What does the term “e-waste” bring to mind?

At Agbogbloshie, the fastest, cheapest, and favored way to recycle copper from insulated wire is to burn it. (©Jon Spaull/SciDev.Net)

Workers salvage metal from broken tools. (Jon Spaull/SciDev.Net)

MICHAEL HARDY PHOTO 01.08.18 11:00 AM

THE HELLISH E-WASTE GRAVEYARDS WHERE COMPUTERS ARE MINED FOR METAL

WIRED

1 / 16 Tires burn in the background as a boy at the world's largest e-dump in Ghana repeatedly smashes a TV into the ground to break it open. KAI LÖFFELBEIN

11 / 16 A lot of e-waste ends up in landfills, like this one outside of New Delhi. KAI LÖFFELBEIN

https://www.smithsonianmag.com/science-nature/burning-truth-behind-e-waste-dump-africa-180957597/

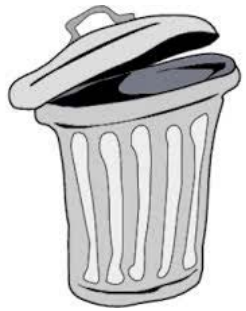
https://www.wired.com/story/international-electronic-waste-photographs/

E-waste recycling *does* look like that…

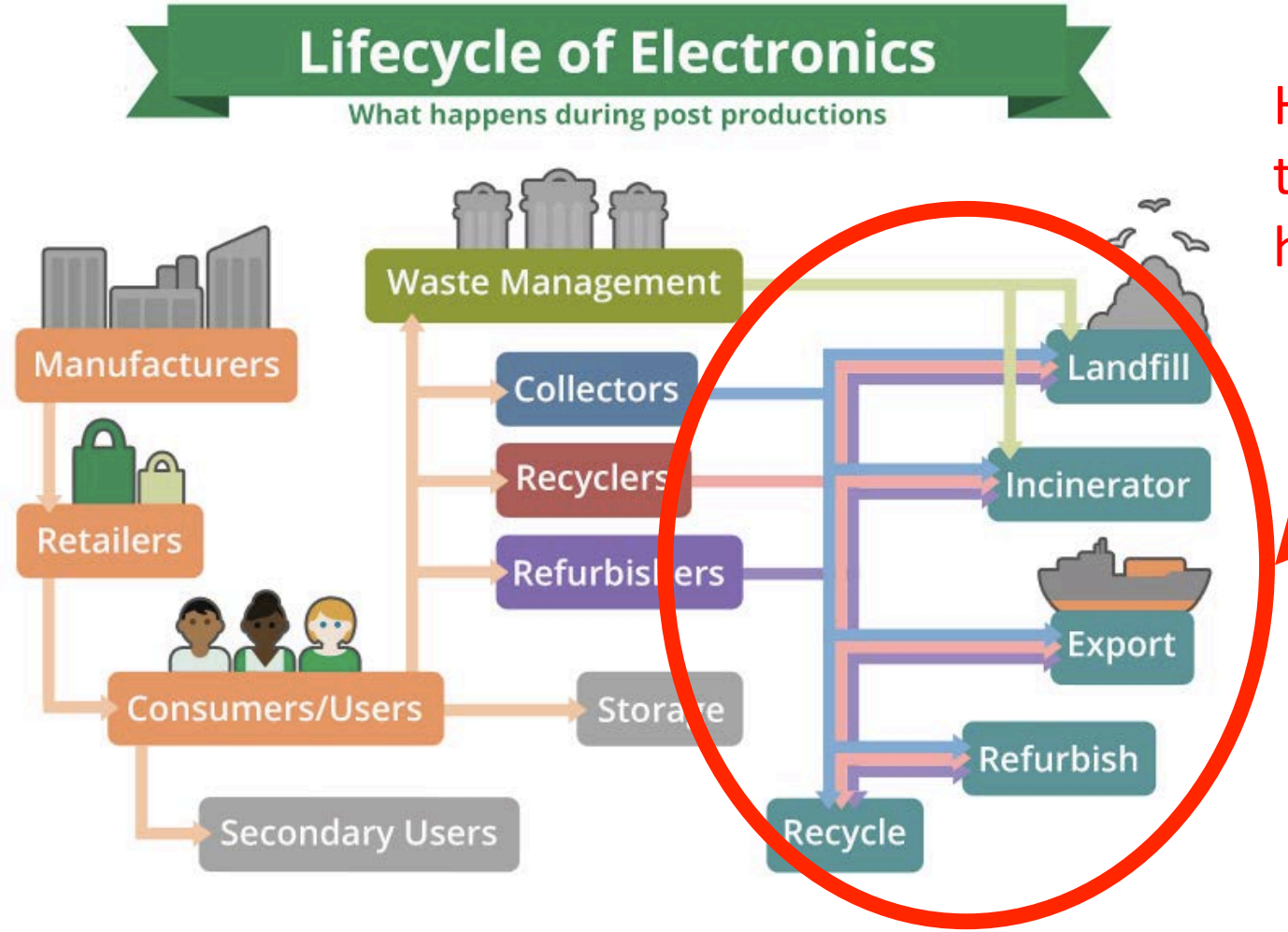
BUT!

Now, a personal question: where does *your* e-waste go?

