Strategies To Make The Manufacturing Processes More Environment Friendly

S.C. Singh*

ABSTRACT

For many reasons, strategies to make the manufacturing processes more environment friendly must come form the corporation as a whole, not from any one functional area. Sustainable development is aimed at meeting current needs without compromising with the ability of future generations to do so. Environmentally conscious manufacturing or ECM, involves planning, developing, and implementing manufacturing processes and techniques that minimize or eliminate hazardous waste and reduce scrap. In this paper efforts have been made to identify and describe the basic elements of an environmentally conscious manufacturing strategy. After this description of some of the tools and techniques that can enable businesses to pursue environment conscious manufacturing strategies will be done.

---

* Associate Professor, Faculty of Management Studies, Banaras Hindu University, Varanasi-221005 (Inida)
Email Id : scsingh@fmsbhu.ac.in

INTRODUCTION

Environmentalism is no longer an issue of reluctant compliance with regulatory requirements. In the last decade, it has increasingly emerged as a potential mechanism for gaining competitive advantage and has become an important aspect of strategic management (EPA,1990). Being environmentally conscious involves detailed attention to a variety of issues, such as energy conservation, pollution prevention and avoidance of ecological degradation (Allenby, 1993). Our current levels of resource consumption and waste generation are unsustainable in the long run. A 1987 report by the World Commission on Environment and Development (WCED) warns that current environmental trends threaten to radically alter the planet and many species upon it, including the human species.

The transition from an agricultural to an industrial civilization is accompanied by increasing exploitation of scarce resources and destruction of the natural environment at an alarming rate. Industrial production technology has traditionally focused on improving the quality and quantity of production with little attention paid to environmental or social costs (Ashley, 1993). The growth in environmental consciousness has led to a significant change in this attitude, and – willingly or otherwise – businesses are now forced to confront the consequences of their actions. Modern technology offers the promise of dramatically changing the products we use, how we use them, and how they are made.

A major objective of ECM is to design products that are recyclable or can be remanufactured or reused. Expected benefits of ECM include safer and cleaner facilities, lower future costs for disposal and worker protection, reduced environmental and health risks, and improved product quality at lower cost and higher productivity (EPA, 1992a; 1992b).

ELEMENTS OF ENVIRONMENTALLY CONSCIOUS MANUFACTURING STRATEGY

The three R's of environmentally conscious manufacturing are: reduce, remanufacture, and reuse recycle. Together, these three strategies can result in less consumption of nonreplenishable resources and considerably lower levels of pollution (Dechant and Altman, 1994). In this section, we will discuss each of these environmentally responsible approaches to manufacturing.

Reduction

Reduction refers to efforts undertaken by manufacturing firms to minimize waste. The initial impetus for was the reduction came from legislative and governmental initiatives in this direction. For example, the 1994 Hazardous and Solid Wastes Amendments of the Resource Recovery Act (RCRA) passed by Congress specifically mandate waste minimization as a policy. Similarly, provisions of the comprehensive Environmental Response, Compensation and Liabilities Act (CERCLA) – aka the Superfund – have made waste minimization strategies absolutely essential for manufacturing firms.

The main emphasis in waste minimization is on source reduction (Lorton et al., 1988). As defined by the Federal Pollution Prevention Act, this includes products, processes and technologies that will reduce 'in process' waste streams as distinct from "end-of-pipe" waste. Source reduction activities include:

- input changes;
- operational improvement that leads to loss prevention;

- production process changes;
- product reformulation;
- inventory control; and
- administrative and organizational activities such as training.

Many of the recent practices, philosophies, and approaches to manufacturing management such as Total Quality Management (TQM), Just-In-Time (JIT) and JIT II, can also result in the reduction of in-process waste streams. The role of TQM in ECM practices has been discussed by a number of authors, such as (Willig, 1994), and is practiced by a number of organizations. Eliminating wastes and continuous improvement are basic tenets of the TQM philosophy. The TQM objectives of quality at the source and defect reduction have direct implications for total waste reduction. While scrap reduction directly results in less waste, defect reduction indirectly does the same by minimizing the need for rework and the consequent consumption of additional energy (Kaplan, 1988; Kleiner, 1991).

