Cadmium 2003

Batteries, China and the European Commission

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Introduction

There are a number of major factors shaping the cadmium market today. The three which are believed to be of most importance are the continued growth of the nickel-cadmium (NiCd) battery market, the emergence of a very strong cadmium and NiCd battery market in China, and the proposed and imposed Directives by the European Commission against cadmium-containing products. This paper will first present the cadmium market situation as it exists today, and then discuss in more detail how each of these three factors have affected cadmium and how they might affect it in the future.

As all of you are no doubt aware, cadmium production is mainly a by-product of primary zinc production, and, to a lesser extent, of primary lead and copper production. Cadmium is produced whether or not a demand exists for it, and the level of its production will depend to a great extent upon the world's zinc production level.

Cadmium is also a toxic material in certain forms and concentrations. Therefore, much of the history of the cadmium market has been closely linked to environmental and human health regulations and concerns, most particularly in Scandinavia and Europe. This situation has resulted in a strong emphasis on cadmium recycling in some areas and on cadmium product restrictions in other areas.

The Cadmium Market in 2003

Production and consumption of primary cadmium over the past ten years are shown in Figure 1 below. As will be explained subsequently in more detail, the figures published by the World Bureau of Metal Statistics and gathered by most organizations reflect production and consumption of primary cadmium. Increasingly during the 1990s the amount of secondary or recycled cadmium has become a strong factor in the market, but its amount is not nearly as well documented as are the figures for primary cadmium.

As is evident from the data in Figure 1, production of primary cadmium has been slowly decreasing from 1992 through 2002. At the same time, however, cadmium consumption has been slowly increasing, due to the strength of the NiCd battery market and, in particular, the Chinese NiCd battery market in more recent years. The shortfall between supply and demand has, of course, been supplied by secondary cadmium from the recycling of NiCd batteries, from cadmium stocks built up during earlier years of high zinc production, and from sales of excess cadmium from the United States Defense Logistics Agency's (DLA) stockpile. There are indications now, however, that, with efforts to curtail zinc production in the face of low zinc prices and with depletion of both the DLA cadmium stockpile and past high producer stockpiles, cadmium supply has become somewhat tighter and accordingly cadmium prices have begun to move up again.

However, to partially offset the decline in primary cadmium production during the 1990s, the increase in secondary cadmium production must also be considered. While the available data is not considered as complete and accurate as that for primary production,

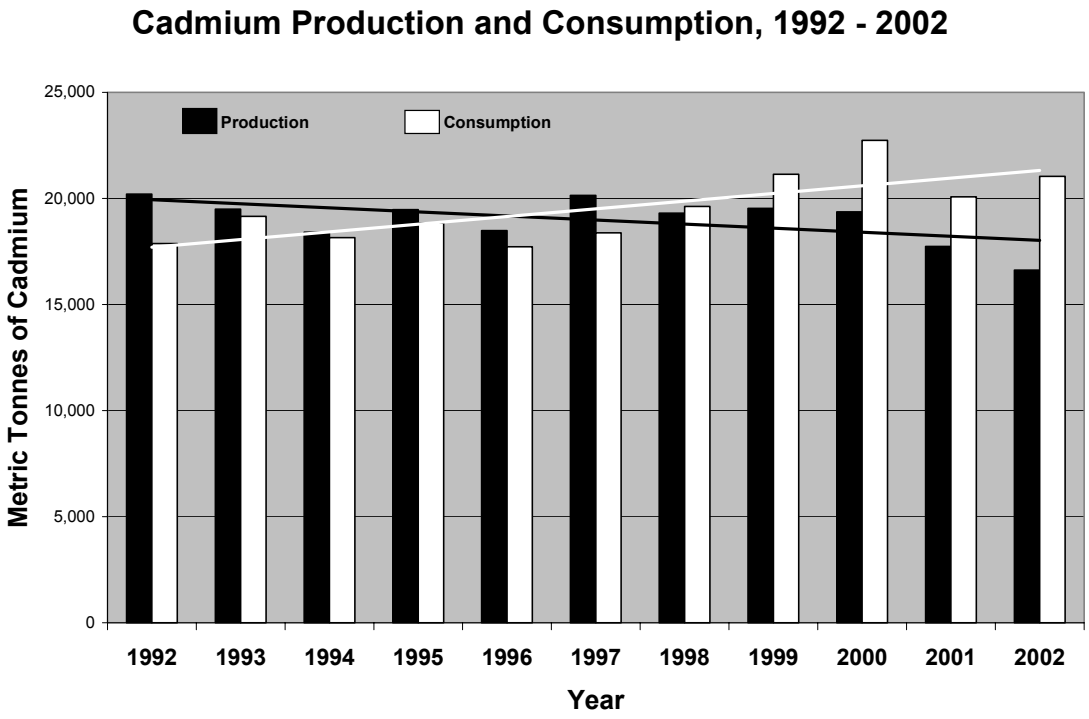

Figure 1. Primary Cadmium Production and Consumption, 1992 – 2002

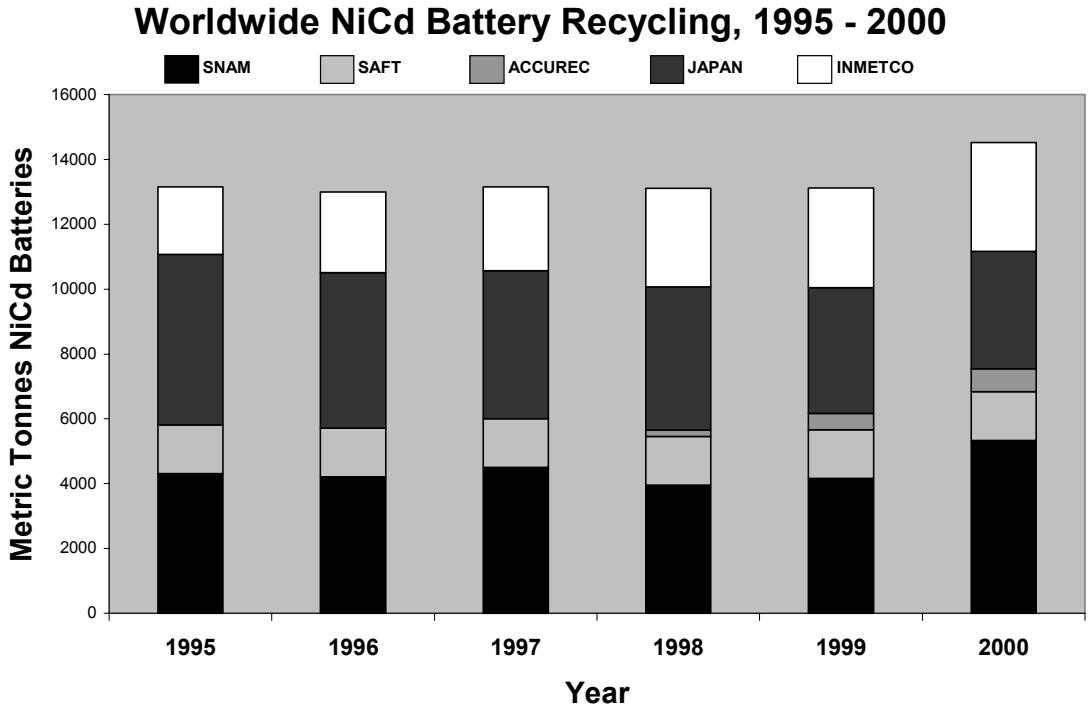

Figure 2. Worldwide NiCd Battery Recycling, 1995 – 2000

there are clear indications that the amount of cadmium produced from secondary sources is increasing, as shown in Figure 2 above. SNAM, SAFT and Accurec are the three major European NiCd recyclers, while INMETCO is the largest NiCd battery recycler in North America. The Japanese NiCd battery recycling program involves the Battery Association of Japan and several recyclers, including Mitsui Mining & Smelting and Toho Zinc. The only decrease in secondary cadmium production from 1995 to 2000 was registered in Japan because of a decrease in the recycling of battery manufacturing wastes as Japanese NiCd battery production was shifted to China.