Make a Donation



The e-waste cycle: production to disposal



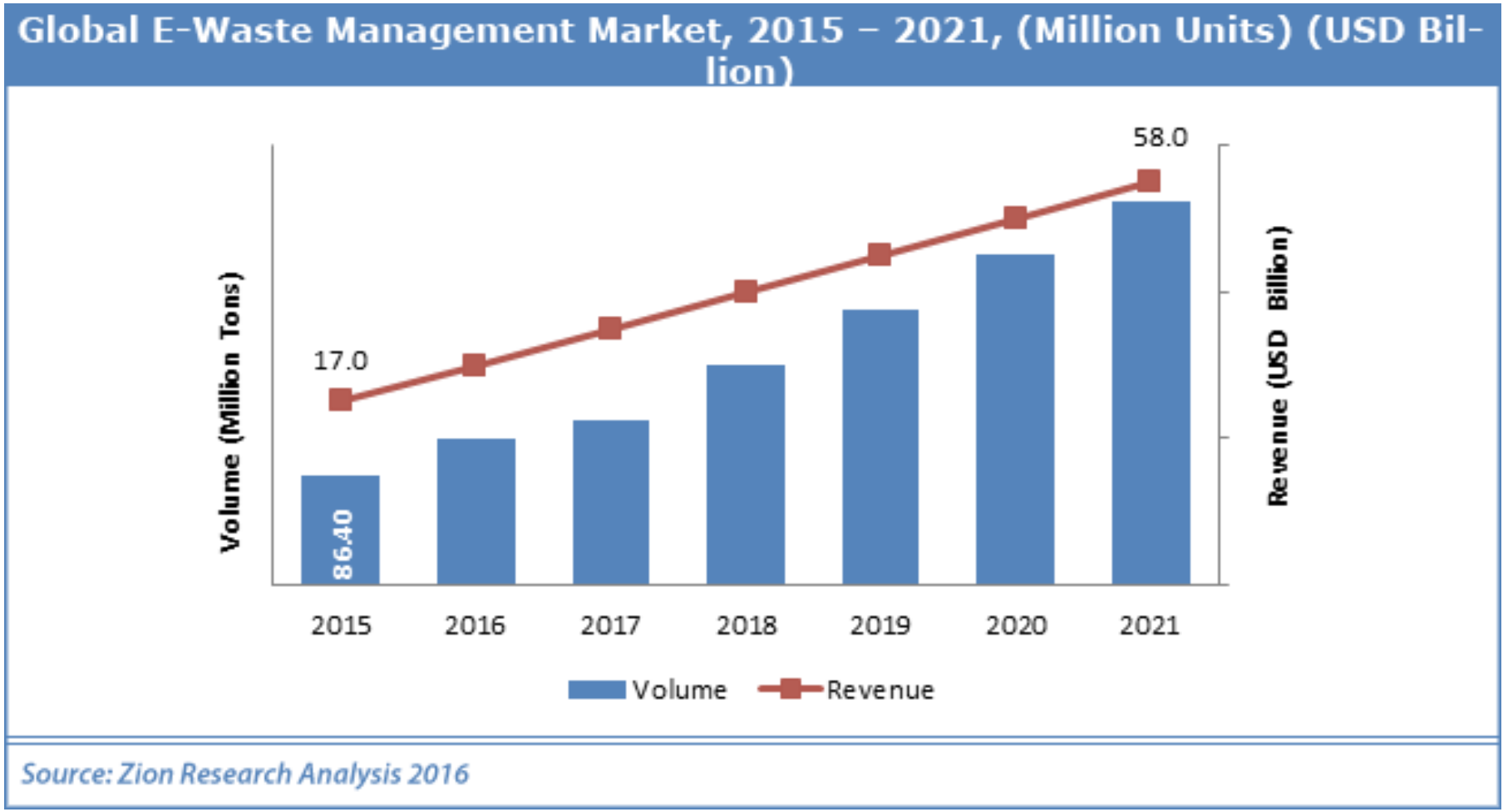
How far away do these activities happen from you?

http://e-stewards.org/learn-more/for-consumers/overview/where-does-your-e-waste-go/

Global movement of e-waste

http://worldloop.org/e-waste/illegal-flows/

Why are we talking about this *now*?

