Future Challenges in Battery Recycling

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Global Lead Poisoning Epidemic

- The World Health Organization estimates that 240 million people are overexposed and 99 % of those with blood levels above 20 µg/dl are in the developing world.
- Lead exposures account for 853,000 deaths annually vs. 852,000 for all other occupational risk factors (or 1.1 million AIDS related deaths).
- Greatest burden is in low and middle income countries.

LEAD POISONING

Children with Low Level exposures:

- IQ deficits, lower school performance, lower scores on standardized tests,
- Behavior problems,
- Hearing deficits,

Adults:

- High blood pressure linked to heart disease and stroke;
- Reproductive system effects include miscarriages, preterm deliveries, low birth weight, miscarriages, & stillbirths.

Recent Actions On Low Level Lead

- In 2012 CDC eliminated the "level of concern" for children of 10 µg/dl and adopted a reference value (5 µg/dl);
- 535,000 children in the U.S. have BLLs exceeding the reference value;
- The National Toxicology Program (NTP) 2012: "sufficient" evidence that blood lead levels **<10 µg/dL** in adults are associated with adverse **cardiovascular function**;

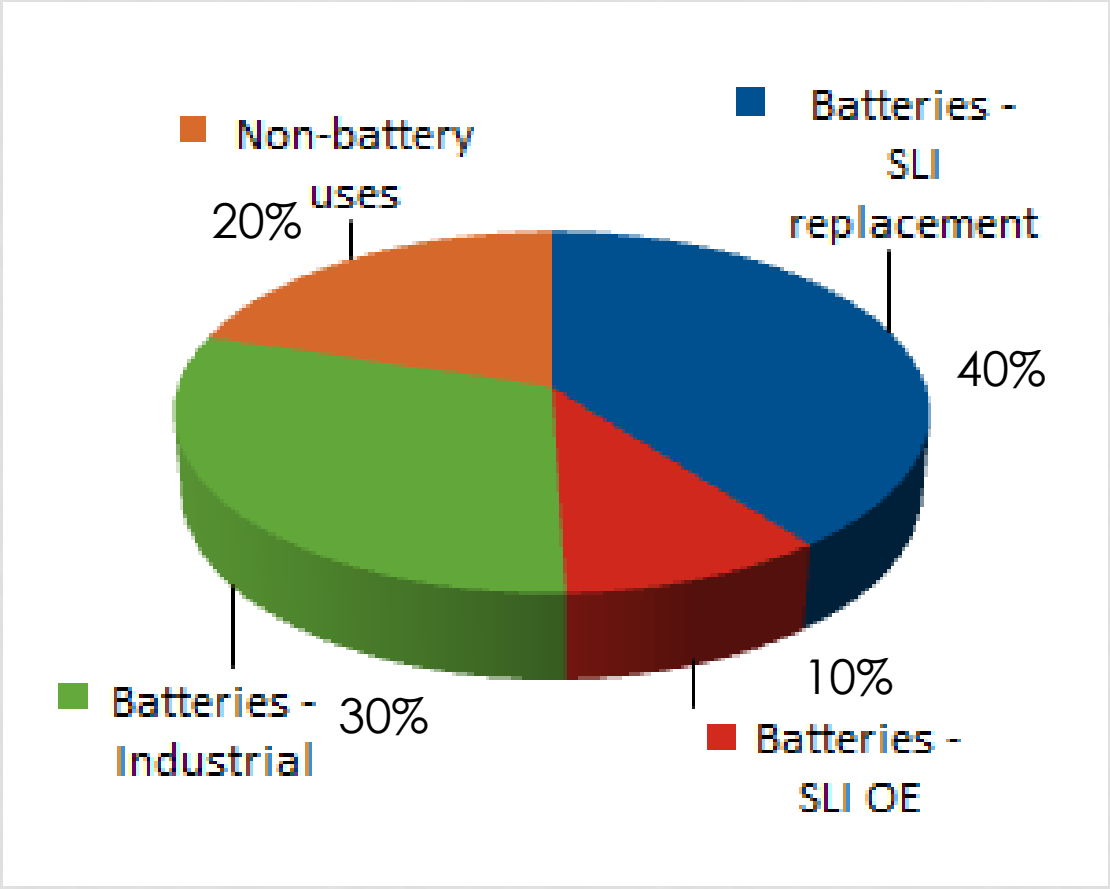
Recent Actions on Occupational Lead Poisoning Prevention

