CITRECYCLE

SUSTAINABLE LEAD ACID BATTERY RECYCLING

University of Cambridge
Joshua George, George Lane, Jashan Bhumkar, Vladan Martinovic
Contact e-mail: info@citrecycle.co.uk

Problem

In the developed world lead is one of the most efficiently recycled metal commodities: up to 90% of the lead from used lead-acid batteries is recovered and re-used. However conventional lead recycling plants use a pyrometallurgical technology that have very high energy requirements, need to be large to be economical and, unless carefully controlled, can cause significant negative environmental impacts. These plants are effective and economical in developed world contexts characterised by sound infrastructure able to support large, centralised plants, and extensive, well implemented regulation with regard to environmental impact.

In many places in the developing world however, recycling takes place in less coherent infrastructural and regulatory environments, which all too often result in the exposure of local communities and the environment to lead contamination. The backyard smelting methods that characterise the informal lead recycling sector create serious environmental and health hazards, as does ineffective formal recycling. In Mombasa, Kenya, for example, between 2008 and 2014 the residents of the Owino Uhuru informal settlement were exposed to systemic lead poisoning from a badly built and poorly regulated lead-acid battery recycling plant. In this period lead content in the dust adjacent to the battery recycling plant, ranged from 45.586 mg/L to 207.840 mg/L. Exposure to such high lead concentrations caused a host of health problems in the local population. Eventually the plant was closed as a result, but the negative impact on residents continues.

As a toxicant, lead accumulates in human and animal tissue causing pain and disrupting multiple systems within the body. Currently, the World Health Organisation estimates that 143,000 deaths per year are associated with lead poisoning. A high concentration of lead in the blood disproportionately affects children because its effect on the brain and neurological system impairs development, affecting their long term health. The World Health Organisation states that blood lead concentrations as low as 5 μg/dl may result in decreased intelligence in children, behavioural difficulties and learning problems.

Apart from health and environmental concerns, informal, artisanal recycling methods are also economically marginal due to the fact that that only a fraction of the lead can be recovered from batteries due to the inability to generate industrial smelting temperatures. The personal incomes of those working in the informal sector often are just sufficient to keep their families above the subsistence level. Nevertheless, the informal sector accounts for up to 60% of the overall lead recycling market in some developing countries, generating revenues of millions of dollars.

As a result of combination of the failure of the formal recycling sector in developing countries to provide adequate protection for people and the environment, and the economic ineffectiveness of informal recycling for local artisans, dumping of used batteries continues to contaminate the environment. This toxic waste problem is increasing along with the rising demand for lead acid batteries generated by growth in the motor industry and solar photo voltaic sector in many of these countries. For instance, Kenya's automobile retail and distribution sector is expanding rapidly in response to increasing infrastructure development, higher incomes and access to credit facilities. The lack of recycling provision coupled with the surge in demand for lead acid batteries heightens the need for a solution exponentially: there is an increasingly urgent need for the country's lead acid battery recycling industry to address these environmental, social and economic challenges effectively.

The proposed solution

Citrecycle has adapted new technology developed by scientists in Cambridge University for developing world conditions. The technology itself has vast inherent advantages over current recycling techniques, in both the developed and developing context, yet by acknowledging the unique constraints that arise in developing countries, Citrecycle is able to unlock an array of integral social and economic advantages. A combination of the characteristics of the hydrometallurgy based technology and the socially conscious business model, establishes an environmentally, socially and economically sustainable solution to a dangerous, fatal and increasingly prominent global problem. An overview of the technological advantages are listed below:

1. The newly developed process has near-zero emission levels of lead particulates, dust and fumes that causes severe health hazards. By using solvents ('hydrometallurgy') rather than smelting ('pyrometallurgy'), direct carbon dioxide emissions are kept consistently minimal, and dangerous toxic bi-products are eliminated. The advantages are twofold: the carbon footprint compared to existing formal sector lead recycling plants and current informal practices is greatly reduced, aiding environmental sustainability; and the emission of dangerous lead particulates, dust and fumes that cause severe health hazards are eradicated, significantly improving health impacts.

2. Hydrometallurgy improves overall sustainability and the indirect carbon footprint by significantly reducing energy requirements: the thermal energy output is 550 kWh/kg of lead paste, a hundred-fold improvement from the current technology.

3. The process is profitable at a small scale (1-2 tons/day) relative to typical plants in the developed world, the smallest of which process 10,000 tons/day. At this scale, capital costs are relatively low (approximately £300,000) as compared with £5 million required to establish a 10,000 tons/day plant.

4. Selling lead on the global commodities market, or directly to local battery manufacturers, will generate enough income to cover running costs, the cost of buying used batteries from local people and generate a profit. This enables income to be generated fairly at every level of the overall supply chain.

5. The technology recovers metal from the entire battery, including the oxide component that makes up 40% of the battery, which currently is discarded by recyclers in the informal sector.

The table below summarises the key advantages of the new technology over the current recycling methods.

Table 1 Key differences between current and novel technology

Current technology	New technology
Pollution and contamination of environment	Near-zero emissions
High carbon footprint due to CO_2 emission	Low carbon footprint due to reduced CO_2 emission
Net energy output negative	Net energy output 500 kWh/kg paste
Extremely large plant required to operate 10000 tons/day	Profitable at small scales 1-2 tons/day
Capital costs £5 million	Capital costs £300,000 - 500,000
Informal sector does not recycle entire battery	Can recycle oxides and thus, full battery

Beyond the advantages of the technology itself, which is by far better suited to the development context due to its scalable nature and low capital cost, a key additional benefit is that it can contribute directly to formalising the informal sector. This is particularly significant in places where the informal sector constitutes up to 60% of all recycling.

To ensure that the potential social benefits of the technology are fully realised, the business model proposed entails setting up a network of local battery collection centres, run as collector-owned co-operatives, as satellites to small-scale (1-2 tons/day) recycling plants. The co-operatives will function as independent businesses. Their collectors will acquire discarded batteries from households and local businesses at a set, agreed price and deliver these to the collection centre, also for a set, agreed price. Each centre will deliver batteries in bulk to the nearest plant for recycling, once again at an agreed price. Payments throughout will be made using a mobile payment system (called M-PESA in Kenya), which will ensure transparency and the fair distribution of funds from the plant to co-operatives, co-operatives to collectors, and from collectors to battery owners. By employing this model, the establishment of a recycling plant will boost socio-economic conditions in local communities by creating income-generating opportunities, and where the lead-recycling sector has retracted almost entirely, reinvigorate a whole industry; generating a new market with lead-acid batteries at the nucleus.

Furthermore, generation of a new market, stimulated by positive financial incentives rather than fines or levies, will encourage users of lead-acid batteries to recycle rather than discard their used batteries, therefore reducing lead contamination and improving environmental and health conditions for communities.

Citrecycle