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Recycling and Take-Back Opportunities for Batteries, With Particular Attention to Household Alkaline Batteries

by Jeremy Arling

The disposal of consumer batteries constitutes a significant flow of toxic materials into municipal solid waste (MSW). While there have been efforts to recycle consumer batteries in the United States for the last 15 years, the vast majority of batteries still end up in landfills and incinerators. Efforts to recycle nickel-cadmium (Ni-Cd) batteries increased dramatically when they were classified as a "universal waste" and the complicated requirements under the Resource Conservation and Recovery Act (RCRA) were removed. However, while the regulatory environment for battery transport and recycling has improved, economics have become the limiting factor in further recycling growth.

There is significant potential to improve this problem through the implementation of improved battery recycling legislation, including the option of requiring manufacturers to take back waste batteries. Many European countries have implemented manufacturer take-back laws of both rechargeable and alkaline batteries. If such programs are designed efficiently with convenient collection programs and provide appropriate incentives to industry, they may create substantial environmental benefits, at low or break-even costs.

This Article begins with a background of the battery industry and a synopsis of the problem of battery waste. Section II details the various state and federal waste laws relevant to discarded batteries. Section III briefly discusses the existing battery recycling infrastructure. Section IV presents the various battery collection methods and programs that exist in the United States, and provides numerous examples of Asian and European programs for comparison. Section V addresses the legal, economic, and practical barriers to battery collection, recycling, and take-back. The Article concludes with regulatory and economic solutions to increase battery recycling.

I. Background on the Battery Industry and Battery Waste

Historically, the majority of dry-cell (nonautomotive) batteries used in the United States were for industrial purposes. However, as technologies improved and consumers became more mobile, computers, telephones, and even power tools were released of their tether to the electrical socket. The result was that in 1998, consumer batteries outnumbered industrial batteries three to one.[1] That year, an estimated three billion consumer batteries were sold in the United States.[2]

The chemistries of these consumer batteries includes numerous toxic materials. Ninety percent of consumer batteries sold in 1992 were primary, or disposable, batteries.[3] About two-thirds of disposable batteries sold are the familiar alkaline (alkaline manganese) batteries, but other types include zinc carbon, silver oxide, mercuric oxide, zinc oxide, and lithium batteries. Secondary, or rechargeable,[4] batteries account for the remaining 10% of consumer batteries sold, although that percentage is increasing. The first significant rechargeable battery chemistry was Ni-Cd, which now constitutes only 20% of the rechargeable battery market.[5] By 2002, 50% of rechargeable batteries sold were the newer nickel metal hydride (Ni-MH) batteries.[6] In addition, small sealed lead-acid (SSLA) and lithium ion (Li-ion) are other, less common, rechargeable chemistries.

Consumer batteries pose a major toxic material problem when discarded in the MSW stream.[7] Although consumer batteries comprised less than 0.1% of MSW in 1992, they are a significant source of toxic heavy metals. It was estimated that by 2000, Ni-Cd batteries would account for 75% of cadmium found in MSW.[8] This is not surprising as 75% of all cadmium consumed in the United States is for Ni-Cd batteries.[9] Depleted industrial batteries pose less of a waste problem than consumer batteries, as there are fewer of them and 90% of them are collected.

The most toxic metals[10] found in batteries are cadmium, cobalt, lead, mercury, and silver. Metals that are less toxic include manganese, nickel, and zinc. These heavy metals can enter the air through incineration or leach from landfills into the soil, surface water, and groundwater. Incinerating

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1. Rebecca L. Lankey, Materials Management and Recycling for Nickel Cadmium-Batteries 48 (1998) (unpublished Ph.D. dissertation, Carnegie Mellon University) (on file with author), *available at* http://gdi.ce.cmu.edu/theses/lankey_thesis.pdf (last visited July 15, 2003).
2. U.S. Environmental Protection Agency (EPA), *Batteries*, *at* http://www.epa.gov/epr/products/batteries.html (last visited Feb. 26, 2004). Based on the 1992 report *Getting a Charge Out of the Wastestream* by David J. Hurd.
3. Bette Fishbein, Inform, Industry Program to Collect Nickel-Cadmium (Ni-Cd) Batteries 2 (1997), *available at* http://www.informinc.org/recyclenicd.php (last visited Feb. 26, 2004).
4. Rechargeable batteries are also called accumulators in Europe.
5. Raymond Communications, Battery Recovery Laws Worldwide 11 (2001).
6. Rayovac, *Rechargeable Market Facts*, *at* http://www.rayovac.com/products/recharge/mar_fac.shtml (last visited July 15, 2003).
7. Fishbein, *supra* note 3, at 5.
8. *Id.*
9. Jozef Plachy, U.S. Department of the Interior (DOI), Cadmium Recycling in the United States in 2000, at 3, *available at* http://pubs.usgs.gov/of/2003/of03-049/of03-049.pdf (last visited July 15, 2003).
10. In addition to these metals, each battery type contains a different electrolyte that could be toxic, caustic, corrosive, and/or flammable.

batteries may introduce metals to both the air and water as the metals remaining in the resulting ash are landfilled. The health effects of the heavy metals may vary depending upon how they enter the body. However, in high concentrations, most cause organ damage, and many attack various organ systems such as the reproductive, nervous, or immune systems.[11] Finally, though not a toxic metal, metallic lithium produces explosive hydrogen gas when exposed to moisture.

II. Existing Solid Waste Legal Framework

The following discussion describes the existing legal framework with regard to disposal of batteries.

A. MSW

Currently, most consumer batteries are disposed of as MSW and are not recycled. MSW is what most people think of simply as garbage: packaging, furniture, appliances, food scraps, bottles, etc. Any programs for collecting and recycling consumer batteries must be based on how other MSW is handled.

One of the best opportunities to increase battery recycling would be to incorporate it into existing recycling programs. However, curbside collection of batteries would only be reasonable in communities serviced by a recycling truck. In 2000, there were 9,247 curbside recycling collection programs serving 49% of the U.S. population.[12] Some communities may not have curbside collection of recyclables, but at least are visited by a truck to pick up their MSW. Some rural residents may have to drop off all their waste at a local dump.

B. RCRA

Batteries are not an explicitly listed hazardous waste under RCRA. Therefore, to be classified as such, they must meet RCRA's definitions for either ignitability, corrosivity, reactivity, or toxicity.[13] Ni-Cd batteries are hazardous wastes under RCRA as its cadmium meets the toxicity characteristic. The high lead content in SSLA batteries also leads to their hazardous classification. Though containing cobalt, Ni-MH batteries are not classified as hazardous.

Alkaline batteries are also not considered hazardous, though before mercury was banned from use, there was some question as to their toxicity. Tests conducted in 1992 by Martin Marietta Energy Systems, Inc., concluded that alkaline batteries did not meet the toxicity requirements as determined by the U.S. Environmental Protection Agency's (EPA's) toxicity characteristic leaching procedure. The study also found that alkaline batteries were toxic using an aquatic bioassay procedure. However, since the tests were conducted in 1992, before mercury was banned from new batteries, the toxic effects may no longer exist.

C. Universal Waste Rule

One barrier to battery recycling a decade ago was the federal hazardous waste regulations that affected anyone collecting or recycling Ni-Cd batteries. Fear of being classified as a treatment, storage, or disposal facility and being charged with all the associated requirements limited the number of facilities willing to collect any battery type.[14]

In 1995, EPA promulgated the universal waste rule[15] to facilitate the recycling and proper disposal of common hazardous wastes including some types of batteries. This rule streamlines the RCRA requirements for those who handle batteries that are considered hazardous.[16] Therefore, the rule applies to Ni-Cd and SSLA batteries, but not to alkaline or Ni-MH batteries as they are not considered hazardous.

Originally, the universal waste rule did not impose a uniform national standard, so states were free to apply their own existing hazardous wastes standards. This created difficulty for the interstate transport of hazardous waste batteries. In 1996, this changed with the passage of the federal Mercury-Containing and Rechargeable Battery Management Act (Battery Act).[17] The Battery Act established the universal waste rule as the ceiling for state requirements regarding the collection, transportation, and storage of rechargeable batteries. This law became the uniform national standard.

One issue that varies by state is to whom the universal waste rule applies. RCRA exempts households and certain conditionally exempt small-quantity generators (CESQGs), thus allowing them to dispose of all batteries in their normal trash.[18] Most states choose not to modify this section of RCRA. Florida,[19] Maryland,[20] Minnesota,[21] New Jersey,[22] and Rhode Island,[23] however, have banned household disposal of rechargeable batteries.

California currently exempts households and CESQGs from the proper disposal of universal wastes. However, this exemption will expire in February 2006,[24] at which time households will be required to divert their batteries, fluorescent lamps, thermostats, and cathode ray tubes to a household hazardous waste (HHW) facility. As of February 2004, CESQGs have been limited to the disposal of only 20 pounds of HHW per month.[25]

D. The Battery Act

The Battery Act, in addition to limiting the use of mercury in batteries, streamlines the requirements for regulated re-

11. For a description of the health effects of each metal, see Agency for Toxic Substances and Disease Registry, *ToxFAQs*, *at* http://www.atsdr.cdc.gov/toxfaq.html (last visited July 15, 2003).
12. U.S. EPA, Municipal Solid Waste in the United States: 2000 Facts and Figures 112 (2002), *available at* http://www.epa.gov/epaoswer/non-hw/muncpl/report-00/report-00.pdf (last visited July 16, 2003) [hereinafter EPA 2000 Facts and Figures].
13. 40 C.F.R. §261.
14. James Salzman, *Symposium on Population Law: Sustainable Consumption and the Law*, 27 Envtl. L. 1243, 1287-88 (1997).
15. 40 C.F.R. §273.
16. *Id.* §273.2(b)(3).
17. 42 U.S.C. §§14301 et seq.
18. CESQGs are those businesses that generate less than 220 pounds of RCRA hazardous waste and universal waste per month.
19. Fla. Stat. Ann. §403.7192(3)(b) (West 2002).
20. Md. Code Ann., Envir. §6-1106 (1996).
21. Minn. Stat. Ann. §115A.9157 (West 1997).
22. N.J. Stat. Ann. §13:1E-99.69 (West 2003).
23. R.I. Code R. 23-60.1-5 (1997).
24. Cal. Code Regs. tit. 22, §66273.8(a) (2003).
25. *Id.* §66273.8(a)(3)(A).

chargeable batteries.[26] The rechargeable battery industry, which was starting to be subjected to legislation in varying states, supported the Act. The Act thus applies the universal waste rule to the collection, storage, and transportation of most rechargeable batteries in all 50 states, preempting the state regulatory authority in this area.[27]

The Act also serves several other purposes. First, it established uniform national labeling requirements for regulated batteries, products, and packaging.[28] The labels must be on the regulated battery or the rechargeable product, and must contain the three chasing arrows or a comparable recycling symbol, an abbreviation identifying the battery type, e.g., Ni-Cd, lead, etc., and a phrase indicating that it must be recycled.[29] Second, to facilitate recycling, the Act requires that regulated batteries be easily removed from the rechargeable product or sold separately.[30] Third, the Act seeks to educate the public about the proper disposal of rechargeable batteries. EPA, in consultation with the rechargeable battery sector, is charged with establishing a public information program for that purpose.[31]

E. More Restrictive State Hazardous Waste Laws

The universal waste rule subjected those persons who collect, store, or transport hazardous rechargeable batteries to uniform federal hazardous waste handling requirements. The universal waste rule did not, however, negate states' other rights in implementing RCRA.

The most applicable method for states to regulate batteries would be to make additions to the universal waste rule by adding state-only universal wastes such as cathode ray tubes, antifreeze, or aerosol cans.[32] While the Battery Act prevents states from changing the status of hazardous rechargeable batteries,[33] they remain free to regulate "nonhazardous" batteries, such as alkaline, Ni-MH, and Li-ion batteries. However, states have rarely added batteries as a state universal waste.

