Batteries for IT Systems: Environmental Issues

"Everywhere but out of sight…simply put, 21st century life would not be possible without lead-acid batteries." (Battery Council International, 2004) Batteries smooth out the load from electrical utilities provide backup power for telephone companies, power two-way radio, mobile phone and computer systems—in fact, batteries play a hidden but fundamental support role in nearly every kind of IT system. Uninterrupted power is becoming increasingly important for the smooth functioning of sensitive computing equipment, networks, and test equipment. (Frost and Sullivan, 2004a)

Other than fluorescent light bulbs, batteries are likely the most common items in commercial buildings that contain high concentrations of toxic materials. Worldwide, batteries account for the majority of lead use. (ICCL, 2001) Even though the battery industry overall has made significant efforts to reduce and recycle toxic materials, "virtually all batteries exhibit a characteristic of a hazardous waste, including rechargeable nickel-cadmium batteries, silver button batteries, mercury batteries, small sealed lead-acid batteries, and alkaline batteries." (California State University, Long Beach, 2005) Batteries of all types are now widely classified as toxic waste and disposal of batteries is regulated.

All IT systems use batteries, but few enterprises have procedures for battery recycling or for managing the environmental effects of battery use associated with IT systems.

Environmental Concerns

The main environmental concerns related to batteries are:

- Lead mining
- Health effects on manufacturing workers
- Health effects on building occupants in a fire
- Disposal at the end of useful life

Scale of the Problem

Global demand for primary and secondary batteries is forecast to reach $65.1 billion by 2008, growing at 6.5% annually. (APC, 2005) In the U.S 350 million rechargeable batteries are sold every year and 3 billion batteries are thrown away. (Earth911, 2005 and Rechargeable Battery Recycling Corporation, 2003) In 2001 alone, Californians purchased over 500 million primary and secondary batteries. (CIWMB, 2005).

Batteries – The Basics

Batteries either directly power or provide back-up power for IT systems, including data centers, network infrastructure, wireless devices, desktop and laptop computers, servers, and telephone systems. The use of batteries for IT applications is growing for three main reasons: 1) the

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continuing proliferation of electronic devices that require an uninterrupted supply of power, 2) the increased unreliability of commercial power sources, and 3) rapid growth in the use of mobile IT devices.

There are two general categories of batteries.

Primary batteries— Alkaline, lithium, silver oxide, zinc-air, zinc-carbon and zinc-chloride are non-rechargeable batteries that are thrown away or recycled after discharge, and have historically been used mostly in consumer settings. This trend is expected to continue with 70% of all primary batteries being used by consumers in 2009. (Freedonia Group, 2005)

Secondary batteries—Nickel-cadmium, nickel metal hydride, lithium-ion, and lead-acid batteries are rechargeable, and are more heavily used in commercial settings than primary batteries. Frost and Sullivan (2004b) notes that approximately "50 percent of the UPS market uses lead-acid technologies" and that more than 50% of SLA sales are for telecom applications. (2004a) Freedonia expects nearly 60% of all secondary battery sales to be of the lead-acid type by 2009. (*ibid*.)

The main secondary battery types are:

Stationary Lead-Acid (SLA) - Stationary batteries are the workhorses of the IT industry for uninterruptible power supplies to IT systems. (Frost and Sullivan, 2004b) SLA's are an essential element of public and private communications networks, data centers of all sizes, building emergency back-up systems, and increasingly, home and office desk-top IT systems.

