

CONSUMER ELECTRONICS AND THE CIRCULAR ECONOMY

JULIA L F GOLDSTEIN '88 P18

MUDD TALKS

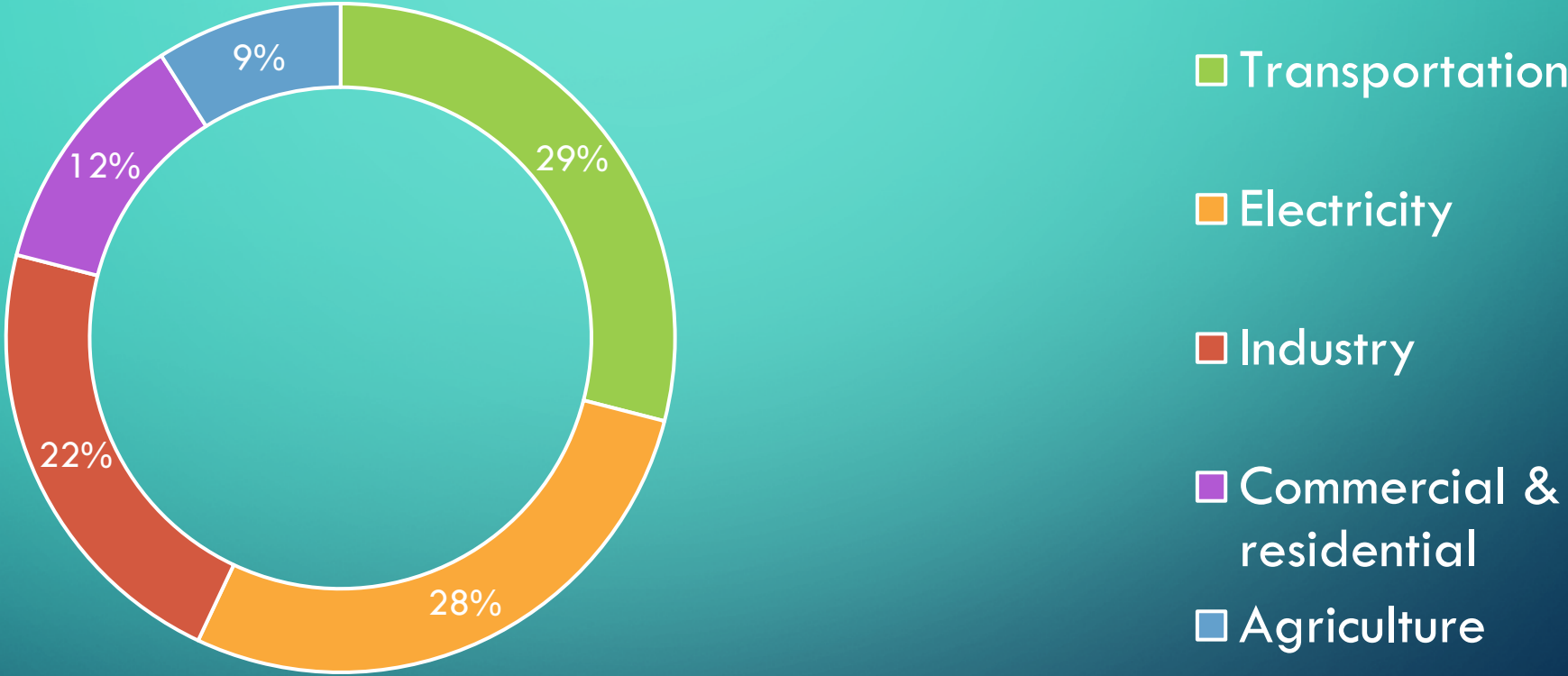
APRIL 21, 2021

SMALLER, FASTER, CHEAPER CLEANER, GREENER

- **Why should you care?**
- Why listen to me?
- Definitions
- What's in your phone?
- Signs of progress