One state that has acted is California, which unlike EPA, analyzes nickel for its toxicity characteristics.[34] If the concentration of nickel in a waste Ni-MH battery meets or exceeds the threshold value, that battery would be considered a hazardous waste in California.[35] California also analyzes zinc in the same way, thus potentially leading to the classification of alkaline batteries as hazardous. California, however, now makes explicit that discarded alkaline batteries are not a hazardous waste.[36]

Hennepin County, Minnesota, has designated alkaline batteries as a "problem material" requiring disposal at a household hazardous waste facility or battery collection site. Hennepin County has this power as Minnesota has granted its counties the authority to regulate hazardous wastes.[37]

F. Transportation Regulations

1. Alkaline Battery Transportation Regulations

Alkaline batteries, like most dry cells, are not specifically regulated under the U.S. Department of Transportation (DOT) Hazardous Materials Table.[38] They need only be "offered for transportation in a manner that prevents the dangerous evolution of heat (for example, by the effective insulation of exposed terminals)."[39] Likewise, the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) prohibit transporting batteries or battery powered devices "having the potential of dangerous evolutions of heat that is not prepared so as to prevent a short circuit (e.g., in the case of batteries, by the effective insulation of exposed terminals; or in the case of equipment, by disconnection of the battery and protection of exposed terminals)."[40] Overall, transportation regulations for alkaline batteries do not affect systems for their recycling.

2. Ni-Cd Battery Transportation Regulations

As described above, Ni-Cd batteries are subject to the transportation requirements of the universal waste rule, which adds some cost and complexity to their transport, but much less than what other hazardous wastes face under RCRA. Also, nonhazardous batteries that are shipped to or from a state that classifies it as a hazardous waste are regulated under 40 C.F.R. §172.101 as an "environmentally hazardous substance." This may be the case for Ni-MH batteries in California, for instance.

3. Lithium Battery Transportation Regulations

All lithium batteries, whether new or discharged, are subject to DOT regulation. Whether this affects their transport depends on the amount of lithium in the battery. Batteries with more than 5.0 grams of lithium in the primary cell, or more than 25 grams of lithium total, are considered a Class 9 hazardous material. To be transported in the United States, they

26. The "regulated batteries" under the Act include rechargeable batteries that contain cadmium or lead electrodes (Ni-Cd and SSLA batteries), and other rechargeable batteries designated by EPA under 42 U.S.C. §14322(d). 42 U.S.C. §14302(7). The Act excludes lead-acid batteries in vehicles, batteries used as a backup power source for memory or program storage, and rechargeable alkaline batteries. *Id.* §14302(5). The definition of rechargeable consumer products is likewise limited, as it applies only to products whose "primary energy supply" comes from a regulated battery and only to products "primarily intended for personal or household use." *Id.* §14302(6)(A). Products that use a regulated battery as a source of backup power are excluded from the definition. *Id.* §14302(6)(B).

27. Under 42 U.S.C. §14323, the collection, storage, and transportation of rechargeable batteries and rechargeable products containing not easily removable batteries are regulated under 60 Fed. Reg. 25492 (May 11, 1995) or equivalent state requirements, except that the regulations of 40 C.F.R. §§260.20, 260.40, and 260.41 (and their equivalent state requirements) are not to apply.

28. 42 U.S.C. §14301(2).

29. *Id.* §14322(b).

30. *Id.* §14322(a)(2).

31. *Id.* §§14301(1)(B), 14303.

32. For a listing of state-only universal wastes, see U.S. EPA, *State-Specific Universal Waste Regulations*, *at* http://www.epa.gov/epaoswer/hazwaste/id/univwast/uwsum.htm (last visited July 15, 2003).

33. 42 U.S.C. §14306.

34. Cal. Code Regs. tit. 22, §66261.24(a)(2)(A) (2003).

35. E-mail from James Stettler, Public and Business Liaison, California Dep't of Toxic Substance Control (June 18, 2003) (on file with author).

36. Cal. Health & Safety Code §25216.3(b) (West 1999).

37. Minn. Stat. Ann. §400.161 (West 1997).

38. 40 C.F.R. §172.101.

39. *Id.* §172.102(a)(1), Special Provision 130.

40. *Id.* Special Provision A123.

must meet six United Nations (U.N.) packaging and transportation tests, U.N. T1-T6, and have proper labels, markings, and shipping documents. Lithium cells with a solid anode that contains less than 1.0 gram of lithium and lithium ion cells with less than 1.5 grams of lithium (or whole batteries containing less than 2.0 grams or less than 8.0 grams, respectively) are exempt from all testing, marking, packaging, or labeling requirements.[41] Most consumer lithium metal and Li-ion batteries fall into this exception, so transportation regulations are not a serious obstacle.

Lithium batteries being transported for disposal by motor vehicle must: "(1) Be equipped with an effective means of preventing external short circuits; and (2) Be packed in a strong outer packaging conforming to the requirements of Secs. 173.24 and 173.24a."[42] These are essentially the same requirements for rechargeable batteries, and, thus, consumer lithium batteries are often simply treated like other rechargeable batteries.

However, even though consumer lithium batteries are exempt, they are not necessarily risk free. In 1999, two cargo pallets of consumer lithium batteries caught on fire after one was accidentally overturned in the Northwest Airlines cargo facility at the Los Angeles International Airport.[43] These batteries were exempted from the hazardous materials regulations as they contained only 0.4 grams of lithium. As a result of this incident, the National Transportation Safety Board "conclude[d] that lithium batteries may present an unacceptable risk to aircraft and occupants"[44] and recommended prohibiting the transportation of lithium batteries on passenger-carrying aircraft.

This event has led to changes in the ICAO's Technical Instructions, the IATA's Dangerous Goods Regulations (DGR), and the International Maritime Dangerous Goods (IMDG) Code. The DOT matching regulations became effective in October 2003.[45] The new ICAO and IATA rules went into effect in January 2003, and the IMDG rules may go into effect sometime in 2004. These rules lower the threshold weight of lithium and strengthen the testing and packaging requirements for all lithium batteries regardless of weight. Lithium cells with a solid anode that contain less than or equal to 1.0 gram of lithium and Li-ion cells with less than or equal to 1.5 grams of lithium (or whole batteries containing less than or equal to 2.0 grams or less than or equal to 8.0 grams, respectively) are still exempt from Class 9 hazardous waste classification.[46] However, they must now meet two additional U.N. tests, U.N. T7-T8, and new packaging and labeling requirements. But the new regulations do not affect the lowest tier, so most consumer lithium batteries are still exempted.

III. Existing Battery Recycling Infrastructure

A. Facilities

Most of the battery recycling plants servicing North America are in Canada. Toxco has the only lithium recycling facility in North America and it is located in Trail, British Columbia. The Raw Materials Company, which recycles alkaline batteries is located in Ontario. This may be because the regulatory burden placed on batteries in the United States before the passage of the universal waste rule was greater than that of Canada. However, the International Metals Reclamation Company, Inc. (INMETCO) is located in Pennsylvania and Toxco plans to build a facility in Ohio.

INMETCO operates the only Ni-Cd recycling plant in the United States that can capture cadmium in addition to nickel, until Toxco completes its plant in Ohio. INMETCO added this capability to its existing Ni-Cd battery facility in 1995. Using best demonstrated available technology, INMETCO can capture cadmium that is 99.95% pure.[47] It then resells the cadmium to battery manufacturers, thereby closing the loop. The recovered nickel and iron is used as alloys in stainless steel and the electrolyte from industrial Ni-Cd batteries is recovered for use as a reagent in the plant's wastewater treatment system.[48]

In 2002, Toxco expanded its lithium battery recycling facility, the only in North America, to allow for the recycling of alkaline batteries. The Raw Materials Company, owned by the International Marine Group, also recycles alkaline batteries. Toxco's unique cryogenic process produces a zinc-manganese paste that they sell to a primary zinc smelter in Canada for further processing. California law does not consider materials sent to secondary smelters to be classified as "recycled" for purposes of the RCRA recycling exception, so it must be taken to a primary smelter.[49]

Though there are only a few facilities that recycle consumer batteries in North America, the current infrastructure has the capacity to recycle the volume of batteries presently being recycled. While the industry can meet the current rate of increase in recycling volume,[50] it does not have the capacity to recycle the volume of batteries currently being used. Furthermore, the paucity of facilities means that current batteries must be transported over greater distances and, thus, at greater expense.

B. Sorting Technology

Under the current system, batteries are repeatedly sorted by any of three groups (the consumer, the collector, and the recycler) at any of four sites (the home, the collection center, the aggregation center, and the recycling facility).

41. *Id.* §173.185(b).

42. *Id.* §173.185(h).

43. National Transportation Safety Board, Safety Recommendation A-99-85 1 (1999), *available at* http://www.ntsb.gov/Recs/letters/1999/A99_85.pdf (last visited July 15, 2003).

44. *Id.* at 5.

45. Research and Special Programs Administration, Hazardous Materials; Transportation of Lithium Batteries, 67 Fed. Reg. 15510, 15563 (Apr. 2, 2002).

46. IATA DGR Special Provision A45.

47. Isidor Buchmann, Batteries in a Portable World (2001), *available at* http://www.buchmann.ca/Article16-page2.asp (last visited Feb. 26, 2004).

48. Rebecca Lankey & Francis McMichael, Rechargeable Battery Management and Recycling: A Green Design Educational Module 8 (1999), *available at* http://www.ce.cmu.edu/GreenDesign/Battery.pdf (last visited July 16, 2003).

49. Cal. Health & Safety Code §25143.2 (West 1999).

50. Telephone Interview with James Ewles, General Manager, Hazardous Materials Division, International Marine Group (June 19, 2003); Telephone Interview with John Onuska, Environmental Health and Safety Manager, INMETCO (July 1, 2003).

Since not every collection program recycles all battery types, sorting is necessary to remove batteries that fall outside of its scope. Additionally, sorting ensures that the proper battery chemistries are sent to a facility that can handle those chemistries.

Even after these initial one or two sortings, the recycling plant must again sort the batteries. The first reason for this is to ensure safety. For example, the accidental introduction of lithium batteries with a batch of alkaline batteries could cause an explosion. Because of the safety risk of contamination, sorting is something that is "best done by the experts."[51] The second reason is to avoid the introduction of hazardous materials that would trigger RCRA. Toxco, which reduces the danger of lithium battery explosion by using a cryogenic recycling process, is concerned with contamination because it does not wish to mix RCRA with non-RCRA wastes. If the contamination is too great, the resulting wastes would also be classified as hazardous.[52] Finally, limiting contamination ensures a higher grade product that can be sold for a greater price.

Currently, most facilities sort batteries by hand. The use of automated sorting technology is not widespread because it is not yet accurate enough to prevent potentially dangerous contamination.[53] According to Gemeinsames Rücknahmesystem Batterien Stiftung (GRS Batterien), the accuracy is around 98% while a purity level of 99% is required for Ni-Cd and Ni-MH batteries.[54] Europe is currently leading the development of improved sorting technology. The European Portable Battery Association (EPBA) has designed and developed automatic high speed battery technology. The front-end of the machine sorts the batteries by size while the back end uses both electronic sensors and high speed weighing to detect and sort batteries by chemistry. To facilitate the further sorting of alkaline batteries, members of the EPBA have marked all batteries that have no added mercury with easily detectable fluorescent ink since 1997.[55]

IV. Existing Battery Recycling Programs

Existing battery recycling programs can be classified based on either the method of collection or the method of finance. The various collection methods are drop-off (bring), curbside pickup, and mail-in. While there is no special designation for recycling programs paid for by the consumer or municipality, collection and disposal financed by the manufacturers is called take-back. Take-back programs can incorporate a number of different collection methods such as drop-off and curbside collection.