- U.S. CDC/NIOSH 2015 changed the case definition for **adults** to level **≥5 µg/dL** ("notifiable condition").
- **Cal-OSHA** updating occupational lead standard:
  - Proposed changing the airborne lead PEL from **50 µg/m³ to 2.1 µg/m³** (with goal to keep workers blood lead level below 10 µg/dl).
  - Proposed medical removal protection for blood lead levels:
    - BLL ≥ 30 µg/dl; or
    - Last 2 BLLs ≥ 20 µg/dl; or
    - Avg. BLL in last 6 mos. ≥ 20 µg/dl ; or
    - Final medical determination
- Washington State Labor & Industries

Global Mined Lead Production (1995-2014)

Source: U.S. Geological Survey "Lead 2015"
http://minerals.usgs.gov/minerals/pubs/commodity/lead/

LEAD CONSUMPTION

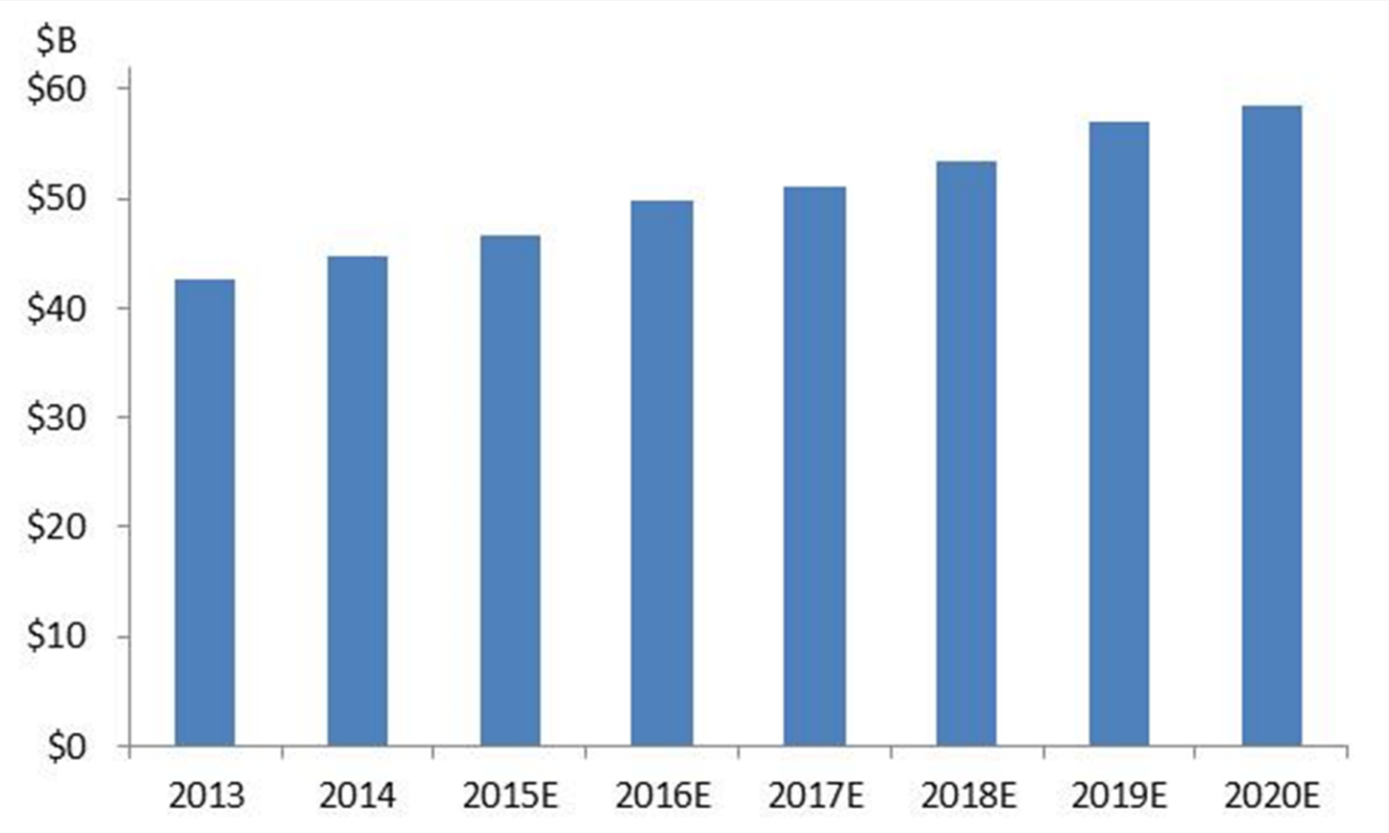


85% into batteries

https://www.lme.com/en-gb/metals/non-ferrous/lead/production-and-consumption/

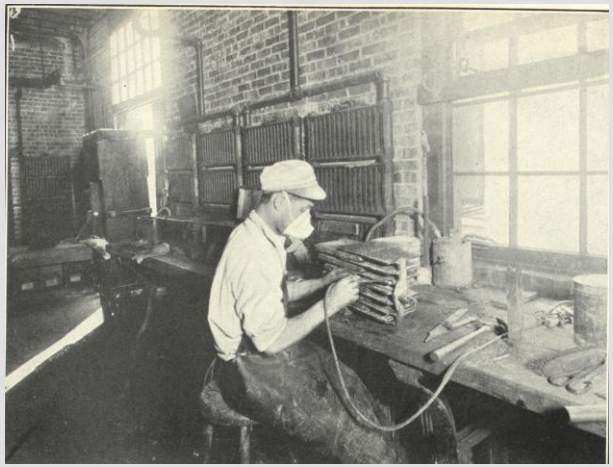
GROWTH IN LEAD BATTERY MARKET

Lead-Acid Battery Market ($ Billions)



Source: FMI, 2014

Lead Battery Manufacturing



1914

Today

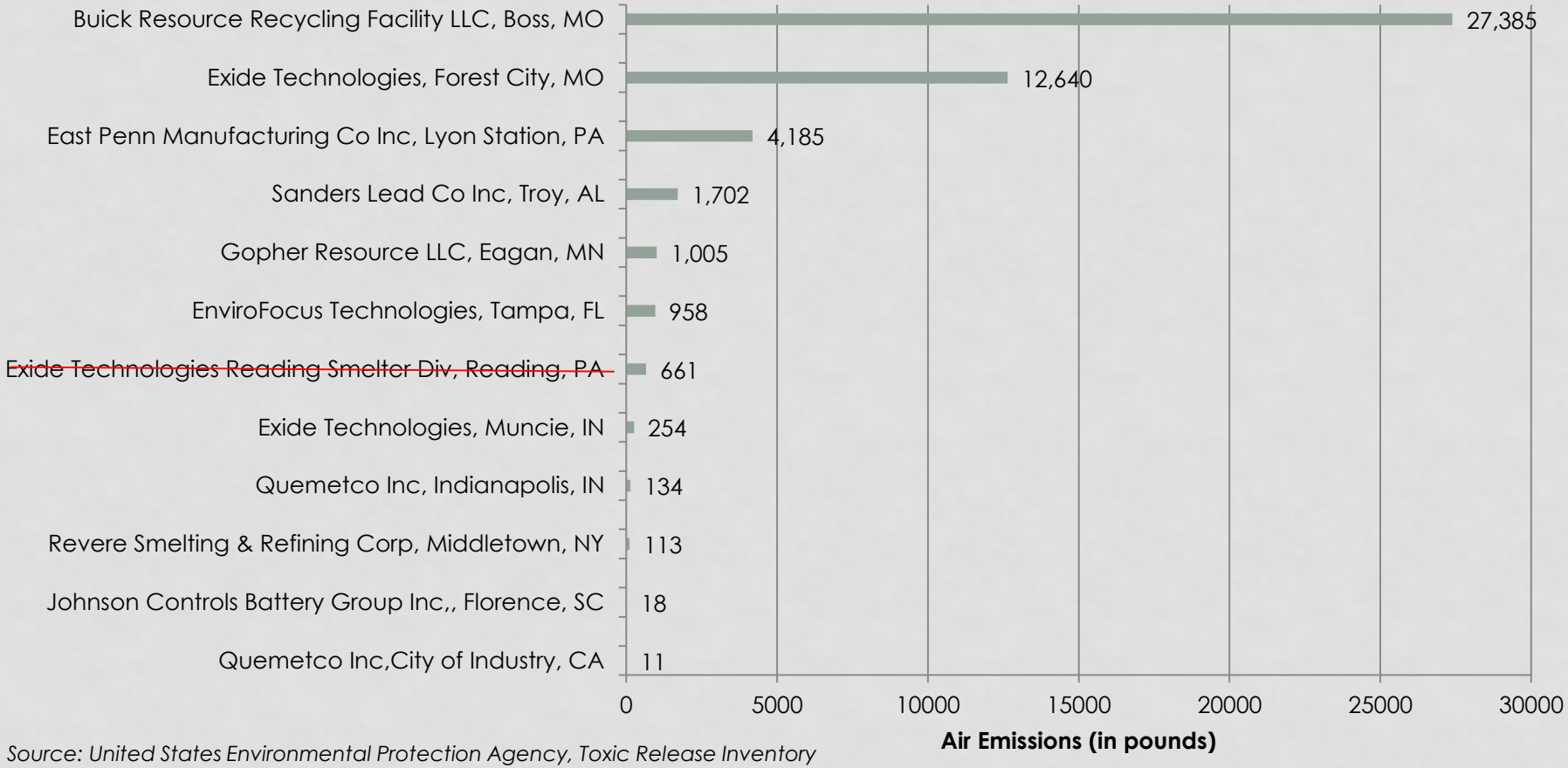
Welding battery plates together by melting lead with an open flame.

