Economics of Conversion to Mercury-Free Products
Final Draft

UNEP DTIE Chemicals Branch

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Executive Summary

The United Nations Environment Programme (UNEP) Chemicals Branch works to protect humans and the environment from adverse effects caused by chemicals throughout their lifecycle, including hazardous waste. Mercury is considered a chemical of global concern due to its long-range transport in the atmosphere, its persistence in the environment, its ability to bioaccumulate in ecosystems and its significant negative effect on human health and the environment. UNEP has been working to address issues associated with the use of mercury since 2003. Governing Council 25/5 called for the elaboration of a legally binding instrument on mercury with negotiations that commenced in 2010 and planned to be finalized in 2013. The third session of the Intergovernmental Negotiating Committee to prepare a global legally binding instrument on mercury is planned to take place at UNEP Headquarters in Nairobi, from 31 October to 4 November 2011. This study was commissioned in July 2011 by the UNEP Chemicals Branch with study results aimed to inform the negotiations.

This report provides information from case studies of two firms involved with transitioning from mercury-containing to mercury-free products in the medical technology industry. One firm, American Diagnostic Corporation (ADC), is a manufacturer of diagnostic medical devices with operations in Hauppauge, New York, United States. The ADC study, which is more quantitative in nature, examines the company's experience with sphygmomanometers and digital thermometers. The other participating firm, Rayovac Hearing Aid Battery Division, is a manufacturer of miniature batteries for the hearing instrument market with plant operations in Portage, Wisconsin, USA and Washington, United Kingdom.

The Rayovac study is more qualitative in nature as a result of Rayovac's decision not to release specific financial information regarding the transition costs to mercury-free product manufacturing. In addition to the view into specific product sectors, the study illustrated two firms with distinct positions in a global supply chain. Rayovac's technology finds use within other manufacturer's products, while ADC represents branded product integration and testing immediately prior to end use. Despite the firms' occupancy of differing nodes along the supply chain, their experiences have led to similar decisions regarding transition to mercury free-products.

The manufacturers have demonstrated that they can provide mercury-free products with equivalent performance to the mercury-containing products for hearing aid batteries, thermometer batteries, and most sphygmomanometer applications. The results of the case studies suggest that the lack of a coherent, legally binding agreement for adoption of proven mercury-free alternatives has created a market place that requires manufacturers willing to invest in the development of mercury-free solutions to continue offering both mercury-containing and mercury–free devices. This scenario has delayed universal adoption of mercury-free devices and obligates firms to expend resources on less economically productive activity such as mercury management and production line changeovers while failing to capitalize fully on the economies of scale that could accrue from full conversion to mercury-free alternatives.

At this time, sufficient mercury-free manufacturing capacity exists within the product sectors examined in this study to assure supply of mercury-free products to meet consumer demand. In addition, a mandate to provide only mercury-free products in the sectors examined would foster competition among suppliers that will further promote innovation in mercury-free technologies to ultimately benefit consumers and the environment.

Introduction

Background
The United Nations Environment Programme (UNEP) Chemicals Branch works to protect humans and the environment from adverse effects caused by chemicals throughout their lifecycle, including hazardous waste. UNEP Chemicals' program reflects global priorities identified by governments around the world. In response to mandates from UNEP's Governing Council, UNEP facilitates global action, including the development of international policy frameworks, guidelines and programs, to reduce and/or eliminate risks from chemicals. Mercury is considered a chemical of global concern due to its long-range transport in the atmosphere, its persistence in the environment, its ability to bioaccumulate in ecosystems and its significant negative effect on human health and the environment. Mercury is known to produce a range of adverse human health effects, including damage to the nervous system, in particular the developing nervous system.

UNEP has been working to address issues associated with the use of mercury since 2003. During 2009, the Governing Council of UNEP agreed on the need to develop a global legally binding instrument on mercury. The work to prepare this instrument was undertaken by an intergovernmental negotiating committee supported by the Chemicals Branch of the UNEP Division of Technology, Industry and Economics as secretariat. The goal is to complete the negotiations before the twenty-seventh regular session of the Governing Council/Global Ministerial Environment Forum to be held in 2013. The third session of the Intergovernmental Negotiating Committee to prepare a global legally binding instrument on mercury is planned to take place at UNEP Headquarters in Nairobi, from 31 October to 4 November 2011 (UNEP, 2011). This study was commissioned in July 2011 by the UNEP Chemicals Branch to the Lowell Center for Sustainable Production (LCSP) with results aimed to inform the negotiations.

Objective
The objectives of this study were to accomplish the following:

- Investigate the cost of transition and technological shift in the manufacturing of mercury-containing to mercury-free product alternatives.
- Focus the investigation within the medical device technology sector.
- Involve two manufacturing firms from the North American and European geographic regions in the development of case studies representative of the medical device technology sector.
- Generalize the results obtained from the two firms to the broader market sector, and investigate options for financing the technology transition to mercury-free product alternatives.

Methodology

The intent of this study was to obtain primary data from two manufacturers that have made the transition from manufacturing and selling mercury-containing products, to manufacturing and selling mercury-free products. One firm should have manufacturing locations in the United States, and one firm should have manufacturing locations in Europe. The primary data would then be reviewed, analyzed and documented in a case study for each manufacturer. The type of primary data collected from the two manufacturers included the following:

a) Costs and challenges of transition to non-mercury alternatives
b) Economic elements: research and development costs, manufacturing costs, marketing costs, regulatory compliance costs and other costs saved or incurred during the technological shift
c) Payback period or Return on Investment (ROI)
d) Extrapolation to the entire product category sector
e) Financing options for transition costs

The first step was to identify manufacturers of devices in the medical technology sector that had manufactured mercury containing products and had partially or fully transitioned to manufacturing mercury-free products. Also, the manufacturing locations for these targeted firms should be in the North American and/or European geographic area. The LCSP identified thirty-two manufacturing firms that potentially met this requirement. This included fifteen firms with facilities in North America, and seventeen firms with facilities in Europe. The following is a listing of these companies:

North America
- MDF Instruments
- American Diagnostic Corp.
- GF Health Products Inc.
- W. A. Baum
- Welch Allyn
- Rayovac US
- Medline Industries, Inc.
- Sper Scientific Ltd.
- Taylor Precision Products
- Vee Gee Scientific
- Anderson Instrument Company
- BD Diagnostic Systems
- Miller & Weber, Inc
- Coto Relay
- GE Healthcare

Europe

- Rudolf Riester GmbH
- Brannan
- A C Cossor & Son
- Keeler LTD
- Heine Optotechnik
- Istar Solar
- Encapsulite
- Pickering Electronics
- Comus
- Siemens
- Philips Medical
- Varta
- Cegasa
- Leclanche
- Osram
- Celduc Relais
- Rayovac Europe

These thirty-two firms involved with manufacturing of mercury-containing and/or mercury-free medical technology devices were contacted via email and/or telephone to introduce the study objective and to solicit participation.

Firms that expressed interest in obtaining more information were provided with 1) the UNEP Introductory Letter and 2) the Case Study Information Request Form (see Appendix A). The purpose of the UNEP Introductory Letter was to emphasize the importance of this initiative and how UNEP would use the information provided by the manufacturer. The purpose of the Case Study Information Request Form was to educate the firm on the type of primary data that would need to be collected from them to support the development of the case studies. Many companies were non-responsive to these requests. Several companies were responsive, but upon learning more details about the case study requirements, declined to further participate. The most common objection to case study participation was the unwillingness of firms to provide confidential financial information that would be required for completing the case study.

Of the thirty-two North American and European firms contacted, the only two firms that were willing to participate and provide information for the case studies were: American Diagnostic Corporation (ADC) and Rayovac Hearing Aid Battery Division (Rayovac). ADC has a manufacturing location in Hauppauge, New York, United States, and Rayovac has manufacturing facilities in Portage, Wisconsin, United States and Washington, United Kingdom. The information for the case studies was obtained from these two firms in an iterative manner that included many phone conversations, email correspondence, document exchange, and on-site visits.

The on-site visits were conducted at the manufacturing facility locations and included interviews with key personnel and a review of the actual manufacturing processes. The site visit for ADC was conducted on September 7, 2011 with Quality Manager Michael Falco at the Hauppauge, New York, United States manufacturing facility. This facility manufactures both mercury-containing and mercury-free medical devices.

Two site visits were conducted for Rayovac. The first site visit was conducted on September 14, 2011 at the Portage, Wisconsin, United States manufacturing facility with Hearing Aid Battery Division Vice President Randy Raymond and Plant Manager Dave Young. The second site visit was conducted on September 27, 2011 at the Washington, United Kingdom plant with Hearing Aid Battery Division Vice President Vince Armitage, Plant Manager Glen Rutherford, Europe, Middle East and Africa (EMEA) Marketing Manager Paula Brinson Pyke, and by teleconference with David Reynolds of the battery recycling firm Battery Back.

The Portage, Wisconsin, United States facility primarily manufactures mercury free hearing aid batteries, and the Washington, United Kingdom facility primarily manufactures mercury-containing batteries. However, both manufacturing plants have the dual capability to manufacture mercury-free and mercury-containing hearing aid batteries. This is accomplished by conducting production line changeovers to meet the needs of their customers. Therefore, two site visits were required for Rayovac to fully understand the implications of transitioning from the manufacturing of mercury-containing to mercury-free batteries.

American Diagnostic Corporation (ADC)

American Diagnostic Corporation (ADC) was founded in 1984 and is considered one of the world's leading suppliers of diagnostic medical products, personal instruments, and accessories within the medical device industry. ADC is a privately held corporation with estimated annual revenues greater than 10 million USD (Manta, 2011).

ADC's corporate headquarters are located in Hauppauge, New York, United States. There are approximately 110 employees located at the Corporate Headquarters in Hauppauge NY. The headquarters occupies a 44,000 square foot office that includes quality control, sales, manufacturing, and distribution operations. ADC operates sales offices in London, England, and Tokyo, Japan to support European and Pacific Rim markets. ADC also operates quality control and sourcing offices in Taipei, Taiwan and Ningbo, China to oversee ADC's Asian contract manufacturing facilities. Products and operations are covered by ISO 13485:2003 and ISO 9001:2008 certifications.

ADC products are sold in thirty countries and are in use by thousands of health care institutions and millions of health care professionals world wide. ADC partners with subcontractors to produce approximately two thousand different proprietary components to international or ADC internal standards. These proprietary components are then inspected, tested, assembled, and packaged at the company’s Hauppauge, New York facility into over 6,500 different products in the following eight distinct product categories.

