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THE CONCEPT OF ENVIRONMENTAL MANAGEMENT AND DISCUSSING ITS IMPACT ON PRODUCTION/OPERATIONS MANAGEMENT (POM)

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ABSTRACT: This study delves into the concept of environmental management and explores its implications on Production/Operations Management (POM). Environmental management, as a multidisciplinary approach, addresses the sustainable utilization of resources and the minimization of environmental impact in organizational processes. The research investigates the integration of environmental considerations into POM strategies, emphasizing the potential impacts on production efficiency, waste reduction, and overall sustainability. By analyzing relevant literature and case studies, this study aims to provide insights into the symbiotic relationship between environmental management practices and POM, highlighting the potential benefits of aligning production operations with environmentally conscious principles. The findings contribute to a better understanding of how environmental considerations can be strategically incorporated into production processes, fostering a more sustainable and responsible approach to operations management.

Keywords: Environmental, Management, POM

INTRODUCTION

Today, the power of science and technology has allowed the industrial world to produce a large number of excessively desirable products which in turn, results in mass consumption and the habit of littering. This has depleted scarce natural resources, produced excessive solid and hazardous waste, and polluted the earth. In addition, a series of events occurring such as accidents, oil spills, have led to an explosion of environmental awareness among companies as well as consumers (industry and end users) around the world. In a McKinsey & Co. survey, 92 percent of 400 CEOs and top executives agreed that environmental challenges are one of the central issues of the 21st century and 83 percent agreed that companies need to assume responsibility for their products. They produce, even after they leave the factory (Maulyan et al., 2022).

Recently, some corporate executives have declared themselves

as environmental activists and world-class companies have integrated environmental aspects in the development of corporate policies and strategies. At the same time, eco-friendly consumerism is at an all-time high. Consumers are willing to pay top dollar for items that are reusable, recyclable, and do not harm the environment. 80 percent of buyers say that protecting the environment is so important that it costs a lot to process. In another survey, 27 percent of consumers boycott a product because of the manufacturer's image that is not environmentally friendly (Sudarti &; Susanto, 2015). Industrial consumers are also increasingly demanding that the goods and equipment they buy are environmentally friendly. They demand more detailed information regarding the processes used and products made by their suppliers. As a result, environmental protection and green consumerism began to influence decision-making in operations management as a structured management system (referred to as an environmental management system by the British Standards Institution in BS 7750) (British Standards Institution, 1992).

Operations managers are supposed to play an important role in the development and implementation of an environmental management system (EMS). The main focus of EMS is to prevent adverse impacts on the environment and improve environmental performance by instituting various environmental programs and practices such as initiating environment-related performance measurement and developing eco-friendly technologies, processes, and products. The EMS specification indicates that the competitiveness of an enterprise as a whole can be significantly improved if the EMS is fully integrated with all functional areas, especially with operations management (British Standards Institution, 1992).

According to BSI's "Specification for environmental management systems" (adopted from BS 7750), EMS should:

1. identify and assess environmental impacts arising from an organization's existing or proposed activities, products or services;
2. identify and assess environmental impacts arising from incidents, accidents and potential emergency situations;
3. identify relevant regulatory requirements;
4. allow priorities to be identified and associated environmental goals and targets set;
5. facilitate planning and control activities, audits and reviews to ensure that the policy is adhered to and remains relevant;
6. able to evolve to fit changing circumstances.

Therefore, the main purpose of this article is to introduce the concept of environmental management and discuss its impact on production/operations management (POM). POM is defined as

the process of making ongoing operational decisions (such as product planning, capacity planning and scheduling, process design, workforce management, inventory management, and quality management) to efficiently convert various inputs into a flow of products and/or services. More and more companies are successfully integrating EMS features with their decisions regarding operations and thus realizing a number of strategic benefits. World-class companies are constantly improving their operations to go beyond compliance and stay ahead of their industries.

