A Strategic Environmental Management System (SEMS)

Innovation—Both Entrepreneurial and Technological—Is the Key

Roberto Del Rio-Soto
Assistant Manager in Technology Strategy
Pemex Refinación—R&D Management
Mexico, D.F.

ABSTRACT

Leading companies in the world are on a path to a new environmental protection strategy based on pollution prevention, clean technologies, and environmentally responsible products. This new strategy requires the full participation of everyone in the organization, supported by an aggressive entrepreneurial and technological innovation effort.

In this article, a new model is proposed as an organizational framework for the chemical and process industry (CPI) in order to attain a sustainable development approach in the mid-term. This a model is based on a creative strategic environmental management system (SEMS) and is formed by the following key elements:

a) Corporate environmental excellence and stewardship philosophies.

b) A life cycle analysis approach.

c) A pollution prevention focus linked to total quality management.

d) Clean technology application through pollution prevention strategies and practices.

e) The manufacture of ecological products based on environmental marketing.

f) A system supported on entrepreneurial and technological innovation.

The proposed SEMS model, designed with a holistic focus, considers that environmentally sound products and manufacturing processes can have many benefits. In other words, a proactive and global environmental management will be the essence of sustainable development in industry.

INTRODUCTION

Nowadays, some leading companies in the world are on a path to an environmental protection strategy based on pollution prevention, life cycle analysis, and environmentally responsible products. This new strategy requires the full participation of everyone in the organization, supported by an aggressive entrepreneurial and technological innovation effort. However, many other companies do not know how to initiate and implement such an environmental management system[1,2,3,4].

One problem in the environmental quality arena is the confusion between a pollution prevention strategy, with emphasis on clean technologies and clean products, versus traditional "end-of-pipe" thinking with its heavy emphasis on regulatory compliance. Achieving true corporate success means recognizing that quality must be linked primarily to pollution prevention performance. Regulatory compliance is the least of what is expected by the public.

Pollution prevention, when properly defined, is a sea change in environmental thinking. Proactive prevention is a much more difficult and complex challenge to corporate management than compliance[5,6].

Many environmentalists and business managers believe that the beginning of this new century will be not only the time of pollution prevention but also the historic time when consumer and industrial products drive the most substantial changes. Those people in business who are willing to believe that the global pollution prevention movement supported on innovation will be a major stimulus to a global re-

structuring and modernization of industry will be the ones who profit from it.

Many people speak of sustainable economic growth. To be sustainable is to avoid self-destruction through pollution, contamination by toxic substances, and depiction of non-renewable resources. The specific advantages of pollution prevention and innovation allow sustainability to be reached, so that global population and industrial growth can occur with minimal harm to health and environment.

Industry needs to recognize the business opportunities offered by the pollution prevention movement (based on technological innovation), and it needs to creatively redefine its products, as well as reorganize itself and retrain its work force with a new corporate culture (based on entrepreneurial innovation)[7,8,9,10].

A NEW MODEL FOR A STRATEGIC ENVIRONMENTAL MANAGEMENT SYSTEM

Despite the increasing importance of environmental management as a critical resource in modern firms, there is no strategic model that allows us to study and analyze the influence of environmental issues inside the corporation in a coherent, integral, and comprehensive manner.

To put it differently, although companies are attempting to manage environment strategically, there is as yet no consensus on the essentials of an environmental strategy framework. This article argues that the conceptualization of environmental strategy is still incomplete, mainly because the specialized literature relating to this topic has approached it up till now only in an oblique and partial way.

This article develops a new model for discussing and analyzing a strategic environmental management system. The general conceptualization of such novel organizational framework is presented in Figure 1.

The new model is proposed as an organizational framework for the chemical and process industry (CPI) in order to attain a sustainable development approach in the mid-term. Such a model is based on a creative strategic environmental management system (SEMS) and is formed by the following main elements:

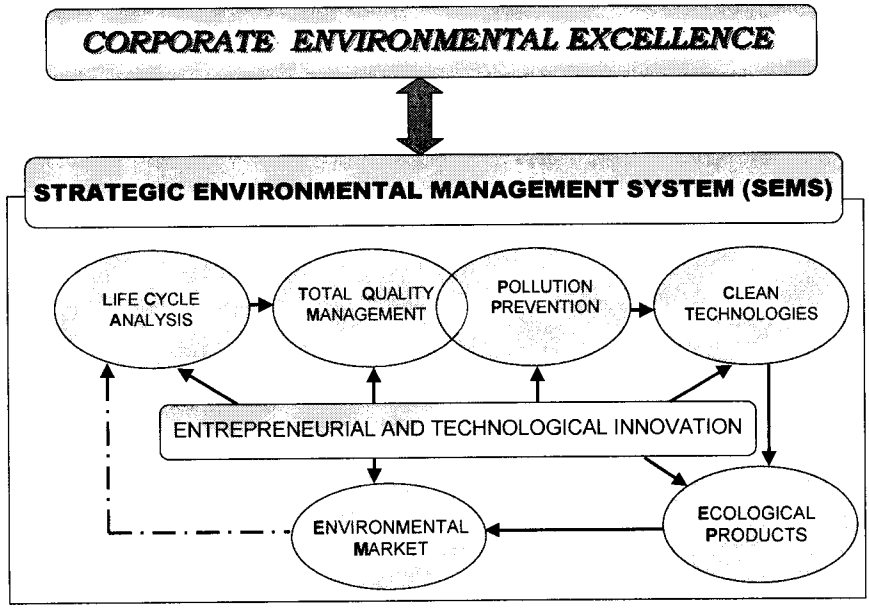


Figure 1. Integral model for industrial sustainable development.