The primary material used in stationary battery systems for IT applications is lead. The constituents of an SLA are lead (71-76%), sulfuric acid electrolyte (16-19%), and 8-10% other materials, including case, vents and other components. (Exide, 2003b) Battery production remains America's main consumer of lead, consuming 88% lead used in the U.S. (USGS, 2005a)

Portable Batteries - There are three battery types that dominate the secondary market for portable applications (Webber 2001):

> Nickel-Cadmium (NiCad) - Commercially available since early 1980s, NiCad batteries can be recharged many hundreds of times, though they have a "memory" that can compromise lifespan. Cadmium is toxic and poses an environmental hazard. NiCad market share is dropping swiftly (-8.7 revenue growth in 1999) and is expected to decrease further, both due to its memory effect and its environmental problems. (Krishnamurthi, 2003)
>
> Nickel-Metal Hydride (NiMH) - Commercially available since 1997, NiMH does not suffer from the memory effect that NiCad does. Increased energy density (power/weight) offers longer use between charges. Lack of cadmium makes NiMH more environmentally friendly. Krishnamurthi notes that "NiMH has been considered as 'green chemistry' in

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the sense that it has no toxic metals and unlike many other battery chemistries does not pose any environmental and safety concerns." (*Ibid*.)

Lithium-Ion (Li-I) - Li-I batteries have higher energy density than NiCad and NiMH batteries. They are often found in laptop computers and cell phones. However, Frost and Sullivan (2004b) notes that lithium polymer batteries—a variation of Li-I—are entering the same markets served by lead acid and are one-third the size and one-fifth the weight of a lead-acid battery. Lithium batteries do not suffer from memory issues or contain heavy metals such as cadmium or mercury**.** (*Ibid.*)

Environmental Concerns About Batteries

Lead Mining

"Lead is used by all industrialised nations. The USA is by far the biggest consumer, with some countries in Asia (China, Japan, Korea) and Europe (UK, Germany, France and Italy) also using large amounts. Most of the lead is used for batteries, an application which has grown enormously in importance." Approximately 3 million metric tons of lead ore is mined worldwide each year with 75% of the production coming from six countries: China, Australia, U.S.A., Peru, Canada, and Mexico. (ICCL, 2001 and ILZSG, 2005).

The environmental effects of lead mining are several: most lead is mined underground and near the surface (EERE, 2003) which often results in "open mine shafts, collapsed mine shafts, and subsidence areas [which] have claimed lives, caused property damage, and created avenues for water to enter and leave the mines." (Kansas Geological Survey, 2005) The highly acidic water leaving mine tunnels carries toxic dissolved metals which contaminate local ground water, springs, and surface water. (*ibid*) There are also concerns about the quantity of water used in mining and the possible spread of lead-containing dust. At 29.5 million Btu per 1.1 tons of refined lead, lead mining—like all mining—is energy intensive, though it is about 25 percent of that required for copper. (EERE, 2003)

Health Effects on Manufacturing Workers

Lead is not readily absorbed through the skin. However, lead dust or fumes may cause respiratory and eye problems, as well abdominal pain, nausea, headaches, vomiting, diarrhea, severe cramping, and difficulty in sleeping. Lead may also cause anemia, kidney and nervous system damage, as well as reproductive harm in both men and women. The EPA and the International Agency for Research on Cancer (IARC) categorize lead as a probable human carcinogen. (Exide, 2003b)

In industries such as lead mining and smelting, as well as manufacturing settings where lead and lead-based products are present, workers are subject to exposure and poisoning. People who live near lead mining, smelting, processing or manufacturing industries are at particular risk through industrial emissions, industry waste disposal, and contamination of soil or clothing and footwear from family members working in those industries. (Leadpoison.net, 2002) Recent

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research in the United States found that many children with high levels of lead in their blood were contaminated by "take home" lead dust on parents' work clothes, hair, skin and vehicles or home activities that contaminated living and eating areas. (*ibid.*) A report by Centers for Disease Control and Prevention agency NIOSH (National Institute for Occupational Health and Safety, 2002) notes that take-home contamination risks for families have been largely ignored, that no national mechanism exists to monitor poisonings, and that problems are likely to continue and grow in the future.

Health Effects on Building Occupants in a Fire

Batteries pose clear hazards during the material extraction/manufacturing process and after disposal, but only potential hazards during use. Under normal conditions, SLA batteries do not generate lead dust, vapors or fumes. However, hazardous exposure may occur when SLAs are overheated, oxidized, or processed or damaged to create dust, vapor, or fumes—such as during fires in buildings.