TQM tools such as concurrent engineering can be used at various levels of analysis to cut waste. Concurrent engineering is a systematic approach to the integrated and simultaneous design of products and related processes, including manufacture, marketing, and support. Requiring close coordination among various functional areas, it results in benefits that go well beyond the reduction of waste. It also requires the consideration of manufacturing cost, quality control, production scheduling, marketing (including packaging and point of sale), user requirement disposal, recycling, remanufacture, and disassembly characteristics (McConocha and Spech, 1991).

The objective of concurrent engineering is the simultaneous consideration of the life cycle impacts during preliminary system design along with the immediate considerations of functionality (Fellows, 1993). One of the goals of TQM is to simplify the design of products. Not only does it lessen the variety of items in the inventory, but it may also result in less work, energy, and time that are usually associated with the production process. In addition (Wheeler, 1992), has found that companies that have achieved environmental excellence use continual benchmarking and do not deviate from their goals.

Just-in-Time inventory practices can also lead to waste reduction. Because fewer materials, components, and parts are held in inventory, there is less potential for waste. Other developments and approaches that can lead to waste reduction include additive fabrication processes (instead of subtractive), databases that help identify less hazardous substitutes, and waste monitoring technologies that reduce leakage into the environment.

Remanufacturing

Remanufacturing refers to the repair, rework, or refurbishment of components and equipments for either sale or internal use. The remanufacturing process basically includes the disassembly of components (MCC, 1993), inspection and testing of the remanufacturable components, incorporation of any new improvements, and reassembly of components with newer systems. The product is assembled, finished, tested, packaged, and distributed in the same manner as new products.

Remanufacturing has a number of implications for ECM. If pursued on a large scale, it can significantly reduce both the consumption of raw materials and pollution resulting from discarded used components and subassemblies (Ottman, 1992; Rose, 1990).

The major differences between manufacturing and remanufacturing, writes (Gravin, 1992), arise as a consequence of using worn-out, discarded, or defective products as a primary materials source.

Criteria that distinguish products that lend themselves to remanufacturing include the following:

- the product technology is stable;
- the process technology is stable;
- the product is one that fails functionally rather than by dissolution or dissipation;
- the product has a “core” that can be the basis of the restored product;
- a continuing supply of such cores is available;
- the core is capable of being disassemble and restored to its original condition;
- the product is one that is factory built rather than field assembled;
- the recoverable value added in the core is high relative to both its market value and its original cost.

Recycling and Reuse

Most of the raw materials used in manufacturing can be recycled, although in many cases it may be difficult to pass on the costs associated with doing so. Solid waste materials such as paper, glass, plastics, and metals are abundant, with more and more being stored in landfills daily (Biddle, 1993). More than 100 million tons of nonperishable wastes are buried in landfills every year, with at least 78 million tons being made up to recyclable materials. This includes 50 million tons of paper, 12 million tons of glass, 11 million tons of plastics, and 5 million tons of aluminum, with mandatory recycling laws in many states, the availability of recyclable material is steadily increasing every year (Walley and Whitehead, 1994).

Although the terms “recycling” and “reuse” are used interchangeably there is a slight distinction between the two. If a material can be used with minimal treatment, the term reuse is more appropriate, whereas a material that has undergone a significant amount of treatment may be considered to be recycled.

From a procurement perspective, selection processes for suppliers and vendors need to include the criteria of being able to supply environmentally friendly products, especially those that make use of recycled materials. The Buy Recycled Business Alliance, an association of organizations that prefer to buy recycled raw materials and products.

Although the availability of recycled material is not a problem, two basic issues that need to be addressed before they are widely accepted commercially are cost and quality.

There are several ways of addressing the problem of cost. First, local governments can sometimes be persuaded to bear part of the cost because it relieves them of the disposal problem. Second, products can be designed for easier disassembly, which makes the recycling process less labor-intensive.

The issue of the quality of products using recycled materials is partly substantive and partly perceptual. In some cases, the quality of recycled materials is already superior to that of virgin materials.

Customer perception is the problem in the case of many other products. For example, plastic lumber, which can be made from recycled plastic, is in many ways superior to wood because it does not rot or splinter and has almost no maintenance cost.

But in customers' minds, wood is superior to plastic. It would take a considerable effort in terms of advertising and customer education to overcome these perceptual problems.

FORMULATING AND IMPLEMENTING ECM STRATEGIES

The three major elements of an ECM strategy discussed above cannot be formulated and implemented in a piecemeal fashion. Organizations must establish strategies, structures, and systems that can effectively help managers in making environmentally responsible decisions without necessarily sacrificing the economic interests of the firm to any great extent. It this section we shall discuss some of the strategies and tools for the formulation and implementation of an environmentally conscious approach to manufacturing.

