Designing for the Environment Turns Intel Fabs Green

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Overview: Environmental Commitment the Norm at Intel

Compute power, cooler systems, fat pipes for bandwidth—when users think of new technologies coming out, they don't necessarily first think of the environment. Not to worry: Intel is doing that for you.

Intel is known for integrating a variety of technology performance goals into each platform. What is less well known is that Intel also integrates environmental performance goals into both the platform and the way platform components are manufactured. Along with Moore’s Law, this is one of the legacies that Intel co-founder Gordon Moore has left behind. Over the years, Moore has not only made environmental conservation one of the key focus areas of the Gordon and Betty Moore foundation, but also established management practices that encouraged pro-environmental practices at Intel for product design, manufacturing, and facilities.

Moore’s commitment to the environment has become both a fundamental part of Intel culture and an important performance ideal for all aspects of Intel’s business. Moore’s legacy continues today and has been embraced and driven by Intel’s current chairman, Craig Barrett. ”At Intel we pursue EHS (environmental, health and safety) performance the same way we pursue performance in the marketplace,” said Barrett. “We have worked to become global leaders in EHS. This commitment is integrated throughout the corporation from our leaders to every employee.” Intel encourages every employee to apply the same level of brain power to solving the environmental challenges of design and production as they do to solving the problems of new technology itself.

Designing for Environmental Protection

Manufacturing facilities face obvious environmental challenges: energy efficiency, water recycling, air quality, materials recycling, etc. Today, as materials science is pushed to its physical boundaries, the environmental challenges for fabricating this cutting-edge technology grow more complicated. The key question for progress is how does a manufacturer push those technological boundaries without causing environmental problems?

Every year, Intel spends enormous resources on research and development, and very large sums of capital to turn innovation into real-world components. For Intel's environmental, health and safety engineers, the goal is to build environmental health and safety attributes into this design and development process to ensure a number of goals. First, new technologies should not create environmental or safety problems. Second, engineers work to make sure good design up front prevents the high end-costs of dealing with environmental issues that are examined after the capital has been laid out. Third, by addressing any potential environmental issues of each new generation of technology *before* the manufacturing processes are put in place, EHS engineers help drive the continual improvement and evolution of environmental health and safety performance.

Because Intel recognizes the benefits of that work, Intel’s EHS engineers are closely integrated into all design and development processes. For example, they help drive the design and innovation of new products that have better environmental performance, such as lead-free products or products that use less energy. They also participate in building design, help establish environmental budgets for buildings and technology production, and calculate environmental performance levels for tools and processes. They then set performance goals that allow expansion within environmental budget levels, prevent environmental problems, and drive environmental excellence.

Intel’s EHS engineers also deal with public concerns that are not just regulated issues. For example, water use in New Mexico is a major public concern. Understanding and accepting the concerns of the public, Intel has spent millions in water conservation measures and continues to push the envelope in developing new water-saving technologies.

Another example is global warming. Although there is scientific consensus about this phenomena there are no regulations affecting U.S.-based operations. Years ago, Intel anticipated this trend and took action. Intel engineers drove a first-of-its-kind worldwide agreement to voluntarily reduce chemicals with high global warming potential throughout the global semiconductor industry.

Once again, Intel is fulfilling this agreement by employing the design-for-the-environment (DFE) process. Intel’s engineers found appropriate substitutes for extremely high global-warming gases, and in so doing did the right thing for the environment long before government regulations required it. This example shows that Intel’s engineers must be both technically competent and able to understand and develop consensus for environmental goals, improve processes, and balance expectations with reasonable actual outcomes.

Building for the Environment

One point about the DFE process is very clear: The best time to consider environmental issues is up front, during the design phase. For new fabs (fabrication, or manufacturing buildings), this is when it is still relatively easy and inexpensive to make changes in the design of the buildings and facilities.

For example, traditional fab facilities use cooling towers to cool the building. Water used to cool the buildings is sprayed in a cooling tower, and air is blown on the water to cause cooling by evaporation. The cooled water is then recirculated through the building cooling system and the cooling towers again. All the heat that is removed from the building goes into evaporating water and it cannot be reused.

Intel's latest fabrication facility at Ronler Acres (in Hillsboro, Oregon), includes heat-recovery chillers instead. The chillers are heat pumps that reduce the need for cooling towers by recovering some of the heat for reuse. Water resource requirements are reduced because water is not lost through evaporation. Air pollution is reduced because the fab does not need to run boilers as frequently to heat water for manufacturing and facilities use. Since the process is more energy efficient, overall energy requirements for the facility go down.

Facilities also include separate drains to help with the separation and recycling of various materials, and include an extensive water recycling system. For new facilities, one environmental performance goal is to recycle 100 percent of the ultrapure water (UPW) that is used to manufacture silicon wafers for reuse as the primary source of the industrial water needed for the wafer fab.

