Question 4:
What are the environmental and health impacts of CRTs?

This section presents a summary of the results for each impact category described in Question 3, for which CRTs had associated impacts. Although some LCAs assign importance ranks or weights to impact categories, this step was intentionally excluded from this study because it requires subjective choices that might not be appropriate for all stakeholders with an interest in this project. Table 4.1 identifies the process that contributes most significantly to each impact category.

Table 4.1. Summary of most significant CRT processes

Impact category	Most significant process	Associated life stage	Percent contribution to category score
Natural Resource Impacts			
renewable resource use	LPG production for glass manufacturing	manufacturing	79%
nonrenewable resource use/depletion	LPG production for glass manufacturing	manufacturing	56%
energy use	LPG production for glass manufacturing	manufacturing	72%
solid waste landfill use	coal waste from electricity generation	use	38%
hazardous waste landfill use	landfilled CRT monitor	end of life	91%
radioactive waste landfill use	low-level radioactive waste from electricity generation	use	61%
Abiotic Ecosystem Impacts			
global warming	carbon dioxide from electricity generation	use	64%
stratospheric ozone depletion	bromomethane from coal burned for electricity generation	use	49%
photochemical smog	hydrocarbons from energy generation used for LPG production for glass manufacturing	manufacturing	36%
acidification	sulfur dioxide from electricity generation	use	47%
air quality (air particulates)	particulate matter from energy generation used for LPG production for glass manufacturing	manufacturing	43%
water eutrophication (nutrient enrichment)	chemical oxygen demand from energy generation used for LPG production for glass manufacturing	manufacturing	72%
water quality: BOD	BOD from energy generation used for LPG production for glass manufacturing	manufacturing	96%
water quality: TSS	TSS from energy generation used for LPG production for glass manufacturing	manufacturing	97%
radioactivity	Plutonium released from energy generation used for steel production	upstream	62%

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Table 4.1. Summary of most significant CRT processes (continued)

Impact category	Most significant process	Associated life stage	Percent contribution to category score
Human Health and Ecotoxicity			
chronic human health effects - occupational	LPG used for glass manufacturing	manufacturing	78%
chronic human health effects - public	Sulfur dioxide from fossil fuels burned for electricity generation	use	83%
aesthetic impacts (odor)	Hydrogen sulfide from energy generation used for LPG production for glass manufacturing	manufacturing	94%
aquatic ecotoxicity	phosphorous used in CRT tube manufacturing	manufacturing	26%
terrestrial ecotoxicity	Sulfur dioxide from fossil fuels burned for electricity generation	use	83%

[a]Acronyms: liquified petroleum gas (LPG), particulate matter with diameter less than 10 micrometers (PM_{10}), biological oxygen demand (BOD), total suspended solids (TSS).

Natural Resource Impacts

Renewable resource use. Renewable resources are materials found in nature that generally are replenished through natural processes. The most significant examples are water and forest products. The CRT manufacturing life stage creates the largest impact with respect to renewable resource consumption, representing 87 percent of the total in this impact category. More specifically, the production of liquified petroleum gas (LPG), which is subsequently used as an energy source in the glass manufacturing process, contributed nearly 80 percent alone to the impact score due to the water requirements of LPG manufacturing.

Nonrenewable resource use/depletion. Nonrenewable resources are materials, such as metals or fossil fuels, that are not readily regenerated naturally. The depletion of LPG reserves for glass manufacturing creates the largest impact in the CRT life cycle. The petroleum used to make LPG contributed 56 percent of the mass of nonrenewable resources used. Much of the remaining resource use is associated with other fuels. Less than two percent by weight of the nonrenewable resources used were actually incorporated into the CRT (i.e., were processed into metals, plastics, or other materials).

Energy use. This impact category considers only energy consumed during a display's life cycle; it does not include the releases associated with energy production. (Those effects are reported under other appropriate impact categories.) Most of the energy use associated with the CRT life cycle is consumed during the glass/frit manufacturing process (72 percent on a megajoule basis). Electricity consumed during the use of CRTs represented an additional 11 percent.

Solid waste landfill use. By consuming space in a landfill, solid waste necessitates the use of open land. The largest demand for solid waste space is caused by the use life stage. Solid wastes (primarily coal wastes) are created during the generation of electricity. Interestingly, based on an end-of-life scenario assuming that 15 percent of CRTs are incinerated, 71 percent are landfilled (46 percent as hazardous waste, 25 percent as solid waste), and 14 percent are recycled or remanufactured, the end-of-life stage of the CRT has a beneficial effect on solid waste landfill

use. The solid waste avoided by recovering energy to generate electricity during CRT incineration (i.e., the solid waste that would have been generated from fossil fuel-burning electricity plants) more than offsets the volume of a CRT that is landfilled.

Hazardous waste landfill use. Hazardous waste consists of materials that are regulated under the Resource Conservation and Recovery Act. Like solid waste, this material contributes to the consumption of open land but also demands additional safety and environmental protection precautions. In contrast to the results for solid waste landfill use, the largest life stage for this impact category is the end-of-life stage. Over 90 percent of the weight disposed of in a hazardous waste landfill is attributed to the CRT itself.

Radioactive waste landfill use. Like hazardous waste, radioactive waste contributes to the consumption of open land and creates safety and environmental challenges. Nearly 80 percent of the CRT material disposed of in a radioactive waste landfill results from the electricity consumed during CRT use. This material principally is low-level radioactive waste and depleted uranium produced by nuclear power plants.

