



ENGINEERING SOLUTIONS FOR SUSTAINABILITY:
MATERIALS AND RESOURCES 3

Toward a Circular Economy

February 18–19, 2017 | Denver, Colorado



Session #7: SYSTEM IMPLEMENTATION

The Circular Economy for electronics – gold mine or race to the bottom?

Colton Bangs, Christina Meskers, Thierry Van Kerckhoven, Mark Caffarey

Introducing Umicore Precious Metals Refining



Largest and most complex precious metals recycling operation in the world.



Processes more than 200 different types of raw materials.



World leading refiner of 17 different metals.



World class environmental and quality standards.



The great divide (1/3)

Conflicting messages on the e-waste market are everywhere

*“Is there a future for e-waste recycling? Yes, and it’s **worth billions**” (Elsevier, 2015)*

*“The global electronic scrap recycling market was worth US\$ 11.03 Bn in 2014 and is expected to reach **US\$ 34.32 Bn** by 2022, growing at a CAGR of **15.7%** from 2015 to 2022” (Transparency Market Research, 2016)*

*“The 41.8 Mt weight of last year’s [2014] e-waste is comparable to that of 1.15 million 40-ton 18-wheel trucks — enough to form **a line of trucks 23,000 kilometres long**, or the distance from New York to Tokyo and back.” (UNU, 2015)*

*“We have also seen some [European] recyclers go out of business, and we have seen cutbacks in different local collection programs... Overall, it’s been a pretty **challenging time** for the electronics recycling industry” (Waste360, 2016)*

*“The e-scrap recycling sector in Europe is facing tough times right now... you could argue that there is an **overcapacity** in the European market” (Recycling International, 2016)*

*“Many e-recyclers are being left holding the nation’s consumer and corporate e-waste, with **inadequate resources** to responsibly manage it and remain **profitable**” (Basel Action Network, 2015)*



Canaries in the electronics urban mine

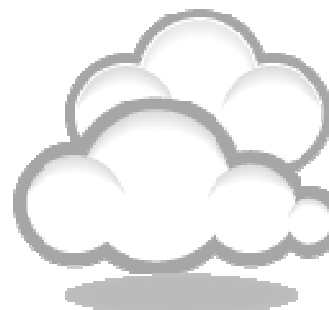
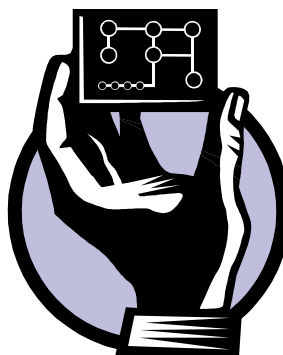
Recycling economics becoming increasingly constrained