The third element in cadmium production is disposal of cadmium from the U.S. DLA stockpile. Whereas primary cadmium production generally ranges from 16,000 to 20,000 metric tones (mt) per annum, secondary cadmium production has ranged from 1,500 to 3,000 mt per annum. The maximum amount of cadmium sold in any one year from the DLA over the past ten years is only about 540 mt. DLA cadmium sales, along with the authorized fiscal year disposal limit, are shown in Figure 3 below. Nonetheless, DLA sales have exercised a disproportionate effect on cadmium price over the past ten years, first because they have often been at levels significantly below published *Metal Bulletin* prices for cadmium of comparable grade, and second because they usually constitute a major fraction of cadmium trader sales upon which the *Metal Bulletin* published prices are based. However, the DLA's excess cadmium stockpile will effectively be gone by March 2003 and should no longer be a factor in the cadmium marketplace.

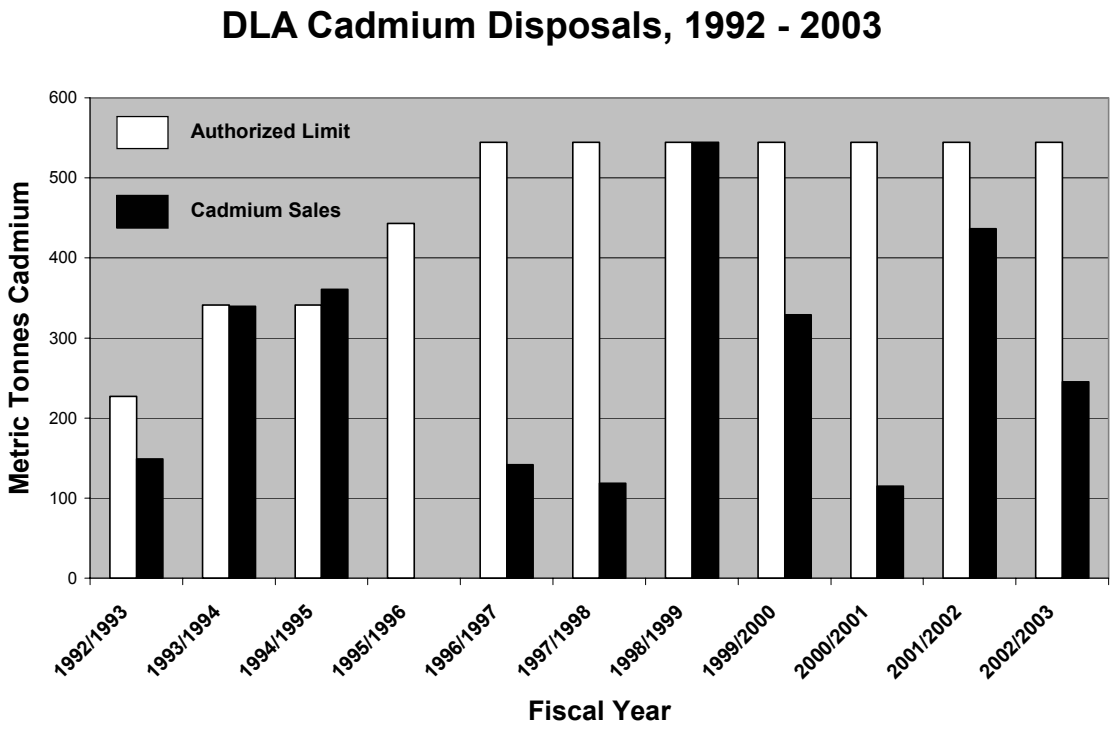

Figure 3. DLA Cadmium Disposals, 1992 - 2003

In the early 1990s, cadmium primary production was evenly divided between the three major continental areas – the Americas, Europe and Asia – with significant production from Australia and negligible production from Africa. Since that time, Asia has come to dominate worldwide cadmium as both European and American production have declined. The trends in geographical primary cadmium production are summarized in Figure 4 below. Amongst the leaders in Asian cadmium production are Japan, China and Korea. While Japan has been a leading cadmium producer for many years, China and Korea have increased their production markedly over this same time frame. The largest producers in the Americas are Canada and Mexico, while the United States has dropped significantly as a major cadmium producer. The largest European producers are now Finland, Netherlands, Italy, and Germany. Belgium, which used to be one of the world's largest cadmium producers, ceased primary cadmium metal production early in 2002.

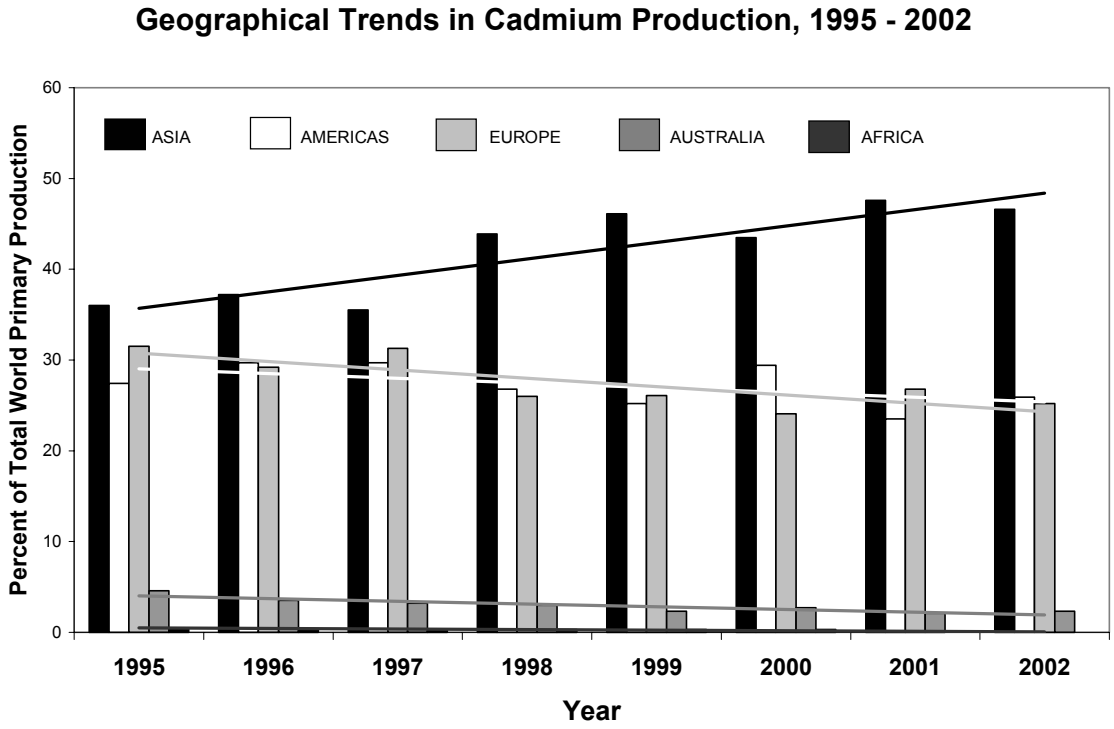

Figure 4. Geographical Trends in Cadmium Production, 1995 – 2002

Cadmium consumption, as shown in Figure 1, has been gradually increasing over the 1990s. This growth has been due almost exclusively to the growth in the nickel-cadmium rechargeable battery market. There are five major application areas for cadmium and cadmium compounds – NiCd batteries, pigments, coatings, stabilizers and alloys, electronic compounds and other miscellaneous uses. In the 1950s and 1960s, coatings accounted for about 50% of the cadmium market, but, with the explosion of the portable battery-operated consumer appliances market in the 1980s, cadmium consumption soon came to be dominated by NiCd batteries. The worldwide consumption patterns for cadmium by application area are summarized in Figure 5.

