The Secret Life of A Computer

The Oklahoma Department of Environmental Quality's Use Less Stuff Week's goal is to increase citizen awareness about the total environmental impact of some of the items they consume. One crucial item that we can't do without in the 21st Century is computers. Computers use electricity both in production and in usage--chips and chip packages, and circuit boards. They contain glass, copper and about 700 other materials. Many of these materials must be extracted from the earth and about half of them are hazardous, making their disposal difficult. Chemical use and pollution remain heavy in this industry. The United States owns 40% of the world's 300 million computers.

A 150-watt current brings our computer to life—enough to power two incandescent light bulbs. Computers take 5% of the electricity used in American offices. (In comparison, lighting uses 2-25%.) Complicated screen savers with moving images do not save energy. Most of the time personal computers are turned on, they are not actually being used. One-third of computers in the United States are left on all the time, including nights and weekends when they are not used. (Turning a computer off and on is actually GOOD for it.) Consequences of electricity generation depend upon the area served, but in Seattle it is would be powered by a hydroelectric dam walling off salmon habitat in the upper Columbia River.

That beige computer that stares at you 40 hours a week consists of about 55 pounds of plastic, metals, glass and silicon. The heart of it is one-fiftieth of a pound of silicon and metal formed into integrated circuits known as chips or semiconductors. The 400-step process of making the chips generates more waste than any other part of the computer.

The process begins with silica (or silicon dioxide, the basic ingredient of sand) mined in Washington. The silica is heated with carbon in an Oregon plant to form carbon monoxide and 98% pure silicon. This silicon is heated with hydrochloric acid, then with hydrogen gas, and cooled to form a "hyper-pure" silicon rod eight inches across. The crystalline rod is sliced into wafers less than a millimeter thick which are then ground and chemically polished to a mirror-like shine and trucked to the chip manufacturer in California's Silicon Valley.

The chip factory, called a wafer fab, stretched longer than two football fields and housed equipment manufactured by more than 100 companies around the world. One computer's worth of chips or "wafers" are made in "clean rooms", where only one to five particles are present in each cubic foot of air and workers wear gowns, booties and gloves to avoid contaminating the chips. Keeping these rooms particle free requires pumping the inside air thorough special filters that remove fine particles. But the filters do not remove solvent vapors, some of which are toxic, from the air the workers breathed.

Next the silicon wafer is cleaned with acid, then heated to form a protective surface layer of silicon dioxide. Workers look through microscopes using ultraviolet light, light-sensitive chemicals, chemical developers, patterned masks and some of the most precise machinery ever invented to etch a pattern of minute circuits across the wafer.

Further etching created holes in which high-energy machines planted phosphorus and boron, which would eventually carry electricity through the finished chips. Each of these steps is repeated several times, and after most of the steps, the chips were chemically or mechanically

cleaned. Producing the chips in your computer generated 89 pounds of waste—4500 times the chips' own weight!—and used 2800 gallons of water.

Paper-thin layers of Arizona copper are applied to each chip's surface, chemically etched, cleaned, then oxidized for insulation. Machines apply an even thinner layer of gold to the back of each chip. After more chemical cleaning, a ship carries the wafer to Malaysia in a box of unbleached Oregon Douglas-fir pulp with shock-absorbing insets of black polypropylene foam from Japan. The shippers will reuse the box and inserts six times before recycling them.

Chip packages are made In a factory operating around the clock in Malaysia. Workers earning about $2 an hour and Japanese robots running on coal-fired electricity cut the wafer into hundreds of individual chips and assembled into packages. Each package consists of a chip, frame, wires and plastic housing. Face-masked, gloved workers glue each chip to an etched copper frame, run tiny wires of South African gold between the frame and the chip, and a molded plastic compound around the package. Because gold is so expensive, gold miners can profitably mine ores that have less than one part per million of gold, leaving behind huge piles of mineral waste contaminated with toxic metals and the cyanide used to extract gold.

After the completed chip packages are shipped back to the United States, the computer manufacturer inserts them into printed circuit board in the disk drives, keyboard and other devices, as well as into the "motherboard," the main circuit board on which most internal components are mounted. When a Texas factory makes the circuit boards, the manufacturing process uses more chemicals, energy and water as well as generates more hazardous waste, than the making of any other part of my computer. Machines cut boards made of copper, fiberglass, and epoxy resin to size, drilling holes in them and cleaning them.

In a process not unlike making chips, the holes are plated with a thin layer of copper and the boards etched with circuit patterns. This process generates airborne particulates, acid fumes, VOC's (volatile organic compunds) and other chemical wastes. Then the boards are plated with layers of copper and tin-lead solder. The tin is imported from Brazil and the lead is recovered from dead car batteries in Houston. (Recycled lead meets 60% of U.S. demand annually.) The U.S. consumes half the world's lead, mostly for car parts. Because lead is highly toxic and hard to dispose of legally, 90% of car batteries are recycled. Yet lead waste from electronic goods is almost never recycled because it is scattered throughout the computer. Etching and cleaning left behind a pattern of copper wiring on the circuit boards. Assembling and soldering the boards also produced lead, copper, VOC's and solvent wastes.