A. Drop-Off Programs

Drop-off programs require that consumers bring their depleted batteries to a central location for HHW.[56] Many municipalities have drop-off facilities for HHW or periodically hold HHW collection events.[57] However, typically only 1% of households utilize county or municipal HHW services.[58] A 2002 study published by the California Integrated Waste Management Board (CIWMB) examined various counties' capabilities to handle batteries and other HHW. With 57% of the counties in California responding, not one county collection center in California reported that the volume of batteries exceeded their handling capacity.[59] However, the collection rate, at 162,509 pounds, represented only 0.55% of battery sales that fiscal year (FY). Lack of consumer participation therefore appears to be a major problem causing low collection rates with drop-off programs.

One way to address low consumer participation in drop-off programs is to increase the number of collection locations. Businesses, offices, and even environmental clubs have initiated their own drop-off battery collection programs. In May 2002, the Illinois Student Environmental Network (ISEN) began providing an alkaline and rechargeable battery recycling service for Champaign County using Battery Solutions' Pail Mail program. ISEN established seven drop-off sites around the county. After operating one year, they recycled 2,800 pounds of batteries, twice their target volume.[60]

Michigan tried to encourage Ni-Cd battery drop-off by establishing a deposit system. Passed in March of 1995, the law was repealed three months later without ever being implemented.[61] Under the ephemeral law's system, consumers would have had to pay a $2.00 deposit unless they dropped off a used Ni-Cd battery at the time of purchase. The $2.00 deposit would be refunded if the consumer returned to that retailer within 30 days, or any collection or recycling facility after any length of time, with a used Ni-Cd battery. Collection or recycling facilities receiving batteries could seek reimbursement of the two dollars from the retailer. Any batteries collected by the store must be sent to a collection or recycling facility. Unredeemed deposits were to go from the retailer into an environmental response fund. However, due to the efforts of the Portable Rechargeable Battery Association (PRBA), the organization that founded the Rechargeable Battery Recycling Corporation (RBRC), the legislature repealed this law on June 30, 1995, and replaced it with the existing voluntary collection program.[62]

B. Curbside Battery Collection

Of the 9,247 curbside recycling collection programs in the

51. Ewles, *supra* note 50.
52. *See* Cal. Health & Safety Code §25143.2(d)(2)(A)(i) (West 1999).
53. Ewles, *supra* note 50; Onuska, *supra* note 50.
54. GRS Batterien, 2002 Annual Report 20 (2003), *available at* http://www.grs-batterien.de/english/monitor/download/monitor2.pdf (last visited Feb. 25, 2004) [hereinafter GRS Batterien Annual Report].
55. Environmental Resource Management, Analysis of the Environmental Impact and Financial Costs of a Possible New European Directive on Batteries 69 (2000).
56. While take-back programs require the consumer to drop off their batteries at a retailer or other location, they are considered a different category.
57. Just because batteries are dropped off at a collection center does not guarantee that they will be recycled. Only a few communities work with the Rechargeable Battery Recycling Corporation (RBRC) to recycle rechargeable batteries and most municipalities simply prepare alkaline batteries for proper disposal.
58. Telephone Interview with Bill Anderson, President, Curbside, Inc. (July 11, 2003) [hereinafter Anderson Interview].
59. Integrated Waste Management Board, Household Universal Waste Generation in California 11 (2002).
60. Telephone Interview with Laura Huth, Director, ISEN (June 23, 2003) [hereinafter Huth Interview].
61. Mich. Comp. Laws §324.17106a (1995).
62. *Id.* §324.17105c.

United States, only Minneapolis, in Hennepin County, Minnesota, collects consumer batteries. While most recyclables are collected weekly, the small volume of batteries allows for a less expensive bimonthly collection. Residents need only place their batteries in a clear plastic bag next to their other recyclables. The city then takes the batteries to the Hennepin County facility to be sorted. However, only the rechargeable batteries are recycled. Lithium batteries are disposed of in a hazardous waste incinerator, and alkaline batteries are disposed of at a hazardous waste landfill.[63]

Private hazardous waste haulers provide an alternative to municipal collection. Curbside, Inc. operates in 350 to 400 cities and counties nationwide.[64] Residents schedule a time for Curbside to pick up all of their HHW, including batteries. The waste is placed in a clear heavy-duty plastic bag. The cost for the consumer varies from $0 to $100 per bag depending on the level of community funding and the nature of the items collected.[65] Most of the waste, including all of the batteries, are recycled. Because of the high volume of batteries collected, Curbside ships them directly to the smelters. Curbside's participation rate for its first year of operations in each locality was around 4%, which is four times greater than participation in HHW collection events.

C. Mail-In Programs

One collection method that ensures the recycling of alkaline batteries is a mail-in program. These services are run by battery aggregators, such as Battery Solutions, or the recycling facilities themselves, such as INMETCO. The chemistries collected vary depending upon who runs the service but may include alkaline, rechargeable, or both. Businesses, agencies, county governments, or even environmental clubs can purchase special receptacles in which to store and ship their batteries. The cost of recycling the batteries and returning the bin is included in the purchase price. Typically the receptacles are 2-gallon or 5-gallon plastic bins, though industrial participants have the option of using 55-gallon drums. Once full, the collector mails the bin to either the aggregation or recycling facility.

Large generators of consumer batteries have the additional option of arranging a "milk run." Such a system is typically utilized by businesses that generate more batteries than can be economically mailed, but fewer batteries than can be individually transported to a recycling plant. In these programs, multiple generators agree to share the costs of hiring a single transporter to take the batteries directly to the recycling facility. This system reduces the expense to each business of mailing or shipping the batteries themselves.

D. Take-Back Programs

1. Benefits of Take-Back Programs

☐ *Solves Payment Problem*. Battery Solutions' president, Chris Sova, estimates that all consumer batteries could be recycled at a cost of only $.10 per battery. He also believes that the greatest barrier to recycling batteries is determining who is going to pay.[66] While seemingly small when viewed as cost per battery, with three billion consumer batteries sold each year, the total cost to recycle them would be $300 million.

The essence of a take-back program is moving the responsibility of disposal from the consumer to the manufacturer, the entity most capable of creating an efficient recycling system. The costs are ultimately passed back to the consumer, but would be lower than that of other systems, thereby creating efficiency. For instance, it is estimated that the cost of the RBRC program is roughly equal to 1% of total Ni-Cd sales. However, passing this cost to the consumers will not increase the price of the product by even 1%. That is because most batteries are included with the products, and thus contribute only a small percentage to the product's total cost.[67] Furthermore, the costs of take-back programs appear to be less because they are paid with the purchase of each battery or product rather than with the return of multiple batteries.

☐ *Increases Accountability*. Manufacturers are more accountable than consumers. It is impossible to enforce prohibitions against the improper disposal of hazardous materials imposed on households. However, the number of regulated entities decreases and the ease of enforcement increases if those batteries are collected by the manufacturers. Furthermore, it is easier to ensure that the batteries are recycled rather than merely disposed of properly. Policymakers or concerned consumers need only convince the take-back program operators rather than each and every municipal collection program. That the RBRC has chosen to recycle all of the rechargeable batteries that it collects suggests that this hurdle may have already been overcome.

☐ *Promotes Reuse*. Placing responsibility on the manufacturer promotes reuse of batteries if they are defective or damaged. Sometimes even recently purchased rechargeable batteries behave as if they are dead. Rather than disposal, these batteries may simply require service. One cellular phone manufacturer found that 80% to 90% of such batteries returned to it could be repaired, recharged, and resold.[68] While their capacity was slightly reduced (80% of original charge), they were resold at a discount. The resale value of even a refurbished battery is greater than the metals that may be recovered through recycling.

☐ *May Promote Redesign and Reduce Toxic Materials*. Since manufacturers pay for the collection and recycling of their own batteries, take-back systems provide an incentive to make the system work as efficiently as possible. This includes redesigning batteries for the ease of collection, sorting, and recycling. For instance, the industry may implement a better labeling scheme that facilitates sorting. Alternatively, taking-back alkaline batteries would provide manufacturers with an incentive to more aggressively market rechargeable batteries in order to reduce the volume of waste that they would have to transport and discard.

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63. City of Minneapolis, *Technical Details*, *at* http://www.ci.minneapolis.mn.us/solid-waste/tech.asp (last visited July 16, 2003).

64. Anderson Interview, *supra* note 58.

65. Curbside, Inc., *at* http://www.curbsideinc.com (last visited July 16, 2003).

66. Telephone Interview with Chris Sova, President, Battery Solutions, Inc. (July 8, 2003) [hereinafter Sova Interview].

67. Fishbein, *supra* note 3, at 19.

68. Buchmann, *supra* note 47, at http://www.buchmann.ca/Chap15-page4.asp (last visited July 16, 2003).

Take-back programs for other products, for instance, consumer electronics, also led to the reduction of hazardous materials. This potential may exist for batteries as well. The elimination of added mercury in alkaline batteries allowed for a less expensive recycling process and for less expensive alkaline battery recycling in general. Mercury is still present in button cell batteries (in trace amounts) and is a concern because of its explosive reaction with lithium. Ni-Cd batteries, though, cannot be redesigned to remove the cadmium, as it is essential to the battery design.

2. Take-Back Programs in the United States

☐ *State Take-Back Requirements*. One dozen states now impose take-back requirements on the manufacturers of rechargeable batteries. With the exception of Rhode Island, those states prohibiting the disposal of certain rechargeable batteries as MSW have also required a manufacturer take-back system. In the early and mid-1990s, Connecticut,[69] Florida,[70] Iowa,[71] Maine,[72] Maryland,[73] Minnesota,[74] New Jersey,[75] and Vermont[76] passed laws making manufacturers responsible for the collection, transportation, recycling, and proper disposal of rechargeable batteries.

Many components are common to all the various state programs. An example is Florida's law, which requires manufacturers, distributors, and marketers of rechargeable batteries to "implement a unit management program."[77] The law does not mandate the form that the program should take, though it must be in addition to any curbside collection system unless the local government agrees otherwise. It must also be "accessible to consumers," which requires that the manufacturers accept brands that are not their own as long as they are of the same general type. Another common feature of most state laws is the requirement that manufacturers clearly inform each purchaser of the take-back system and the prohibition on discarding rechargeable batteries into the MSW stream if that state prohibits it. Manufacturers failing to comply with the collection program requirements are prohibited from selling their batteries in the state, and most states have fines ranging from $100 to $10,000 per violation.

While most state laws hold manufacturers responsible for all existing batteries, Florida holds manufacturers liable for only the number of batteries that they manufactured and sold in the state that year. Theoretically, this protects the manufacturers from being responsible for tons of batteries that consumers have hoarded in anticipation of a proper method of disposal. In practice, with return rates so low, it is unlikely that the volume of returned batteries will exceed sold batteries, even in the law's initial year.

Minnesota has the only law that sets a collection target. It requires that a take-back program be established by 1995 and that it be "reasonably expected to collect [90%] of the waste rechargeable batteries" generated in the state.[78] The law also requires the operators of that program, currently the RBRC, to biannually prepare a report to the Legislative Commission on Waste Management. This report was to detail the estimated amount of batteries sold and collected in the state. However, in 1995, that commission, along with numerous others, was disbanded and the requirement neglected. Though there are no concrete numbers or rates, the estimated collection rate in Minnesota is believed to fall far short of the 90% target.

These state take-back laws, though their requirements may or may not have been met, have furthered the goal of increased battery recycling. First, they were crucial in promoting the development of battery recycling plants capable of handling the new waste. Second, the differing state laws provided an impetus for the creation of the RBRC to provide reverse distribution infrastructure. Finally, they led the industry to seek passage of the Battery Act.