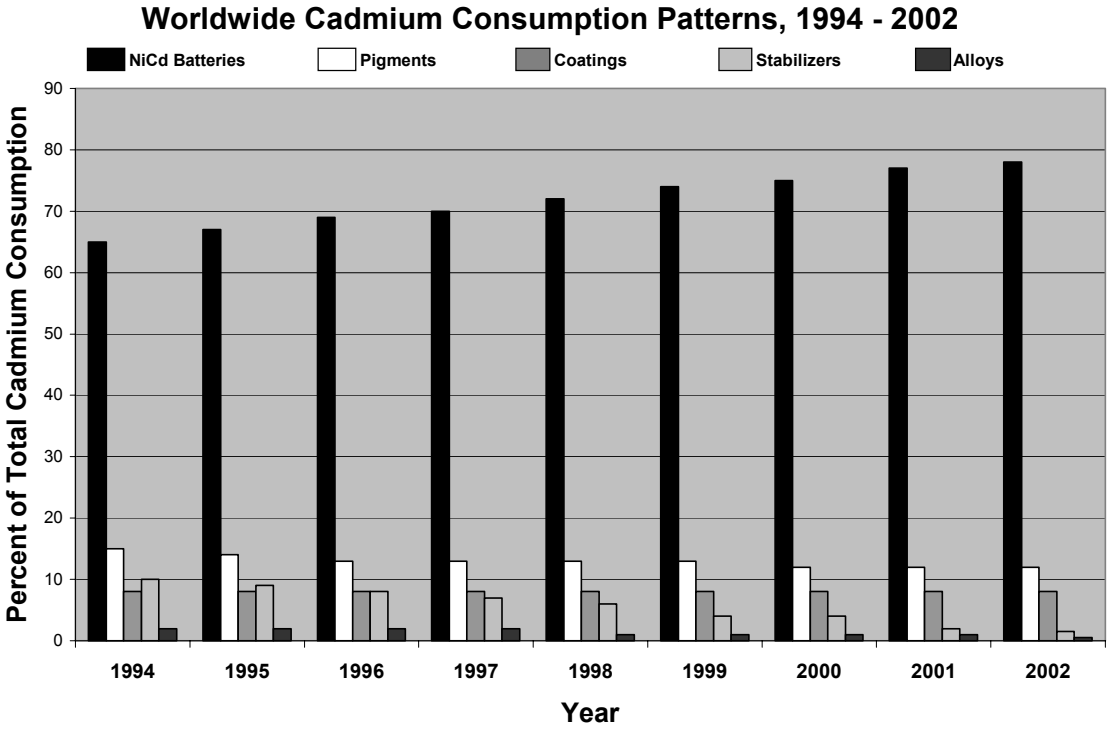

Figure 5. Worldwide Cadmium Consumption Patterns, 1994 – 2002

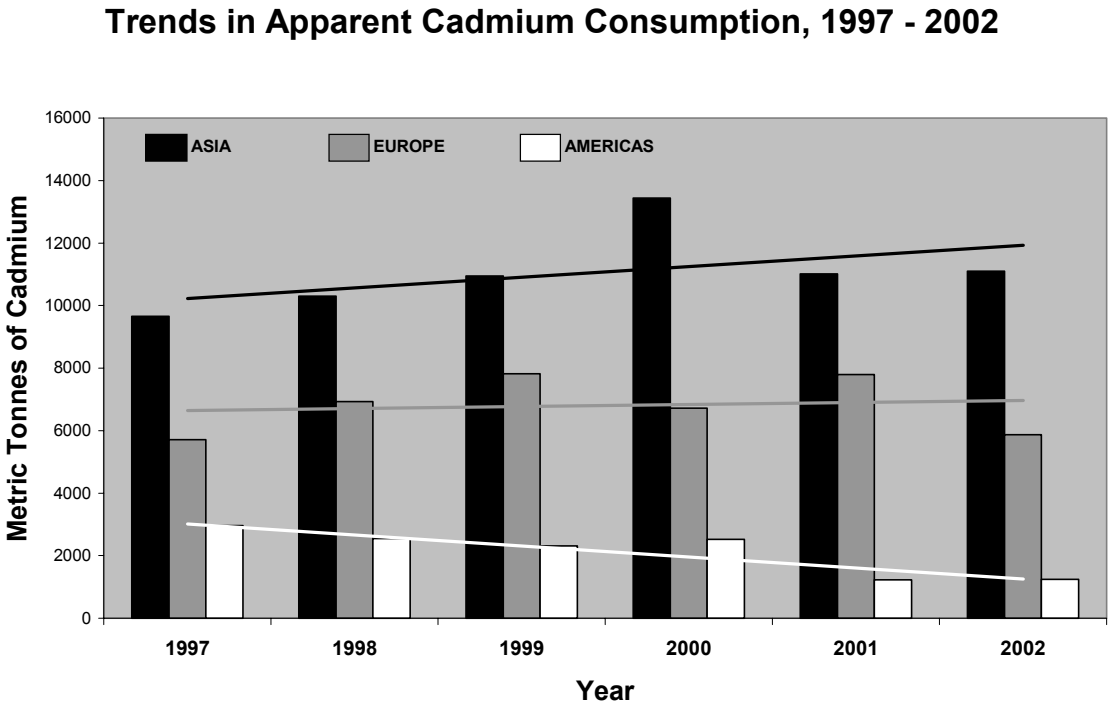

Figure 6. Trends in Apparent Cadmium Consumption, 1997 – 2002

Since most of the world's NiCd batteries are now produced in either Japan or China, it is not surprising that Asia has also come to dominate world cadmium consumption as well as cadmium production. France remains a significant producer of NiCd batteries and, as a result, European cadmium consumption has been reasonably steady for the past 5 years. The geographical trends in apparent cadmium consumption are shown in Figure 6 above. The term "apparent cadmium consumption" is used here because a great deal of cadmium metal is converted into cadmium oxide in Europe, and it is uncertain whether that conversion amount has been counted as both consumption in Belgium where it was converted to oxide and in Japan or China where the oxide is incorporated into NiCd batteries. Without this conversion of metal to oxide in Europe, cadmium consumption in Europe might also be declining as it is in the Americas.

Finally, cadmium price has historically always been volatile. As previously noted, cadmium is principally a zinc by-product, and is therefore not subject to the ordinary supply-demand dynamics of the marketplace. Total cadmium production level is, to a very large extent, controlled by zinc supply-demand dynamics. Therefore, at those times when cadmium demand is high and supply limited because of zinc market factors, cadmium price can escalate to very high levels as it did in the late 1980s, reaching levels of $8 to $10 per pound. During the 1990s, cadmium prices have generally been depressed except for a brief period in 1994-1995. The *Metal Bulletin* published prices for the high end of the range for 99.99% purity cadmium are shown in Figure 7 from 1993 through 2002.

