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Is the Deposit Refund System for Lead Batteries in Delhi and the National Capital Region Effective?

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April 2012

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Abstract

Lead acid batteries generate hazardous waste in the form of lead, with serious environmental and health implications. These batteries are recyclable and the present Deposit Refund System for recycling operating in Delhi provides a discount to consumers when they purchase a new battery and return used batteries to retailers. The retailers in turn determine whether the batteries will be recycled in an environment-friendly or unfriendly manner by selling them to manufacturers or informal sector scrap dealers, who then sell them to un-registered smelters. This study finds that that the economic instrument that brings used batteries into the recycling system works exceptionally well. However, organized lead recycling is undertaken only in a limited manner. Rather, retailers prefer to sell used batteries to the informal sector because they obtain higher prices, and incur lower storage costs and taxes. Current rules prevent scrap dealers from selling batteries to regulated smelters. Relaxing these rules would reduce raw material shortfalls currently experienced by the sector and bring more batteries into the formal recycling market. In addition, an alternate policy instrument to consider is a green tax on batteries coupled with a partial or complete refund when the manufacturer ensures environment-friendly recycling.

Key Words: lead battery, recycling, deposit refund systems, extended producer responsibility, green tax

Is the Deposit Refund System for Lead Batteries in Delhi and the National Capital Region Effective?

1. Introduction

About 80% of the lead produced worldwide is used in the manufacture of automotive lead acid batteries (Kreusch et al., 2007). India is one of the fastest growing markets for passenger cars and the world's second largest manufacturer of two wheelers. It holds the distinction of being the largest manufacturer of motorcycles and the fifth largest manufacturer of commercial vehicles. Thus, the demand and use of lead in India is expected to significantly expand in the coming years. The industry manufacturing lead-acid batteries (automotive as well as other) in India is currently growing at a rate of over 20% per annum (EIL, 2009), and is heavily dependent on lead, which constitutes 50% of the operational cost of producing a battery (Das, 2009).

Lead acid batteries have a life of three to four years. This contributes to an almost un-noticed but serious environmental problem of hazardous waste.[1] Lead is a highly toxic metal and is considered one of the 17 most dangerous chemicals in terms of the threat it poses to human beings and the environment by the US Environmental Protection Agency (Wu et al., 2004). Lead can cause behavioral problems and learning disabilities and can be fatal to children who inhale or ingest it. Lead poisoning can lead to impaired physical growth, kidney damage, retardation, and in extreme cases even death. Birth defects like cardiovascular defects, oral clefts and musculoskeletal anomalies diagnosed in newborns are also associated with lead exposure (Vinceti et al. 2001). Furthermore, lead can also be toxic to plants, diminishing their productivity or biomass, and eliminating some species (Singh, et al., 1997; Xiong, 1997; Patra et al., 2004).

Globally, recycled lead is an important source of lead, which offers both a solution and challenges to the health hazards posed by this mineral. Demand for lead is met from both primary and secondary sources. Primary sources constitute lead ores extracted from mines, whereas secondary sources of lead are smelters who recycle lead from lead scrap. The scrap mainly comprises of used lead-acid batteries, old lead pipes and cables. Lead acid batteries are among the most recyclable products in the world with a reported collection and recovery rate of 96% in the US during 2004 to 2008 (Battery Council International, 2009) and 85% in Western Europe (Bied-Charreton, 1993). Used lead acid batteries (all types) with an average 10.5 kg of lead (Smith, 1999) serve as a source of raw material required for battery manufacturing. High rates of recycling are achieved in the countries where there is legislation governing the collection and recycling of lead-acid batteries. In poorer economies such as Egypt and India, very high rates of recycling are found but not reported because a large quantity of lead is recycled informally (Roberts, 2003). The informal sector in lead recycling can be extremely hazardous, particularly for workers.

Lead recycling is often supported through a well-functioning Deposit Refund System (DRS) in the market for batteries (branded and generic). In this system, people can get a discount on the purchase of a new battery if they return the used one to the retailer. Peter Bohm (1981) describes this as an arrangement between consumers and producers where a refund is provided even without taking a deposit. While a DRS has existed in the Indian battery markets for a long time, in 2001 the Indian Government put in place a set of rules to regulate the recycled lead market. These rules stipulate where and how lead is supposed to be recycled and have supported the development of a market for recycled lead through a DRS for batteries.

Since a legal framework for using recycled lead batteries has been in place in India for over ten years, it is important to assess how effective the regulations have been in terms of recycling and disposal of lead-acid batteries. Thus, the objectives of this study are to: a) understand the strengths and weaknesses of the current DRS in order to

[1] Lead acid batteries are classified as a hazardous waste under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

ensure better recycling of lead-acid batteries; and b) identify policy instruments that could complement the existing system. We do this by studying the roles of and incentives faced by major stakeholders in both the organized and unorganized battery recycling sectors.

The rest of this paper has the following structure: section two discusses the deposit refund system and extended producer responsibility in the context of battery recycling in India. The third and fourth sections describe the data and methodology used in this study. Sections five and six discuss results and alternative policy instruments to complement the DRS. The conclusion with policy recommendations forms the last section.

2. The Deposit Refund Scheme and Battery Recycling in the National Capital Region

While small-scale industries are very valuable for sustainable development, they can create problems when they generate high levels of pollution (Dasgupta et al., 1998). This is the case with lead acid batteries in India, which are recycled mainly by small scale smelting units operating in the organized as well as unorganized sectors.

The lead acid battery recycling industry in India lacked any kind of regulation till 2001. In the absence of proper smelting facilities and legislation, a large number of backyard smelting units and recyclers operated in India (and some still continue to operate). These backyard smelters recover lead from batteries in a crude manner, causing lead pollution in surrounding areas and affecting the health of the workers. Rao et al. (2007), estimate that nearly 11.35 kg of lead are released to the environment from the production of 1000 batteries. Recycling of battery scrap can cause environmental problems through the emission of dust containing lead particulates and sulphur oxides (Valdez, 1997).

In battery manufacturing plants, lead exposure to workers is a major occupational hazard (Yamin, 2007). Poor hygiene, inappropriate protection and lack of awareness increase the risk of lead poisoning. Most workers are ignorant of the ill effects of lead and do not take precautions such as wearing masks, gloves and safety glasses while handling lead. They also indulge in practices like eating, smoking and sleeping in the same premises, resulting in accumulation of dangerously high blood lead levels (Herman et al. 2007). In India, Rao et al. (2007), for instance, found that the average blood lead levels of battery workers were significantly higher than those of control groups. Hsiao et al. (2001), in another study in Taiwan, found that long-term exposure to lead among lead battery factory workers resulted in high levels of lead in their bones even after devices to reduce exposure were installed. The occupational hazards resulting from lead battery recycling in the un-organized sector was a motivating factor for India to formulate stronger regulations.

In 2001, the Ministry of Environment and Forests (MoEF) of the Government of India (GoI) came up with 'The Batteries (Management and Handling) Rules, 2001' (BMHR), henceforth referred to as the "Rules", which require retailers to sell the used batteries to registered smelters who are required to use technologies that do not have a harmful impact on the environment. It further stipulates that battery manufacturers must collect (through the DRS or buy-back system) at least 90% of new batteries sold for organized smelting/recycling. The legal framework requires manufacturers and importers of batteries to be involved in the buy-back system either directly or indirectly. By doing this, the BMHR, 2001 have (without explicitly naming it) laid down the legal framework for "Extended Producer Responsibility" (EPR) in this industry. EPR is an environmental protection strategy that makes the manufacturer of a product responsible for the entire life-cycle of the product (Lindqvist, 2000).

A well-functioning DRS exists in the market for lead acid batteries in Delhi and the National Capital Region (NCR). The battery recycling industry in Delhi and NCR includes consumers, battery manufacturers, retailers, registered or organized smelters, scrap dealers and unorganized or backyard smelters called "*bhattis*."