Source: "Lead Poisoning in the Manufacture of Storage Batteries"
Alice Hamilton, M.A., M.D., 1914

California Lead Battery Recycling Plant Ordered To Close

- Lead battery recycling plant outside Los Angeles ordered to close in 2015.
- Exide agreed to spend at least $47 million dollars on cleaning up the site and contaminated properties up to 1.7 miles away!
- Actual cleanup cost may exceed $500 million dollars.

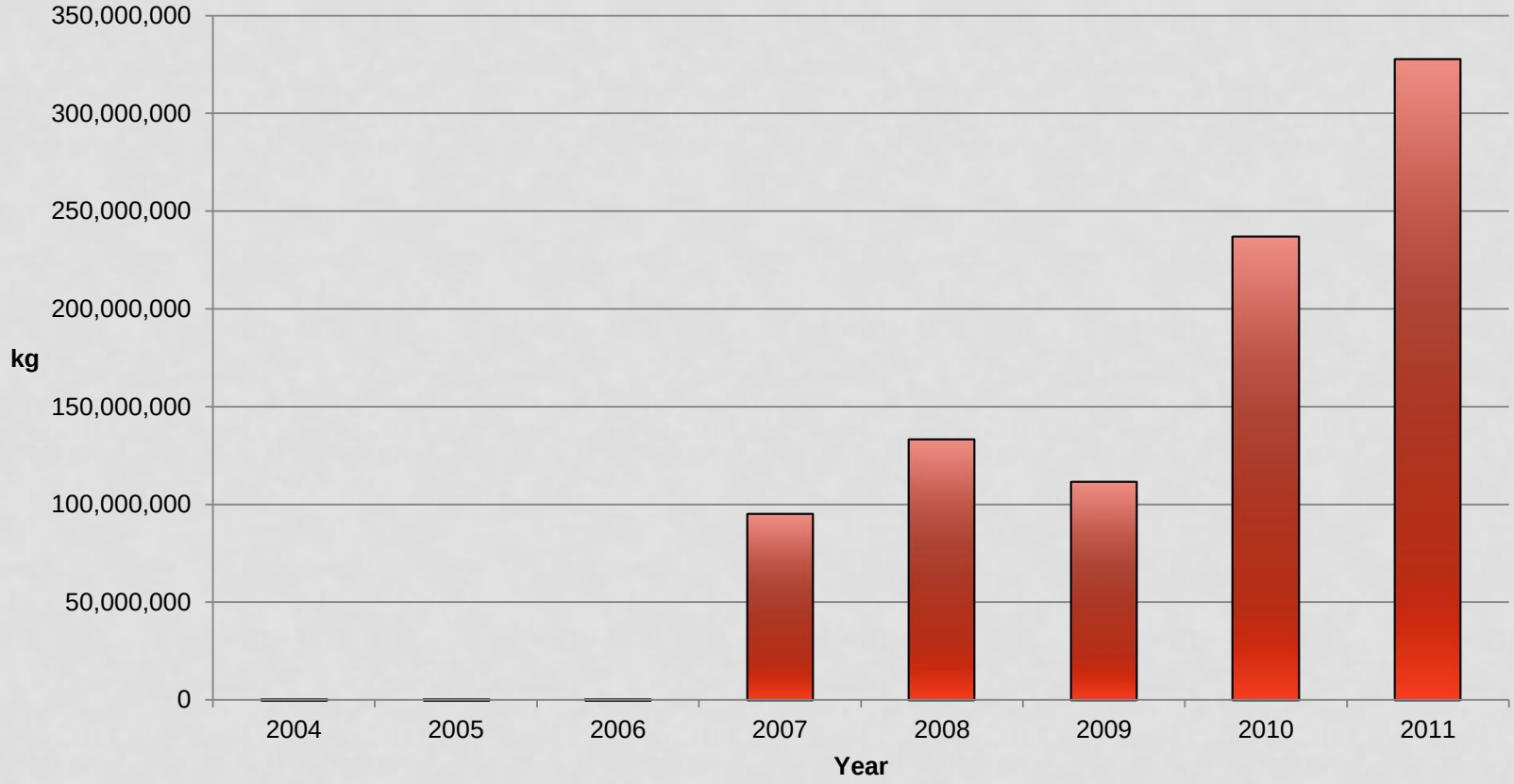
U.S. Lead Battery Recycling Plant Air Emissions
Lead & Lead Compounds 2013