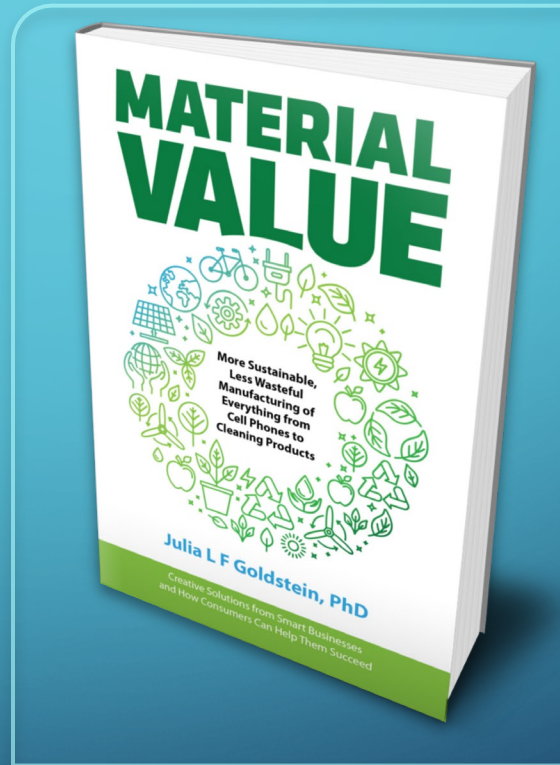
WHY SHOULD YOU CARE?



Total US Greenhouse Gas Emissions by Economic Sector, 2017

ABOUT JULIA

- Author
- Materials geek
- Semiconductor industry background



SMALLER, FASTER, CHEAPER CLEANER, GREENER

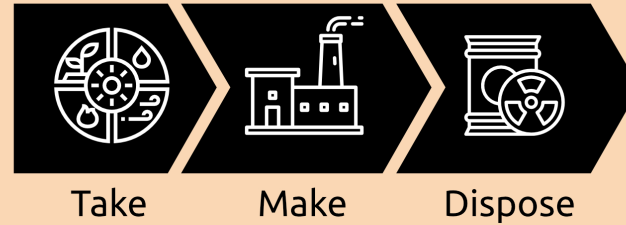
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CIRCULAR ECONOMY

- Ideal: nothing goes to waste
- Organic cycle
- Technical cycle
- ellenmacarthurfoundation.org/

Linear Economy



Circular Economy



Image credit: Sirajum Munir Galib, from *Rethink the Bins*

TRIPLE BOTTOM LINE

- Three interrelated aspects:
 - People
 - Planet
 - Profit
- All three in balance
- Lead or be left behind



GREENWASHING

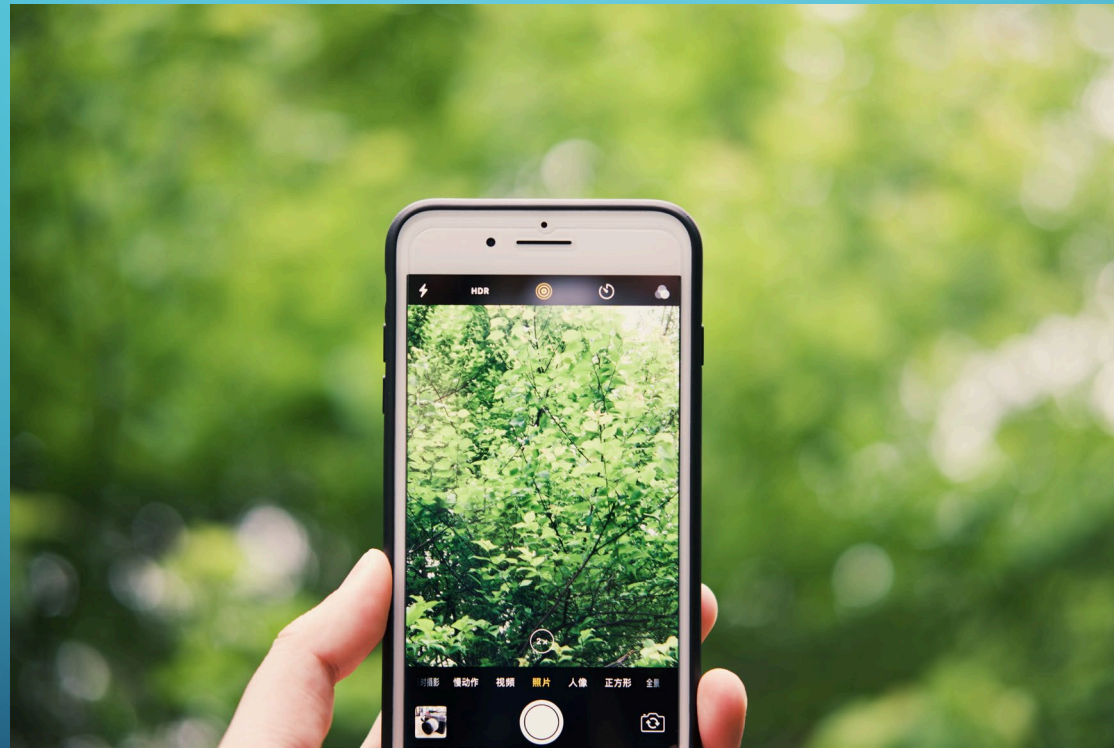
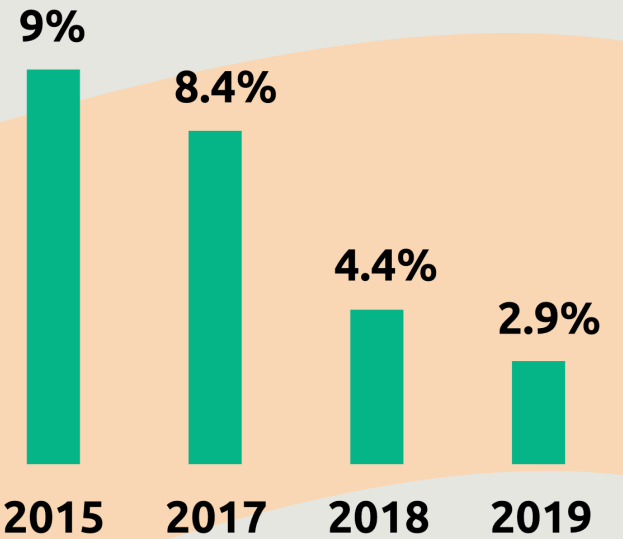