Declining precious
metal content



Convergence of
devices

Unit weight decrease
& miniaturization



Cloud

Internet of
Things





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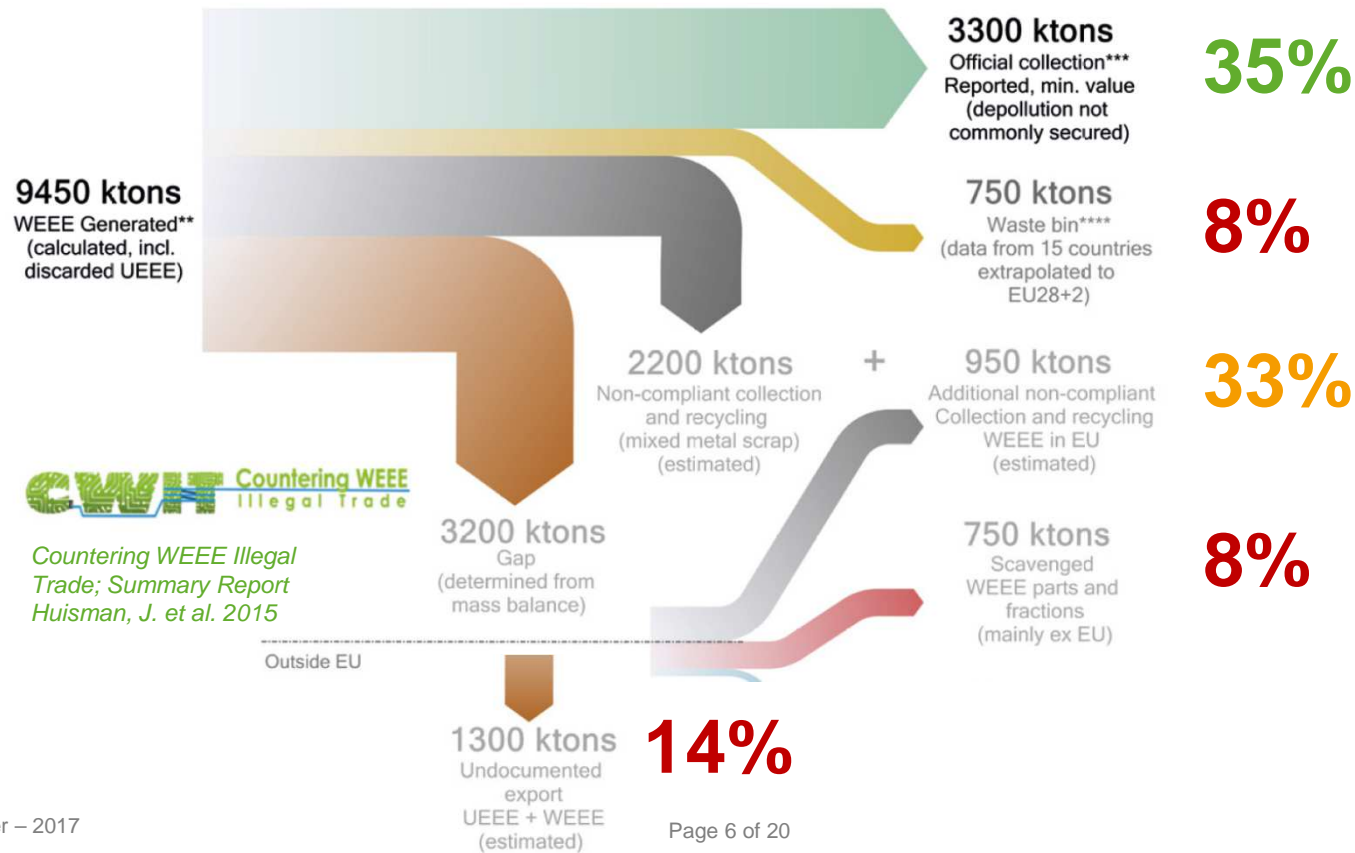
The great divide (2/3)

E-scrap growth drivers are misunderstood

“Europe was the largest market for electronic scrap recycling in 2014. Growth in this region is expected to be driven by stringent **government regulations** and **huge profits** generated through the recovery of **precious metals** from electronic scrap.” (Transparency Market Research, 2015)

EU: more to the story than low official recycling rates

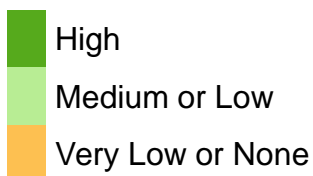
“~50% of PWBs to formal end-processing” – CWIT project



Material value of electronic waste is misunderstood

Most e-waste is not a gold mine!