RESULT AND DISCUSSION

The meaning of "environment" or "greening" is ambiguous and may mean different things to professionals in different fields. In medicine, for example, greening can mean minimizing damage to human health; In business, the term may mean aligning a company's environmental performance with shareholder expectations and is a significant source of new and superior to competitive ones, such as lower costs and expanded market share. Siregar (2016) further argues that the concept of greening will remain ambiguous because it has not been developed theoretically and is poorly researched from the point of view of rigorous empirical testing.

In a more general and broader scope, the term refers to the quantity and quality of natural resources, and the living environment consisting of water, air, landscape, and atmosphere. Defined thus, the environment is an important determinant of the quantity, quality and sustainability of human activities and industrial development (Panayotou, 1992). Rapid deforestation, loss of biodiversity biological resources, release of toxic and hazardous waste, water pollution, air pollution, and urban congestion are some examples of environmental damage that refers to the reduction of the environment in quantity as a decrease in its quality. For example, the environment related to water. This degradation includes water shortages and deterioration of water quality through pollution and contamination. Panayotou (1992) suggests some environmental degradation may be necessary and also beneficial from an economic growth standpoint as long as all costs have been taken into account, then the productivity and sustainability of alternative uses have been considered with a reasonable margin of error, and any side effects have been borne by those who do so. However, research findings show that negligent consumption and production patterns have caused disproportionate environmental damage in the past half-century. An estimated 25 percent of the world's population in industrialized countries consumes 70 percent of the world's resources. Seven advanced industrialized countries, including the United States, account for 45 percent of greenhouse gas emissions caused by human activities. As developing countries industrialize and increase their

economic growth, the demand for resources and pollution around the world will increase rapidly. In addition, developing countries are spending environmental resources to cope with population increases and consequent problems such as poverty.

As a result, this can hinder economic growth and cause environmental damage around the world in the long run (Hasid et al., 2022). The increasing conflict between economic growth and environmental degradation has given rise to a principle called "sustainable development", which means balancing two goals: economic development and improved environmental performance. It is widely recognized that although this bicriterion problem may not be solved optimally due to its interdependent nature, everyone must constantly strive to get the desired solution. Just like the total quality movement, the concept of "environmentally sustainable economic growth" has received worldwide attention from governments, companies, consumers and academics, so this concept is accepted as the ultimate goal of environmental management by international, national and regional economies (Suparmoko, 2020).

A number of different, albeit interrelated, environmental pressures from governments, investors, customers, suppliers, and communities, raise environmental awareness and thus affect company operations. Schot and Fischer (1993) state that the intensity of this pressure may vary by country, industry, sector, and company. They also point out that companies' responses to environmental challenges have changed over a period of time. From the beginning, the company changed from struggling and/or resisting adaptation to external pressures to accepting these pressures. Recently, many companies have been found to be acting beyond compliance with government regulations. As a result, the company's environmental programs and policies can be imagined at different stages of development. Recently, a number of empirical studies have been conducted to synthesize developments in this area.

In the company's environmental management program survey, Petulla suggested three categories of environmental management: *crisis-oriented, cost-oriented*, and *elightened*. Companies with crisis-oriented management deal with environmental conflicts on a "firefighting" basis. These companies do not have an environmental policy strategy to comply with laws and regulations and do not have a separate environmental unit within the company. Companies with cost-oriented management accept environmental regulations as a cost of doing business, and make efforts to comply with them as efficiently as possible. This company establishes corporate policies, separate units, and procedures for environmental compliance. They have spent capital on pollution control devices to comply with regulations. Companies with smart

management have strong corporate support to go beyond regulatory compliance. Other characteristics of these companies are: a strong environmental management division under the officials of large corporations; trained environmental personnel; state-of-the-art pollution control equipment; periodic environmental audits with reports to the head office of the company; cooperation between environmental and production staff; ongoing research to determine cost-effective methods of maintaining environmental quality and good resource recovery; and generally have good relations with officials of institutions and society.