Image credit: Benny Liu on Unsplash

RECYCLABLE VS RECYCLED

- Science
- Technology
- Economics

The downward trend in the percentage of plastic that gets recycled



*No data for 2016

Image credit: Sirajum Munir Galib, from *Rethink the Bins*
Data from the Plastic Pollution Coalition, 2018



CONFLICT MINERALS

- Democratic Republic of the Congo (DRC)
- 3TG: Tin (Sn), Tungsten (W), Tantalum (Ta), Gold (Au)
- Cobalt (Co) added
- Child and slave labor
- Artisanal mines

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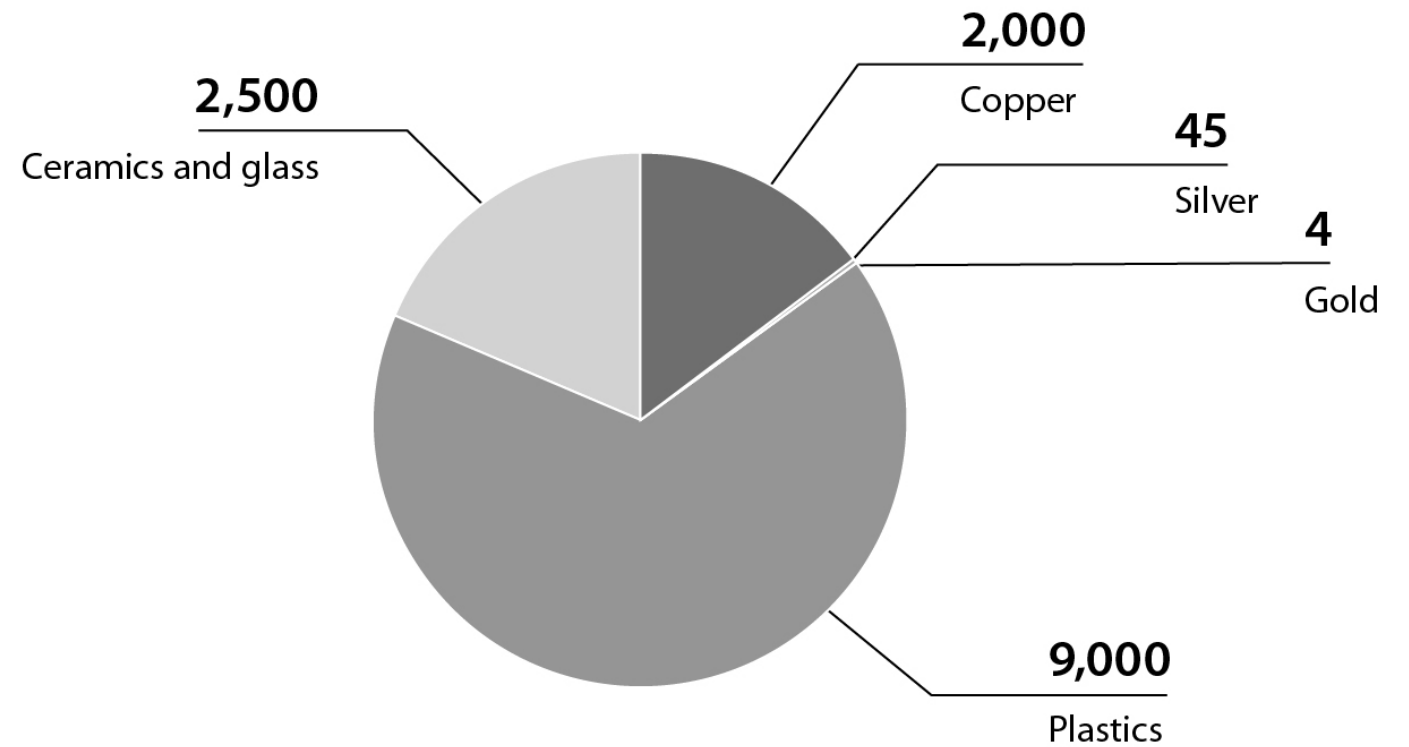
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WHAT'S IN YOUR PHONE?