☐ *The RBRC*.

(1) Process

One significant battery recycling program is only for rechargeable batteries. In 1994, the PRBA established the RBRC. Impetus for the RBRC's creation came from the state take-back laws and its allowance of a trade association to act in place of the manufacturers.[79] The RBRC is a nonprofit organization with over 320 member manufacturers totaling 90% of the battery industry.[80] Its goals are to promote the recycling of rechargeable batteries and to lobby on the manufacturers' behalf.

The RBRC implemented four types of collection systems. First, households may return their rechargeable batteries, free of charge, to any of over 30,000 retail locations such as RadioShack or Target. The RBRC provides each retailer with collection containers, plastic bags for each individual battery, signs and promotional materials, and prepaid, preaddressed shipping labels. The retailer then ships the batteries, free of charge, to one of RBRC's four aggregation centers. This is the only collection system whose costs are wholly covered by the RBRC.

The second system utilizes a municipality's existing HHW collection site/event or curbside recycling program. Municipalities must sort out the rechargeable batteries and gather them in a single location. The RBRC will then transport them to one of its own aggregation centers. The municipality must pay for the existing collection system and sorting of all batteries, and the aggregation, storage, and disposal of those batteries not included in the RBRC program. The municipality need not pay for further transport and disposal of the rechargeable batteries, though. In 2002, only 674 municipalities took the RBRC up on this service.[81]

69. Conn. Gen. Stat. Ann. §22a-256c (West 1995). This take-back program applies only to mercuric oxide batteries, while the other states' programs apply to mercuric oxide, Ni-Cd, and SSLA batteries.
70. Fla. Stat. Ann. §403.7192(6) (West 2002).
71. Iowa Code Ann. §455D.10A(3)(a) (West 1997).
72. Me. Rev. Stat. Ann. tit. 38, §2165(4) (West 2001).
73. Md. Code Ann., Envir. §6-1102 (1996).
74. Minn. Stat. Ann. §§115A.9155-57 (West 1997).
75. N.J. Stat. Ann. §13:1E-99.65(7)(b) (West 2003).
76. Vt. Stat. Ann. tit. 10, §6621(b) (1997).
77. Fla. Stat. Ann. §403.7192(6) (West 2002).
78. Minn. Stat. Ann. §115A.9157.
79. *See* Fla. Stat. Ann. §403.7192(8).
80. Rechargeable Battery Recycling Corporation, Annual Report 2002, at 1 (2003), *available at* http://www.rbrc.org/graphics/PDF/AnnualReport.pdf (last visited July 16, 2003) [hereinafter RBRC Annual Report].
81. E-mail from Ralph Millard, Executive Vice President, RBRC (June 9, 2003) (on file with author).

The third system utilizes the existing business and government agency collection systems required by RCRA. The RBRC has since distinguished between these two programs by providing collection materials at no cost and paying for shipping at government agency collection sites. Businesses must still pay to ship their batteries to one of the RBRC aggregation centers. The RBRC merely eliminates the recycling or disposal costs for businesses. This could serve as a disincentive for businesses to participate in the program. The rationale possibly is because businesses are already required to recycle their rechargeable batteries under RCRA.

The fourth system utilizes the RBRC licensees' existing distribution network. Black & Decker, for instance, can collect batteries from its own retailers and service centers and ship them directly to the recycling facility. In return, the RBRC rebates some of the fee they charge the licensee for the use of their seal.

Once at the aggregation centers—which occurs in all but the licensee take-back system—the batteries are sorted, bulked into shipments of 10,000 to 40,000 pounds, and sent to either INMETCO or Toxco to be recycled.

(2) Effectiveness

After almost one decade of effort, the RBRC's program has not lived up to its hopes, achieving only a 6% to 15% recycling rate. On the positive side, the number of drop-off locations, battery chemistries, and total pounds collected have all increased. Initially, retail collection was established only in those states that had adopted the universal waste rule to ensure that the retailers would not be classified as hazardous waste handlers. Only two weeks after the passage of the Battery Act, the program grew from 16 to 35 states.[82] Today, it operates nationwide and in Canada with 35 retail partners at over 30,000 locations.

The RBRC is financed through license fees charged to those battery and product manufacturers who wish to use the RBRC seal on their products. The fee is based on the weight of the batteries that the manufacturer placed on the market in the previous quarter, thus linking sales volume to disposal responsibility. However, the fees are determined only after the education, collection, and recycling budget is established. Therefore, manufacturers are not being charged for the cost of disposing every battery manufactured, but rather the cost of every battery recycled, which is much less. Though this system has the potential to pay for the collection and recycling of every rechargeable battery sold in the United States, the cost of such a thorough recycling program may act as a disincentive for an aggressive expansion of the program.

The volume of rechargeable batteries recycled by the RBRC has increased every year since its establishment. INMETCO received 69% more batteries, by volume, in the fourth quarter of 1996 as it did the previous quarter. This increase has been attributed to the RBRC's efforts.[83] In 1998, INMETCO added three new furnaces to the four existing ones and dedicated them solely to portable Ni-Cd battery recycling.[84]

Volume of Batteries Collected by RBRC (in thousands of pounds)[85]

RRBC Program	1995	1996	1997	1998	1999	2000	2001	2002	Total
Ni-Cd	928	1,619	1,944	2,142	2,239	2,457	2,513	2,679	16,521
Other Chemistries						123	494	686	1,303
Total	928	1,619	1,944	2,142	2,239	2,580	3,007	3,365	17,824
% Increase		74%	20%	10%	5%	15%	17%	12%	

82. Fishbein, *supra* note 3, at 12.

83. Lankey & McMichael, *supra* note 48, at 8.

84. Plachy, *supra* note 9, at 6.

85. Millard, *supra* note 81.

The RBRC has expanded from initially accepting only Ni-Cd batteries, which was the battery of main concern for most states, to accepting Ni-MH, Li-ion, and SSLA batteries as well. The expansion was facilitated by adding capacity at recycling plants for additional battery types. INMETCO is capable of recycling Ni-Cd, Ni-MH, and Li-ion batteries,[86] while Toxco recycles lithium metal and Li-ion batteries.[87] It is noteworthy that even though Toxco had facilities for lithium metal batteries, the RBRC did not expand to include that type. This is possibly due to the extra transportation requirements. More likely, the RBRC probably decided that since lithium metal batteries are not rechargeable, recycling them falls outside of their responsibility.

Critics of the RBRC point out that it has failed to reach its stated goals. In 1993, 2% of Ni-Cd batteries sold in the United States were recycled. In 1995, that number rose to 15%. Buoyed by such a dramatic increase, the RBRC predicted that it would recycle 5.1 million pounds, or 25% of the estimated Ni-Cd sales volume, in 1996 and 26.3 million pounds, or 70% of the estimated Ni-Cd sales volume, in 2001.[88] However, recycling rates have not matched the RBRC's hopes. In 2002, the RBRC recycled only 2.7 million pounds, achieving less than a 6% recycling rate for Ni-Cd batteries, far below what the RBRC predicted.[89]

Another concern some critics have had about the RBRC is that it is not actually diverting batteries from the waste stream. In 1995, less than 4% of the total batteries the RBRC recycled were from households.[90] The remaining batteries were diverted from the industrial waste stream which, under RCRA, were required to have been recycled anyway. In 2002, the RBRC approximated that it collected 44% of its battery volume through retailers, which is where most consumer batteries would be returned, 30% through businesses, 20% through licensees, and 6% through communities and public agencies.[91] Since the sales volume for industrial batteries has remained constant over the last few years, most of the recent increase must have come from consumer batteries. In 2000 it was estimated that 60% of the RBRC's batteries were consumer batteries, though comparing batteries to volume is difficult since consumer batteries are smaller than industrial batteries.[92]

Finally, while the RBRC touts itself as a voluntary industry initiative, it is only partially correct. Its member manufacturers are required under a few state laws to take back their batteries. The manufacturers found it easier to work through the RBRC then to each individually comply with different state laws. However, if the RBRC fails to meet the requirements of the state laws, the manufacturers would be held liable. One unaddressed question is the state of the program in Minnesota. Minnesota's law requires that the RBRC be reasonably expected to collect 90% of the batteries sold in the state. However, it appears that the state has abandoned its expectations that the RBRC could perform so well.

☐ *Individual Company Take-Back Programs*. Before the RBRC, a few individual companies had their own take-back programs. In 1992, Black & Decker offered a five dollar discount on purchases if they returned their old Ni-Cd battery to a service center. Compaq provided their laptop customers with a postage paid envelope to ship their batteries directly to INMETCO and would pay the recycling fee.

3. International Take-Back Programs

Most European take-back laws are based on the European Community (EC) (formerly named the European Economic Community (EEC)) Directive 91/157/EEC, which requires the separate collection and disposal of SSLA and Ni-Cd batteries.[93] The directive requires the marking of batteries to indicate separate collection, recycling (where appropriate), and heavy metal content. It does not require that the batteries be recycled, however. EC Directive 93/86/EEC specifies the markings and symbols required by 91/157/EEC.

Many European nations have expanded upon EC Directive 91/157/EEC. Some countries, when faced with the mandate of collecting and disposing SSLA and Ni-Cd batteries, chose to hold the manufacturers and distributors responsible instead. Some countries also require the collection of alkaline, lithium, and Ni-MH batteries. The various Asian and European take-back programs present a diverse range of structures for implementation and financing that may serve as a model for U.S. legislation.

☐ *Payment by Manufacturer to Industry Organization*. The most common strategy for collecting consumer batteries is having the manufacturers contribute to an organization that they have formed for that purpose. The organization then either pays to collect batteries itself or pays municipalities for their efforts. This system is also employed by U.S. battery manufacturers through the RBRC.

(1) Austria

The Ordinance on the Take-Back and Limitation of Batteries and Accumulator Pollutants requires that dealers take back all the types of batteries they sell, including alkaline, lithium, and Ni-Cd batteries.[94] Manufacturers and importers established the Umweltforum Batterien (UFB) to collect batteries from the retailers free of charge.[95] The UFB provides collection boxes to retailers and bags to households. Consumers are rewarded for returning their batteries with lottery tickets. In 2000, the UFB collected 53% of the nation's total battery waste.[96] In 2001, Austria set a target collection rate of 65% in 2005.

86. *See* INMETCO, *Battery Recycling at INMETCO*, *at* http://www.INMETCO.com/batt.htm (last visited July 16, 2003).

87. Buchmann, *supra* note 47, at http://www.buchmann.ca/Article16-Page1.asp (last visited July 16, 2003).

88. Fishbein, *supra* note 3, at 18; Lankey, *supra* note 1, at 126.

89. Using the sales volume for 2001 that they estimated in 1995. Sales figures are considered proprietary and are not released.

90. Francis C. McMichael & Chris Henderson, *Recycling Batteries*, IEEE Spectrum, Feb. 1998, at 38.

91. Millard, *supra* note 81.

92. Plachy, *supra* note 9, at 6.

93. EC Directive 91/157/EEC also limits the use of mercury in batteries like the U.S. Battery Act did a few years later.

94. *Available at* http://www.collectnicad.org/legislation/pdf/AUSTRIA_EngBattV.pdf (last visited July 25, 2003).

95. Raymond Communications, *supra* note 5, at 51.

96. European Portable Battery Ass'n, *Battery Statistics*, *at* http://www.styrax.com/demons/epba/Recycling_ (last visited Feb. 26, 2004). The uncertainties in calculating recycling rates and the inconsistencies between different studies should be noted throughout this section.