The most important factors leading to the development of "enlightened" environmental management are: strong commitment of the president or CEO and their lawyers to environmental compliance; recognition that corporate responsibility to the environment can affect both short- and long-term profits; and the realization of the fact that the cost of environmental responsibility can be minimized and even a certain amount of profit can be obtained.

Steger (1993) discusses four possible types of general environmental strategies based on two conditions: a firm's potential for market opportunities through environmental protection, and the level of environmental risk inherent in a firm's activities. Therefore, a defensive strategy (i.e. little potential market opportunity and large environmental risk) implies that the company might invest in *end-of-pipe* technology and incur large environmental costs. Offensive strategy (i.e. large potential market opportunities and small environmental risks) implies that a company can develop or modify existing products to demonstrate environmental improvements and, thus, gain a competitive advantage. Innovative strategies (large potential market opportunities and large environmental risks) imply that companies can tap into market potential through major changes in the production process of product design. In an indifferent strategy, companies see little potential market opportunity and little environmental risk.

Steger (1993) argues that firms can no longer justify reliance on defensive or indifferent strategies due to new environmental market pressures and innovation potential. Companies must integrate offensive and/or innovative strategies with their corporate strategies such as product differentiation and cost leadership. For example, 3M integrates cost leadership strategies with efforts to achieve environmental efficiencies through its Pollution Prevention Payment (3P) program. BMW differentiates its Z1 models in an environmentally oriented way.

Van Wassenhove and Corbett (1991) identified three possible strategies for integrating environmental issues with a firm's manufacturing strategy:

1. The "follower" strategy involves compliance with all legal requirements.
2. The "market-oriented" strategy is driven by market conditions under which the environment falls subordinate but supports the fulfillment of the business strategy.
3. An "environmentally-oriented" strategy is one that views the environment as a key factor and is fully integrated with business strategy.

Van Wassenhove and Corbett (1991) argue that none of these three strategies is superior in all circumstances and it is possible that for certain firms a combination of response patterns is the best option (e.g. "environmentally-oriented strategies" in many highly publicized and sensitive issues, and "follower strategies" in less visible situations). The authors also identify the need for conceptual and empirical research to understand these strategies better.

A company's environment encompasses a set of programs and practices that may include articulating environmental policy statements, developing environmental strategies, creating environmental staff functions, implementing aggressive pollution prevention programs, initiating environment-related performance measurement and developing environmentally friendly technologies and product processes (Smart, 1992). Greeno (1989) predicted that environmental initiatives already undertaken (e.g. Clean Air and Water Act, RCRA, Superfund) and other imminent initiatives would reshape the business and operating strategies of companies in the next decade. Greeno (1989) found that world-class companies incorporate environmental, health, and safety perspectives into their strategic planning as well as day-to-day operations management decisions to ensure that their operations not only comply with legal requirements but are also managed in an environmentally sound and responsible manner.

At the company level, environmental SWOT analysis can be helpful in identifying external threats (e.g. competitors gaining market share with eco-friendly products and improving environmental regulations) and opportunities (e.g. offering eco-friendly products and saving resources), and linking them to internal strengths (e.g. research and development capabilities for clean processes and eco-friendly products, as well as human resources that exist. committed to environmental protection) and weaknesses (e.g. non-recyclable products, and hazardous waste) of an enterprise (North, 1992). An environmental audit (EA) is a management tool that can be used to assess the environmental performance of a company and its units as well as to identify its weak points. EA consists of systematic, documented, periodic and objective performance evaluations of the management environment and facilities. Evaluation in its

implementation can be done by examination. Systematic and periodic evaluations are carried out with documented monitoring in order to ensure objectivity. Thus, the other party can carry out the Re-examination. From this explanation, the environmental audit is an examination to find out the portrait of the state of the environment (Fandeli et al., 2017). A well-designed EMS ensures that SWOT and EA analyses are carried out in a structured management system to address all desired aspects of environmental performance, and are integrated with the company's overall long-term objectives (British Standards Institution, 1992).