- Plastics
- Metals
- Ceramics
- Glass

Metric tons of material in 130 million cell phones



Data from Vaclav Smil, *Making the Modern World*.

Image credit: Janine Milstrey, from *Material Value*

ELEMENTS OF A SMARTPHONE

ELEMENTS COLOUR KEY: ● ALKALI METAL ● ALKALINE EARTH METAL ● TRANSITION METAL ● GROUP 13 ● GROUP 14 ● GROUP 15 ● GROUP 16 ● HALOGEN ● LANTHANIDE

SCREEN



Indium tin oxide is a mixture of indium oxide and tin oxide, used in a transparent film in the screen that conducts electricity. This allows the screen to function as a touch screen.



The glass used on the majority of smartphones is an aluminosilicate glass, composed of a mix of alumina (Al_2O_3) and silica (SiO_2). This glass also contains potassium ions, which help to strengthen it.



A variety of Rare Earth Element compounds are used in small quantities to produce the colours in the smartphone's screen. Some compounds are also used to reduce UV light penetration into the phone.

BATTERY



The majority of phones use lithium ion batteries, which are composed of lithium cobalt oxide as a positive electrode and graphite (carbon) as the negative electrode. Some batteries use other metals, such as manganese, in place of cobalt. The battery's casing is made of aluminium.

ELECTRONICS

Copper is used for wiring in the phone, whilst copper, gold and silver are the major metals from which microelectrical components are fashioned. Tantalum is the major component of micro-capacitors.



Nickel is used in the microphone as well as for other electrical connections. Alloys including the elements praseodymium, gadolinium and neodymium are used in the magnets in the speaker and microphone. Neodymium, terbium and dysprosium are used in the vibration unit.



Pure silicon is used to manufacture the chip in the phone. It is oxidised to produce non-conducting regions, then other elements are added in order to allow the chip to conduct electricity.



Tin & lead are used to solder electronics in the phone. Newer lead-free solders use a mix of tin, copper and silver.



CASING



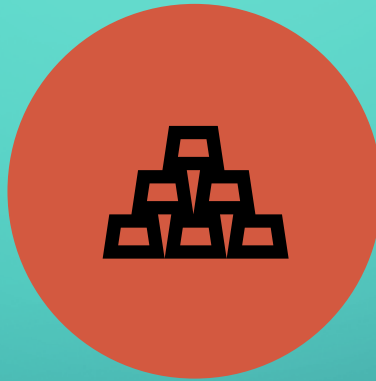
Magnesium compounds are alloyed to make some phone cases, whilst many are made of plastics. Plastics will also include flame retardant compounds, some of which contain bromine, whilst nickel can be included to reduce electromagnetic interference.