BMHR (2001) requires retailers to sell the batteries collected through the DRS back to manufacturers or registered lead smelters to prevent them from reaching the unorganized or back yard smelters. This is a variant of a typical DRS in which consumers make deposits that are added to the price of a product and receive refunds when they return used products (Bohm, 1981). The DRS facilitates consumers of lead acid batteries (excluding bulk consumers such as the railways, the defense establishment and large industrial houses) with a discount on the purchase of new batteries on the return of used lead acid batteries to retailers (without any prior deposit made by them). The discount given by the retailers is determined by the market price of lead at the London Metal Exchange.[2]

Once consumers return used batteries to retailers, the recycling of these batteries is carried out through two modes (see Figure 2). The first mode complies with the Rules and involves retailers selling used batteries returned by the consumers to the manufacturers. As shown in Figure 2, a used battery goes from the consumer to the retailer and then to the manufacturer or organized smelter. The second pathway is of non-compliance with the Rules, which involves retailers selling the used batteries to scrap dealers, who then sell them further to the unorganized smelters or "*bhattis*."

Lead smelters are not legally allowed to operate in the city of Delhi. While registered smelters are located in industrial areas in the NCR, unregistered smelters operate from remote agricultural and other areas in the outskirts of the city. An informal sector smelter is able to extract lead worth approximately Rs. 515 from an average car battery (as shown in Figure 3). These unorganized smelters sell the secondary lead (ingots/"silli") they produce to local battery manufacturers or scrap dealers.

3. Study Area & Data

This study was conducted in the National Capital Region (NCR) of Delhi with an area of 1483 square kilometers. The data for the study comes from questionnaire based surveys and unstructured interviews carried out in 2010.

A retailer survey was conducted to identify the factors that affect the decision of retailers to sell batteries to manufacturers or scrap dealers. To survey the retailers, we first undertook a pilot survey of some retailers. Then, we created a sampling frame of 150 retailers located in the commercial and residential areas of North, South, East, West, Central Delhi and NCR (Vaishali and Gurgaon) using information from the "Battery Year Book-2005", a directory of battery retailers. Finally 96 retailers were surveyed by randomly identifying markets that had a cluster (more than two) of battery retailers.[3] Twenty-eight percent of the sample was located in South Delhi, twenty-two, seventeen, fourteen, 12% and 7% in East, West, Central Delhi and NCR respectively (see Figure 4).We obtained information on issues such as their status (authorized or not); awareness of the Rules; how many used batteries they bought back every week; who they sold the used batteries to; discount given on new batteries; selling price of used batteries; frequency of battery collection by manufacturer and scrap dealer and their location.

We found that 44% of the retailers surveyed were 'authorized' to sell certain brands and sold only those, 17% were not authorized and 35% sold multiple brands of which they were authorized to sell some. The majority (65%) of the retailers were aware of the Rules. Fifty-four percent of the retailers were located in residential areas. Only 26% of the retailers admitted to complying with the Rules and selling the used batteries to the manufacturers. Sixty percent sold to scrap dealers and about 13% sold to both manufacturer and scrap dealers.

Simultaneously, another questionnaire was prepared to assess the level of awareness and participation of consumers in the deposit refund system. We divided the city of Delhi and NCR into 6 zones: North, South, East, West, Central and NCR. From within these zones, we administered the questionnaire to 106 households that owned cars using convenience sampling. Seventy percent of these households were located in Delhi and 30% in the NCR. This survey was undertaken in January and February 2010.

In order to understand how the formal sector operates, we undertook a case study of Exide India Limited, one of few battery manufacturers in India with a recycling business for batteries. We obtained data on Exide's recycling unit–Chloride Metals. Data was obtained from annual reports and interviews with senior officials of Exide using a structured questionnaire.

Information from other organized smelters, unorganized smelters and scrap dealers was collected through unstructured interviews. The informal sector stakeholders like scrap dealers and smelters were reluctant to share

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2 The price of lead (primary lead from mines and secondary lead from recycling of the used batteries) depends on the market price guided by the London Metal Exchange (LME). Figure 1 shows the trend of lead price (US$/Ton) of the last five years from Jan 2005 to December 2010 (LME). Variation in the price of lead at LME has a direct impact on the price of the new and used batteries and recycling scrap.

3 We chose this method of sampling because some of the shops mentioned in the directory had either shut down or had moved away.

any information as their operation is primarily illegal. Small lead smelters in the organized sector were also unwilling to share any financial information. Thus, we used unstructured interviews to understand their role, incentives and the socio-economic and health impacts in the lead recycling industry. We undertook interviews with five organized smelters in addition to Chloride Metals. The unorganized smelters or "*Bhattis*" located in Mandoli and Ghaziabad, close to the eastern border of Delhi were interviewed to understand their mode of operation, availability of raw materials, cost and profitability of their business and problems including health concerns faced by the workers. We visited these Bhattis for seven days and had interviewed ten operators.

4. Methodology

The entire chain of recycling depends on the retailers' choice to sell the used batteries either back to the manufacturer (which results in recycling through the organized sector) or to scrap dealers (which results in recycling through the unorganized sector). As Figure 5 shows, the retailer acts as the interface between the consumer and the manufacturer and recycler of batteries. Local and branded battery manufacturers sell their product through retailers. Once a retailer receives a used battery it gets recycled either by registered smelters or unorganized smelters/ "*bhattis*". The recycled lead reaches both types of manufacturers. We also found evidence that indicates some movement of used batteries from scrap dealers to registered smelters.

4.1 Examining Consumer and Retailer Decision-making

The first question of interest to us was the extent to which consumers are willing to sell batteries back to retailers. They have a choice of selling batteries to scrap dealers directly, thus, we probed this issue through surveys and report some simple evidence of very high levels of awareness and participation in the buy-back system (DRS).

The second issue of interest is how retailers are making their decisions to sell batteries to the organized or un-organized sector. To address this question, we undertook an econometric analysis of retailers' sales decisions. Retailers face a dichotomous choice of who to sell the used batteries to – they can either sell it to manufacturers or to scrap dealers. The dependent variable (*Y*) "*comply*" takes on a value of one when retailers sell used batteries only to the manufacturer (compliance with BMHR) and zero otherwise.

Equation 1 presents a logistic regression model used to analyze the responses from the retailers:

$$P = \text{Probability}\,(Y=1 \mid X_1 = x_1, X_2 = x_2 \text{--}) = \ln\,[\pi/\,(1-\pi)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \_\,\_\,\_ + \beta_p X_p \qquad (1)$$

Where π is the probability of the event i.e. of the retailer complying with BMHR and selling to manufacturers, β_0 is the intercept, β_p are regression coefficients and X_p are a set of predictors that influence the retailer's decision. Y is the decision of retailers to sell batteries only to the manufacturer or not only to manufacturer (to scrap dealers or scrap dealers and manufacturers).

An important factor that affects compliance is the location of the retailers (*location*). This variable takes on the value 0 when location is in a residential area and the value 1 when the location is in a commercial area. We hypothesize that retailers located in commercial areas are more likely to comply. Therefore this variable is expected to have a positive sign in the regression model.

The type of retailer (*type*) also matters. We identified three types of retailers: authorized, general and both. Authorized retailers are those who are authorized to sell certain brands and general retailers are those that sell only un-branded batteries. Some retailers sold authorized brands and also unauthorized brands – such retailers were clubbed with the authorized retailers. Thus, the variable *type* takes the value 0 if the retailer is selling any branded batteries and 1 if he only sells un-branded batteries. A manufacturer is not likely to visit and collect used batteries from a retailer who sells only un-branded batteries, therefore, this variable is expected to have a negative sign.

Awareness about BMHR, 2001 (*awareness*) is a dummy variable and takes on a value of 1 when retailers are aware of BMHR and 0 otherwise. Since awareness is expected to increase compliance, this variable should have a positive sign in the regression model. The number of used batteries bought back for every 100 batteries sold per week (*bought back*) is a variable that allows us to understand the scale of the retailer's operations. To answer this question, retailers were asked to identify percent of batteries bought back by choosing from among various options: 51-60%, 61-70%, 71-80%, 81-90% and 91-100%. The percent of batteries bought back for every 100 batteries sold was calculated by taking the mid-point of these options. We hypothesize that the higher the percentage of batteries bought back each week, the less likely it is for retailers to comply because of high storage costs (so the variable should have a negative sign).