- Airway Management
- Diagnostic Instruments
- Medical Caseware
- Personal Instruments
- Pulse Oximeters
- Sphygmomanometers
- Stethoscopes
- Thermometers

ADC products are marketed under various brands including the following: ADC, MEDICUT, ADSCOPE, ADView, PROSCOPE, DIAGNOSTIX, PROSPHYG, ADTEMP, MULTIKUF, ADLITE, POCKET PAL, RESPONDER, ADCUFF, SYSTEM 5, and ADFLOW. ADC also manufactures products under OEM (original equipment manufacturer), and private label contracts for manufacturers and distributors in various healthcare markets. ADC is currently the largest private label supplier of stethoscopes and blood pressure instruments in the United States. (ADC, 2011)

ADC has an internet presence at the following URL: http://www.adctoday.com/

ADC Representative
ADC Quality Manager Mr. Michael Falco was the key contact for developing the ADC case study. Mr. Falco has been with the company for nine years and is presently responsible for all facets of the company's quality management program including medical device registration. He also manages ADC's safety program including mercury handling, recovery and recycling. Mr. Falco is active with the New York Department of Environmental Conservation as an industry representative to the mercury taskforce. He has a degree in Business Administration and has undergone extensive ASQ (American Society for Quality) training.

Rayovac
Rayovac is a division of Spectrum Brands Inc. It was founded in 1906 as the French Battery Company in Madison, Wisconsin, United States. The Rayovac name was adopted in 1930. Rayovac has an extensive history of technology innovation and patent holdings. The company headquarters is located in Madison, Wisconsin, United States. Rayovac manufactures a wide range of batteries including hearing aid batteries at its Portage, Wisconsin, United States and Washington, United Kingdom plants. The Portage, Wisconsin, United States plant maintains certification to the ISO9001 and ISO14001 standards. Rayovac is the world's largest manufacturer of zinc air batteries used in hearing aids and cochlear implants. Spectrum Brands Inc is a publically traded corporation with annual revenues in excess of $3 billion. Global battery sales in the third quarter of 2011 were $221.9 million with North American sales at $102.3 million and European sales were $78.3 million. (Spectrum Brands, 2011)

Rayovac has an internet presence at the following URL: http://www.rayovac.com/

Rayovac Representative
Randall A. Raymond ("Randy"), Vice President of Global Sales for Hearing Aid Battery Sales and Marketing for Rayovac, a division of Spectrum Brands, Inc was the key contact for developing the Rayovac case study. He has managed this business unit since 1999. Randy has served on several industry Boards including the Hearing Industry Association, the Better Hearing Institute, and Crop Life Canada. He attended the University of Western Ontario in Canada, where he majored in Economics. Randy is also an alumnus of the University of Virginia, completing The Executive Program at the Darden School of Business in 2000.

Sources
The data from these two firms were the primary sources of information for this report. Other published sources of information included: UNEP website; UNEP Report on the major mercury-containing products and processes, their substitutes and experience in switching to mercury-free products and processes; UNEP, The Use of Economic Instruments for Environmental and Natural Resource Management; UNEP , Chemicals Branch, An Analysis of Economic Instruments in Sound Management of Chemicals; World Bank, World Development Indicators Database and Northeast Waste Management Official's Association (NEWMOA), and the Interstate Mercury Education & Reduction Clearinghouse (IMERC) Database.

Report Format
The "Findings" portion of the report is organized into three sections based on the medical device technologies produced by the participating firms: Sphygmomanometers (ADC), Hearing Aid Batteries (Rayovac)' and Thermometers (ADC). Each section is further divided into sub-sections describing the manufacturer's approach to transitioning from mercury-containing to mercury-free products, the summary economic elements and an extrapolation to the global product sector. The ADC study is more quantitative in nature due to the availability of primary financial data, while the Rayovac study is more qualitative in nature as it examines the marketplace and the company's key decision points for investment in mercury-free technology. Rayovac considers their financial information pertaining to the transition to mercury-free manufacturing confidential business information that should not be made publicly available.

The estimates and economic indicators presented in the report do not include factors for inflation. This is because the primary source information obtained for the case studies is relatively current, and also because the variability inherent in the estimates provided by the manufacturers is likely much greater than the impact of inflation. Additionally, the cost estimates associated with mercury content in products presented in this report do not incorporate the economic externalities associated with the broader aspects of environmental pollution and worker health that are inherent to the global production and disposal of mercury itself.

Findings

1. Sphygmomanometers

Overview

Sphygmomanometers measure both systolic and diastolic blood pressure. Blood pressure measurement devices commonly use an air filled cuff to temporarily block blood flow through the artery, and then apply a particular technique to obtain blood pressure data while the cuff deflates. Common techniques for pressure measurement include listening for characteristic blood flow sounds (auscultation), and oscillometric techniques. The auscultatory method involves the use of a stethoscope while the oscillometric technique uses a pressure transducer. Sphygmomanometers are commercially available in different styles such as wall unit, mobile unit, pocket unit, and desk model. (UNEP 2008)

Mercury Sphygmomanometers

The mercury-containing sphygmomanometer uses the auscultatory method to measure blood flow. The clinician determines both systolic and diastolic blood pressures by listening for Korotkoff sounds, or sounds that characterize different stages of blood flow during cuff deflation. The clinician reads the pressure level at certain points in the sound pattern. The mercury sphygmomanometer uses a column of mercury to provide the pressure readout. The known expansion and contraction of mercury in response to pressure are very suitable for pressure indication. The column of mercury typically reads between 0 to 300 millimeters of mercury. The amount of mercury content in sphygmomanometers has been reported to be from 50 to 140 grams per sphygmomanometer.
(UNEP 2008)

Alternative Sphygmomanometers

There are two primary types of alternatives to mercury sphygmomanometers: aneroid sphygmomanometers and electronic sphygmomanometers. Aneroid sphygmomanometers use the auscultatory method to measure blood flow. An aneroid gauge consists of a dial that reads in units of 0 to 300 millimeters of mercury and a thin brass corrugated bellows that is responsive to changes in pressure. The electronic sphygmomanometer uses the oscillometric technique. The electronic sphygmomanometer utilizes a pressure sensor and a microprocessor instead of the human ear and simple gauge. During cuff deflation, a pressure sensor transmits an electric signal to a microprocessor that translates the signal to systolic and diastolic blood pressure. (UNEP 2008)

ADC Products

ADC offers thirty-one models of sphygmomanometers for applications ranging from home to clinical use. Four of the models are mercury tube sphygmomanometers. Eighteen of the models are aneroid sphygmomanometers, and nine of the models are electronic sphygmomanometers. (ADC, 2011)

Approach to Transition: Method and Challenges

ADC offers several mercury-free alternative products for replacing existing mercurial sphygmomanometers. The firm has developed a mercury exchange program in the United States to help companies offset the total cost for disposal of their original equipment and having it properly recycled. This recycling program is discussed in greater depth later in this report.

Motivation for undertaking transition to Mercury Free Products

For the past several years a number of new regulations and ordinances have been passed in states and counties throughout the United States in order to reduce or eliminate products containing mercury or mercury-added components. For example, the Northeast Waste Management Official's Association (NEWMOA) has established the Interstate Mercury Education and Reduction Clearinghouse (IMERC) to track these products and limit their use throughout participating states. In order to maintain compliance with the increasing number of ordinances, American Diagnostic Corporation (ADC) is working to reduce the number of mercury units distributed and is offering a line of mercury-free alternatives. Since current legislation is fragmented and may vary from state to state, it is difficult to track where such products will be banned in the future and as a result, ADC anticipates declining sales of its mercury sphygmomanometers in the United States. (Falco, 2011)

ADC Approach

Currently ADC does not have a specific timeline for the elimination of all mercury-containing sphygmomanometers because of ongoing customer demand. According to ADC, the mercury column sphygmomanometers require no regular calibration and are highly reliable short of catastrophic breakage with no moving parts, whereas aneroid and electronic sphygmomanometers require regular calibration and include mechanical and/or electronic components that can fail or be damaged through mishandling. Consequently, the mercury-containing sphygmomanometer products will likely remain on the market beside their mercury-free alternatives for several more years.

Over time, it is likely that additional states, localities, and other regulatory bodies will pass ordinances requiring the reduction of mercury-containing sphygmomanometer products or banning them outright. As it becomes more difficult and costly to manage compliance with the laws that vary from state to state, it will become a financial burden for ADC to continue the distribution of the mercury containing products. As costs increase, the mercury-containing product line will be phased out entirely.

Additional costs associated with mercury-containing sphygmomanometers include the rising cost of the elemental mercury that is used in these products. As bans increase worldwide on various mercury-added products, the effect will be that the materials needed to make these products will become scarcer and the costs of manufacturing will increase. This situation will also serve to reduce the profitability of the mercury-containing product line and accelerate the phasing out of these products. (Falco, 2011)

Mercury Sphygmomanometer Exchange Program
ADC has developed an exchange program in the United States to help with the proper disposal of mercury-containing sphygmomanometers. This program applies to any sphygmomanometer type (desk top, wall mount, or mobile) or brand. In exchange for a customer purchasing a comparable quantity of their wall (750W series) or mobile (752M series) clock aneroid instruments, ADC will provide a sufficient number of mailers (carton, polybag, labels) allowing for the safe return to ADC of an equivalent number of mercury-containing sphygmomanometers. For a nominal fee to the customer, ADC assumes all costs for the proper disposal of the liquid mercury and instrument. (ADC, 2011) Results of this program are presented below in Table 1 for calendar year 2010.

Table 1 – ADC Sphygmomanometer Exchange Program

Mercury containing sphygmomanometers returned	Mercury recovered from returned sphygmomanometers	Mercury shipped in all products	*Mercury recovered (as % shipped)
213	64lb (29 kg)	386lb (175kg)	17%

*Note that the total quantity of mercury shipped in 2010 is an aggregate for all products including digital thermometers. Thermometers contain only 1.4 mg of mercury per cell and are not considered a significant contribution to the total amount. (Falco, 2011)

The exchange program resulted in sales of 213 aneroid sphygmomanometers and directed 64 lbs (29 kg) of mercury to recycling facilities in the United States. Appendix B includes samples of ADC exchange program promotional documentation as well as mercury sphygmomanometer shipping instructions.

Economic elements: Costs and ROI/Payback
ADC is a privately held corporation, and therefore is not required to do extensive financial disclosure reporting. As a result, ADC chose not to disclose specific financial information including annual sales by product line. Instead, ADC performed calculations of Return on Investment (ROI) for the line of blood pressure monitoring devices impacted by the transition to mercury-free technology.

The results were calculated according to the following definitions and formulas:

<u>Return on Investment (ROI)</u>: A ratio of loss or gain relative to the initial investment. This ratio is used to evaluate the efficiency of an investment.
ROI = [(annual net impact from transition)/transition costs] x 100 (expressed as a percentile)

<u>Simple Payback:</u> The period of time required for the return resulting from an investment to become equal to the initial investment.
Simple Payback = [total transition costs/ annual net impact from transition costs] (expressed in years)

Annual net impact from transition: Annual cost savings that result from the transition to mercury-free manufacturing such as reduced regulatory compliance costs, reduced employee training/testing costs, reduced hazardous waste/disposal costs, eliminating purchase of mercury, etc. Reduced regulatory compliance costs include report preparation time and fees associated with compliance to current regulations. These savings are reduced by any annual costs that result from transition to mercury-free manufacturing. Annual Net Impact = Annual cost savings – Annual costs

Total transition costs: Transition costs such as research and development costs, materials and components costs, manufacturing transition related costs, marketing costs and other costs related to the initial investment to transition to mercury-free manufacturing.

