# The High Tech Sector and the Environment in the New Millennium: Performance, Prescriptions and Policy

Report to the California Global Corporate Accountability Project

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**HUMAN RIGHTS ADVOCATES**

**Contents**

**List of Tables**

## Glossary

American Electronics Association (AEA)
Application specific integrated circuits (ASICs)
Carbon dioxide ($CO_2$)
Chemical vapor deposition (CVD)
Chemical Manufacturer's Association (CMA)
Chlorofluorocarbons (CFCs)
Common Sense Initiative (CSI)
Coalition for Environmentally Responsible Economies (CERES)
Environment, health, and safety (EHS)
Electronics Industry Alliance (EIA)
Environmental management systems (EMSs)
Environmental performance indictors (EPIs)
European Commission (EC)
European Eco-Management and Audit Scheme (EMAS)
European Union (EU)
Global Reporting Initiative (GRI)
Greenhouse gas (GHG)
Gross Domestic Product (GDP)
Information technology (IT)
Internal rate of return (IRR)
International Organization for Standardization (ISO)
Million metric tons of carbon equivalent (MMTCE)
Multi State Working Group (MSWG)
Non-governmental organizations (NGOs)
Ozone Depleting Substances (ODS)
Perfluorocompounds or (PFCs)
Printed circuit boards (PCBs)
Silicon Valley Environmental Partnership (SVEP)
Silicon Valley Manufacturing Group (SVMG)
Spontaneous abortion (SAB)
Sulfur dioxide ($S0_2$)
Toxics Release Inventory (TRI)
U.S. Securities and Exchange Commission (SEC
U.S. Environmental Protection Agency (EPA)
Volatile organic compound (VOC)
Waste from electrical and electronic equipment (WEEE)

## Introduction: From Pilots to Programs

This chapter identifies the most pressing environmental issues associated with hardware firms in the information technology (IT) sector. Due to the diversity of industries, firms, and products that comprise the IT sector and the heterogeneity of environmental problems associated with the sector, the focus of this chapter primarily is on the semiconductor industry, an industry poised on the brink of dramatic technological change. This chapter then examines the extent to which voluntary industry efforts to improve environmental performance may successfully be developed and applied to IT firms in California and to IT firms outside California, in other parts of the world. Before turning to these questions, the following discussion provides an overview of the environmental, economic, and geographic features of the sector. The second concludes by presenting an analytic framework that guides the presentation of ideas and development of policy recommendations presented in this chapter.

### Environmental legacy

In the United States, environmental registries such as the Toxics Release Inventory (TRI) show industries in the IT sector to be among the cleanest of industrial sectors. Yet the sector's early environmental history contains a few notable cases of serious environmental and human health problems. Contrary to the sector's clean image, IT manufacturer historically has relied on hundreds of chemicals and gases to insure that products with dimensions hundreds of times smaller than the width of a human hair remain free of contaminants -- a leading source of device failure. Although the industry's rapid pace of innovation and capitol replacement has allow it to move faster than most to address pollution problems, some problems, such as soil and groundwater contamination, persist. Consider that Santa Clara County, where the sector grew up, contains more Superfund sites than any other county in the United States.

During the 1990s, public and private policy experiments in the United States focused on voluntary efforts to improve the IT sector's environmental performance. For example, during the early 1990s, semiconductor manufacturers began to work with trade organizations to develop and popularize voluntary guidelines for issues such as the environmental performance of manufacturing equipment.[1] Today, IT companies outstrip all other sectors in the number of registrations to industry-led voluntary efforts to achieve continuous environmental improvements.

Though industry-led efforts to improve product and process design are significant and are on the rise, most observers agree that environmental, health, and safety improvements have been driven by federal laws.[2] Therefore, this chapter focuses on several federal initiatives to improve the sector's environmental performance. In part, the voluntary federal initiatives targeted the sector due to the growing economic importance of information technology. Among these voluntary government initiatives were the U.S. Environmental Protection Agency's (EPA) Project XL and Common Sense Initiative (CSI).

Whereas high profile federal environmental initiatives such as Project XL drew enormous attention to IT sector participants such as Intel Corporation, few lessons from these high profile voluntary policy pilots have been applied. However, a growing number of observers, including representatives from IT corporations such as Intel say it is time to move from "pilots to programs."[i]

**Economic overview**

The IT sector is one of the fastest growing and most important segments of the U.S. and the global economy. According to the U.S. Department of Commerce, the IT Sector's share of investment activity and of the gross domestic product (GDP) grew from 4.9 percent of the economy in 1985 to an estimated 8.2 percent by 1998.[3] According to the Electronics Industry Alliance (EIA), one of the fastest growing segments of the IT sector is in telecommunications, with an 18 percent increase in sales over 1998, and components, which reached over $72.5 billion in sales in 1999. [4] 1999 also marked a significant rebound for semiconductor manufacturers. For the worldwide market, total semiconductor sales for 1999 were $149.4 billion, an increase of 18.9 percent from 1998's $126.0 billion.[5]

To some degree, the engine of this phenomenal growth resides in a region once referred to as the "Valley of Heart's Delight" – Silicon Valley, a region roughly contiguous with Santa Clara County, California. However, a number of prominent semiconductor manufacturers -- Texas Instruments, Motorola, and IBM -- historically have housed their corporate headquarters outside of California.

California-based companies such as Intel, Hewlett Packard, Agilent, and AMD continue to house their corporate headquarters and research and development in Silicon Valley. Yet a number of industries in the sector -- most notably, semiconductor manufacturers -- in recent years have relocated manufacturing operations from California to other parts of the United States and the world or simply have moved to a business model where they design, but no longer manufacture products.[6]

**Organization**

In the next decade, the technological rules that have governed the industry throughout its 30 year history will change as it becomes physically impossible to place more transistors on a piece of silicon. Given such economic, environmental, and technological developments, to what extent may California play a role in improving the sector's environmental performance? In order to address this question, this chapter is organized into the following four sections:

• **Section 1**: Given the sectors' early environmental history, what are the most important environmental issues in the sector today? Tomorrow? How are corporations in the sector responding to environmental issues? What progress has been made?

• **Section 2**: What are incentives to improve corporate environmental performance and accountability?

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[i] Timothy Mohin, Director, Corporate Environmental Health and Safety. Intel Corporation.

- **Section 3**: What are the major lessons from federal environmental pilots to date?
- **Section 4**: What are the next steps to promote environmental accountability in the IT sector, with attention to the role that California can play?

**Findings**

The first section of this chapter provides an overview of environmental issues historically associated with semiconductor manufacturing and identifies the most pressing environmental and human health issues in the sector. Section 1 draws from the major scientific, trade, and policy literature as well as from informal interviews with representatives in industry, government, and non-governmental organizations (NGOs).

Section 1 shows that constant innovation, the lack of health and safety data, and the sensitive nature of information in the industry make it difficult to draw firm conclusions about risks to human health and the environment posed by hardware producers, particularly semiconductor firms. The experience of Silicon Valley makes clear that the current system of laws to control pollution has helped to address some of the most visible problems associated with the industry. Today, however, some leading IT firms now as a policy seek to over-comply with environmental laws and regulations as a means in which to best avoid costs associated with the current system. *The challenge is to provide incentives for top firms to do even better and to develop policies to improve the environmental practices of firms that have not yet adopted pro-active environmental policies.* In addition, changes in how and where the industry makes products further demand new environmental policies and accountability measures.

Section 2 of this chapter describes major public and private efforts to develop policies to improve corporate environmental performance and to develop environmental performance indicators (EPIs). The purpose of Section 2 is to describe a set of potential policy and accountability measures on which industry, NGOs, and regulators can agree. This section surveys efforts on behalf of public and private organizations to adopt and harness management practices and metrics that could provide a common set of environmental performance measures and sustainability indicators for public policy.

Efforts surveyed include the Coalition for Environmentally Responsible Economies/Global Reporting Initiative (GRI), the 14001 reporting series by the International Organization for Standardization (ISO), and the Multi State Working Group (MSWG). GRI furnishes a process and some substantive analysis needed to further develop a global framework for environmental management and reporting. But GRI does not embrace or advance the concept of measurable performance improvement. Furthermore, there is enough parallel agreement or overlap between any number of ongoing efforts to identify a core set of indicators or metrics. However, there is as yet no organized attempt to create or establish environmental performance goals other than compliance with the current set of environmental laws and regulations.

Section 3 identifies and summarizes key lessons learned from innovative environmental approaches applied to the hardwire side of the IT sector to date. The efforts evaluated include high profile federal experiments such as Project XL to state initiatives such as Oregon's Green Permits program. Section 3 concludes that past voluntary initiatives to target IT firms have foundered because most existing pilots require government and the public to possess as much expertise on industry products and processes as industry. Other problems include: lack of coordination among agencies and interest groups; undo overlap among initiatives; and the lack of tangible environmental and economic benefits to the private sector and to the public. The lack of tangible benefits is partly attributable to poor program design and to the accompanying lack of accurate, cost effective environmental performance measures.

Section 4 identifies policy options that the public and private sector can forge to promote corporate environmental performance among the leaders and to assist laggards. The experience of environmental pilots to date make clear that a "Second Generation" of environmental legislation, programs, and corporate practices is necessary to make environmental concerns apparent and internal to business practices.[7]

Such policies would provide greater incentives to top performers to reduce pollution and to promote sustainability in exchange for greater assurance that environmental goals are being met. Such approaches would harness the potential of third parties, including trade organizations, accounting firms, and non-governmental organizations to report, to monitor, and to verify data. To reduce administrative burden, improve transparency, and adequately target practices at a global, rather than simply local, regional, or national scale, it is clear that the public sector must harness existing conduct codes and practices to improve corporate environmental accountability and performance. Before turning to these issues, the following discussion provides an overview of the IT sector, with attention to semiconductors and describes the environmental issues associated historically with the sector. Before doing so, it is necessary to define what is meant by IT sector and semiconductor industry.

**Definitions**

Although software and Internet applications have in recent years driven the most powerful economic activity in Silicon Valley, this chapter focuses primarily on the hardware side of the sector, with attention to the semiconductor industry. The Office of Management and Budget classifies and defines IT industries according to the 1987 Standard Industrial Codes manual. By this method, IT industries are separated further the following categories: hardware, software, and communications. Hardware includes computers and printed circuit boards. Software includes programming, prepackaged software, and computer rentals. Communications equipment includes household audio and video equipment, radio and TV equipment and telephone and telegraph equipment.

By the SIC code definition, hardware industries include computers and equipment, including wholesale and retail sales, semiconductors, office equipment, other electronic components industries and industries that produce measurement and laboratory analytical instruments. It is important to note that such distinctions are subjective. It increasingly is difficult to determine where the boundary of one industry ends and another begins. For example, semiconductors, which are silicon devices that transmit electronic signals, are found in computers, but also in tennis shoes, automobiles, and home appliances.

**Analytic Framework**

The foregoing discussion suggests that it is necessary make several distinctions when assessing the environmental impact of hardware manufacture. Growing anecdotal evidence suggests that a two-tier system has emerged in the IT sector, in terms of environmental standards and performance. It therefore is necessary to distinguish between companies that are pro-active on environmental issues from those that either lack the resources or the interest in developing strong environmental management systems (**Table i.1**). It also is necessary to distinguish between environmental issues that are associated with Silicon Valley from those that are associated with regions in which the industry now manufacturers IT hardware (**Table i.2**).

In terms of the former distinction, there is likely to be a strong correspondence between large corporations that innovate rapidly, from those in which the need to constantly upgrade capital equipment Rapid innovators are companies that historically have doubled the power of computer chips every 18 to 24 months, a phenomenon known as “Moore’s Law.” Such advances historically have been achieved by increasing the number of transistors on a piece of silicon.[ii] Rapid innovators tend to be companies that produce semiconductors for use in personal computers – microprocessors, and memory devices, as well as manufacturers of semiconductor technology used in personal communication equipment such as cellular telephones. In general, rapid innovators also possess the resources to invest in new plants, equipment, and sizeable environmental, health, and safety programs.

Table i.1 illustrates that the leading corporations are more likely than laggards to have reduced *known* risks to human health and to the environment traditionally associated with IT -- groundwater contamination, conventional air pollution, and the use of toxics linked to reproductive problems. One reason is that leading firms innovate rapidly and require the latest and best machinery to make cutting-

[ii] By most accounts, molecular electronics -- where individual atoms and molecules replace lithographically drawn transistors -- will replace conventional semiconductor production as early as 2010.

edge products. Rapid innovators have a greater opportunity to design environmental criteria into new products and processes than firms that innovate more slowly.

Increasingly, innovators are moving from a business mode in which environmental, health and safety improvements are made in reaction to environment, health, and safety risks and the real or perceived threat of regulation. Such firms are shifting to a proactive mode that focuses on the development of cleaner processes in the design phase, voluntary environmental performance standards, and the voluntary development of corporate-wide performance measures to assess environmental problems and to identify areas for improvement.

**Table i.1 Leader and laggard characteristics**

| **Likely to be top environmental performers** | **Likely to require improvement** |
|---|---|
| Plants less than 20 years old | Plants more than 20 years old |
| New products every 18-24 months | New products not introduced as rapidly |
| Retain some production in-house | Dedicated, third-party suppliers |
| Dedicated environment, health, and safety staff | No dedicated environment, health, and safety staff |
| More than 500 employees | Less than 500 employees |

By extension, risks to human health and to the environment associated with leaders are likely to be lower than those associated with "laggards" -- firms and suppliers that operate older plants and equipment and possess fewer resources to make environmental, health and safety improvements. Such firms produce products that change less rapidly than microprocessors and are less sophisticated technologically (e.g., photo sensors, application specific integrated circuits (ASICs)).

Such firms also may be third-party suppliers that occupy a niche that specializes in manufacturing products with capital equipment too obsolete to make cutting-edge microprocessors or memory chips (e.g., second, third, or fourth generation memory chips). The most innovative firms have addressed environmental challenges through a combination of factors including process re-design, elimination of certain gases and solvents, and improved health and safety practices.[8]

For the purposes of developing a California policy to improve environmental performance, one paradox is that the companies likely to be most proactive on the environment (e.g., Intel, Agilent, and Hewlett-Packard) typically are most likely to participate in voluntary initiatives to improve environmental performance. Conversely, companies that most require improvement are unlikely to participate, either because they seek to avoid scrutiny and potentially adverse publicity or simply lack the resources to participate in voluntary endeavors.[9]

**Table i.2 Local and global environmental characteristics**

| **Silicon Valley characteristics** | **Global characteristics** |
|---|---|
| Corporate headquarters, some research | Manufacturing facilities of IT firms.<br>Third-party suppliers |

| | |
|---|---|
| Non-point source pollution | Point source as a concern today, but non-point source pollution as a concern tomorrow. |
| Residual point-source problems | Emerging point source problems? |

Table i.2 distinguishes between environmental challenges in Silicon Valley and environmental issues in regions where IT hardware now is mostly manufactured. It is estimated that more than 900 semiconductor plants operate worldwide. In the United States, they now are located mostly outside California in states such as Arizona, New Mexico, Texas, Idaho, Oregon, Massachusetts, and Virginia. Texas now contains the most semiconductor plants, followed by New Mexico and Arizona.[10] Outside the United States, the manufacture of semiconductors and related equipment is concentrated in Ireland, Scotland, Taiwan, South Korea, and Malaysia.[11]

In the context of the framework developed above, this chapter examines policy approaches and performance metrics to encourage top corporate performers and mature semiconductor producing regions to do even better and for firms and regions in need to assistance to improve as well. Before turning to such questions, Section 1 draws from interviews and literature reviews to identify the environmental issues of most concern historically, as well as issues of most concern to policy makers, industry, and non-governmental organizations in the United States today.

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[9] For empirical evidence, see Arora, S. and T.N. Cason. 1995. "Why Do Firms Overcomply with Environmental Regulations?" Understanding Participation in EPA's 33/50 Program," Discussion Paper 95-38. Washington, D.C.: Resources for the Future; and Blackman, A. and J. Mazurek. 1999. "The Cost of Developing Site-Specific Environmental Regulations: Evidence from EPA's Project XL," Discussion Paper 99-35. Washington, D.C.: Resources for the Future.
[10] SEMI (Semiconductor Equipment and Materials International). 1994. Fabs of the Southwest. Mountain View, CA: SEMI.
[11] For an excellent map of firms and facilities, see Silicon Valley Toxics Coalition website. Available at: http://www.svtc.org/global/index.html

## Section 1. Setting Priorities, Getting Results

### Introduction

This section provides an overview of environmental issues associated historically with semiconductor production in Silicon Valley and then identifies high-priority environmental issues now associated with the industry. The list that follows is based not on a problem's relative risk to humans or to the environment, but on the frequency of references in the engineering and human health literature, trade press, and in informal interviews with representatives from industry, government, and non-governmental organizations. Using the analytic framework developed above, this section analyzes issues of importance at both the local scale (i.e., Silicon Valley) and to regions outside California in which hardware manufacturing increasingly takes place.