The largest component of SLAs after lead is sulfuric acid. Under normal conditions, SLAs do not generate acid vapors or mist. However like lead, such hazards can be generated when fire occurs. Under such conditions, acid vapors or mist may cause severe skin, stomach and respiratory irritation, as well as burns and ulceration. In the eyes, acid vapors can cause severe irritation, burns, cornea damage and possible blindness.

Disposal at the End of Useful Life

While most lead-acid batteries are properly disposed of and recycled in the U.S., the vast majority of both primary and secondary batteries sold are not and end up in the waste stream.

<u>Lead-Acid Batteries</u>

Globally, 50% of the lead used in manufacturing is produced from the recycling of existing lead products. (ICCL, 2001) Recycling percentages are higher in industrialized countries, particularly in the U.S. where 80% or more of domestic lead consumption was recovered from used batteries. Exide, a world leader in the lead-acid battery marketplace recycles approximately 50 million batteries per year. Exide claims that it is one of the few companies in the world to reclaim virtually all of its spent products. (Exide, 2005b)

However, while most commercial and industrial SLAs are likely to be recycled, others are not. Smaller UPS's for desktop, telecom closet, or workgroup support accounted for 37% of total North American UPS shipments in 2002 (Venture Development Corporation, 2004). Many of these products are used in commercial applications as supplementary back-up power units in larger IT systems or in Small Office/Home Office (SoHo) applications. In these cases, users are generally unaware or unconcerned that their small UPS contains a sealed lead-acid battery and that state and federal laws prohibit disposal of lead batteries as normal waste.

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Ni-Cad, NiMH, and Li-I Batteries

Smaller rechargeable batteries are much more likely to be thrown away than their generally much larger lead acid cousins, and this is almost always their fate—every year, Americans throw away over 3 billion primary and secondary batteries, 250 million pounds worth. (Rechargeable Battery Recycling Corporation, 2003) The California Integrated Waste Management Board report indicates that of the 507,259,000 batteries sold in California in the year 2001, only 0.55% batteries were recycled. (CIWMB, 2005). While proper disposal for recycling presents few problems, in the municipal solid waste (MSW) stream hazards emerge.

According to U.S. EPA (2004a), "many batteries contain toxic constituents such as mercury and cadmium…[and] pose a potential threat to human health and the environment when improperly disposed *[sic]*"…"when MSW is incinerated or disposed of in landfills, under certain improper management scenarios, these toxics can be released into the environment. EPA also notes that even as batteries make up less than 1% of municipal solid waste (MSW) "…they account for a disproportionate amount of the toxic heavy metals in MSW." (*ibid.*) The same source provides an example: as of 1995, 75 percent of the cadmium found in MSW came from Ni-Cad batteries. Fortunately, Ni-Cad batteries are on the decline as noted above, and "since the early 1980s, manufacturers have reduced their use of mercury by over 98 percent." (*ibid.*) Nevertheless, the sheer volume of batteries disposed of is a toxic waste problem. EPA's March 2002 Enforcement Alert indicates that roughly 73 percent of MSW is either land-filled or incinerated, and that neither of these disposal methods is appropriate for the disposal of rechargeable batteries. (U.S. EPA, 2002)

Batteries in the waste stream are often incinerated with other solid waste and the vaporized toxic metals pollute lakes and streams, while the toxins from batteries buried in landfills leach into ground water. In either case, such toxins ultimately end up in the food chain affecting plants, animals, and people alike. (Earth911, 2005)

Though Li-I and NiMH batteries are not considered hazardous waste (*ibid.*), 80 to 90% of Li-I batteries (Tullo, 2002) contain polyvinylidene fluoride (PVDF), which is toxic when burned (Fluoride Action Network, 2005), while NiMH batteries contain "mild toxins". (Battery Digest, 2001)