As a result of rational strategic analysis of the EMS, companies may choose to integrate environmental principles into mission statements or adopt environment-related policy statements. Furthermore, a green business strategy (GBS) can be developed and that will define the products and markets in which the firm wants to compete along with an indication of whether the firm will pursue cost advantage, product differentiation or niche markets (North, 1992). Each GBS involves the search for different types of competitive advantages. For example, 3M implemented a cost leadership strategy by focusing on environmental efficiency and saved more than US$537 million with its Pollution Prevention Payments program. Loblaw Cos., a Toronto-based company that operates a chain of 340 supermarkets, has differentiated by introducing more than 100 eco-friendly products under the "Green" label. Similarly, a number of European companies gained market sharing by targeting environmentally friendly consumers and obtaining premium prices (Fischer &; Schot, 1993; Gladwin, 1992).

GBS's goal is not only to comply with ever-changing government regulations but also to stay ahead of the industry and consumers through continuous experimentation of the product value chain. Value chains break down firms into strategically relevant activities to understand cost behavior and existing and potential sources of differentiation (Porter, 1994). The value chain shows how a product moves from the raw material stage to the end customer (Hitt et al., 2001). Value chain activities are related to marketing, design, production, delivery, and support of products or services (Segara et al., 2019). A successful GBS provides competitive advantage by analyzing the value chain of activities to create superior value that exceeds the cost of its creation (cost leadership) or that provides unique benefits (product differentiation).

Corbett and Van Wassenhove (1993) propose an excellent framework so that a company's responses to environmental issues can be internalized in a way consistent with its long-term goals. They also argue that internalization alone is not enough; Any

environmental intention ultimately needs to be operationalized by exploring and utilizing analogies and synergies between environmental programs and operations management concepts. All functional areas (such as marketing, finance, and operations) of the company are responsible for the implementation of the selected GBS by developing a consistent functional strategy.

The operating function of a company faces environmental protection issues head-on as it is a major source of operating emissions and therefore, EM programs and policies must be carefully developed to strengthen its operating strategy. Operations strategy, guided by a specific business strategy, results in a consistent pattern of operating decisions so that the objectives of the operating strategy are achieved. The four common operating goals are cost efficiency, quality, delivery and flexibility. Operating decisions are categorized into: strategic decisions (e.g. product planning and process selection), as well as tactical decisions (e.g. production planning and scheduling, inventory management).

Van Wassenhove and Corbett (1991) show that environmental management has a significant impact on operational objectives and thus can influence various operational decisions. The main reason for developing environmental management programs and policies is to support operations strategies, and thus help operations managers to develop specific competencies and gain competitive advantage. For example, AT&T has set aggressive and assertive environmental goals (e.g., a 25 percent reduction in total manufacturing process waste disposal, 35 percent recycling of goods, and a 15 percent reduction in goods use) to create superior value by minimizing environmental impact. The results are impressive. AT&T saved $1.4 million just from up The Gulf Coast Acid team, an employee task force at Dow Chemical, recommended installing an advanced recycling system that resulted in annual savings of $20 million. On the other hand, BMW supports its differentiation strategy by incorporating eco-friendly technologies in its two-seater model, ZI, in Europe. The $55,000 limited-production car has doors, bumpers and front, rear and side panels made from recyclable thermoplastics supplied by GE Plastics. Electrolux Corp., another European company, sells dishwashers that are "designed to disassemble".

The concept of EM with its implications for operations management. Many of these concepts have been internalized by companies to achieve their operational goals and objectives, but some concepts are still in their infancy and show great potential for internalization.