Source: United States Environmental Protection Agency, Toxic Release Inventory

11 secondary refineries in 9 States have capacities of at least 30,000 tons per year. Source:
https://minerals.usgs.gov/minerals/pubs/commodity/lead/mcs-2017-lead.pdf

U.S. Exports of Used Batteries to Mexico



Source U.S. Customs HT Codes 8548100540 and 8548100580

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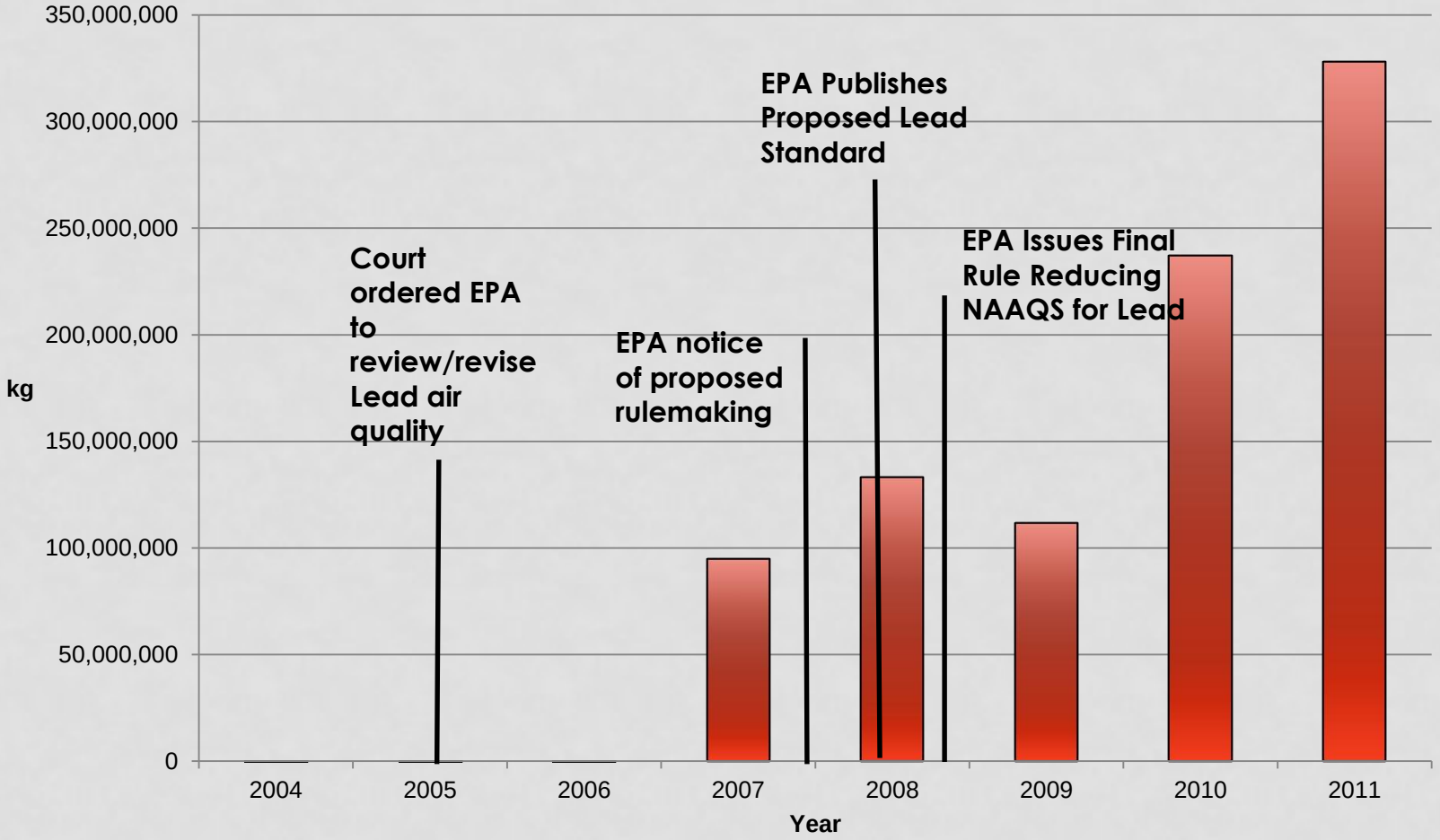
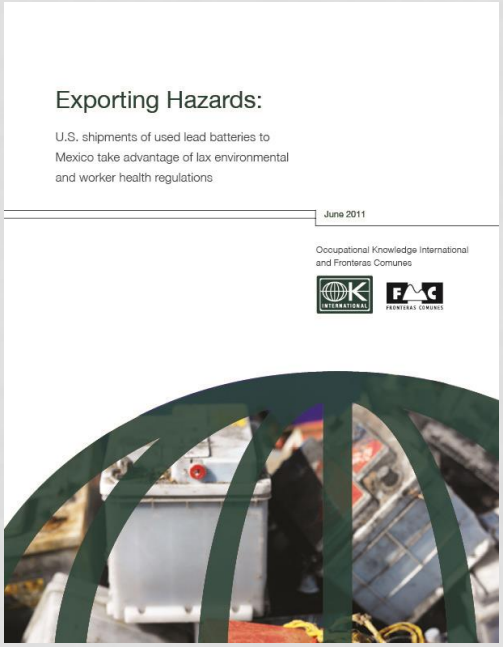
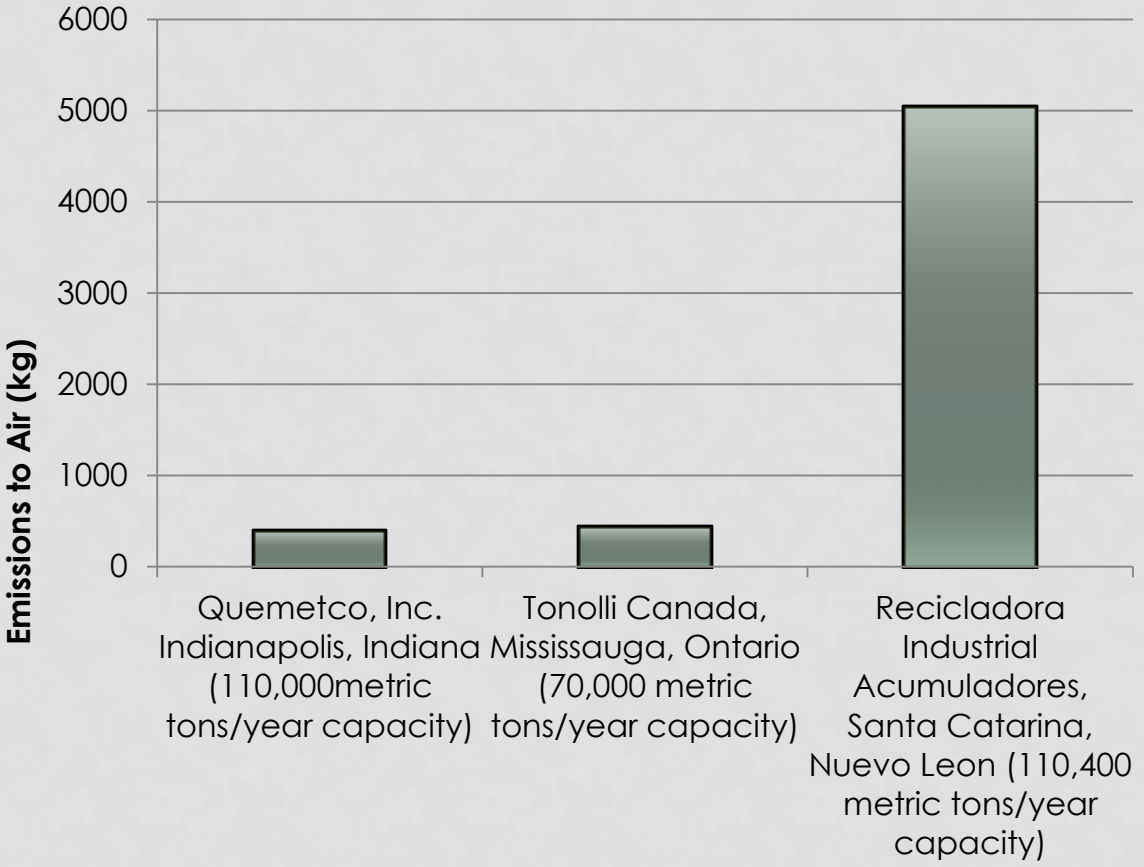