Legislation and Regulation Affecting Batteries

United States

With exceptions for household and small quantity business use, U.S. Federal law requires used Ni-Cad and lead-containing batteries to be managed as universal (hazardous) waste and to be recycled. (U.S. EPA, 2004b) The 1996 Mercury-Containing and Rechargeable Battery Management Act mandated the phase out of mercury in batteries and the implementation of battery labeling and standardization approaches that facilitate the recovery and recycling of Ni-Cads, batteries containing mercury, and small sealed lead batteries. The Act also regulates

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rechargeable consumer products and "rechargeable batteries found in consumer products like cellular phones and laptop computers" and other products for "personal or household use," including cell phones, laptops, PCs and UPS. (U.S. EPA, 2002) The Act does not cover internal uninterrupted power supplies under its definition of rechargeable battery.

Some 30 states also have disposal bans covering all types of lead batteries whereby all such batteries must be returned for recycling. They include Arizona, New Hampshire, Arkansas, New Mexico, California, North Carolina, Connecticut, North Dakota, Florida, Oregon, Hawaii, Pennsylvania, Indiana, South Carolina, Iowa, South Dakota, Kentucky, Texas, Louisiana, Utah, Maine, Vermont, Minnesota, Virginia, Mississippi, West Virginia, Missouri, Wisconsin, Nebraska, and Wyoming. (Rechargeable Battery Recycling Corporation, 2005)

California has the most stringent U.S. legislation to date on batteries. All batteries, both rechargeable and single use, are considered hazardous waste when they are discarded, and "after February 8, 2006, all batteries in California must be recycled, taken to a household hazardous waste disposal facility, or taken to a hazardous waste disposal facility." (CIWMB, 2005).

<u>International Legislation</u>

In 1991, the EU passed legislation on Ni-Cad and mercury-containing batteries very similar to the U.S. Federal laws. (U.S. EPA, 2004a) In addition, the EU-wide Restriction of Hazardous Substances Directive (RoHS), which takes effect across the European Union (EU) in 2006, bans outright the use of toxic materials such as lead and cadmium. (Greiner 2002)

A number of countries have also passed more stringent legislation regarding batteries.

As of 1998, German battery manufacturers assumed total responsibility for all batteries regardless of type, manufacturer, or retailer, and all batteries must be collected and responsibly managed. The ordinance also restricts the heavy metal content of certain batteries and requires that battery manufacturers label all hazardous batteries as such and produce long-life, reusable batteries. (*ibid*)

In the Netherlands (1995) manufacturers and importers are responsible for collecting and recovering all batteries weighing less than 1 kilogram. Manufacturers and importers have also formed a member-funded collection foundation that takes back batteries weighing up to 100 kilograms which had achieved a 53 percent collection rate for all batteries by 1996. (*ibid*)

Norway established a similar product stewardship law in 2000 for all rechargeables, and Taiwan's battery recycling program covers all types of batteries, adding recycling fees to the purchase price depending on the heavy metal content of the battery. The aim of the Taiwanese program is to encourage manufacturers to produce batteries that contain less toxic material. (*ibid*)

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Sources for additional information

A good resource center from U.S. EPA http://www.epa.gov/epaoswer/non-hw/reduce/epr/products/bat-resources.htm
Good general information
http://www.ehso.com/ehshome/batteries.php

Sources For This Paper

APC. (2002). Material Safety Data Sheet. http://nam-en.apc.com/cgi-bin/nam_en.cfg/php/enduser/fattach_get.php?p_sid=oxEq1hGh&p_tbl=9&p_id=564&p_created=1027522456

APC. (2003). Determining Total Cost of Ownership for Data Center and Network Room Infrastructure http://searchdatacenter.bitpipe.com/detail/RES/1036330833_699.html\

APC. (2005). APC Annual Report 2004. http://www.apcc.com/go/2004annual/financial.cfm

Battery Council International. (2004). Batteries Day to Day http://www.batterycouncil.org/daytoday.html