Table 2 – Summary Economic Indicators for ADC Mercury-Free Sphygmomanometers (Falco, 2011)

	Return on Investment (ROI)
Sphygmomanometers	100.06%

The ROI presented in Table 2 is the result of cost reductions incurred through elimination of mercury as well as the very low transition costs resulting from the ADC supplier business model described below. The exact sales numbers, annual net impact from transition, and transition costs used by ADC to calculate the ROI were considered confidential business information and were not provided for this case study.

Specific annual costs provided by ADC that are associated with the ongoing manufacture of mercury-containing sphygmomanometers are presented in Table 3.

Table 3 – Annual ADC Mercury-containing Sphygmomanometer Costs

Cost Category	Annual Cost
Exchange Program	$ 488
Regulatory Compliance	$ 1,100
Regulated Waste Handling, Disposal and Exposure Monitoring	$ 3,758
Total	$ 5,346

Exchange program costs are directly assignable to the special packaging kits that ADC purchases to handle in-bound mercury containing sphygmomanometers returned by customers. The exchange program that ADC offers is unique among U.S. manufacturers. However ADC anticipates that mandated product stewardship requirements, including take back, will soon appear thereby initially increasing the number of manufacturers offering exchange programs and costs associated with selling mercury-added products. As the programs are implemented state by state, compliance will become more difficult and management of the various registrations and requirements will create a significant burden for manufacturers. ADC anticipates that widespread mandated product stewardship programs will eventually result in phasing out or complete elimination of mercury sphygmomanometers.

Regulatory compliance costs are based on the amount of time spent per year to prepare reports, supply data and respond to customer inquiries about mercury related legislation. Regulated waste handling and disposal costs are expressed as a three year average. These costs include mercury collection and recycling.

Other costs categories were considered including business liability insurance, energy savings, worker related health claims and cost of mercury. Business liability insurance does not change significantly with the transition to mercury-free manufacturing because product liability associated with medical devices drives most of the risk to the business. The complete transition to mercury-free would however eliminate the risk of off-premises product leakage during transportation and the associated liability for clean-up. With regard to energy savings, the costs associated with the mercury product lines versus the non-mercury product lines are relatively similar. Both product lines are tested with the same equipment and therefore use a similar amount of electrical power.

There have been no occupational health claims related to the relatively small amount of mercury handling that occurs in the assembly and testing process since manometers tubes are delivered sealed from a supplier. All evidence obtained during regular air monitoring indicates that employee exposure is well controlled. There is associated cost for mercury vapor testing and employee monitoring that would be eliminated in a complete transition to mercury free. That cost is included in Table 3 along with costs for regulated waste management. Mercury costs are rising to the point where several of the ADC mercurial models are threatened with becoming unprofitable. This cost increase is embedded in supplier material costs that were not disclosed. ADC believes that the increasing price of mercury (see Annex 2 for mercury price and production trend) is being driven by material use bans that are contributing to a decrease in profitable mercury production and reduced availability. ADC anticipates that if this trend continues mercurial sphygmomanometers will either become much more expensive (and therefore less competitive) in the market or simply unprofitable to manufacture when compared to non-mercury alternatives. (Falco, 2011)

Table 4 summarizes initial transition costs associated with mercury-free sphygmomanometers. ADC performs value-added manufacturing steps within its facility in the form of component testing, product assembly and final product testing. ADC indicated that there were no incremental costs associated with manufacturing the mercury-containing versus the mercury-free alternative sphygmomanometers based on the similarity in testing and assembly requirements among the mercury and non-mercury products. ADC also indicated that there were no incremental R&D costs associated with the transition to mercury-free sphygmomanometer alternatives. This was attributed to the assignment of R&D activity to ADC's large component supply chain base.

ADC's supplier business model typically involves exclusivity agreements with component suppliers for its North America products. As a result ADC provides suppliers with its expert knowledge of the North American marketplace to facilitate effective collaboration on product development. Supplier component development thereby meets ADC specifications but is leveraged by the supplier to improve its products for other global customers. This arrangement allows the suppliers to distribute development costs that benefit ADC across a larger customer base. (Falco, 2011) ADC suppliers would have to be contacted to determine the manufacturing and research & development costs.

Table 4 – Initial ADC Mercury-free Sphygmomanometer Transition Costs

Cost Category	Annual Cost
Manufacturing	$ 0
Research and Development	$ 0

Estimated Average Transition Cost Savings per Device Distributed The average cost savings to transition from a mercury-containing to a mercury-free sphygmomanometer can in part be approximated from the cost savings associated with avoiding unique expenses associated with mercury content that are summarized in Table 3. The method employed to determine this value is as follows:

Step 1

The number of mercury containing sphygmomanometers is estimated by dividing the total quantity of mercury sold (Table 1) by an assumed average mass of mercury contained in each device. Ninety-five grams of mercury per sphygmomanometer has been selected as an average representation of the mass range reported in the Interstate Mercury Education & Reduction Clearinghouse (IMERC) database. This value is the average of the IMERC range between 50 gm and 140 gm for sphygmomanometers (NEWMOA, 2008)

386 lb mercury * 454 gm per lb / 95 gm mercury per sphygmomanometer = 1,845 mercury containing sphygmomanometers sold by ADC

Step 2

The total annual mercury related costs from Table 3 are divided by an estimate of the number of mercury containing sphygmomanometers sold during the same time period to obtain the cost avoidance per device.

$5,346 / 1,845 sphygmomanometers = **$2.90 annual** cost avoidance per sphygmomanometer sold by ADC

Result

Table 5 - Estimated Average Operational Cost Savings in Distributing Mercury-Free Sphygmomanometers

Estimated Average Transition Cost Savings per Sphygmomanometer
$2.90

Extrapolation to Entire Product Sector

Figures on global sales of mercury sphygmomanometers were not readily available from public reference sources. Therefore the extrapolation to the global sector required developing estimates based on available sources of data. The method utilized to extrapolate from the results of the ADC economic elements associated with the conversion from mercury-containing to mercury-free sphygmomanometers to the entire product sector is presented below.

Step 1

The total quantity of mercury used to manufacture sphygmomanometers was based on the completion of mercury demand surveys or request for information (RFI) provided to UNEP in 2008. The total demand reported was 97.8 metric tons as outlined in the table below.

Table 6 - Mercury Demand for Sphygmomanometers (sorted by Estimated Mercury Demand)

Country	Source of Data	Estimated Mercury Demand/Quantity Used (metric tonnes/year)
China	Other	94.9 (2004)
Japan	RFI	1.89 (2005)
United States	RFI	1 (2004)
Argentina	RFI	0.006
Sweden	RFI	< 0.001
Belarus	RFI	0
Netherlands	RFI	0
Norway	RFI	0
TOTAL		**97.8**

(UNEP, 2008)

Step 2

Ninety-five grams of mercury per sphygmomanometer has been selected as an average representation of the mass range reported in the Interstate Mercury Education & Reduction Clearinghouse (IMERC) database. This value is the average of the IMERC range between 50 gm and 140 gm for sphygmomanometers (NEWMOA, 2008).

Estimated number of mercury sphygmomanometers sold per year = Estimated global mercury usage for sphygmomanometers/ Average mercury content per sphygmomanometer

- Estimated global mercury usage for sphygmomanometers

  (97.8 metric tons [table 6] * 1000 kg per metric ton * 1000 grams per kg) = 97,800,000 grams of mercury

- Average mercury content per sphygmomanometer

  95 grams per sphygmomanometer

- Estimated number of sphygmomanometers sold per year

  97,800,000 grams of mercury/95 grams per sphygmomanometer = **1,029,474** sphygmomanometers sold per year

Step 3

Table 7 – Summary Data for Sector Cost Savings for Suppliers through Mercury-Related Cost Avoidance

Estimated Number of Sphygmomanometers Sold	Estimated Average Transition Cost Savings (Table 4)
1,029,474	$ 2.90

Number of sphygmomanometers sold * average cost savings for mercury-free transition per sphygmomanometer = Global Product Sector Cost for Mercury Free Transition

1,029,474 sphygmomanometers * $2.90 cost savings per sphygmomanometer = **$2,985,475** annual sector cost avoidance

Result

Table 8 – Global Sector Annual Cost Avoidance for Suppliers through Mercury Content Elimination

Annual Cost Avoidance
$2,985,475

This estimate is based on the mercury management costs associated with a single United States manufacturer of sphygmomanometers. The actual costs and savings associated with mercury management programs could vary significantly between different sphygmomanometer manufacturers based upon such factors as: regulatory compliance with local, state and national requirements, manufacturing technology utilized, use of subcontractors for manufacturing components and manufacturing techniques such as lean manufacturing. Additionally the estimates of cost associated with mercury content in products presented in this report do not incorporate the economic externalities associated with the broader aspects of environmental pollution and worker health that are inherent to the global production and disposal of mercury itself.

The estimate of annual global sphygmomanometer sales at approximately 1 million is supported by two additional market estimates. One estimate was published by Health Care without Harm of more than 1.5 million sphygmomanometers produced within China, the largest global manufacturer, in 2005 (Health Care without Harm, 2007). The other estimate was calculated by LCSP at approximately 951,000 mercury-tube sphygmomanometers. (see Annex 1 for calculation method)

2. Hearing Aid Batteries

Overview

Miniature Batteries

Miniature batteries are used in a variety of products that require compact sources of electrical power. Miniature batteries are often used for supplying electrical power for toys, hearing aids, watches, calculators, and other portable devices. Miniature batteries are typically coin or button shaped. The four common technologies used for miniature batteries are: silver oxide, zinc air, alkaline, and lithium. The lithium miniature batteries contain no intentionally added mercury. However, there is typically 0.1% to 2.0% mercury content in most silver oxide, zinc air, and alkaline miniature batteries. The UNEP toolkit provides mercury content for miniature batteries in the European Union as outlined in the following table. (UNEP, 2005)

Table 9 - Mercury Content in Miniature Batteries

Battery Type	Kilograms of Mercury Per Metric Ton of Batteries
Mercury oxide	320
Zinc air	12.4
Alkaline	4.5 - 10
Silver oxide	3.4 - 10

The function of the mercury is to inhibit corrosion inside the miniature battery cell. Corrosion can cause electrolysis in the electrolyte and initiate the production of hydrogen gas. Gas buildup inside the cell could lead to bulging and potentially result in leakage of battery cell materials, as well as impair the ability of the battery to continue functioning. Several alternatives to mercury-containing miniature batteries were identified. There are mercury-free models commercially available for silver oxide, zinc air, and alkaline miniature batteries. In addition, lithium miniature batteries, which do not contain mercury, are sometimes considered as a potential alternative to mercury containing miniature batteries.