Source U.S. Customs HT Codes 8548100540 and 8548100580

Lead Air Emissions From Recycling Facilities Reporting To Mexico, Canada and U.S. (2010)





Lead Battery Recycling


National

NEW RECYCLING TECHNOLOGY?

Aqua Metals claims:

- "AquaRefining is a room temperature, water-based process that is fundamentally non-polluting"
- "Clean recycling of lead-acid batteries using an ambient temperature process that does not produce gas, doesn't product slag, doesn't produce solid waste but does produce very high purity lead"

Sources: http://investors.aquametals.com/phoenix.zhtml?c=254050&p=irol-newsArticle&ID=2278037
https://seekingalpha.com/article/3977530-aqua-metals-aqms-ceo-stephen-clarke-first-quarter-2016-corporate-update-earnings-call

Source: http://www.sustainablebrands.com/news_and_views/chemistry_materials/sustainable_brands/nevada_facility_begins_clean_lead_recycling

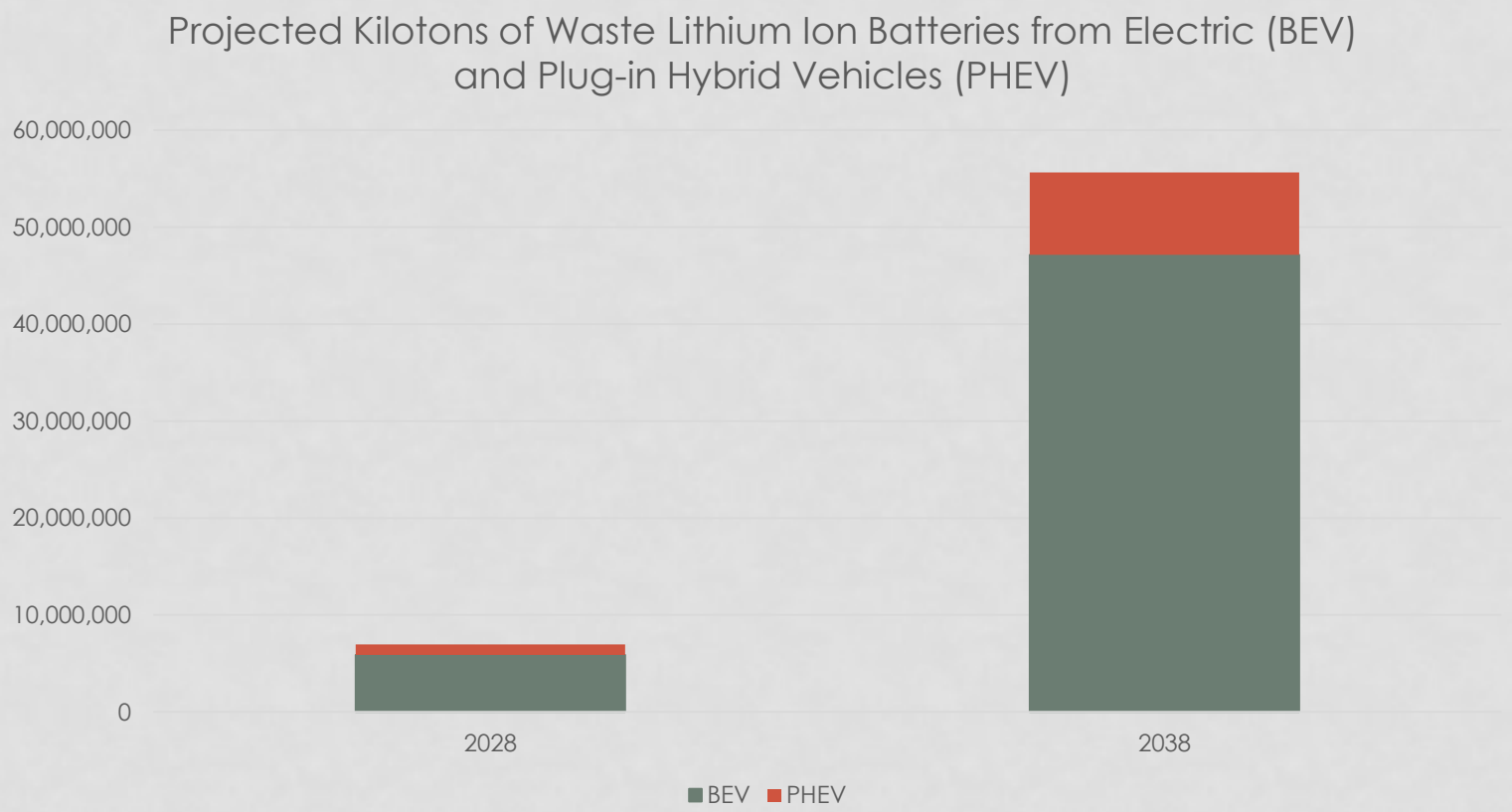
AQUA METALS UNCOVERED

- The process requires refining lead (separation of impurities by melting lead) at temperatures of 1050˚F (565˚C) in large 50 ton "kettles";
- The company claims to be exempt from 40 CFR Part 63 Subpart X NESHAPs definition of a "secondary lead smelter";
- Earthjustice has petitioned the EPA to revise the NESHAP standards to clearly apply to all secondary lead processing facilities and all battery recyclers.

Are Li-ion Batteries a Better Alternative?

- Lithium-ion batteries contain hazardous metals (including cobalt, manganese, nickel) and solvents.
- With current technology Lithium-ion batteries are not "recycled" but are "downcycled".
- The best processes results in 5 - 40% recovery of some metals but the rest is waste slag.
- Challenges are the low value of key components and the number of different chemistries (without labeling or color coding).
- We calculated the waste batteries that will be generated from vehicles based on projections from International Energy Agency (IEA) and using 8 years as an average battery warranty period.

HOW MUCH WASTE?




2028
20 X

Why Must We Act Now?