Product Development Life Cycle and Life Cycle Assessment

The basic argument for life cycle assessment methodologies from a manufacturing point of view has been succinctly stated by (Frosch and Gallopoulos, 1989):

> Like their biological counterparts, individual manufacturing processes in an effective industrial ecosystem contribute to the optimal function of the entire system. Processes are required that minimize the generation of unrecyclable wastes (including waste heat) as well as minimize the permanent consumption of scarce material and energy resources (Fouchy, 1993). Individual manufacturing processes cannot be considered in isolation. A process that produces relatively large quantities of waste that can be

used in another process may be preferable to one that produces smaller amounts of waste for which there is no use.

Product development life cycle (PDLC) assessment is one of the most effective tools that enable managers to evaluate the environmental implications of any manufacturing activity. It measures the environmental impact of a product from cradle to grave and even into its "afterlife". "Standardized" life cycle assessments for products and material are now being completed by industries as well as by individual enterprises.

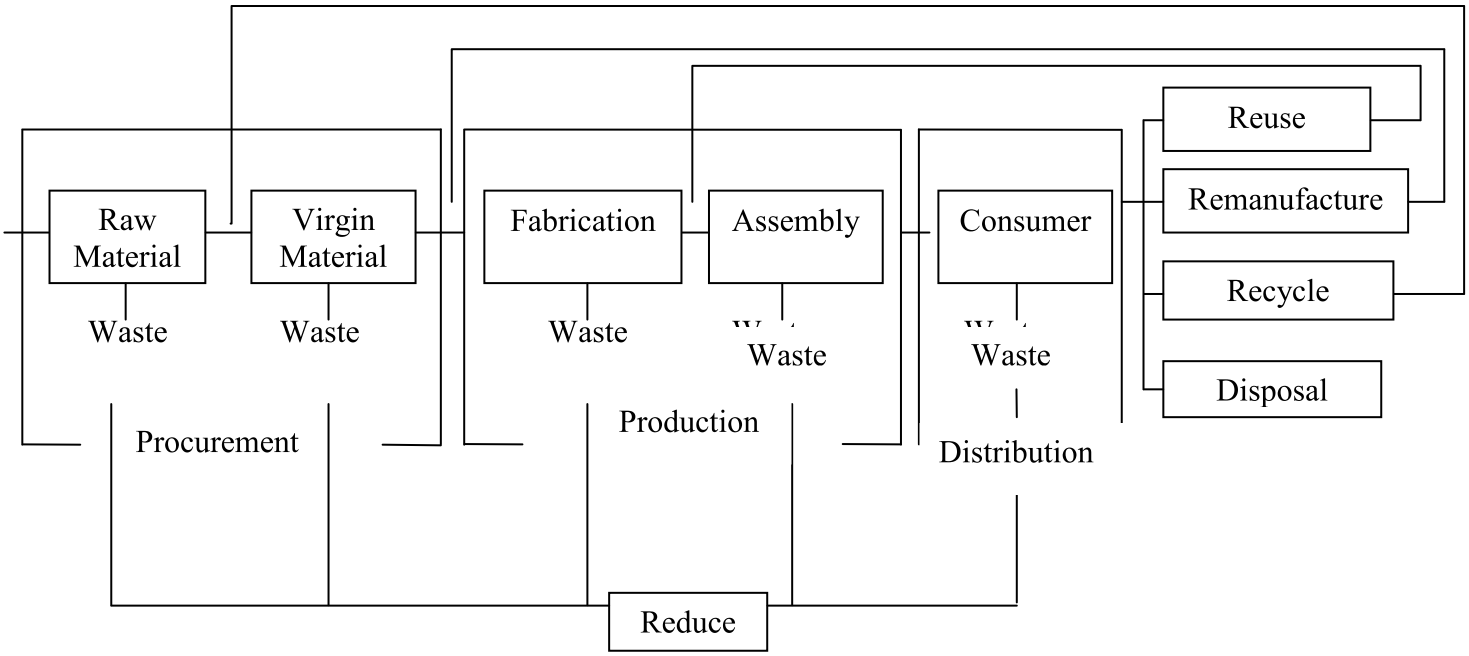
In the future, life cycle assessment is expected to play a significant role in shaping both public policy and corporate strategy. Consider the production of super-lightweight automobile using man-made materials that would greatly enhance fuel efficiency. Although this might appear to be of great environmental benefit because of reduced energy consumption and carbon emission, there may be an environmental benefit because of reduced energy consumption and carbon emission, there may be an emission, there may be an environmental cost: The lighter synthetic materials may be more difficult and expensive to recycle than the heavier materials they replaced. The PDLC assessment approach, by considering the lifetime environmental impact of a product, can bring to our attention the complex tradeoffs involved in the choice of materials and technologies for manufacturing activities.