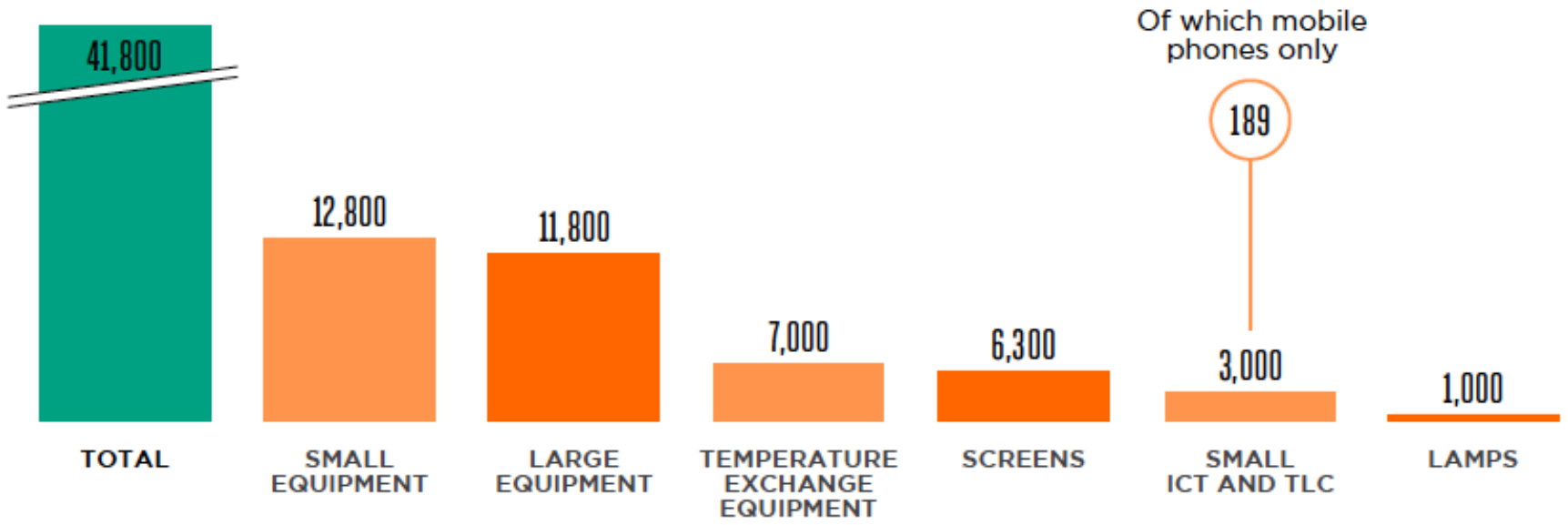


http://www.marketresearchstore.com/news/global-e-waste-management-market-255

Global e-waste generation by equipment type

Table 3

Total e-waste generated worldwide in 2014 in kt



[9] MAGALINI ET. AL, STUDY ON COLLECTION RATES OF WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE): POSSIBLE MEASURES TO BE INITIATED BY THE COMMISSION AS REQUIRED BY ARTICLE 7(4), 7(5), 7(6) AND 7(7) OF DIRECTIVE 2012/19/EU ON WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE), 2014.

[10] WANG, F., ET AL., ENHANCING E-WASTE ESTIMATES: IMPROVING DATA QUALITY BY MULTIVARIATE INPUT–OUTPUT ANALYSIS. WASTE MANAGEMENT 33(11): 2397–2407, 2013.

[11] EU WEEE DIRECTIVE (2012/18/EU), WHICH CLUSTERS PRODUCTS ACCORDING TO TREATMENT TECHNOLOGY REQUIREMENTS AND OPERATIONS PRACTICES.

https://www.gsma.com/latinamerica/wp-content/uploads/2015/11/gsma-unu-ewaste2015-eng.pdf

Global e-waste production by region

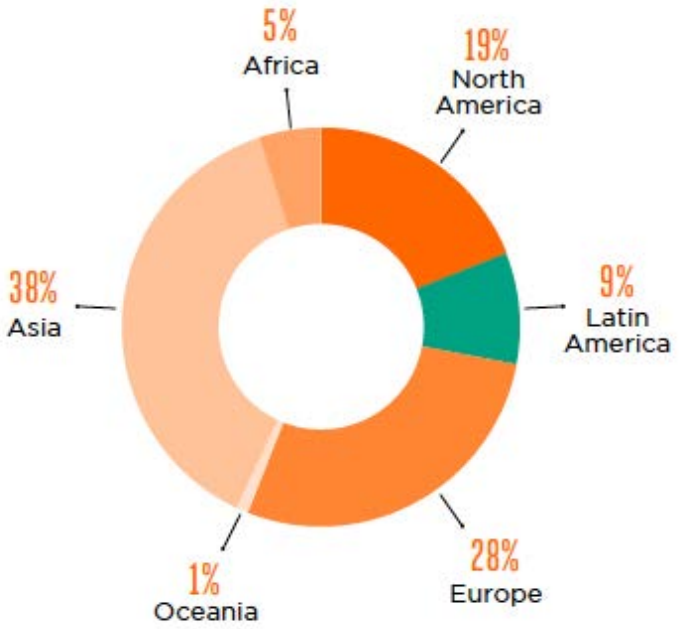
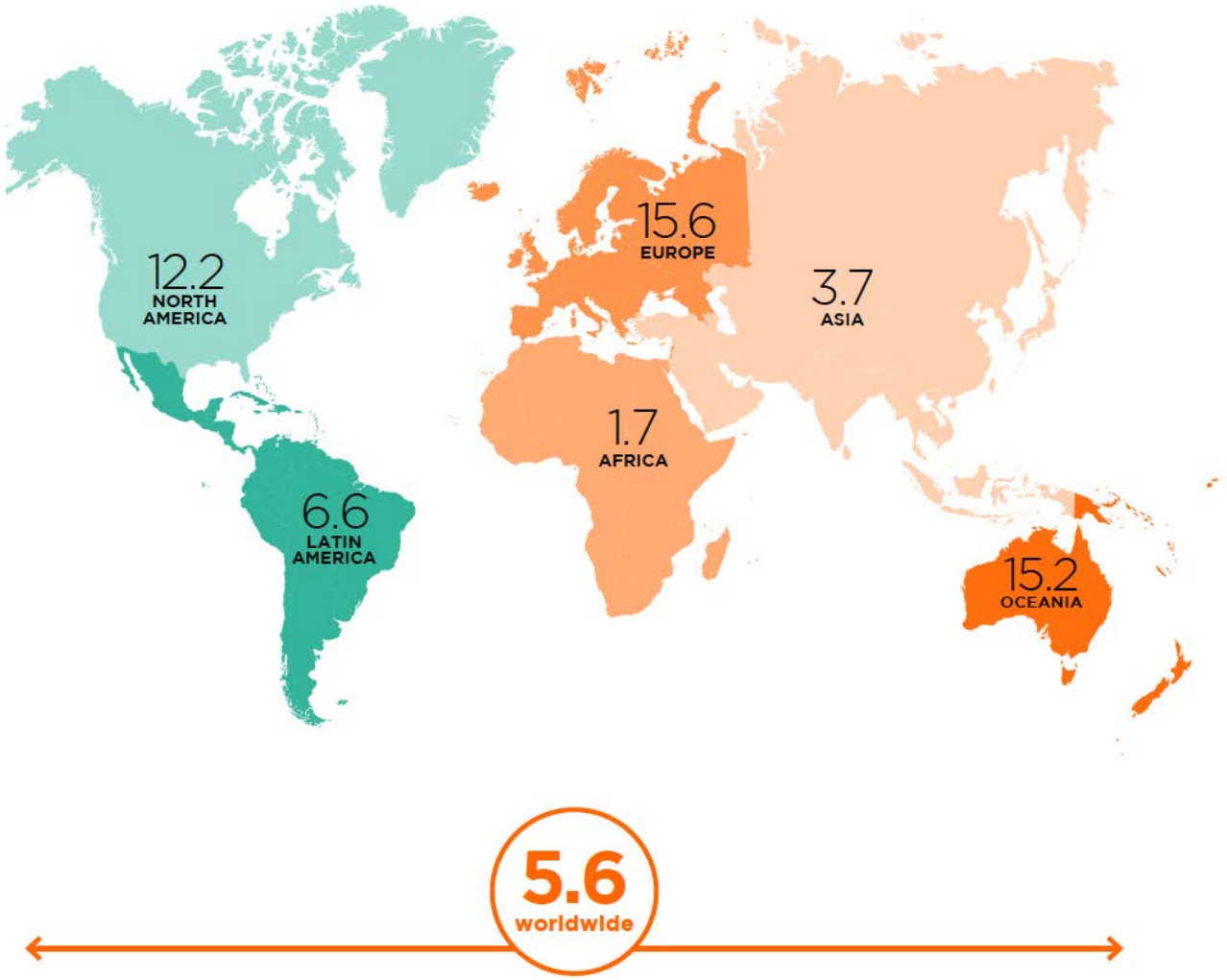