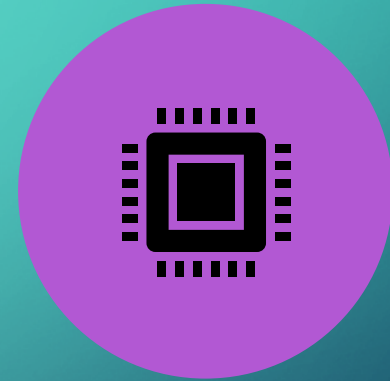
THE ENERGY COST OF MATERIALS



ALUMINUM =
MOST RECYCLED

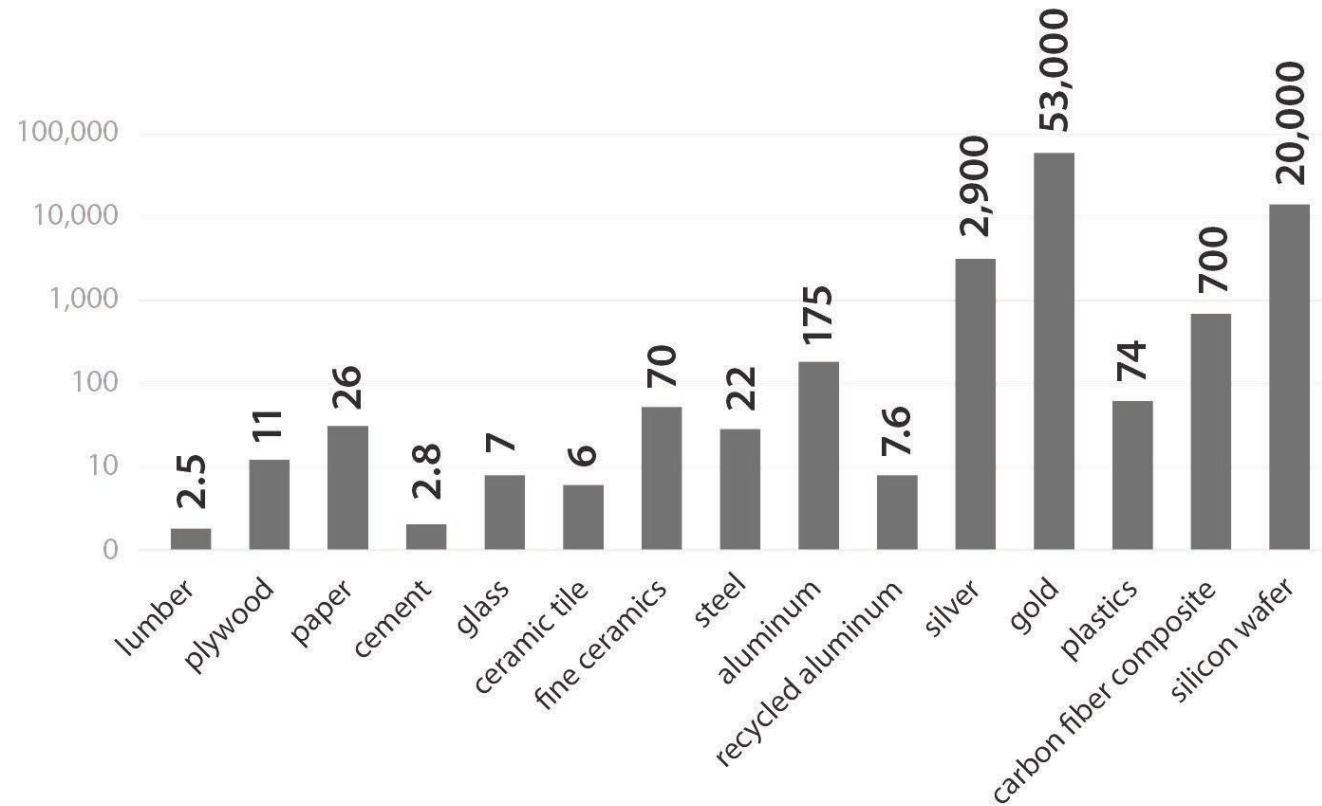


GOLD IS EXPENSIVE



SO IS SILICON

Energy cost of various materials, gigajoules per ton



Data from Vaclav Smil,
Making the Modern World.