(2) France

Decree No. 99/1171 requires that manufacturers and distributors collect and recover all consumer battery types.[97] Retail stores are required to collect any returned batteries, who in turn pass them along to the manufacturers.[98] There are a number of organizations that collect batteries and battery-containing electronics in France, the most notable of which is Fibat. Fibat collects a fee from manufacturers based on market share.[99]

(3) Germany

The German Battery Decree requires consumers to return all their spent batteries to the retailer or a specified public waste disposal collection point.[100] Retailers must accept used batteries even if they were purchased from another vendor and may not charge a fee. Manufacturers are required to take the batteries from the retailers and collection points and recycle or dispose of them properly, also without charging a fee. All vendors must have highly visible signs that notify consumers of their legal responsibility to return the batteries, that they may be returned free of charge, and a description of the hazardous substance labels on the batteries. The German Battery Decree also mandates the collection and dissemination of data that is unavailable in the United States. Manufacturers must submit information to the government on the volume of batteries put into circulation and taken back, the qualitative and quantitative recycling and disposal results, and the total prices paid for the sorting, recycling, and disposal.[101]

As a result of the decree, major battery manufacturing companies formed GRS Batterien, a nonprofit organization, to organize battery collection, sorting, and disposal. Manufacturers pay a fee proportional to their sales. The response of GRS Batterien as to whether commercial producers or even municipalities should sort their batteries is "[n]o. There are over 300 different battery types and more than 10 different battery [chemistries], the sorting of which would overtax anyone."[102] In 2002, GRS Batterien spent €12.6 million (euros).[103] Germany has over 140,000 stores that participate in the collection of batteries,[104] far more than the 30,000 stores that the RBRC has established in the whole of Canada and the United States. The recovery rate is around 38%.[105]

(4) Hungary

In order to meet European Union (EU) requirements, Hungary has required since January 1, 2002, that manufacturers or dealers in Hungary collect all consumer battery types. They may collect batteries themselves, establish a common collection network, or contract with municipalities to collect the batteries for them.[106] Lower capacity batteries of all chemistries may be collected in a single container at collection points. Higher capacity batteries, which pose a greater risk of short-circuiting and fire, must be collected in special receptacles. Collection may be done in retail stores.

(5) Italy

Italy requires that manufacturers provide retailers with a receptacle for depleted Ni-Cd and SSLA batteries.[107] Manufacturers have also established a voluntary deposit system for Ni-Cd batteries.[108]

(6) Japan

Japan initially began with a voluntary program. After failing to meet collection targets, Japan required that manufacturers and importers collect and recycle their rechargeable batteries. Collection targets set for the year 2003 are 60% of Ni-Cd batteries, 55% of Ni-MH batteries, 50% of SSLA batteries, and 30% of lithium batteries. The average collection rate in 1998 was 28% for Ni-Cd batteries.[109] Data for the other chemistries is not available. Eighty percent of the collected batteries were appliance batteries and were collected by appliance retailers. Seventeen percent of the batteries collected were from internal industry recycling programs. The remaining 3% came from collection sites in retail stores and municipal recycling programs.[110]

(7) The Netherlands

In the Netherlands, manufacturers must ensure that any consumer battery they sell is collected.[111] The Dutch Decree sets a collection target of 90%. If unmet, the law allows for the creation of a deposit. To achieve this task, Dutch manufacturers and importers pay a fee to an industry organization called Stibat. Much of the responsibility for collecting batteries falls on municipalities.[112] Consumers must generally bring their batteries to community collection centers, though participating retail stores also serve as drop-off points. In 1996, the collection rate was 52%. This rose to 70% in 1999 albeit under a different estimation tech-

97. *Available at* http://www.collectnicad.org/legislation/pdf/FRANCE_Eng_Bat_Decree-29_12_99-Fra.pdf (last visited July 25, 2003).

98. Decree No. 99/374, *available at* http://www.collectnicad.org/legislation/pdf/FRANCE_Eng_Bat_Decree12_05_99-Fra.pdf (last visited July 25, 2003).

99. Raymond Communications, *supra* note 5, at 60.

100. Decree Regarding the Collection and Disposal of Used Batteries and Accumulators, *available at* http://www.grs-batterien.de/english/manufact/download/battv_en.pdf (last visited July 16, 2003).

101. Raymond Communications, *supra* note 5, at 62.

102. GRS Batterien, *Questions and Answers for Municipalities*, *at* http://www.grs-batterien.de/english/faq/municipa.htm (last visited July 16, 2003).

103. GRS Batterien Annual Report, *supra* note 54, at 28.

104. *Id.* at 15.

105. This is a rough estimate comparing the volume sold in 2001 (29,012 tons) to the volume collected in 2002 (11,393 tons).

106. Decree by the Minister of Environment Protection 09/2001, *available at* http://www.collectnicad.org/legislation/pdf/HUNGARY_Hungary_env_regul.pdf (last visited July 25, 2003).

107. Decree No. 476, *available at* http://www.collectnicad.org/legislation/pdf/ITALY_Eng_Bat_Decree20_11_97-It.pdf (last visited July 25, 2003).

108. Raymond Communications, *supra* note 5, at 65.

109. Environmental Resource Management, *supra* note 55, at F4.

110. *Id.*

111. Batteries Disposal Decree, *available at* http://www.collectnicad.org/legislation/pdf/NETHERLANDS_Battery_DecreeJan95.pdf (last visited July 25, 2003)

112. Raymond Communications, *supra* note 5, at 68.

nique.[113] Other sources suggest that the rate was only 32% in 2000.[114] The cost of the program is about €9 million a year.[115]

(8) Portugal

Decree No. 62/2001 requires the collection of industrial and all consumer battery types.[116] Battery manufacturers and importers are entirely responsible for the collection of industrial batteries. Municipalities and large retail stores, however, must be collection points for consumer batteries, though the manufacturers are still required to pay for it. Collection is organized through a manufacturer established "entity" to which each member contributes according to their market share. This program is one of the most recent in Europe and the collection rate is around 5%.[117] Portugal also established the Commission to Follow Up Battery and Accumulator Management to ensure that the requirements are met.

☐ *Payment by Manufacturer to Government Agency.* Another common payment system is to have the battery manufacturers pay a tax or fee to the government that then distributes the money.

(1) Belgium

In 1996, Belgium established a fund called BEBAT to finance the collection of used batteries.[118] Battery producers, importers, and distributors may voluntarily contribute to the fund in order to receive an exemption from Belgium's eco-tax.[119] However, the exemption only applies if BEBAT meets its 75% recovery target. If unmet, Belgium will retroactively charge BEBAT's members for the eco-tax on the amount of batteries by which they are short. Current recovery rates are around 67%, though data from 2000 suggest the rate is around 54%.[120] This take-back system has been criticized for being the most expensive system in Europe.

(2) Denmark

Denmark's 1995 Law No. 414[121] placed an eco-tax on Ni-Cd batteries and was followed in 1996 by Order No. 93, which established a bonus for the collection of Ni-Cd batteries.[122] Manufacturers and importers pay the eco-tax that is then paid to battery collectors. The tax has resulted in $6.4 million in 1996 and $4 million in 1998, and the payment to collectors averages $16.60 per kilogram of batteries. Not surprisingly, collection rates vary depending upon the measuring parameters. One source estimates that the collection rate was around 50% in 1997.[123] The Danish EPA, analyzing solely Ni-Cd batteries, places the rate at 79% and has set a goal of 95% collection by 2004.[124] Denmark's solid waste management plan, Waste 21, has also called for the end of the distinction between "hazardous" and "nonhazardous batteries" and for the collection of all battery types.[125]

(3) Slovakia

Manufacturers and importers of batteries are required to contribute to the national Recycling Fund.[126] They must also submit production and collection data to the Recycling Fund.[127] The Recycling Fund is a legal entity established to facilitate the collection and disposal of numerous recyclable and hazardous wastes. Contribution to the fund is based on the quantity or weight of the product sold in the country plus a charge based on the estimated cost of collecting and recycling those wastes.[128]

(4) Sweden

Swedish battery suppliers, importers, wholesalers, and retailers agreed to a voluntary take-back program in 1993 in order to avoid formal take-back legislation.[129] The agreement set a collection goal of 90%, though the rate wound up only being around 30%. Sweden now requires that manufacturers and importers pay a fee depending upon the battery chemistry, the revenue of which goes to the Swedish EPA. Municipalities, however, still collect, sort, and transport the batteries for disposal,[130] which is as it was under the voluntary program. In 1998, the collection rate was estimated at 40%.[131]

(5) Taiwan

Taiwan requires the take-back of all battery chemistries.[132] It has set collection targets of 40% through 75% depending upon the battery chemistry. The Taiwanese EPA pays for the program by collecting fees from the manufacturers and importers based on the battery chemistry.

113. Environmental Resource Management, *supra* note 55, at F3.

114. European Portable Battery Ass'n, *supra* note 96.

115. Raymond Communications, *supra* note 5, at 68.

116. Raymond Communications, *supra* note 5, at 72, *available at* http://www.collectnicad.org/legislation/pdf/PORTUGAL_Portugal_law_decree_on_batt.pdf (last visited July 25, 2003).

117. Edie, *How Should Battery Recycling Be Calculated?*, Oct. 18, 2002, *at* http://www.edie.net/news/Archive/6153.cfm (last visited Feb. 26, 2004).

118. Royal Order concerning the methods for providing evidence of the purchase in Belgium of batteries which are the subject of a deposit or a return premium, *available at* http://www.collectnicad.org/legislation/pdf/BELGIUM_Eng_Bat_Order-16_04_96-Bel.pdf (last visited July 25, 2003).

119. Raymond Communications, *supra* note 5, at 53.

120. European Portable Battery Ass'n, *supra* note 96.

121. *Available at* http://www.collectnicad.org/legislation/pdf/DENMARK_Eng_Bat_Bill-22_02_95-Den.pdf (last visited July 25, 2003)

122. Raymond Communications, *supra* note 5, at 55.

123. Environmental Resource Management, *supra* note 55, at F3.

124. 120 tons of Ni-Cd batteries were generated in 1997 and 95 tons were collected for recycling. *See* Danish EPA, *Waste 21*, *at* http://www.mst.dk/udgiv/Publications/1999/87-7909-571-2/html/bilag05_eng.htm (last visited July 16, 2003).

125. Steen Gade, Danish Ministry of the Environment, *Separate Collection of All Batteries*, *at* http://www.mst.dk/news/06010000.htm (last visited July 16, 2003).

126. Act on Waste, §41(11), *at* http://www.collectnicad.org/legislation/pdf/SLOWAKIA_Slovakia_Waste_Legislation_Zakon.pdf (last visited July 25, 2003).

127. *Id.* §41(17-18).

128. *Id.* §56.

129. Raymond Communications, *supra* note 5, at 76.

130. Battery Ordinance §§8-9, *at* http://www.collectnicad.org/legislation/pdf/SWEDEN_Eng_Bat_Ordinance_19_6_97_Swe.pdf (last visited July 25, 2003).

131. Environmental Resource Management, *supra* note 55, at F3.

132. Raymond Communications, *supra* note 5, at 92.

☐ *Payment by Consumer (Hybrid Take-Back)*. A few countries hold battery manufacturers responsible for collecting spent consumer batteries but do not require them to finance the collection. Instead, the costs of these hybrid take-back systems fall upon the consumers or the municipalities.