We have information on two price variables. The price paid by retailers for used batteries is the buy-back price. Retailers were asked about the price (*buy-back price*) which they paid to consumers for used batteries and the price (*selling price*) they obtained from manufacturers or scrap dealers for used batteries. Since most responses were in terms of a range of prices, the mid-point was taken. The difference between the buy-back price and selling price is called *profit* and is hypothesized to have a negative effect on the probability of selling batteries to manufacturers. We also created a ratio of selling prices to the buy-back prices (*price ratio*). Both these variables are expected to have a negative impact on compliance and are expected to have a negative sign.

The frequency of visits from scrap dealers and manufacturers to collect used batteries is important because retailers find it difficult to store bulky batteries. Two variables reflect frequency of visits by the manufacturer (*manufacturer visit*) and by scrap dealers (*scrap visit*). These refer to the number of days per month that the manufacturer/scrap dealer visited retailers to collect used batteries. The frequency of collection visits by the manufacturer is hypothesized to increase the probability of compliance (positive sign), while the frequency of collection visits by scrap dealers is hypothesized to have an opposite effect (negative sign).

There are two explanatory variables that are of interest from a policy perspective: *awareness* and *manufacturer visit*. The higher the level of awareness of the Rules and the greater the frequency of manufacturer visits per month, the higher is the probability of compliance. The remaining explanatory variables discussed above act as control variables.

4.2 Incentives Faced by the Un-organized and Organized battery recycling sectors

To better understand the incentives facing the un-organized sector we used qualitative information obtained from scrap dealers and smelters. It is important to understand the costs of compliance to those in the un-organized sector. Thus, we estimated the costs of setting up a plant in an industrial zone and running a smelting unit (including taxes) and the additional cost incurred on compliance in accordance with the requirements of the pollution control authority (pollution control equipment and its maintenance). Information from the un-organized sector on wages, number of employees, number of days worked etc. were used to estimate the cost to society if compliance for this sector meant shutting down of operations

A final set of issues that we analyzed was the incentives facing the organized sector. An important issue to establish is whether it is profitable for the formal sector to recycle batteries. To understand the economic viability of this business, we did a case study of Exide's recycling unit—Chloride Metals. In this case study, we calculated the NPV and IRR of operating the unit. Data from Chloride Metals Limited was used to establish financial viability of organized smelting.

5. Results and Discussion

5.1 Consumers and the DRS

The results of the consumer survey revealed that 88% of the respondents were well aware of the deposit refund system and 90% of them returned their used battery back to the retailers irrespective of the discount price. The difference in these numbers could be because the deposit-refund system is so well established in the market for lead-acid batteries that some people return/recycle used batteries without even realizing it. The survey results also show that the average consumer in our study was aware of the DRS and about 95% consumers preferred to buy a branded battery. Consumers sold used batteries back to retailers and received on average about Rs. 372 (this number ranged from Rs. 200 to Rs. 500) for a used battery. This discount is available only when a new battery is purchased and covers approximately 9% of the cost of a new battery.

5.2 The Retailers' Decision to Comply

A logistic regression was used to analyze the responses from retailers. Table 1 shows the summary statistics of the dependent and the independent variables. On average, a retailer is able to buy back 69 used batteries for every 100 batteries sold in a week. Table 1 indicates that on average the manufacturer's representatives collect used batteries twice a month, while scrap dealers collect used batteries on average every 10 days per month. The mean price retailers pay for buying back used batteries is Rs. 416 while the mean price retailers get for these batteries is about Rs. 456.[4] Retailers obtain 0.9% higher price when they sell to scrap dealers instead of manufacturers (as shown in Figures 2 and 3).

Results of the logit estimation of the compliance decision of retailers are presented in Table 2. The models estimated were tested for multicollinearity and model specification. The results of these tests showed neither multicollinearity nor any model misspecification. The signs and significance of the variables in the models I and II are the same. All variables are significant at least at the 5% level of significance except *manufacturer visit*. This may be because this variable has very little variation with a mean of 2, standard deviation of 5.38.

As expected, *awareness* of the BMHR rules and being located in a commercial area, have a positive impact on the probability of selling only to the manufacturer. The variables *type*, *scrap visit* and *bought back* have negative signs. This shows that being a general battery retailer (as compared to an authorized one), the higher the number of scrap dealer visits in a month, and the larger the percentage of used batteries bought back have a negative effect on the probability of selling used batteries only to the manufacturer. This makes sense because the manufacturer is not likely to visit a 'general' retailer (who sells only un-branded batteries) to collect battery scrap. Storing used batteries has a cost associated with it, so retailers would be more inclined to reduce this cost by selling to scrap dealers if they come to collect often. How many batteries they have to store would also depend on how many they buy back.

Several retailers told us that the scrap dealers pay more for used batteries.[5] The coefficient of *profit* is significant and has a negative sign (in model I), showing that the higher the profit earned by recycling the less likely it is for retailers to sell the used batteries to manufacturers. In model II, the coefficient of the *price ratio* is significant with a negative sign indicating again that as the ratio of selling price to buying price of battery scrap increases, it is less likely for this scrap to be sold to manufacturers.

5.3 The Unorganized Battery Recycling Sector

Lack of awareness, illiteracy, complexity of paper work, restrictions on location, maintenance of pollution control equipment and reluctance to pay taxes keeps the unorganized smelters from getting their units registered and complying with BMHR. There are about 70 unorganized smelters operating in the outskirts of Delhi but in the NCR (40 in Mandoli and 30 in Ghaziabad) with about 840 employees.

Interviews with the organized and unorganized smelters revealed that at present both types use the same pollution control technology – bag-house filters, which collect the ash from the flue. Ash has a high content of lead. Almost 50% of the recycled lead obtained from the used batteries comes from this ash. The recovery of ash controls air pollution since if not recovered through bag-house filters, the ash and the lead within it, would simply linger in the air. Further, it is also a source of profit for smelters as lead ash is valued at about Rs. 2/- per kg. This is an incentive for all unorganized smelters to install the bag–house filter technology. But, as we observed, the filter equipment used was crude, badly maintained and prone to leakage and thus posed a threat to the environment and health of the workers.

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4 A paired t-test shows that we can reject the null hypothesis of no difference between the mean buy-back price and mean selling price at the 1% level of significance

5 Scrap dealers buy back used batteries based on their lead content. The price of lead is determined by the daily price of lead on the LME. The scrap dealers may therefore be able to pass on large daily variations in the price of lead which manufacturers may not because of a fixed price that is changed periodically.

Unorganized smelting units are of similar capacity and employ 3 - 4 workers (1 "*mistry*" or the main worker and two or three helpers) to run the bhatti in each shift. These units run in three consecutive shifts every day as they have sufficient raw material. In addition they also employ 8 to 10 laborers on a contract/daily wage basis (mostly women) to break the batteries. Each smelting unit has a pool of about 100 workers hailing from villages in Varanasi district of Uttar Pradesh.

Most workers in unorganized smelting units live on the premises. The workers are usually employed for a period of two to three months at a stretch. They develop health problems after that and quit or are forced to go back to their villages. The typical symptoms of indigestion, abdominal pain and severe constipation are treated by local doctors. Very few workers are taken to hospitals because the smelters are not willing to disclose their occupation.

Workers earn about three thousand rupees a month. Some of them return to work on call while most do not and continue with other jobs in their villages. Those with no other employment options return to these smelters on call once they have recovered. These workers stand to lose about 30,000 rupees annually because they fall sick and cannot continue working in the smelting units. (If we assume that they have no other employment.) Sometimes the smelters pay the workers in advance while they are recovering at home to prevent them from moving to other smelting units.