Therefore, it is clear that EM influences various aspects of an enterprise's operating function, from the purchase of various inputs (e.g. raw materials and energy) to the control and change of processes (e.g. air and water pollution control, waste disposal

operations, and new pollution control technologies) to its own output (e.g. environmentally friendly and clean products). From an operations management standpoint, environmental understanding requires a thorough assessment of all processes and then striving for continuous improvement in the consumption of various inputs, process and product efficiency. North (1992) defines continuous improvement of the EM process as a process "to continuously improve corporate policies, programs and environmental performance, taking into account technical developments, scientific understanding, consumer needs and societal expectations, with legal regulation as a starting point; and apply the same environmental criteria internationally". North further suggests that EM processes should be systematic, detailed and integrated into the entire functional strategy (more importantly, into the operations function).

Recently, the design concept for manufacturing and assembly (DFMA) has been accepted by the design community. *Design for manufacturing and assembly* (DFMA) is a structured method for analyzing a product. Reducing the number of parts, increased manufacturing capabilities and ease of assembly where the overall cost of the product can be reduced are the main advantages of using DFMA (Azalia &; Mendrofa, 2023). Reducing components in a product is a major challenge for designers and reducing assembly time leads to lower product costs (Naiju, 2020). DFMA, which stands for Design for Manufacturing and Assembly, *is the result of combining two concepts, namely* Design for Manufacture (DFM) and *Design* for Assembly (DFA). DFM is used as a guide in the early phases of product design, focusing on restrictions related to the manufacturing process. Meanwhile, DFA focuses on product or component design that facilitates and facilitates the assembly process with other components (Faizal et al., 2017). Van Weenen and Eekels argue that the environmental impact of a product is largely established at the product and process design stage because a product and its manufacturing processes need to be designed before a product is manufactured. Therefore, product design decisions and operations management processes have been extensively investigated as the best starting point for operationalizing environmental strategies.

For example, Dow Chemical Co. has integrated its product safety review (PSR) process with its product strategy. The PSR board (composed of cross-functional and experienced managers) receives support from top management and reviews each product regularly to ensure that the product management team has maintained and continuously improved the necessary product and environmental management procedures. Gregory Bond, chief product steward, said, "Products with the greatest potential hazards are reviewed most often". The PSR process

was well received by the product management team as it helped them maintain a broad view of environmental needs and community concerns.

To integrate environmental concerns with product design decisions, a number of world-class companies have augmented DFMA with concepts such as design-for-recycling (DFR), design-for-disassembly (DFD) and *design-for-servicability*. These concepts are related and complementary because current recycling technologies require that products be easy to disassemble. Dewhurst argued that such design requirements would result in cheaper service procedures, more efficient final disassembly, delayed product disposal and, crucially, more profitable parts and material recovery procedures. For example, the Z1 model plastic body panels introduced by BMW are designed to be easily removed by removing some fasteners.

Similarly, each plastic table regulating part introduced by 3M is marked with a recycling symbol and a number indicating the type of plastic resin. These products can be put together for use and can be easily disassembled by separating them. Matsushita Electric Industrial Co., considered the boldest pioneer in the design-for-disassembly field, has developed a washing machine that can be disassembled with just a screwdriver and each piece of plastic larger than 100 grams is precisely labeled according to the material. Similarly, the goal of the vehicle recycling partnership consortium (VRP) formulated by the three major automotive companies has two aspects: first, to develop technologies that enable the recycling of materials in an economically and environmentally acceptable way, and second, to make motor vehicles recyclable, drawing boards to make them easier to recycle when the time comes.

Researchers at Carnegie Mellon University have introduced the concept of "design for environmentability" (also known as green engineering design) to integrate the entire field of "design for". They argue that the product should be designed for remanufacture and reuse, not just for recycling or dismantling materials. For example, a computer manufacturer might lease its fastest machines to companies that need the latest technology, and then, might sell those new, more advanced computers, while at the same time, updating old models and leasing them out to customers who need fewer computers. "Every time you reuse a product, you can save on machining costs, reprocessing costs, and disposal costs", says D. Navin Chandra, research faculty member.