(1) Switzerland

In 1986, Switzerland established a voluntary program for all consumer batteries and set a collection target of 80%.[133] Interestingly, in 1991 Switzerland banned the export of discharged batteries, increasing the cost of their program sixfold. In 1998, Switzerland required manufacturers and importers to take back all battery chemistries as the goals were not met through the voluntary program.[134] This was, in part, due to the presence of free-riders—companies that benefitted, but did not participate—in the voluntary program.[135] Recycling is paid for by the consumer at the time of purchase through a fee called the prepaid disposal charge. The proceeds then go to Inobat, a battery disposal interest group, that collects, transports, and recycles the waste batteries. The recovery rate in 2000 was around 71%.[136]

(2) Spain

Spain's legal framework for battery collection is similar to the U.S. framework in that the absence of a national law has led individual states to create their own programs.[137] Typically, municipalities must collect the batteries while manufacturers and importers must see to their disposal. Spain's law applies to all battery chemistries. This program is paid for by the consumer through increased battery costs. There is no deposit, tax, or fee on the batteries. Collection rates in Spain are as low as 5%.[138]

☐ *Future EU Take-Back Legislation*. The EU is preparing an ambitious take-back program for electronics that would be implemented under the Waste Electrical and Electronic Equipment Directive. This will come into force once it is adopted by the European Parliament and Council, which is expected by August 2004.[139] The directive requires manufacturers of electrical equipment to take back their product. Though batteries are not one of the categories upon which the directive focuses, they are typically present in many of the electronic devices that are regulated. The directive will encourage electrical equipment reuse and establish collection, recovery, and recycling targets for the producers to meet. The directive will require distributors to ensure that the equipment can be conveniently returned without cost to the consumer. A second directive, the Restriction of Hazardous Substances Directive, is expected to restrict and phase out the use of certain hazardous substances in electrical and electronic equipment.

V. Barriers to Increased Battery Recycling

A. Collection Barriers

The cost and difficulty of collection, along with sorting, pose the most difficult challenges to battery recycling according to James Ewles at the Raw Materials Corporation.[140] We discuss below some of the issues in collecting batteries for recycling.

1. High Cost of Collection

The cost of collecting batteries for recycling varies depending upon the method used. Environmental Resources Management estimated the annual financial costs for curbside, drop-off, and take-back collection methods for the United Kingdom.[141] They estimated that the curbside program would cost $6 to $14 million if joined with an existing curbside collection system, or $20 to $49 million if it were a stand alone program. A drop-off program would cost between $7 to $17 million, and a take-back program would cost $44 to $111 million. The collection costs would be 85% to 97% of the total costs for the curbside collection and take-back systems, and 55% to 70% for the drop-off system.[142]

A 2002 study published by the CIWMB examined the costs of municipal drop-off programs in California.[143] The 2000-2001 FY cost associated with collecting batteries was $172,560.[144] This is a result of a return rate of around 0.55%.[145] The CIWMB estimated the cost in 2006 for the 32 counties surveyed to be $31,072,760, reflecting an unachievable 100% collection rate.

2. Consumer Inconvenience

Those recycling systems that depend on consumer participation, e.g., drop-off and curbside, have very low recycling rates due to low participation. One problem is that most consumers will not make a special trip to a HHW facility or even arrange for curbside pickup unless they have a critical mass of wastes. This applies to all HHW, but is even more problematic for consumer batteries because of their small volume. Similarly, since most batteries expire individually or in pairs, this volume of waste is considered inconsequential

133. *Id*. at 78.

134. Order Regulating Materials Harmful to the Environment, *available at* http://www.collectnicad.org/legislation/pdf/SWITZERLAND_Eng_Haz_Mat_Order1Jul98_Swi.pdf (last visited July 29, 2003).

135. Swiss Agency for the Environment, Forests, and Landscape, *A Guide to Waste: Batteries and Accumulators*, *at* http://www.umwelt-schweiz.ch/buwal/eng/fachgebiete/fg_abfall/abfallwegweiser/batterien/index.html (last visited Feb. 26, 2004).

136. Swiss Agency for the Environment, Forests, and Landscape, Batterie Statistik 1 (2001), *available at* http://www.umwelt-schweiz.ch/imperia/md/content/abfall/batteriestatistik.pdf. (in German).

137. Raymond Communications, *supra* note 5, at 74.

138. Edie, *supra* note 117.

139. United Kingdom Department of Trade and Industry, *EC Directive on Waste Electrical and Electronic Equipment and EC Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment*, *at* http://164.36.253.20/sustainability/weee/index.htm (last visited July 16, 2003).

140. Ewles, *supra* note 50.

141. Environmental Resource Management, *supra* note 55.

142. Collection and recycling costs could be significantly greater than the above approximations if the mercury content of the batteries is such that the use of electric arc furnaces would not be deemed acceptable.

143. Integrated Waste Management Board, *supra* note 59.

144. This applies to only those responding, which was 52% of the total number of counties representing 57.7% of the state's population. Furthermore, this study isolated the costs for batteries while other HHW was collected by those facilities.

145. Integrated Waste Management Board, *supra* note 59, at 12.

and is simply discarded. Curbside, Inc. believes that this is the reason the volume of batteries that they collect is far less than it "should be."[146] Curbside has also noticed that attaining this critical mass is facilitated through the disposal of other HHW. Its customers do not arrange pickups solely for batteries, but they are more likely to include batteries when disposing of bulkier objects such as cans of paint.

A second problem is that some systems, such as consumer drop-off, have inherently weak economics. It probably does not make sense, either from an individual economy or environmental quality perspective, for millions of consumers to make special trips to drop off a few pounds of batteries at a remote location. Given the time costs involved, it certainly would not make economic sense to most consumers to participate in drop-off programs, and given the gasoline and energy consumed, drop-off programs may not even create any net environmental benefit.

A third problem is that consumers are faced with difficult sorting requirements, as most consumers do not know the chemistries of the batteries that they use. They may be able to recognize that their AA, AAA, C, or D batteries are alkalines, but this may decrease should rechargeable batteries of these sizes increase in popularity and comingle with the familiar alkaline market. The sorting difficulty is inherent in consumer-initiated recycling methods, making improved facility-based sorting technology essential.

3. Difficulty in Measuring the Problem

There is a severe lack of public data regarding the composition of the battery market. Battery manufacturers do not release annual sales volume data as they are considered proprietary. This ignorance leads to a fundamental misunderstanding of the composition of the industry and the characteristics of the waste. Though most reports follow EPA's lead in stating that three billion consumer batteries were used in 1998, that value was determined in the 1992 report, *Getting a Charge Out of the Wastestream*, by David Hurd. That report actually estimated the number of consumer batteries used in 1992 to be closer to 3.5 billion. In the decade that has passed since the report was written, Ni-MH and Li-ion batteries were invented and their use in cellphones, laptop computers, and other personal electronics has exploded. The amount of batteries sold and discarded is undoubtedly much greater than that figure suggests.

4. Difficulty in Estimating Success (Collection Rates)

Currently it is very difficulty for a recycling program that establishes targets to be able to correctly measure the collection rate to determine the program's success. First, as described above, much of the necessary data is not collected or made public. Without this information, researchers are forced to estimate the sales volume, leading to varied results. Reviewing a number of different sources led one researcher to estimate that annual battery waste for 1998 in the United States was between 245 and 735 million pounds.[147] If a collection target were 50%, would the volume be 123 or 368 million pounds? Necessary state specific data is similarly unavailable for those states like Minnesota that have set a target.

Second, there are multiple, uncoordinated efforts to collect and recycle batteries. Measuring any one program only captures a fraction of the total waste. For instance, RBRC, Curbside, Inc., and INMETCO all collect batteries independent of one another. Each organization's collection rate would thus be an underestimate.

Third, some researchers use INMETCO's volume, which is a combination of both industrial and consumer batteries, as a basis for a recycling rate. Neither the company, nor the recycling process, distinguish the two battery types. The result is that the high collection rate of industrial batteries (approximately 90%) may conceal the collection rate for consumer batteries.

Fourth, there is no established method to calculate collection rates. Battery Council International created a standard formula to determine the recycling rate for automotive lead-acid batteries, however, no such rate exists for consumer batteries. The most common method is to compare the weight of batteries collected to the weight of batteries sold, thus requiring the above assumptions. The second method is to compare the weight of the batteries collected to the amount found in MSW. This method requires continued sampling of MSW, but since that has not been done, the data from this method are less reliable.[148]

Finally, the sales volume cannot be equated to that year's discarded volume because batteries remain in consumers' possession for years. Using the number sold as a proxy for number discarded in a given year is acceptable, but will produce a lower than actual collection rate, since typically, fewer batteries were manufactured in previous years. Some studies compensate by presuming an average life of a battery and comparing it to the market in that year. However, different studies assume different life-spans, leading to various collection rates.

B. Transportation Barriers

1. Potential Difficulty of Transporting Lithium Batteries

Though transporters of lithium batteries face additional regulations, these have not proven to hinder the movement of batteries for disposal. For one, most consumer lithium batteries contain less lithium than is necessary to trigger the regulations. Also, depleted lithium batteries pose less of a hazard than new ones, as the reactive lithium metal undergoes a chemical conversion in order to produce electricity. When depleted, most of the lithium is unreactive. However, larger sizes may be present and undischarged batteries still find their way into the waste stream, and so transportation regulations for lithium batteries may pose a problem.

2. Interstate Shipping

One concern of recyclers is being subject to different state regulations as they ship the batteries to the recycling facility. The classification of certain Ni-MH batteries as hazardous in California may pose transportation difficulties for transporters passing through California.

146. Anderson, *supra* note 58. That is, people use far more batteries than they set out to recycle.

147. Lankey, *supra* note 1, at 50.

148. Carl Johan Rydh & Magnus Karlström, *Life-Cycle Inventory of Recycling Portable Nickel-Cadmium Batteries*, 34 Resources, Conservation & Recycling 289, 294 (2002).

3. Shipping Costs

Shipping costs present a barrier to increased battery recycling, as the small number of recycling facilities means that batteries must be transported over a greater distance. All lithium batteries have to be shipped to Toxco in British Columbia and all Ni-Cd batteries must be shipped to INMETCO in Pennsylvania. The long distances that batteries must travel increases the overall financial (and environmental) costs of recycling batteries. As mentioned above, some generators coordinate shipments so that they need not pay the whole expense themselves.

C. Sorting and Processing Barriers

1. Sorting Costs

A key barrier to increased recycling is the high cost of sorting waste batteries. The cost of sorting is tied primarily to the cost of labor. Automatic battery sorting machines are too inaccurate to justify their high cost, leaving slower manual sorting as the favored option. Sorting costs are estimated to be between $.10 and $.20 cents per pound,[149] which although relatively small, must then be multiplied by the number of times batteries are sorted. This includes sorting by the county/municipality, sorting by the aggregator, and sorting by the recycling facility. Improved automated battery sorting technology is a pivotal need for enhanced recycling.

Since sorting relies on manual labor, the more difficult the process, the greater the expense. One of the most difficult, and thus expensive, batteries to recycle are button cells. Without formal training or reference materials, it may be impossible to determine their chemistry. Most button cell batteries have no writing on them, but are instead referenced by number. The numbers are not standardized across the industry so each manufacturer has its own number code and the sorter must use a key provided by the manufacturer. However, because the manufacturer is often not apparent, it is difficult to even determine which key to use.

2. Other Costs of Recycling

Another major expense in battery recycling is the energy cost of crushing, chipping, and processing waste batteries. There are as many processes for recycling batteries as there are battery chemistries. Though the engineering aspects of various methods are beyond the scope of this Article, it is worth mentioning that some facilities, like Electric Arc Furnace, require much more electricity than others.