Table 6

E-waste generated per capita by all world regions



https://www.gsma.com/latinamerica/wp-content/uploads/2015/11/gsma-unu-ewaste2015-eng.pdf

Why recycle e-waste?

Table 5
Recycled material energy savings over virgin materials

Material	Energy savings (%)
Aluminum	95
Copper	85
Iron and steel	74
Lead	65
Zinc	60
Paper	64
Plastic	>80

Source: Cui and Forssberg (2003).

Nnorom and Osibanjo, *Waste Manag* 2008; 28(8); 1472-9

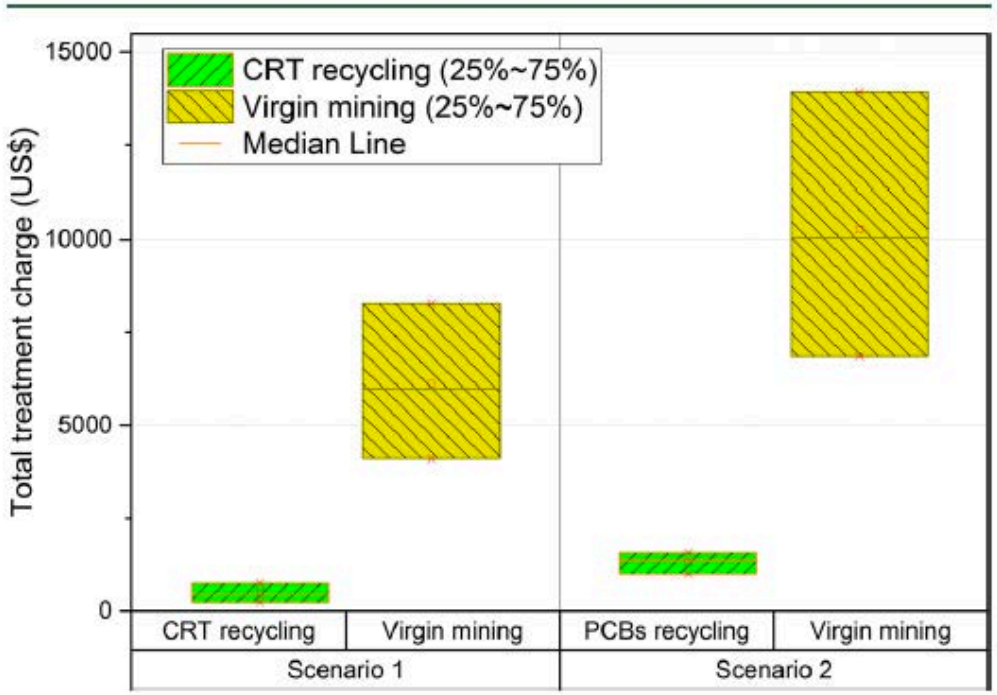


Figure 2. Comparison of total integrated treatment charge for urban mining and virgin mining for same metals yield. Note: Scenario 1 with equivalent yield as CRT recycling, and scenario 2 with equivalent yield as PCBs recycling. Dash area indicates the range of value.

Zeng et al, *Environ Sci Tech* 2018; in press

Why recycle e-waste *carefully*?

BAD!!