- Battery consumption is growing.
- We have no plan to deal with waste li-ion.
- Few countries adequately regulate the lead battery industry.
- There are very few lead recycling plants with adequate emission controls.
- It will cost billions of dollars to deal with the legacy of lead contaminated soil and resulting poisoning cases unless we address this now!

LI-ION BATTERY RECOMMENDATIONS

- Require all lithium ion batteries to be color coded by chemistry (eg. Li-iron-phophate vs. Li-Nickel-cobalt);
- Clarify waste classification for lithium-ion batteries as hazardous or "universal" waste.
- Require auto, solar and wind power companies to take back used li-ion batteries with a specified "refundable deposit" amount;
- U.S. should ban exports of used li-ion batteries.

LEAD BATTERY RECOMMENDATIONS

- Provide financial incentives and/or regulatory requirement for third party testing/certification for manufacturers to extend lead battery life;
- Specify an increased mandatory refundable deposit or purchase discount amount to encourage higher rates of return for used batteries;
- Extend lead battery recycling provisions of the SCAQMD to all of California;
- U.S. should ban exports of used lead batteries to countries with weaker standards for stack emissions and ambient air;

SUPPLY CHAIN RESPONSIBILITY

- Vehicle manufacturers, telecommunications companies, Internet server farms, and the photovoltaic solar industry should develop and support minimum standards for manufacturing and recycling lead and lithium ion batteries.
- Plants should be certified against industry specific standards with an annual third party independent audits.
- IBM, Sprint, and AT&T, have agreed to voluntarily stop exporting used lead batteries from the U.S. ….other should follow.

WHEN WILL WE EVER LEARN?

“You will observe with Concern how long a useful truth may be known, and exist, before it is generally received and practiced on.”

Benjamin Franklin

“Letter on Lead Poisoning”

July 31, 1786

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