Unorganized smelters face no shortage of raw material as scrap dealers provide them with a constant supply of used batteries. Extracted lead ingots or "*silli*", are either sold to units that manufacture lead oxide, cables and generic batteries (usually co-located with the smelters) or to scrap dealers and secondary lead dealers in Delhi. The difference in the price at which smelters buy lead (in the form of batteries) and sell it is, on average, Rs 5/kg of lead. The smelters also perform "job work" for retailers in Delhi who send used batteries to them and buy back the extracted lead. The hard poly- propylene plastic cover of the batteries is sold to plastic recyclers.

A scrap dealer serves as the middle-man who collects used batteries from battery retailers and sells them to the unorganized smelters at a profit margin of Rs. 1.50 per kg of lead in the battery. This is mostly paid in secondary lead. The scrap dealers then sell this secondary lead to small battery manufacturers. Some scrap dealers we interviewed felt that their business had been adversely affected by the recent decision made by some bulk battery consumers to float tenders to sell battery scrap instead of holding open auctions. A few claimed to sell battery scrap only to registered smelters. All the registered smelters we spoke to insisted that they bought used batteries only from bulk consumers through auction or tenders (implying compliance with BMHR) and not from scrap dealers.

An average scrap dealer collects about two tons of used batteries (both branded and generic batteries) every day. This would give the scrap dealer revenue of about Rs. 1800 per day (at Rs. 1.50 per kg of lead). The scrap dealers reported that retailers prefer to sell the used batteries to them because the manufacturer's representatives visit them infrequently or their collection centers are located at long distances and because they have to buy new batteries in lieu of the ones returned. As a result, the majority of the used batteries recycled under the present DRS find their way to informal smelters through scrap dealers. The results of our retailer survey substantiate this claim because 60% of retailers reported that they sold used batteries to scrap dealers and 13% said they sold to both scrap dealers and manufacturers. Only 27% sold only to manufacturers.

5.4 The Organized Battery Recycling Sector

Organized smelters acquire the battery scrap through government auctions (Railways, Defense etc.) and also from the import of lead scrap (under license from the Ministry of Environment and Forest (MoEF)). The capacity utilization of organized smelters is low because of a limited supply of battery scrap. The installation and maintenance of pollution control equipment (other than bag filters) together with applicable taxes (as shown in Table 3) and transportation costs[6] add to the cost of running the smelting units. This additional cost can be considered the compliance cost for the organized smelters.

6 According to an order of the Delhi High Court all registered smelters have to be located beyond a radius of 60km from Delhi. The terms of the auctions require the buyer to arrange for the transport of raw materials from the auction site to their units within the stipulated time.

The BMHR require battery manufacturers to be involved directly or indirectly in the buy-back of used batteries and ensure that they are smelted by registered smelters with environment-friendly technology. The financial information on the smelting operations of Chloride Metals Limited (CML), one of Exide's smelters, is shown in table 4 for the year 2008-09. Exide acquired CML at an initial cost of Rs. 43 crores with an installed capacity of smelting 36,000 tons. CML smelted 16,707 tons of lead (8,441 tons from used batteries and 8,508 tons from other sources) during 2008-09. The operating cost of the unit included cost of energy, labor, occupational health and safety and maintenance. Revenue earned was from sale of recycled lead, job work and sale of bye products. Analyses of input costs and output revenues (Table 4) show that the smelting unit has an NPV of Rs. 96.05 crores and Rs. 87.47 crores at 8% and 10% discount rates respectively. As the NPV is positive, running the smelting unit is economically viable. Therefore, at this capacity of operation, the market provides a battery manufacturer with adequate economic incentive to comply with the BMHR.

5.5 Cost of Complying with BMHR (2001)

The stakeholders in the organized sector of lead recycling incur a cost of complying with BMHR. We discuss the costs of compliance to each of the different stakeholders in Table 5.

As shown in Table 5, consumers get a discount (Rs. 372) on a new battery when they return a used battery to the retailer. So compliance with BMHR gives them a net benefit of Rs. 44 per kg of recycled lead.

If battery retailers sell all used batteries to the manufacturer (assuming that they don't sell directly to organized smelters) they would be complying with the BMHR. Assuming that the manufacturers' representatives visit all retailers to collect the battery scrap, the retailers would incur a cost of storing the battery till it is collected, the opportunity cost of not selling it to a scrap dealer plus the taxes applicable on sales. The retailers we surveyed were unable to quantify the cost of storage. The average price a scrap dealer pays for a battery is about 459 rupees, while a manufacturer's representative pays about 455 rupees. So the compliance cost (excluding storage cost and taxes) incurred by an average retailer who buys back sixty-nine batteries in a week would be the difference in the two prices, i.e. Rs. 4 per battery or approximately Rs. 0.50 per kg week (or Rs. 500 per ton of recycled lead). This is a very small amount and indicates that the main incentive to sell to scrap dealers comes from significant storage costs and taxes.

For organized smelters, the costs of compliance include installation and maintenance of pollution control equipment (other than bag filters), taxes on purchase of battery scrap, and transportation costs. Table 3 gives an illustrative estimate of costs associated with setting up and running a smelting unit of 5000 MT capacity in the Delhi region based on interviews with organized smelters for illustrative purposes.

The market provides a battery manufacturer with adequate economic incentive to comply with the BMHR (see section 5.4). The main issue is more of coordination. If manufacturers accept their "extended producer responsibility" and join the battery buy back process and ensure more frequent collection from authorized and other retailers, they will be able to capture a larger share of battery scrap. The costs associated with this process are likely to be small.

The stakeholders in the un-organized sector do not comply with the BMHR so they do not incur a cost of compliance. If scrap dealers were to comply in the current scenario by selling the battery scrap to manufacturers, they would incur a loss of Rs. 4 per battery (since scrap dealers pay Rs. 459 per battery to retailers and manufacturers pay Rs. 455). This would mean that the scrap dealers would go out of business.

Since the smelters in this sector do not feel the need to adopt better technology and get registered with the pollution control authorities, compliance would imply that their operations are shut down. The cost to society of closing these units would be in terms of about 840 workers losing their jobs around Delhi and NCR. If they did choose to comply, their compliance cost would be reflected by the costs estimates shown in table 3. The cost of compliance is high for these stakeholders.

6. Policy Options for Safe Disposal of Used Batteries

The current deposit refund instrument is unable to discourage unorganized smelting of used batteries in Delhi. Non-compliance with BMHR happens because of: a) costs borne by retailers if they sell only to the organized sector; b) profit incentives for the unorganized smelters to use inefficient technologies; c) coordination problems that limit the amount and frequency of collection and recycling that is done by the organized sector; and d) inability of the regulator to fully monitor the market for recycled lead. Based on this analysis, we identify several policy options in Table 6.

One policy option would be to impose a penalty on battery manufacturers and importers for non-compliance. This would ensure that all used batteries manufactured in this sector are collected and recycled/disposed safely. However, the impact of this policy would depend on the magnitude of the penalty and would be limited because of the presence of a large unorganized sector in the battery manufacturing industry.[7] Monitoring agencies are understaffed and will be unable to monitor all units. Imposing penalties for non-compliance on all organized sector stakeholders is likely to have a good impact. However, this would also prove costly to implement.

Another policy option would be to impose a non-compliance penalty on retailers to make them sell all the used batteries to manufacturers or organized smelters. The inability to monitor the large number of retailers in this market would limit the impact of this policy.[8]

A green tax per battery produced on manufacturers and a subsidy for a battery properly disposed (disposed by organized smelting) in combination with the current deposit refunding to users of batteries could ensure the manufacturer complies with extended producer responsibility. Since it is the lead used in making batteries that causes the environmental problem, alternatively there could be a tax on lead used and a subsidy on lead recovered by the manufacturer. It may however be difficult for the regulator to fix the rate/amount of tax since the international price of lead varies on a daily basis. A subsidy on the safe disposal of batteries provides incentives to do organized-smelting. This subsidy could be a partial or complete refund of the tax paid by the manufacturer on batteries for complying with BMHR. For the regulator or government, this tax-subsidy scheme could be revenue neutral.

The tax amount should be such that, the manufacturer would have an incentive to offer a price for battery scrap that would be high enough to wipe out all incentives for recycling lead in the informal sector. To the extent that the manufacturer is unable to buy back used batteries, the tax amount collected could be used to subsidize the use of clean technology in the informal sector. The presence of the unorganized sector in battery manufacturing would limit the impact of this policy tool.