Original equipment manufacturers (OEMs) need to evaluate numerous design considerations when selecting the best miniature battery for their end product. The most important considerations for OEMs appear to be cost, nominal voltage, capacity, physical size/shape, and discharge profile. Other considerations for OEM's include: type of discharge, shelf life, energy density, operating temperature, replacement availability, and leakage resistance. The level of importance for each of these considerations can vary greatly depending upon the requirements of each particular end product. Thus, the suitability for replacing one miniature battery technology with another miniature battery technology must be determined on a case-by-case basis by OEMs based upon the particular requirements of their products.

Silver Oxide Miniature Batteries

Silver oxide miniature batteries are used for numerous products such as watches, miniature clocks, calculators, electronic games, and cameras. The voltage of the silver oxide miniature battery is 1.55Volts. The cathode of a silver oxide battery contains monovalent silver oxide (Ag_2O), and the anode contains powdered zinc. Silver oxide miniature batteries provide long shelf and operational life. Most silver oxide batteries are designed to operate watches for five years without leakage. Battery test data indicate that storage up to ten years is possible at 21 degrees C. Silver oxide batteries come in a variety of shapes and sizes. For example, the SR41 battery is button shaped with a diameter of 7.8 mm and a height of 3.6 mm. The SR1116 battery is coin shaped with a diameter of 11.6 mm and a height of 1.65 mm. The mercury content of the silver oxide miniature battery is often between 0.2% and 1.0% of total battery weight.

Alkaline Miniature Batteries

Alkaline manganese dioxide miniature batteries are used in numerous products including: calculators, toys, key chains, tire gauges, remote controls, and photographic products. The cathode consists of electrolytic manganese dioxide, and the anode material is powdered zinc. The alkaline manganese dioxide miniature battery has a voltage of 1.5 Volts. Alkaline manganese dioxide miniature batteries are most commonly available in button shapes. The mercury content of the alkaline manganese dioxide miniature battery is usually 0.1% to 0.9% of total battery weight.

Zinc Air Miniature Batteries

Zinc air miniature batteries are mostly used for hearing aids, but can also be used for other applications such as pagers, behind-the-ear speech processors, and cochlear (inner ear) implants. Zinc air miniature batteries use oxygen from ambient air as the cathode material, and use granulated zinc powder as the anode material. The ambient air enters the battery through a hole on the positive terminal. The zinc air miniature battery has a voltage of 1.4 Volts. Zinc air miniature batteries are mostly button shaped; however there are some commercially available coin-shaped batteries. Zinc air miniature batteries are excellent candidates for continuous, low-discharge applications, and they also provide good leakage resistance. The mercury content of the zinc air miniature battery is usually between 0.3% and 2.0% of total battery weight.

Mercury-Free Miniature Battery Technologies
Lithium miniature batteries do not contain mercury, and can be considered a potential alternative to mercury containing miniature batteries. Lithium miniature batteries have a much higher nominal voltage and a different physical shape (typically flatter and wider - coin shaped) than the other three miniature battery technologies, and therefore cannot easily be substituted in existing products.

Lithium miniature batteries have a voltage of 3.0 Volts. Lithium miniature batteries are commercially available in a wide range of capacities, from 25 to 1,000 mAh, and are mostly available in coin-shaped batteries. However, there are some lithium battery models available in button shapes. Lithium miniature batteries have excellent storage characteristics, and also provide excellent leakage resistance. Lithium miniature batteries can be used for a wide range of operating temperatures, from about –20 degrees C to 55 degrees C.

Lithium miniature batteries are commonly used in products such as electronic games, watches, calculators, car lock systems, electronic organizers, and garage door openers. The two primary lithium miniature battery chemistries both use lithium as the anode material but use different cathode materials: 1) lithium/manganese dioxide, and 2) lithium/carbon monofluoride. Lithium metal can react vigorously with water, and as a result must be used with non-aqueous electrolytes. Another consideration is that there is the potential for fire when lithium batteries are collected. (UNEP, 2008)

Rayovac Hearing Aid Batteries

Product Lines Relevant to the Case Study
Rayovac continues to offer hearing aid batteries using both mercury-containing and mercury-free chemistries in order to address existing market segments. The hearing aid batteries are offered in three lines: *Retail Batterie*s in four different sizes: [10(or230), 312, 13, 675] *Proline Advanced* in four different sizes: [10(or230), 312, 13, 675] and *Cochlear Advanced* in one size: [675]. Each of the product lines is available in a mercury-containing and mercury-free version. The batteries are all examples of the zinc air cell design. (Rayovac, 2011)

Background
Mercury has been used in batteries for many years because of its inherent properties as a good conductor of electricity, ability to maintain constant voltage performance, and its ability to suppress gas formation in a cell that may be caused by the chemical reaction of the internal cell contents. Initially, hearing aids used mercuric oxide button battery cells. These button battery cells contained significant amounts of mercury and according to Denis Carpenter, Zinc Air Technical Manager for Rayovac, “Almost half of the battery was mercury”. In the 1980’s, zinc air button cells became the dominant chemistry for powering hearing aids. This was due to their high energy density since they use ambient air in combination with an internal zinc anode to produce the chemical reaction that generates electricity. The initial zinc air batteries contained almost 7% mercury by weight in the anode of the battery cell. In response to legislation in the early 1990’s, the battery

industry responded to eliminate added mercury from widely used alkaline and zinc carbon batteries. While mercuric oxide hearing aid batteries were replaced by zinc air, these battery cells also contained added mercury.

The 1996 Mercury Containing and Rechargeable Battery Act, a U.S. law, capped the level of mercury in button cells to 25 mg per cell and according to the U.S. based National Electrical Manufacturers Association in a March 2006 press release, "By 2002, the industry average was less than half this value". Mercury is still present in many zinc air hearing aid batteries sold today. The mercury concentration is now roughly 3% of the zinc component in the anode. Many consumers who use hearing aids or cochlear implants, and even professionals who sell hearing aids and batteries, are unaware that in many cases the zinc air batteries they are using still contain added mercury.

According to Rayovac, they are currently the world leader in manufacturing and selling zinc air hearing aid batteries. This market position has come from strategy of investment in research and development to maximize the performance of the product. This research and development investment, combined with further investment in sophisticated manufacturing and quality control processes such as statistical process control and lean manufacturing, helped to ensure that Rayovac hearing aid batteries would provide high performance, reliability and quality.

The hearing aid battery category is a market segment that Rayovac has developed a substantial core competency. Rayovac has dedicated personnel to the zinc air button battery technology in research & development, manufacturing, quality, and even in roles such as sales and marketing. Key market channels for zinc air batteries include the professional and retail channels. The professional channel consists of hearing care professionals, hearing aid manufacturers and other distributors which serve the professional channel. The retail channel includes pharmacy chains, mass retailers, grocery stores, warehouse clubs, discount chains and hardware stores. The retail channel is most developed in the United States, Canada and Japan. The retail market comprises as much as 50% of the United States market.

While the overall market for hearing aid batteries versus other battery chemistries is relatively small, the demographic trend to an aging population in much of the world should lead to continued growth for hearing aid batteries. The average age of the user is 68 years old, and the user wears the hearing aid for eleven hours per day on average. The demographics support a long term growth trend and additional opportunities for growth exist in developing markets around the world. All of these factors combine to support Rayovac's decision to invest in the hearing aid battery segment and to invest in mercury-free hearing aid battery technology. (Raymond, 2011)

Approach to Transition: Method and Challenges

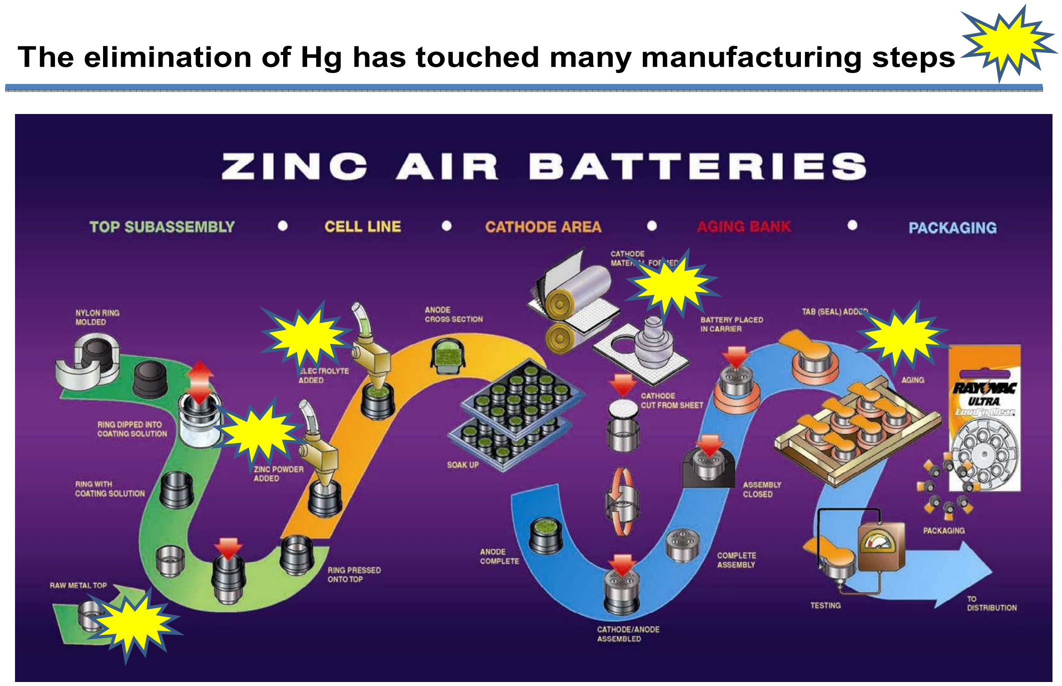
Approximately a decade ago, Rayovac decided to initiate early stage development activity for mercury free formulations for zinc air batteries. Rayovac's experience with legislation impacting alkaline and zinc carbon battery technologies in the 1990's, combined with an emerging consumer desire for more environmentally responsible product alternatives, led Rayovac to conclude that such an investment would be wise from both a market opportunity perspective and a legislative risk management perspective. The former was viewed cautiously as consumer research at the time had prioritized environmental benefits well below other consumer needs such as battery life, quality and price. In the late 1990's, another manufacturer had introduced a mercury-free zinc air hearing aid battery. Rayovac testing and analysis of market samples, combined with market reports, indicated that the technical challenges with cell gassing and performance relative to mercury-containing cells had not been adequately addressed.

Rayovac pursued development of the mercury-free option zinc air battery with the same commitment to reliability and performance that they had established for their mercury-containing zinc air batteries. Rayovac was also determined that the development of the mercury-free option zinc air battery would not dramatically escalate battery cost to the consumer. Rayovac concluded that only modest cost increases could be passed along to the consumer because the competitive environment and consumer reluctance to spend more money on batteries would limit the ability to increase prices. However, Rayovac anticipated increases in material costs, development costs and capital outlay to bring a mercury-free product to market.