A pilot project is underway to recycle alkaline batteries by inserting them directly into the furnace. By negating a step of chipping and crushing of batteries into smaller pieces, this process can reduce overall recycling costs by one-third.[150]

3. Lack of an After-Market

One of the reasons battery recycling is not a highly profitable industry is that the after-market for raw materials is weak. The metal recovered from batteries is not particularly valuable, while the cost of labor and energy to recycle them is high, averaging $1,000 to $2,000 per ton recycled,[151] though this varies by battery chemistry. The high nickel content in Ni-MH batteries make them the only type of battery to break even or to possibly provide a small return; next comes alkaline batteries, which result in only a small net loss, as alkaline batteries have a high iron content that is in demand. Ni-Cd batteries lose three times as much as alkaline batteries do, as cadmium is neither expensive nor in demand, with the only demand for cadmium being other Ni-Cd batteries.[152]

Under current economics, the consumer must subsidize the costs of recycling for most battery chemistries. The Illinois Student Environmental Network estimates that its program costs around $1.32 per pound, most of which is due to the fee for recycling the batteries.[153] Kinsbursky Brothers, Inc., typically charges between $.65 to $.85 per pound to recycle alkaline batteries but only $.20 per pound to dispose of them in a hazardous waste landfill.[154] Therefore, Kinsbursky Brothers, Inc., estimates that of the 250,000 pounds of alkaline batteries that they receive annually, only 20% are recycled because consumers do not want to pay extra.

4. Life-Cycle Costs

Battery manufacturers and trade organizations urge that attention be focused on the most hazardous batteries. They often cite Environmental Resource Management's 2000 report for the United Kingdom's Department of Trade and Industry that concluded that the environmental benefit of reducing battery heavy metal inputs to landfills or incinerators can be outweighed by the environmental impacts of collection and recycling. The incremental resources and energy used to collect and process waste batteries would increase pollution and resource use. If recycling is done in an inefficient manner, the latter impacts may outweigh the benefits.

While the collection and recycling of consumer batteries will undoubtedly shift environmental effects, the overall impacts may not be as severe as that report concludes or as battery manufacturers claim. According to the model used, the primary source of these environmental impacts is the manufacture of new household receptacles.[155] The model

149. Sova Interview, *supra* note 66.

150. *Id.*

151. Buchmann, *supra* note 47.

152. Closing the loop for Ni-Cd batteries may be both a positive and a negative. It provides an additional product for INMETCO to sell, thus improving the economics Ni-Cd battery recycling, and also keeps that cadmium out of the waste stream. However, cadmium is currently being phased out of other products because of its toxicity. In fact, INMETCO's plant was one of only two cadmium producers in the United States in 2002. U.S. DOI, Mineral Commodity Summaries 2003, at 42 (2003), *available at* http://minerals.usgs.gov/minerals/pubs/mcs/2003/mcs2003.pdf (last visited July 16, 2003). In the last four years, American consumption of cadmium has dropped 73%. Seventy-five percent of the cadmium that remains in use is used in batteries. It appears that Ni-Cd recycling and production is what keeps cadmium within the technosphere. A policy question to be asked is whether the phaseout of Ni-Cd batteries, such as the one Sweden is calling for, should be supported to encourage the removal of this metal from production. The counterargument, however, is that cadmium will always be produced as long as zinc is used, as it is a byproduct in the refining of zinc.

153. Huth Interview, *supra* note 60.

154. Telephone Interview with Paul Schneider, Director of Marketing, Kinbursky Brothers, Inc. (Oct. 23, 2003).

155. Environmental Resource Management, *supra* note 55, at 107, B2.

assumes that each recycling bin or "sock" would be made of 1 kilogram (2.2 pounds) of virgin plastic,[156] equivalent to one five-gallon bucket capable of containing up to 60 pounds of batteries.[157] Such a large bin may be an unreasonable assumption in their model. While the receptacle would need to be large enough to fit oddly shaped and sized batteries, no household generates the volume of batteries needed to fill such a large collection bin. Also, such a receptacle need not be made from hard plastic. Minneapolis' curbside battery recycling program, the only one in the United States, requires that batteries need only be placed in a clear plastic bag.[158]

The model found the energy used by collection vehicles to be the other significant pollution source from a curbside pickup program, accounting for over 90% of the nitrogen oxides and ozone-depleting chemicals emitted.[159] However, Environmental Resource Management's model assumes that the vehicle is additional to any existing curbside pickup system. The report then dismisses the benefit of using an existing collection vehicle on existing runs for other recyclables because the environmental benefit would still be outweighed by the production of the collection bins. However, seeing how the model may have overestimated the resources necessary to create the bins, this dismissal may not be warranted. Ultimately, the report concedes that should consumer batteries be collected alongside other recyclables and in the existing bins, the curbside collection would essentially be "burden free" and far more environmentally friendly than either a bring- or take-back system.[160]

Other studies conclude that collection and sorting have few significant environmental impacts on a rechargeable battery's life cycle, and that recycling produces an overall net benefit. One study found that battery distribution, collection, and sorting for recycling uses only 0.9% of the total energy and produces only 0.8% of the carbon dioxide emissions over the life of a Ni-Cd battery.[161] The authors of that study intentionally excluded energy use from the production of battery collection boxes as they determined it to be insignificant.[162] Another study estimated that, though collection for recycling requires approximately 150 times more energy than collection for disposal, it still accounted for only 1.6% of the total life-cycle energy.[163] All told, manufacturing batteries from recycled rather than virgin materials requires one-half the energy.

The point addressed by the above studies is that life-cycle costs of recycling do matter and that collection and processing may have significant environmental costs. Therefore, minimizing collection and processing costs through efficient processes is necessary both for environmental and economic reasons. The high costs of some recycling programs may indicate that they are using such high levels of energy and resources that they are not worthwhile. Attaining efficient, economic recycling programs should be a major focus of recycling efforts, coupled with the goal of increasing recycling rates.

D. Other Potential Barriers to Take-Back Programs

1. Liability

One potential problem with a take-back system is liability if a battery leaks or explodes. The RBRC was formed to protect the members of the PRBA from Superfund liability through its state collection programs.[164]

2. Anti-Competitive Behavior

Another concern that has been addressed by some state laws is the monopolistic effect of all battery manufacturers working together to set fees. Maryland, for instance, shields those participating in the program from state antitrust laws for "any cooperative activities arising out of the collection and management" of waste batteries,[165] and Minnesota has a similar provision.

3. Expansion of the RBRC

The RBRC was established by the manufacturers of rechargeable batteries. They have expressed no desire to expand their take-back system to include alkaline batteries. This is a problem because it continues the need for consumers to identify and separate batteries by chemistry. Also, accepting alkaline batteries could help address the critical mass problem since the consumer's collection of waste batteries would grow more quickly. Ultimately, it is likely that accepting alkaline batteries would increase the volume of rechargeable batteries collected as well.

E. Lack of Consumer Awareness

It is apparent that batteries are not nearly as prominent a recycling concern to most consumers as paper, metal, and glass. In 2000, 45% of paper and paperboard, 35% of metals, and 23% of glass were recycled.[166] However, through either apathy or ignorance, 40% of households will not recycle their HHW even if convenient to do so.[167] Currently only one in six households recycle rechargeable batteries, and even fewer recycle their alkaline batteries. Though no reliable figures exist, rates for consumer battery recycling are probably in the single digits. The labeling requirements under some state laws and later under the federal Battery Act have not appeared to greatly increase consumer awareness.

One of the RBRC's measures of success is the amount of media attention generated annually. In 2002, the RBRC had 366 million media impressions.[168] However, despite this

156. *Id.*

157. Battery Solutions, Inc., *at* http://www.batteryrecycling.com (last visited July 16, 2003).

158. City of Minneapolis, *Recycling Collection*, *at* http://www.ci.minneapolis.mn.us/solid-waste/rec.asp (last visited July 16, 2003).

159. Environmental Resource Management, *supra* note 55, at 107.

160. *Id.*

161. Rydh & Karlström, *supra* note 148, at 296.

162. *Id.* at 294.

163. Lankey & McMichael, *supra* note 48, at 7.

164. *Id.* at 8 (citing A.M. Mossbarger, *Small Sealed Rechargeable Batteries and the Environment: Past, Present, and Future*, 1993 Int'l Power Conversion Conf. 475).

165. Md. Code Ann., Envir. §6-1113 (1996).

166. EPA 2000 Facts and Figures, *supra* note 12, at 7.

167. Anderson Interview, *supra* note 58.

168. RBRC Annual Report, *supra* note 80, at 5. Put in other terms, the total subscribership and viewership of all the magazines and television stations carrying the RBRC's advertisements was 366 million people.

high number, consumer awareness remains low. Just because an advertisement was printed does not mean that it was read or that the message was conveyed. Furthermore, most messages have to be repeated to remain in the consumer's consciousness.[169] The RBRC's advertising efforts would benefit from a survey of consumer opinions to determine how they could better craft and deliver their message.

Merely knowing that batteries can be recycled, however, is insufficient. Studies in Belgium, Germany, and the Netherlands show that 80% to 90% of the population know about their battery recycling programs, while only 30% to 50% of the population uses them.[170]

VI. Options to Increase Recycling

A. Regulatory Solutions

1. Establish or Expand Take-Back Programs

A take-back program could potentially be very effective for alkaline batteries. A limited take-back program could be incorporated into the existing mail-in programs. Alternatively or additionally, battery companies and the RBRC could be urged to collect and recycle alkaline batteries alongside their other rechargeable batteries.

Much can be learned from the various take-back programs in Asia and Europe. In general, European collection programs that require consumers to bring their batteries to various convenient locations is the least expensive method of collection. Because they require greater initiative on behalf of the consumer, though, they result in a lower collection rate. Curbside recycling programs have a greater participation rate, but cost more.[171]

Voluntary programs have proven to be unsuccessful. Every country with a voluntary program (Japan, Sweden, Switzerland, and the RBRC program in the United States) has failed to meet its collection target. In response to that failure, Japan, Sweden, and Switzerland have made their programs mandatory. While this does not prove that mandatory programs are successful, it does suggest that voluntary programs are not.

2. Create Economic Incentive Programs

There are a number of ways to make battery recycling more economically beneficial for consumers that fall short of a take-back program. First, states could make improper disposal uneconomical for consumers. States could require a deposit or a return incentive fee (also called a disposal tax) at the time of purchase. For instance, Michigan's deposit law would have required consumers pay a $2.00 deposit for each Ni-Cd battery, unless they were returning one to the store for disposal. They could also receive their deposit back from a collection or recycling facility. Alternatively, states could make recycling or proper disposal of batteries economically beneficial by paying consumers for their waste batteries or establishing a rebate program.

3. Regulate Toxic Materials to Increase Value of Recycled Materials

One of the key barriers to enhanced recycling of products with toxic materials such as batteries is the very low commercial price of toxic materials. Although a business is required to spend $1,000 to $5,000 per pound to abate mercury emissions, mercury costs only $2 per pound to purchase.[172] Cadmium costs $.30 per pound,[173] and nickel $3.07 per pound.[174] These statistics reveal a major problem with our environmental law, which was designed to regulate wastes. Businesses must make major expenditures to remove toxics from the waste stream but can place the same toxic substance into disposable products at trivial costs.

B. Economic Solutions

1. Improve Automatic Sorting

One of the most important advances needed for effective battery recycling is an automatic sorting technology that is both accurate and economic.

2. Require Uniform Label Markings

Automatic sorting could be facilitated by requiring uniform label markings that are readable by automatic sorters, such as was implemented in Europe in 1997. While labeling requirements currently exist, they are for the benefit of the consumer and the manual sorters. Neither of these groups are ideally served by the current labeling, however.

3. Develop More Efficient Recycling Processes

In the long term, sorting costs can be reduced or even completely avoided by changing the structure of recycling facilities. If a recycling plant were able to recycle all battery chemistries, batteries would not have to be sorted to ensure that they are shipped to the correct plants. This would still require that the batteries be sorted at the recycling facility, though. Even sorting at the recycling facility, however, may become less important. Research in Europe is leading to a process whereby all battery chemistries are recycled in a single furnace.[175] This process presents a possible long-term solution to one of the most difficult challenges in battery recycling.