GOOD!!

Table 2
Potential environmental contaminants arising from E-waste disposal or recycling.

Contaminant	Relationship with E-waste	Typical E-waste concentration (mg/kg)[a]	Annual global emission in E-waste (tons)[b]
Polybrominated diphenyl ethers (PBDEs) polybrominated biphenyls (PBBs) tetrabromobisphenol-A (TBBPA)	Flame retardants		
Polychlorinated biphenyls (PCB)	Condensers, transformers	14	280
Chlorofluorocarbon (CFC)	Cooling units, insulation foam		
Polycyclic aromatic hydrocarbons (PAHs)	Product of combustion		
Polyhalogenated aromatic hydrocarbons (PHAHs)	Product of low-temperature combustion		
Polychlronated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs)	Product of low-temperature combustion of PVCs and other plastics		
Americium (Am)	Smoke detectors		
Antimony	Flame retardants, plastics (Ernst et al, (2003))	1700	34,000
Arsenic (As)	Doping material for Si		
Barium (Ba)	Getters in cathode ray tubes (CRTs)		
Beryllium (Be)	Silicon-controlled rectifiers		
Cadmium (Cd)	Batteries, toners, plastics	180	3600
Chromium (Cr)	Data tapes and floppy disks	9900	198,000
Copper (Cu)	Wiring	41,000	820,000
Gallium (Ga)	Semiconductors		
Indium (In)	LCD displays		
Lead (Pb)	Solder (Kang and Schoenung, (2005)), CRTs, batteries	2900	58,000
Lithium (Li)	Batteries		
Mercury (Hg)	Fluorescent lamps, batteries, switches	0.68	13.6
Nickel (Ni)	Batteries	10,300	206,000
Selenium (Se)	Rectifiers		
Silver (Ag)	Wiring, switches		
Tin (Sn)	Solder (Kang and Schoenung, (2005)), LCD screens	2400	48,000
Zinc (Zn)		5100	102,000
Rare earth elements	CRT screens		

Adapted from (e-waste, 2009).
[a] (Morf et al., 2007).
[b] Assuming a global e-waste production of 20 million tonnes per year.

Robinson, *Sci Tot Environ*, 2009 408, 183-191

What does *formal* e-waste recycling look like?