Despite the technological and financial challenges, and the limited expectation of market changing legislation or growing consumer demand, Rayovac determined that the elimination of mercury from zinc air batteries was inevitable and "the right thing to do". Additionally, because the technological challenges associated with the elimination of mercury were significant, Rayovac considered the mercury-free battery initiative to be strategically important, since competitive breakthroughs or future government legislation could put Rayovac's market leadership position at risk. These responses to risk were underscored by the knowledge that the company would not be able to react quickly to potential threats "from a standing start" due to the lengthy development time it would take to finalize a design, engineer robust manufacturing and quality processes and scale up manufacturing capacity. Conversely, it was believed that these investments could result in competitive advantage for the company if planning, preparation and investment coincided with a future environment that created demand for mercury-free batteries.

In March, 2006 that new environment began to take shape, when NEMA, on behalf of the members of the Dry Battery Section, of which Rayovac was part, issued a press release announcing the commitment of its members to eliminating added mercury from button cells by June 30, 2011. This commitment timeline was crafted to allow the industry to resolve technical challenges and gear up production capacity in the face of legislation in several U.S. states. Three relatively small states, Maine, Rhode Island and Connecticut had all adopted legislation that would have imposed bans on mercury containing button cells at a much earlier date. Fortunately for Rayovac, mercury-free zinc air battery development activities were successfully progressing by this point in time and the company felt confident that a robust, high performing product could be brought to market on or before agreed deadline. (Raymond, 2011)

Figure 1 - Rayovac Mercury-Free Zinc Air Manufacturing Process (Raymond, 2011)



By late 2008, Rayovac conducted testing to ensure that their mercury free zinc air formulation was highly robust in terms of resistance to gassing which would lead to leakage and swelling. Cell capacity (life) was also shown to be very similar to their mercury-containing product. The outstanding areas for improvement of the mercury-free technology were to address a small decrease in voltage and moderately higher cost relative to the mercury containing zinc air technology. The voltage deficit affected approximately 5% of users, primarily those who had very high power demand hearing aids.

Rayovac concluded that some of the increased cost could be passed along in the market and that these cost were not sufficiently high as to act as a barrier to adoption. The company also concluded that because manufacturing mercury free zinc air was challenging, it would be far better in terms of safeguarding customer quality and service levels, to gain experience by ramping up volume over time rather than abruptly converting near the deadline date.

Rayovac assumed that although the impending legislative bans impacted only the relatively small states of Maine, Rhode Island and Connecticut, many customers who did business nationally would not want to carry redundant inventories of mercury and mercury-free hearing aid batteries. To minimize risk in the transition process, Rayovac decided to launch mercury-free zinc air batteries in the U.S. in March, 2009, more than two years before the deadline date. This would reduce risk by allowing for a more gradual ramp up which afforded the company time to gain valuable experience in large scale production.

Rayovac has two zinc air manufacturing plants, one in Portage, Wisconsin, United States, and the other in Washington, United Kingdom. Rayovac is the only zinc air manufacturer in the world to operate two manufacturing plants. Both manufacturing plants are engaged in manufacturing mercury-containing and mercury-free hearing aid batteries. Neither plant has dedicated production lines for mercury-containing and mercury-free products. Instead, production lines are converted from one product capability to the other as needed to fill orders. Therefore, significant production inefficiencies are generated by this continual change of production lines. Machine dies must be changed, automated programs must be updated, among many other requirements. This adds costs to the production of both technologies. Further, this hinders the gaining of economies of scale of working with a single technology. The economies of scale could be realized in areas such as material procurement costs, employee training, and production optimization. A ban on mercury-containing button batteries would allow manufacturers to achieve these economies of scale in the area of mercury-free battery production.

Rayovac decided that although Europe did not have any current legislation banning mercury containing button cell batteries, it would also launch mercury-free products in these markets following the U.S. introduction. Due to the absence of mercury-free battery legislation in Europe there has been a slower rate of conversion over time than in the United States. The result was that in less than two years after launch, Rayovac substantially increased distribution and share in all market segments. Now, following the effective dates of the Maine, Rhode Island and Connecticut bans, and the NEMA voluntary conversion date, the NEMA member companies have largely met their commitment and as a result, the majority of the US retail market has converted to mercury free designs and mercury free has also had significant penetration in the professional segment. There are, however, substantial portions of the total U.S. market and significant suppliers of hearing aid batteries that have yet to convert to mercury-free zinc air products.

Encouraged by the success of the first generation of mercury-free formulation, Rayovac introduced a second generation design early in 2011. While the first generation design had focused heavily on the anode side of the cells, the second generation design was intended to address the cathode side to recover the small voltage compromise inherent in the first generation design. The result of the enhanced design is a cell that not only offers the consumer capacity (life) that is comparable to Rayovac's mercury-containing battery cell, but also has an operating voltage high enough to support even the highest power demand hearing aids. Rayovac's second generation design has also successfully met the needs of many of the hearing aid manufacturers who were concerned about compromises affecting capacity, voltage and robustness. In virtually every instance, the community of hearing instrument manufacturers viewed Rayovac's mercury-free cell as providing acceptable performance on these criteria.

In the U.S., even though NEMA member battery manufacturers made a commitment to converting to mercury-free button cells by 2011, the NEMA member companies do not represent the entirety of the supply chain for zinc air batteries and only two manufacturers have zinc air plants in the U.S., namely Rayovac and Energizer. Mercury-containing product from non-NEMA members continues to be imported into the U.S. from manufacturers or distributors in Europe, China, Japan and South Korea.

The three New England states that had originally implemented a ban on sales of mercury containing button cells have not yet been joined by other states to enact similar legislation. Without similar legislation at a federal level or without more states and larger states moving to mercury-free product legislation, there is a lack of incentive for a number of these non-NEMA manufacturers to drive conversions, given the development and capital costs associated with undertaking the conversion, along with higher manufacturing/material costs and the heightened potential for quality issues and impacts to cells performance.

Beyond the U.S. market, there are no other regulations or legislation requiring conversion to mercury-free designs in button cells. At present, the impact on the level of conversion to mercury-free zinc air between the markets in the U.S. and Europe is dramatically different as evidenced by the level of conversion even in Rayovac's own two plants. The Portage, Wisconsin plant is now highly converted to mercury-free product while only a relatively small proportion of the output at the Washington, UK plant has converted to mercury-free technologies. In markets or regions where there is no legislation that mandates mercury-free zinc air, it would appear that some of Rayovac's competitors are choosing to continue to supply only mercury-containing product. Furthermore, the lack of mercury-free legislation in these markets means customers and consumers are less likely to pay even a small price premium for mercury-free products.

The end result of all these factors is that competitive forces and margin pressure compel even manufacturers like Rayovac who have robust mercury-free products and manufacturing capabilities to convert at a slower rate than they would otherwise choose. The delayed conversion to 100% mercury-free product carries a financial penalty since maintaining a dual product capability with both mercury-free and mercury-containing cells introduces greater complexity and inefficiency and reduces economies of scale that would accrue to manufacturing in a common mercury-free formulation. (Raymond, 2011)

Economic elements: Costs and ROI/Payback

The LCSP requested transition costs for establishing the mercury-free technology, as well as the ongoing annual costs and savings associated with products manufactured with mercury-free technology as compared to the mercury-containing products. In order to maintain confidentiality of financial information, Rayovac declined to provide financial information related to transition costs for their product line of mercury-free zinc air hearing aid batteries.

Rayovac did provide some cost components related to hazardous material management, disposal and battery recycling costs for their United Kingdom operations. To meet battery recycling legislation in the United Kingdom, Rayovac has joined a compliance scheme called Battery Pack. The following is a summary of the costs associated with meeting the battery recycling requirements in the United Kingdom:

1) Environment Agency (EA) charges all large producers £680 on an annual basis. Rayovac is considered a large producer and pays the compliance scheme manager who then pays the full amount to the EA.
2) Annual administration costs for compliance scheme members are between £600 and £1,000. This fee is dependent on the actual compliance scheme and what the producer negotiates based upon their assistance with the program.
3) There is a cost per ton for collection and recycling charge that varies by collection scheme and member. Currently this charge is between £600 and £1,000. This fee is charged as a percentage of the collection target for that year. For example, in Year 1 of the program, there was an interim collection step of 10%, so the charge was 10% of the per ton charge multiplied by the number of ton of batteries that a battery manufacturer places on the market. The recycling targets will increase to 25% in 2012 and 45% in 2016. (Brinson Pyke, 2011)

These recycling costs are the same for both mercury-containing and mercury-free batteries. However, if the industry reached the point where mercury in button batteries were eliminated, there would potentially be cost benefits through simplification of the sorting and recycling process which could eventually be passed back to manufacturers and ultimately consumers.

For hazardous material management and disposal costs related to mercury in zinc air batteries, Rayovac has indicated that the cost difference to mercury-free battery production is insignificant. The justification for this statement is that there are very small amounts of process waste due to the use of sophisticated manufacturing techniques at Rayovac such as statistical process control, lean, and six sigma. The process waste that is comprised of full batteries are sent to Battery Back, and other process waste for battery components are disposed of as hazardous waste with or without mercury in the zinc material. (Brinson Pyke, 2011) In addition, Rayovac did report that the Return on Investment (ROI) has been positive for its zinc air mercury-free line of products and that the payback interval has met expectations. (Raymond, 2011)

Extrapolation to Entire Product Sector

Rayovac estimates put the amount of mercury disposed of in all hearing aid batteries at almost 14,000 lbs (6,364 kg) per year globally (Raymond, 2011). With approximately 1 billion zinc air hearing aid batteries produced annually by battery manufacturers (Brinson Pyke, 2011) there is good reason to advance agreements or legislation toward an entirely mercury-free product offering. Additionally, as average life span and global per capita GDP increases, it is likely that more consumers will avail themselves of hearing instruments to improve their quality of life.

3. Thermometers

Overview

Thermometers are devices that are used to measure temperature for various applications. This study is focused on devices within the medical technology sector and will therefore focus on thermometers used for medical applications. The most common application of medical thermometers is measuring human body temperature. Body temperature can be measured internally (oral/rectal), at skin surface or within the ear canal.

Mercury Thermometer

Mercury thermometers commonly consist of mercury inside a thin glass tube that rises and falls with corresponding changes in temperature. The mercury content of thermometers reported as a range to IMERC by manufacturers for mercury thermometers was in one of the following two ranges: 100 to 1,000 milligrams per device or greater than 1,000 milligrams per device. Some manufacturers reported exact amounts to IMERC, and these amounts varied from 0.5 to 54 grams per thermometer. (NEWMOA, 2008)

The UNEP Toolkit (UNEP, 2005) provided examples of mercury content for the following examples:

- Medical thermometers (0.5 – 1.5 grams in the European Union)
- Household thermometers (0.5 – 2.25 grams in the European Union)
- Laboratory thermometers (1.4 – 48 grams in Russia).