a) Today's environmental driving forces are having an important impact on how companies reshape strategy and competitive success—and these are causing senior management to be concerned. The SEMS must be fostered by a corporate environmental excellence and stewardship philosophy supported by top managers.

b) The product life cycle analysis provides a logical system for addressing pollution prevention because the full range of environmental consequences associated with the product can be considered. Through integration of environmental requirements into the earliest stages of product development, adverse environmental impacts can be reduced or eliminated in the manufacture, use, and end-of-life management of a product. Pollution prevention by design is the antithesis of "end-of-pipe" treatment or remedial action.

c) Although simple to understand, implementing changes that reduce the very generation of waste requires a lot of work and evaluation. The source reduction level is the most important step in the hierarchy, and should not be bypassed. It is this source reduction as-

pect that has caused parallel management models of total quality management (TQM) and pollution prevention to actually merge. Like TQM, pollution prevention means total process consciousness and the flexibility to pursue and make radical change.

d) Pollution prevention is a term used to describe clean technologies and strategies that result in eliminating or reducing waste streams. The idea underlying the promotion of pollution prevention is that it makes more sense for a generator to not produce waste than to develop extensive treatment schemes to ensure that the waste poses no threat to the quality of the environment.

e) Through the identification and publication of "environmentally friendly" or "green" products, advocates believe the public will be better equipped to "vote with their pocketbooks." The assumption is that consumers need better information about the true characteristics of the products they purchase and that, once given, consumers will act on those data. Product-labeling systems have sprung up in Europe and Canada, and have had some advance in the United States and Japan.

f) Traditionally, the perceptions and goals of major business units (design, engineering, manufacturing, marketing, and the like) have determined business strategy. More recently, corporate cost reduction and restructuring priorities, as well as mergers and acquisitions opportunities, have also driven those strategies. Today, more than ever, entrepreneurial and technological innovation has moved to the forefront as a key strategic driver. Innovation strategy must support the pollution prevention effort, and be fully aligned with the company's strategic vision. Innovation strategy should also be tailored to the needs and strengths of a corporation's environmental and technological assets, and those of its extended enterprise of partners, suppliers, and customers.

CORPORATE ENVIRONMENTAL EXCELLENCE

Progressive companies with superior management will understand the historical shift in emphasis from reaction and control to prevention.

The global prevention movement includes the "green consumer" movement also. Indeed, it would be useful for industrial managers to understand that there are three levels to the global prevention approach, in order of decreasing importance:

a) Products: changing their design, composition, and packaging to offer environmental benefits, and creating totally new products to replace old ones.

b) Materials: changing materials to reduce use of toxic substances that may only be used in processing and that may reside in products.

c) Manufacturing: making improvements in all processes, technologies, operations, and procedures to reduce and eliminate the generation of all wastes at their sources.

Nowadays, it should be the rule that the corporation's senior management—generally the chief executive officer, often supported by the board of directors—commits to making sure they have in place environmental programs and systems that are consistent with the objectives and culture of the company and the expectations of shareholders[5-13].

Moreover, in these leading companies, top management wants confirmation that there are environmental management systems in place in accordance with a well defined corporate environmental excellence philosophy. Such progressive companies usually implement and practice the Principles of the Business Charter for Sustainable Development formulated by the International Chamber of Commerce, as shown in Table 1.

LIFE CYCLE ANALYSIS

Life cycle analysis is an evolving management approach for reducing the impact of a product, package, or activity upon human health and the environment. It should examine each stage of the life span of manu-

Table 1. Principles of the Business Charter for Sustainable Development

1. **Corporate priority.** To recognize environmental management as among the highest corporate priorities and as a key determinant to sustainable development; to establish policies, programs, and practices for conducting operations in an environmentally sound manner

2. **Integrated management.** To integrate these policies, programs, and practices fully into each business as an essential element of management in all its functions

3. **Process of improvement.** To continue to improve corporate policies, programs and environmental performance, taking into account technical development, scientific understanding, consumer needs and community expectations, with legal regulations as a starting point; and to apply the same environmental criteria intentionally

4. **Employee education.** To educate, train, and motivate employees to conduct their activities in an environmentally responsible manner

5. **Prior assessment.** To assess environmental impacts before starting a new activity or project and before decommissioning a facility or leaving a site

6. **Products and services.** To develop and provide products or services that have no undue environmental impact and are safe in their intended use, that are efficient in their consumption of energy and natural resources, and that can be recycled, reused, or disposed of safely

7. **Customer advice.** To advise, and where relevant educate, customers, distributors and the public in the safe use, transportation, storage, and disposal of products provided; and to apply similar considerations to the provision of services

8. **Facilities and operations.** To develop, design, and operate facilities and conduct activities taking into consideration the efficient use of energy and material, the sustainable use of renewable resources, the minimization of adverse environmental impact and waste generation, and the safe and responsible disposal of residual wastes

9. **Research**. To conduct or support research on the environmental impacts of raw materials, products, processes, emis-

sions, and wastes associated with those of the enterprise; and to encourage the wider adoption of these principles by suppliers

10. **Precautionary approach.** To modify the manufacture, marketing, or use of products or services or the conduct of activities, consistent with scientific and technical understanding, to prevent serious or irreversible environmental degradation