It is important to note that the results are based not on the use of a scientific sample or survey. Instead, the sample reflects the concerns and orientations of corporations, organizations, and individuals that agreed to be interviewed. In all cases, the companies interviewed represent large firms with dedicated environment, health, and safety departments and not small companies. Furthermore, the results reflect the concerns and orientations of firms and organizations in the industrialized, rather than developing world. The latter set of concerns is encapsulated in companion papers to this chapter.

### Environmental Background

Before turning to a discussion of current environmental issues associated with the industry, it is important to review some of the most prominent environmental issues historically associated with IT manufacturing in Silicon Valley. In addition to providing a brief description of the issue, the following discussion first provides an overview of federal environmental laws and how they increasingly fail to target this industry.

#### Pollution Control System

Historically, the U.S. has led the world in successfully defining contemporary environmental protection. To date, the complex and imperfect air, water, waste, and toxic laws that govern environmental management have reduced some forms of pollution (e.g., air emissions).[1] But serious problems remain. Consider that the nation's major toxics law only has banned the use of six toxic chemicals and furthermore developed scant health and safety data on the hundreds of chemicals used to manufacture IT hardware.[2]

The status quo system of laws and regulations reduces pollution primarily through the use of standards that specify how much pollution a source may emit. Standards are implemented through permits and enforced through compliance and inspections. Permits only provide environmental data at one point in time, when the permit is issued and revised. And inspections are infrequent and uneven, providing little guarantee or assurance that the nation's environmental goals are being met.[3] Although they are inefficient and provide little data on actual environmental quality, the current system has helped to stem some of the most visible issues associated with semiconductor manufacturing.

**Table 1.1 Most prominent issues historically**

| |
|---|
| Hazardous waste |
| Air Pollution |
| Ozone Depleting Substances (ODS) |
| Toxic Chemicals |

**Manufacturing overview**

To understand the environmental problems associated historically with semiconductor manufacturing, it is useful to know something about they are made. In general, the entire semiconductor production process involves the following phases: design, ingot growing, wafer manufacturing, cleaning, testing, and assembly. Manufacturing or fabrication is the most chemical-intensive phases of the process and typically occurs inside "clean rooms" where the air continuously is filtered to remove dust and potential contaminants.

The number of manufacturing steps varies, depending on the product and its intended use. Manufacturing of application-specific integrated circuits (ASICs) tends to involve the fewest manufacturing steps. A memory chip requires roughly 100, while microprocessors, considered the most complex semiconductor to produce, may require more than 300 manufacturing steps. Semiconductors currently are fashioned from polished, silicon wafers with the thickness of a credit card and anywhere from three to eight (and soon, twelve) inches in diameter, depending on the wafer size and function for which the semiconductor is ultimately designed.

In the design phase, firms use computer models to develop and test layouts of circuit paths. The purpose of the design process is to create a master circuit pattern or “mask” that ultimately will guide the process of inscribing circuitry on silicon. Typically, the most advanced products are designed years in advance of manufacturing. A number of large companies now develop manufacturing prototypes following design to minimize production uncertainties and improve product yield.

Fabrication draws from the same principles as developing a photograph; fabrication combines complicated exposure techniques (photolithography) with a sequence of precisely controlled chemical reactions. Semiconductors are built, layer upon layer, by exposing some parts of the product to light, and employing chemicals and water to etch away others. The semiconductor is then bombarded with ions to build electrical, “semi-conducting” regions on some parts of the semiconductor. These regions are then wired together with a conducting metal that may be just 200 to 400 times smaller in width than that of a single human hair. Following fabrication, the raw material is sliced into "dies," tested, cleaned and assembled into semiconductors.

**Hazardous waste**

Historically, chemical leaks from storage tanks to land and groundwater have been the most visible problem associated with hardware production. In October 1984, the Santa Clara Valley Integrated Environmental Management Project identified 93 soil and groundwater contamination sites in the region.[4] Of the 93 sites, 63 were related to high tech firms. Subsequent investigations by the U.S. Environmental Protection Agency (EPA) identified 29 sites so contaminated that they were added to the Superfund National Priority List of cleanup sites. As of 1996, the processes of producing semiconductors and other hardware components directly caused 20 of the 29 Superfund sites in Santa Clara County.

In the past, companies commonly buried supply hoses, tanks, and ducts underground and out-of-view, tanks and wastewater pipes. However, in response to regulatory action, stricter state laws and the risk of liability most new facilities contain safeguards to prevent spills from reoccurring. For example, manufacturers now build storage tanks and chemical supply lines elevated on tracks above ground to promote visibility and early leak detection.[5]

**Air pollution**

Conventional and hazardous air emissions from hardware manufacturing once were a significant source of air pollution in Silicon Valley.[6] Conventional pollution is generated by combustion and hazardous pollutants largely are due to the use of chemical solvents in the semiconductor industry. Conventional pollution contributes to urban smog whereas hazardous chemicals are thought to contribute to more localized problems and are toxic to humans and the environment in much smaller amounts than conventional pollutants.

Relocation of manufacturing out of Silicon Valley and out of the United States to other parts of the world has eliminated a significant amount of industrial air pollution in the Valley. It is not known whether air emissions from the industry have been transferred to regions outside the Valley where the industry is now located. However, it is likely that air pollution from the top environmental performers in the industry has decreased worldwide. For example, rapid innovation has allowed firms such as Intel to reduce considerably emissions of conventional and hazardous pollutants in all their facilities. Between 1990 and 1994, Intel's semiconductor production increased 98 percent. But during the same period, the company reports volatile organic compound (VOC) emissions per square inch of silicon increased only 18 percent. In terms of VOC emissions per square inch of silicon processed, emissions fell by 75 percent over four successive process generations.[7] Intel used a mix of strategies, including improvements to manufacturing equipment, to achieve the reductions. Other strategies include improved chemical utilization, solvent substitution, and better pollution abatement methods.

**Ozone depleting substances**

Chlorofluorocarbons (CFCs) are another example of how rapid innovation allows firms in the hardware industries in the sector to quickly phase the substances out. Electronics, computer and chip producers used CFCs to clean sensitive parts such as disk drives and printed circuit boards (PCBs). CFCs are linked to global warming and depletion of the earth's protective upper-level ozone. Although CFCs pose little or no health risk at ground level, their properties in the upper atmosphere made CFC a target for phase-out under the provisions of the 1987 Montreal Protocol. IT hardware firms were among the first industries to phase out use of CFCs. Observers attribute the industry's rapid phase out of CFCs to the relatively short product cycles (e.g., 18 to 24 months) that characterize computer and electronics manufacturing.[8]

**Toxic chemicals**

Semiconductor manufacturing requires the use of hundreds of chemicals and gases to insure micro-thin products are free of defects. Among the chemicals used to make semiconductors are highly corrosive hydrochloric acid; metals such as arsenic, cadmium, and lead; volatile solvents such as methyl chloroform, toluene, benzene, acetone, and trichloroethylene; and toxic gases such as arsine. Many of these chemicals are known or probable human carcinogens.[9] However, nothing is known about long-term exposure to low levels of combinations of chemicals and reaction products.

From a weight-based perspective, toxic releases from hardware producers are low relative to other industries. For example, IT hardware (electronics and computer) manufacturers who meet certain reporting thresholds are required to report on toxic releases to the EPA. In 1997, the most recent year for which data are available, on-site toxic releases from the electronics sector (SIC 36) stood at roughly 22 million pounds.[10] Toxic releases from the semiconductor industry alone (SIC 3674) that year were merely 2.5 million pounds.[11] The chemical industry (SIC 28) in 1997 reported on-site releases of 742 million pounds. On-site releases from the primary metals industry (SIC 33) were 406 million pounds.[12]

From a weight-based perspective, the impact of the industry appears slight. However, from a risk-based perspective, some believe that the harmful effects of chemicals on humans used to manufacture IT hardware are just coming to light. A growing body of circumstantial evidence, ranging from worker anecdotes to federal job-safety data, suggests chip making may be dangerous and damaging work, especially in older plants built in the early 1970s. By one estimate, approximately 150 of the world's 900 chip plants are older operations that generally use equipment recycled from U.S. factories after the equipment becomes too obsolete to create the leading edge technology.

To date, the most-closely studied human health issue among electronics and computer workers involves shorter-term problems linked to a group of solvents commonly used to apply and strip spent chemicals.[13] Glycol ethers were a long-time staple of semiconductor manufacture but largely were phased out by the industry during the early 1990s, as the risks to humans exposed to the substances became increasingly apparent.

The sector did not begin to document the potential effects on humans of glycol ethers until 1986, after the use of the substance was embedded in production. Subsequently, three independent studies on thousands of women who worked in semiconductor manufacturing facilities or "fabs"[i] found that subjects had higher than average rates of reproductive problems including spontaneous abortion (SAB).

More recently, some semiconductor workers in California, New York, and in Scotland have charged that exposure to toxic chemicals has contributed to or caused cancer.[14] No health authorities have concluded that there is a definitive link between chip making and cancer or birth defects, in part, because establishing causality to exposure to hundreds of different chemicals, years and even decades ago is extremely difficult, if not impossible. No efforts are underway to develop studies in part because the industry claims epidemiological studies of cancer rates in workers or birth defects in their children because are unwarranted.

**Findings**

Table 1.2 shows what respondents consistently identified as pressing environmental issues. It is important to note that all issues fall outside the scope of federal air, water, waste, and toxics laws -- or the "pollution control system."[15]

**Table 1.2 Most prominent issues today**

| |
|---|
| Solid and hazardous waste |
| Energy use and climate change |
| Water use |
| Livability |
| Supply-chain management |

Whereas federal law does regulate hazardous waste associated with the mounting pile of consumer electronics, federal law does not regulate solid waste. Similarly, federal law does not regulate energy use, water consumption, and greenhouse gas GHG emissions.[ii] Livability concerns such as housing cost, time spent commuting to work, or pollution from diffuse sources, are not addressed under the status quo system.

[i] The term, "fab" is short for semiconductor fabrication plant.
[ii] Primarily, the extremely conservative elements of the U.S. Senate have refused to ratify an international treaty to regulate greenhouse gases (e.g., the Kyoto Protocol) because they argue that the scientific evidence is uncertain and

In the case of supply-chain management, outsourcing production to third parties was uncommon during the 1960s and 1970s when Congress expanded the current system of federal law. Moreover, at the time the computer and electronics industry was still in its early infancy.

In some cases, such as waste and greenhouse gas (GHG) emissions, global and local themes overlap. That is, GHG emissions, notably, per capita emissions of carbon dioxide associated with home energy consumption and fuel use, are just as likely to be an area of concern in Silicon Valley as they are at an semiconductor manufacturing facility in Ireland, Israel, or Costa Rica. In other cases, industrial relocation out of Silicon Valley coupled with innovation has eliminated many environmental problems traditionally associated with manufacturing there. Yet it is unclear whether, and, if so, to what extent such environmental problems simply have been transferred elsewhere.

Environmental challenges in Silicon Valley now are more likely to be negative externalities associated with the region's boom in software and Internet applications, rather than with manufacturing. Current challenges in Silicon Valley include high housing cost, high energy and water consumption, and high vehicle emissions rather than pollution from manufacturing.[16]

It is plausible to assume that environmental issues in Silicon Valley today will be the problems in other parts of the United States and the world that increasingly specialize in semiconductor manufacturing tomorrow, if not already. That is, air pollution from automobiles or water pollution from urban runoff already may be just as much of a problem in Arizona's Silicon Mesa as in Silicon Valley, California.

Finally, it is perhaps axiomatic that political and institutional currency of the issue also explains why interview respondents consistently mentioned waste and global warming as issues of concern. For example, the work in Europe at this writing on the draft directive on waste from electrical and electronic equipment (WEEE) helps to account for why the international issue of product take-back was mentioned most in informal interviews and the industry press. The current attention and controversy surrounding the waste directive in Europe is eclipsed in scope and prominence by decade-long international efforts to ratify a global treaty, such as the Kyoto Protocol, to reduce greenhouse gas emissions. To examine environmental issues associated with the IT sector, the following discussion first provides some background on the environmental issue, followed by a summary of how the industry and/or government are addressing the issue.

**Solid and Hazardous Waste**

**Problem statement**

As semiconductor companies release newer, more powerful products, computers and electronic equipment become obsolete more rapidly. Researchers at Carnegie Mellon University estimate that more

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that costs of regulation outweigh environmental benefits. For this reason, the U.S. Congress has prohibited EPA than 2 million tons of computers will be sent to U.S. landfills by the year 2000.[17] Researchers expect computer disposal challenges to climb as semiconductor manufacturers continue to release newer, faster semiconductors. The Carnegie Mellon study predicts that by 2005, a computer will become obsolete just as fast as a new computer is made.[18] The Carnegie Mellon researchers furthermore estimate that up to three-quarters of the machinery manufactured to date has not been disposed of, but instead sent to storage facilities.

According to the Gartner Group, a marketing and research firm in Stamford, Connecticut, about 79 million computers had been retired from their primary lives in 1996. By 1999 another 42 million machines were retired. About sixty-five percent of machines used by business are not disposed but simply placed in storage areas. About fifteen percent are resold, and another 15 percent are dismantled for scrap or recycling. About five percent find their way to schools and to nonprofit organizations that either rebuild and redistribute the machines or use them in-house.

**Policy context**

In the United States, EPA and states such as Minnesota have addressed computer and electronics waste through voluntary programs to promote recycling. However, the European Commission (EC) has proposed that electronics and computer producers "take back" products once their useful life has ended. The draft Directive on Waste from Electrical and Electronic Equipment (WEEE) is designed to minimize any adverse environmental impacts from electronic products, including efforts to increase the recycling of products at the end of their useful lives (**see Appendix B**). The draft directive applies to most categories of electronic and electrical products sold in the European Union (EU) and would thereby affect U.S companies doing business in Europe.

In the United States, industry maintains that the directive would impose very high costs to industry and to consumers with very little environmental benefit. Members of the Electronics Industry Alliance (EIA), a leading U.S. trade association, have expressed two main provisions of concern with the WEEE draft: First, EIA argues that the draft directive would ban the use of certain critical substances in electronic products such as lead. EIA and a number of industry members surveyed for this report maintain that is no demonstrated need to prohibit these substances and no viable substitutes. Second, EIA is concerned that the draft directive would require manufacturers to assume sole responsibility for the collection and recovery of used products, including "historic" products sold long before the issuance of the directive.[19]

The American Electronics Association (AEA) furthermore argues that setting up a separate collection system for electronic scrap would place an additional burden on the environment.[20] AEA

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from working on any policies that appear to regulate greenhouse gases.

instead prefers for municipalities to assume responsibility for collection and sorting, with shared responsibility and industry participation along fundamentally voluntary lines. According to AEA, experiments with purely private systems had failed to boost recycling levels.

Conversely, NGOs maintain that the bans on critical substances are necessary, warranted, and carry both economic and environmental benefits. For example, in a letter to the European Union, the Silicon Valley Toxics Coalition writes: "We believe that placing the financial responsibility for take-back on the producer will encourage better product design such as durability, repairability and cleaner material use."[21]

**Energy Use and Climate Change**

**Problem statement**

Greenhouse gas emissions include substances such as carbon dioxide ($CO_2$) and methane where are released when fuel is burned or when they are used or created as a by-product in production. On the ground they mostly are harmless to humans and to the environment. However, greenhouse gases trap heat in the earth's atmosphere and cause gradual warming and weather changes in the earth's temperature. The potential impact of climate change on the economy, livability, and natural systems is significant. The IT sector plays a potentially important role in policies to address global warming. Scientific evidence suggests that climate change pose risks to human health, ecosystems, food security, and water resources in many parts of the world. In response, an international treaty was put forth in Kyoto, Japan. If ratified, the Kyoto Protocol would require signatories to regulate GHG emissions.