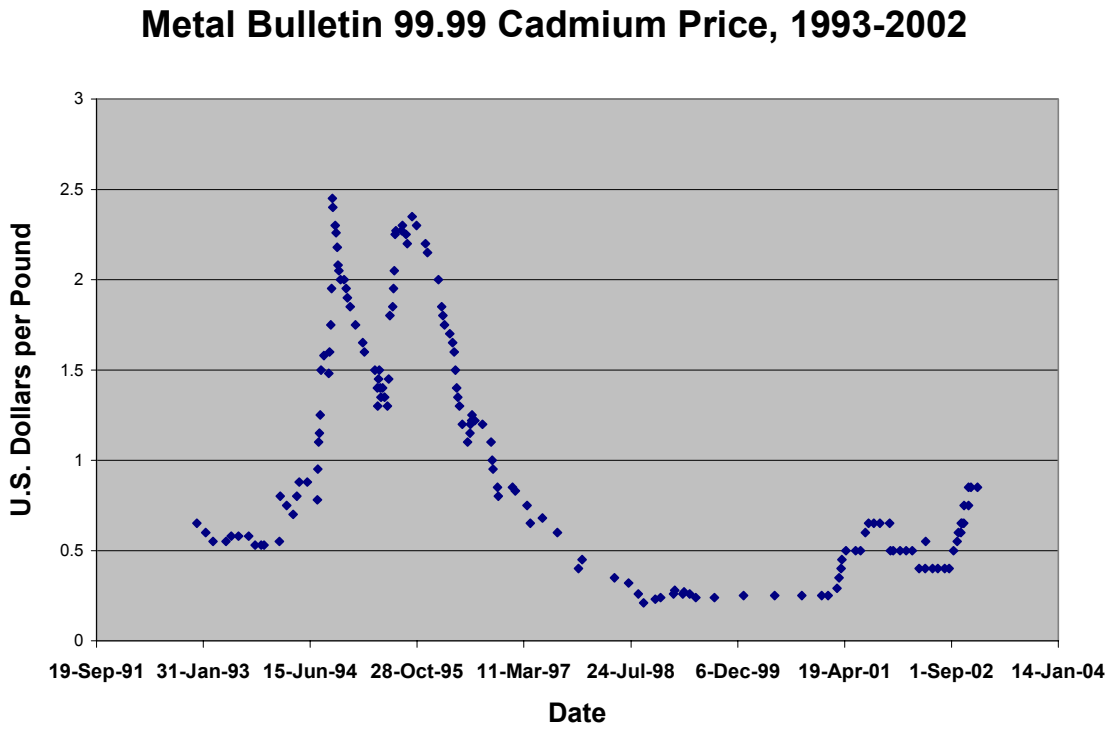

Figure 7. *Metal Bulletin* 99.99 Cadmium Price, 1993 - 2002

Over the past 50 years, the average price for cadmium has been $2 per pound, expressed in actual dollars not corrected for inflation. Most cadmium producers today feel that their cadmium production costs are approximately $1 per pound. If they receive less than that amount, they lose money on cadmium and must charge it as an expense against their zinc production costs. If they receive more than $1 per pound, then it is considered a by-product profit. As shown by Figure 7, zinc producers have been losing money on cadmium since about 1996 and are only now beginning to recover to the breakeven point.

Average cadmium prices for both the 99.95 and 99.99 grades of cadmium in the past two years are shown in Figure 8 to show that there is normally a $0.05 to as much as $0.35 differential between the two grades. In the Spring of 2001, prices for 99.99 NiCd battery grade material climbed rapidly but prices for the 99.95 grade used in other applications remained at relatively depressed levels. By the Fall of 2002, prices for both grades began to increase strongly, an indication of an overall cadmium shortage and not just in the high purity battery grade material.

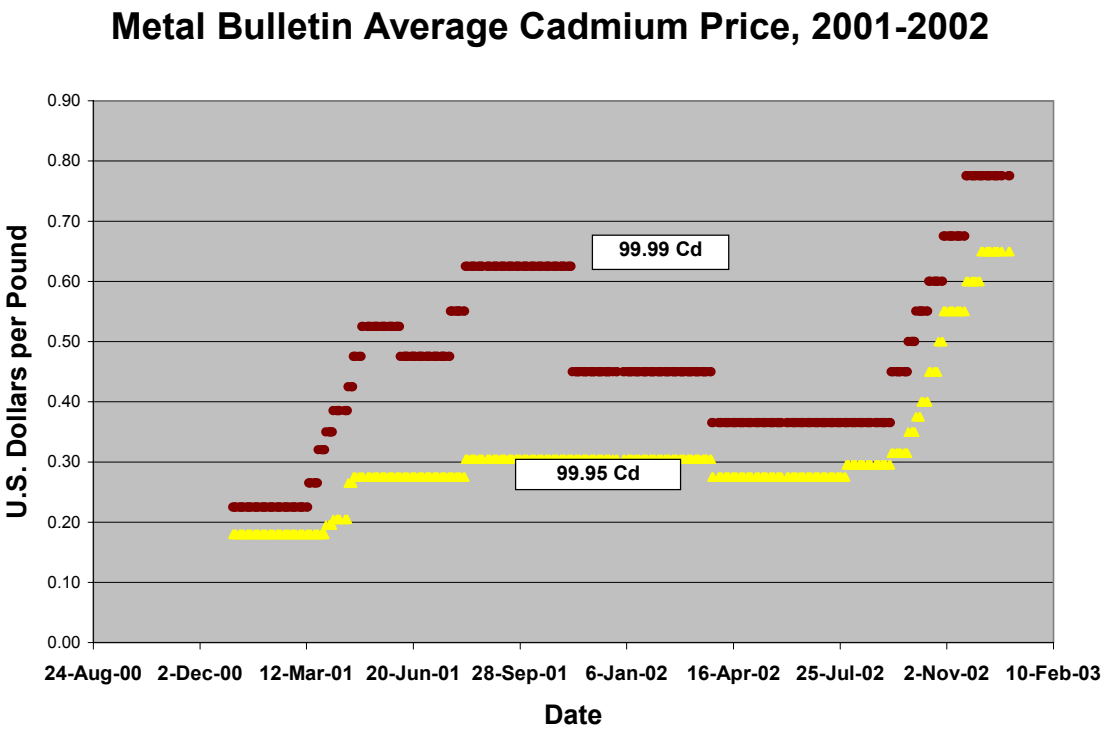

Figure 8. *Metal Bulletin* Average Cadmium Price, 2001 – 2002

In summary, today's cadmium market is one characterized by slowly increasing demand and slowly decreasing primary supply partially offset by an increased secondary supply with the result that prices have begun to move back to more normal historical levels. Continued growth in the NiCd battery market and particularly the Chinese NiCd battery market is expected to continue although the proposed regulations by the European Commission may produce a negative effect on the continued growth of cadmium. Each of these three factors will now be discussed in more detail.

The Nickel-Cadmium Battery Market

Nickel-cadmium batteries are normally divided into two general classes – the small, portable consumer cells and the large industrial cells. Within each of these two classes, there are many different sizes of batteries for many different applications. A sampling of the sizes and shapes of portable consumer NiCds is shown in Figure 9 below.

Figure 9. Portable Consumer Nickel-Cadmium Batteries

From the perspective of cadmium consumption, approximately 80% of the cadmium consumed in NiCd batteries today is utilized in the portable consumer cells in applications such as dustbusters, cordless shavers and toothbrushes, power tools, communication devices such as the Walkman and Diskman, camcorders and cordless phones. The remaining 20% of the cadmium consumed in NiCd batteries is utilized for large industrial batteries utilized in applications such as emergency lighting and security, aircraft and railway emergency lighting, switching and signaling, stationary and stand-by power, and electric vehicles.

While there have been many studies which break down the NiCd battery market by applications in terms of millions of cells sold or market value of the cells sold, the most useful analyses to the cadmium industry have been those which delineate the amounts of cadmium consumed in the batteries in each application. Large industrial NiCd batteries are produced in relatively limited numbers, but they are often very large batteries with a considerable quantity of cadmium. Industrial NiCds may also vary in composition quite widely, all the way from 10% cadmium by weight to 25% cadmium by weight. The small consumer NiCd batteries are produced in huge numbers, hundreds of millions of cells, but are relatively small in size and generally average about 15% to 17% cadmium by weight. One study, by CollectNiCad in Europe, has analyzed cadmium consumption in NiCd batteries in Europe by application. These data are shown in Figure 10 below.