Intel also applies DFE processes to general facilities management. For example, low-water landscaping reduces water needs, while contractor incentives promote the recycling of materials used during building construction.

Setting Attainable Goals

One of the biggest challenges in setting an environmental performance goal is to encourage people to accomplish the goal by changing a process. When a goal is too ambitious (or regulations too stringent), people tend to give up on innovating the design up front. They assume there is no way they could possibly meet the goal, so a waste-treatment process must be the only reasonable answer. Unfortunately, waste treatment is usually the most complicated answer, the process most likely to fail, and it is likely to be the most costly approach to achieving environmental goals.

What Intel leaders prefer is for developers to look for ways to change design and fabrication processes up front to accomplish the goals. For example, the recommended hierarchy of approaches to environmental performance begins with substitution of a less harmful material (or process) for the material in question. When the substitution occurs in the design phase, there is no manufacturing process to fail, a negligible cost in resources, and almost no capital outlay to offset.

The optimum time to engage is during process development (**Figure 1**). When technologists do not anticipate the potentially harmful effects of a material before the corporation invests in development of new manufacturing processes, the costs of making the change late in development or during high volume manufacturing can be extremely high. The only feasible solution at that point is likely to be a waste-processing facility for manufacturing byproducts—a high-cost alternative that could have potentially been avoided or reduced if changes had been made up front.

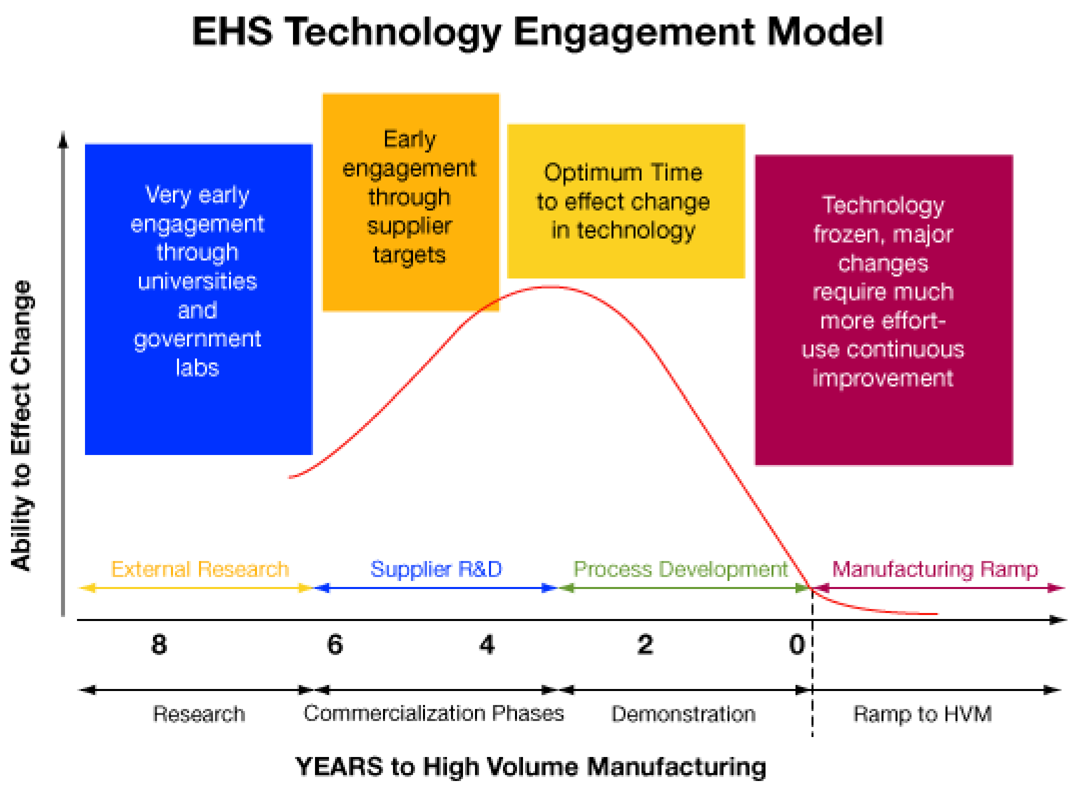

Figure 1. *The optimum time to engage in design-for-the-environment.*

Very early engagement can be wasteful as most research ideas are not commercialized; also, early researchers need flexibility to try many alternatives that can be optimized later if successful. At the research stage it is more important for researchers to understand the general principles of environmental, health and safety concerns.

The Die Is Not Yet Cast...

A process change can be as simple as the substitution of a less-harmful substance for another material. For example, a typical issue in the semiconductor industry is finding less-volatile chemicals for manufacturing processes. Volatility indicates (among other things) the ease with which a chemical evaporates into the atmosphere.