The relative contribution of the IT sector to GHG emissions varies, depending in part on the assumptions employed by the analyst as well as the methods used to define IT sector. For example, it is clear that hardware IT manufacturing is an energy intensive process. This is particularly true for semiconductor manufacturers. By 1993, an average manufacturing facility used 240,000-kilowatt hours of energy per day. More than one-half that amount is used to clean and condition the air inside semiconductor clean rooms.[22]

The semiconductor industry currently emits a number of potent greenhouse gases from its manufacturing process including fluorocarbons ($CF_4$, $C_2F_6$, $C_3F_8$, C4F8, $CHF_3$), nitrogen trifluoride ($NF_3$) and sulfur hexafluoride ($SF_6$). These gases, which collectively are referred to as perfluorocompounds or (PFCs) are used in two important processes -- plasma etching thin films and cleaning chemical vapor deposition (CVD) tool chambers and are critical to current manufacturing methods. In 1997, EPA estimated the U.S. semiconductor industry's emissions of PFCs at 1.3 million metric tons of carbon equivalent (MMTCE).

Although the PFC issue is significant, when the potential impacts of the entire IT sector are taken into account, it may be that the sector is contributing to a net decrease in energy consumption and the consequent release of greenhouse gases. For example, although the United States grew at a rate of about 4 percent per year in 1997 and 1998, the nation's energy consumption—the principal source of air pollution and the gases linked to global warming—hardly grew at all. In the previous 10 years, U.S. *energy intensity*, measured in energy consumed per dollar of gross domestic product declined (i.e., improved) by under 1percent per year. In both 1997 and 1998, it improved by more than 3percent—an unprecedented change during a time of low energy prices. In 1998, U.S. emissions of greenhouse gases rose only 0.2percent, the smallest rise since 1991 (which was a recession year).

**Policy Context**

It remains to be seen whether semiconductors and the hardware and software applications empowered by them are driving a net increase or decrease in energy demand. Several computer simulation exercises have been conducted to analyze effects of IT on global warming. The results turn on assumptions regarding whether Internet is a major energy consumer or producer of new business methods that economize significantly on energy use. For example, in May 1999, *Forbes* magazine published an article that argues the Internet has become a major energy *consumer* because it supposedly requires a great deal of electricity to run the computers and other pieces of hardware that make the Internet economy work.[23] The *Forbes* piece claimed that from 1996 to 1997, the increase in electricity consumed by all computers used for the Internet represented more than 1.5 percent of all U.S. electricity consumed that year. However, scientists at Lawrence Berkeley National Laboratory recently examined in detail the numbers underlying the *Forbes* analysis.[24] The Lawrence Berkeley scientists found that the estimates of the electricity used by the Internet were high by a factor of eight.

In December 1999, a team of current and former government energy experts published a study that posits that the Internet economy is driving structural changes in the economy that permit reduced energy consumption.[25] Preliminary analysis by EPA and Argonne National Laboratory suggests that roughly one third of the recent improvements in energy intensity are “structural.” Structural gains traditionally occur when economic growth comes in sectors of the economy that are not particularly energy intensive, such as the IT-producing sector, which includes computer manufacturing and software (as opposed to more energy-intensive sectors, including chemical manufacturing, the pulp and paper industry, and construction).

Such improvements are expected to continue and to increase as the IT-producing sector continues to grow. For example, EPA has performed a preliminary analysis of the potential impact of structural changes driven by rapid growth of the IT-producing industries.[26] The analysis suggests that mainstream forecasts may be *overestimating* U.S. energy and carbon dioxide emissions in the year 2010 by up to 5percent— while significantly *underestimating* overall U.S. economic growth.

**Water use and discharge**

**Problem statement**

Water consumption and discharge historically have been challenges associated with semiconductor manufacturing. Recently, the issue of water consumption and discharge has intensified for two reasons. First, the manufacturing process has become more water intensive. Whereas production facilities once required two to three million gallons of water per day, increasingly they consume five to eight million gallons per day. Water is used to rinse microscopic contaminants from the product's surface in the "rinse" process. The process requires ultra-pure de-ionized water. To purify water, firms typically “manufacture” it by treating incoming water supplies to remove impurities. Typically, the process has efficiency rates around 50 percent. In other words, it takes two gallons of city water for a firm to manufacture one gallon of de-ionized, ultra-pure water. As semiconductors have become more technically sophisticated, more water is required in the rinse process.

The second reason water has become a more prominent issue is because the semiconductor industry in recent years has constructed new manufacturing facilities in United States outside Silicon Valley in southwestern states such as Arizona and New Mexico, where water is comparatively scarce. Combined, technical change and relocation account for increased concern with water use and conservation.

**Policy Context**

In 1997, several non-governmental organizations published a book that criticized the industry’s decision to locate new plants in regions where water supply is scarce.[27] The book questions the long-term ecological viability of IT firms in the desert southwest. For example, to secure adequate water supplies in New Mexico, Intel Corporation sought to purchase and retire rights to 2207-acre feet of water from the Rio Grande. The rights would have been purchased primarily from indigenous family farmers. Intel’s plan was hotly criticized by some environmental and human rights organizations in New Mexico.

Industry counters that such charges fail to acknowledge advances made in recent years to reduce water consumption and water discharge. In response to mounting challenges associated with water supply and wastewater disposal, a number of computer and electronics facilities have sought to develop methods to treat wastewater at the site where it is generated in order to recycle water back into production. Indeed, most large companies maintain that 100 recycling percent of the water used to make semiconductors is an attainable goal. However, the goal remains elusive, in part because the industry relies upon so many different types of chemicals that it remains difficult to identify and remove them from the effluent stream.

For example, Intel Corporation, at the company's manufacturing facility in near Phoenix, Arizona supports a $28 million water purification plant. The purification plant uses reverse osmosis to treat effluent to a point where it is at least as clean as drinking water. At those levels, however, the water is too dirty to manufacture semiconductors. However, the new purification plant makes it possible for Intel's water to be injected back into the region's local aquifer or used in irrigation.

To a lesser extent, the industry is coupling water-recycling methods with efforts to develop cleaner production methods that for example, reduce the water needed to manufacture semiconductors. However, as the industry's recent exodus from Silicon Valley to desert regions of the United States illustrates, water availability does not appear to be a major factor for the industry in deciding where to locate. Historically, state and local tax incentives have been in the key determinants in the industry's decisions regarding where to build new plants. Other factors include "livability" issues such as the availability of a skilled workforce, housing, and transportation infrastructure.

**Livability Issues**

**Problem statement**

The experience of Silicon Valley most plainly underscores the success and the inadequacy of the current set of pollution control laws. Historically, pollution problems such as groundwater contamination, air pollution, and toxics use and disposal -- problems associated with IT hardware manufacturing -- were widespread in the region just 10 to 15 years ago. Today, exercises to develop a set of environmental indictors for the region show that residual threats to human health and to the environment are from more diffuse sources that are hard to pin-point and harder to regulate with blunt regulatory instruments.[28] Pollution problems in Silicon Valley now are more likely to stem from driving cars to and from IT firms, rather than from production processes inside a semiconductor plant. This finding is particularly relevant for regions that seek to replicate the Silicon Valley experience.

To illustrate, consider that in 1999 emissions of reactive organic gases from semiconductor manufacturing operations were .8 tons per day in Silicon Valley, whereas emissions from motor vehicles are 186.7 tons per day.[29] Moreover, innovation has allowed firms such as Intel to reduce considerably emissions of conventional pollutants in their facilities worldwide. For example, Intel adopted a corporate policy of structuring almost all of its U.S. facilities to emit pollutants well under the threshold limits that would trigger reporting for major sources of conventional pollutants in response to the Clean Air Act Amendments of 1990.[30]

Indeed, some challenges in Silicon Valley -- high housing cost, congested highways -- may carry environmental impacts as well as cost time and/or money to the people that live and work there. Other challenges include problems associated with the use of products designed and/or made in Silicon Valley -- repetitive motion injury from typing at a computer or operating a particular piece of industrial equipment.

Among the challenges identified by a recent multi-stakeholder report to develop environmental indicators for Silicon Valley found: [31]

- Transportation is perhaps the single largest contributor to environmental impacts in Silicon Valley. The study found that vehicles are responsible for more than one-half of Silicon Valley's air pollution and virtually all of the increase in carbon emissions over the past decade.
- Habitat loss and non-native species are imperiled by human-induced pressures, including farming, salt production, and urbanization.
- Despite improvements in industrial discharges such as copper and nickel, urban runoff (including oil, pesticides, and metals) persists as a threat to water quality.

**Policy context**

Voluntary alternatives to pollution control laws are an increasingly popular way to address environmental problems from diffuse sources such as homes and cars -- areas that are hard to regulate for political and administrative cost reasons.[32] Voluntary pollution control and prevention efforts Silicon Valley have been advanced by organizations such as the Silicon Valley Manufacturing Group (SVMG). Formed in 1978, the SVMG is comprised of principal officers and senior managers of 130 member companies. The group works with local, regional, state, and federal government officials to address major public policy issues affecting the economic health and livability in Silicon Valley. For example, when regulators discovered recently that freshwater discharged from Silicon Valley homes and businesses was harming the San Francisco Bay, SVMG developed a voluntary program to "Slow the Flow" to the Bay. SVMG encouraged homes and business to install toilets, new showerheads and washing machines that conserve water. Such voluntary measures helped to exceed a limit set on freshwater flow set by the State of California by more than one million gallons per day. Based on such voluntary successes, the California Environmental Protection Agency (EPA) in late 1999 approached SVMG to develop a voluntary partnership.

The voluntary partnership would seek to achieve environmental improvements in Silicon Valley that are based on existing environmental indicators (e.g., reduce air pollution from automobiles). As envisioned, the partnership would target a manufacturing sector and use negotiation to set a specific environmental goal. To achieve the goal, the partnership would harness environmental management systems (EMS). Section 2 discusses the use and application of EMS approaches and efforts to devise uniform sets of corporate environmental performance indicators. Appendix A provides an overview of the proposed partnership.

**Suppliers and location**

**Problem statement**

To improve their competitive position, a number of IT firms, particularly semiconductor companies in the 1990s moved toward a production model in which semiconductors no longer were made in house-but contracted to third party suppliers. In most cases, suppliers are located outside California and outside the United States. Those companies that continued to manufacture their own semiconductors in house increasingly built new plants outside California. Whereas major electronics firms such as IBM, Intel, IBM, and National Semiconductor report on the environmental activities of their overseas facilities, few firms report on the activities of their suppliers.[iii] Such developments make it more difficult to assess how well firms and the industry is performing on environmental issues.

For example, the major federal database on toxic substances consistently has shown that toxic releases from the semiconductor companies in the United States have declined since 1988, when EPA first required firms to report (**Table 1.3**). The Toxics Release Inventory (TRI) requires manufacturers to report annually on toxic releases and, more recently on production related waste. Yet it is difficult, if not impossible, to know whether nationwide declines in TRI emissions from the semiconductor industry and individual semiconductor companies are due to improvements in environmental performance or simply to transfers, mergers, divestitures, or outsourcing.[33]

**Table 1.3 Toxic releases and production waste in the semiconductor industry, 1988-1997**

| Year | Releases | Waste |
|---|---|---|
| 1997 | 2,595,284 | 61,898,455 |
| 1996 | 2,322,630 | 57,849,342 |
| 1995 | 1,989,531 | 70,904,365 |
| 1994 | 1,591,027 | 92,566,511 |
| 1993 | 3,310,601 | 120,049,490 |
| 1992 | 4,983,206 | 120,946,271 |
| 1991 | 7,032,226 | 132,114,814 |
| 1990 | 8,309,479 | |
| 1989 | 11,390,410 | |
| 1988 | 11,495,810 | |

Source: Right to Know Network. 2000. Available at www.RTK-NET.org
Search code SIC 3674 (semiconductors and related devices.

In a world where a semiconductor designed in Silicon Valley is manufactured in Ireland for assembly in Singapore and sold in Australia, what methods enable civil society to insure that environmental goals are being met? Combined, the twin forces of globalization and restructuring suggest that the administrative complexity and cost to EPA to accurately pinpoint and identify industry pollution sources will continue to mount. More important, as heated economic change increases, the ability of public environmental agencies to target the most important environmental problems will decrease.

**Policy context**

Studies have shown that large electronics firms are more likely than small companies to use environmental criteria when selecting suppliers.[34] In the semiconductor industry, most third-party supplier agreements historically have been short term (i.e., five years and less) and have changed quickly when participants sought to modify or terminate supplier agreements. At least one study has found that large firms that involve suppliers at the design phase experience economic benefits.[35] The report found that suppliers who demonstrate skill and ingenuity in their involvement with environmental solutions would likely receive customer loyalty. They also will save effort and expense for their customers by eliminating problems early in the supply chain.

More importantly, the report found that electronics companies are relying on fewer but larger suppliers for incoming products. If environmental performance is a function of firm size, this development is a positive trend. However, as small suppliers lose contracts, they may alternatively seek to occupy highly specialized niche markets or sell to intermediate customers. Increasing supplier-to-supplier sales would extend and redistribute risk through the supply chain. In response, legal and environment, health, and safety (EHS) departments in companies are increasingly involved in evaluating contracts for potential risk.[36]

Another development that may help to improve the environmental management practices of suppliers is the use of voluntary standards and conduct codes. Large companies increasingly are incorporating standards such as the International Organization for Standardization (ISO) 14000 series into their global purchasing policies. Firms such as IBM and Xerox strongly are encouraging their supplier to adopt and certify environmental management systems standards. ISO clearly is becoming one method in which corporations in one country can compel suppliers in another to adopt more uniform management systems.[37] It is important to note that such standards were not developed to improve actual environmental performance. Increasingly, firms and NGOs are working to develop and refine public policies that capitalize on the existence of private corporate codes, the focus of Section 2 of this chapter.

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## Section 2: Performance, Improvement and Accountability

### Introduction

Section 1 illustrates that the most pressing environmental issues facing the IT sector fall outside the scope of U.S. laws and regulations to control and manage pollution. The point is particularly apt for the IT sector, where products change every 18 to 24 months and third party suppliers increasingly manufacture products. If the status quo system is increasingly inept to target both leaders and laggards in the IT sector, what, if any potential tools exist to improve corporate environmental performance?

This section examines the evolution of voluntary, industry-led standards to promote the use of systems to improve corporate environmental management and accountability. It them examines the potential application of voluntary, industry led programs to public environmental policy. This section demonstrates how such policy developments are particularly promising for use with leading, or "top tier" firms in the IT sector, many of which have environmental management systems in place.[1] In the United States, IT corporations lead all other industries in the number of new registrations to verify their environmental management systems.[2]

The first part of this section provides overview of current trends in the development of environmental management systems (EMSs). Absent a public policy and accountability component, EMSs will remain as a tool for firms to monitor environmental management practices internally. However, if harnessed with proper reporting, accounting, and verification methods EMS-based approaches have the potential to improve how current laws and regulations target IT firms. Before turning to these issues, it is helpful to understand the evolution of EMS-based approaches.

### Background

Federal environmental laws have helped to address some environmental issues historically associated with the IT sector. However, they are an increasingly inept to address the semiconductor industry. For one thing, current pollution control laws impose uniform standards across an industry that is heterogeneous in its products, processes, and types and quantity of pollution. As a result, the status quo approach is costly, inflexible, and ill suited for an industry in which manufacturing increasingly is decentralized and products change in a matter of months.

In response, industry and government are experimenting with an array of alternative approaches to reduce pollution abatement cost, to control and prevent more pollution, and provide more information than the status quo system. Alternatives to the current pollution control system range from voluntary initiatives, the subject of Section 3, to market based pollution trading schemes. Among the most novel are public policies that attempt to harness the emergence of corporate environmental management systems to improve performance and accountability.[3]

**Table 2.1 Environmental Policy Instruments**

| | **Pollution control** | **Market based** | **Voluntary** | **EMS-*plus*** |
|---|---|---|---|---|
| *How the instrument sets pollution reductions target* | Uniform standards | Sets goal or emissions limit with performance standards | Sets goal or allows participant to set goal | Needs to translate current standards into goals |
| *How the instrument reduces pollution* | Assigns cost to polluting activity | Allows high cost sources to trade ability to control pollution from low cost sources | Promotes abatement and prevention investment by providing additional information. Uses public recognition. | Shifts the cost of pollution management to the firm and the cost of monitoring to third parties. Provides information "feedback" loop to the polluter. |
| *How the polluter meets the target* | Pollution abatement technology | Firm decides | Regulator shows firm most cost effective method | Firm sets and meets own goals, relative to current EMS. |
| *What information does effective function of the instrument require?* | Emissions, environmental concentrations, technology in place | Continuous, real time emissions data to insure integrity of permit trades, but not production data. | Firm's processes and products, emissions, monitoring methods | Environmental concentrations, Whether firm meets EMS requirement; how firm compares to others. |

In contrast to the status quo system, which controls pollution by assigning a cost to polluting activities, market based approaches allow sources with low abatement cost to "sell" their ability to control pollution to sources whose control costs are higher. To insure the environmental and economic integrity of the pollutant traded, programs such as EPA's Acid Rain effort require pollution sources to install smokestack monitors that measure pollution continuously, in real-time. In contrast to command-and-control or voluntary approaches, which require the regulator to insure that an abatement technology is in place or to understand production and process methods, market based systems only require the regulator to collect and monitor emissions data.