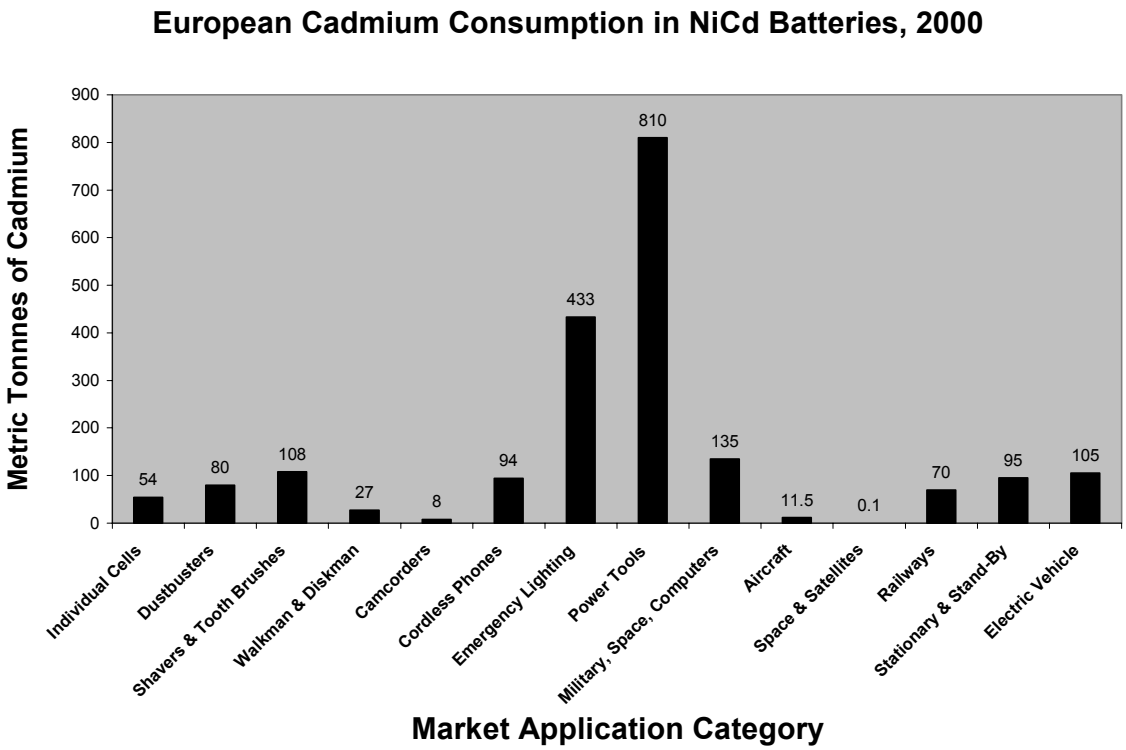

Figure 10. European Cadmium Consumption in NiCd Batteries, 2000

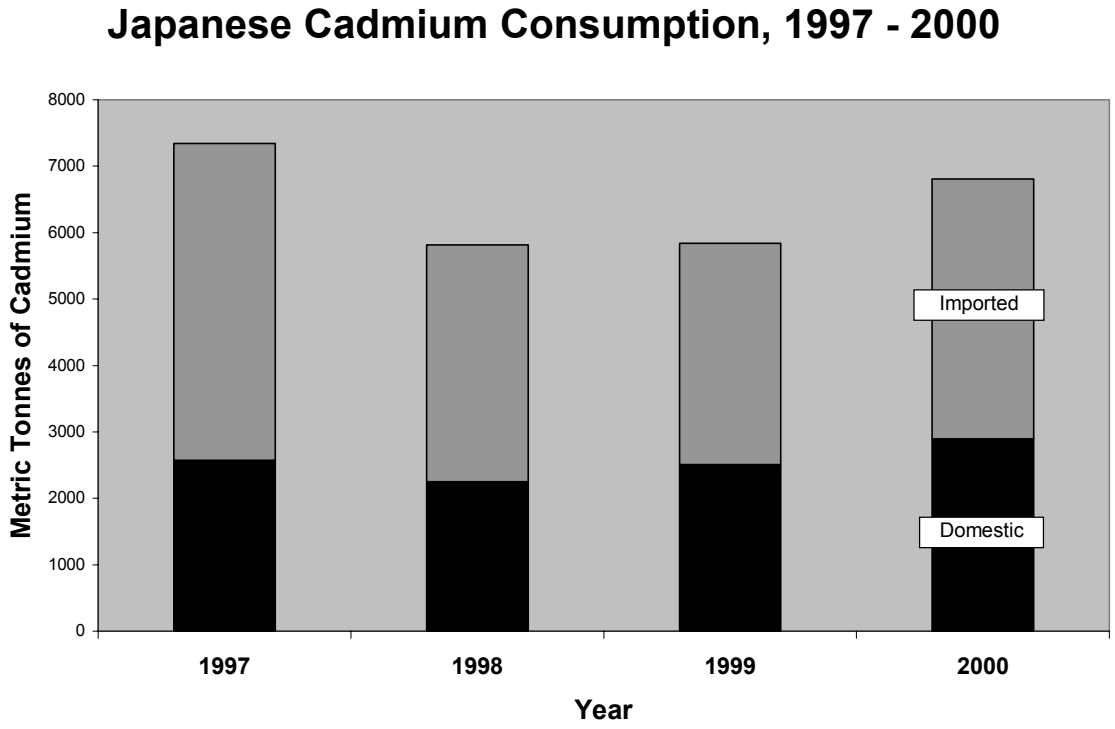

Figure 11. Japanese Cadmium Consumption, 1997 – 2000

The data in Figure 10 clearly show that, in terms of cadmium consumption, power tools are by far the most important application for NiCd batteries. Emergency lighting and security applications, which are normally characterized by far fewer batteries but by larger sized cells, consume about half as much cadmium. There is a surprising amount of cadmium utilized for large military NiCd batteries and electric vehicles, and less cadmium than one would expect for cordless telephones, shavers and toothbrushes, mainly because these latter batteries are generally fairly small.

Figure 11 presents Japanese cadmium consumption, both domestic and imported, from 1997 through 2000. It is evident, first of all, that the Japanese NiCd battery producers must rely heavily upon imported cadmium to meet all of their production needs. Second, in spite of all the predictions that the NiCd battery industry is rapidly declining at the expense of other battery chemistries, most notably nickel metal hydride (NiMH) and lithium-ion (Li-ion), Japanese cadmium consumption which is devoted almost entirely to NiCd battery production continues to increase.

A 2002 battery industry study by the Institute for Information Technology (IIT) showed that the NiCd battery production probably reached its peak in about 1995 and has been declining since then. These results are summarized in Figure 12 below. While most NiCd

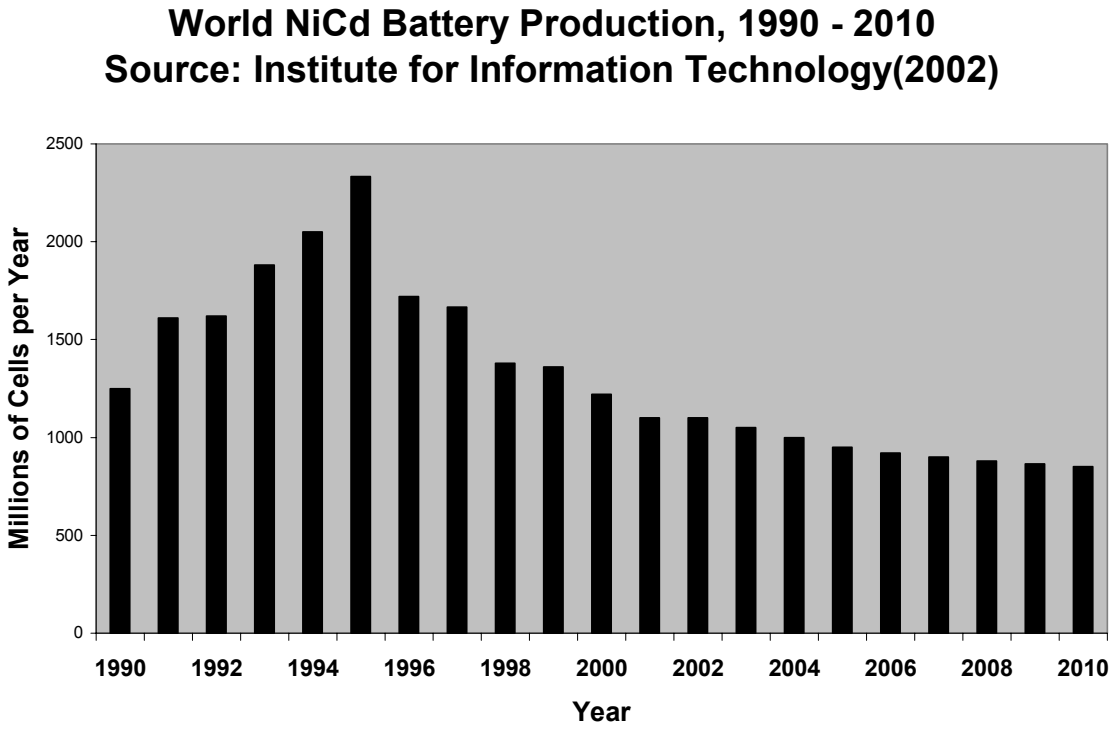

Figure 12. World NiCd Battery Production, 1990 – 2010 (Source: Institute for Information Technology, 2002)

battery industry observers agree with the marked drop after 1995, many today argue that NiCd battery market growth in 2002 and beyond will be much flatter than indicated in Figure 12 and may even show some growth. The second wind, so to speak, will be provided by the strong growth of the Chinese NiCd battery industry, the continued strong growth within the cordless power tool industry, the overall continued rapid growth of the portable battery industry, and a developing worldwide NiCd battery collection and recycling infrastructure. While no one disagrees that lithium-based batteries will grow most strongly in the future, many feel that they will do so at the expense of NiMH batteries and that a solid foundation of NiCd battery use will remain where replacement by NiMH is not warranted or feasible for cost or performance reasons.