Image credit: Janine Milstrey, from *Material Value*



A CLOSER LOOK AT MINING

- Dangerous, dirty work
- Hazardous waste
- Greenhouse gas emissions and water use
- More destructive methods as reserves are depleted

URBAN MINING

- 0.03 grams of Au per phone
- Phone weighs 0.5 pounds

Two ways to extract an ounce of gold

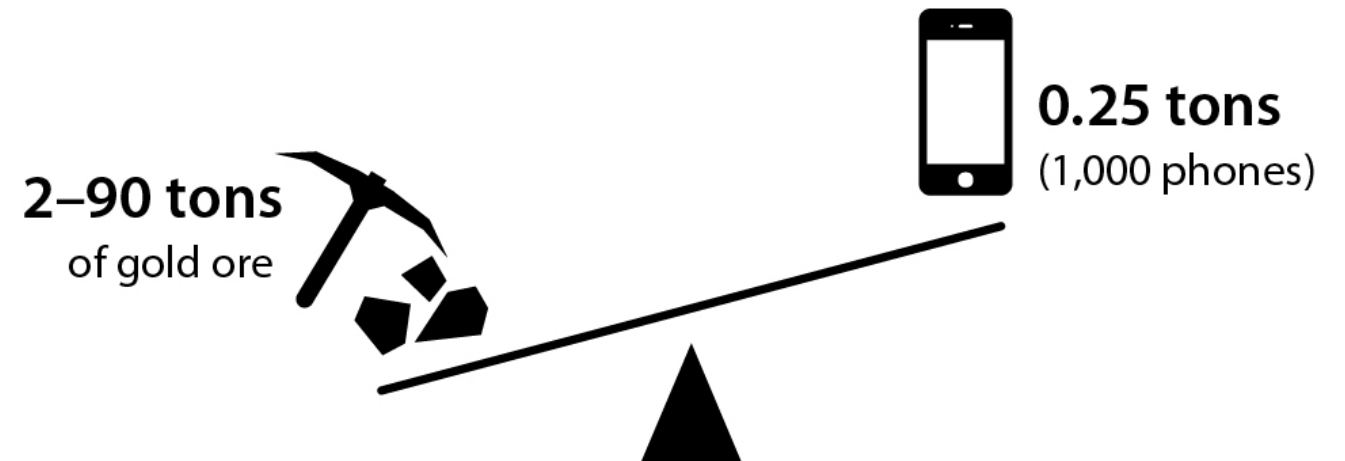


Image credit: Janine Milstrey, from *Material Value*

RBA Circular Material Flow Model



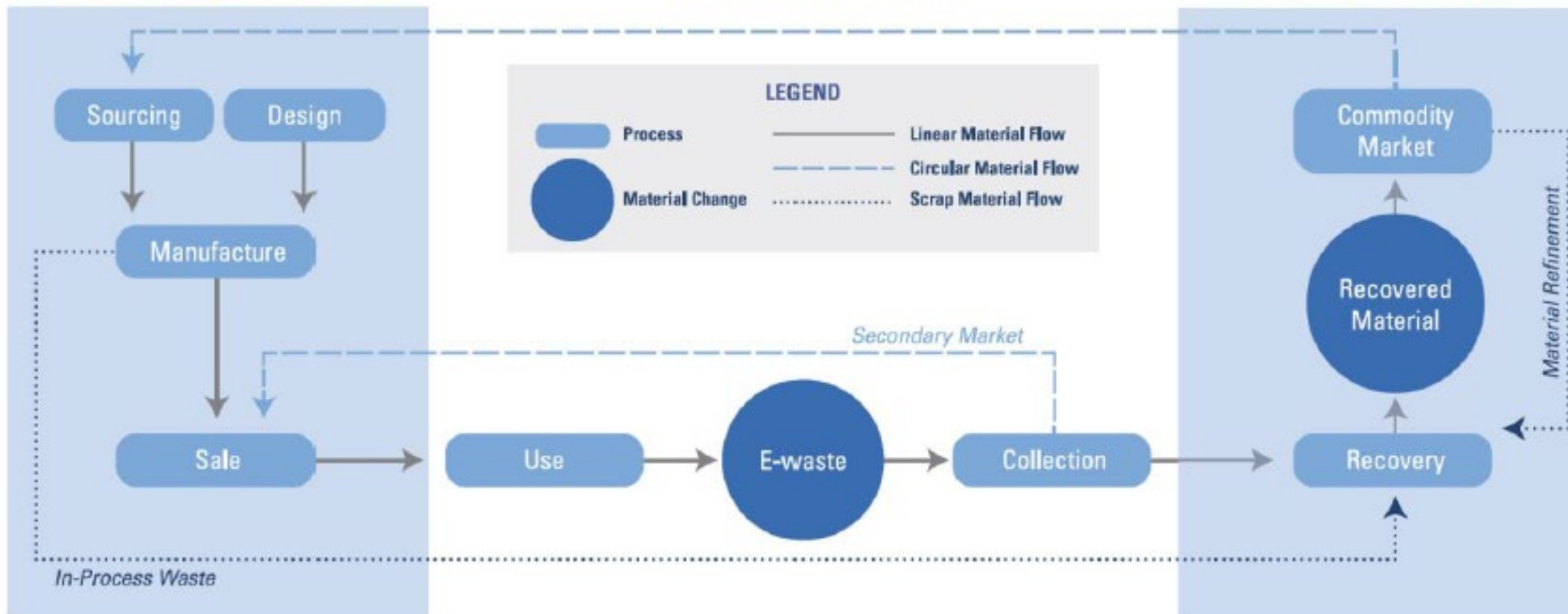
Responsible Business Alliance
Advancing Sustainability Globally