In this way, market-based approaches thereby reduce the total cost of preventing and controlling pollution. But trading schemes have limited applications. They work best for industries where products (e.g., electricity) are uniform and easy to exchange. Trading schemes also are more suited to cases where the pollutant traded does not increase risks to human health and to the environment, for example, atmospheric greenhouse gases. They are less suited to industries such as semiconductor manufacturing, where products and processes shift constantly and vary from facility to facility. Trading systems are less suited to chemicals such as hazardous air pollutants, which are suspected to pose high risks to humans and to the environment near the pollution source.

Voluntary efforts, in turn, attempt to correct market imperfections by disseminating new information on abatement technologies or providing intangible benefits in the form of public recognition. As Section 3 of this chapter shows, voluntary approaches to improve environmental performance in the IT sector have faired poorly because they require the public and the regulator to know even more about production processes and chemicals used in the sector than pollution control or market-based systems require.

EMS-based public policies are intended to make the firm's management system a basis for tracking, measuring and continuously improving environmental performance -- a function increasingly difficult for a regulatory agency in the context of constant economic restructuring, innovation, and outsourcing. To they extent that they make the EMS a basis from which to gauge performance, EMS based approaches potentially shift the cost of pollution monitoring and management away from public agencies to where pollution is generated, monitored, and managed -- within the firm or organization.

EMS public policy approaches appear more well suited to the IT sector than other instruments for several reasons: First, the heterogeneous and constantly changing products and processes make emissions trading approaches hard to design and to implement. Second, voluntary approaches fail typically because they require regulators to know more about the sector or firm that either market-based or status quo. Finally, the status quo approach increasingly is ill suited for dynamic industries characterized by constant changes in how and where its products are made. Finally, and perhaps most importantly, in an industry where a product designed in California may be manufactured in Malaysia, assembled in Thailand, and sold in Germany, EMS public policies may provide at least some level of assurance the firms and their network of global operations and suppliers are incorporating environmental criteria into their business operations.[4]

**I. Environmental Management Systems**

Since the late 1980s industry leaders or "innovators" have moved from a business mode in which environmental, health and safety improvements were made in reaction to environment, health, and safety risks and the real or perceived threat of regulation. One popular method is through the voluntary development and adoption of Environmental Management System (EMS) frameworks. EMSs may be understood as a set of management and measurement tools to improve the environmental performance of a company or an organization. Typically, an EMS consists of a formal set of practices and policies designed to help entities to better account for their environmental impacts. EMSs are premised on the idea that improved environmental management practices increase the statistical probability of reducing pollution and accidental spills or releases or hazardous or toxic substances. There is little empirical data to support this assumption, although EPA is supporting efforts to research and document the case (**Appendix G**).

In general, EMS-based approaches are designed to improve public confidence in corporate environmental performance by reducing risks to humans and to the environment through better environmental management practices. Although more direct environmental and economic benefits have not yet been quantified, industry observers say that standard practice codes among facilities or among firms in and industry or sector help to reduce administrative burden or what institutional economists refer to as "transaction costs."

EMSs typically consist of a policy statement and descriptions of best management practices. For example, the Chemical Manufacturer's Association (CMA) six codes outline 106 management practices to promote better stewardship in the chemical industry. The management practice codes cover the lifecycle of a chemical -- from production to handling, use, recycling, and disposal.

As risks to human health and to the environment associated with semiconductor manufacturing started to become apparent during the 1980s, semiconductor manufacturers in the United States developed environment, health, and safety guidelines and corporate policies. Historically, semiconductor manufacturers addressed EHS during the course of equipment installation or product manufacturing. During the 1990s, however, firms in the United States started to shift such concerns upstream into product design in order to improve environmental performance and simultaneously compress the time between product design and planning and final product shipment.

EMSs vary across corporations and even among facilities. As the CMA effort shows, private organizations and trade associations have attempted to make EMSs more uniform. With regard to semiconductor manufacturers, Intel Corporation sought to develop more uniform environmental, health, and safety guidelines for manufacturing equipment performance. The purpose of the move was to integrate environment, health and safety concerns into equipment design. Intel's guidelines were adopted and published by the Semiconductor Equipment and Materials International (SEMI) in 1991.

It is believed that making EMSs more uniform will reduce the likelihood of unintended trade barriers and also reduce the cost of administering transactions between and among firms with different EMSs. Uniformity therefore also increases the ease of EMS adoption among firms in an industry, industries in a sector as well as up and down the supply chain. The challenge in designing such a standard is to make it sufficiently flexible to accommodate all the environmental management applications used by corporations worldwide. Efforts to standardize the use of EMSs include: The International Chamber of Commerce (ICC) Business Charter for Sustainable Development; the Chemical Manufacturers Association's (CMA)

Responsible Care Program; and the Coalition for Environmentally Responsible Economies (CERES) principles (**Table 2.2**).

**Table 2.2 Examples of Environmental Standards and Codes of Conduct**

| Code | Implementing Organization | Goals |
|---|---|---|
| Business Charter for Sustainable Development: Principles for Environmental Management | International Chamber of Commerce | To make environmental management a key corporate priority and to establish policies, programs and practices to improve corporate environmental management. |
| Responsible Care Program | Chemical Manufacturers Association | To improve public perception of the chemical industry through the adoption of conduct codes and management practices to improve corporate environmental performance. |
| CERES Principles | Coalition for Environmentally Responsible Economies | To reduce and make continual progress toward eliminating the release of any substance that may cause environmental damage to air, water, or to earth of its inhabitants. |
| Community Eco-Management and Audit Scheme | European Commission | To require the adoption by corporations of EMSs that are audited or "reviewed" for conformity with the firm's environmental policy and programs. |

Sources: Pacific Institute for Studies in Development, Environment, and Security. 2000. "Managing a Better Environment: Opportunities and Obstacles for ISO 14001 in Public Policy and Commerce. March. Oakland, CA: Pacific Institute. Appendix D: Environmental Standards and Codes of Conduct; Organization for Economic Cooperation and Development (OECD). 1998. "Voluntary Approaches for Environmental Protection in OECD Countries." ENV/EPOC/GEEI(98)29/FINAL. Paris, France: OECD.

In addition, the French, Irish, Dutch, and Spanish governments developed their own voluntary EMS standards in part to promote greater uniformity in EMSs among firms. Few of these EMS initiatives, however, are designed to identify or develop environmental performance goals and standards that translate into quantitative environmental results.

**The ISO 14001 EMS Standard**

To make EMSs more uniform, the International Organization for Standardization (ISO) adopted the ISO 14001 Environmental Management Standard in September 1996. As of September 1999, roughly 13,370 organizations in 75 countries were certified to the ISO 14001 EMS standard. More than 90 percent are in middle and high-income countries.[5] Japan far outranks all other countries in the number of ISO 14001 certifications, with 2,043. The United States/North America has 460.

ISO 14001 contains five key elements -- policies, planning, management programs, internal auditing and operation controls.[6] The standard lays out a systematic and iterative set of methods to identify environmental impacts, to set goals, and to measure performance. For example, the standard requires top-level corporate management to establish an environmental policy. The policy must provide a framework to set and review environmental objectives and targets. The firm must communicate the policy to all its employees, and make the policy available to the public. ISO 14001 also requires organizations to identify environmental impacts "aspects" (e.g., sulfur dioxide ($S0_2$) emissions) and identify goals and targets to minimize impacts. From the standpoint of public policy, the most potentially significant aspect of the ISO 14001 is the requirement for periodic, comprehensive audits of the EMS.

Certification to ISO 14001 means that an organization's EMS confirms to the specifications of a standard, as verified by an audit process. In the United States, the electronics industry (SIC 36) leads all other industries in the number of firms who have used third parties to register their EMSs to ISO 14001. A number of experts say the increase may indicate that companies are beginning to see the value of third party registration of their EMSs. According to a recent survey, 111 U.S. firms under the Standard Industrial Classification 3600 (Electronic and Other Electrical Equipment excluding Computers) were certified under the ISO 14001 by registrars. The industry is followed by firms in the chemical sector (SIC 2800) with 42 certificates.[7]

ISO 14001 is the only standard within the 14000 series that is intended to be auditable and to which organizations can be certified. Organizations that adopt ISO 14001 are not required to follow the guidance provided in the other ISO 14000 series standards. The 14000 series has the potential to improve environmental management in several ways.

Like Responsible Care, the 14000 series contains guidance for companies that seek to assess the relative impacts of products and services throughout their lifecycle -- from initial research and development to recycling and/or product disposal. The standard also contains an eco labeling series to help end-use consumers compare products. The 14000 series on performance evaluation helps companies to evaluate and monitor their performance over time. In sum, the standard serves as an objective measure to help firms and consumers evaluate qualitatively measures to reduce industry's environmental impacts.

It is important to note that ISO 14001 is not, nor was it intended to be, an environmental performance standard. Adoption or certification of an EMS pursuant to ISO 14001 does not constitute or guarantee compliance with legal requirements, does not create environmental performance standards or set environmental goals, and does not in any way prevent the government from taking enforcement actions where appropriate. This is not a criticism of ISO 14001, but a widely misunderstood and unfounded expectation that ISO should produce better environmental results.

**EMS Plus as Public Policy**

To date, most EMS approaches, including ISO 14000, are voluntary industry-led efforts that promote the adoption of qualitative management practices. In general, they are designed for internal use by a firm and organization, as opposed to the public or public agencies. For this reason, they often are criticized as lacking in credibility and in transparency. To make such measures prevent and reduce pollution, as well as what is known about corporate environmental performance, most observers agree that EMS must be combined with verifiable public reporting and quantitative environmental performance standards developed by a public agency.[8] As the President's Council on Sustainable Development (PCSD) found:

> Alone, environmental management systems (including properly certified ISO 14001 systems) do not necessarily ensure improved environmental protection and performance. Rather, effective EMSs can provide significant structural support for improving performance if coupled with qualitative and quantitative performance commitments and goals.[9]

Due to some confusion and concern over the use of EMSs, it is very important to distinguish between the private sector use of EMSs (that only measures a company's performance against what it says it wants to do), and the public policy use of EMSs in alternative regulatory strategies. Innovative regulatory strategies and incentives for environmental management systems that set-up criteria for demonstrating, auditing, and reporting environmental performance, and other critical information on actual environmental performance results, are sometimes referred to as being an EMS-*plus* system.

**Evaluating EMS Potential**

To evaluate whether EMSs in general and ISO in particular translate into improved performance at least one major U.S. research initiative and several federal and states voluntary pilots are underway. Section 3 provides some examples of EMS-*plus* initiatives. In terms of research, the Multi-State Working Group (MSWG) on EMSs has entered a pilot program with EPA, the Environmental Law Institute, and University of North Carolina specifically to test and measure whether EMSs outperform the status quo system of laws and regulations. The MSWG is a coalition of federal and state environmental agency officials representing respective EMS-based pilots in their states and regions. Like the Responsible Care program, the MSWG initiative is not prescriptive: it is not designed to state what environmental performance standards ought to be for various products, manufacturing processes, or industrial sectors, but instead, whether improved management practices are more effective and efficient than the status quo pollution control system. The MSWG is collecting information on the results of EMSs in six general areas:

- Environmental performance

- Environmental conditions
- Environmental compliance
- Pollution Prevention
- Costs and benefits
- Stakeholder participation

Although the MSWG effort is sure to generate much needed empirical data, it also is important to mention a few limitations of the exercise. Most notably, the study is developing data on a non-random, self-selected set of firms. Second, results are non-representative of all regulated industry because the sample size is too small to represent the population of all, regulated facilities. Nonetheless, the exercise will shed led on the policy potential of EMSs.

EPA, in its effort to experiment with alternatives to the status quo system also has developed programs to test the ability of EMSs to improve environmental performance. Project XL (eXcellence in Leadership), the Environmental Leadership Program, and StarTrack to varying extent all rely on the use of EMSs. Similarly, several states including Connecticut, Florida, Massachusetts, New Jersey, Oregon, and Wisconsin have created alternative or supplementary regulatory programs that offer various administrative incentives for participating companies. Most state and federal initiatives require a participating company to demonstrate other commitments in addition to having an EMS in place. These include a good compliance record, a robust environmental policy, some form of auditing either internally or by a third party, and a commitment to continuous improvement and better environmental results. In exchange, the government programs usually offer incentives such as:

- “one-stop shopping” (consolidated permits for greater convenience and efficiency);
- expedited processing or more flexibility for permits;
- an audit policy to allow a company time enough to identify and correct problems detected by the EMS or audit (c.f., not to be confused with state audit privilege policies that “shield” companies from liability or offer them “immunity"); and
- reduced inspections.

As the foregoing examples suggest, most existing EMS-approaches focus on compliance with existing laws and use regulatory compliance as the benchmark or measure of environmental performance rather than materials use accounting, monitoring or environmental metrics. However, such approaches fail to provide to participants more direct economic incentives to improve environmental performance.

**Elements of EMS-*Plus***

To provide participants with sufficient economic incentives to exceed status quo requirements and to insure that environmental goals will be met and exceeded, most agree that existing EMS based approaches must be *coupled* with sustainable environmental policy objectives that:[10]

- explicitly incorporate the environmental standards required by law;

- focus on improved environmental performance as well as source reduction (pollution prevention);
- specify quality data on the environmental performance of the EMS to determine the extent to which the system can help bring about actual environmental improvements;
- are developed through an open and inclusive process with bona fide stakeholders;
- maintain accountability for the performance outcomes of their ISO/EMSs through measurable objectives and targets that can be verified by third party professionals; and
- make information on the relevant environmental performance available to the public and governmental agencies.

As one major study has found, perhaps the single most important factor to improve the potential of EMSs for public policy is to develop public reporting requirements for them.[11] This observation is particularly true for ISO 14001, which currently lacks such a mechanism. Although ISO 14001 certification provides assurance to external stakeholders that the system meets the requirements of the standard, it does not provide customers, local communities, or end-use consumers with information on environmental performance levels, the subject of part two.

**II. Environmental Performance Indicators (EPIs) and Accountability**

The evolution of EMSs has coincided with the emergence of corporate efforts to report on environmental, social, and economic aspects of their operations. Like EMSs, corporate sustainability reports traditionally are tailored to the individual organization. In recent years, a number of efforts have attempted to make reports, and more importantly, what is reported to the public about a firm's environmental performance, more uniform. The following discussion reviews briefly the evolution of efforts to improve corporate environmental reporting and then concludes by identifying what multi-stakeholder efforts have identified as a core set of elements corporate reports should possess.

**European Eco-Management**

In part, the European Eco-Management and Audit Scheme (EMAS) and not ISO 14000 has driven the trend toward greater use and development of corporate reporting. Unlike ISO, EMAS requires a site-specific environmental report or statement. EMAS borrows from the model of auditing used in the financial services sector to provide third party verification of a firm's site audits and its public statement. The EMAS public environmental statement must provide information on raw material, water and energy use, pollutant emissions, waste generation, noise and other significant environmental effects.

**Financial Industry Analysis**

The financial industry is both a model for and a potential driver of efforts to improve corporate environmental reports. Indeed, publicly owned corporations typically issue corporate environmental reports annually and often in conjunction with the publication of their annual financial statements. As the foregoing discussion suggests, the concept of auditors to verify independently a company's environmental report is borrowed from requirements established in the United States by laws to protect investors administered by the U.S. Securities and Exchange Commission (SEC).[12] Under the financial industry model, a corporation's financial report is audited by an independent consulting firm, which then certifies that the information reported. The U.S. SEC furthermore requires publicly owned firms to report on environmental factors that could contribute to investment risk. Such disclosures typically are no more than a paragraph in length in a firm's annual earnings filing and typically are confined to general statements regarding potential liability and cost of legal action.

More recently, anecdotal evidence and some research as been undertaken to establish the link between corporate environmental and financial performance, but a clear, quantifiable link between has not yet been established.[13] The trend is driven in part by "socially responsible" investors and investment firms that use their position as shareholders to persuade corporations to improve environmental, labor, or human rights performance.