The next two policy options target the informal sector. Our survey results show that 60% of the retailers prefer to sell used batteries to scrap dealers who offered a higher price and came for collection as often as every three days. Hence, one way to ensure that all used batteries reach manufacturers or organized smelters would be to legitimize the role of scrap dealers and allow the organized sector to buy battery scrap from them. Further, if unorganized smelters can be identified and monitored, they can be encouraged through financial assistance and tax breaks to adopt green technology. The resources to implement this policy tool can be raised from the penalties and tax suggested in the earlier policy options.

7. Conclusion and Policy Recommendation

This study set out to understand the role of and incentives to different stakeholders in the lead recycling industry and how they affected the efficient functioning of the deposit refund system. The results indicate that the deposit-refund system is well established in this industry and 90% of consumers recycle lead-acid batteries by selling them to battery retailers. Consumers, who obtain a net benefit of approximately Rs. 44 to 49 per kg of lead recycled, have a clear incentive to recycle.

[7] The presence of the unorganized sector in battery manufacturing is reported to be three times the size of the organized sector (EIL, 2009).

[8] There are more than 600 organized sector battery retailers listed in Delhi as per the Battery Directory and Year Book 2010 published by the Federation of Indian Small Scale Battery Associations (Regd.)

However, the BMHR have not had the desired impact on the structure of the battery recycling industry and the informal sector continues to operate causing significant environmental pollution. Some 73% of surveyed retailers sold batteries to scrap dealers, who in turn sold them to informal smelters. The higher frequency of scrap dealer visits (almost three times a week), higher price received, storage costs, and taxes avoided motivate retailers to sell to the informal sector.

For a battery manufacturer, depending on the scale of operation, collecting used batteries from retailers and operating smelting units can be economically viable. Thus, if manufacturers simply increased the frequency with which they collected batteries from retailers and bore the storage costs, they would be in compliance with BMHR. However, the cost of complying with the BMHR is high for registered lead smelters. They are unable to operate at full capacity because of a limited supply of battery scrap. This is mainly because they are currently banned from buying battery scrap directly from scrap dealers.

One policy option that might improve the recycling of lead within the formal sector is a green tax and linked subsidy on each battery produced in the organized sector. A large enough tax per battery manufactured along with an equivalent subsidy if the manufacturer shows that the battery was bought back (and properly disposed), could provide the necessary incentives for organized smelting. Other policy options to consider are allowing the organized sector to buy from scrap dealers and providing assistance to unorganized smelters to ensure green recycling and disposal. However, the latter option would be costly to the tax payer.

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Tables

Table 1: Summary Statistics of the Variables in the Retailer Study

Variable	Obs.	Variable Description	Mean	Std. Dev.	Min	Max
Comply	94	Retailers returning used batteries back to the manufacturer or not (1 if sells to manufacturer only, 0 otherwise)	.2659	.4442	0	1
Location	96	Location of the retailers (1 if commercial, 0 if residential)	.4375	.4986	0	1
Type	96	Types of retailers (1 if sells un-branded batteries only, 0 otherwise)	.3437	.4774	0	1
Awareness	96	Awareness about BMHR, 2001(1 if aware, 0 otherwise)	.3541	.4807	0	1
Bought back	96	Number of used batteries bought back/100 batteries sold	69.3750	32.51	0	95
Manufacturer visit	96	Frequency of visits by the manufacturer per month	2	5.3802	0	26
Scrap visit	96	Frequency of visits by the scrap dealers per month	10.2291	11.9679	0	26
Buy-back price	90	Price paid by retailers for used batteries	415.7444	28.3511	350	500
Selling price	87	Average selling price of used batteries	455.9195	34.8061	375	575
Price ratio	87	Ratio of the selling price to buy-back price	1.097999	.0737344	1	1.357
Profit	87	Difference between selling price and buy back price	39.54023	29.44005	0	125

Table 2: Logistic Regression of Independent Variable 'comply'- Compliance with BMHR by Selling Used Batteries only to Manufacturer

	Model I		Model II	
Variable	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Location	2.1738** (0.033)	0.1092 (0.176)	2.2182** (0.030)	0.1090 (0.169)
Type	-4.5022*** (0.003)	-0.1745** (0.032)	-4.4780*** (0.003)	-0.1683** (0.036)
Awareness	3.0978*** (0.002)	0.2181* (0.091)	3.0978*** (0.002)	0.2125* (0.098)
Bought back	-0.0370** (0.024)	-0.0014 (0.111)	-0.0359** (0.024)	-0.0013 (0.119)
Manufacturer visit	-0.0917 (0.117)	-0.0035 (0.234)	-0.0925 (0.116)	-0.0034 (0.232)
Scrap visit	-0.2408*** (0.001)	-0.0091* (0.076)	-0.2411*** (0.001)	-0.0088* (0.079)
Price ratio	—	—	-17.9045** (0.011)	-0.6564 (0.128)
Profit	-0.0429** (0.012)	-0.0016 (0.128)	—	—
N	87	87	87	87
Pseudo R2	0.5611		0.5628	
LR chi2 Prob>chi2	57.51 0.000		57.68 0.000	
Hosmer-Lemeshow chi2(8) = Prob > chi2	6.46 0.5957		10.83 0.2115	

The numbers in parentheses are p-values.

***,**,* denote significance at the 1, 5, and 10% levels respectively

Table 3: Illustrative Costs of setting up a smelting unit in the organized sector in NCR—an example for Mandir-Bhatti or Open Hearth furnace with a capacity of 5000 Mt/year

Costs	Figures in Indian Rupees
Cost of Land	3,000,000 (1500 sq. yard @Rs. 2000/sq. yard)
Infrastructure Cost	4,000,000 (7500 sq. ft @ Rs. 500/sq. ft.)
Equipment Cost	1,500,000 (furnace, pollution control device)
Fuel	2,400,000 per annum
Electricity	360,000 per annum
Maintenance	30,000 per annum
Revenue	
Revenue from Ash	4,800,000 per annum (200 Mt/month @Rs. 2 per kg)
Taxes on Sales	
Central Sales Tax	2% if selling outside the region
Excise Tax	10.3%
VAT	5% if selling within the same region
Taxes of Raw Materials	
Central Sales Tax	2% if buying from Government Organization and Private Company
Excise Tax	10.3% if buying from Private Company
Customs Duty	If importing

Source: Interviews with organized smelters

Table 4: Financial Details of Chloride Metals Ltd.

General Information	**(all figures in metric tons)**
Total Capacity (amount of lead smelted annually)	36000
Capacity Utilization of the Unit	16707
Amount of lead recycled from old batteries	8441
Amount of lead recycled From other sources (cables, pipes etc.)	8508
Financial Details for the year (2008-09)	**(all figures in Rs. Crores)**
Costs	
Initial Investment/ Cost of Acquisition (For Exide)-	28
Additional Capital Cost after acquisition -	15
Cost of old Batteries	42
Cost of other sources of raw material	77
Energy Cost	5.97
Labor Cost	0.4
Revenues	
Sale of recycled lead	148
Job Work	5.16
Sale of by-products	0.2