11. **Contractors and suppliers.** To promote the adoption of these principles by contractors acting on behalf of the enterprise, encouraging and, where appropriate, requiring improvements in their practices to make them consistent with those of the enterprise; and to encourage the wider adoption of these principles by suppliers

12. **Emergency preparedness.** To develop and maintain, where significant hazards exist, emergency preparedness plans in conjunction with the emergency services, relevant authorities, and the local community, recognizing potential transboundary impacts

13. **Transfer of technology.** To contribute to the transfer of environmentally sound technology and management methods throughout the industrial and public sectors

14. **Contributing to the common effort.** To contribute to the development of public policy and to business, governmental, and intergovernmental programs and educational initiatives that will enhance environmental awareness and protection

15. **Openness to concerns**. To foster openness and dialogue with employees and the public, anticipating and responding to their concerns about the potential hazards and impacts of operations, products, wastes, or services, including those of transboundary or global significance

16. **Compliance and reporting.** To measure environmental performance; to conduct regular environmental audits and assessments of compliance with company requirements, legal requirements, and these principles; and periodically to provide appropriate information to the board of directors, shareholders, employees, the authorities, and the public.

Source: International Chamber of Commerce.

factured items from extraction of raw materials through production or construction, distribution, use, support, and disposal or recycling. By focusing on the product life-cycle system, designers can prevent the shifting impacts between media (air, water, land) and between stages of the life cycle.

In addition, this framework encompasses the many stakeholders (suppliers, manufacturers, consumers/users, resource recovery and waste managers) whose involvement is critical to successful design improvement. The life-cycle system is complex due to its dynamic nature and its geographical scope. Stages of the life cycle are changing continuously and changes often occur independently[3,4].

The essential goal of life-cycle design is to foster sustainable development at the global, regional, and local level. In simple terms, sustainable development seeks to meet current needs without compromising the ability of future generations to satisfy their needs.

Fundamental elements of sustainable development include pollution prevention, resource conservation, environmental equity, human health, and maintenance of ecosystem structure and function.

Stated succinctly, life-cycle design seeks to minimize environmental impacts and utilize resources efficiently in meeting basic societal needs[8,14,15,16,17].

Life-cycle design goals should be articulated through the strategic environmental management system (SEMS) proposed in this article. This system must then provide the structure for the product development team inside the corporation to specify environmental requirements that shape or reshape the design.

In summary, the life-cycle design principles for achieving pollution prevention and guiding the environmental improvement of the product system are as follows:

1. **Addressing environmental issues in the earliest stages of design is one of the most efficient approaches to achieving pollution prevention. Other related benefits include enhancing resource efficiency, reducing liabilities, and achieving competitiveness.**

2. **The ultimate goal of life-cycle design is to achieve sustainable development. Sustainable development seeks to satisfy basic societal needs of today without compromising future generations' ability to meet their needs. Maintenance of ecosystem**

structure and function (the planet's life support system) is critical to achieving this goal.

3. **The product life cycle is a useful framework for evaluating and reducing adverse environmental impacts associated with the manufacture, use, and end-of-life management of a product. Designers can prevent the shifting of adverse impacts between media and life-cycle stages.**

4. **Both internal and external factors strongly influence design. Internally, the environmental management system, which includes goals and performance measures, provides the organizational structure within a company to implement pollution prevention by design. Access to accurate information about environmental impacts is also critical for achieving environmental improvement. External factors that shape design include government regulations, market forces, infrastructure, and state of the environment, as well as scientific understanding and public perception of risks.**

5. **The concurrent design of product system components (product, process, distribution, and information/management) is an important principle in life-cycle design management. Interdisciplinary participation is key to defining requirements that reflect the needs of multiple stakeholders: suppliers, manufacturers, consumers, resource recovery and waste managers, the public, regulators.**

6. **Specification of requirements is one of the most critical design functions. Requirements guide designers in translating needs and environmental objectives into successful designs. Environmental requirements should focus on minimizing natural resource consumption, energy consumption, waste generation, and human health risks, as well as promoting the sustainability of ecosystems.**

7. **Life-cycle design seeks to optimize environmental objectives while also optimizing cost, performance, cultural, and legal requirements. The challenge is to apply value-added design strategies that resolve conflicting requirements.**

It should be emphasized that successful life-cycle design projects depend on commitment from all employees and all levels of management. The aim should be to have the life cycle analysis module as a key element of SEMS, which supports environmental improvement through design.

TQM AND POLLUTION PREVENTION

Both total quality management (TQM) and pollution prevention are a pattern or model or paradigm for their respective concepts to be followed and put into effect by industry. They each represent a framework for making things better, doing things smarter, and for the examination and evaluation of current practices. Both TQM and pollution prevention welcome innovative thought and the mandate to question the validity of practices conducted simply because "that's the way we have always done it."[18,19].

TQM involves tile application of quality management principles to all aspects of the business, including customers and suppliers. The principles of TQM should be applied in every branch and at every level in the organization. It is a company-wide approach to quality, with improvements undertaken on a continuous basis by everyone in the organization.

There are many interpretations and definitions of TQM. According to British Standards (BS. 4778, Part 2, 1991), it is defined as:

"A management philosophy embracing all activities through which the needs and expectations of the customer and the community, and the objectives of the organization are satisfied in the most efficient and cost effective way by maximizing the potential of all employees in a continuing drive for improvement."