To date, such resolutions have been targeted heavily by firms in electronics and computer industry. In 1994, for example, some Intel Corporation shareholders adopted a resolution that said that the company "jeopardizes stockholder investments by picking environmentally risky sites for its operations."[14] The resolution persuaded Intel to change its corporate policy to share some environmental information with local communities in which the company's plants were located.

The push to link financial and economic performance also is driven by multi-stakeholder efforts to promote the adoption of environmental management systems and uniform corporate environmental performance indicators. Whether or not a company has an EMS may influence the way in which financial analysts from insurance, equity, or lending institutions value the company. Furthermore, the EMS serves as a benchmark for analysts to assess whether or not the company fulfilled its stated EMS goals and objectives. In this regard, the EMS provides an objective way in which to demonstrate that the policy and a process are in place. However, some note that the widespread adoption in the financial services sector of EMSs as a measure of financial performance will require the adoption of a standardized guide to corporate environmental reporting.[15]

**Audits and Audit Policies**

In simple terms, an audit is a process to verify that information reported, for example on a personal income tax reform, is accurate. In recent years, organizations with and without ISO-certified EMSs have adopted auditing processes to identify environmental impacts or "aspects" of their activities. In the context of ISO, firms are required to audit their EMSs. The audit consists of checking the performance of the system relative to the system's goals as well as evaluating compliance with relevant environmental legislation and regulations. More formally, ISO 14011 defines and environmental management system audit as a "systematic and documented verification process of objectively obtaining and evaluating audit evidence to determine whether an organization's EMS conforms to the EMS audit criteria, and communicating the results of this process to the client."[16]

EMS audits may not only reveal procedural deficiencies in a firm's management systems but also may uncover violations of existing regulations. To avoid the possibility that an audit report could be subpoenaed as evidence in a trial about a compliance issue, some firms hire their registrars through their legal counsel "in order to guard results under attorney-client privilege." To guard against disclosure, some companies have suggested offering "affirmative statements" signed by lawyers and executives, in lieu of data or documents, stating that appropriate procedures are in place. If bodies that govern ISO allow registrars to continue basing registrations on affirmative statements, it would essentially be replacing third-party certification with self-certification for a central piece of the EMS.

Although public agencies have not yet adopted policies that address how to address cases in which nonconformance or noncompliance information is discovered through the course of an EMS audit, it is somewhat instructive to examine audit policies that public agencies have developed in the context of pollution prevention.

To date, EPA and the Department of Justice have looked favorably upon self-audits on the assumption that the process promotes environmental improvements.[17] In contrast, nearly 30 states in recent years have passed audit privilege laws, which shield audit information from disclosure to the public or to regulatory agencies. Such laws also provide firms with immunity from finals or penalties during an audit. However, such laws potentially impede the public policy potential of EMSs.

The EPA's audit policy exempts from fines those violations that are promptly reported and corrected upon discovery unless the violations are of a repeated nature, produced economic gain, or harmed human health and the environment.[18] EPA's existing audit policy may be adapted to address EMSs should public agencies adopt EMS-*plus* regulatory strategies.

**Third-Party Certification**

Under ISO 14001, "certification" means that the organization's EMS meets the specifications of the standard, as verified by an audit process. The audit may be conducted by personnel within the firm or by independent third parties. Beyond ISO, third-party certification of the company's conformance with an EMS potentially serves several functions: First, the use of third parties may improve confidence among the public and among regulators in the accuracy of information reported by firms. Second, in the context of ISO 14001, a firm simply may find more objective value in using a third party, as opposed to performing the function strictly in house. Third, the use of independent third parties may allow the reporting firm to shield data deemed confidential from the public, regulators, and potential competitors, provided that third parties audit and certify reports. Finally, by shifting the oversight function from public agencies to independent agents, the administrative cost of reporting, monitoring and verification ostensibly is borne by the private sector instead of public agencies.

In terms of public environmental policy, regulatory agencies use third parties to verify or to insure the credibility of information reported by a firm or by an organization. The use of independent agents represents an expenditure that is in addition to the costs of permitting, inspection, and fees under the status quo system. As a result regulators use third parties typically in proportion to the priority of the environmental goal, or target. The priority of the goal or target determines how accurate the information reported by corporations or organizations must be. In cases where companies voluntary make pollution reductions beyond those required by federal standards, the information reported typically is not verified. However, in cases where harm to human health or to the environment may result from reporting error (e.g., $S0_2$, carbon dioxide), agencies require more accurate reporting, monitoring, and verification measures. For example, most U.S. federal programs to voluntarily encourage greenhouse gas emissions rely on self-audits and not third party verification. However, Congressional proposals that would give monetary credits for greenhouse gas reductions made in anticipation of future regulation require third parties to verify reductions.[19]

Verification methods may range from government or third party inspection of industry reports such as billing data to on-site inspections. All U.S. public programs that use third parties, industry bears the cost of verification. However, the Danish government subsidizes the cost of third party verification of greenhouse gas emissions. [20]

Under an EMS-*plus* approach, public agencies could offer incentives for firms to bear the cost of verification, such as reduced or consolidated permitting and inspections requirements in exchange for an annual audit certified by an independent third party.

Offering some flexibility in exchange for the use of third parties addresses costs borne by private firms to pay verifiers. However, lingering questions that are being addressed under EMS public pilots in the United States include who verifies the verifier? And what government standards, policies and protocols are necessary to approve audits and auditors? In both cases, EPA and states have looked to accreditation measures used by in the insurance, medical licensing, and financial services industries as models.[21]

**Environmental Performance Indicators**

Audits and third party certification can serve to improve public and regulatory confidence that an organization is meeting goals set forth in an EMS. However, the audit and verification process alone are inadequate to illustrate environmental performance. Corporate environmental reports currently provide some environmental performance information and help firms to gauge progress internally. But the reporting and monitoring methods, as well as what is monitored vary by company and thus make it impossible for regulators or for the public to compare how one firm or industry performs relative to another.

Recently, a number of multi-stakeholder groups have attempted to develop a uniform set of environmental performance indicators. The efforts include: Public Reporting Under EMAS; the CERES Global Reporting Initiative; the WRI Corporate Sustainability Metrics Project; the World Business Council's Eco-Efficiency Metrics and Reporting Project; Environmental Defense's Scorecard; and the Common Sense Initiative's (CSI) “CURE” pilot (Combined Uniform Report for the Environment) (**Table 2.3**).

**Table 2.3 Corporate Environmental Performance Indictors (EPIs)**

| EPI | Implementing Organization | Goal |
|---|---|---|
| European Eco-Management and Audit Scheme (EMAS) Public Reporting | European Commission | To require participating firms to measure and report on raw material, water and energy use, pollutant emissions, waste generation, noise. |
| Corporate Sustainability Metrics Project | World Resources Institute | To develop metrics for business and the financial community that measure, reward, and spur sustainable business practices. |
| Eco-efficiency Metrics and Reporting Project | World Business Council for Sustainable Development | To define a standardized set of metrics for Eco efficiency for use by member companies. |
| Global Reporting Initiative | Coalition for Environmentally Responsible Economies | To make environmental performance reporting as routine and credible as financial reporting in terms of comparability, accountability, and generally accepted practices. |
| Scorecard | Environmental Defense | To combine data from the Toxics Release Inventory (TRI) with information on capacity to benchmark industrial facilities by pollutant emissions and waste generation. |
| Combined, Uniform Report for the Environment | EPA Common Sense Initiative, Electronics and Computer Sector | To consolidate information currently collected under air, water, waste and toxics laws for the electronics and computer industry and to assess what information the public needs to know. |

Source: Ditz, D. and J. Ranganathan. 1998. "Global Developments on Environmental Performance Indicators." Corporate Environmental Strategy. 5(3): 47-52.

In general, these groups agree that environmental measures should include a set of four environmental performance indicators (EPIs): materials use, energy consumption, non-product output, and pollutant releases (**Table 2.4**). Absent such uniform indicators, governments, communities and companies have no coherent way to track corporate environmental performance.

**Table 2.4 Specific EPIs**

| |
|---|
| Materials Use |
| Energy Consumption |
| Non-Product Output |
| Pollutant Releases |

Although there is agreement on the types of indicators that should be used, there is no unanimous agreement on a universal protocol for measuring sustainable environmental performance globally, although more than one initiative is underway. The Global Reporting Initiative (GRI), for instance, is one such attempt to find agreement among businesses, environmental groups, accounting firms, and others on guidelines for standardized environmental management and sustainability reporting.

GRI has adopted the following hierarchy for organizing and presenting information in sustainability reports:[22]

- Category--i.e., general class or grouping of issues of concern to stakeholders (e.g., air, energy, labor practices, local economic impacts).
- Aspect--i.e., specific issue about which information is to be reported (e.g., smog precursors, greenhouse gas emissions, energy consumed by source, energy efficiency, child labor practices).
- Indicator--i.e., the most precise (and usually quantitative) measured of performance during a reporting period (e.g., metric tons of emissions, joules used from a specific energy source, water consumption per unit of output.

GRI's hierarchy is consistent with the approach adopted by both ISO 14000 and the World Business Council for Sustainable Development (WBCSD). Unfortunately, like the ISO 14000 reporting series, the GRI uniform corporate environmental reporting effort does not necessarily translate into a comparable format for measuring or demonstrating actual environmental performance results or goals.

GRI, which recently has received significant support from the United Nations, furnishes a process and some substantive analysis needed for further developing a global framework for environmental management and reporting, but does not embrace or advance the concept of measurable performance improvement. There is enough parallel agreement or overlap between any number of ongoing efforts to identify a core set of indicators or metrics, however, there is as yet no organized attempt to create or establish environmental performance goals other than legal compliance.

**Setting Goals, Getting Results**

Although most major U.S. IT firms have an EMS, there is no standard way to translate the current system of U.S. laws, regulations, and policies into performance indicators that are being contemplated by various multi-stakeholder groups. In other words, in the United States "top down" national indicators of environmental quality fail to correspond to "bottom up" or firm level performance indicators. To make a public policy system based on EMSs meaningful, the state and federal environmental protection agencies need to identify how much pollution the current system actually prevents or controls and from these results determine how to set performance-based standards to reduce environmental emissions, releases and impacts.

Making EMSs measure environmental performance quantitatively will require the EPA, states, and organizations interested in improving corporate performance and accountability to convert standards under the current system of laws into quantitative environmental goals. One way in which such an ambitious undertaking could be accomplished is through the development of quantitative emissions reduction targets for industrial sectors, akin to the Dutch model of National Environmental Goals. The Dutch have established a set of national environmental goals that cover climate change, ozone depletion, acidification, eutrophication, dispersion of toxic substance, and solid waste disposal.

In the United States, Congress has created only one such performance-based set of goals. Title IV of the Clean Air Act sets as its primary goal the reduction of annual sulfur dioxide (S02) emissions from electric utilities by 10 million tons below 1980 levels. The EPA grants participants flexibility to meet the target in any way they chose -- fuel switching, prevention, control technology -- as long as the emissions reduction goal is being met. Under the S02 model, utilities use continuous emissions monitors to track emissions of S02, nitrogen oxide (NOx), and carbon dioxide (CO2).

In contrast, the Netherlands reformed its individual air, water, waste, and toxics laws into a uniform set of environmental goals. Under the Dutch system, "bottom up" facility and firm-level EPIs are matched with "top down" indicators to track national progress towards meeting goals. EPA patterned its voluntary 33/50 program after the Dutch model. EPA designed 33/50 to promote pollution prevention by creating performance goals and encouraging a voluntary reduction of emissions of seventeen toxic chemicals by fifty percent. Concluded in 1995, firms exceeded the goal a year in advance.

The 33/50 program targeted for reduction 17 of the most high-volume toxic chemicals in production. A performance-based program that targets the IT sector similarly could seek to reduce or phase out lingering toxics such as arsine or gallium arsenide (which contain arsenic) or certain types of hazardous air pollutants.

Alternatively, the goal could be to attain 100 percent recycling rates in waste water from semiconductor manufacturing facilities or 100 percent recycling of post-consumer electronic equipment.

**Incentives for Continuous Improvement**

**Proportional Flexibility**

Under the status quo environmental laws, and even under a performance based target or emissions cap, regulated entities only have the incentive to attain the goal or regulatory standard. For the most part, there exist no incentives under the current system or under a goal based approach to exceed the target or regulatory standard.

A more forward looking set of policies would provide incentives for regulated entities to continually reduce emissions, effluents, and pollution loadings. The electronics and computer sector participants in EPA's Common Sense Initiative (CSI) – including industry, NGOs, and regulators -- developed and agreed to provide regulated entities with relief from some regulatory requirements, for example permitting, in exchange for demonstrated continuous environmental improvement. Other examples of relief include relief from standards that dictate what type of abatement technology to use. Such incentives operate by offering potential reductions in abatement cost and/or administrative cost to firms. Presumably such relief would offset the increased private abatement cost to firms of greater abatement or prevention necessary to continually reduce emissions.

Under CSI, a national voluntary experiment to create "cleaner, cheaper, smarter" environmental laws and policies, companies such as Intel and IBM created and jointly adopted a statement that called for the development of an environmental management system (EMS) approach. The EMS approach would set performance objectives and stress continuous environmental improvement. Most central to the vision statement was the concept of "proportionality." In other words, firms that seek substantial regulatory flexibility must demonstrate equally substantial improvements in environmental, health, and safety performances beyond what current regulatory standards require (**Appendix C**).

**Proportional Monitoring and Reporting**

By extension, the type and degree of disclosure required by the public and/or regulators or firms should be proportional to the degree of flexibility offered to firms. For example, programs that promise to provide firms with public recognition for voluntary reductions of substances which are not yet regulated should impose less stringent (and by extension less costly) reporting requirements than programs that promise to provide substantial private benefits by providing firms with relief from regulatory requirements. Because they do not dictate what types of abatement technology firms should use, performance-based approaches save firms money by reducing abatement and/or administrative cost associated with status quo regulations. However, performance based approaches require a greater degree of assurance than the status quo to assure the public and regulators that environmental goals are being met.

Consider the Title IV program under the Clean Air Act. Title IV is performance based in the sense that it allows electric utilities to choose the most efficient abatement or prevention method. In exchange for this flexibility, Title IV requires sources to monitor and report emissions continuously, in real time. Continuous, real time emissions monitoring is the most accurate – and most costly – form of monitoring in existence. Ostensibly, costs to electric utilities of such monitoring devices are outweighed by the benefits of flexibility and gains from the trade of emissions permits.

To date, firms in the computer and electronics industry have resisted using continuous emissions monitors on the grounds that the technology is costly and may introduce contaminants into the manufacturing process. Historically, IT firms also have resisted the use of such monitoring methods on the grounds that valuable production information or trade secrets would be revealed. In cases where firms stand to benefit privately from substantial relief from existing regulatory requirements, public policy should improve the most stringent monitoring and reporting requrements.

**Benchmarks and Baselines**

As the current state of corporate reporting illustrates, disparate monitoring, reporting and verification procedures make it difficult, if not impossible, to compare how an organization performs relative to other firms in the industry or how one industry compares to another. If the status quo is supplemented by performance-based approaches that goals for continuous improvement, it is necessary to develop a yardstick to measure the performance of firms relative to each other and relative to an initial yardstick or baseline.

Benchmarks are a tool for firms to assess performance relative to each other. Benchmarks rely on uniform monitoring, reporting, and verification procedures and protocols. With regard to the semiconductor industry, firms would need to develop common measurement techniques and methods to adjust emissions by unit of output. Such an industry-wide benchmark would make it possible to compare how firms perform relative to each other and how industries perform. Data collected and verified by third parties or public regulatory agencies would then be in a format to allow meaningful comparison.

Baselines, in turn, establish a base case or scenario from which environmental performance over time can be measured. Typically, baselines adjust or normalize emissions per some unit of output to help insure that gains are due to changes in emissions and not simply to changes in production levels. In the semiconductor industry, for example, a baseline may include emissions per square inch of silcon per year.

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## Section 3. From Pilots to Programs: Learning from Voluntary Approaches to Improve Corporate Environmental Performance

### Introduction

This section examines the extent to which federal voluntary efforts to improve the environmental performance of corporations may successfully be developed and applied to information technology (IT) firms in California. Before turning to this question, this section provides an overview of new voluntary proposals underway at the U.S. Environmental Protection Agency and in the U.S. Congress and reviews some of the more prominent federal voluntary pilots, including the 33/50 program, the Common Sense Initiative (CSI), Project XL, and StarTrack. As EPA, Congress, and states such as California continue to contemplate how to design a system of incentives based on the use of EMS, what lessons may be drawn from the time, effort, and experience of voluntary initiatives such as EPA's Project XL and StarTrack? Moreover, how might these lessons provide a blueprint for the design of a computer and electronics industry initiative in California?