China

Where, five to ten years ago, nickel-cadmium batteries produced in China were considered inferior products, quality control and production costs for manufacturing NiCd batteries in China are now so advantageous that much of the world's NiCd battery production has shifted from Japan to China. In 1993, NiCd battery production from China was reported to be negligible. Today, a substantial portion of the world's output of NiCd batteries is produced in China and more is being shifted there because of advantageous labor costs. The increase in Chinese NiCd battery production during the 1990s is shown in Figure 13.

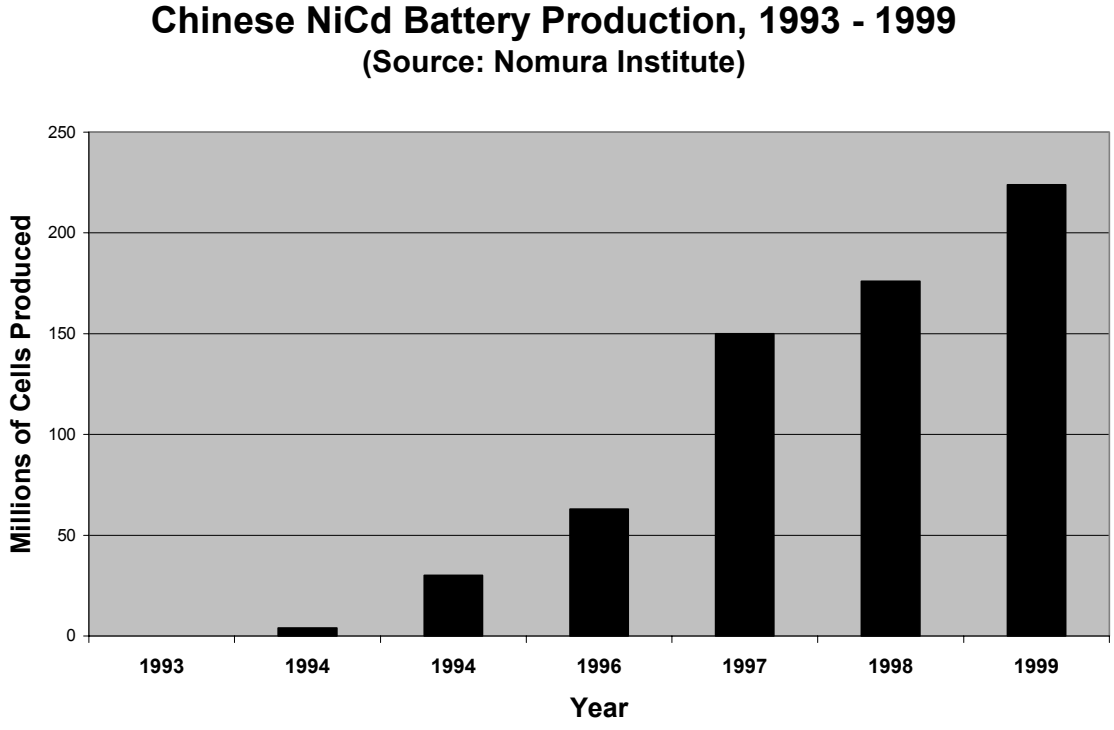

Figure 13. Chinese NiCd Battery Production, 1993 – 1999

While the metals industry was unaware for many years of the growing strength of the cadmium business in China, the battery industry certainly was not. As early as 1994, *Batteries International* magazine featured an entire issue on the Chinese NiCd battery industry and its rapid growth. However, until well into the late 1990s, the World Bureau of Metal Statistics continued to report Chinese cadmium consumption at only 600 mt per year. In more recent years, more accurate figures have been developed which are shown in Figure 14 below. The situation in China today is very much like that in Japan during the early explosion of the NiCd battery market. China consumes today far more cadmium than it produces and must rely increasingly on imports to meet its production needs. The extent to which this trend will continue in the future is, of course, the big question in the future of the cadmium market.

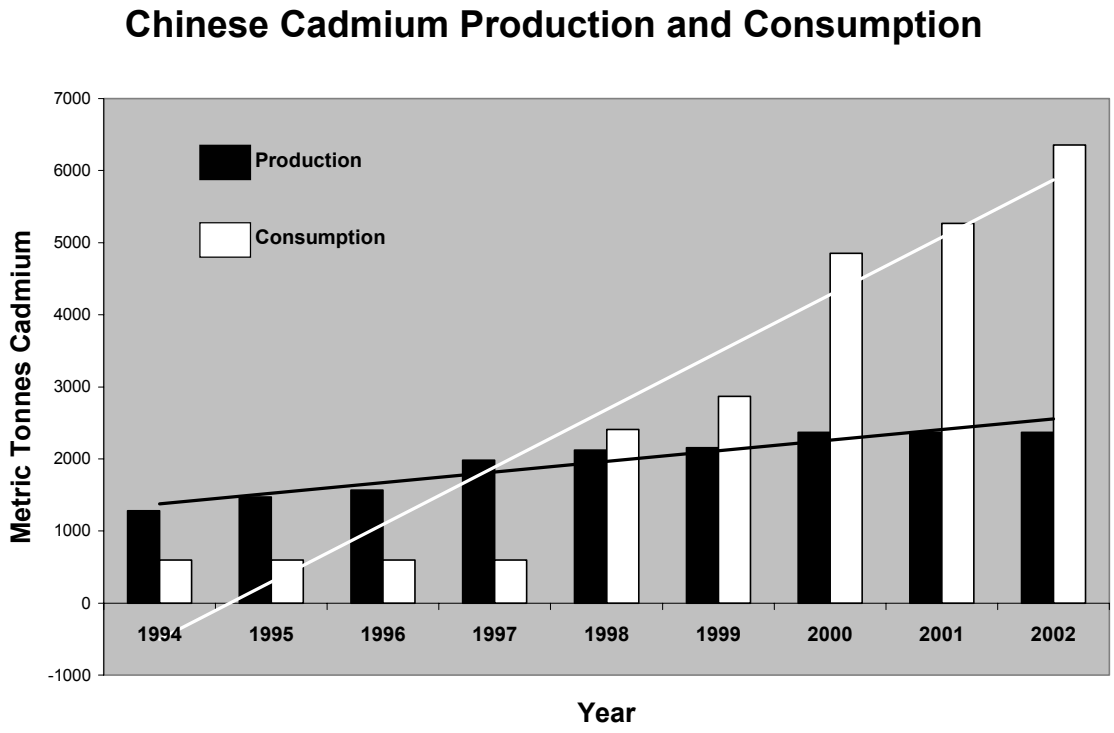

Figure 14. Chinese Cadmium Production and Consumption, 1994 – 2002

It is most likely that the explosive consumption growth in China will begin to moderate as it did in Japan about eight years ago, although it could continue if more countries shift their NiCd battery production to China because of lower production costs. It should also be noted that the trend for increased cadmium production in China may not continue because of the depressed and over-supplied worldwide zinc market. If zinc production is curtailed in China, then primary cadmium production will be lowered as well. An interesting additional question is whether or not China will establish an extensive recycling infrastructure to process NiCd battery manufacturing wastes and spent NiCd batteries as Japan previously did. This factor will, of course, significantly affect the cadmium supply-demand balance both in China and in the cadmium-producing world which exports into China.

The European Commission

Up to this point, the information presented on cadmium and the nickel-cadmium battery industry has been fairly optimistic. Worldwide demand continues to be strong. Primary supply is decreasing, but secondary supply from recycling programs is increasing. Price is also moving back to more normal levels after about five years of depressed prices. The one very negative factor in the cadmium and nickel-cadmium battery market worldwide is the extent of regulation on cadmium products, including NiCd batteries, imposed and proposed in the European Union.

