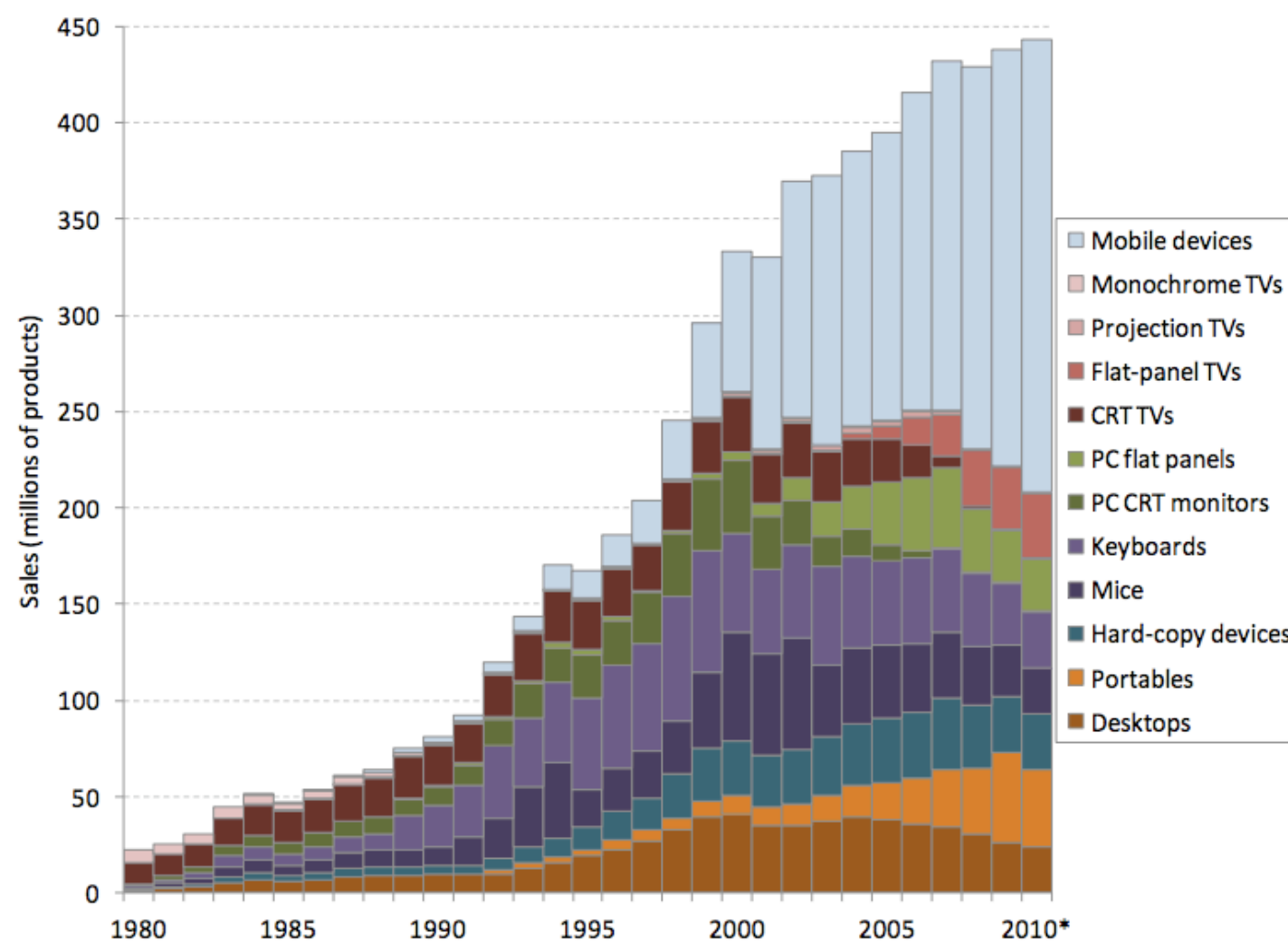


Calculating electronic product recyclability: A new approach

Funding Sources: Industrial Affiliates of LMAS

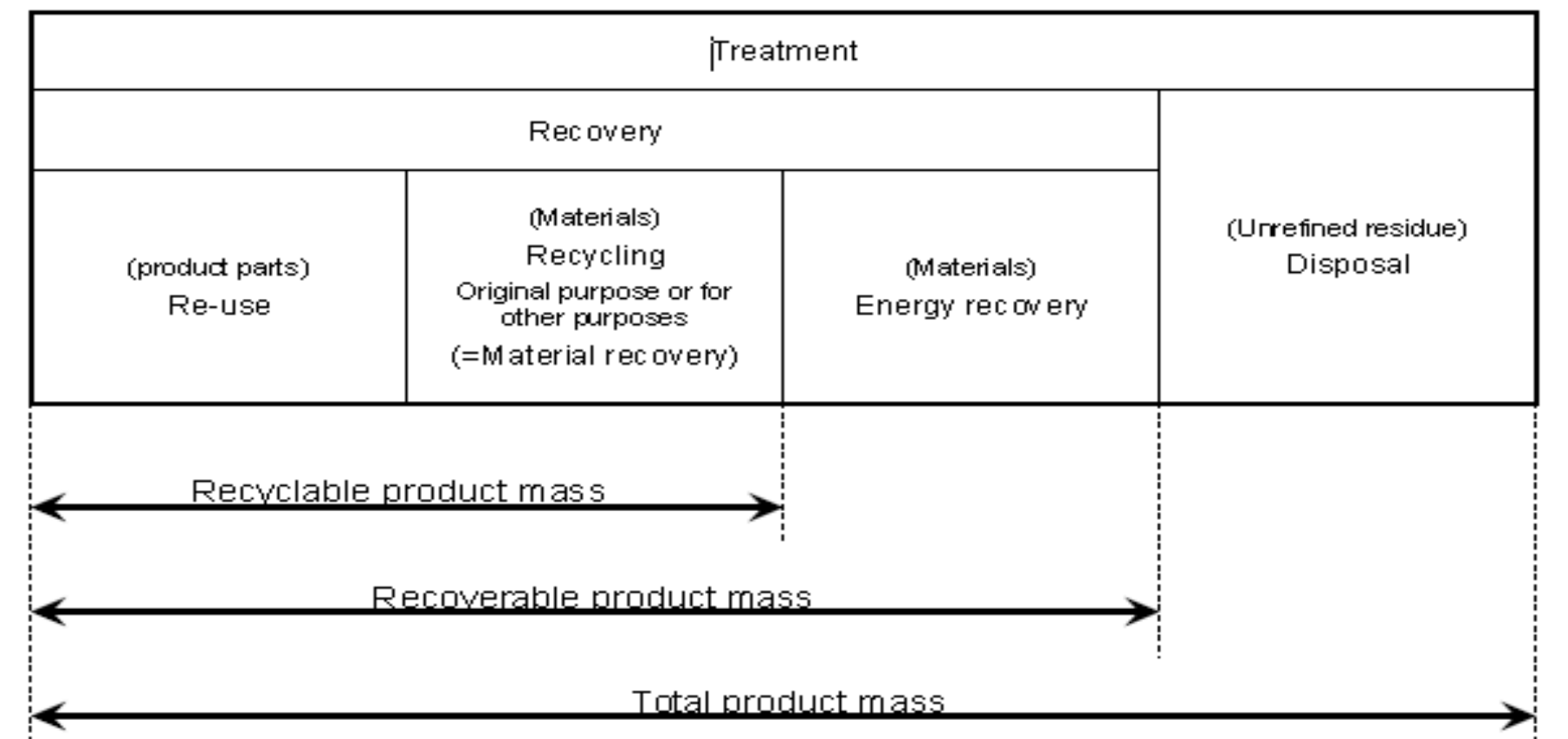
Motivation

- The attention to the rise in e-waste, along with regulations has put pressure on original equipment manufacturers (OEMs) of consumer electronics to manage their products in an environmentally responsible way at the end-of-life (EoL) phase of the product life cycle.



