management and Networking Services

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Radian & Dow

Company Profiles

Dow Chemical is a diversified multinational supplier and manufacturer of chemicals, plastics and agricultural products. The fifth largest chemical company in the world, Dow operates in 164 countries with 114 manufacturing sites and 43,000 employees. 1997 operating income was $2.73 billion on sales of $20.02 billion. The company is divided into six business segments Performance Plastics, Performance Chemicals, Plastics, Chemicals and Metals, Hydrocarbons and Energy, and Diversified Businesses.

Radian International, LLC is an environmentally focused science and engineering firm with approximately 2000 employees. Headquartered in Austin, Radian has 36 offices in the U.S. and 12 offices abroad. Its services include Engineering, Information Technology, Regulatory Compliance, Environmental Health & Safety, Remedial Construction, Technology Development and Application, as well as related services for air pollution, remediation, waste water treatment, hazardous and solid waste management, and total chemical management.

Dow acquired a majority share in Radian in 1997, and complete ownership in early 1998[19] — in substantial part to develop a chemical services business. By August 1998, however, Dow had completed sale of Radian to the Dames and Moore Group, a diversified engineering, science and technical consulting and services firm based in Los Angeles.[20]

The sale of Radian to Dames & Moore ended this association between a chemical services business and a chemical manufacturer — an association of intrinsic interest to this study of product "servicizing."

Evolution of Radian's chemical management service offerings

In the early 1990s, Radian saw its traditional environmental consulting business peaking. This business focused on compliance assistance for the private sector and scientific consulting work for the EPA; the latter was seen to be particularly problematic for future growth. An extended strategic assessment process resulted from this realization — a process of identifying the company's competencies and options for diversification. In the private market, Radian believed that it had a reputation for and a core competency in compliance assistance across the environment, health and safety areas.

Two issues emerging at that time sharpened Radian's choice between pursuing familiar government work on the one hand and service-oriented private sector business development on the other. The first was enactment of Title V of the Clean Air Act Amendments, which presented the prospect of growth in government contracting work. The second were conflict of interest issues arising out of Radian's work for both government and private firms under CERCLA and RCRA.

By the mid-1990s, Radian was developing chemical management services for the private sector based on a new business model. In this model, the company would assume all or some elements of chemical management operations for client manufacturing firms or facilities — from sourcing, and inventory management to delivery in use, waste management, and EH&S training and reporting compliance. The model drew on customer interactions; many of Radian's long-term clients had expressed an interest

[19] (In January 1998, the Hartford Steam Boiler Inspection and Insurance Company exercised a put option to sell its 40% stake in Radian to Dow.)

[20] 1997 net earnings for the group were $19.3 million on revenues of $700 million. The Radian acquisition is expected to increase 1998 revenues above $1 billion.

in more complete management of chemicals — in some cases wishing to rent all chemicals rather than purchasing them. To the client, this chemical services model could be marketed as an outsourcing option, permitting the client to concentrate resources on the core business while realizing significant cost savings.

These savings would derive from two key characteristics of chemical management activities:

- Chemical management costs may exceed purchase costs by a factor of 5 – 10; these costs are often not appreciated by the firm and provide opportunities for cost savings and efficiency improvements when addressed by a specialist chemical services provider.
- The specialized nature of chemicals and the regulatory requirements attendant to their use and disposal demand attention and expertise throughout their lifecycle — including procurement, delivery, inspection, inventory, storage, labeling, and safety precautions, not to mention the many required resources for training, tracking, legal liabilities and disposal. These are in many cases more efficiently addressed by a specialist provider

Radian's revenues, in turn, would be based on a combination of fees and gain-sharing resulting from cost savings delivered to the client.

Acquisition by Dow: a brief affiliation

Unlike Radian, which exists to provide professional services to clients in a number of fields, Dow has historically been and continues to market itself primarily as a products company, one whose competitiveness is rooted in product innovation and manufacturing expertise.

For a number of years, Dow has provided services related to its products — though not as a strategic, corporate-wide focus:

- Dow Europe, for example, offers a chlorinated solvents service which delivers, recovers, and reclaims used solvents from the company's customers. Available in Germany, the UK, France, and Scandinavia, the service involves collection of spent solvent from use sites and its regeneration at reconditioning/recycling centers. Dow developed specialized safe containers for collection of solvent on site and its transport, as well as the reverse logistics infrastructure.
- Through a joint venture, Dow had previously been significantly involved in oilfield (drilling) support services (the business was sold in the late 1980s).
- Dow provides windshield mounting services to "big three" auto manufacturers.

Dow management in the mid-90s, however, saw services as the next business wave. The company faced a number of obstacles to becoming a services or "solutions" provider. These included

- the fragmented nature of Dow's service offerings,
- the difficulty encountered by marketers in Dow's Environmental Services business in successfully pitching Dow in the market as a "solutions provider."
- The high cost — in money, time, and manpower — of making the case for chemical management services to customers. This typically required extensive prospective studies for which customers were unwilling to pay.