The mercury content reported by digital thermometer manufacturers to IMERC was either 0 to 5 milligrams per device, or 5 to 10 milligrams per device. However, the mercury content reported was for the mercury contained in the miniature button battery that was used inside the digital thermometer. (UNEP, 2008)

Alternative Thermometers

There are three primary types of alternative thermometers: liquid, dial and digital. Liquid thermometers consist of a cylindrical tube containing a liquid that expands and contracts with increasing and decreasing temperature. Liquid thermometers use common organic liquids such as alcohol, kerosene, and citrus extract based solvents that are dyed blue, red or green. In addition, "galinstan" type liquid thermometers consist of silvery liquid in a glass tube. The liquid is a mixture of gallium, indium, and tin that expands with temperature to provide a reading. "Galinstan" type liquid thermometers are comparable in function to mercury, because it consists of a glass tube containing a silvery liquid that rises in a column with increasing temperature. However, the toxicity of the gallium-indium-tin mixture is not well understood. The liquid thermometer is the most common replacement for the mercury thermometer.

Dial thermometers typically use a bimetal coil that consists of two dissimilar metals bonded together. The metals have different coefficients of expansion, and rotate the coil when exposed to a temperature change. Dial thermometers can be used for applications in industrial settings, and operate in wide temperature ranges.

Digital thermometers use temperature sensors such as thermistors or thermocouples. Thermistor operation is based on the principle that electrical resistance of the thermistor material changes as its temperature changes. Thermocouples are comprised of two wire strips of dissimilar metals. The metal wires are joined at one end, and the voltage is measured at the other end. A circuit measures the resistance or voltage changes and converts them into a temperature reading. The digital thermometer provides several advantages such as shorter time to obtain a temperature reading, and the digital thermometer can beep to signal when the peak temperature is reached. A disadvantage is that the digital thermometer often uses miniature button batteries that may contain mercury. (UNEP, 2008)

ADC Products

ADC offers eleven models of digital electronic thermometers. Ten of the models are for medical use and one is for veterinary use. Within the range of medical thermometers one model is for temple skin surface, two are for use in the ear canal and eight are for oral, axillary or rectal temperature measurement. All of the thermometers utilize a small button cell battery, typically silver oxide or alkaline, some of which contain mercury. (Falco, 2011)

Approach to Transition: Method and Challenges

ADC has launched efforts to eliminate any mercury-added button cell batteries from their digital thermometer line. ADC's digital stick thermometers are designed to be used as alternatives to mercury-column thermometers for both professional and home use.

The majority of digital thermometer products have already transitioned to use mercury-free alternative batteries due to local ordinances that have come into effect since June 2011. Several states have independently banned mercury-added button cell batteries in products distributed within their state. Due to these bans, ADC has accelerated efforts to eliminate mercury-added button cell batteries in their digital thermometer line to allow their products to remain in these regulated markets. (Falco, 2011)

Economic elements: Costs and ROI/Payback

ADC as a privately held corporation is not required to do extensive financial disclosure reporting. As a result, ADC chose not to disclose all specific financial information for this case study. Instead, ADC provided a subset of the financial information requested by the Lowell Center for the case studies. ADC provided their ongoing annual costs for transitioning to mercury-free thermometers, and they also performed calculations of Return on Investment (ROI) for the line of thermometers impacted by the transition to mercury-free technology.

The results were calculated according to the following definitions and formulas:

Return on Investment (ROI): A ratio of loss or gain relative to the initial investment. This ratio is used to evaluate the efficiency of an investment.
ROI = [(annual net impact from transition)/transition costs] x 100 (expressed as a percentile)

Simple Payback: The period of time required for the return resulting from an investment to become equal to the initial investment.
Simple Payback = [total transition costs/ annual net impact from transition costs] (expressed in years)

Annual net impact from transition: Annual cost savings that result from the transition to mercury-free manufacturing such as reduced regulatory compliance costs, reduced employee training/testing costs, reduced hazardous waste/disposal costs, eliminating purchase of mercury, etc. These savings are reduced by any annual costs that result from transition to mercury-free manufacturing.
Annual Net Impact = Annual cost savings – Annual costs

Total transition costs: Transition costs such as research and development costs, materials and components costs, manufacturing transition related costs, marketing costs and other costs related to the initial investment to transition to mercury-free manufacturing

Table 10 - Summary Economic Indicators for ADC Digital Thermometers

Product	Return on Investment (ROI)
Thermometers	99.54%

The ROI presented in Table 10 is a result of very low transition costs due to the small incremental increase associated with the mercury-free battery change and no change to fixed costs associated with digital thermometer manufacturing. The exact sales numbers, annual net impact from transition, and transition costs used by ADC to calculate the ROI were considered confidential business information and were not provided for this case study.

Specific Costs Provided by ADC associated with digital thermometers were:

Table 11 – ADC Digital Thermometer Cost Summary

Cost Category	Annual Cost
Mercury-Free Battery	$10,597

The costs listed in the above table are associated with transitioning from traditional mercury-containing button cell batteries to mercury-free alternatives for ADC's thermometry products. This is a requirement in several states in the US and as such ADC has begun the process of eliminating these battery types from their thermometer products.

According to ADC the only component of the digital thermometer with mercury content is the battery and the mercury-free battery is interchangeable with the mercury cell. Therefore, no change in thermometer design is required to eliminate the mercury cell. The only cost differential is associated with changing the battery. The cost in Table 11 represents the difference in battery prices between mercury-containing and mercury free button cell battery types at a range of $0.01 - $0.02 per button cell battery. The range of digital thermometers offered by ADC use a similar battery size, therefore pricing variability due to battery size is not a factor for this calculation. The annual cost is based on estimated usage of battery models that may be included in thermometry products impacted by regulatory requirements to remove mercury content. (Falco, 2011)

Extrapolation to Entire Product Sector

Figures on global sales of digital thermometers were not readily available from either ADC or other publicly available reference sources. Therefore, the extrapolation to the global sector was based on a simple estimate of relative retail price differential. The method utilized to extrapolate from the results of the ADC economic elements associated with the conversion from mercury-containing to mercury-free batteries in digital thermometers to the entire product sector is presented below.

Table 12 - Representative Retail Prices for Similar Digital Thermometers

Manufacturer	Location	Website	Model	Pricing (USD)
American Diagnostic Corp.	Hauppauge, New York, USA	www.adctoday.com	414 ADTEMP III	$7.82, (Nextag)
American Diagnostic Corp	Hauppauge, New York, USA	www.adctoday.com	415 ADTEMP IV	$6.88 (Nextag)
Becton Dickinson and Company	Franklin Lakes, New Jersey, USA	www.bd.com	Accu-Beep	$7.99, (Nextag)
Omron Healthcare Inc.	Kyoto, Japan	www.omronhealthcare.com	MC Series, 343	$5.99, (Nextag)

Based on a retail pricing differential after distribution and retail mark-ups of $0.05 per digital thermometer for a mercury-free button cell, the average price differential between thermometers with and without mercury-containing batteries can be estimated as:

Average retail price differential between thermometers with and without mercury-containing batteries = Average retail pricing difference/Average sample price of digital thermometer with mercury-free battery

$0.05 / ($7.17) * 100 = **0.7%**

This mark-up was selected after discussion with Mr. Falco based on reasonable assumptions about price changes during product transfer from manufacturer to distributor to retailer.

One market research firm, Global Industry Analysts Inc has forecasted a global market of $694.4 million USD for consumer medical temperature measuring devices by 2015 (PRWeb, 2011). Applying the 2011 market sample estimated retail price increase to fully transition to mercury-free button cells, the net cost to consumers can be estimated at:

$694,400,000 * 0.007 = $4,860,800 USD

Assuming all sales in consumer medical digital thermometers, the forecast quantity to be sold can be estimated from the 2011 market sample retail price estimate as:

$694,400,000 / $7.17 = 96,847,978 Digital Thermometers in 2015

Table 13 – Global Sector Estimated Retail Price Differential

2015 market of 96,847,978 Digital Thermometers
$4,860,800 USD

With an estimated differential price increase of less than 1%, the conversion to mercury-free power sources in the digital thermometer market would not seem to present a major economic obstacle. This outcome is reflected in ADC's efforts to accelerate the complete conversion of all digital thermometers to mercury free button cells beyond just the product sales impacted by mercury-free battery regulations.

4. Financing Options for Transition Costs

Private Financing

The case studies presented in this document are firms from the private sector operating in the United States and the United Kingdom. The specific means by which the two participating firms have financed transition to mercury-free technologies were considered confidential information and were not disclosed. However, there are a set of options available to privately held and publically traded firms in the US and UK for raising capital. We can reasonably assume that both the privately held firm (ADC) and the publically traded firm (Rayovac/Spectrum Brands) employed one or more of the following methods.

Debt - Issue of bonds which are a financial instrument that promises to pay back a specific amount of money at a specific date with a schedule of interest payments to the bond holder.

Debt - Borrowing from a lending institution over a period of time in exchange for a combination of fees, interest charges and repayment of principle.

Equity – issue of shares that convey ownership in exchange for a purchase price (may apply to Rayovac but not to ADC).

Profits – a firm can redeploy earnings to specific projects generally based on a business case with assumptions for payback period and return on investment.

Rayovac as a subsidiary of Spectrum Brands likely uses a combination of all of the above means of financing to raise money for a technology transition such as the development of its mercury-free zinc air hearing aid batteries. Although the specific method of financing the development of the product line is unknown, Rayovac has indicated that the return on investment has been positive and the payback period has met expectations. These outcomes suggest that the decision to develop the mercury-free line of hearing aid batteries has returned profits to the firm.

ADC as a privately held firm does not issue equity and therefore must rely on a combination of debt and investment of earnings to finance whatever technological innovation it undertakes independently. Interviews with ADC suggest that the development of technology happens through an arrangement with component suppliers where ADC provides market expertise and exclusive supply agreements in exchange for supplier product development expertise. The firm has provided summary economic indicators in the form of return on investment for two product lines.

Economic Instruments for Public Policy

Economic instruments are considered to be important components of modern environmental policy making. Economic instruments can provide effective incentives to influence behavior that impact environmental quality, and by extension human health and economic development while complementing traditional legal measures. Economic instruments can also help attain policy goals at lower cost and have the potential to raise revenue for government programs that otherwise would encounter difficulties in mobilizing financial resources. (UNEP, 2011)

Mechanisms for Implementing Economic Instruments

Sound processes to develop economic instruments are the best way to use these measures successfully. Process implementation requires a good understanding of the mechanisms by which these instruments seek to fulfill their various roles and objectives. These mechanisms can be classified as:

- **Prices** - Price-based economic instruments raise the cost of natural resource use and environmental pollution, and/or create subsidies and tax-incentives that reduce the cost of transitioning to environmentally preferable activities and technologies.

- **Property Rights** - Property rights instruments create and consolidate property rights for both tangible and artificial assets.

- **Legal** - Legal measures establish liability for pollution effects thereby ensuring that culpable parties pay clean-up, restoration costs and/or compensation.

- **Information** - Information-based instruments such as labeling, environmental certification and public disclosure can raise consumer awareness to promote adoption of more environmentally sound production methods amongst producers who wish to compete for 'green segments' of the market.