Put simply, TQM is the mutual cooperation of everyone in an organization and associated business processes to produce products and services which meet the needs and expectations of customers. TQM is both a philosophy and a set of guiding principles for managing an organization. The spread of the TQM philosophy would also be expected to be accompanied by greater sophistication in the application of quality management tools and techniques and increases emphasis on people[20,21,22].

Meanwhile, the U.S. Environmental Protection Agency (EPA) defines pollution prevention as "the use of materials, processes, or prac-

tices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous materials, energy, water, or other resources and practices that protect natural resources through conservation or more efficient use."

But pollution prevention also requires fostering a **fundamental caring attitude**, not only for the environment, but for the quality of the product being made. It requires top management commitment and buy-in, but also across-the-board acceptance and employee participation. It means that, finally, environmental impacts can be fully considered as another factor in the process of making decisions at the strategic level.

The process used to conduct pollution prevention programs is startlingly similar to those requirements of TQM: **rethinking why things are done the way they are is fundamental to fostering accountability in employees, forcing management to respond positively and fairly to change, and ultimately effecting better product quality and customer satisfaction**[23,24,25].

The heart of TQM is the systematic analysis of processes or services by empowered, cross-functional, multidisciplinary teams. The same is true regarding pollution prevention. Emission or waste reduction opportunities are most successful when groups of employees with diverse skills and experiences are fully empowered to identify sources of pollution and to make innovative, cost-effective recommendations for addressing identified sources. TQM tools are useful at every step in the pollution prevention process.

Industries should consider the environmental implications of a new product, service, or workload. It should involve pollution prevention since its research stages. It should insist on pollution prevention in the acquisition of new components or systems from others so that waste generation in the life cycle of its product will be minimized. Industries should constantly use TQM tools and pollution prevention strategies to find problems and seek solutions. It should inculcate the TQM and pollution prevention philosophies into every person in its companies.

APPLICATION OF CLEAN TECHNOLOGIES

Industrial waste generation in developed and developing countries averages billions of pounds daily. Discharged to the air, water, or land, this waste represents a significant loss of raw materials and a potential

threat to human health and the environment. To be responsible guardians of environmental quality, industries must review their production processes and business operations as well as consider the economic, energetic, and ecological benefits of implementing clean technologies through a pollution prevention program. It must be emphasized that the concept of "clean technologies" is not necessarily referred to sophisticated or last generation technologies, but to the most appropriate use of available technologies[26,27].

Diverse types of clean technologies through pollution prevention strategies and practices can be applied in many different opportunity areas in companies of the CPI as it is shown in Figure 2 in order to minimize wastes and reduce pollution in a global way[28-50].

Pollution prevention can be viewed as business planning with environmental benefits, such as: reduced operating cost, improved worker safety, reduced compliance costs, increased productivity, continuous improvement, and increased environmental protection. The steps to establish and maintain a pollution prevention program are as follows:

1. **Obtain support from top management.**

2. **Get the program started by beginning to incorporate changes throughout the company, developing a written pollution prevention plan, and training employees in pollution prevention.**

3. **Review and describe in detail the manufacturing processes within the facility to determine the raw materials used and the sources of waste generation and to define a baseline inventory to be used to set goals and evaluate progress.**

4. **Identify potential pollution prevention opportunities in different areas for the facility.**

5. **Determine cost of current waste generation and establish a system of proportional waste management charges for those departments that generate waste.**

6. **Select the best pollution prevention options for the organization and implement these choices.**