Electronic Product Lifecycle Overview

PHASE 1 - MANUFACTURER

PHASE 2 - CONSUMER

PHASE 3 - RECYCLER



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THE NEEDLE IS MOVING

“Ideally, electronics manufacturers will become vocal advocates of the circular economy.”

Julia Goldstein, Material Value

“To protect the Earth’s finite resources, we’re also challenging ourselves to one day end our reliance on mining altogether. In the spring of 2017, we made public our commitment to using only recycled and renewable material in our products.”

Apple, Inc., Material Impact Profile report, 2019

WHO'S ON BOARD? APPLE

H																	He	
Li	Be											B	C	N	O	F	Ne	
Na	Mg											Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba			Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra			Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

TOP PRIORITY MATERIALS

- Al
- Au
- Co, Li
- Cu
- Nd, Pr, Dy
- Sn
- Ta
- W
- Zn
- Glass
- Plastics
- Paper
- Steel

Risks: supply, environment, social

WHO'S ON BOARD? HP

- Recycled plastic in inkjet and toner cartridges: 99,000 tonnes through 2017
- Forest Stewardship Council (FSC) certified paper: zero deforestation



EVALUATING PROGRESS



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New this year, and also chosen by a special committee, we're presenting the **3D InCites Sustainability Award**, given to a company that sets an example through best practices for sustainable semiconductor manufacturing.

3D InCites Sustainability Award Committee



Deborah Knuckey, Managing Director, Sustainability Strategy, Kiterocket



Julia Goldstein, Owner, JLFG Communications, Author of Material Value



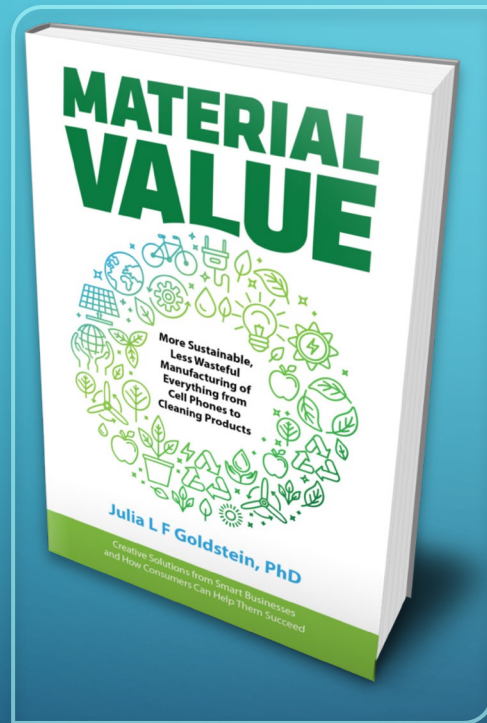
Dean Freeman, Chief Analyst, Freeman Technology and Market Advisors



COMMITMENTS

- Keep devices for as long as possible
- Buy secondhand or donate old devices
- Responsible e-waste recycling
- Resource Guide: juliagoldsteinauthor.com/resource-guide

ANY QUESTIONS?



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