The traditional application of life cycle assessment approaches has focused on a product's manufacturing life cycle and the selection of alternative product characteristics, especially the types of materials to be used in manufacturing. This approach can be broadened to include analysis of alternative processes and technologies that can be used to produce the same product.

Figure 1 presents the life cycle of a product in a flow chart form, identifying three primary phases of the cycle from an operations perspective; procurement, production and distribution. Within the chain, we see that each of the major activities generates waste, the reduction of which is a major goal of ECM. Any waste that cannot be eliminated may be reused, recycled, remanufactured, or disposed of. The main objective is to keep all materials within the life cycle and minimize any flow into the external environment.

As seen in Figure 1, the only activity that conflicts with this goal is disposal. Disposing of wastes into the environment should be minimized, if not eliminated. Even in the "after-market", the product and materials can follow the same ECM strategies to integrate the product back into the life cycle. The feedback arrows show the general paths in which products and materials ideally will flow. As an example, if a product is recycled, it will most likely enter the life cycle chain in the procurement stage, where, after some initial processing, it may be used along with other raw materials to produce the virgin material. For such a system to be effective, a larger industrial ecosystem infrastructure must exist. The PDLC assessment methodology considers the flow of materials as well as their linkages and relationships with various activities and processes. This is achieved by developing functional representations of the business processes within an organization, or a set of enterprise models.

Figure 1 Operational Stages of a Life Cycle Assessment



The traditional belief in manufacturing has been that planning for the product is no longer important once it leaves the shipping dock. The new imperative is that manufacturers should be aware of and plan for the product long after its delivery and distribution. This would include such issues as field maintenance and disposal of the product. Development of standard and generic PDLC processes for various products can help a number of firms develop their own specific models, especially companies that have limited resources.

The life cycles of several products within a geographical region can be understood and their systematic environmental impact assessed by modeling industrial ecosystems. Just as a natural ecosystem consists of a network of interdependent organisms and their environment in a state of dynamic balance through an ongoing exchange of resources, the industrial ecosystem consists of a network of organizations that collectively minimize environmental degradation by using each other's wastes and by-products.

Figure 2 Environmental Performance Measures

Recycled Content	Water Pollution
Recyclability	Soil Pollution
Reusability	Air Pollution
Remanufacturability	Noise Pollution
Degradability	Resource/Energy Usage
Hazardous Toxic Waste Content	Regulatory Compliance

ECM Project Planning and Management

The central role of the manufacturing function in enabling a company to gain competitive advantage in the marketplace is being increasingly recognized. Previously, manufacturing was viewed as a purely operational consideration in which planning was short-term and much focused. Instead, the manufacturing strategy of a firm should follow from and be integrated with the overall business strategy to be an effective competitive weapon.

The justification and adoption of ECM programs necessarily follow a strategy-driven approach. The major interrelated steps in this process are strategic planning, enterprise assessment, strategic justification, implementation, and audit.

Strategic planning. Driven by the organization's vision, mission, and objectives, strategic planning at the corporate and business levels is the first phase of the ECM process. Environmental issues need to be explicitly incorporated into the mission and objectives of the firm as well as in the analysis of external opportunities and threats. Consequently, environmental objectives should be built into the plans for each of the functional areas, including manufacturing.

Enterprise assessment. The second phase of the methodology involves enterprise assessment, which will help determine the need for and configurations of ECM technologies. An important step in this phase is the development of the environmental performance measures necessary to evaluate and continually improve the success of ECM strategies. The development of the appropriate measures will also be necessary in later stages, especially when seeking to justify evaluate, and eventually audit the various technologies.

A number of performance measures exist for various elements of the manufacturing and related functions. Selecting the appropriate ones is important, because the optimization of the systems will be based on them. Environmental performance measures should not be developed in isolation but, again, must be derived from the mission, objectives, and strategies of the firm.