Strong anti-cadmium sentiments have a long history in the Scandinavian countries, particularly in Sweden where much of the early cadmium-related health and environmental research was carried out at the Karolinska Institute. Restrictions on cadmium-containing pigments, stabilizers and coatings were instituted in various European countries beginning in the late 1970s and culminated with a European Union Cadmium Action Programme in 1988 and a Cadmium Products Directive in 1991. These early restrictions were as follows:

1979	Sweden
1984	Denmark
1987	Switzerland
1991	Netherlands

These restrictions were then harmonized to the entire European Union in 1991 with the finalization of Directive 91/338/EEC which covered cadmium pigments, coatings and stabilizers but not NiCd batteries or alloys. It should also be noted that, because suitable substitutes were not readily available in many of these applications, there were many exemptions to 91/338/EEC.

The earlier Cadmium Action Program (88/C 30/01 dated 25 January 1988) have invited EU Member States to participate in a strategy to reduce environmental and human cadmium exposure. Among the elements proposed for that strategy were:

- Limitation of the uses of cadmium to cases where suitable alternatives do not exist;
- Stimulation of research and development:
    - of substitutes ….. to the use of cadmium in pigments, stabilizers and plating;
    - related to the cadmium content of phosphate fertilizers;
    - of varieties of tobacco and food plants with lower cadmium contents
- Collection and recycling of products containing cadmium, for example batteries;
- Development of a strategy designed to reduce cadmium input in soil …. By appropriate control measures for the cadmium content of phosphate fertilizers ….;

- Combating significant sources of airborne and water pollution

What has, in fact, happened over the past fifteen years is that, again mainly at the behest of the Nordic countries, the strategy of banning, restricting or limiting the uses of cadmium has become the only strategy pursued by the Environmental Directorate of the European Commission. Attempts to facilitate the recycling of NiCd batteries in Europe by adoption of common battery labels have, in fact, been vigorously opposed by the European Commission and many of the Nordic countries. They would prefer to ban NiCd batteries rather than establish the actual risks associated with them, and then manage those risks. The European Commission has not pursued alternatives such as reducing the cadmium content of fertilizers, nor has it even examined cadmium contamination from other sources such as fossil fuels, the iron and steel industry, the cement industry, and the construction industry. It has focused all of its attention on the cadmium products sector even though at least two studies have shown that only about 2.5% of total human exposure to cadmium arises from the manufacture, use and disposal of cadmium products.

At the same time, many countries within the European Union, again led by the Nordics, had initiated labeling requirements, proper disposal requirements and even punitive taxes on certain battery chemistries which were deemed environmentally unacceptable, including lead acid, nickel-cadmium and mercury-containing alkaline-manganese and carbon-zinc batteries. European Commission regulation harmonized the various different European State laws with the issuance of Directives 91/157/EEC and 93/86. The NiCd battery label required is shown in Figure 15. The label requires identification of the "toxic" material in the battery even those most batteries contain many more than just one such substance as identified in EU Hazardous Substances Directives.

This label clearly emphasizes that the battery is not to be disposed of as ordinary trash in the dustbin and that it contains cadmium. Industry, on the other hand, prefers to emphasize that the battery is recyclable and that it is a nickel-cadmium battery which facilitates sorting for recycling. However, it soon became apparent that the labeling and proper disposal requirements of 91/157 and 93/86 were not satisfactory to the Nordic States and to DG XI (Environment) of the European Commission. By late 1996, initial proposals were made within the European Commission to restrict the use of NiCd batteries for virtually all portable consumer applications. Because of heated opposition to this proposal from other Directorates (DGs) of the European Commission, from some European Member States, from countries outside the European Union who contended that this Directive would be a violation of WTO agreements, and from international industry, the proposed Directive has been revised twice and has still not been issued.

Without going into all the laborious detail of the battle which has been waged over this proposed revision to the Battery Directive, industry has established a proactive NiCd battery collection and recycling program in Europe ("CollectNiCad") and has thoroughly analyzed the collection and recycling situation in Europe today. DG Environment and some Nordic countries have maintained that the environmental and human health risk from NiCd batteries is too great and cannot be mitigated by a collection and recycling

EC Ni-Cd Battery Label

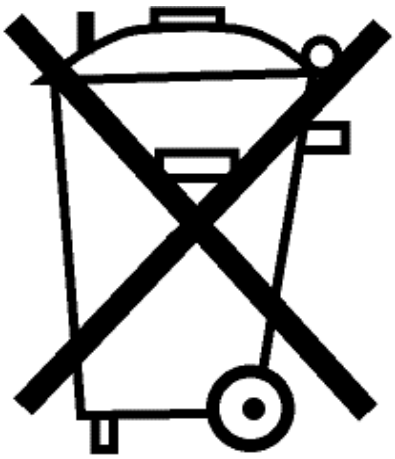

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Figure 15. NiCd Battery Labeling Requirement of 91/157/EEC and 93/86/EEC

solution. Their position is that virtually all NiCd batteries must be banned and their applications switched over to the use of NiMH batteries. While some applications such as cellular telephones and laptop computers have indeed moved away from NiCd batteries to NiMH and Li-ion chemistries, there are many applications where the performance and cost of these alternatives simply preclude their use in place of NiCds. Moreover, some life cycle analyses of NiCd and NiMH batteries suggest that there are really very little differences in total life cycle impact between the two chemistries. In addition, NiCd batteries are virtually completely recyclable whereas NiMH batteries may only be about 80% recyclable, depending upon specific composition. At present, the European Commission is awaiting the final results of a risk analysis on cadmium and cadmium oxide (not NiCd batteries) to determine if a proposal for a ban on NiCd batteries in the EU seems to be warranted. These final results are expected about the middle of this year, and the in-fighting to sway the final results of this risk analysis have been considerable. A second targeted risk assessment specifically on nickel-cadmium batteries has also been underway, but its finalization is still somewhat problematic. The earliest the NiCd battery targeted risk assessment is likely to be completed would be the end of 2003. At that point, the debate on risk management options would ensue. Thus, our view is that a complete ban on NiCd batteries in the European Union will be difficult to obtain, and will require some time. The original DG Environment proposal specified a 2008 phaseout date for NiCd batteries in Europe.

In spite of the fact that the proposed ban on NiCd batteries has not been put into effect for over six years since its initial proposal, there is no doubt that the proposal itself has had a serious effect on the NiCd battery industry in Europe. At the same time, DG Environment and the Nordic countries have been actively working to establish and have succeeded in imposing other EU Directives which ban the use of cadmium in some products. These include the following:

91/338	Cadmium Pigments, Coatings and Stabilizers
91/157	Proposed Revision to Battery Directive
2000/53	End-of-Life Vehicles Directive
2000/0158/COD	Proposed Waste Electrical Electronic Equipment Directive
2000/0159/COD	Proposed Restriction of Hazardous Substances Directive

Each of these Directives is seeking to abolish the utilization of cadmium, along with lead, mercury and hexavalent chromium, in many different products. Thus, it is expected that continued pressure will be exerted on NiCd batteries in the European Union and, by extension throughout the world, by the proposed EU restrictions on cadmium in products.