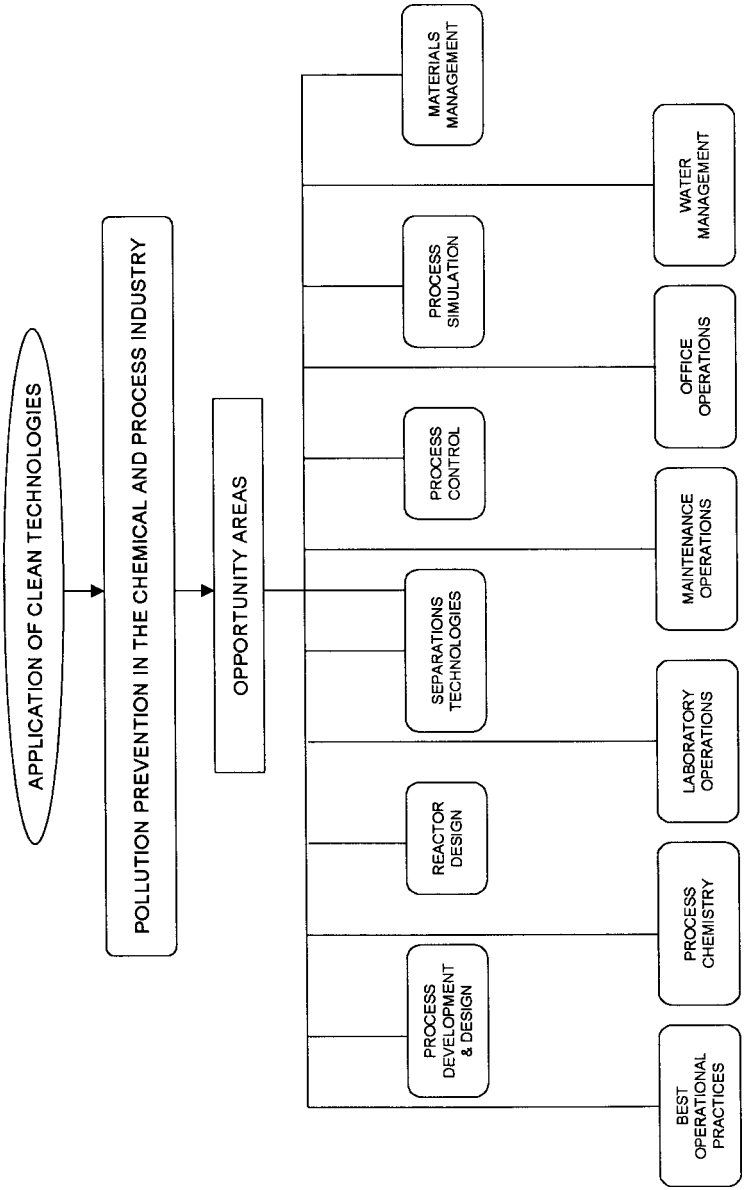


Figure 2. Opportunity areas to abate pollution in the chemical and process industry (CPI).

7. **Evaluate the pollution prevention program on a company wide basis, as well as evaluating specific pollution prevention projects.**

8. **Maintain and sustain the pollution prevention program for continued growth and benefits to the corporation.**

9. **Reevaluate the program as economic situations change and/or process equipment requires upgrading.**

ECOLOGICAL PRODUCTS AND ENVIRONMENTAL MARKETING

In recent years, attitudes of both industry and consumers toward the environment have changed appreciably. Businesses are folding a heightened sense of environmental responsibility into their policies and practices, while consumers' green concerns are increasingly being reflected in both their purchase and post-purchase behavior.

Traditionally, marketers have depended largely on market research, quality and financial controls, trade regulations, and promotion to sell their products. Recently, a new factor has entered the picture—the environment. Shareholders, consumer activists, environmental groups, regulators, and even retailers are collectively demanding that industries consider the environmental impact of everything they do.

This puts industries under tremendous pressure, but it creates substantial opportunities, too. This is why: **"Environmental marketing consists of the set of practices that enables companies to put consumers' and others' concerns about the environment to their financial advantage, in an ethically appropriate context."**

But environmental marketing is about more than a new set of marketing practices. It is also about a change in attitude. The environmentally oriented marketer factors the environment into virtually all business decision. No matter what the specific subject is—product and packaging design and development, labeling and advertising, or promotional strategies—the environmental marketer should take the environment into account. In this context, environmental marketing also defines a changed attitude about and new approach for making marketing de-

cisions—one in which the environment is a major, indeed ubiquitous, consideration.

More and more companies are engaging in environmental marketing, on either an *ad hoc* or a comprehensive basis. As this becomes standard industry practice, organizations which do not engage in environmental marketing will be forced to play a game of catch-up which, by virtue of its timing alone, will invite a perception of shallowness[14,51].

One way to significantly reduce the amount and toxicity of discarded waste is to purchase only those products whose production, use, and disposal do the least possible harm to the environment. To do so requires that manufacturers take into account the environmental impacts of their products and inform consumers about these impacts.

Green labeling is one of the best mechanisms for providing consumers with the information they need to select environmentally preferable products from among essentially equivalent items. Purchasing decisions made by environmentally concerned consumers can help to push manufacturers toward decreasing the environmental impacts associated with the production, use, and disposal of their products, by rewarding manufacturers that do so with consumer money. For the power of consumers spending to be effectively harnessed, consumers must have complete confidence in the accuracy of the environmental labels that guide their purchasing decisions.

Educated people are growing increasingly sensitive to environmental issues, and this is being reflected in their attitudes and buying behavior. Corporations, too, are becoming more and more "green." Slowly but surely, a fundamental change is taking place in how people view their relationship with and responsibilities toward the environment. Because of this enduring transformation, environmental marketing should be a core marketing strategy for the next years to come[52,53].

ENTREPRENEURIAL AND TECHNOLOGICAL INNOVATION

In this article innovation is used in its broadest sense, including everything that goes into the creation of new products, services, and processes, start to finish, and having the aim of eliminating or minimizing pollution.

Recently, some studies have demonstrated that the most successful firms are those that have been able to systematically exploit entrepre-

neurial and technological innovation. Nevertheless, management of innovation is an organizational challenge. The architecture of an organization—its formal structure, its competencies, its job and career structure, its culture, and its power—determines its capacity to nurture, sustain, and exploit innovation. There is no one best way to organize, but absent an effective organizational "weapon," brilliant ideas, good timing, and incentive strategies very seldom lead to successful innovation[54,55,56].

In contrast to the limited approach of non-innovative and bureaucratic companies, innovative firms operate based on two main principles:

a) **Management must drive entrepreneurial innovation across the entire corporation to create value.**

b) **Management must leverage technological innovation supported by core competencies—to drive sustainable development and capture competitive advantage.**

To activate these two principles, a company needs to align and fine-tune its management efforts in five key areas: **strategy, process, resources, organization, and learning**.

Nowadays, more than ever, as corporations strive to grow both the top and bottom line, entrepreneurial and technological innovation should move to the forefront as a key strategic driver to abate pollution. Innovation strategy should be fully aligned with the corporation's strategic vision and should be tailored to the needs and strengths of a company's innovation and technology infrastructure, and that of its extended enterprise of partners, suppliers, and customers.

In the conventional view product development begins with research and development and ends with a product or service offered to the market. In innovative companies, employees should expand their thinking to include the entire process, from the point of origin of raw ideas to the point at which the product is in the hands of a loyal customer and there is an intricate system of feedback loops in between, in order to reduce wastes.