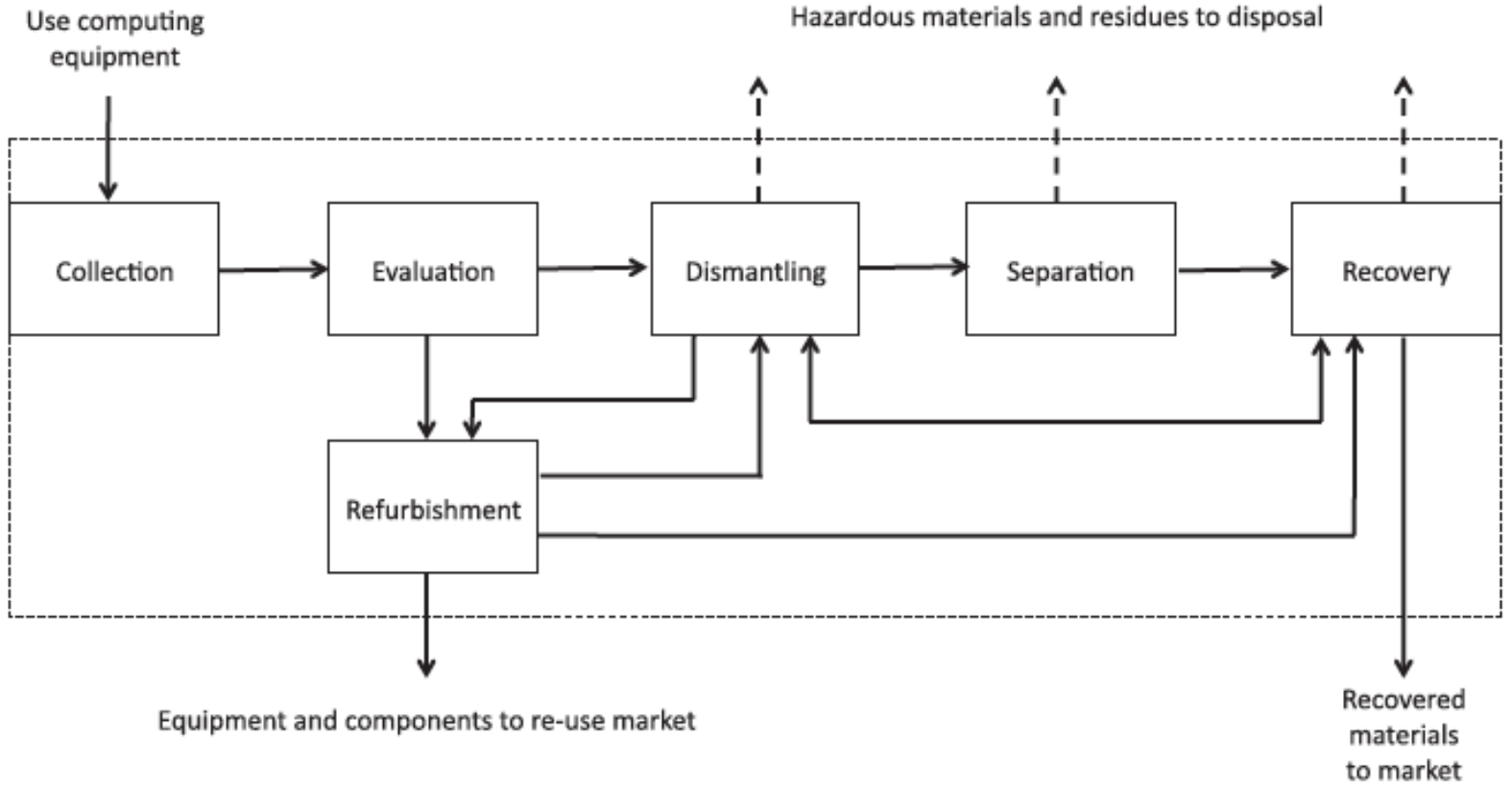


Figure 2. Desired flow diagram for ESM of used EEE within a recycling facility. Abbreviations: EEE, electrical and electronic equipment; ESM, environmentally sound management. (Adapted from ref 15.)

Perkins et al, *Ann Global Health*, 2014 80; 286-295

Images: http://www.electronicstakeback.com/wp-content/uploads/goodrecycler3.jpg
http://www.cpmfg.com/material-recovery-facility/e-waste-recycling-equipment/

What does *informal* e-waste recycling look like?

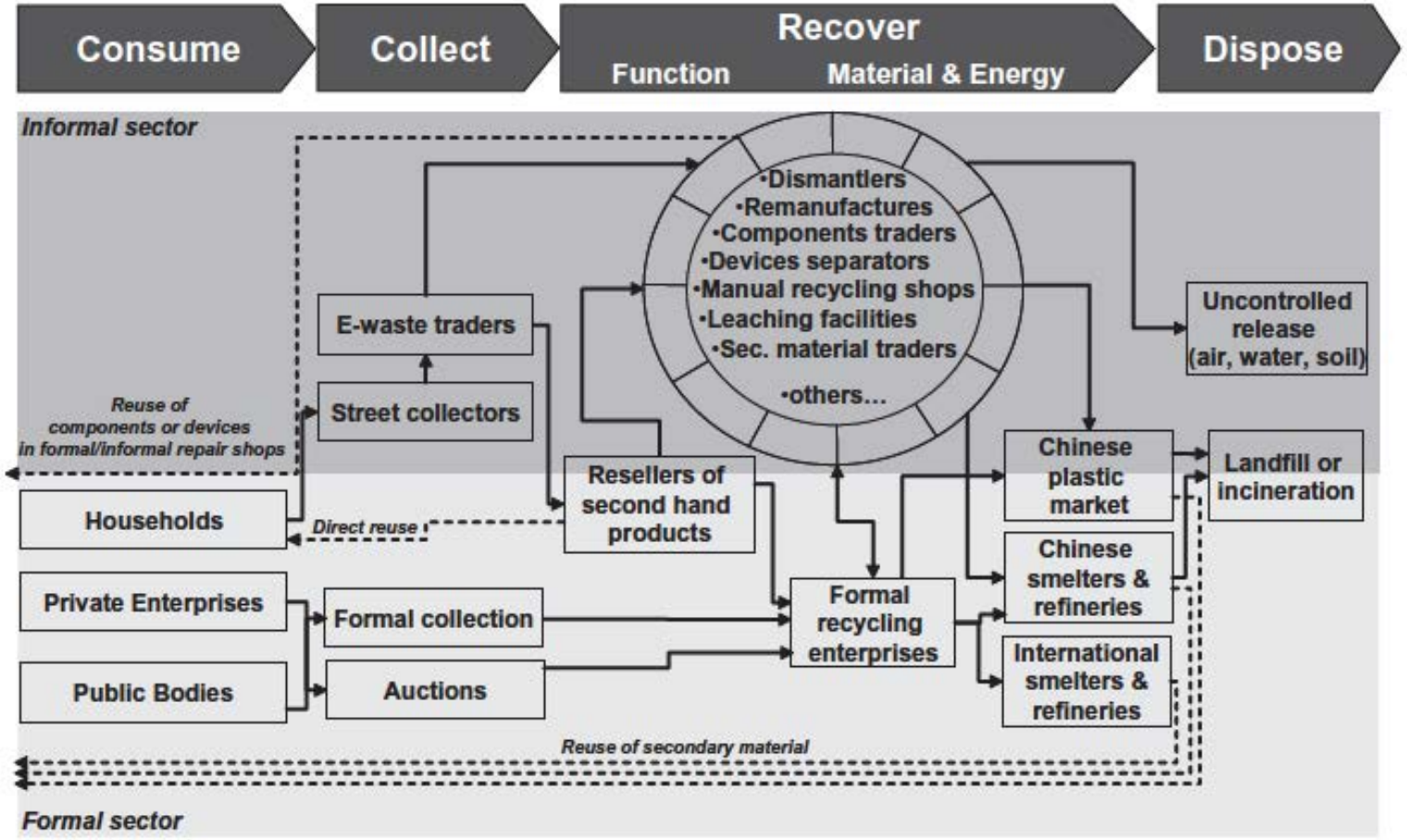
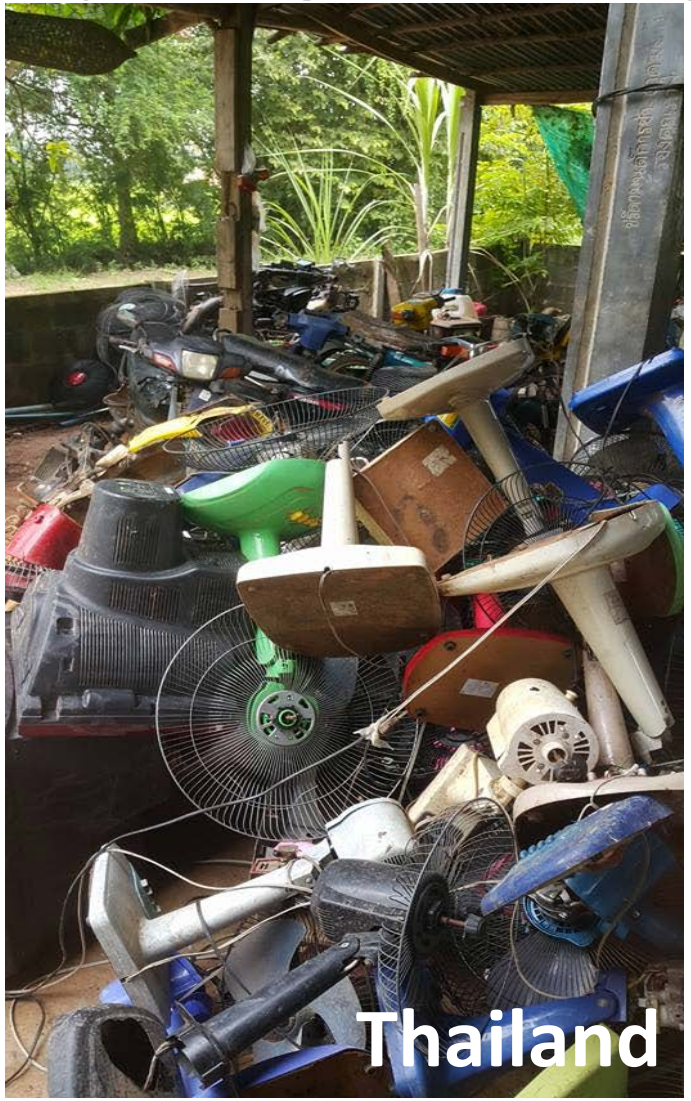