- **Voluntary** - Voluntary environmental agreements are formally negotiated among companies and groups of companies and the government on environmental standards for a given market or production activity in order to avoid the alternative of stronger government legislation.
(UNEP, 2011)

Applicability to Transition to Mercury-free Alternatives

1. Price instruments would seem to offer a set of options that are applicable to transitioning to a preferable solution such as mercury-free alternatives. They are levied either directly on pollution emissions or on natural resource and other inputs, outputs, trade or consumption and are among the most commonly-used economic instruments. Examples include taxes, user fees and administrative fees for licensing. (UNEP, 2011). These price instruments can in-turn be used to fund financing mechanisms such as grants and revolving loan programs to subsidize manufacturer costs associated with new product development and manufacturing technology transition. In the context of mercury-in-products, an environmental tax mechanism could be added to elemental mercury, as an example of applying this class of economic instrument.

2. Property Rights instruments as applied to intellectual property awarded to the developer of a new technology under certain legal systems can create incentives for research investment. Technology patents are an example of such an instrument. The protection from patent infringement as well as the opportunities for licensing and sale of intellectual property should promote return on a viable mercury-free technology innovation.

3. Legal instruments do currently apply in some countries as a form of incentive to transitioning away from the use of a hazardous material such as mercury where liabilities exist for mismanagement of waste streams and failure to safeguard employee exposure. Presumably, legislated product bans on material content in certain products as presently exist in some countries would also fall within this category.

4. Information-based instruments are already in use in some countries where product labeling for mercury content is required. Manufacturers who have successfully transitioned to mercury-free product offerings see market opportunities and

prominently label products as “mercury-free” or “green” alternatives to mercury-containing products.

5. Voluntary instruments would also appear to apply to transitioning to mercury-free technology. An example of this is the NEMA member agreement to produce mercury-free hearing aid batteries for the US market. (Raymond, 2011)

Examples of Application of Economic Instruments
Legal instruments in the form of product bans have created incentives for the development of alternative solutions. For example the bans on mercury containing thermostats in the U.S. states of California, Connecticut, Illinois, Louisiana, Maine, Massachusetts, Minnesota, New Hampshire, Rhode Island, Vermont, and Washington along with restrictions implemented in Iowa, Michigan, Montana, Ohio, Oregon, and Pennsylvania resulted in decreased mercury use in thermostats by approximately 73 percent between 2001 and 2007. Major manufacturers of mercury containing thermostats, such as Honeywell, have developed mercury-free thermostats that not only replace the older mercury containing technology but offer enhanced features such as programmability to more efficiently manage building energy consumption. (Honeywell, 2011)

An example of a price based instrument was previous described in Rayovac’s experience with compliance to the UK Battery Recycling legislation. Fees are assessed on battery manufacturers by the UK Environmental Agency (EA) in part to fund a management scheme for battery recycling post-consumer. The legislation incorporates increasing recycling targets over the course of succeeding years. An individual manufacturer’s fee schedule is tied to their level of battery sales.

Interviews with Participating Firms
Participants in the case studies were asked about their experiences with financing transition to mercury-free products. Both ADC and Rayovac had relied entirely on private financing mechanisms although specific details were not disclosed. When asked to comment on alternative funding schemes associated with policy instruments such as national strategic research funding, revolving loans for capital investments, end user fees or fees on manufacturers, each firm indicated that the availability of government sponsored grants for product development would have been beneficial to their transitional efforts. As discussed previously, ADC product design and development costs are within their component supply chain. Consequently, the manufacturing, test, and assembly operations at their facility did not require additional investment to introduce their mercury-free lines. Rayovac described significant research and development investments over the course of nearly a decade to bring the capability of their mercury-free zinc air cells to the technical performance equivalent (e.g. voltage and service life) of their existing mercury-containing zinc air button cells.

Rayovac was very supportive of legislated product bans for the discontinuance of mercury-containing zinc air button batteries. This would be necessary to “level the playing field” so that Rayovac could transition to 100% mercury-free battery production and would not be subject to erosion of market share by other battery manufacturers that would provide mercury-containing batteries at a lower price. Further, this would enable Rayovac and all other battery manufacturers to achieve the economies of scale attributable to 100% mercury-free battery production.

Integration of Private and Public Approaches

The two firms (ADC, Rayovac) and three product sectors (sphygmomanometers, thermometers, hearing aid batteries) presented in this report have demonstrated transition to mercury-free devices along a continuum that is for the most part, market driven and financed privately. Were it not for the impact of enacted and anticipated product bans on the market for the products of these two firms, it seems unlikely that either would have moved as rapidly to develop and offer mercury-free alternatives. There was certainly a significant investment for the development of mercury-free alternatives although the exact costs remain unknown.

All private financing alternatives available to the two firms required decisions to be made about prioritizing areas of investment and opportunities for growth. As of the point in time when the interviews with the representatives of the firms were conducted, the final results of the investment choices taken by the firms were yet to be fully understood. For both participating firms, the product bans that have been enacted as well as those that may yet be enacted represent only a partial shift in markets. Given that these legislative actions are, in the case of the United States, occurring on a state by state basis and have not yet been enacted in even 50% of jurisdictions (14 states for measuring devices including sphygmomanometers; 20 states for fever thermometers and 3 states for button cell batteries) (NEWMOA, 2011), there remains the necessity of offering both mercury and mercury free devices in order to meet market demands as well as to maintain the brand's competitive presence against firms that offer only mercury containing products.

A similar situation exists in Europe where mercury content bans within the sectors represented in this report are not universal (sphygmomanometers banned from public sale but not for sale to healthcare; fever thermometers banned from public and healthcare sale (Health Care Without Harm, 2011) and a restriction of up to 2% mercury by weight for button cells) (Europa.eu, 2011). Providing incentives for manufacturers to transition from mercury containing to mercury free devices in both the European and United States markets will require additional public policy action. This action should follow the lead of the product content bans that have, even with limited geographic adoption to-date, already significantly altered the strategy of forward-looking firms such as the participants in this study.

It is reasonable to assume that as the more reluctant manufacturers encounter legislative action to restrict the markets for mercury containing products developing, they will review their positions in markets and make choices based on their own growth strategies to invest in competitive technology or abandon the market in pursuit of other opportunities. With proven technologies already extant within the market sectors covered by the case studies in this report, it seems unlikely that price-based mechanisms to raise funds for publically supported technology transition aid to private firms in the form of grants or revolving loan programs would be necessary. The efforts and successes of the firms presented in this report demonstrate that where private capital markets are functioning to support investment by debt, equity or a combination of the two, legislative action need only create reasonable timetables for the phase-out of mercury content. These timetables can be achieved through cooperative efforts involving voluntary mechanisms where industry groups can represent technology sectors to either unilaterally present acceptable timelines for transition or to serve as negotiating representatives in discussion with government and other stakeholder groups.

Conclusions

Detailed transitional costs to mercury-free products are considered confidential information by private industry. Given the competitive marketplace within which medical technology devices are developed and sold, this is not an unexpected position for private firms to take. Although participants in the two case studies contained in this report were willing to provide qualitative descriptions of their successful efforts to develop and market mercury-free product alternatives within their sectors, they were unwilling to disclose comprehensive and detailed financial data (for example: product sales, R&D cost, manufacturing retooling cost, materials and components costs) to permit the independent calculation of summary economic indicators such as Return on Investment (ROI) and Simple Payback Period.

One of the two participating firms, American Diagnostic Corporation (ADC) did however provide summary indicators of Return on Investment (ROI) based on their confidential information for sphygmomanometers and digital thermometers that were developed as mercury-free alternatives. The two firms also provided information on costs associated with mercury management. Rayovac shared their experience with compliance to United Kingdom mandatory battery recycling legislation. ADC provided information on a successful exchange program designed to return mercury tube sphygmomanometers from customers who purchased specific mercury-free alternatives. ADC also provided costs associated with transitioning to mercury-free batteries for digital thermometers.

The summary indicators associated with ADC include:

1) Estimated global sphygmomanometer sector annual cost avoidance through mercury handling cost elimination (cost savings to manufacturers) at $2.90 per mercury-free sphygmomanometer produced, or $2,985,475 USD for an estimated global market of 1,029,474 sphygmomanometers. Transitioning to mercury-free sphygmomanometers produced a Return on Investment (ROI) at 100.06%

2) Estimated global digital thermometer sector annual retail price differential to transition to mercury-free batteries (cost increase to consumers) at 0.7% ($0.05 per digital thermometer), or $4,860,800 US for an estimated global market of 96,847,978 digital

thermometers. Transitioning to mercury-free batteries in digital thermometers produced a Return on Investment of 99.54%.

Despite limitations in quantitative conclusions to be reached based on available data, the qualitative content and conclusions to be drawn from it are clear and supportive of regulatory action to remove mercury from medical devices within the technology sectors represented by the participating firms. In addition to the view into specific product sectors, the study illustrated two firms at distinct positions in a global supply chain with Rayovac's technology finding use within other manufacturer's products while ADC represents branded product integration and testing immediately prior to end use. Despite the firms' occupancy of differing nodes along the supply chain, their experiences have lead to similar decisions regarding transition to mercury free-products. The valuable insights into the decision making process, the business strategy and impact of regulatory uncertainty provided by the participating firms offer direction to global policy makers on control of mercury in products. These insights are summarized below:

- Firms operating in United States and European markets have relied on self-financing for research & development and capital modifications to manufacturing plant for transitioning to mercury-free product manufacturing.
- Firms believe that access to non-private funding in the form of grants or other mechanisms could advance research & development for mercury-free technologies.
- Firms recognize a brand value advantage in the offering of mercury-free alternatives to their traditionally mercury-containing products.
- Firms continue to offer mercury-containing products along with their mercury-free alternatives based on their understanding of market and customer demands.
- Firm are marketing mercury-free alternatives to their customer base and having sales success.
- Firms view regulatory uncertainty as an impediment to fully realizing economies of scale in manufacturing and best return on R&D investment due to ongoing need to offer both mercury-containing and mercury-free products.
- Firms support clear and consistent policy and regulatory environments across product markets to maximize investment in their technology transition to mercury-free products. This support extends to banning mercury content within specific product sectors.
- Firms that have developed proven mercury-free alternatives possess the capacity to satisfy current market demand within sector, and sufficient diversity of suppliers exists to assure a competitive market place that will foster further innovation to benefit consumers.

- Product bans on mercury-containing products in the sectors examined would enable manufacturers to eliminate costly production line changeovers between mercury-containing and mercury-free manufacturing, attain economies of scale for mercury-free product manufacturing through material procurement and manufacturing efficiencies, avoid cross contamination between mercury-containing and mercury-free products, and reduce the number of stock keeping units (SKUs) that need to be managed.

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Annex 1: Calculation of Estimate for Global Mercury Sphygmomanometer Sales

The calculation is based on a current global retail sphygmomanometer market estimate of $346 million USD, a 50% market share for mercury-tube models (Falco, 2011), and an average retail price of $182 for the portable mercury-tube models listed in Table 14 below.