Innovative organizations enlarge the definition of entrepreneurial and technological innovation resources to integrate all of the capital, facilities, competencies, and people that are part of or connected to the innovation process. Customers and suppliers are definitely an important

part of this. Managers need to determine whether and how to leverage these resources to drive innovation to prevent pollution.

Certainly, innovative companies should build a highly collaborative organization from the top down and the bottom up, one that is thoroughly networked in ways that enable people to communicate rapidly with one another. By connecting employees at every level and in every corner of the company and beyond, managers encourage the personal interactions and cross-fertilization that foster innovation oriented to minimize pollutants.

And last but not least, innovative firms should be a dynamic, knowledge-based learning organization, committed to continuous and sustainable innovation. For the aims of this article, constant entrepreneurial and technological innovation should steer pollution prevention and be a cornerstone of the SEMS itself.

CONCLUSIONS

We have proposed a new model for a strategic environmental management system (SEMS) for the chemical and process industry (CPI) in order to achieve a sustainable development path within some years. It is an integral framework because it considers both external and internal factors to the corporation, taking them account in a broader perspective. Besides, it is a dynamic approach because it is not static in time or context.

Our model is built upon six fundamental elements:

first, a corporate environmental excellence and stewardship philosophy;

second, the product life cycle analysis;

third, the linkages between total quality management (TQM) and pollution prevention;

fourth, the use of clean technologies supported by pollution prevention strategies and practices;

fifth, the manufacture of ecological products related to environmental marketing; and

sixth, the whole system to be based on entrepreneurial and technological innovation.

We should emphasize that in our framework: **first**, senior manage-

ment commits to making sure they have in place environmental programs and systems that are consistent with the vision and mission of the corporation; **second**, the life cycle analysis in an important methodology to foster sustainable development at industrial scale; **third**, the CPI should continuously apply TQM tools and pollution prevention strategies to abate pollution; **fourth**, clean technologies can be used in many different opportunity areas; **fifth**, ecological products and environmental marketing are more than simply new products or novel practices, they mean a change in mind and attitude; and **sixth**, entrepreneurial and technological innovation is a key strategic driver to promote sustainable development.

References

1. Kolluru, R.V., (ed), "Environmental Strategies Handbook: A Guide to Effective Policies and Practices," McGraw-Hill, New York, 1994.
2. Buchholz, R., "Principles of Environmental Management: The Greening of Business," Prentice Hall, Englewood Cliffs, MD, 1993.
3. Keolcian, G.A., "Pollution Prevention through Life-Cycle Design," Chapter 18 in Freeman, H.M., op. cit. in Ref. 27.
4. Henn, C.L. And Fava, J.A., "Life Cycle Analysis and Resource Management," Chapter 14 in Kolluru, R.V., op. cit. in Ref. 1.
5. Hirschhorn, J.S., "Business and the Environment" Chapter 2 in Kolluru, R. V., Environmental Strategies Handbook, McGraw-Hill, 1993.
6. Schmidheiny, S. and Business Council for Sustainable Development, "Changing Course: A Global Business Perspective on Business and the Environment," MIT Press, Cambridge, 1992.
7. Arthur D. Little Inc., "Sustainable Development: How Real, How Soon, and Who's Doing What," Prism, Fourth Quarter, 1998.
8. Arthur D. Little Inc., "Seizing Strategic Environmental Advantage: A Life Cycle Approach," Cambridge, Mass, 1991.
9. Silverstein, M., "Environmental Economic Revolution," St. Martin's Press, New York, 1993.
10. United Nations Centre on Transnational Corporations (UNCTC), "Criteria for Sustainable Development Management," New York, 1991.
11. Costanza, R. (ed.), "Ecological Economics: The Science and Management of Sustainability," Columbia University Press, New York, 1991.
12. World Commission on Environment and Development, "Our Common Future," Oxford University Press, New York, 1987.
13. Arthur D. Little, Inc., "Achieving Environmental Excellence: Ten Tools for CEO," The Best of Prism, 1993.
14. Office of Technology Assessment, U.S. Congress, "Green Products by Design, Choices for a Cleaner Environment," Sept., 1992.
15. Arthur D. Little, Inc., "Improved Products through Design for Environment Tools," The Best of Prism 11, 1996.
16. Keoleian, G.A., and Menerey D., "Life Cycle Design Guidance Manual: Environmental Requirements and the Product System," EPA/600/R-92/226, U.S. EPA, 1993.