When less of a chemical evaporates (because of a lower volatility), the chemical causes less air pollution than a more-volatile material. More of the chemical can be collected as a liquid, which can then be recycled more easily and at less cost to both business and society.

For example, most manufacturers use volatile organic compounds, or VOCs, which cause smog when emitted into the air, but which are important for wafer fabrication. During the masking process, when liquid photo resist is applied to a wafer, the wafer is spun to help the photo resist spread across the wafer's surface and form a very uniform crust on the silicon.

In the past, the photo resist at the edge of the wafer would bake, harden, crack, and form particles that broke off and became a potential problem in manufacturing. Traditionally, manufacturers used a solvent called isopropyl alcohol to clean the edge and underside of the wafer in a process called edge-bead removal. Unfortunately, isopropyl alcohol is fairly volatile and known to contribute to smog.

Today, manufacturers such as Intel use a less-volatile chemical that still effectively cleans the wafer edge. Since this chemical doesn't evaporate as easily as isopropyl alcohol, it can be more easily collected in liquid form and sent off for recycling.

20-20 Vision

One of the most important lessons Intel DFE engineers have learned is that it typically takes two to three technology generations for developers to find an elegant solution to an environmental problem caused by the technology. When developers don't start looking for solutions until after manufacturing starts (and environmental issues start becoming apparent), by the time a solution can be found the technology is already becoming obsolete.

Intel developers now get help from EHS engineers to look ahead to identify potential issues early in the design process. For example, today's developers are looking at the environmental challenges inherent in 32nm technology planned for 2009.

In some cases, EHS goal-setting is incremental, to help developers establish a process to achieve an ambitious goal. For example, the first concrete performance goal for a new silicon process might be only one-third of the final, desired outcome for that component line. The second goal, for the second generation of that silicon, might be to reach two-thirds of the final desired outcome. The third goal would be to bring the entire manufacturing process in line with the final, ambitious metric.

Good design today isn't just about having the vision to create tomorrow's technology, but having the foresight to anticipate and address its associated implications and issues. It is impossible to design out all waste-treatment systems, but good planning can help Intel avoid the high costs and complications often required by end-of-pipe problem-solving.

Summary

Intel takes environmental protection seriously, and is committed to incorporating environmental performance goals into product design, manufacturing processes, and facilities use. The bottom line is that doing the right thing for the environment means doing the right thing for business. This is both a top-down and bottom-up ideal of environmentalism at Intel and, as the company has reaffirmed again and again, it is not a solely altruistic process. There are significant benefits to maintaining a strong, pro-environment policy.

One huge benefit of this approach is that the time to market for new technology is reduced. For example, one of the benefits of designing for environmental performance is that Intel maintains a corporate status as what the U.S. Environmental Protection Agency (EPA) calls a "minor source for air emissions." For a manufacturer, this means that the process of acquiring necessary local and federal permits for new facilities and processes is less complicated, less time consuming, and less costly. The result is a corporation that can move quickly and more flexibly toward new, emerging technologies. And, communities are often more willing to have a corporate neighbor when they know that neighbor will be environmentally responsible.

Like research and development engineers, Intel's EHS engineers live in the future, looking ahead to anticipate potential risks and opportunities and avoid problems before they become costly issues. Incorporating "greenness" into the design of some of the most complicated products known to man is not just altruistic, it is plain good business.

More Info

Discover more about Intel's work on clean and green technologies at the Intel Web site:
Environmental, Health and Safety
Lead-Free Silicon Solutions
Global Citizenship Report
Corporate Governance and Social Responsibility

Author Bios

John Harland, a principal environmental engineer with the Environmental Health and Safety business unit, has been with Intel for 22 years. Initially, he was responsible for driving environmental compliance with local, federal, and international government regulations. Currently, he is responsible for integrating environmental performance goals into the design of new technology, such as Intel's breakthrough power-thermal and silicon-process technologies. Harland earned his B.S. in chemical engineering from the University of Edinburgh, UK, and was awarded an M.S. in environmental engineering, from Caltech. He has published three papers in industry journals, has received two Intel Achievement Awards, and has received the Intel Technology and Manufacturing Group Excellence Award for enabling Intel's growth and manufacturing flexibility through environmental excellence.

Tim Mohin is the director of Sustainable Development for Intel Corporation. In this newly created position, he is building a global program based on the strong foundation of environmental and social responsibility that Intel has achieved. This role includes the development of a program to anticipate trends and emerging issues and has oversight of EHS and sustainability issues concerning Intel’s supply chain. In previous roles at Intel, Mohin was director, Worldwide Employee Communications, and Corporate Environmental and EHS design manager. Before joining Intel, he was a professional staff member with the Senate Committee on Environment and Public Works and was a section chief in the EPA’s Office of Air Quality Planning and Standards. Mohin earned his B.S. from the State University of New York at Cortland and an M.S. in environmental management from Duke University.

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