4. Improve Recycling Rate Calculations

Assessing the success of any recycling program requires better methods of measuring collection capabilities and rates. A uniform calculation, such as Battery Council International's, should be agreed upon by the relevant government and industry players. U.S. calculations, which are based only on the total volume of batteries collected, do not

169. The 366 million media impressions averages out so that each American citizen would have heard the message only 1.3 times. GRS Batterien had 470 million media impressions, meaning each German citizen heard the message 5.6 times. GRS Batterien Annual Report, *supra* note 54, at 29.

170. European Portable Battery Ass'n, *supra* note 96.

171. Environmental Resource Management, *supra* note 55, at 84.

172. U.S. DOI, *supra* note 152, at 108.

173. *Id.* at 42.

174. *Id.* at 116.

175. Sova Interview, *supra* note 66.

provide the breadth of information that calculations performed by GRS Batterien in Germany do. Certain key pieces of data that should be collected include:

National annual sales volume of each battery chemistry for both Canada and the United States;

State annual sales volume of each battery chemistry for states with collection targets; and

Annual recycling volumes at each recycling facility

5. Educate Consumers

Any of the above methods would be assisted by greater consumer awareness. Most important are the knowledge of two things: (1) the dangers of improper disposal, or why it is important to recycle their batteries; and (2) the logistics of where and how to recycle.

6. Promote Business and Civic Group Participation in Battery Mail-In Programs

Battery manufacturers, aggregators, and recycling facilities would be well served by increasing the effectiveness of their mail-in programs. While the average consumer will not likely initiate such a program, the advertising could target businesses, churches, community centers, schools, and other large organizations that have enough members to collect a significant volume of batteries. Increasing the number of collection sites makes it more likely that a site will be convenient for consumers' diverse lifestyles.

Similarly, the operators of existing collection sites or mail-in programs should also be more vocal in announcing their programs to their own employees, congregations, members, and students. This would also further the goal of increased consumer education.

Battery recycling remains in such infancy that collection programs themselves are newsworthy. An article was written in a local paper when the ISEN tallied its first year's collection results. The publicity increased not only battery returns but also the organization's visibility.[176] Depending upon the group organizing the collection, such publicity may increase not only consumer awareness of battery recycling but of your organization as well.

7. Preventing Battery Waste

One of the greatest benefits of consumer battery recycling is the removal of toxic heavy metals from the waste stream. This goal can be accomplished through prevention programs in addition to recycling.

☐ *Rechargeable Battery Servicing*. Keeping rechargeable batteries in use for longer periods of time reduces the amount of waste sent to a landfill. Regular battery servicing is one method of extending the life of rechargeable batteries. Consumers could have independent battery refurbishing centers or retail stores test, and, if possible, restore the malfunctioning battery. For batteries still under warranty that are unable to be restored, the consumer would receive a new battery. The manufacturer would receive information as to the problem as well as the date and location of purchase. Such communication could even be done electronically by the testing equipment, facilitating information flow. This meets one of the functions of take-back programs: providing the manufacturer with information as to the cause of defects. However, unless such servicing is paid for by the manufacturer, which it should be if under warranty, it does not provide a financial incentive to design a better product.

Barriers to a refurbishing program are numerous, though they may be surmountable. First, the variety of battery sizes and chemistries may make service difficult for an untrained employee. However, increasingly sophisticated testing hardware and software should facilitate battery repair. Second, depending on the problem, repair might take from a few minutes to a few hours. It is more convenient for the consumer to purchase a new battery than to wait for servicing or return to the store. The solution to this problem is that consumers need not receive their exact battery in return. Rather, they could immediately purchase a refurbished battery and let the store keep the one that they are servicing for the next customer. Creating a pool of refurbished batteries may be difficult but given that such stores are probably drop-off locations for the RBRC, used batteries are likely to be available. A third barrier is that refurbished batteries may be less appealing to consumers. Because they were new, the batteries described in the example above could be restored to 80% of their original charge. Battery refurbishing centers often deal with older batteries that can often only be restored to 40% to 70% of the original charge, though this loss in capacity would be reflected in the price.

☐ *Replace Primary Alkaline Batteries With Rechargeable Batteries*. Reusing rechargeable batteries in place of primary alkaline batteries would reduce the volume of solid waste from 100 to 1,000 times. This number is increased further if the current recycling infrastructure for Ni-MH batteries is utilized. For low- and mid-drain electrical devices, rechargeable alkaline batteries, which are currently only made by Rayovac, are best. When used in low-drain devices, they can be recharged up to 100 times, though intermittent use in high-drain devices will lead to a noticeable drop in performance. For high-drain devices, Ni-MH batteries, which are made in all the common sizes (AA, AAA, C, D, and 9 volt), are better. Ni-MH batteries can be recharged up to 1,000 times. However, though not as toxic as cadmium, nickel is still a toxic metal and should be recycled. Though they have a higher up-front cost, these rechargeables are also more economical than one-time use alkaline batteries.

Battery trade organizations like the National Electrical Manufacturers Association argue that consumers do not want the hassle of rechargeable batteries and that consumer choice is dictating the sale of disposable batteries over alternatives. They add that because alkaline batteries are not considered hazardous and make up less than 1% of the solid waste stream, they are not a major solid waste problem. Instead they advocate that recycling efforts should more efficiently focus on other products such as Ni-Cd batteries.

There are several responses to this. First, it is likely that consumers who have had bad experiences with inferior rechargeable batteries in the past have become accustomed to one-use alkaline batteries and thus prefer them to current rechargeable batteries. It is also true that the Rayovac rechargeable alkaline batteries have not been broadly adver-

176. Huth Interview, *supra* note 60.

tised, nor do they receive equal status and location among regular alkaline batteries in most every major retail store.

Given these advantages, a major regulatory question is thus raised: should nonrechargeable disposable one-use alkaline batteries be prohibited? Certainly the major producers have a very profitable status quo since their batteries are used up quickly, thrown away, and replaced by a new set of batteries. The eagerly consuming public has no financial incentive to reduce their battery waste or to recycle and has thus far not responded to rechargeable products. This ideal market perhaps explains that while there have been some improvements in power and perhaps longevity of one-use alkalines over time, they have not been dramatic, nor have they caused any major shift in the industry.

☐ *Replace Ni-Cd Batteries With Other Less Toxic Battery Chemistries*. Currently, the market is moving away from Ni-Cd batteries and toward less toxic Ni-MH and Li-ion batteries. Ni-MH batteries are classified as a nonhazardous waste—except for certain Ni-MH batteries in California. They are also better for the consumer as they have a higher capacity and energy density and do not develop a memory like Ni-Cds do. The potentially least detrimental rechargeable battery technology, rechargeable alkaline batteries, appears to be the one with the most difficulty in establishing a foothold. These batteries contain no mercury, though they cannot be charged as many times as Ni-Cds can. There are limited incentives to purchase batteries other than Ni-Cds, however.

For the last decade, Sweden has called for the substitution or ban of Ni-Cds. Switzerland is also seeking to reduce the amount of cadmium content in its waste stream. It has set a limit of 3,000 kilograms per year from Ni-Cd batteries. If that target is not met, it will require a deposit on all Ni-Cd batteries.[177]

There is some concern that Ni-Cd batteries cannot be replaced in certain applications such as power tools or emergency lighting, which are high-drain uses after long periods of inactivity.[178] Replacing them with Ni-MH or other battery types may actually be environmentally detrimental because more of the alternative batteries would have to be used and discarded.

☐ *Replace Batteries With Fuel Cells and Other Clean Technologies*. In the foreseeable future, laptops and cellular phone designs could move from rechargeable batteries to fuel cells. Direct methanol fuel cells, which are expected to see commercial use in such devices within two years, have 10 times the power of Li-ion batteries. When the methanol has been depleted, a new cartridge is inserted. The only waste produced from such a system is the empty methanol cartridge, which conceivably could be refilled, and carbon dioxide from the fuel cell process. At this point in time, the greatest barrier to widespread fuel cell use in portable electronics is technological.

8. Make the Process Easier for Consumers

☐ *Collect Batteries Curbside*. Providing curbside collection would reduce the most substantial practical hurdle to consumers. In a consumer survey conducted in 2002 by the RBRC, 60% of consumers said that they would recycle their batteries in a curbside collection program.[179] Municipalities can collect batteries in either of two ways. First, they could add batteries to the traditional curbside material, helping to reduce both the economic and environmental costs of pickup. Alternatively, the household could arrange curbside pickup of all of their household hazardous wastes with the municipality through programs like Curbside, Inc.

☐ *Collect All Battery Types*. Consumer sorting is a vestige of the days when Ni-Cd batteries were not a universal hazardous waste and had to be separated from other battery chemistries before being transported. Because those requirements no longer exist, collection centers should accept all battery chemistries, reducing consumer confusion. It would also move the entire disposal process closer toward recycling all battery types.

The ISEN partially attributes its success in collecting twice their target volume to their willingness to collect all battery types and to do so in only one collection bin. The RBRC provided ISEN with boxes and plastic bags for the take-back of rechargeable batteries. However, consumers choose to avoid the hassle of identifying and separating batteries by chemistry so the boxes mostly go unused.[180] Since sorting will be done by the recycling facility anyway, there is no reason to place that burden on consumers.

Municipalities can also choose not to sort collected batteries either, and leave sorting to more capable aggregation facilities. Such facilities have better trained personnel as well as a continuous stream of batteries, thus making their process more efficient. Finally, the greater volume of batteries experienced by an aggregation facility would make it the most efficient user of any future automatic battery sorting machine, assuming that their cost decreases and accuracy increases.

However, while it would be more convenient for counties and municipalities to collect mixed batteries, it may not necessarily be less expensive.[181] The county would save the labor costs of sorting. However, it would be faced with greater disposal fees, as it would have to pay an aggregator to recycle all battery types, not just rechargeable batteries. Furthermore, the county would be faced with the higher costs of recycling rather than mere proper disposal.

Of course, not all batteries would go through aggregators before reaching the recycling facility. As mentioned earlier, recycling facilities have their own mail-in programs and large industrial customers. Recycling facilities would thus still have to sort the batteries and double check the previous sorting. The volume of these errant batteries, though, would be less because they have already received an initial screening.

Sending mixed batteries to a recycling facility, though equally qualified, has multiple drawbacks. First, since no facility is capable of recycling all battery chemistries, many batteries would have to be shipped elsewhere. This adds to the facility's expense. Second, the increased volume of mixed batteries increases the likelihood of contamination, with all its dangers and drawbacks.

177. Raymond Communications, *supra* note 5, at 79.

178. Lankey & McMichael, *supra* note 48, at 11.

179. RBRC Annual Report, *supra* note 80, at 5.

180. Huth Interview, *supra* note 60.

181. Sova Interview, *supra* note 66.

VII. Conclusion

Toxic consumer battery waste remains a hidden issue because it comprises only a small percentage of total municipal solid waste. While there have been efforts to recycle consumer batteries in the United States for the last 15 years, the vast majority of batteries still end up in landfills and incinerators. Efforts to recycle Ni-Cd batteries increased dramatically when they were classified as a universal waste and when the complicated RCRA requirements were removed. However, while the regulatory environment for battery transport and recycling has improved, economics have become the limiting factor in further recycling growth. Consumers are currently required to subsidize the recycling of their own batteries through the payment of transportation and recycling fees. Most often, consumers, or the municipalities that act on their behalf, choose not to pay the extra recycling fee so batteries are instead discarded.

A limited, and only mildly successful, take-back program in the United States addresses the most toxic battery chemistries. While this program is less hindered by economics, as battery manufacturers have the resources to pay as well as the capability of dispersing those costs among many consumers, it is hindered by its impractical implementation. Europe has demonstrated that manufacturer take-back laws of both rechargeable and alkaline batteries is possible. If the programs are designed efficiently, which is a likely result if industry itself is paying for it, collection programs can be convenient, environmentally beneficial, and economically neutral.