Battery Council International. (2005). Battery Council International Breakdown of U.S./North American Battery Shipments. http://www.batterycouncil.org/BreakdownOfShipmentsChart.pdf

Battery Digest. (2001). Batteries Topics. Batteries Digest Website. http://www.batteriesdigest.com/id392.htm

Buchmann, Isidor. Battery Statistics. 2004. Battery University.com. http://www.batteryuniversity.com/parttwo-55.htm

California Integrated Waste Management Board. (2005). Waste Prevention Information Exchange – Batteries. http://www.ciwmb.ca.gov/WPIE/Batteries/

California State University, Long Beach. (2005). Environmental Compliance. http://daf.csulb.edu/offices/bhr/safetyrisk/envcomp.html

DOE (U.S. Department of Energy) Commercial Buildings Energy Consumption Survey. Table B6. Building Size, Number of Buildings, 1999. www.eia.doe.gov/emeu/cbecs/pdf/b6.pdf

Earth911. (2005). Why Are Some Batteries Harmful For The Environment? http://www.earth911.org/master.asp?s=lib&a=electronics/bat_env.asp

Copyright 2005 – All Rights Reserved

EERE. (2003). Energy and Environmental Profile of the U.S. Mining Industry, Chap. 6, Lead and Zinc. http://www.eere.energy.gov/industry/mining/pdfs/lead_zinc.pdf

Energy End-Use Forecasting. (2005). Information Technology and Resource Use. http://enduse.lbl.gov/Projects/InfoTech.html

Engineeringtalk.com. (2004). Consumer electronics fuels world battery growth. http://www.engineeringtalk.com/news/fee/fee110.html

Evans-Correia, Kate. (2005). Power demands drain data centers. http://searchdatacenter.techtarget.com/originalContent/0,289142,sid80_gci1081270,00.html

Exide. (2001). Exide Environment Brochure. http://www.exide.com/pdf/2001_exide_brochure.pdf

Exide. (2003a). Network Power Applications. http://www.exide.com/network_power.html

Exide. (2003b). Material Safety Data Sheet. Marathon®/Sprinter®, Standard Jar Cover Material. http://www.exide.com/material_safety_data/Z99-MSDS-MARSPR_Rev_AC_2003-09-17_Marathon_and_Sprinter_Sealed_Lead_Acid_Battery.pdf

Exide. (2005a). Investor Fact Sheet. http://media.corporate-ir.net/media_files/IROL/98/98530/FactSheet0305.pdf

Exide. (2005b). Partner with Exide to Protect the Environment. http://www.exide.com/

Exide. (2005c). Battery Recycling and the Environment. http://www.exide.com/recycling.html

Freedonia Group. (2005). Batteries. Cited at Mindbranch.com. http://www.mindbranch.com/products/R154-1302.html

Frost and Sullivan. (2004a). World Stationary Lead Acid Battery Markets. Research Overview. http://www.frost.com/prod/servlet/report-overview.pag?repid=A714-01-00-00-00&title=Research+Overview

Frost and Sullivan. (2004b). Advanced Energy Storage Technologies. Research Overview. http://www.frost.com/prod/servlet/report-overview.pag?repid=D289-01-00-00-00&title=Research+Overview

Greiner Environmental, Inc. (2002). Environmental, Health and Safety Issues in the Coated Wire and Cable Industry. University of Massachusetts, Lowell, Massachusetts Toxics Use Reduction Institute Website: http://www.turi.org/content/content/download/913/4501/file/Wire_Cable_TechReport.pdf

Hammami, Amer et al. (2003). Nature. Volume 424, August 7, 2003. 635.