Dow saw Radian as a vehicle to consolidate/accelerate its chemical management offerings, as a reputable brand name in EH&S management, and as possessing expertise to reduce the high costs of landing chemical management services contracts. Dow's Environmental Services business would be folded into the strategic chemical manage-

ment unit, and Radian's emergent "Total Chemical Management" business would be developed. From Radian's perspective, being a Dow business had a number of potential benefits — Radian had access to Dow's strong product lines and chemical manufacturing expertise.

Soon after the acquisition, however, Dow began to have a number of second thoughts. Dow perceived the Total Chemical Management (TCM) program as slow to develop and slow in becoming profitable, raising increasingly serious questions about Radian management. Too much of Radian's business — such as government consulting services — had little or no connection to Dow's chemical-manufacturing business. While questions were raised internally by some of Dow's senior management about inherent conflict between a chemical service provider and a chemical manufacturer, Dow's bottom line assessment was that Radian was simply not performing acceptably.

On Radian's part, its business model for chemical management services (CMS) was significantly broader than the "Strategic Chemical Management" business which Dow had first envisioned. The Dow vision focused on chemical use optimization, waste reduction and EHS improvements, leveraging Dow competencies in process engineering and EHS knowledge. Radian's vision of CMS included in addition the "supply" cycle of sourcing, procurement, gatekeeping, logistics, and inventory management. Radian's assessment was that the more limited Dow vision would not constitute a sustainable business, and that the Dow-contributed asset to the chemical services business was losing significant money. Radian believes that while Dow was interested in Radian's larger CMS vision, Dow eventually became concerned with potential, future conflicts with their distributors.

Radian's affiliation with Dow was thus a short one, with sale completed in August, 1998, to the Dames and Moore Group.

Radian: future directions in services

As a services firm, Radian has an easily understood commitment to the services model. It has continued to develop its Total Chemical Management program, based on the chemical management services model. From the company's perspective, growth and leverage opportunities in the market include:

- Companies experiencing significant structural changes such as acquisitions and mergers typically undergo reorganization, systematic assessments of cost reduction possibilities, and efforts to standardize systems and operations company-wide. This dynamic environment provides opportunities for introducing Chemical Management System programs.

- Providing chemical management services to a facility requires a distribution and support infrastructure whose costs must be distributed over a minimum volume of business. The TCM model can nonetheless be extended to small client firms, where these firms are geographically close, share similar chemical needs and can consolidate their waste streams. Coordination issues in this context are non-trivial.

- Adoption of chemical management systems can in some cases reduce potential environmental liabilities, which can be a strong incentive for its adoption. In at least one case, chemical management systems have been promoted by a state agency as a shield against Superfund liability on a redeveloped brownfield site — because the CMS tracks chemical purchase, use and disposal very closely, it can be clearly established that a company did not

contribute to a preexisting environmental problem.[21]

Dow: future directions in services

Dow states that it remains very focused on "solutions" businesses for future growth, which may or may not have a strong services component, as need indicates. It is currently, for example, investigating U.S. markets for chlorinated solvents services, patterned after its European offerings.

From Dow's perspective, servicizing as a business strategy was not invalidated by the Radian experience. The experience did, however, demonstrate the importance of timing, fit, and management effectiveness in developing a chemical services business. Further, Dow in general believes that service provision and product manufacturing can, and should be, kept separate as distinct businesses, as there are indeed certain potential cultural conflicts in meshing traditional product sales with service-based offerings.

In general, the company has had experiences illustrating the value of extending business activities to new sections of the value chain through service. One example involves windshields for Chrysler. Dow is a long time supplier to Chrysler, with supply products including windshield components. Through a subsidiary, it has moved from a components supplier to a full windshield supplier. Dow now delivers a fully assembled unit requiring a simple four-step assembly, in contrast to the 100 step-assembly previously undertaken by Chrysler in its assembly lines. This innovation resulted from neither a Dow or Chrysler-only initiative, but from interactions between supplier and customer seeking value–added improvement along the product chain**.**

[21] The example cited involves the California Department of Toxic Substance Control, which has promoted CMS as an effective liability shield to prospective tenants for a brownfield redevelopment project on a former Air Force base.

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Xerox

Company Profile

Xerox Corporation produces copiers, printers, fax machines, scanners, desktop software, digital printing and publishing systems, and supplies. Marketing itself since 1994 as "The Document Company™," Xerox offers comprehensive document-management services, including on and off-site outsourcing, publications system design and process consulting. With 91,000 employees, Xerox operates 29 manufacturing sites in 14 countries. 1997 net income was $1.45 billion on revenues of $18.2 billion.

A pioneering technology company faces competition and technological change

Xerox marketed the first xerographic printer in 1949, and — like IBM — was the subject of considerable anti-trust attention in the 1960s. But by 1985, its copier market share had slipped to 10%. Share had been ceded to a pool of largely Japanese competitors — notable among them the then and current market leader, Canon.