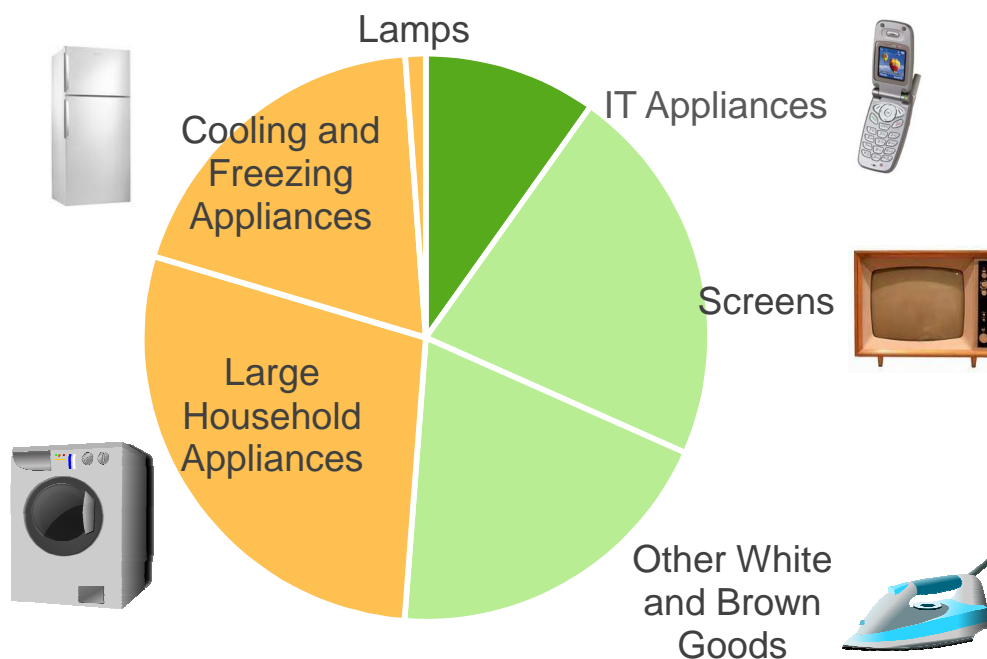
Priority for precious metals recovery



Precious metal components



W-EU e-waste collected, by weight (2013)



Source: figures from WEEE-Forum



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The great divide (3/3)

E-scrap growth drivers are misunderstood

*“...Estimate potential revenues from recycled e-waste at more than 2 billion Euros in the year 2014 for the European market alone. The value associated with those recycled resources is expected to rise by the year 2020 **to more than 3.5 billion Euros.**”*

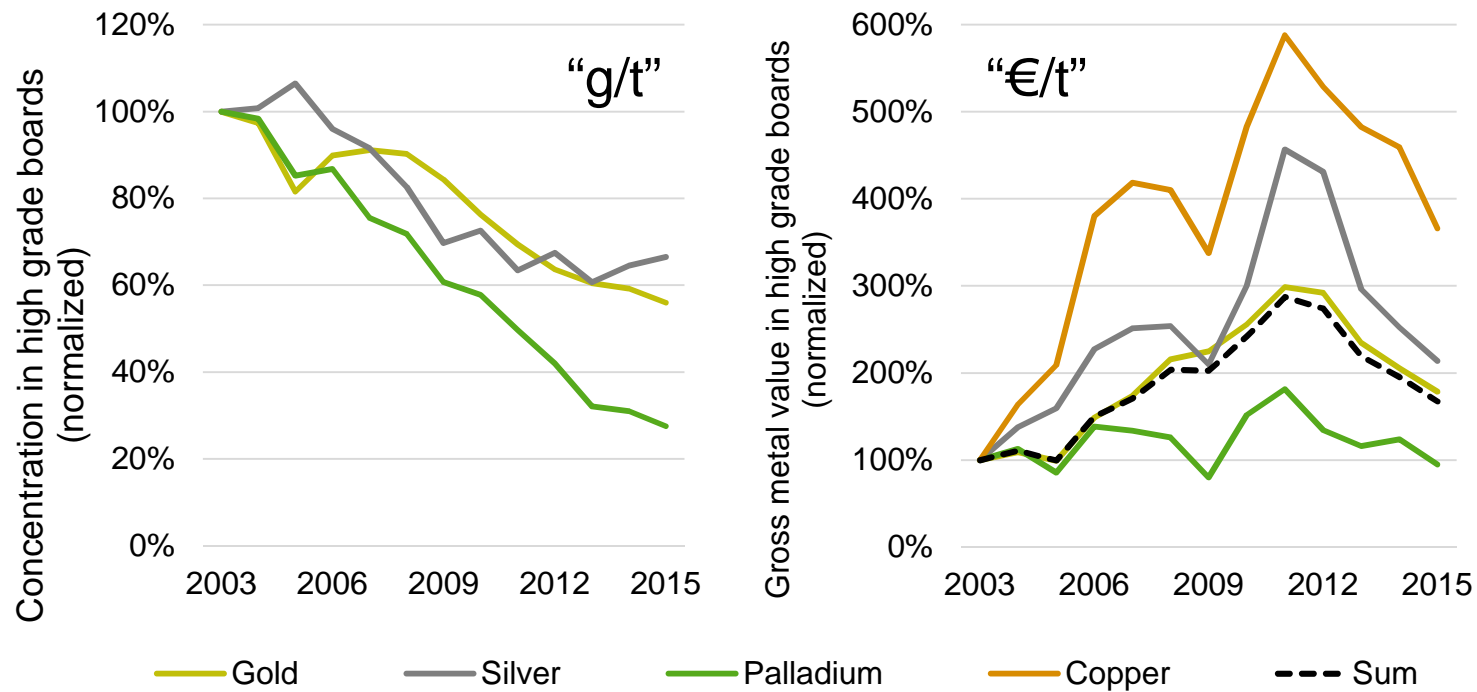
*“**Gold** is the material determining half of the potential revenues by considering all the WEEEs categories selected in this work”*