17. Keoleian, G. and Dan Menerey, "Sustainable Development by Design: Review of Life Cycle Design and Related Approaches," Journal of Air and Waste Management Association, 44 (5): 645-648, 1994.
18. Baker, G.E., "Pollution Prevention and Total Quality Management," Chapter 9 in Freeman, H.M., op. cit. in Ref 27.
19. Bringer, R.P. And Benfordo, D.M., "Pollution Prevention and Total Quality Management," Chapter. 6 in Kolluru, R.V., op. cit. in Ref. 1.
20. Drummond, H., "The Quality Movement," Kogan Page Limited, London, 1992.
21. Dale, B.G. (ed)., "Managing Quality," Prentice Hall, UK, Second Edition, 1994.
22. Deming, W.E., "Quality, Productivity, and Competitive Position," MIT-Center for Advanced Engineering Study, Cambridge, Mass., 1982.
23. U.S. Environmental Protection Agency, "Environmental Protection Agency Pollution Prevention Directive," May 13, 1990.
24. Oliver, J.J., and Anthony, D.B., "Pollution Prevention—A Global Perspective," Hydrocarbon Processing, Nov. 1994.
25. U.S. Environmental Protection Agency, "Facility Pollution Prevention Guide," EPA/600/R-92/088, May 1992.
26. Graedel, T.E. and Allenby, B.R., "Industrial Ecology," Prentice Hall, 1995.
27. Freeman, H.M. (ed), "Industrial Pollution Prevention Handbook," McGraw-Hill, New York, 1995.
28. "Improving Performance in the Chemical Industry: Ten Steps for Pollution Prevention," Chemical Manufacturers Association, Washington, D.C.
29. Theodore, L. and McGuinn, Y.C., "Pollution Prevention," Van Nostrand Reinhold, New York, 1992
30. Corbitt, R.A. (ed.), "Standard Handbook of Environmental Engineering," McGraw-Hill, 1990.
31. Mulholland, K.L. and Dyer, J.A., "Reduce Waste and Make Money," Chemical Engineering Progress, January 2000.
32. Nelson, K.E., "Process Modifications that Reduce Waste," AICHE, 1991.
33. Chemical Manufacturers Association, "Designing Pollution Prevention into the Process: Research, Development, and Engineering," CMA, May 1993.
34. Illman, D.L., "Green Technologies Present Challenge to Chemists," Chemical arid Engineering News, Sept. 6, 1993.
35. Breen, J.J., and Dellarco, M.J., "Pollution Prevention in Industrial Processes: The Role of Process Analytical Chemistry," ACS, Series 508, 1992.
36. King, J., "Separation Processes," McGraw-Hill, New York, 1971.
37. Green, D.W., and Maloney, J.O., "Perry's Chemical Engineers Handbook," McGraw-Hill, New York, 1978.
38. Berglund, R.L., and Lawson, C.T., "Pollution Prevention in the CPF, Chemical Engineering, Sept. 18, 1991.
39. Hyland, R.P., "Environmental and Maintenance: Strategies for the 1990's," Hydrocarbon Processing, May 1991.
40. National Office Products Association, "Resource Guide to Office "Products Manufacturers' Recycling Programs and Products," USA, 1991.
41. Commission on Environmental Quality—Solid Waste Task Force, "Workplace Waste Reduction Guide," US. Government, 1993.
42. Down, R.D., "Environmental Control Systems," ISA Publications, 1992.
43. Waste Minimization-Opportunity Assessment Manual, EPA, 1988.
44. Mobley, T., "Turning Maintenance Dollars into Bottom-Line Profits," CPI Equipment Reporter, May-June, 1988.

45. Early, W.F. and Edison, M.A. "Design for Zero Releases," Hydrocarbon Processing, August 1990.
46. Berglund, R.L. and Snyder, G.E., "Minimize Waste During Design," Hydrocarbon Processing, April 1990.
47. Rase, H.F., "Chemical Reactor Design of Process Plants," 2 vols., Wiley, New York, 1977.
48. Ashbrook, P., Klein-Banay, C., and Maier, Ch., "Pollution Prevention in Laboratories: The How-to Guide," University of Illinois, 1992.
49. Tropp, R.I., "More Efficient Turnarounds," Hydrocarbon Processing, January 1986.
50. Murrill, P.W., "Application Concepts of Process Control," ISA Publications, 1988.
51. Allenby, B.R. and Fullerton, A., "Design for Environment—A New Strategy for Environmental Management," Pollution Prevention Review, Winter 1991-1992.
52. Organization for Economic Cooperation and Development, "Environmental Labeling in OECD Countries," OECD, Paris, 1991.
53. Thompson Publishing Group, "Environmental Packaging: U.S. Guide to Green Labeling, Packaging, and Recycling," Washington, D.C., 1993.
54. Arthur D. Little, Inc., "Findings of the Arthur D. Little Global Survey on Innovation," 1997.
55. Burgelman, R.A., Maidique, M.A., and Wheelwright, S.C., "Strategic Management of Technology and Innovation," Ed. Irwin, 1995.
56. Tushman, M.L., and Anderson, P., "Managing Strategic Innovation and Change," Oxford University Press, 1997.

ABOUT THE AUTHOR

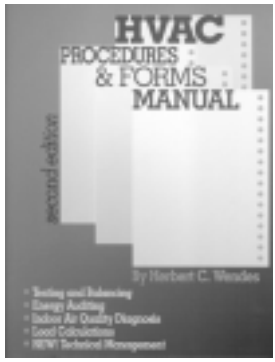
Roberto Del Rio Soto has been assistant manager in technology strategy for Pemex Refinación in its R&D division since 1993. He has worked in the refining and petrochemical industries for 24 years, where he has been involved in applied research, manufacturing, project engineering, industrial planning and R&D management. He specializes in strategic management of technology and innovation, and strategic planning. He teaches these topics for a master degree course at UNAM university and he has taught different courses at five other Mexican universities. He has been president of the Technology Committee of the Mexican Institute of Chemical Engineers since 1996.

Mr. Del Rio Soto has been recognized by the Mexican government as a national specialized technology consultant—(1999). He holds a BSc and MSc degrees in chemical engineering from the University of Guadalajara, Mexico, and also a MSc in technology and innovation management from the University of Sussex, England. He is a Ph.D. candidate in this latter institution.

Pemex Refinación, Umaxal No. 413, Col Narvate, Mexico, D.F. 03020, Mexico; (p) (525) 722.25.00 Ext 219.38 and 272.21; (f) (525) 722.25.00 Ext 249.31; rdelrio@dcpe.pemex.com.