What we spend all of our time looking at is the wide end of a cathode-ray tube (CRT), a vacuum tube made of glass with electron guns at the far end. If the CRT was made in Japan, a manufacturer there used various chemicals and ultraviolet light to etch a minute pattern of black stripes and then red, green and blue phosphors on the glass for the monitor's front panel. Every color we see on the screen is actually a combination of these three colors. The sides of the CRT are soldered to the front panel with lead oxide and heated, fusing the parts together to form a bulb. By the year 2005, about 150 million personal computers will have been sent to landfills in the U.S. They will occupy about 300 million cubic feet, equivalent to a football field stacked a mile high in computer trash

Ships, planes and trucks brings the various computer components to the California plant

where they are assembled. The finished computer is carefully boxed with polystyrene foam inserts and trucked to a suburban superstore just for you. In all, factories the manufacture of just one 55-pound computer generates 139 pounds of waste and uses 7300 gallons of water and 2300 kilowatt-hours of energy (about one-fourth the energy the computer would use over its four-year lifetime). State-of-the art factories could make the same computer with half to two-thirds less waste and different computers—with flat-panel displays (like laptops) instead of today's big vacuum tube monitors, for example—could be made with even less waste

Computers were supposed to herald paperless offices, but with multiple drafts and reprinting to correct every little error, computerization has probably increased paper—and energy—demand. For a typical computer system, it takes at least as much energy to make a year's worth of paper as it does to run the computer for that time.

About 700 different materials and chemicals go into manufacturing your computer—half of these are hazardous. Computer plant workers exposed to toxic chemicals could suffer lung diseases, skin rashes and other health problems. Electronics manufacturers have bestowed California's Silicon Valley (Santa Clara County) with large areas of contaminated groundwater and the highest concentration of Superfund hazardous waste sites in the U.S. Chemical use and pollution remain heavy in the industry, but computer manufacturers, at least in the U.S., have made progress in reducing their toxic releases. According to EPA's Toxic Release Inventory, computer manufacturers generated 10 million pounds of toxic waste in 1997, two-thirds less than they did in 1990.

A glassworks in Kobe made the glass for the front of your monitor, using mostly local sand and electricity from a power plant burning Australian coal. The glass also contained 5-0% each of strontium oxide (from Mexican ore), sodium oxide (from local salt), potassium oxide (from Russian ore), and barium oxide (from Chinese ore). A different manufacturer made the CRT's sides. Its glass contained 22 % lead oxide (to absorb x-rays generated by the CRT) from Australia and was coated with graphite made from Saudi petroleum. Because a monitor contains five different types of glass, and their compositions vary by manufacturer, the glass from old monitors is seldom recycled.

Your computer was enclosed in a shell of ABS (acrylonitrile-butadiene-styrene) plastic. It was mostly Saudi Arabian oil, refined near Los Angeles. A nearby chemical plant turned the oil, along with benzene (from Wyoming coal), ammonia (from Texas natural gas), heat, catalysts, and chemicals, into the ABS ingredients. These ingredients were mixed into small pellets and injected under heat and pressure into a mold. They fused together, taking the basic shape of your computer.

Plastic has a deservedly poor environmental reputation, but it began as an environmental good guy. In 1868, during a severe shortage of tusks, a New England manufacturer of ivory billiard balls offered a $10,000 prize to anyone who could come up with a suitable substitute for ivory. A few years later, a printer from Albany, NY won the prize with a product he called celluloid. The world's first plastic, celluloid, would later be used (and even became synonymous with) motion-picture film. Yet when a British scientist had invented the substance in 1850, he deemed it useless; he gladly sold the patent rights to the American printer.

Your computer‘s 2.5 pounds of copper began as copper sulfide ore, much of it mined from the Chilean Andes for export to Asia. By law, 10% of Chile‘s copper revenues go to the Chilean military. If the ore contained 0.9% copper (the global industry average), making your computer required excavating 280 pounds of ore and at least 300 pounds of other rock lying on top of the ore. The ore was pulverized, mixed with water and chemicals, and boiled to obtain pure copper. Boiling also produced sulfur dioxide (SO_2), which causes acid rain. Worldwide, the SO_2 emitted in copper production is equivalent to one-fourth the SO_2 emissions of all industrial nations. Even though your computer contains less copper than your car (40 pounds) or the pipes and wires in your house (even more), it is still enough to have a big impact. Mining, crushing, grinding and smelting the 2.5 pounds of copper required the energy equivalent of 73 gallons of gasoline. Mining and producing metals accounts for about 7% of global energy consumption.

What can we as citizens do to reduce the impact of our best friend, the computer? Print less often. Turn off your computer, or at least your screen, whenever you’re not using it. Choose the most power-saving settings in your computer’s setup. Look for EPA’s Energy Star logo if you buy new equipment. If you need to upgrade your computer, have new memory or circuit boards added rather than replacing the whole thing. If you need a new computer altogether, refurbish a used one or buy a laptop, before buying a new desktop. Laptop computers weigh about one-tenth as much as desktops and require about one-third the electricity.