(Cucchiella et al. in Renewable and Sustainable Energy Reviews, 2015)

Results from high grade PWBs received for recycling

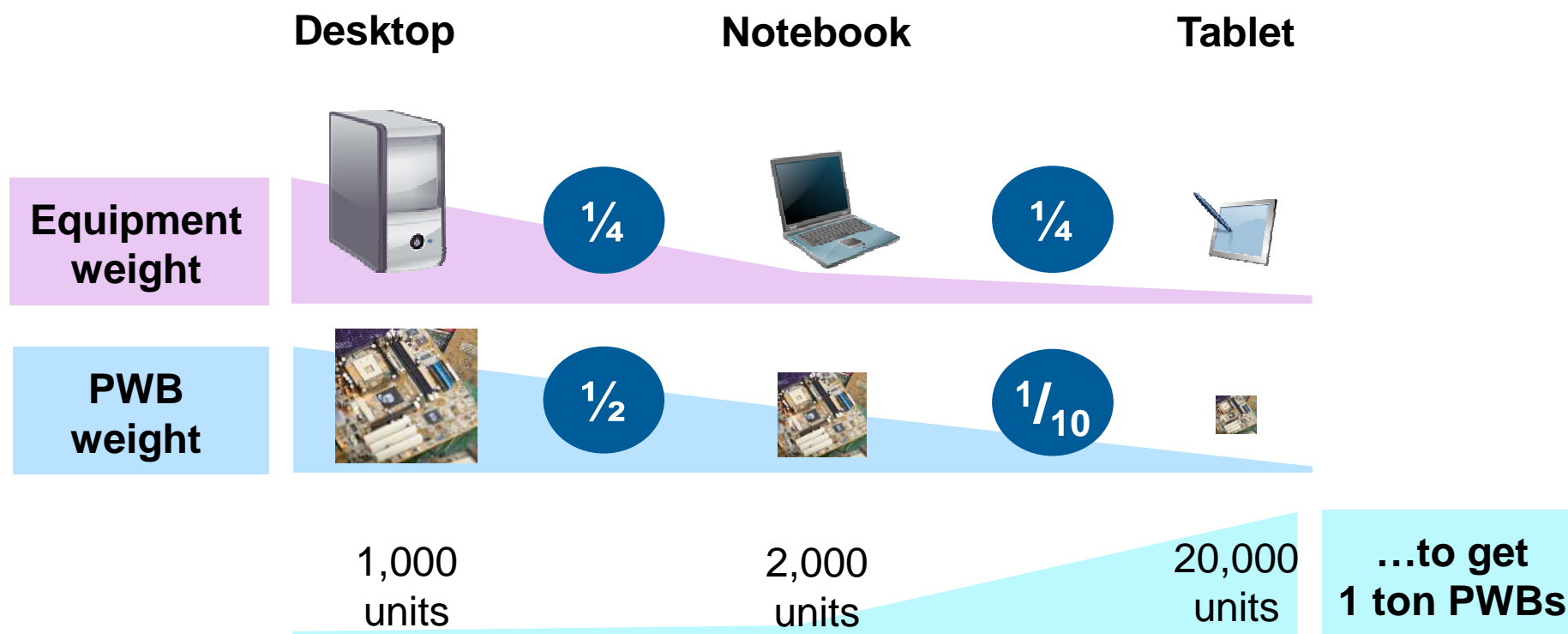


Precious metal content of e-scrap is declining



Impact of miniaturization

Products and their components become drastically smaller



Sources: Umicore team analysis, P. Chancerel & S. Rotter in Waste Management vol 29 issue 8, 2011, Hobi at Green Electronics Council tablets & slates workshop 2013

Declining product weight

Slimmer and more portable means less material for recycling



Laptop	
Model	Weight (kg)
iBook 12" (2000)	3
MacBook Pro 15" (2006)	2.5
MacBook Pro 15" (2015)	2
MacBook Air 13" (2015)	1.35

TV	
Model	Weight (kg)
CRT 25" (2004)	27
LCD 26" (2008)	7.7
LED 24" (2012)	4.8
LED slim 24" (2015)	3





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Quantifying the urban mine

Sound policy and investment decisions are at stake!