### The Emergence of Voluntary Programs

As the experience of Silicon Valley illustrates, the existing federal system of pollution control laws has helped to reduce emissions and ambient concentrations of pollutants by assigning costs to activities (i.e., midnight dumping, smokestacks, etc.) previously free.[1] Today, air pollution in Silicon Valley stems more from mobile sources such as vehicles than from stationary sources such as semiconductor plants. Moreover, the system's legal, administrative, and technical requirements have improved the capacity of some companies, states, tribes, and localities to better manage pollution. However, many are beginning to agree that the current system is increasingly inadequate for the future and that the rate of return on environmental protection is diminishing.[2]

During the late 1980s and throughout the 1990s the U.S. Environmental Protection Agency (EPA) developed and implemented 33 non-regulatory experiments designed to complement, integrate, or reinvent the pollution control system.[3] Such efforts appear increasingly popular in the regulated community. According to EPA estimates, the number of participants in the agency's voluntary initiatives is projected to grow from roughly 400 in 1991 to 13,055 by the year 2000.[4]

### Performance Track

Based on the Agency's experience with voluntary programs to date, EPA is now actively designing a new voluntary "performance track" initiative. In contrast to ongoing voluntary initiatives, the performance track would provide reduced compliance requirements or other forms of regulatory relief to participants with a strong Environmental Management System (EMS) in place. Like ongoing voluntary initiatives, EPA's performance track would operate in tandem with current air, water, waste, and toxic laws that comprise the pollution control system. To guide in its design, EPA is looking at existing EMS pilots in EPA's New England region and states such as Oregon, New Jersey and efforts being contemplated by California EPA in Silicon Valley.[5]

**EMS and Performance Tracks**

In general, the regional and state efforts leverage the development of EMS-based approaches such as ISO 14001 to encourage the adoption of environmental stewardship practices. Although compliance-focused in nature, the initiatives are designed to provide alternative options to the existing regulatory system, which while controlling serious pollution does little to encourage or reward environmental stewardship and pollution prevention. Some, such as Oregon's Green Permits Program also are intended to address environmental issues that cannot be adequately addressed by solely regulatory means.

If successful, EPA may soon adopt a two-tiered "performance track" program that would create incentives to give operators with good compliance records and robust EMSs the flexibility to do more to improve environmental results. The first tier would operate much the way programs such as EPA New England's StarTrack or New Jersey's Silver Track do by offering incentives such as flexible permitting or reduced discretionary inspections, but through a more streamlined nationwide process. The second tier is likely to offer greater flexibility in the use of abatement technology and/or permitting in exchange for greater public accountability and superior environmental performance.

**Case Study 1: StarTrack**

It is very likely that EPA's first nationwide EMS-*plus* program will be modeled, in part, after EPA Region 1's (New England) third-party certification program called "StarTrack." Under StarTrack firms voluntarily agree to a program of audits in return for certain benefits, which include recognition, technical assistance, enforcement discretion. At a later time, EPA also may offer firms reduced inspection, reporting, reduced fines for violations, and expedited permitting. StarTrack participants agree to conduct an audit of compliance with regulatory requirements and a review of progress in implementing an environmental management system, which they agree to use. Participants may use either in-house personnel from different divisions or facilities, or hire an outside firm to conduct audits. A third party must certify the findings of those audits. Once certification is provided, the firm receives regulatory flexibility for a three-year period.

In addition to benefits that are conferred to the regulated entity privately, public benefits that may accrue from such a program include reduced outlays for inspection and increased frequency and scope of activities to monitor firms' environmental performance. The initiative also requires participants to report on environmental performance, which would provide additional data on unregulated concerns. The process of publishing these reports, and the firm's commitment to verifying performance, may induce firms to improve across a broader front.

If audits reveal deficiencies in compliance, the firms in question are given 90 days to rectify them, with no enforcement action during that time (save in certain egregious cases). Deficiencies must be disclosed to relevant regulatory agencies. However, decisions have yet to be made on what level of auditing information will be released to interested members of the public.

**Legislative Performance Proposals**

At this writing, the U.S. Congress also is active again in a bipartisan effort to understand and support a more modern approach to environmental management and has created draft legislation to serve as a progressive platform for discussion.[6] These efforts are underscored by the publication of a new Aspen Institute report that endorses the development and use of performance-based approaches that, if implemented, would move the environmental management framework further toward a system based on actual performance and environmental results.[7] Both proposals mirror EPA's performance track effort.

**EPA Voluntary Approaches**

The 33/50 program, the Common Sense Initiative (CSI), Project XL, and Green Lights arguably are EPA's most prominent voluntary programs (**Appendix D**). EPA's first major voluntary program, 33/50, was designed to promote pollution prevention by creating performance goals and encouraging a voluntary reduction of emissions of seventeen toxic chemicals by fifty percent. Concluded in 1995, firms exceeded the goal a year in advance.

In contrast to 33/50, the Common Sense Initiative and Project XL use multi-stakeholder negotiation to forge agreements that give participants flexibility to select the most cost-effective abatement methods, provided that they reduce as much if not more than pollution control laws require. CSI and Project XL are relevant to the California experience because both focus heavily on ways in which to improve efficiency, effectiveness, and transferability of methods to improve environmental performance in the computer and electronics industry. More recently, EPA launched an initiative with the semiconductor industry to reduce the use of perfluorocompounds or (PFCs) that contribute to global warming. At their third meeting in Fuiggi, Italy in April 1999, the World Semiconductor Council (WSC) agreed to reduce PFC emissions by at least 10 percent below 1995 levels by 2010. Although it appears promising, EPA's semiconductor PFC initiative remains too new to assess with any degree of confidence.

**From Pilots to Programs**

The results of EPA's experiments vary, depending in part on the institutional affiliation and perspective of the evaluator or observer. One of the most important lessons, with respect to the IT sector, is that most existing voluntary initiatives are inadequate because they require EPA and states to know even more about the firm's processes than the pollution control system.[8]

- Information asymmetries:

Two of EPA's most prominent voluntary initiatives, Project XL and the Common Sense Initiative, collapsed because non-governmental organizations maintained that they possessed inadequate information to evaluate the effectiveness and efficiency of company proposals. Under the pollution control system, it simply is necessary for regulators to know whether or not the technology is in place. Voluntary programs that negotiate goals and targets require regulators and the public to know as much about the firm's processes as the firm, in order to bargain effectively and to insure that reported reductions are real.

In the context of the semiconductor industry, where products and processes change constantly, it is unlikely regulators or the public (or even the industry, for that matter) ever will muster sufficient resources and time to fully understand the impacts to humans and to the environment. One reason is that it would require considerable time and effort for laypersons to gain such expertise. Another is that most semiconductor companies jealously guard production data as trade secrets.

That extant voluntary programs are inadequate poses a policy conundrum because as discussed in Sections 1 through 3, the pollution control system is increasingly inadequate to target IT firms as well. The experience of ongoing voluntary initiatives underscores the need for an approach that utilizes neutral third parties to verify that management systems are in place and that reported information is accurate.

- Make It Legal:

It is difficult for EPA, and by extension, state agencies, to implement successful voluntary programs in the context of the pollution control system.[9] Congress and the courts require EPA to focus its attention and resources on meeting legal and technical requirements and judicially imposed deadlines stemming from rules established decades ago.[10] Ultimately, legislation will be necessary to allow EPA and/or states to administer a performance-based system and to avoid administrative costs to participants of operating in both a performance-based and pollution control system.

- Tailor the System:

The goal of maximizing participation or providing recognition to those willing and able to participate in EPA voluntary initiatives is worthy objectives. To do this EPA will need to develop and refine selection criteria for performance-based approaches. In the case of current initiatives, participants tend to be those familiar or active in ongoing EPA efforts with the resources to participate in new initiatives. For example, about sixty percent of all firms participating in 33/50 were characterized as being large companies with high quantities of both 33/50 and total TRI chemical emissions. These participants were more likely to possess the resources to invest in pollution reduction activities.

Under the Common Sense Initiative (CSI), EPA recruited industries active in other ongoing regulatory experiments. Similarly, a number of Project XL participants were solicited due to their involvement in ongoing EPA projects, and in general, EPA's current initiatives appear slightly skewed towards large companies. Of the seven industrial facility participants in Project XL, four employ more than 500 workers. Yet, two of the six CSI sectors– printing and metal finishing–represent sectors comprised of firms that employ less than twenty people. It is clear that participants in voluntary programs represent firms most willing and able to participate--noteworthy objectives. What remains unclear in all of the forgoing examples is how well participants in current initiatives perform relative to other facilities, industries, and industrial sectors. The challenge of all voluntary programs is to attract not merely the top corporate, but participants with the potential to achieve better environmental performance.

- Refine Performance Measures:

The most important lesson demonstrated by Project XL is that voluntary approaches require more robust methods to measure environmental performance. Disagreement regarding how to identify and measure performance increased the time and money required to approve and to implement facility-specific XL agreements. In the case of the most publicized XL effort at an Intel Corporation facility, bitter disputes centered on the question of what constitutes the most appropriate base case or baseline from which to measure environmental performance.

**Case Study 2: Baselines, reporting, and monitoring**

The centerpiece of Intel's XL effort was an air permit that allowed the company to consolidate release and reporting requirements for hazardous air pollutant emissions as long as the emissions did not exceed a single limit or cap. The cap was set well below what federal law requires but there is little scientific evidence on the effects of hazardous air pollutants on human health or the environment. Determining what a participant in a voluntary program would have done in the absence of the program is a difficult, if not analytically impossible task. In the case of Intel, some national environmental groups wanted the facility to reduce more pollution than existing permits. EPA, Intel and XL stakeholders were satisfied with Intel's pledge to reduce more pollution than federal laws require.[11]

Whereas industry XL participants assumed that the initiative would reward past and current practices, many environmental groups assumed the initiative was designed to encourage firms to reduce more pollution than required under the status quo system. Furthermore, many environmental groups sought greater assurance from Intel that the firm would not release spikes or exotic combinations of hazardous pollutants. To insure that goals were being met, some groups lobbied for the use of continuous emissions monitors, which monitor and report emissions continuously and in real time. EPA did not require Intel to use such measures on the grounds that the company pledged to reduce emissions more than federal law required.

- Improve Coordination:

Contrary to intuition, the time and money spent to negotiate facility-specific agreements was not so much a function of environmental group resistance, but due to the lack of coordination, according to the results of a recent survey.[1213] In the context of Project XL, industry and EPA survey respondents cited lack of coordination among EPA program offices as a central source of administrative cost. While the survey did not attempt to isolate where the lack of coordination occurred, qualitative evidence suggests it falls around several axes: among program offices, between the Office of Reinvention[14] and the program offices, and among EPA's voluntary initiatives (see sidebar). This point is particularly relevant in the context of California, where the state is currently contemplating the development of a performance-based EMS approach that targets Silicon Valley.

**Case Study 3: Improving Coordination: Lessons from Intel's Project XL**

The best example of coordination involves the Intel Project XL effort. By most accounts, Intel and stakeholders in the company's Project XL effort spent more time and money to negotiate a final project agreement because outside individuals and groups who were not official stakeholders attempted to stall the project.[15] Less-known is the that most of those who objected to Intel's effort--including Intel--were participants in EPA's Common Sense Initiative.[16] Participants in the CSI electronics and computer sector pilot resented that EPA failed to coordinate the two initiatives and that the agency did not invite CSI participants to contribute directly to Project XL. Moreover, different EPA offices managed the two programs with a sense of dominion that confounded early attempts by EPA staff and the stakeholders to combine purposes and work together.

In theory, Project XL and CSI had the potential to be complementary. EPA missed in CSI an opportunity to develop precisely the types of data necessary to assess Intel's environmental performance relative to other semiconductor manufacturers and to use the consensus-based methods in CSI to develop performance measures for Intel under Project XL that ultimately could have been satisfactory to all parties. Finally, CSI could have provided a way for EPA and Intel to popularize and transfer Intel's facility-based experiment under Project XL to other Intel facilities and to other companies in the semiconductor industry under a proposed "Facility-based Alternative System of Environmental Protection" that achieved consensus at the subcommittee level, but failed to be acted upon by the CSI council (Appendix C).[17]

**Case Study 4: Tie EPA Initiatives to External EMS Efforts**

Lucent Technologies is the leading US maker of telecommunications equipment and software.[i] Lucent also designs, manufactures, and sells integrated circuits, electronic power systems and optoelectronics components for communications applications. Lucent Technologies developed with EPA and with states an XL project that is tied to ongoing efforts in the private sector to recognize and continuously improve upon Environmental Management Systems (EMS).

The pilot is designed to determine to what extent it may be appropriate to use EMS as a basis or flexibility from permitting or other regulatory requirements. Like StarTrack, the Lucent case provides another roadmap for EPA and others who are contemplating the development of an EMS-based performance approach.

Prior to the development of its XL Project, Lucent Technologies implemented the ISO 14001 standard for environmental management systems (EMS) at its microelectronics facilities. ISO 14001 establishes environmental management practice standards. In 1995, Lucent proposed to use EMS as a framework for developing specific proposals to simplify permitting, record keeping, and reporting requirements as part of Project XL. Lucent's XL Final Project Agreement was approved in August 1998.

Lucent's XL agreement is unique from other XL projects in that it does not address any specific regulations. Instead, Lucent's proposal discusses permitting, permit modification, compliance monitoring, and record keeping requirements under Title V of the Clean Air Act, the Clean Water Act, Resource Conservation Act (RCRA), and the Toxic Substances Control Act (TSCA). Lucent's Project XL plan seeks to develop specific proposals for regulatory flexibility at certain microelectronics manufacturing facilities. The first proposed test site for the EMS is Lucent's Allentown, Pennsylvania facility. Lucent would like to use this proposal as a "test bed" to determine the broad applicability of ISO 14001 as a standard to determine regulatory flexibility and enhanced environmental performance. If successful, the Allentown experiment would help to establish an EMS for the entire microelectronics unit of Lucent Technologies.

- Keep It Simple:

According to one study, the fixed costs to industry and to EPA regional offices of putting in place XL agreements were substantial, averaging over $450,000 per firm.[18] The determining factor for cost was the scope and content of the project proposal. In particular, costs were high for firms that submitted relatively complex proposals involving either multiple emissions caps on air pollutants or multiple facilities. In contrast, the administrative costs to companies of participating in the 33/50 program were close to zero: EPA simply asked participants to sign and return a pledge that they would attempt to

[i] Hoover's Online. 1998. Hoover's Company Capsules. Available at http://www.hoovers.com/capsules/10116.html.

voluntarily reduce seventeen chemicals listed on the TRI. When EPA tried to initiate a follow-up to the program with additional reporting and auditing requirements, industry declined to participate.

- Apply Lessons Learned:

Several studies note that EPA and other agencies and organizations must continue to build on their capacity to learn from voluntary initiatives.[19] As the foregoing examples suggest, there is now sufficient experience at the federal, state, and corporate level to design and implement the next generation of voluntary approaches. The challenge of a California based effort is to build on the design of these pilots and to apply the lessons learned that could be implemented across or throughout EPA, regions, and states.

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[1] By "pollution control system" we refer to the set of nine major U.S. environmental laws administered by the U.S. Environmental Protection Agency. For a complete definition, please see Davies, J.C. and J. Mazurek. 1998. Pollution Control in the United States: Evaluating the System. Resources for the Future: Washington, D.C. pp. 2-5.

[2] President's Council on Sustainable Development. 1999. Chapter 3, Environmental Management, *Towards A Sustainable America*, pp. 113-119 (Appendix B-3: K. Hausker, "The Convergence of Ideas on Improving the Environmental Protection System," Washington, DC: Center for Strategic and International Studies).

[3] Mazurek, J. 1999. The Use of Voluntary Agreements in the United States: An Initial Survey. Organization for Economic Co-operation and Development (OECD). ENV/EPOC/GEEI (98) 27/FINAL. OECD: Paris, France.

[4] U.S. Environmental Protection Agency. 1998. Partners for the Environment: Collective Statement of Success. Office of Reinvention. Washington DC: EPA.

[5] Meyer, G.E. 2000. "Move Away From Command and Control." Environmental Management Report. Forum. January: 12-13.

[6] 106th Congress. 1999. "Second Generation of Environmental Improvement Act of 1999" [H.R.3448.IH]. See also, Knopman, D.S. and E. Fleschner. 1999. Second Generation of Environmental Stewardship: Improve Environmental Results and Broaden Civic Engagement, Washington, DC: Progressive Policy Institute.