Chandra defines green engineering as "the study of, and approach to, the evaluation and design of products/processes for environmental conformity that does not compromise product quality or function". The basic idea of the "green

engineering" approach is to incorporate concern for environmental friendliness into the design process, thus avoiding environmental problems before they occur. This approach defines a "green" product as one that is environmentally friendly and commercially profitable. Environmental friendliness assessments are based on a product life cycle view (also known as a "*cradle-to-grave*" approach or "from preconception to reincarnation" that includes the process of manufacturing, distributing, using, and disposing of the product) and commercial. Profitability is determined without sacrificing cost, reliability and manufacturability.

This product design concept, when operationalized to some degree, has significant implications for subsequent operating decisions, including process design decisions. For example, the process of recycling plastic components means grinding or shredding components into particles or flakes, in some cases mixing them with new materials, then making new components. Dvorak points out that although the process sounds simple enough, disassembling and identifying materials on obsolete machines presents particular challenges from a process-design perspective. The process becomes more complicated because each product uses dozens of different types of plastic. Steve DeFosse, principal materials engineer at the Center for Plastic Technology, Lexington, suggests a change in the process (known as mold labeling) where common material names and other information (e.g. percentage of reinforcing fibers) are printed on the part using replaceable plugs, making the recycling process simpler.

The basic concept behind the introduction of eco-friendly electric kettles referred to as "UKettle" (claimed to be America's first recycling equipment) was to redesign products with many complex components, internal components, and fasteners by replacing them with larger, simpler components that required fewer fasteners. This new design not only simplifies manufacturing and assembly operations but also makes product recycling easier. This further reduces the labor and energy required to produce a particular product.

The waste minimization policy, mandated by the U.S. Congress on the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act of 1984, is defined by EPA as "the reduction of hazardous waste generated (during production and operation) or subsequently treated, stored or disposed of" (EPA, 1988). RCRA regulations require companies (particularly hazardous waste producers) to have waste minimization programs in place to reduce or eliminate waste. Process design

decisions are often the first and most significant decisions influenced by the environmental program initiated by the company.

A waste minimization program is an organized, comprehensive, and sustainable effort to systematically reduce waste generation by considering operating strategies (Malinaro, 1991). The program consists of two Engineering categories (EPA, 1988; Molinaro, 1991): source reduction/prevention of pollution and recycling.

Pollution reduction (SR/P2) strategies focus on "preventing" pollution at its source (in products and manufacturing processes) rather than eliminating them after the product has been made. It is based on the fact that pollution control procedures and equipment consume a lot of natural resources, energy, human resources and capital resources but do not stop the creation of pollution.

In general, SR/P2 strategies include good housekeeping practices, input substitution, product reformulation, environmentally friendly technology changes, and/or process modifications. Good housekeeping includes inventory control, improved material handling, spill and leak prevention, improved scheduling, and preventive maintenance. Source reduction (SR) focuses on the production process itself rather than waste management or control. It is a concept to prevent the creation of waste, rather than managing it after it has been generated. SR's efforts are not only environmentally beneficial but also economically healthy. Reducing waste production means companies use less raw materials or use them more efficiently. Thus, a business can save money while reducing waste. The direct involvement of company management and operations managers is key to the successful implementation of source-reduction/pollution prevention strategies throughout the plant.

The 3M company, a leading leader in environmental management, embarked on a 3P (Pollution Prevention Pays) strategy that reportedly saved US$420 million and prevented the disposal of nearly 500,000 tons of air, water and total solid waste emissions. Similarly, Dow Chemical's "Waste Reduction Always Pays" (WRAP) has reduced waste by 250 million pounds at a single site (that's a 30 percent reduction). Dow's goal is to achieve a 50 percent reduction in waste.