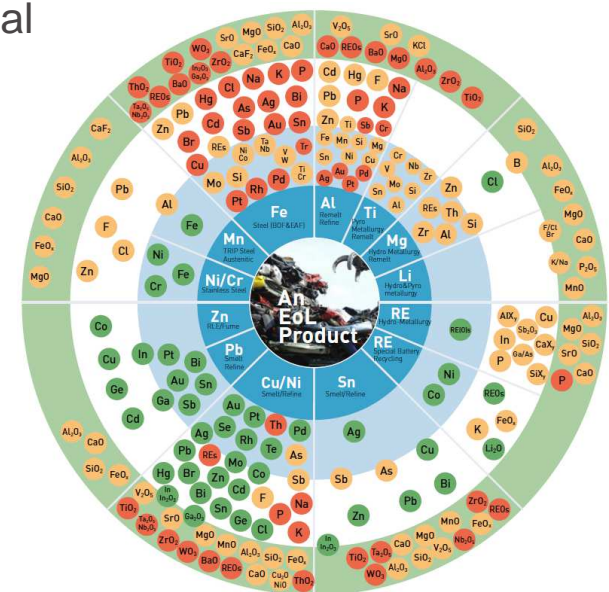
*“Market operations are **significantly helped** when recycling operators can estimate future needs for recycling infrastructure by quantifying the “urban orebody”, its location and waste flows.”*

(“Metal Recycling: Opportunities, Limits, Infrastructure”, UNEP-IRP, 2013)

Recycling fundamentals

Not everything can (or should be) recovered in recycling

- Not all elements can be recovered from a complex material and in a mechanical or metallurgical process, cfr. the metal wheel =>
- No single element can be recovered at 100%
- Recycling viability based on:
 - Concentration (g/t)
 - Chemical form
 - Impurities and associated elements
 - Connections
 - ...
- **Potential recycling revenue \neq material content \times material price !**

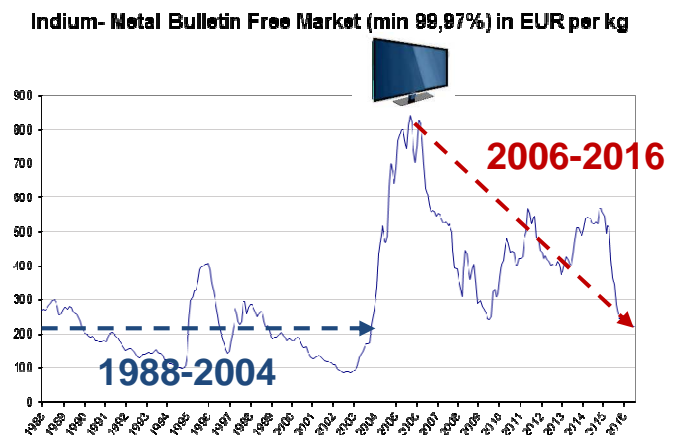


"Metal Recycling: Opportunities, Limits, Infrastructure", UNEP-IRP, 2013

Recycling fundamentals

Recycling potential is largely driven by economics

- Economies of scale required for high-tech recycling
- Low grade materials strongly limited by logistics costs
- Commodity price volatility must be considered =>