Source: Exide India Ltd—Annual Report and Interview with officials

Table 5: Compliance Cost

Stakeholders	Impacts of Compliance	Cost of compliance
Consumers	• Discount on purchase of new battery	• Net benefit of Rs. 44 per kg of lead(as reported by consumers) to Rs. 49 per kg of lead recycled (as reported by retailers)
Retailers	• Difference between selling price to scrap dealers and manufacturers • Cost of storage and applicable taxes when sold to manufacturers	• Rs. 4 per kg of lead plus taxes • Costs of storage significant
Organized Smelters	• Low capacity utilization (shortage of raw materials) • Pollution control devices • Applicable taxes • Transportation cost	• Smelters with an annual turnover of more than Rs. 1.5 crore in a financial year incur : cost of pollution control equipment and its maintenance plus additional transportation cost for inputs(as shown in table 3); they are subject to VAT/Central Sales Tax (depending on the region they sell their product in), Excise duty of 10.3% on the finished product; customs duty; central sales tax and excise duty on purchase of raw material (if they import, buy from Government organizations and private companies respectively) and income tax at the rate of at least 30%. • Smelters with an annual turnover of less than Rs. 1.5 crore only pay the central sales tax. • May be economically viable if more raw material were available
Manufacturers	• Cost of recycling lead or getting it recycled from organized smelters • Collection and transportation cost • Storage costs • Applicable Taxes	• As shown in table 4 • Small, but could not be ascertained • Could not be ascertained • Could not be ascertained • Overall, recycling economically viable, so costs are negligible
Un-organized Smelters	• Current units would need to be closed or fully upgraded to set up registered units	• Do not comply • Costs significant as illustrated in Table 3
Employees of Un-organized smelters	• 840 workers would lose jobs in NCR	• Rs. 3000** per month per worker

Source: Surveys and Interviews conducted

*Excluding the storage cost and applicable taxes

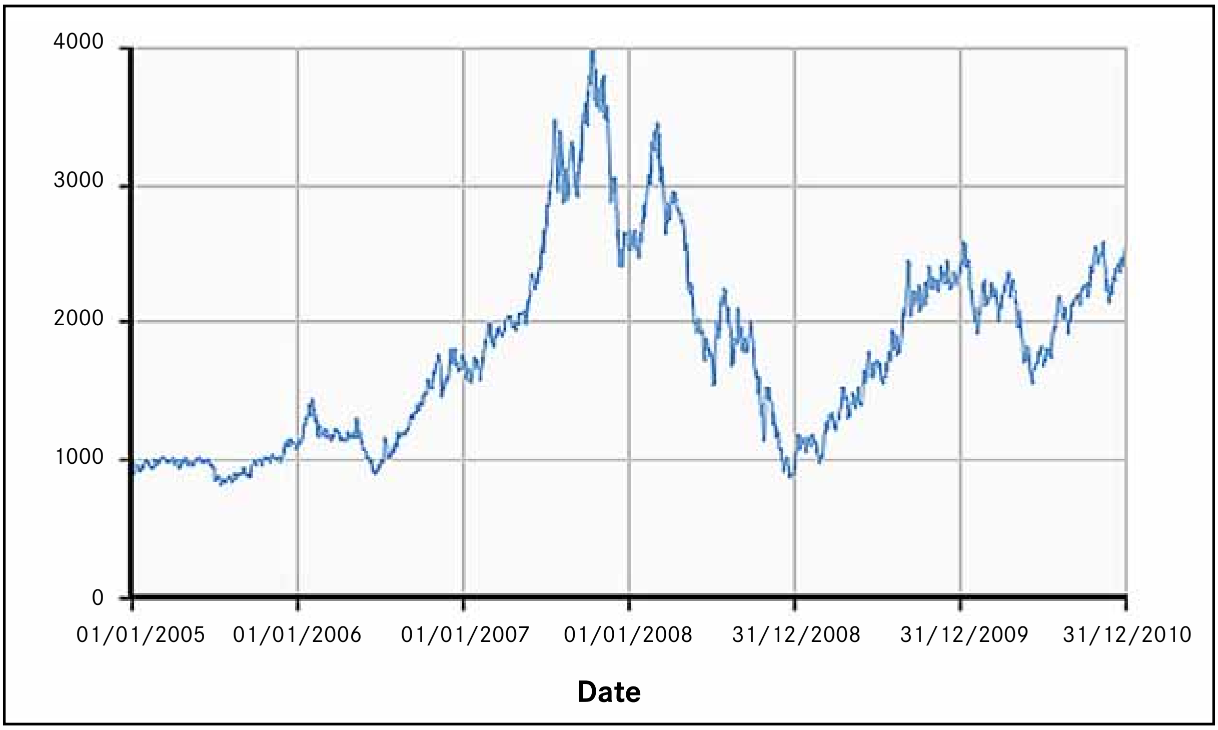
**Average income of the workers employed in un-organized smelters.

Table 6: Policy Options and Recommendations

Policy Measure	Target Group	Objective	Impact/Incentive/Drawback
1a. BMHR with penalty on manufacturer	Battery manufacturer in organized sector	100% buy back and safe disposal of batteries	Limited. Would depend on magnitude of penalty. Batteries are also manufactured in the informal sector and also imported. Monitoring agencies are understaffed.
1b. BMHR with penalty on manufacturer and importer	Manufacturers and Importers	100% buy back and safe disposal of batteries	Limited. Excludes informal sector and would depend on magnitude of penalty. Monitoring agencies are understaffed.
1c. BMHR with penalty on retailer	Retailers	100% sale of used batteries to manufacturer/organized smelter	Limited. Very large number of retailers. Difficult to monitor/ implement. Monitoring agencies are understaffed.
1d. BMHR with penalty on all of above.	All except consumers	No used battery to reach informal sector	Good. Difficult/costly to implement. Would depend on amount of penalty, implementing/monitoring authority. Monitoring agencies are understaffed.
2. BMHR with green tax/ battery on manufacturer and importer, which is refundable on safe disposal	Manufacturer, Importer	100% buy back and safe disposal of batteries	Good. Would depend on the tax/ subsidy structure and won't be able to account for batteries manufactured in the informal sector
3. BMHR with scrap dealers collecting for the organized smelters/manufacturers	Scrap dealers, organized smelters	100% buy back and safe disposal of batteries	Good. Very large numbers. Will sell to organized sector if they get higher price than unorganized sector.
4. BMHR with financial and technical assistance to informal smelters to use green technology (fund from penalty collected in 1 and 2)	Informal smelters	Green recycling and disposal	Good. Difficult to identify because of large number and location. May not want to be monitored and eventually taxed.

Figures

Figure 1: Price Trend of Lead at London Metal Exchange (US$/ton) -January 2005 to December 2010