[7] Aspen Institute Series on the Environment in the 21st Century. 2000. *A Call to Action to Build A Performance-Based Environmental Management System*. Washington, D.C., Aspen Institute.

[8] Boyd, J., A. Krupnick and J. Mazurek. 1998. Intel's XL Permit: A Framework for Evaluation. Discussion Paper 98-11. Washington, D.C.: Resources for the Future.

[9] Davies, J.C., J. Mazurek, N. Darnall, and K. McCarthy. 1996. *Industry Incentives for Environmental Improvement: Evaluation of U.S. Federal Initiatives*. Washington, D.C.: Global Environmental Management Initiative; National Academy of Public Administration (NAPA). 1995. Setting Priorities, Getting Results: A New Direction for EPA. Washington, D.C.: NAPA; National Academy of Public Administration (NAPA). 1997. Resolving the Paradox of Environmental Protection. Washington, D.C.: NAPA; U.S. General Accounting Office (GAO). 1997. Environmental Protection: Challenges Facing EPA's Efforts to Reinvent Environmental Regulation. GAO/RCED-97-155. Washington, D.C.: U.S. GAO.

[10] National Academy of Public Administration (NAPA). 1995. Setting Priorities, Getting Results: A New Direction for EPA. Washington, D.C.: NAPA.

[11] Boyd, J., A. Krupnick and J. Mazurek. 1998. Intel's XL Permit: A Framework for Evaluation. Discussion Paper 98-11. Washington, D.C.: Resources for the Future.

[12] U.S. General Accounting Office (GAO). 1997. Environmental Protection: Challenges Facing EPA's Efforts to Reinvent Environmental Regulation. GAO/RCED-97-155. Washington, D.C.: U.S. GAO.

[13] Blackman, A. and J. Mazurek. 1999. The Cost of Developing Site-Specific Environmental Agreements: Evidence from EPA's Project XL. Discussion Paper 99-35. Washington D.C.: Resources for the Future.

[14] EPA's Office of Reinvention in 1999 was merged into EPA's Office of Policy.

[15] National Academy of Public Administration (NAPA). 1997. Resolving the Paradox of Environmental Protection. Washington, D.C.: NAPA.

[16] Mazurek, J. 1999. Making Microchips: Policy, Globalization, and Economic Restructuring in the Semiconductor Industry. MIT Press: Cambridge.
[17] "A Facility-based Alternative System of Environmental Protection (ASEP)" was drafted by in a working group and submitted to the CSI Subcommittee for the Computers and Electronics Sector, November 1, 1996.
[18] Blackman, A. and J. Mazurek. 1999. The Cost of Developing Site-Specific Environmental Regulations: Evidence from EPA's Project XL. Discussion Paper 99-35. Washington D.C.: Resources for the Future.
[19] National Academy of Public Administration (NAPA). 1997. Resolving the Paradox of Environmental Protection. Washington, D.C.: NAPA; U.S. General Accounting Office (GAO). 1997. Environmental Protection: Challenges Facing EPA's Efforts to Reinvent Environmental Regulation. GAO/RCED-97-155. Washington, D.C.: U.S. GAO.

## Section 4: From Pilots to Programs

### Introduction

Given U.S. efforts to promote corporate accountability and corporate environmental performance, this section outlines briefly some specific policy responses to environmental issues identified in Section 1 (**Tables 1.2 and 4.1**). This section then describes more generally what institutional steps are necessary to improve corporate environmental performance and accountability.

As Sections 1-3 make clear, relocation of manufacturing operations out of Silicon Valley make it difficult to develop an exclusively California-based approach. However, it is clear that that the status quo system and existing voluntary efforts to target the IT sector are inadequate. Growing anecdotal evidence suggests that a two-tier system of environmental performance has emerged in the IT sector, in terms of environmental standards and performance. The system is likely a function of firm size and the type of product manufactured. Preliminary studies suggest that large firms (defined in terms of revenue and number of employees) possess the resources to be more "proactive" on environmental issues than small and medium sized firms. Moreover, rapid innovators, or firms that derive monopoly rents from moving products first to market have a strong incentive to reduce or remove uncertainties associated with environmental regulation. For example, Intel Corporation, which can lose millions of dollars in revenue each day due to manufacturing delays, has a strong incentive to reduce potential delays associated with regulation, such as permitting.

EMS-*plus* approaches coupled with ongoing efforts to devise a common set of indicators appears to be one promising method to help the top tier semiconductor firms to further improve environmental performance and reporting. EMS-*plus* approaches as well as a pending pilot by the Silicon Valley Manufacturing Group illustrate that California can serve as a place in which to pioneer more innovative, performance-based approaches to the status quo pollution control system, which continues to focus largely on pollution from industrial sources. *The challenge is to devise incentives such as EMS-based approaches that target top performers, as well as firms that require improvement.*

A related challenge is to insure that policy experiments are credible and transparent to the public. In addition to serving as a testing grounds for regulatory innovation, Silicon Valley's past and present environmental challenges also can serve to advise and refine the institutional capacity of public and private institutions in regions where the sector now concentrates manufacturing. Efforts underway in Silicon Valley today to understand and address environmental problems associated with the IT sector should serve as a blueprint for environmental policy in regions that have attracted or seek to attract IT firms.

**Table 4.1 Most prominent issues**

| |
|---|
| Solid and hazardous waste |
| Greenhouse gas emissions and energy use |
| Water use |
| Livability concerns |
| Supply-chain management |

**Solid and Hazardous Waste**

Efforts to promote electronics product take back in the United States in the near future are extremely unlikely due both to industry's opposition and the reluctance in the U.S. Congress to consider new environmental laws. Indeed, vehement industry opposition makes it is unclear whether the proposed EU WEEE directive will be adopted even in Europe. In the United States, what appears more probable is that electronic product recycling will remain voluntary and within the province of states, rather than the federal government.

Historically, federal laws in the United States have not addressed solid waste but left the responsibility for its management to states and municipalities. Federal hazardous waste law does address electronics waste from business, but not consumers. However, Massachusetts recently passed a law that requires municipalities to collect and recycle consumer electronics, thus paving the way for other states, and perhaps eventually the federal government, to follow suit. But requiring states and localities to recycling products is a far cry from requiring manufacturers to take back machines once their useful life has ended.

- Examine pricing policies

Experiences with pilot electronics recycling efforts to date have found price to be among the chief barriers to electronics recycling. The prospects for promoting the expansion of salvaged material markets are dim because secondary material prices for computer scrap are very low. For example, a typical 386 personal computer has a resale value of about $10-$20 and a component value of $5. Four megabytes of used memory are worth about $1. The value of metal inside computers is about 50 cents.

In the next five to ten years, the accelerating rate of new personal computer introductions is likely to cause prices for personal computer scrap materials to drop even further. In the short term, practical policy responses must target ways in which to prop up low prices and expand demand for used electronic equipment scrap materials.

- Consider dematerialization implications

Solid and hazardous waste issues associated with consumer electronics will remain a formidable problem for the next five to ten years. After that, the advent of nanotechnologies suggests that the trajectory of IT hardware will be towards smaller, less materials-intensive products. The transition towards less-materials intensive products will cause a glut of obsolete current-generation appliances in the short, term, but obviously will reduce solid and hazardous waste impacts over the longer term. For example, silicon semiconductors of today will likely be replaced by nanotechnologies that perform a semiconductor’s current function but much more efficiently and effectively at the molecular level. The advent of molecular semiconductors will make it unnecessary to etch transistors onto silicon. Moreover, it will make current manufacturing methods and products obsolete. Devices such as miniature screens that can be worn on the wrist, or inside eyeglasses will in all likelihood replace today's personal computer.

It remains unclear what the hazardous and toxics waste issues associated with such policies ultimately will be. However, several observers warn that the move toward nanotechnologies will herald in new threats that greatly overshadow current environmental issues associated with semiconductor manufacturing. According to cofounder and chief scientist of Sun Microsystems, Bill Joy, breakthroughs in the manufacturing of molecular semiconductors will permit the construction of computer a million times more powerful than those built today. Joy, in an article for *Wired* magazine, warns, "As this enormous computing power is combined with the manipulative advances of the physical sciences and the new, deep understandings in genetics, enormous transformative power is being unleashed." In other words, it will become possible to create machines far more intelligent than humans will, this implications of which are beyond the scope of this analysis.

**Greenhouse Gas Emissions and Energy Use**

- Continue to use voluntary measures and explore the use of EMS-*plus*

Until the U.S. Senate ratifies the Kyoto Protocol or similar treaty that would make GHG emissions reductions mandatory it will be necessary to harness voluntary approaches. In terms of PFC emissions from semiconductor firms, the industry has pledged to voluntary reduce emissions at least 10 percent below 1995 levels by 2010. However, if the United States is to effectively reduce emissions of global warming gases from manufacturing, voluntary measures alone are likely to be insufficient. It is likely that a worldwide regulatory system that harnesses GHG emissions trading eventually will be adopted. But pollutant-trading schemes are hard to design and to implement in industries where products and processes are heterogeneous. In the interim, most agree that a domestic regulatory system must be developed and implemented. EMS-plus approaches, which stress continual reductions in energy use and direct release of GHG emissions may be, supplement trading systems and voluntary initiatives.

- Harness IT to reduce indirect impacts

If preliminary studies that show the IT sector is promoting energy efficiency are supported by further research, then the appropriate policy response is to identify where such gains are occurring and devise direct or indirect incentives to accelerate the process. It may be that IT gains in terms of energy efficiency also have the potential to address other concerns, such as long transit time or consumption or natural resource degradation associated with development. For example, at least one study has found that the Internet appears to be promoting greater use of home offices, allowing telecommuters to spend less time at the office and also spawning many purely home-based businesses.

The Internet provides home-based workers with access to information and increasingly high-speed connections to coworkers and/or customers. And as electronic commerce itself grows, both business-to-consumer and business-to-business, more jobs will involve spending more time on the Internet, jobs that can perhaps be done as easily from home as from traditional workplaces. This shift will increase energy consumption in homes, but will likely save far greater energy in avoided office-building construction and utility bills, as well as reduced commuting energy. Co-benefits obviously include less time spent commuting, less money spent on automobile fuel and maintenance, fewer emissions of conventional air pollutants that contribute to smog, and a reduced need to consume land for office construction. In this regard, policies to mitigate climate impacts also may indirectly address "livability" concerns.

**Water use and wastewater discharge**

- Focus on prevention and recycling

The semiconductor industry has made good progress on methods to recycle water, as the Intel case in Section 1 shows. However, some environmental organizations prefer that the industry pursue methods to reduce the need for water by changing how firms manufacture semiconductors. As water increasingly becomes scarce in some regions, recycling alone may be inadequate. It is likely that industry will need to examine methods to reduce the amount of water necessary for production. States and localities where semiconductor manufacturers are concentrated should sponsor voluntary efforts to text the feasibility of production methods, most notably the rinse process to develop more effective, efficient water use practices.

- Examine location policies

Even more pressing than the issue of recycling versus prevention is the question of why water-intensive industries seek to operate in regions where water is relatively scarce. According to Intel, the company sought to build one of its newer plants in New Mexico because the state, unlike California, did not levy costly taxes on manufacturing equipment. For Intel, the cost savings on this element alone amounted to $70 million. If true, then it is obvious that the source of the problem is beyond the scope of conventional environmental laws and regulations.

One alternative response that has proven somewhat effective is through the use of shareholder resolutions. Some socially responsible investors have used the threat of a shareholder resolution and stock sell off to call Intel's decisions on where to build new plants into question. One way in which to improve the effectiveness of such methods would be for socially responsible investors and investment groups to require firm's to report on whether they use environmental criteria such as water availability when firms assess where to build new facilities.

- Improve institutional knowledge

It is likely that methods also are necessary to illustrate to state and local economic development officials the industry's enormous water requirements. California-based non-government organizations such as the Silicon Valley Toxics Coalition provide outreach and assistance to individuals and groups in other regions. In the United States, however, there exists no similar clearinghouse for public agencies. Public university extension programs, which in California provide outreach to agriculture and some industry as part of their land grant charter, are possible way in which to improve the institutional capacity of both within and outside the state to serve this function.

**Livability**

- Promote the development and use of environmental indicators

The Silicon Valley Environmental Partnership (SVEP) in 1999 released a multi-stakeholder report that contained indicators of environmental conditions in Silicon Valley. As discussed in Section 1, the indicators reveal that livability concerns surrounding transportation, water, and energy use and species and habitat loss are among the central concerns in the region today. The purpose of the indicators report was to increase the understanding of environmental issues among community leaders and decision-makers, residents, and workers in Silicon Valley and to promote more fact-based environmental decision-making. The report is an illuminating and instructive illustration of how other communities and regions that either support IT manufacturing or seek to attract IT manufacturers can begin to identify and address environmental issues related to the sector.

- Use indicators to help develop EMS-*plus* approaches

The Silicon Valley environmental indicators report shows that using conventional regulation will not solve many of the Valley's most pressing environmental problems. This is not to suggest that federal laws are ineffective. Indeed, it may be argued that they have been so effective that the most pressing problems remaining are those that fall outside their direct purview and require more innovative approaches, such as market-based trading measures or voluntary approaches. Environmental indicators coupled with environmental data collected by trade associations or other third parties should serve as a foundation for voluntary approaches. Voluntary pollution control and prevention efforts Silicon Valley have been advanced by organizations such as the Silicon Valley Manufacturing Group. The data can be used not only to target environment challenges but also to develop innovative strategies that reward environmental performance that exceeds current regulatory requirements.

- Apply IT technologies to improve livability

In the same way that IT can help to improve the accuracy and timeliness of environmental monitoring and reporting, it may also hold the potential to better address "livability" problems associated with long commutes, development, and automobile use. That employees in Silicon Valley IT firms must commute to work, rather than telecommute from home or from workstation facilities closer to their homes is perhaps one of the greatest ironies associated with the region's current economic boom. In the United States, an estimated 20 million employees, about 9 percent of the workforce, now work from home. In a recent study by Rutgers University, 41 percent of workers surveyed said they believe they could perform part of their work as telecommuters and would like to do so. Despite legitimate business concerns about occupational liability and worker dependability, telecommuting may offer increasingly crucial options to employers (e.g., reaching a diffuse workforce); employees (e.g., childcare and time); and significant environmental and economic benefits as we de-couple the need for driving from work.

**Suppliers and Location**

EMS-*plus* approaches are a promising method in which to compel suppliers to improve environmental practices. EMS-*plus* approaches must be coupled with a public policy approach that rewards continuous reductions in pollution and transparent public reporting. The supplier issue raises two immediate and one more remote set of potential policy responses. Section 1 of this report shows that a growing body of circumstantial evidence, ranging from worker anecdotes to federal job-safety data, suggests semiconductor manufacture may be dangerous and damaging work, especially in older plants built in the early 1970s.

- Identify potentially poor performers

To begin to promote greater accountability among firms that operate older and potentially more risky equipment and processes, it first is necessary to identify what firms are using vintage and/or recycled equipment. The degree to which environmental problems have been transferred to places outside Silicon Valley is likely to depend in part on the following factors: firm size, measured in terms of revenue, employees; environmental sophistication, measured in terms of environmental performance reports; the age of manufacturing equipment that the company uses; and the sophistication and capacity of government and non-governmental organizations in these regions to manage potential risks to humans and to the environment.

It is unlikely that data that identify manufacturing facilities by age of capital equipment are in the public domain, but it a number of private, trade associations *do* sell data on manufacturing facilities. Some data include information on total output, type and nature of products produced, facility location, capital vintage, and contact information. From such information, it would be necessary to identify facilities that use equipment more than 20 years old and then from these data secure any environmental information supplied by the host country government, if available.

Combined, these data could serve two potential functions: 1) to focus public and regulatory attention on firms that are potentially more likely to use equipment associated with risks to humans and to the environment; and/or 2) to provide a potential mechanism for a sectoral voluntary agreement in which firms and third party semiconductor manufacturers, possibly through trade associations, to develop benchmarks against which to gauge and to improve their environmental performance

- Provide incentives to speed rate of capital retirement

As in the case of water, the capital retirement issue illustrates that source of the environmental problem may lie beyond the reach of current environmental laws and regulations. For years, semiconductor manufacturers have appealed to Congress to change the tax code to would them more rapidly depreciate the cost of IT manufacturing equipment and thus retire it more quickly. While such policies would reduce the amount of old capital equipment used by some firms, it also will increase the supply of capital equipment, perhaps accelerating its export abroad. Any domestic capital retirement policy would need to be accompanied by programs to transfer newer technologies abroad. The Clean Development Mechanism, which provides credit to countries and/or firms that develop overseas technologies or programs to reduce greenhouse gas emissions could serve as a potential model for the IT industry. U.S. firms that buy and retire, rather than sell, older capital equipment would receive a tax credit.