Fig. 2. Flow chart of informal and formal e-waste processes in China.

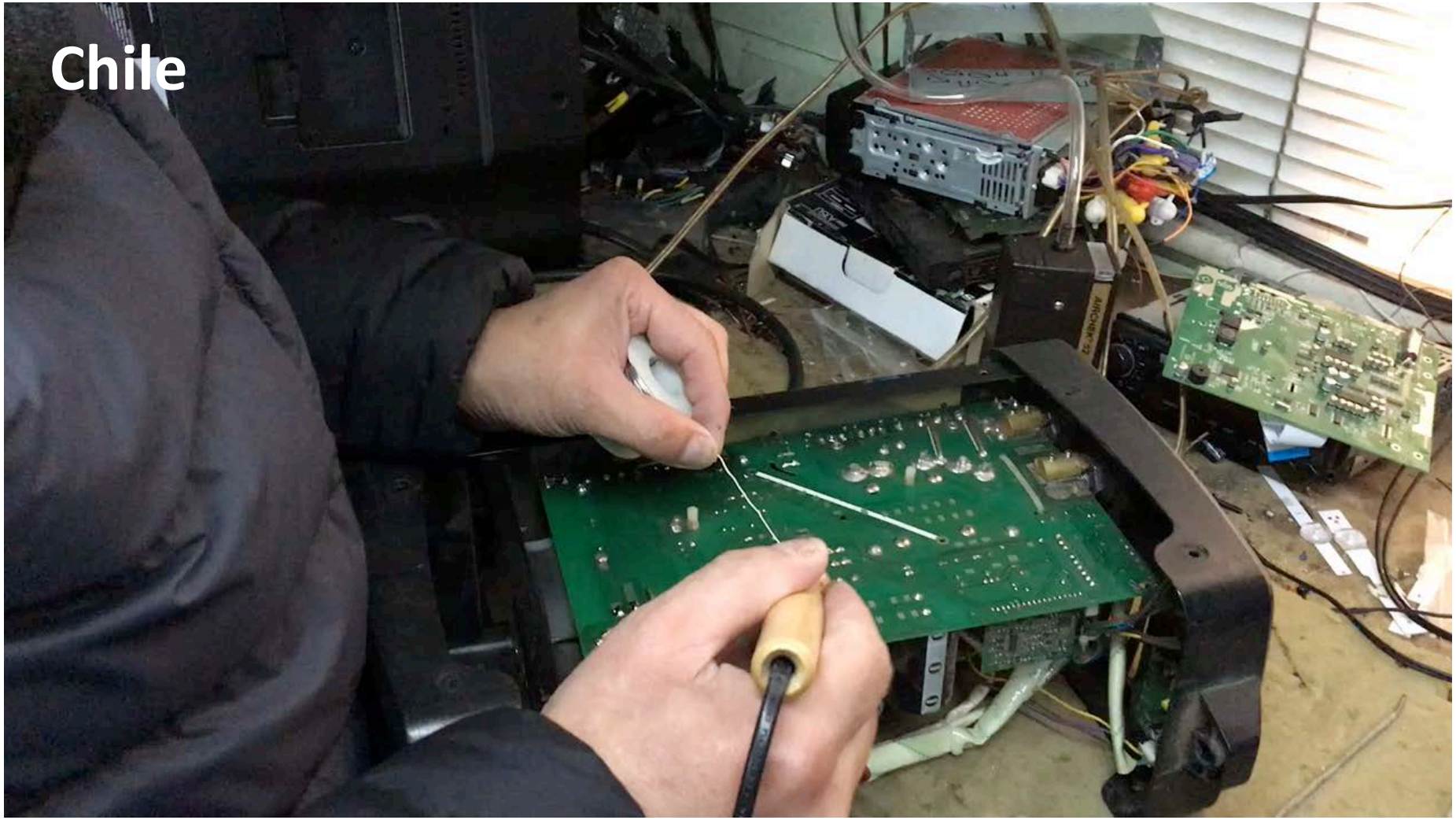
Chi et al, *Waste Manage*, 2011 31; 731-742