Source: London Metal Exchange, http//www.lme.com/lead_graphs.asp

Figure 2: Recycling Pathway of Organized Smelters

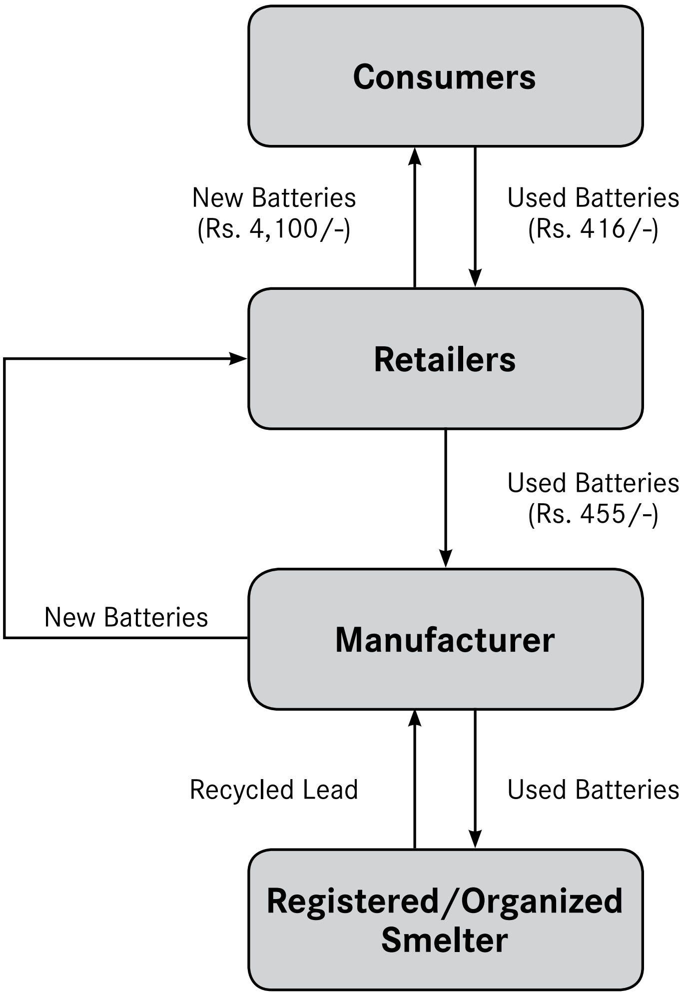
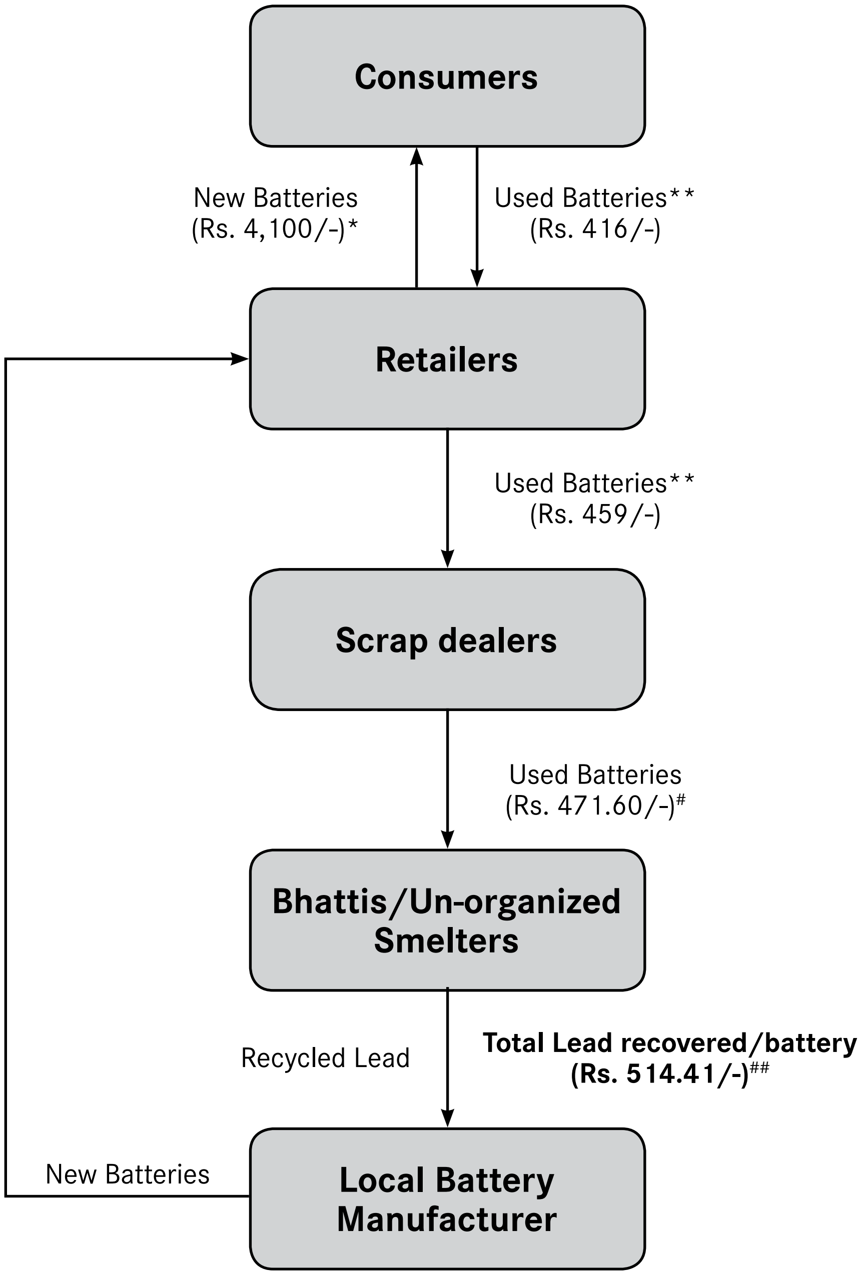


Figure: 3 Recycling Pathway of Un-organized Smelters



Note:

* Price of the new car Batteries ranges from Rs. 2700/- to 5500/-, middle value of the price range (Rs. 4100/-) has been taken.

** Mean value based on survey data

Scrap dealers sell the used batteries to Bhattis or un-organized smelters at profit margin of Rs. 1.5/- per kg of lead present in the used battery. Car battery, on average, has 8.4 kg of lead (60% of the total weight of the battery of 14 kg)). Assuming a profit margin of Rs. 1.50 per kg, price paid by the Bhattis is Rs. 471.60/- (Rs. 459 + 12.60/-). Whereas unorganized smelters buy the batteries by weight at 55% of the LME price of lead. Buying price of Rs. 471.60/- means the LME price would be around Rs. 61.24 per kg.

Lead recovered from a single battery is about 60% of the total weight of the car battery. (Lead recovered multiplied by the LME price (Rs. 61.24/-) gives the price of the total lead recovered from one battery by the unorganized smelters as Rs. 514.41/-.

(These calculations are based on interviews with scrap dealers and other informal sector agents. Figures are representative of the prices existing on the day of survey. The prices vary on daily basis.)