In fact, the EU proposals have already had a marked effect on the NiCd battery market in Europe, just as the original Cadmium Products Directive, 91/338/EEC, produced a marked reduction in the usage of cadmium pigments, stabilizers and coatings in the early 1990s. For example, an analysis of Japanese battery producers rechargeable battery market shares by region, shown in Figure 16, clearly shows the strength of NiMH

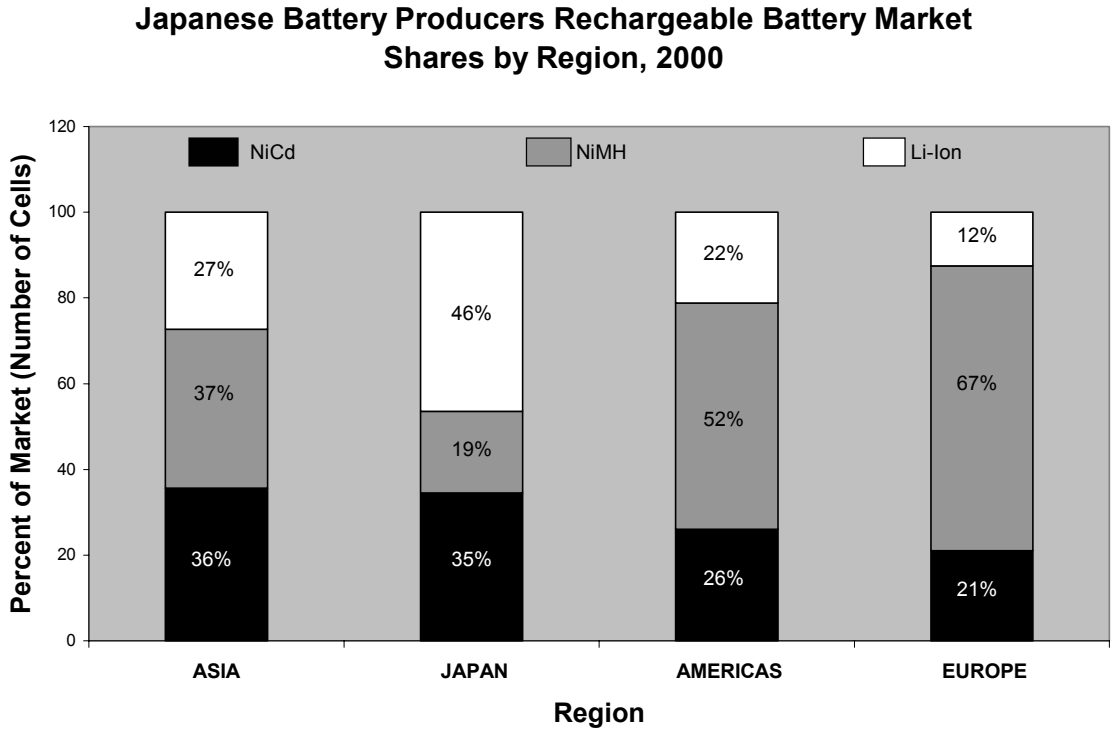

Figure 16. Japanese Battery Producers Market Shares By Region, 2000

batteries in Europe. While these figures do not include the production of Chinese, European and North American consumer battery producers, the Japanese producers, Sanyo and Matsushita/Panasonic, are dominant players in the world market. Another way of showing the same data is summarized in Figure 17 where the percent of market

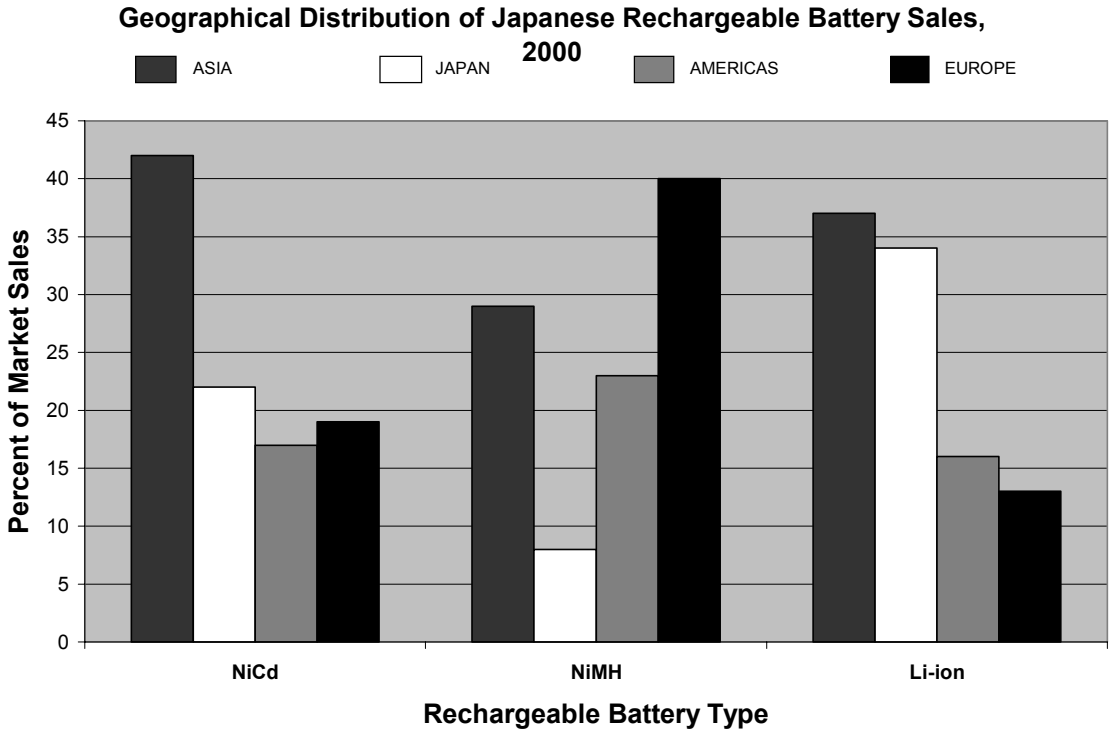

Figure 17. Geographical Distribution of Japanese Rechargeable Battery Sales, 2000

sales for each of the three major portable battery chemistries are shown. Here again, it is obvious that NiMH is a dominant rechargeable battery chemistry in Europe whereas NiCd is strongest in Asia. Li-ion is particularly strong in both Asia and Japan. Battery sales figures from as far back as 1997 indicated that the strong anti-cadmium bias in Europe was beginning to affect the NiCd battery market there.

Summary

In summary, the cadmium market today in 2003 is in a great state of flux. Primary cadmium supply is decreasing, but secondary cadmium supply is increasing. Excess cadmium stocks appear to have diminished or been depleted. As a result, cadmium prices have moved back up towards the breakeven production price of $1 per pound, but are still well below the historical average prices of $2 per pound over the past 50 years. Cadmium applications are increasingly dominated by the nickel-cadmium battery, particularly the small portable consumer cells used in power tools, emergency lighting and security, household appliances, cordless telephones and other communications devices. A modest but steady use continues in cadmium pigments and coatings for certain critical applications where viable substitutes have not been established. Cadmium stabilizers and

alloys are being replaced and eventually will disappear, but a small usage will probably develop for cadmium-based electronic compounds in solar cells and other electronic applications.

The continued strength of the NiCd battery market has been due in large part to the strength of Chinese NiCd battery production due in large part to advantageous labor, production, overhead and profit costs. The real question is whether this increased Chinese production simply represents a shift from Japanese production or if it is new additional production. I believe that it represents elements of both. I also believe that we may in the future see strong growth in other Third World markets such as India, Russia and Brazil, although perhaps not as strong or as rapid as the Chinese explosion of the past 5 years.

However, all this "irrational exuberance" to quote Alan Greenspan, must be tempered with the concerns over the human health and environmental issues surrounding cadmium, and the steps that the Environment Directorate of the European Commission, along with certain Nordic countries, have taken to restrict the use of NiCd batteries. I personally believe that the risk has been greatly exaggerated, that the final risk assessments developed by the European Commission will show that the levels of risk associated with the manufacture, use and disposal of these batteries are not unacceptable. I further think that any risks shown to be present with regard to NiCd batteries can largely be mitigated by the development of NiCd battery collection and recycling programs such as those established by the Battery Association of Japan (BAJ) in Japan, the Rechargeable Battery Recycling Corporation (RBRC) in the United States and Canada, and CollectNiCad (CNC) in Europe. Eventually these programs must be worldwide, and already I know that several countries in Asia and South America have explored the possibilities of establishing labeling, collection and recycling programs for NiCd batteries. Many jurisdictions, indeed, are looking at the collection and recycling of all battery chemistries, recognizing that recycling is probably a far more important environmental impact factor than the actual battery chemistry.

Cadmium will continue to be produced as long as zinc, lead and copper are produced. The real questions are whether primary producers will elect to curtail cadmium production because of environmental regulations and liability, or whether it will continue to be utilized as a valuable by-product and then recycled so as to minimize any human health or environmental impact. Industry would prefer the latter, but at this transition point also must examine all the options. The future is anything but certain.