Informal e-waste recycling: collecting

Informal e-waste recycling: sorting



Informal e-waste recycling: repairing



Informal e-waste recycling: dismantling

Informal e-waste recycling: dismantling

Informal e-waste recycling: dismantling

Informal e-waste recycling: burning

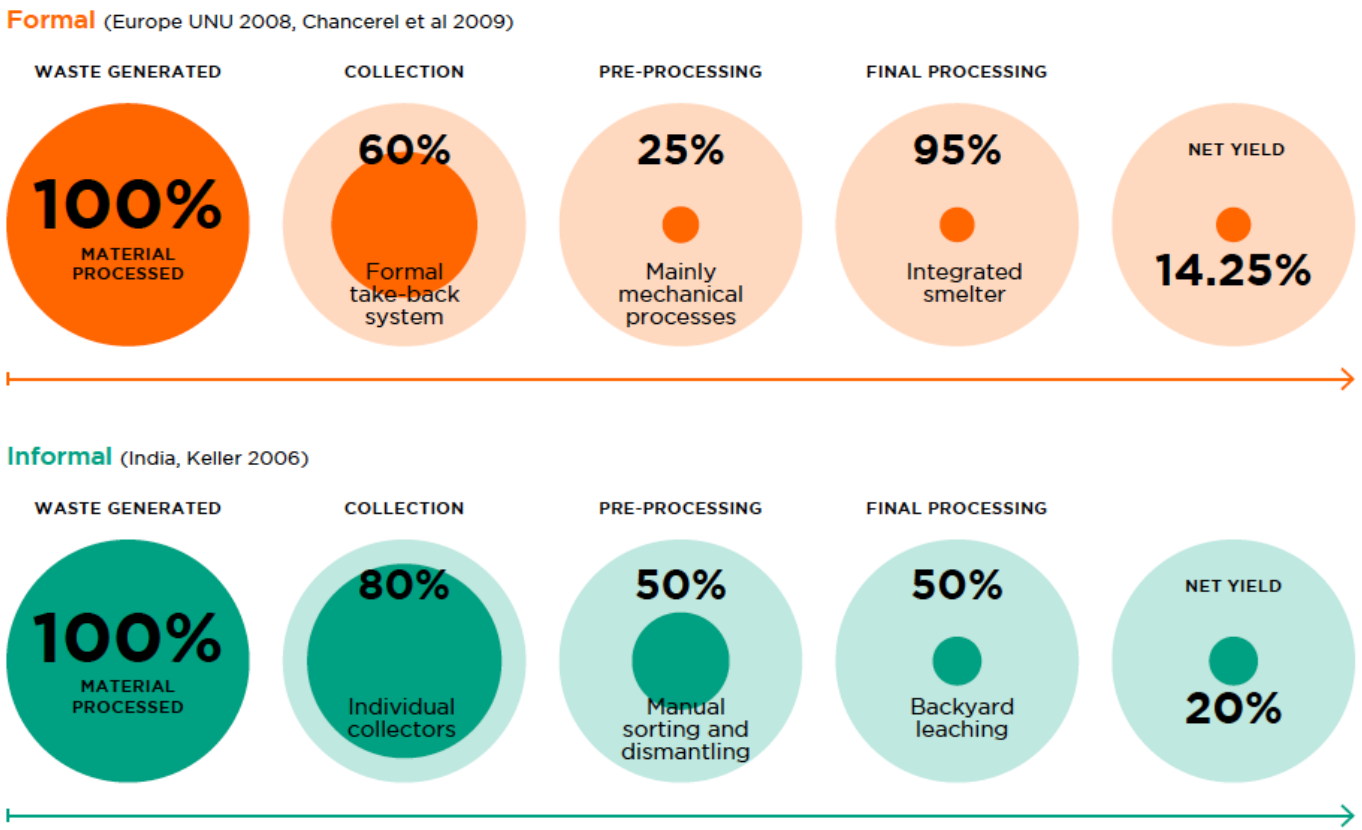
Informal e-waste recycling: burning

Informal e-waste recycling: end product

Informal vs. formal e-waste recycling

Figure 3

Impact of recovery effectiveness in individual recycling chain steps and overall recovery performances[7]



Much great processing efficiency but lower net yield due to low collection and pre-processing

Much lower final processing efficiency but higher net yield due to high collection and pre-processing

https://www.gsma.com/latinamerica/wp-content/uploads/2015/11/gsma-unu-ewaste2015-eng.pdf

Other critical considerations

- Engineering approaches
- Sociotechnical issues
- Sustainability models
- Policy possibilities
- Environmental impacts

Questions?

- Rick Neitzel, PhD, CIH, FAIHA

rneitzel@umich.edu

https://umexposureresearch.org/

http://bit.ly/e-waste2018