The waste audit (WAP) process is at the core of any waste minimization program. WAP examines every aspect of the production process, tracks waste from the front entrance to the trash can at the back door, and monitors how the waste passes through the process. Next, various options for retaining waste coming out of the trash can are investigated. Finally, a "waste minimization matrix" is applied, using options that can reduce the greatest amount of waste with the greatest cost savings. WAP can reduce waste by up to 80 percent and, because this process

eliminates waste in the long run, companies continue to earn savings over the years.

In WAP, areas that generate waste in the production process can be disclosed and ways to reduce and control waste can be analyzed. Various alternatives, e.g. product changes (i.e. product substitution and conservation), input material changes (i.e. material purification and substitution), and technological changes (i.e. automation and equipment to change processes) have been suggested in the "*guidelines for waste minimization*" document issued by the EPA (EPA, 1988). Recently, a number of companies have implemented various changes and reported significant improvements in the performance of their operations in terms of cost efficiency, quality, reliability and flexibility. For example, Emerson Electric Co. has reduced solvent waste and paint solids formation by more than 95 percent simply by replacing its solvent-based painting process with a water-based electrostatic immersion system. In a similar way, ITT telecommunications reduce the solvent waste it generates simply by replacing solvent-based photoproof systems with water-based systems.

Eco-friendly technology. The process strategy of an enterprise can also be affected by the impact of environmental pressure on the technology and pollution control methods used by the company. Sometimes, it is old and inefficient equipment that creates waste and pollution. For example, a company installed a simple drag-out recovery system on a nickel plating machine at a cost of about US$1,000. This saves US$4,200 worth of nickel per year and reduces nickel sludge by 9,500 cargoes per year. Another pesticide manufacturer replaced one baghouse with two separate vacuum-air-bag house systems in its production system that produced toxic dust. The system cost only $9,600 but the company eliminated more than $9,000 in disposal costs and recovered $2,000 worth of material per year. Companies are also often required to invest in green technologies (such as pollution control equipment) and techniques (such as sampling procedures) to comply with new regulations. There is some empirical evidence that new environmentally friendly and clean technologies are being sought, developed, and integrated with manufacturing processes. For example, recently Molten Metal Technology has developed an environmentally friendly technology known as catalytic Extraction Processing (CEP), which produces products from waste (including hazardous, non-hazardous, toxic, industrial, etc.) using liquid metal baths. CEP is a closed recycling technology in which waste is rearranged and recycled into useful products, without release or by-products harmful to the environment. In addition, it can be installed and integrated directly into the manufacturing process. CEP is

expected to treat waste at an efficiency level that exceeds currently required standards in most cases. Therefore, the technology may become a new regulatory benchmark.

BH Electronics, a small electronic component manufacturer in Minnesota, has developed a new dry process technology for printed circuit board manufacturing that will have a significant impact on an industry that currently generates 25 billion gallons of wastewater annually. Similarly, Union Carbide recently introduced a new low-volatile organic compound (VOC) paint technology, called Unicarb, which reduces the amount of VOC solvent used in paint by 70 percent, and thus provides a solution to EPA-level restrictions. VOCs in plastic coating.

Due to increasing recycling regulations, a number of companies have integrated various waste recycling initiatives with production processes in order to recycle materials such as goods, plastics, glass, aluminum, and chemical solvents. Waste and emission products can be recycled as raw materials either in the same or different production processes, processed with the aim of retrieving and reusing those materials, and used for different useful applications within facilities (Molinaro, 1991). In addition, valuable materials recovered from waste streams can also be sold to other companies.

For example, Rexham Corp. installed a $16,000 distillation unit to recover n-propyl alcohol from waste solvents and thus recovered 85 percent of the solvent in the waste stream resulting in annual savings of $15,000 in pure solvent costs and $22,800 in waste disposal costs. In another example, the Hamilton Beach Division of Scovill, Inc. brought in Ashland Chemical Co. to recycle the 1,1,1-trichloroethane solvent (used to degrease metal stamps) and by purchasing back the recycled solvent from Ashland Chemical, Hamilton reduced raw material costs by US$5,320 per year and eliminated disposal costs by US$3,000 per year.