Copyright 2005 – All Rights Reserved

Imperial College Consultants Ltd (2001). "LEAD: the facts". http://www.ldaint.org/factbook/factbookch1.htm

IT Facts. (2005). Linux data infrastructure servers to grow at 46% a year. http://www.itfacts.biz/index.php?id=P2159

International Telecommunications Union. (2002). EPFL – Working Group on the impact of ICT on the Environment. Why and How the Environment has to be Taken into Account at the World Summit on the Information Society. http://www.itu.int/dms_pub/itu-s/md/03/wsispc2/c/S03-WSISPC2-C-0043!!PDF-E.pdf

International Zinc and Lead Study Group (2005). Lead Statistics http://www.ilzsg.org/statistics.asp?pg=lead

Kansas Geological Survey. (2005). Lead and Zinc Mining. http://www.kgs.ku.edu/Extension/ozark/mining.html

Krishnamurthi, Shanthi. (2003). Batteries in Mobile Applications - Which Way Would The Penny Fall? http://powersupplies.frost.com/prod/servlet/market-insight-top.pag?docid=SBRD-5LWJFN&ctxixpLink=FcmCtx3&ctxixpLabel=FcmCtx4

Leadpoison.net. (2002). Lead-Safe Guide for Health Professionals. http://www.leadpoison.net/prevent/guide-professionals.htm

National Institute for Occupational Health and Safety. (2002) Protecting Workers' Families - A Research Agenda. http://www.cdc.gov/niosh/docs/2002-113/2002-113.html

Rayovac. (2005). Rechargeables – Frequently Asked Questions. Rayovac.com http://www.rayovac.com/recharge/faq.htm#6

Rechargeable Battery Recycling Corporation. (2003). Battery Lesson Plan. http://www.rbrc.org/school/lesson_form.cfm

Rechargeable Battery Recycling Corporation. (2005). http://www.rbrc.org/statelaws.html

Saftware.com. (2005). Battery Life Characteristics. http://www.saftware.com/faq_answers.asp?category=battery_life

Smith, Bucklin and Associates, Inc. (2003). NATIONAL RECYCLING RATE STUDY. http://www.batterycouncil.org/recyling_rate_study_july_2003.pdf

Stansberry, Matt. (2005). APC's Sawyer: Energy efficiency in the data center. http://searchdatacenter.techtarget.com/originalContent/0,289142,sid80_gci1088728,00.html

Copyright 2005 – All Rights Reserved

The Battery Bank. (2004). How Long Do Batteries Last? The Battery Bank.com. http://www.batterybank.com/howlong.html

Tullo, Alexander H. (2002). Maintaining a Charge. http://pubs.acs.org/cen/coverstory/8028/8028electronic3.html

U.S. Census. (2000). DP-3. Profile of Selected Economic Characteristics: 2000. http://factfinder.census.gov/servlet/QTTable?_bm=y&-geo_id=01000US&-qr_name=DEC_2000_SF3_U_DP3&-ds_name=DEC_2000_SF3_U&-_lang=en&-redoLog=false&-_sse=on

U.S. EPA. (2002). Enforcement Alert, March 2002. The 'Battery Act'. EPA 300-N-02-002 http://www.rbrc.com/graphics/PDF/BatteryAlert.pdf

U.S. EPA. (2004a). Product Stewardship. Batteries. http://permanent.access.gpo.gov/websites/epagov/www.epa.gov/epaoswer/non-hw/reduce/epr/products/batteries.html

U.S. EPA. (2004b). Universal Waste. http://permanent.access.gpo.gov/websites/epagov/www.epa.gov/epaoswer/hazwaste/id/univwast.htm#bat

U.S. Geological Survey. (2005a). Lead Statistics and Information. http://minerals.usgs.gov/minerals/pubs/commodity/lead/

U.S. Geological Survey. (2005b). Mineral Commodity Summaries, Lead 2005. http://minerals.usgs.gov/minerals/pubs/commodity/lead/lead_mcs05.pdf

Venture Development Corporation. (2004). 2003 Power Protection Market Intelligence Program. http://www.vdc-corp.com/power/white/04/04ups.pdf

Weber, Adam. (2001). Just Add Batteries. http://www.assemblymag.com/CDA/ArticleInformation/coverstory/BNPCoverStoryItem/0,6490,99566,00.html

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