Table 14 - Representative Manufacturers of Mercury Sphygmomanometers

Manufacturer	Location	Website	Model	Pricing (USD)
American Diagnostic Corp.	Hauppauge, New York, USA	www.adctoday.com	972	$217, (Nextag)
MDF Instruments	Agoura Hills, California, USA	www.mdfeurope.com	MDF 800	$77, (Nextag)
W. A. Baum	Copiague, New York, USA	www.wabaum.com	320	$251 (Nextag)

The calculation was performed in the following manner:

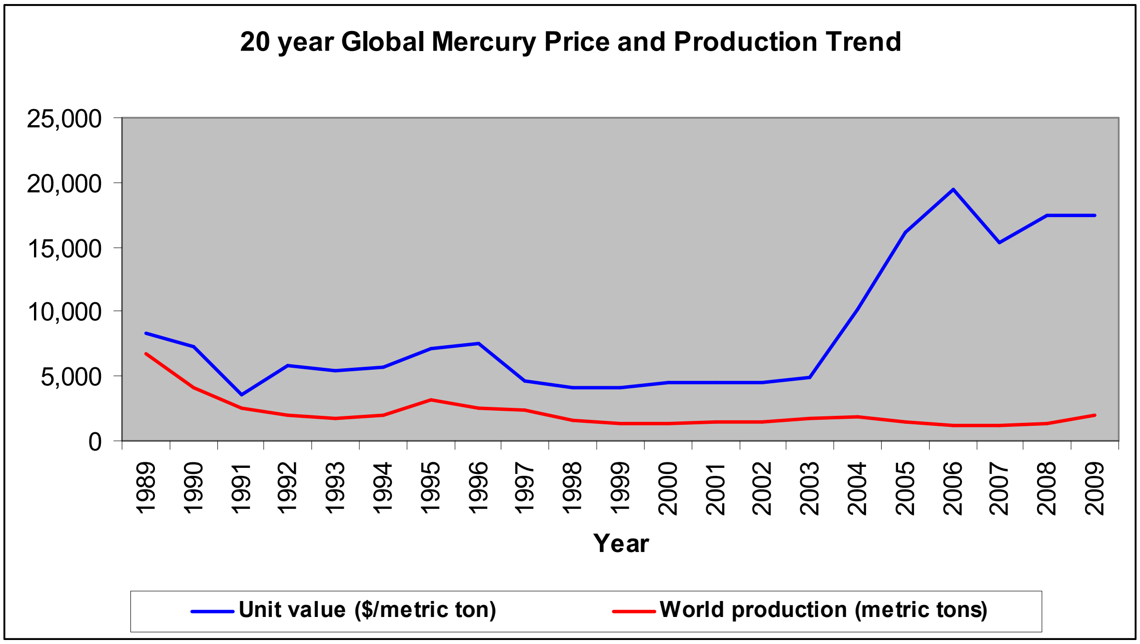
Step 1

Estimated global retail sphygmomanometer market / average retail price of mercury sphygmomanometer from sample * 50% market share for mercury sphygmomanometer = estimated annual global sphygmomanometer sales

Result

$346,000,000/$182 *0.50 = 950,549 units

Annex 2: 20 Year Global Mercury Price and Production Trend



(USGS, 2012)

Year	Unit value ($US/metric ton)	World production (metric tons)
1989	8,350	6,750
1990	7,230	4,100
1991	3,550	2,540
1992	5,840	1,960
1993	5,410	1,730
1994	5,640	1,960
1995	7,180	3,190
1996	7,590	2,560
1997	4,630	2,410
1998	4,060	1,580
1999	4,060	1,320
2000	4,500	1,360
2001	4,500	1,500
2002	4,500	1,490
2003	4,930	1,730
2004	10,200	1,900
2005	16,100	1,520
2006	19,400	1,150
2007	15,400	1,200
2008	17,400	1,320
2009	17,400	1,920

(USGS, 2011)

Appendix A

UNEP Introductory Letter and Information Request

UNITED NATIONS ENVIRONMENT PROGRAMME
Programme des Nations Unies pour l'environnement   Programa de las Naciones Unidas para el Medio Ambiente
Программа Организации Объединенных Наций по окружающей среде   برنامج الأمم المتحدة للبيئة
联合国环境规划署
UNEP

12 July, 2011

Dear Sir/Madam,

The United Nations Environment Programme (UNEP) Governing Council 25/5 agreed to further international action consisting of the elaboration of a legally binding instrument on mercury, which could include both binding and voluntary approaches. As a delivery mechanism of concrete action to reduce mercury pollution, the UNEP Global Mercury Partnership was established. The overall goal of the mercury partnership is to protect human health and the global environment from the release of mercury and its compounds by minimizing and, where feasible, ultimately eliminating global, anthropogenic mercury releases to air, water and land. The Partnership currently has seven identified Priorities for Action (or partnership areas) that are reflective of the major source categories, including the category "Mercury Reduction in Products".

To assist in the partnership area of "Mercury Reduction in Products", UNEP has commissioned the University of Massachusetts to investigate the costs of transitioning from the manufacture of mercury containing products to mercury free product alternatives.

We are contacting your company because it is our understanding that you have made this transition from mercury containing to mercury free products. We would greatly appreciate it if you could help by providing information about your transition to mercury-free products to the University of Massachusetts for this investigation. Further information about the UNEP Global Mercury Partnership, including a list of current members, is available at http://www.unep.org/hazardoussubstances/Mercury/InterimActivities/Partnerships/Products/tabid/3565/language/en-US/Default.aspx

The results from this investigation will be documented in a report and will be valuable to inform negotiating parties at the upcoming session of the Intergovernmental Negotiating Committee (INC). The third session of the mercury INC is being convened to prepare a global legally binding instrument on mercury and will take place at UNEP Headquarters in Nairobi, from 31 October to 4 November 2011.

Chemicals Branch, DTIE // Substances chimiques, DTIE
11-13, chemin des Anémones, CH - 1219 Châtelaine, Geneva, Switzerland
Facsimile: +41 22 797 34 60 // Web: www.unep.org

INFORMATION REQUEST

By : University of Massachusetts Lowell

For :United Nations Environment Programme
Mercury Reduction Case Study

July 12, 2011

Company Name:

Description of mercury and mercury-free products manufactured:

Manufacturing location:

Contact person:

Contact information:

Description of project involving transition from mercury to mercury-free production:

Reason for undertaking project:

Project timeline:

We would like to request the following financial/economic information for the UNEP case study. To minimize the burden of time and effort on the part of participants, we are only requesting existing information, and not requiring that new information be generated at this time. It would be helpful to obtain as many listed items as reasonable, but it is not essential for our efforts to obtain every item on the list. We are also requesting that any information provided would be publishable in the UNEP case study and therefore we are not requesting any information that is considered proprietary to your company.

Associated Project Cost and Savings information (one-time and recurring):
- Research and Development
- Manufacturing
- Marketing
- Regulatory compliance
- Hazardous waste handling and disposal (collection, transportation, disposal, spill clean-up)
- Other relevant costs and savings

The UNEP case study will ideally contain a summary statement of investment payback for the mercury-free conversion so the following information would be most helpful if available:
- Return on investment/Payback
- Discount rate
- Cash flow

Appendix B

Sample Documentation from ADC Mercury Sphygmomanometer Exchange Program

American Diagnostic Corporation

750W Wall Aneroid & 752M Mobile Aneroid

Mercury Sphyg Exchange Program

Are you looking to replace your wall or mobile mercury blood pressure instruments?

Here's how the OUR program works:

Just order any like number of wall and/or mobile clock aneroids as the number of mercury units you wish to return. On the same P.O, order part number #985 Mercury Return Kit

OR

you may order kits separately, by referencing a recently placed purchase order for a like quantity of our clock aneroids.

The Mercury Return Kit is specially designed to reduce the risk of mercury spills in transit to our mercury reclamation center. Kits include all packing materials, cartons and shipping labels necessary for the safe return of the mercury sphygmomanometer. Kits are sold in case packs of three units. Case packs may NOT be split in order to ensure the protection of the mercury instrument during transit. (even when returning one or two instruments, the shipper must ALWAYS use a full case capable of holding 3 units).

You must also supply ADC with end-user facility name, address, and contact information for tracking purposes.

Because the return kits are shipped fully assembled and are quite bulky, we suggest you allow us to drop ship the mercury return kits directly to your customer. Your customer must ship the mercury returns kits to the reclamation indicated on the supplied shipping label via PREPAID UPS GROUND only.

COST: *$30 per case of three Mercury Return Kits ($10 ea.) The cost includes the kit, shipping costs for the kit to you or your customer and proper disposal of the liquid mercury and instrument in accordance with EPA guidelines.*

750W
Wall Aneroid

752M
Mobile Aneroid

American Diagnostic Corporation
55 Commerce Drive, Hauppauge, NY 11788
1-800-ADC-2670

QUALITY • ASSURANCE • SAFETY

REMEMBER:

SEND ONLY!
The main mercury units.

DO NOT!
Send inflations systems, wall brackets, casters, bases, baskets, or other accessories.

DO NOT!
Send damaged and/or broken units or units that are leaking mercury.

ALWAYS!
Seal each mercury unit in two polybags with bubble wrap and cushioning bags.

NEVER!
Place more than 1 mercury unit in a carton.

ALWAYS!
Replace all 3 of the inner cartons back into the outer case *EVEN* if less than 3 units are being returned.
(The cartons add rigidity to the case and minimize the risk of damage in transit.)

DO NOT!
Strap or band multiple cases together.

DO NOT!
Re-use the outer case if it is damaged, torn, or crushed.

Ship via UPS prepaid, ground service ONLY!

No other carriers may be used for the return of the mercury exchange program.

55 Commerce Drive, Hauppauge, NY 11788
1-800-ADC-2670
www.adctoday.com

IB p/n 93-985-00

Printed in the U.S.A.

INSTRUCTIONS

for the Proper Packing and Shipping of the ADC Mercury Return Kit

(p/n 985)

IMPORTANT NOTE:

Failure to follow the proper packing and shipping instructions for mercurial return kits could result in mercury leakage during transit. The shipper will be responsible for all costs, penalties, and fines associated with cleanup of mercurial spills that resulted from improper packing or shipping methods. Failure to adhere to these Packing and Shipping Instructions will result in fines, probationary periods, and/or termination of participation in the program, depending on the severity of the situation as determined by ADC.

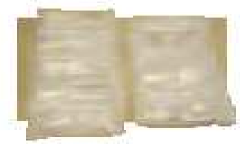
Contents: The enclosed mercury return kit is designed to allow the safe return of up to 3 mercury units. The kit contains the following:

1 Outer Case
(p/n 92-986-00)

3 Inner Cartons
(p/n 92W79-00)

6 Poly Bags
(p/n 9141-00)

6 Bag Closures
(p/n 985CLOSURES)



Cushioning Bags
(p/n 93-6X8AIRBAG)

4 ft. Bubble Wrap
(p/n 93-BUBBLWRAP)

1 Return Label
(p/n 943X8986RET-01)

1 Blank Label
(p/n 9423-00)

Note: If you are missing any parts DO NOT proceed!
Contact our Customer Service department at 1-800-ADC-2670 to obtain replacements.