As another example, the production process of BMW's newly opened European plant is strategically designed to produce 100 percent recycled new BMW cars. The process is designed to turn an old car into a new model for reuse. In another example of recycling (through reclamation), an electrolytic deposition process from a photo processing company recovers silver from rinse water from film processing equipment for sale to small recyclers. By removing silver from this wastewater, wastewater becomes harmless and can be discharged down the drain without additional initial treatment. The process is also capable of burning used film and then collecting silver from the remaining ash. By removing silver from the ashes, the ash becomes harmless. This process would pay off in less than two years with the value of silver recovering (EPA, 1988).

Vandermerwe and Oliff (1991) introduced the concept of reconsumption (i.e. a broad-scale 100

percent recycling approach that suggests longer, repeatable consumption of a product) as an alternative that could revolutionize a firm's process strategy. The reconsumption system is a closed-loop system consisting of a number of interconnected lines and can be identified as at least four lines that have been integrated with production processes in a number of companies:

1. "Existing products are replenished, repaired, restored or rejuvenated to significantly extend their useful life" (Vandermerwe and Oliff, 1991). Accutone, a U.S. manufacturer of laser printer cartridges, changed its process strategy by integrating a process in which its customers' cartridges are refilled after the toner runs out. Accutone toner cartridges, which are refilled seven to ten times, are also reconditioned so that they can be recovered and used indefinitely (in theory). In other electronics companies, process strategies are modified to repair products and keep stock of repaired models in order to replace products brought in for repair instantly. This modified process strategy encourages its customers to use repaired items rather than replace them. Many companies (such as IBM, Thompson and Electrolux) plan to change their process strategy by rejuvenating (i.e. updating products through new technologies and materials). They plan to get back the machine from the customer and repair it with more cutting-edge technology.
2. "Packaging is reused and not thrown away" (Vandermerwe and Oliff, 1991). Suppliers are expected to take back the packaging used for shipping so that it can be used several times after repair (if required). Lego, a Danish toy manufacturer, is integrating its process strategy with a new system for sustainable packaging reconsumption.
3. Products and/or packaging are recycled, partially or completely, into their original form. For example, Canon, a Japanese printer/manufacturer, has set up a new factory in China that aims to recycle one million used cartridges every month.
4. Products and/or packaging are recycled, partially or completely, into new forms, and go through several successive incarnations. For example, GE Plastics is experimenting with the process of extending the life of bumpers through reincarnation with:
   a) grinding it into automotive internal components;
   b) re-grinding it, as a material for the manufacture of plastic benches;
   c) recycle into building materials;
   d) then, after many years it gives it another "life", incinerator fuel (Vandermerwe and Oliff, 1991).

World-class company that is environmentally conscious. The report from the Center for Environmental Assurance at Arthur D. Little Co., Cambridge, Massachusetts, identifies a

number of characteristics of "cutting-edge" companies in EM:

1. long-term planning horizon;
2. risk planning and compliance;
3. a clear and direct relationship between the environmental, safety, and health planning process and the president or CEO;
4. strong interaction between the staff of the company and divisions;
5. formal channels through environmental groups contribute to the strategic planning process;
6. a driving force that goes beyond adherence to social responsibility and preventive environmental policies.

CONCLUSION

In this article, the author provides an overview of environmental management from an operations perspective. It is clear that the availability of advanced eco-friendly technology and measuring instruments has turned greening into a moving target. What was green two years ago is not necessarily green today and what is green today is not necessarily green tomorrow. Therefore, EM should be viewed as an ongoing process to improve the company's environmental policies and programs taking into account regulations, technical developments, scientific developments, and should be fully integrated with operations management as well as other functional areas. Operations management strategies, objectives and decisions should be reviewed continuously taking into account environmental opportunities so that acquired manufacturing capabilities can be used to gain competitive advantage and new manufacturing capabilities can be identified for long-term enterprise planning.

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