Figure 2 provides a list of environmental performance measures addressing issues that relate to the product, process, and technology. Most of these are relatively general and can be disaggregated into lower level operational performance measures, which can be used to manage the products and processes. Some of these criteria are easy to quantify and measure; others are not. For many of them, methods of appropriate measurement and estimation need to be derived.

An integral part of the assessment phase is some form of project or program evaluation to determine needs for an enterprise. Examples of specific approaches to be used in assessing technology or project needs in an environmental setting include using logic diagrams and material balancing for technology evaluation. Enterprise models, simulation tools, checklists, and prioritization schemes may also be used for determining various technology needs.

Strategic justification. Development tools and techniques for the financial and strategic justification of environmental initiatives is particularly important, considering the controversies and conflicting evidence in this area. Some authors hold that the costs of organizational greening often exceed any benefits accruing from it, whereas others argue that environmental initiatives improve public image, increase customer acceptance, attract funding for investments, and lead to overall competitive advantage.

For any ECM initiative to be seriously considered in a manufacturing firm, it must be justified. Traditionally, justification of projects that involve a big initial investment has focused on economic and financial factors. But these factors alone may not be adequate for evaluating and justifying ECM technologies and practices. Typically, project evaluation models and criteria have focused on short-term tangible gains and ignored more strategic and intangible benefits. A complete justification analysis of any ECM technology or project needs to consider the long-term quantifiable and non-quantifiable strategic benefits.

Cost management systems must also be developed that can provide useful information for determining the costs and benefits associated with pursuing, or not pursuing, strategic ECM programs.

Traditional cost management systems are deficient in their ability to accurately measure the costs associated with the activities that are part of a manufacturing process. This presents a major difficulty in tracking and estimating such costs. To address these problems, activity-based costing and management approaches have been recommended that, although in their initial stages of development, have great promise for data acquisition that can be used for justification.

It is important to consider the ever increasing legal costs not just of noncompliance but of the failure to actively pursue environmental initiatives. Similarly, in addition to the marginal costs or savings that accompany changes in inputs or processes, the less measurable but very real increases or decreases in market acceptance of a product that can be attributed to these changes must also be considered.

Once the necessary data are acquired, the next step is using the cost data through a strategic justification model. The literature currently contains a number of models that can simultaneously consider multiple dimensions of various strategic manufacturing technologies. Many of them are specific to various manufacturing characteristics. Yet few have specifically focused on justifying ECM-related technologies. The existing justification models, with some modifications, can be adapted to ECM programs.

Implementation. Implementing ECM programs and projects is usually the most critical step in ensuring success. This includes all tasks necessary to take the program from design to an actual working system. This stage in itself is very dynamic and may require numerous iterations. Unlike the previous phases in the ECM management cycle, in which upper management played a major role in the decision-making process, the planning and design in this stage are the responsibility of an integrated resource management group – a project team comprised of representatives from every function within the organization.

The steps in the implementation process include: (1) acquisition and procurement, (2) operational planning, (3) implementation and installation, and (4) integration. The first three can occur simultaneously, though all the stages require some sort of planning before beginning the actual process. Integration should also be planned, but knowing which operations and processes are needed as well as which type of equipment should be acquired is necessary before full-fledged integration can take place.

This critical transition period involves several activities. Implementation includes training, testing, pilot programs, and integration steps. The roles and relationships of legacy (existing) systems must be made very clear in the project plan. Various strategies exist for the implementation phase, including phasing-in systems, cutover to new systems, parallel system in operation followed by cutover, and prototyping systems to full implementation. When starting ECM technology, a firm should monitor the actual implementation continuously to guarantee that the initial performance of the system achieves pollution prevention requirements. This should also be done after implementation for data acquisition purposes.

Audit. Although it is often neglected, the auditing process is important for a number of reasons. Clearly, it will help identify whether the decisions made are meeting the expectations in terms of various environmental performance measures. The feedback gained should be used for continuous improvement and for help in identifying unexpected events or outcomes from the implemented technologies. Auditing may involve reviewing the adequacy of the various performance measures in use and implications of the interrelationships among the performance measure. Establishing and maintaining an auditing system will also help acquire data and generate reports that will reduce the probability of liability risk and regulatory penalties. New international standards for environmental management systems, called ISO 14000, require effective auditing practices to be in place.

GLOBAL ECM STRATEGIES

Environmentalism has emerged as a universal concern among the developed industrial countries. Even in the newly industrialized developing nations, there is growing awareness of the environmental costs of development.