Abiotic Ecosystem Impacts

Global warming. Gases such as carbon dioxide and methane trap heat in the atmosphere. It is believed that by increasing the concentrations of these gases, humans are causing the atmosphere to become warmer and induce global climate change. Electricity consumption during the use of CRTs is the largest contributor of global warming impacts; carbon dioxide produced by power plants contributed 64 percent of the global warming potential associated with CRTs. This result should be compared with the energy use findings. Although CRT use is not the most significant life stage for energy use, electricity production generates considerably more carbon dioxide per unit of energy than LPG or other fossil fuels used directly.

Stratospheric ozone depletion. The stratospheric ozone layer blocks harmful ultraviolet (UV) sunlight from reaching the earth's surface. Chemicals such as chlorofluorocarbons (CFCs) may destroy ozone in the stratosphere, causing an increase in UV radiation on the earth's surface. The largest contributor to ozone depletion (weighted according to potency) is electricity production for CRT use. Bromomethane, an ozone depleting compound, is produced during the combustion of coal. CFCs used in the manufacture of some CRT materials are also an issue. It should be noted that the calculations for this impact category are uncertain because some secondary data for materials processing were collected prior to the phase-out of CFCs.

Photochemical smog. Photochemical smog is produced in the atmosphere by the reaction of hydrocarbons and nitrogen oxides in the presence of sunlight. Smog may cause or aggravate health problems, toxicity in plants, and deterioration of materials. The largest contributor to this impact category was the production of LPG used to manufacture glass. This process emitted chemicals that accounted for 67 percent of the photochemical smog.

Acidification. The release of acids into the air causes acid rain. Acid rain in turn harms surface water, soil, and plants. The production of electricity for the use of CRTs was the largest source of acidifying emissions. This process produced sulfur dioxide, nitrogen oxides, and hydrochloric acid to contribute 63 percent to the overall score for this category.

Air quality (particulate matter). Particulates in the air, especially those that have a diameter smaller than 10 micrometers (PM10), can cause respiratory illnesses in humans and animals. Two processes that significantly affect this impact category are LPG production for glass manufacturing, and steel production (in the materials processing life stage). It should be noted that because some of the output data did not specify the size of the particulates, some of the results for PM10 might be overestimated.

Water eutrophication (nutrient enrichment). In most surface water, the level of biological activity is limited by the concentration of nitrogen and phosphorous. When these two nutrients are released to water, fast-growing organisms such as algae outcompete established organisms such as fish. LPG production for glass manufacturing was the source of roughly 90 percent of the impacts in this category. This process released chemical oxygen demand-related chemicals and ammonia ions.

Water quality (BOD). Organic chemicals that are released to water ultimately lead to a depletion of dissolved oxygen, which in turn reduces the survival rate of organisms such as fish. One measure of this impact is biological oxygen demand (BOD). As for water eutrophication, LPG production was the source of most (96 percent) of the impacts in this category.

Water quality (TSS). In turbid (cloudy) water, only a fraction of the usual amount of sunlight penetrates the water. As a result, less sunlight reaches plants and other dependent organisms and less biological activity occurs. Total suspended solids (TSS) indicates the magnitude of this effect for a stream of wastewater. LPG production is the primary influence (97 percent) for this impact category.

Radioactivity. Radioactive materials released to the environment can cause cancer in humans and animals. Nearly all of the radioactivity releases are associated with materials processing, particularly steel, invar, and ferrite. Specifically, the impacts result from reprocessing nuclear fuel used to generate electricity at steel, invar, and ferrite facilities outside the United States. Because reprocessing is not conducted in the U.S., only a minute amount of radioactivity release is associated with electricity consumption during CRT use.

Human Health and Ecotoxicity

Chronic human health effects – occupational. Workers might experience health effects, including cancer, from long term exposure to materials associated with computer displays. LPG used in glass manufacturing accounted for much of the impact score in this category.

Chronic human health effects – public. Members of the general public might be at risk of developing adverse health effects, including cancer, due to air or water releases from the life cycle of computer displays. The largest impact on the public is the sulfur dioxide (SO_2) released due to electricity generation for CRT use. SO_2 produced for the product use stage contributed 83 percent of the score because of this pollutant's relatively high non-cancer hazard value and high release rate.

Aesthetic impacts (odor). Some air emissions may be released in concentrations that are detectable by smell. Odor does not by itself represent a human health or environmental prob-

lem, but it is considered a nuisance. Hydrogen sulfide produced during the production of LPG for glass manufacturing generated the largest odor impact. This chemical accounted for 94 percent of the impacts in this category.

Aquatic ecotoxicity. Organisms that live in water, particularly fish, can be harmed by toxic chemicals released to water. The results were broadly distributed. Phosphorous, used in the manufacturing life-cycle stage to produce the CRT tube, was the most significant contributor but accounted for only 26 percent of the impact score. Other materials contributing significantly to the aquatic ecotoxicity score included aluminum, copper, and zinc from the materials processing stage.

Terrestrial ecotoxicity. Organisms living on land can be adversely affected by toxic chemicals in the air or in surface water. Results for this impact category are based on the effects on rodents. As for chronic public health effects, SO_2 produced during electricity generation for CRT use was the most significant material. In large part, this similarity resulted because the same non-cancer toxicity rating for SO_2 applies for both impact categories.

Comparison across CRT life stages

As shown in Figure 4.1, the manufacturing life-cycle stage was the largest contributor in 11 of the 20 impact categories. In most cases, this was due to the very high requirements of LPG in the glass manufacturing process and the associated environmental impacts of processing that LPG. CRT use was important in seven of the impact categories, due mainly to the diverse impacts of electricity generation. It is important to note that the figure does not indicate the overall magnitude of impacts in each life-cycle stage; it was beyond the scope of the project to weigh the relative importance of each impact category. Instead, the figure indicates the areas in the CRT life cycle where the effects of certain processes may be more multifaceted or worthy of further investigation.

Figure 4.1. Distribution of Largst CRT Impacts