- Provide suppliers with technical assistance to improve practices

On the supplier side, voluntary initiatives in the host country could be developed to help illustrative the direct economic benefits of environmental performance, in terms of securing production contracts from U.S. firms. Such voluntary programs could be akin to the EPA's "Green Lights" program, which simply provides technical assistance to help participants install more energy efficient lighting and experience positive returns on the investment over time (**Appendix D**).

- Require international TRI reports

More direct regulatory measures would be to require U.S. companies to report toxic releases and transfers offsite to the EPA's Toxics Release Inventory (TRI). Reporting also could be broadened to require firms to report on the emissions of third party suppliers, or at least to identify whom these suppliers are and whether suppliers have been screened for environmental performance.

- Promote the adoption of supplier EMSs

Given the likely shortage of environmental data on old suppliers in some countries and the unlikelihood of direct government intervention to more rapidly retire older capital stock in the IT sector and transfer technology to potential competitors overseas, the adoption of voluntary unilateral standards such as ISO could offer at least some form of assurance that a set of minimum environmental management practice measures are in place.

Automobile manufacturers in the United States including Ford and General Motors require their suppliers to obtain ISO 14001 certification. A California based effort to improve accountability of suppliers could borrow from the big three model to require suppliers of IT equipment, such as semiconductors, to adopt a certified EMS. Although the EMS will not in the near term provide greater assurance that pollution goals are being met, it may at least provide some level of assurance that certified suppliers adhere to a minimum set of management practice standards.

**Moving toward a performance-based system**

As Sections 2 and 3 illustrate, certification programs that attest to a company's conformity with its stated EMS and environmental policies exist and are in use. However, much must be done before such programs are able to improve the environmental performance or all firms and assure government agencies and the public that certification programs translate into less pollution.

- Develop voluntary sectoral benchmarking approaches.

A chief drawback of existing voluntary and EMS-based approaches it that they target typically only top corporate performers. A process must be created to identify firms that require improvement and incentives to reduce more pollution. The development of such systems requires a way for companies to know how they performance relative to other firms in a sector. Benchmarking requires that manufacturers report environmental, health, and safety data to a third party, be it an independent consulting firm, auditor, or trade association. Such systems are well suited to the IT industry, where firms closely guard product and process information. If confidentiality concerns are an issue to reporting firms, a third party could screen the data in such as a way to shield sensitive information, and, if necessary, the identity of the reporting companies.

To make the data useful to reporting companies, the third party would need to compile and present the data in such a way as to provide a statistical ranking or score of performance relative to other companies. The score could be reported to the public to rank companies and apply pressure to firms who need to improve performance. Alternatively, the data could be used by industries internally.

Although the IT industry has jealously guarded production and emissions data, examples of using third parties to collect, compile, "scrub," and report potentially sensitive IT industry data exist. Perhaps the most notable example is the U.S. EPA's semiconductor PFC partnership.

The semiconductor industry currently emits a number of potent greenhouse gases from its manufacturing process including fluorocarbons ($CF_4$, $C_2F_6$, $C_3F_8$, $C_4F_8$, $CHF_3$), nitrogen trifluoride ($NF_3$) and sulfur hexafluoride ($SF_6$). These gases, which collectively are referred to as perfluorocompounds or (PFCs) are used in two important processes -- plasma etching thin films and cleaning chemical vapor deposition (CVD) tool chambers and are critical to current manufacturing methods. Under this voluntary initiative, 23 major semiconductor manufacturers report data to a third party (a law firm) under a confidentiality agreement.

Under the agreement, the 23 firms report to the law firm, which them collects the data, strips sensitive information and company identity from the data and then provides reports on each firm to the EPA. Insuring the accuracy of the data is crucial because it likely will be used by firms in the future to calculate a baseline from which their allocations under a regulatory greenhouse gas emissions trading are based. Inaccurate data would both jeopardize the environmental integrity of a future regulatory system and provide a windfall to firms that overstate the amount of their emissions reductions to buy, trade, and sell emissions permits.

EPA then aggregates annual emissions reduction information and reports on these data annually to the public. EPA also audits the data annually through a third party, usually an industry expert. The audit consists of reviewing reports, raw data, calculations and assumptions by the firms, whose identity is concealed, to insure that the reports are free or accidental error or deliberate under reporting. If the auditor finds accidental or deliberate errors, she reports her findings to EPA and to the law firm, which then reports the problem back to the reporting company. To date, auditors report no systemic, egregious reporting problems and firms report no accidental releases of sensitive trade secrets under the PFC program.

- Use independent, third parties

As the above case suggests, the use of third parties to collect, audit, and report pollution data is one potential method to deal with sensitive production information. The use of third parties, whether law firms, auditors, or trade associations also may be one way in which to help top tier firms transfer environmental management practices to firms that need to improve performance. In this way a neutral agent assumes the responsibility and bears the administrative burden for both verifying that information reported is accurate as well as any transfer of information that is required. Moreover, the third party could shield the identity of the top performers to safeguard trade data. Such an effort currently is underway through the Responsible Care program, administered by the Chemical Manufacturers Association (CMA). CMA currently encourages top performers to assist firms that require improvement, but the trade association does not act as a third-party information broker. The Responsible Care program may serve as a potential model to transfer best environmental management practices from top to lower tier firms in the IT sector.

- Make flexibility proportional to performance

The electronics and computer sector participants in EPA's Common Sense Initiative (CSI) developed and agreed upon a vision statement, which remains viable and could apply to a California effort to promote global corporate accountability. Under CSI, companies such as Intel and IBM adopted the statement as well as non-governmental organizations such as the Silicon Valley Toxics Coalition. The statement called for the development of an environmental management system (EMS) approach that sets performance objectives and stresses continuous improvement. Most central to the vision statement is the concept of proportionality: firms that seek substantial regulatory flexibility must demonstrate equally substantial improvements in environmental, health, and safety performances beyond what current regulatory standards require (**Appendix C**).

- Make monitoring and reporting (disclosure) proportional to performance

In cases where firms stand to benefit privately by receiving significant relief from existing regulatory requirements, the public and/or regulators should impose stringent monitoring and reporting. In cases where the private economic benefits to the firm are intangible, for example, voluntary programs to reduce unregulated substances, less stringent, less costly monitoring and reporting requirements would in most cases be sufficient. This observation suggests the development of a continuum of reporting requirements, where the accuracy and amount of data required of reporting companies is proportional to the degree of flexibility granted. Under such a system, firms that trade C02 under a mandatory greenhouse gas emissions trading system would likely be required to report emissions continuously, in real time, whereas firms that voluntarily reduce C02 in advance of a regulatory system simply could estimate emissions, subject to internal fact checking or third party audits.

When applied to the IT sector, the continuum would suggest that a firm which receives flexibility to trade hazardous air pollutants as long as aggregate emissions remain under a limit or cap would be required to monitor emissions continuously, whereas participants who voluntarily reduce PFC emissions in the absence of a regulatory system to reduce greenhouse gas emissions would be granted confidentiality and be required to estimate emissions based on engineering estimates that are subject to independent, third-party audits.

- Incentives for environmental leaders to do even better

The California Environmental Protection Agency, in cooperation with SVMG and other stakeholders is contemplating the design of a pilot effort that would use the data collected under the indicators report and similar efforts to create a voluntary initiative that rewards environmental performance. The "Partnership for a Sustainable Silicon Valley" would measure, report on and recognize progress towards, and accomplishment of, the targeted improvements.

The Partnership would harness an environmental management system (EMS) approach for the region as a method of developing a policy and long-term goals. Such a pilot could reward top performers by providing reduced compliance requirements or other forms of regulatory relief to participants with "proportional" environmental improvements. Like ongoing performance-track initiatives at the federal level, the Silicon Valley Partnership would operate in tandem with current air, water, waste, and toxic laws that comprise the pollution control system.

The Partnership could harness benchmarking techniques to help firms identify, compare, and transfer best practices from top performers to firms in need or improvement, or small and medium size companies that may lack resources comparable to those of top tier firms to operate sophisticated environmental, health, and safety programs.

- Improve transparency

To promote credibility and transparency, an EMS-*plus* strategy must require multiple stakeholders to agree on a core set of environmental reporting indicators and right-to-know information, and recognize that not all audit information is in the public interest. Allowing some period of time for companies to detect and correct sub-standard environmental performance, and compliance failures, is necessary for the compliance auditing policies to work as an incentive for companies to audit ongoing environmental management performance.

- Set goals and establish priorities

Although most major U.S. IT firms have an EMS, there is no standard way to translate the current system of U.S. laws, regulations, and policies into performance indicators that are being contemplated by various multi-stakeholder groups. In other words, in the United States "top down" national indicators of environmental quality fail to correspond to "bottom up" or firm level performance indicators. To make a public policy system based on EMSs meaningful, the state and federal environmental protection agencies need to identify how much pollution the current system actually prevents or controls and from these results determine how to set performance-based standards to reduce environmental emissions, releases and impacts.

Making EMSs measure environmental performance quantitatively will require the EPA, states, and organizations interested in improve corporate performance and accountability to convert standards under the current system of laws into quantitative environmental goals. One way in which such an ambitious undertaking could be accomplished is through the development of quantitative emissions reduction targets for industrial sectors.

Under a goal-based, rather than standard-driven system, environmental regulators could harness the existing private system of third party certification to review, attest and verify companies' actual environmental results (much the same way that financial auditors are able to assess and document conformity with generally accepted accounting practices). Although many of the major firms have eschewed this potential service due to liability, others are stepping forward.

If the United States would move towards a goal based approach, it is likely that policy makers would make the amount of information that organizations must report and verify commensurate to the importance or priority of the goal. Priorities could be risk-based or they could reflect what the public cares about most. Under a risk-based system, for example, reporting and verification requirements for high priority problems such as known carcinogens or the release of greenhouse gases could be higher than for problems were voluntary approaches alone are deemed as appropriate (e.g., water recycling, solid waste recycling).

- Build on existing voluntary approaches

In the interim, EPA and states are using EMS-based initiatives to help firms and industry sectors collect and report quantitative environmental performance data. As mentioned, many voluntary EPA initiatives are designed to help companies monitor, report, and verify greenhouse gas emissions. Such initiatives can be expanded to include data on goals, accurate compliance information, public reporting and involvement, and additional reporting elements on emissions, energy and material flows and water use. Combined with better knowledge about industrial sectors, and what kind of information is needed to track environmental performance (e.g., metrics or indicators), agencies would be able to enter into an entirely new level of oversight and public accountability. Moreover, such an oversight system would be more directly related to meeting environmental goals and far more transparent than the piecemeal methods employed by the current's systems to collect and report information and to insure compliance.

- Improve Information Management

As the current state of corporate reporting illustrates, disparate monitoring, reporting and verification procedures make it difficult, if not impossible, to compare how an organization performs relative to other firms in the industry or how one industry compares to another. A system for managing and protecting human health and the environment, whether it is a performance-focused system utilizing EMSs or the traditional regulatory system, performance baselines (i.e., benchmarks) need to be established for facilities, firms and sectors. Benchmarks rely on uniform monitoring, reporting, and verification procedures and protocols. With regard to the semiconductor industry, firms would need to develop common measurement techniques and methods to adjust emissions by unit of output. Such an industry-wide benchmark would make it possible to compare how firms perform relative to each other and how industries perform. Data collected and verified by third parties or public regulatory agencies would then be in a format to allow meaningful comparison.

Under the pollution control system, information is reported by environmental medium (e.g., air, water, or land). Most data are based on engineering estimates or educated guesses. To make an EMS-based system truly effective, it is necessary to establish public agency information collection or retrieval systems that combine information across environmental media. The information furthermore should perform multiple jobs including:

- Provide environmental performance indicators and benchmarks (e.g., energy efficiency and use, water use, discharge, releases, toxics use, resource productivity, etc.)
- Report information on various levels (facility, firm, sector...);
- Collect information that satisfies regulatory requirements but also shows environmental performance information (e.g., indicators) and results;
- Monitor, calculate and track ambient environmental conditions; Toxics Release Inventory (TRI) data for communities (i.e., accountability); and improvement or progress (this information is useful to the government, financial community, and the public).

EPA in cooperation with several states and the University of North Carolina are constructing such an EMS-based reporting system. In order to make such a system effective, it is obvious that federal and state regulatory agency require a set of common environmental performance, management, and compliance metrics in order to implement performance-focused use of EMSs.

- Harness IT technology to improve environmental information

For years, environmental managers at all levels of government have envisioned moving towards a more comprehensive system where meters are placed on pollution sources to continuously measure emissions. To some degree, the same forces that drive globalization and restructuring -- that is, enable a company in Silicon Valley to communicate rapidly designs and transmit manufacturing protocols to production teams in Ireland and Israel -- make it possible to envision environmental management methods that function with reasonable administrative cost and greater public assurance that goals are being met. For example, EPA's sulfur dioxide (S02) emissions trading program harnesses information technology to minimize reporting burden while maximizing public and private confidence in the accuracy of environmental reports.

The S02 trading program is the first air program to rely exclusively on emissions for determining compliance as opposed to relying on traditional pollution control approaches. Under the S02 program, affected sources (i.e., electric utilities) continuously monitor their emissions of sulfur dioxide, nitrogen oxide, carbon dioxide, heat input, and flow. Companies then transmit their reports directly to an EPA mainframe, which analyzes the data. Beginning in 1999, EPA began posting final, quality assured quarterly emissions data on the Acid Rain Web site. It is likely that similar market-based systems will be adopted eventually in the United States and abroad to address GHG emissions from climate change. As long as GHG emissions remain unregulated, however, agencies only require those who make voluntary reductions to use engineering estimates or best guesses to monitor emissions reductions. If Congress does eventually chose to regulate GHGs through a trading system, a monitoring method that provides the highest degree of assurance that goals are being met will be necessary to insure proper function of a GHG trading system.

Continuous monitoring could have been used to provide assurance to the public and to regulators under Intel's Project XL effort. In that instance, the firm received the ability to, in effect, "trade" hazardous air pollutants internally at the facility, as long as the total level of emissions remained under a cap. Firms in the semiconductor industry have resisted the idea of putting materials meters on individual tools for fear that such gauges might introduce contamination and divulge trade secrets. As the Intel Project XL effort illustrates, however, the use of continuous monitoring technology may be necessary in cases where scientific evidence on the effects to humans and to the environment remains highly uncertain.

**Summary and Conclusion**

The U.S. pollution control system is designed to improve environmental quality by enforcing compliance with a complex array of technology forcing and control-based management programs. The control-based approach acts as a proxy for measuring and reporting actual environmental performance results. For instance, compliance with requirements imposed at the time of a permit or a rule create a stationary baseline and a range of possible emission levels (e.g., from actual to allowable) devised to meet national air quality standards. The current system's operational definition of environmental protection, however, does not generate as much information about the condition of the environment as it does about technical and legal compliance. The result is that the current system illustrates environmental performance at one point in time, but not in a real-time, continuous manner.

The need to move toward a performance-focused environmental management system is primarily an information management and performance-measuring challenge. All polluting entities, public and private, will need to adopt improved information and monitoring systems to demonstrate actual environmental conditions and performance levels. The state and federal environmental protection agencies need to demonstrate the actual environmental value of current regulatory practices, and then determine how to set performance-based standards to reduce environmental emissions, releases and impacts. To do this, it is necessary to translate the environmental goals of the statutory and regulatory requirements into environmental performance standards that then may be continuously improved. Consequently, agencies and organizations must begin to identify a threshold or baseline level of environmental performance and then use science to extrapolate and to set new environmental goals and standards set. This recommendation is particularly apt for industries that are highly dependent on chemicals such as IT hardware producers who use high volumes of hundreds of toxic substances are in use but where processes and chemical inventories constantly change.

As the case of the semiconductor industry shows, under the status quo system, most chemicals in use are ‘legal’ because only six have been banned under federal law. Furthermore, little or nothing is known about the effects of most chemicals in production on humans and the natural environment. Until the U.S. adopts sectoral toxic-use-reduction goals and employs performance-based environmental management systems in tandem with laws, regulations and other policy instruments, efforts to make environmental progress in chemical intensive industries such as the IT sector will continue to rely on paper trails, time consuming, and labor intensive environmental campaigns and research, and forever fall behind changes in the industry and the global economy.