CONCLUSION

Manufacturing firms are moving toward greater environmental awareness and responsibility. Compared to other functional areas, environmental concerns have greater reliance for the manufacturing activity. Greater public awareness of these issues has created two different sets of pressures on businesses to be environmentally responsible. First, public concerns often result in environmental legislation, especially if the industry does not actively respond to these concerns. Second, recent years have seen a strong "green" consumer movement that has greatly influenced manufacturing firms to be more careful of harming the environment.

One of the basic arguments of this paper is that environmentally responsible strategies can neither originate from nor to be confined to any one functional area. They should be an integral part of the corporate strategy and organizational philosophy permeating every functional area and activity within a firm. This is particularly important because of the many interdependencies across the functional areas. Environmental degradation is the consequence of all stages of industrial activity, not just manufacturing. An integrated approach to environmental responsibility should encompass all stages of a product's life cycle design, manufacturing, packaging, maintenance and eventual disposal.

The development of more environmentally responsible technologies and processes is likely to flourish if tools and techniques for the assessment of these are developed. Given the profit imperative of all businesses, it is equally important to develop methodologies for the economic evaluation and justification of environmentally friendly processes and products.

References

1. Allenby, B.R., Industrial Ecology (New York: Prentice-Hall, 1993)

2. Ashley, S., "Designing for the Environment," Mechanical Engineering, March 1993, pp52-55

3. Briddle, D., "Recycling for Profit: The New Green Business Frontier," Harvard Business Review, November-December 1993, pp 145-156

4. Dechant K. and Altman B., "Environmental Leadership, From Compliance to Competitive Advantage," Academy of Management Executive, 8, 3 (1994): 7-20

5. EPA, Pollution Prevention Benefits Manual, Washington, DC, 1990

6. EPA, Strategic Waste Minimization Initiative (SWAMI). USEPA, Office of

Research and Development, Washington, DC, 1992(a)

7. EPA, Pollution Prevention Research Branch: Current Projects, USEPA, Risk Reduction Engineering Laboratory, Cincinnati, Ohio, 1992(b)

8. EPA, Faculty Pollution Prevention Guide, USEPA, Office of Research and development, EPA/600/r-92/088, Washington, DC, 1992(c)

9. Fellows, R.F., "Technology Logic Diagrams and Their Use in the Identification of Technology Needs," Proceedings of the Second International Conference on Environmentally Conscious Manufacturing, Arlington, Virginia, 1993

10. Fouhy, K., "Life Cycle Analysis Sets New Priorities," Chemical Engineering, 100, 7 (1993): 30-34

11. Frosch, R.A. and Gallopoulos N. E., " Strategies for Manufacturing," Scientific American, September 1989. pp. 144-152

12. Gravin, D.A., Operations Strategy: Text and cases (Englewood Cliffs, NJ: Prentice-Hall, 1992)

13. Kaplan, R.S., "One Cost System Isn't Enough," Harvard Business Review, January-February 1988, pp. 61-66

14. Kleiner, A., "What Does It Mean to Be Green?" Harvard Business Review, July-August 1991, pp. 38-47

15. Lorton, G.A., Fromm, C.H., and Freeman, H., The EPA Manual for Waste Minimization Opportunity Assessments. U.S. EPA, EPA/600/S2-88/025, Cincinnati, Ohio, 1988

16. McConocha, D.M. and Speh, T.M., "Remarketing: Commercialization of Remanufacturing Technology," Journal of Business and Industrial Marketing, 6, 1-2 (1991): 23-37

17. MCC (The Microelectronics and Computer Technology Corporation), Environmental Consciousness: A Strategic Competitiveness Issue for the Electronics and Computer Industry, Austin, Texas, 1993

18. Ottman, J.A., "Green Consumerism: The Trend is Your Friend," Directors and Boards, 16, 4 (1992): 47-50

19. Rose, R.A., "Environmental Investing," Garbage, 2,5 (1990): 48-53

20. Walley, N. and Whitehead, B., "It's Not Easy Being Green," Harvard Business Review, May-June 1994, pp. 46-52

21. Wheeler, W.A., "The Revival in Reverse Manufacturing," Journal of Business Strategy, 13, 4(1992):8-13

22. WILLIG, J., Environmental TQM (New York: McGraw-Hill, Inc., 1994)

23. World Commission on Environment and Development, Our Common Future (Brundtland Commission Report) (Oxford: Oxford University Press, 1987).