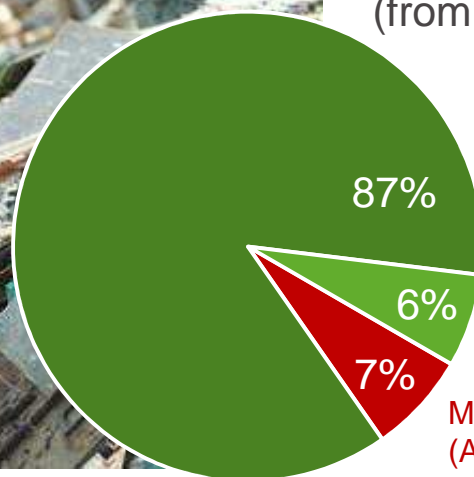
- *If costs exceed revenues, recycling may be enabled by frame conditions or bridging economic gaps (especially in collection)*

Recycling technologies are mature

State-of-the-art PWB refining recovers a large share of material value



Gross value of metals in PWBs (from lightly processed mixed e-waste)



Metals recovered and value returned to recycling chain (Ag, Au, Cu, Pd)

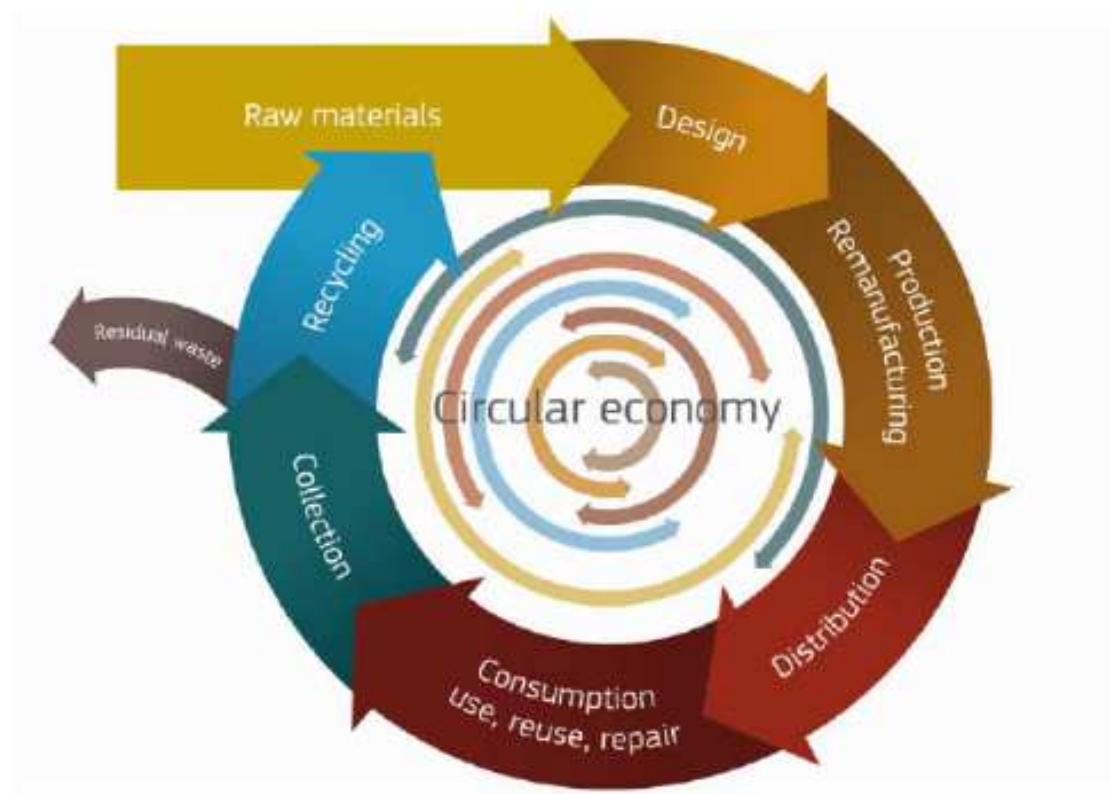
Metals recovered (by Umicore) but no value returned to recycling chain (Ni, Pb, Sb, Sn)

Metals not recovered as refined metal (Al, Fe, Mn, Si, Ta, Ti, Zn)

Notes:

- 2016 avg metal prices
- other metals analyzed but not detected,
- total gross value = ~7500 \$/t

Circular Economy



Circular Economy: what to work on?

1. Get materials into the existing quality recycling processes
2. Optimize the recycling process chain
3. Expand quality recycling processes globally
4. Pursue new business models and designs for keeping materials in the loop

Circular Economy: how to get a transition?