Use the forms contained in this manual to save countless hours assimilating data, and preparing professional looking reports of your findings...

NEW



HVAC PROCEDURES & FORMS MANUAL

SECOND EDITION
By Herbert C. Wendes

Developed over the course of many years of on-the-job projects involving HVAC energy auditing, testing/balancing and cost estimating, and refined through feedback from thousands of engineers and technicians who have used them, the forms contained in this manual are concise, comprehensive, and optimally organized for easy reference. Complete sets of forms are provided for all aspects of testing and balancing, energy auditing, indoor quality diagnosis, and load calculations. The first edition, entitled HVAC Energy Audit & Balancing Forms Manual compiled these time-saving forms for the first time in a single reference. This enhanced second edition adds a new chapter on technical management, providing procedures for achieving thorough, systematic and accurate problem solving, troubleshooting and decision making in building systems management and contracting.

ISBN: 0-88173-359-8

ORDER CODE: 0491

8½ x 11, 268 pp., Illus.
Softcover, $82.00

CONTENTS

BOOK ORDER FORM

① Complete quantity, book title, order code, price and amount due for each book you wish to order:

Quantity	Book Title	Order Code	Price	Amount Due
	HVAC Procedures & Forms Manual, Second Edition	**0491**	**$82.00**	
			Applicable Discount	
			Georgia Residents add 6% Sales Tax	
			Shipping Fees	6.50
			TOTAL	

② Indicate shipping address: **CODE: Journal 2001**

NAME (Please print) BUSINESS PHONE

SIGNATURE (Required to process order)

COMPANY

STREET ADDRESS ONLY (No P.O. Box)

CITY, STATE, ZIP

③ Select method of payment:

☐ **CHECK ENCLOSED**
☐ **CHARGE TO MY CREDIT CARD**
☐ *VISA* ☐ *MASTERCARD* ☐ *AMERICAN EXPRESS*

CARD NO.

Expiration date *Signature*

Make check payable in U.S. funds to:
AEE ENERGY BOOKS

MEMBER DISCOUNTS
A 15% discount is allowed to AEE members.
☐ AEE Member (Member No._____)

√ Send your order to:
AEE BOOKS
P.O. Box 1026
Lilburn, GA 30048

INTERNET ORDERING
www.aeecenter.org

TO ORDER BY PHONE
Use your credit card and call :
(770) 925-9558

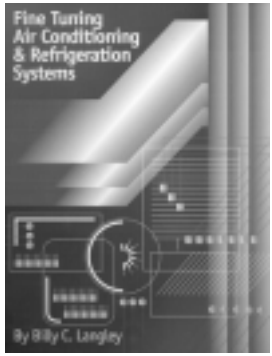
TO ORDER BY FAX
Complete and Fax to:
(770) 381-9865

INTERNATIONAL ORDERS
Must be prepaid in U.S. dollars and must include an additional charge of $10.00 per book plus 15% for shipping and handling by surface mail.

Achieve optimum performance from all types of HVAC or refrigeration systems...

FINE TUNING AIR CONDITIONING & REFRIGERATION SYSTEMS

NEW



By Billy C. Langley

This comprehensive hands-on manual covers all the procedures necessary to fine tune heating, ventilating, air conditioning and refrigeration systems for optimum operating efficiency. Easy-to-follow guidelines and worksheets guide you each step of the process giving you the tools you need to assure that equipment can operate at peak efficiency as designed by the manufacturer. The full spectrum of systems and equipment are covered, including electric heating, gas heating, oil burners, air conditioning systems, heat pumps, and refrigeration equipment. A wealth of helpful diagrams, illustrations, estimating tools, and worksheets are also provided. Multiple tear-out copies of each worksheet are provided for use on the job.

ISBN: 0-88173-358-X

ORDER CODE: 0488

8½ x 11, 327 pp., Illus.
Softcover, $84.00

CONTENTS

BOOK ORDER FORM

① Complete quantity, book title, order code, price and amount due for each book you wish to order:

Quantity	Book Title	Order Code	Price	Amount Due
	Fine Tuning Air Conditioning & Refrigeration Systems	**0488**	**$84.00**	

② Indicate shipping address: **CODE: Journal 2001**

NAME (Please print) BUSINESS PHONE

SIGNATURE (Required to process order)

COMPANY

STREET ADDRESS ONLY (No P.O. Box)

CITY, STATE, ZIP

Applicable Discount	
Georgia Residents add 6% Sales Tax	
Shipping Fees	6.50
TOTAL	

MEMBER DISCOUNTS
A 15% discount is allowed to AEE members.
☐ AEE Member (Member No._____)

③ Select method of payment:
☐ **CHECK ENCLOSED**
☐ **CHARGE TO MY CREDIT CARD**
☐ *VISA* ☐ *MASTERCARD* ☐ *AMERICAN EXPRESS*

Make check payable in U.S. funds to:
AEE ENERGY BOOKS

CARD NO.

Expiration date *Signature*

√ Send your order to:
AEE BOOKS
P.O. Box 1026
Lilburn, GA 30048

INTERNET ORDERING
www.aeecenter.org

TO ORDER BY PHONE
Use your credit card and call :
(770) 925-9558

TO ORDER BY FAX
Complete and Fax to:
(770) 381-9865

INTERNATIONAL ORDERS
Must be prepaid in U.S. dollars and must include an additional charge of $10.00 per book plus 15% for shipping and handling by surface mail.