The company turned to "total quality management" (TQM) in the mid 1980s in an effort to produce more competitive products and regain lost market share. The company did win a series of quality awards and succeeded in regaining a 17% share from its Japanese competitors by the early 1990s — the first major U.S. corporation to do so. In defending its core light-lens copier business, however, Xerox failed to capitalize on a number of internal inventions and innovations, particularly those generated by its Palo Alto Research Center (PARC). A number of these "Xerox firsts" were exploited with great success by others in what became the personal computer revolution: graphical user interfaces, mice, windows, laser printing, distributed computing, and the Ethernet.

Against this backdrop of missed opportunities, CEO Paul Allaire — a Xerox veteran named to the position in 1990 — realized that the market Xerox served was being redefined by technological change. In his words, as the worlds of paper-information and information began to merge (Howard, 1992), the relevance and utility of the stand-alone, light-lens copier would inevitably diminish. Digital reproduction and printing technology offered clear advantages over the traditional light-lens copier. A digital copier — essentially, a scanner integrated with a laser printer — could integrate with office information systems, becoming network printer and just-in-time press. The required tight integration with office systems, however, meant that Xerox would no longer be able to offer the copier as a stand-alone office appliance.

Beyond total quality. . . an ongoing drive towards service

In response to these competitive pressures, Allaire engineered a sweeping reorganization of the company in the early 1990s. Xerox relabeled itself "the document company™" in 1994 and began a strategic effort to market its in-depth capabilities across the entirety of the document process. Company strategic statements focus on documents as mission-critical business elements —as both the end, value-added product (for some enterprises), and the vehicle by which business is conducted for all enterprises:

> *"Documents are. . . the vehicles within which information is created, structured, communicated and preserved. Without the document, business as we know it today wouldn't exist."*[22]

The strategy envisions increasing integration of document management activities within a networked enterprise. In this model, data and text required for documents are assembled electronically from diverse business functions, and from supplier and customer transactions. Documents are digi-

[22] Xerox web site, "The document cycle"

tally printed on a just-in-time, highly customized basis. The copier as a stand-alone unit is replaced by digital printing stations which reproduce paper originals, but also serve as network printers or, at the higher end, as digital presses replacing an entire inventory-heavy printing infrastructure of photocopiers, offset presses, binders, and document assembly operations. (Xerox calls this method of document delivery "Automated Fulfillment.")

Allaire believed that "the document company™" strategy would, in theory, benefit the company in a number of ways. First and foremost, it would provide direction and focus for a proactive response to technological changes which were diminishing the role of the company's core product. Under its aegis, Xerox could structure its attempts to penetrate and establish a brand presence within a wide range of document-related activities. Because of the complex, networked environment it envisioned, this would create opportunities to develop and market integrated suites of equipment. Moreover, the "technological intensification" of the document production would create markets for specialist integration services and products to marry corporate information systems to document generation and reproduction.

All of these business opportunities implicit in the strategy, however, would require Xerox to move increasingly toward service provision. As Allaire noted in 1992:

> *"As we move into this systems world, we aren't just making and selling boxes anymore. Increasingly we are working with customers to design and redesign their basic business processes. In the future, Xerox won't just sell copiers. It will sell innovative approaches for performing work and for enhancing productivity. . .it's a partnership [with the customer] in which we take a more consultative approach" (Howard, 1992).*

The service provision concept was not new to Xerox. The company had provided traditional document outsourcing services for a number of years — essentially running copy, document assembly, and distribution services for firms, either in dedicated on-site facilities or at off-site reproduction centers serving firms in a geographical area. Until the advent of serious competition, Xerox copiers were always leased rather than sold, and on-site copier service has always been a significant focus for the company.

The focus on integrated services offerings across the document cycle, however, was new, as was the integration of the document cycle made possible by a networked office environment. In the 1990s, Xerox has, in the view of those who track the industry, largely succeeded in its reorientation to "documents" rather than copiers. Services is the fastest-growing area of the company, and Xerox's current investor presentations highlight document services as ultimately becoming the company's "lead offering to major customers." Xerox' service offerings today include:

- Traditional document outsourcing
- Document production process assessment and redesign,
- Network, software and hardware integration
- Training

Environmental implications

Xerox has a reputation for environmental innovation, and has actively pursued a number of EPR activities, including cross-cutting DfE standards, and consumable and durable product take-back and remanufacturing. It does not, however, tie its "document" strategy to environmental performance. Indeed, while conscious efforts have been made to improve product energy efficiency and to reduce manufacturing and disposal impacts or products, Xerox believes that each of the technological transformations affecting its market (analog to digital products, black and white to color, non-networked to networked) will actually increase page volume and/or the average

percentage of page covered with toner.[23] Both trends are positive business indicators, signaling increased revenues — but have negative environmental implications.

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