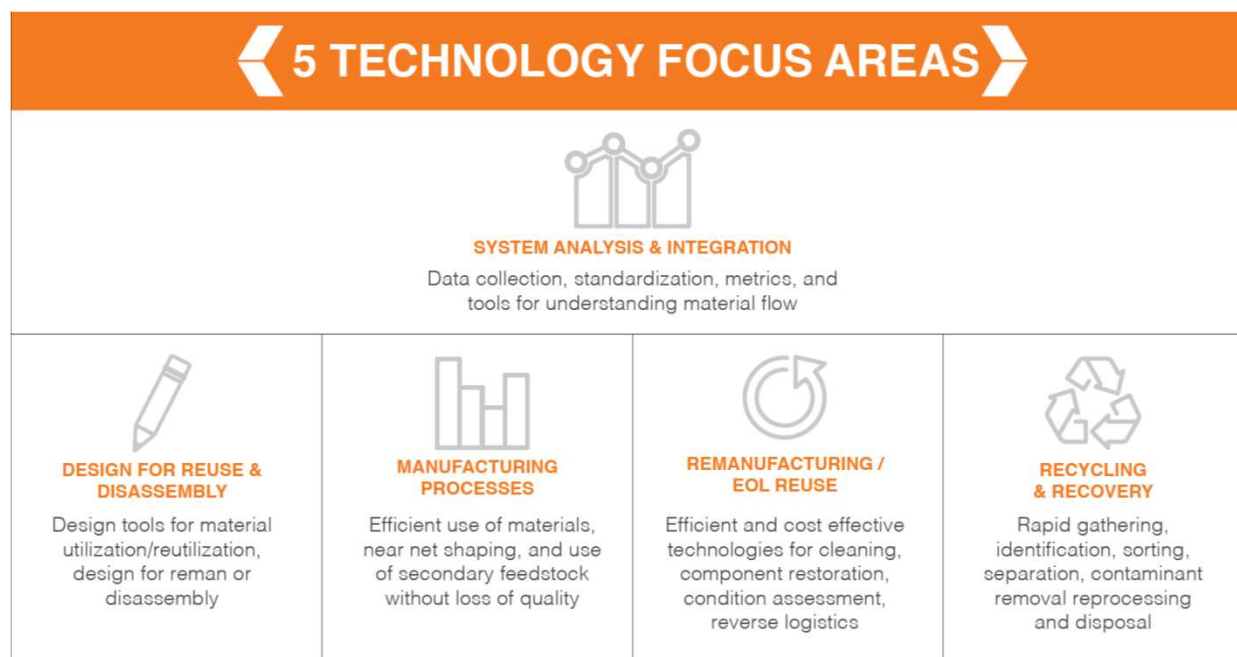
1. Triple Helix: a conceptual framework for driving transitions, characterized by:
 - Multi-stakeholder collaborative partnerships between academia-industry-government
 - Multi-disciplinary approaches
 - Innovation and entrepreneurship skills are required
2. Systems perspective
 - Electronics life cycle is complex, interconnected
 - Long-term perspective
3. Rigorous technical detail and hands-on work
 - Critical for making good decisions on policy and investment



The Triple Helix
(academia, industry, government)
See: M. Ranga, and H. Etzkowitz, 2013



- Contracted by US DOE
- Led by RIT (Rochester Institute of Technology)
- Consortium of:
 - 26 universities
 - 44 companies
 - 7 nat'l labs
 - 26 industry trade associations and foundations
- Mission: accelerate manufacturing innovation and scale-up technologies for RRR
- Plastics, e-waste, fibers and metals





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Thank you

Circular Economy: what to work on?

1. Get materials into the existing quality recycling processes

- Use quality standards and certifications
- Use transboundary movement
- Bridge economic gaps to match revenues and costs
- Enable economies of scale

2. Optimize the recycling process chain

- Assess added value of each processing step
- Rationalize investment based on product trends
- Pursue processing flexibility
- Improve stakeholder cooperation and dialogue

Circular Economy: what to work on?

3. Expand quality recycling processes globally

- Develop appropriate local infrastructure
- Improve access to global market
- Improve international cooperation

4. Pursue new business models and designs for keeping materials in the loop

- Improve collection
- Don't forget the inescapable need for recycling!