Figure 4: Structure of Lead Acid Battery Recycling Industry in Delhi

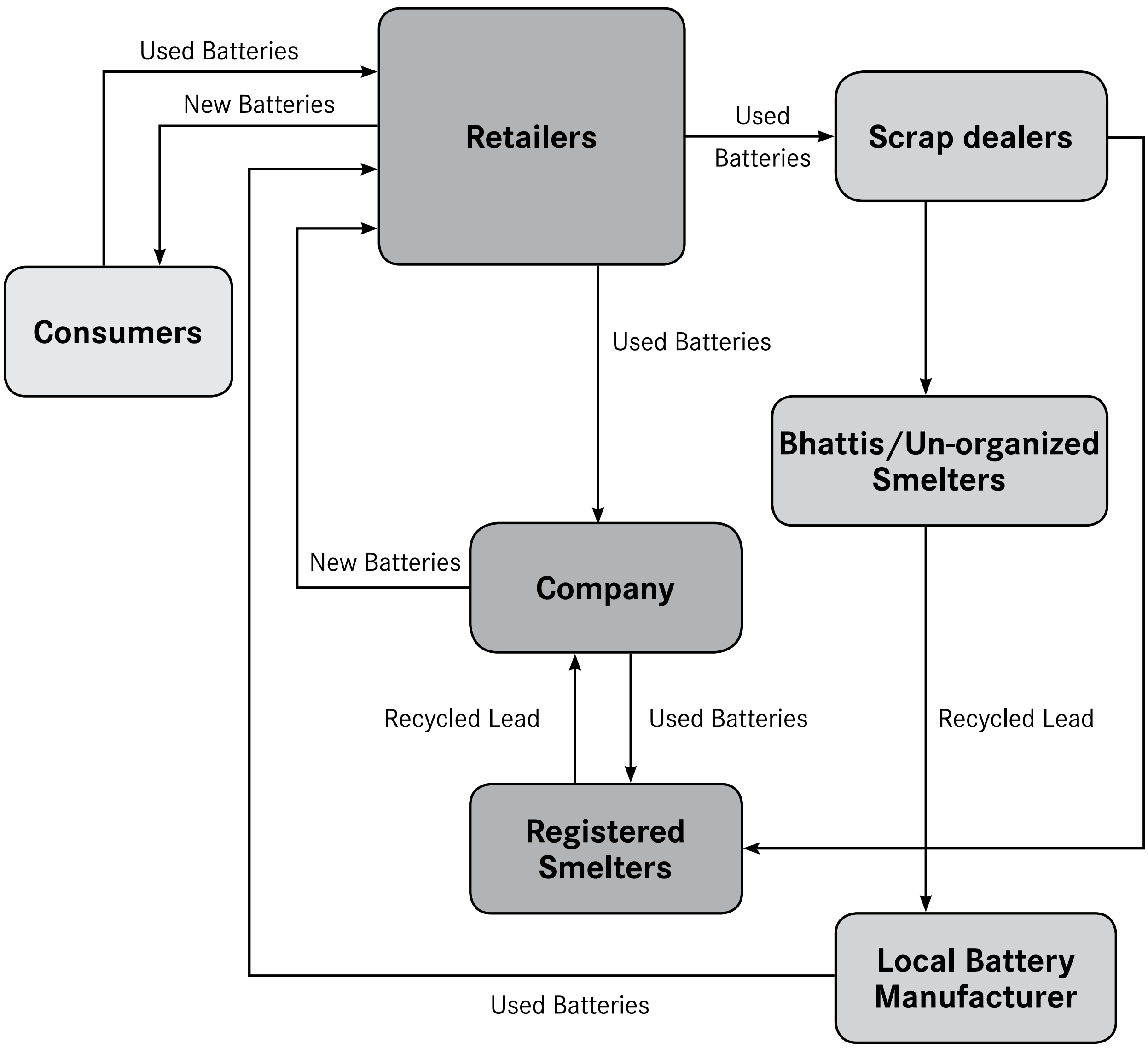
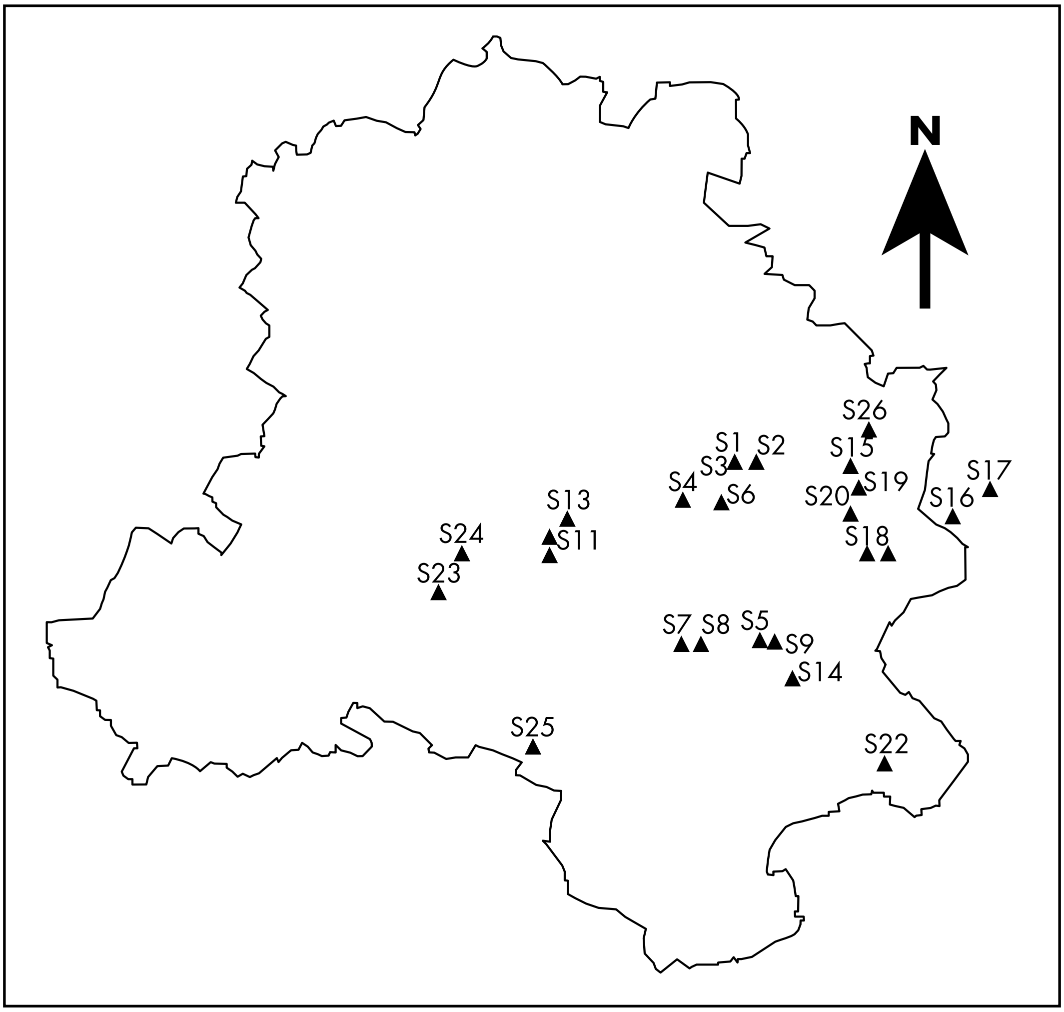


Figure 5: Locations of the Retailers Surveyed



Location	Code	No. of retailers	Location	Code	No. of retailers
TisHazari	S1	04	KailashColony	S14	02
Mori Gate	S2	01	East Azad Nagar	S15	01
Ghokhle Market	S3	09	Vaishali	S16	02
Karol Bagh	S4	08	Vasundhra	S17	02
Kotla	S5	06	Pandav Nagar	S18	01
Jhandewalan	S6	04	East Krishna Nagar	S19	04
PalikaBhavan	S7	07	VikashMarg	S20	02
SarojniNagar	S8	03	MayurVihar	S21	05
Defence Colony	S9	01	Badarpur	S22	01
Shanker Market	S10	02	Dwarka	S23	05
Mayapuri	S11	04	Uttam Nagar	S24	01
Hari Nagar	S12	01	Gurgaon	S25	04
RajouriGarden	S13	01	Shahadra	S26	01

Note: Sampling was done in the urban areas which had clusters of battery retailers. North and South west parts of Delhi are predominantly rural with agricultural land use and not many battery retailers.

Appendix I: Questionnaire for Consumers

1. Place of residence ______________________________

2. What car do you drive? ______________________________

3. Which type of car battery do you prefer?

   ☐ National brand Please specify name ______________________________

   ☐ Local brand

   Why? ______________________________

   ____

4. If you prefer locally manufactured battery, then where do you buy it from? ______________________________

   ____

5. What is the price which you pay for a new battery?

   ☐ Rs. 1000- Rs. 1500

   ☐ Rs. 1501- Rs, 2000

   ☐ Rs. 2001- Rs. 2500

   ☐ Rs. 2501- Rs. 3000

   ☐ Rs. 3001- Rs. 3500

   ☐ Rs. 3501- Rs. 4000

6. Are you aware of the buyback system (Deposit Refund System) for batteries?

   ☐ Yes

   ☐ No

7. Do you exchange your old battery for a new one?

   ☐ Yes

   ☐ No

8. If yes, then how much discount did you get for a new battery when you returned the old one? ____________

   ____

9. If no, then for what purpose do you use the old battery? ______________________________

   ____

Appendix II: Questionnaire for Retailers

1. Are you an authorized or a general dealer of batteries?

   ☐ Authorized

   ☐ General

   ☐ Both

2. If you are an authorized dealer, then which brand(s) of batteries do you sell? ________________________

   ____

3. If you are a general dealer, then which brands of batteries (both local and national) do you sell? ________

   ____

4. Are you aware of the Batteries (Management and Handling) Rules, 2001 (BMHR)?

   ☐ Yes

   ☐ No

5. How many batteries are you able to buy back, in say one week, as compared to the number of batteries sold?

   ☐ 51%- 60%

   ☐ 61%- 70%

   ☐ 71%- 80%

   ☐ 81%- 90%

   ☐ 91%- 100%

6. How much do you pay customers for their used batteries? ________________________________

7. To whom do you sell the used batteries which you buy back from customers? ________________________

   ____

8. If batteries are sold to scrap dealers, then why don't you sell the used batteries to companies? __________

   ____

9. For how much do you sell the used batteries? ____

10. What is the frequency of collection of used batteries by companies (per week)? ____________________

    ____

11. What is the frequency of collection of used batteries by scrap dealers (per week)? __________________

    ____

12. Does a company buy back its own brand only or other local and national brands too?

    ☐ Only its own brand

    ☐ Other brands too

13. Is there a difference between the prices you pay for used batteries of local and national brands?

☐ Yes

☐ No

If yes, then what is the difference? ____________________

14. Is there a difference between the prices you receive for used batteries of local and national brands from scrap dealers?

☐ Yes

☐ No

If yes, then what is the difference? ____________________

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