Objectives

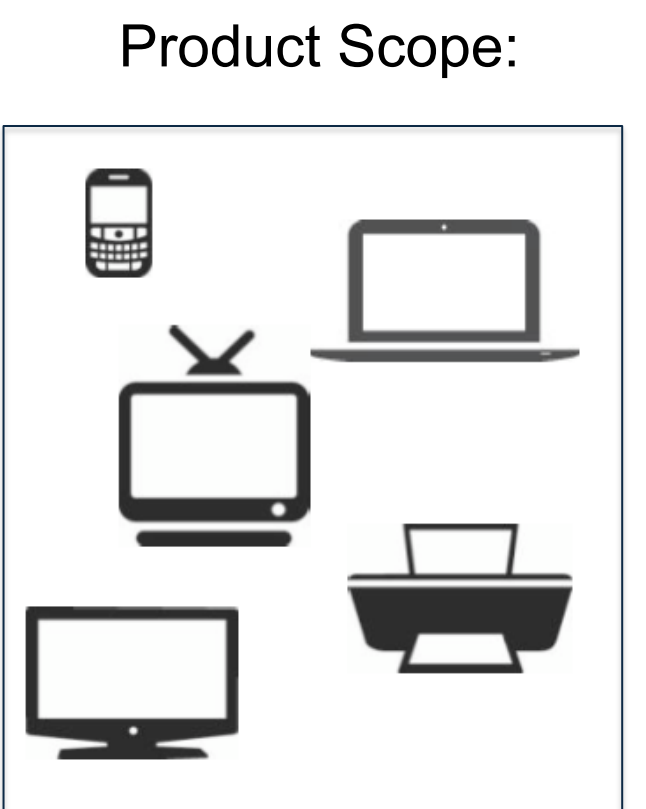
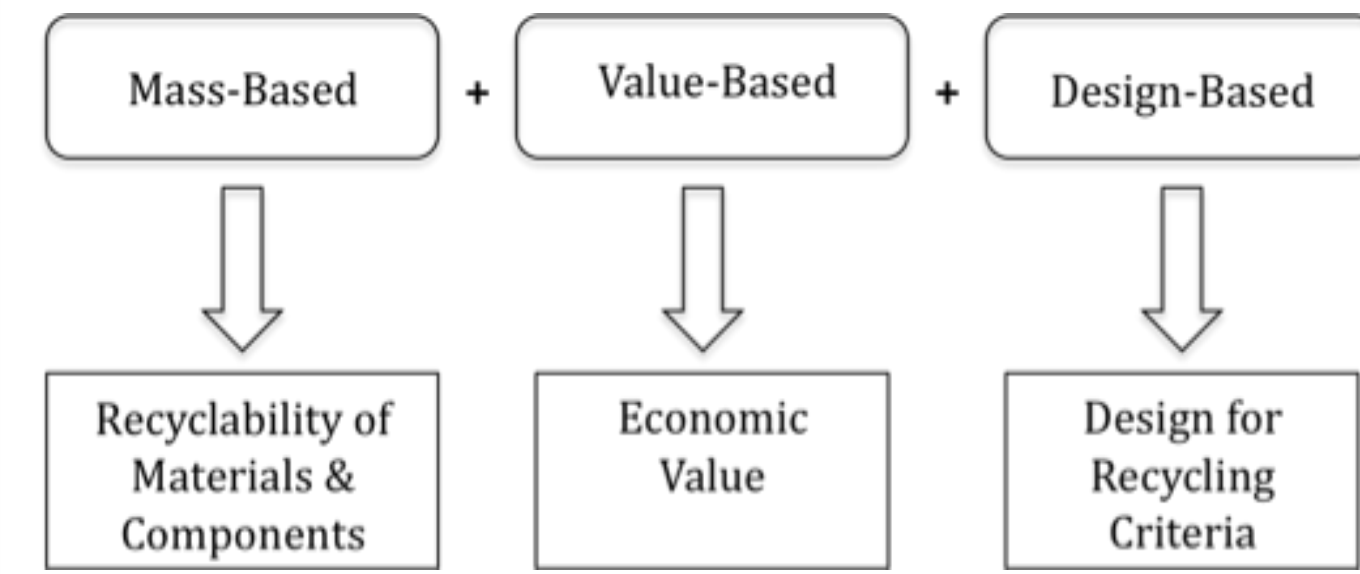
- Develop a methodology to calculate recyclability of consumer electronic products in order to provide a single approach for a theoretical recyclability calculation.
 - Aligned with current industry efforts and standards
 - (WEEE, IEEE 1680.1, IEC technical report)
 - Designed to be used by any original equipment manufacturer



- OEMs are motivated to improve their product designs to become more suitable for EoL recycling and recovery processes in an effort to reduce their environmental impact.
- Evaluating recyclability of a product is the most common method used by stakeholders in producer responsibility to determine the environmental performance of products in the EoL phase.
- Limitations of current recyclability rate methodologies**
 - Mass-based recyclability can be misleading when materials are present in low amounts, but have high economic and environmental value
 - Value-based metrics have been proposed, but not successfully implemented in industry
 - Life-cycle assessment metrics have been developed, but it is often difficult and time-consuming to obtain data

Approach

- The methodology presented combines mass, value, and design based recyclability metrics in order to obtain a more realistic view of how efficiently a products and its materials can be recycled.

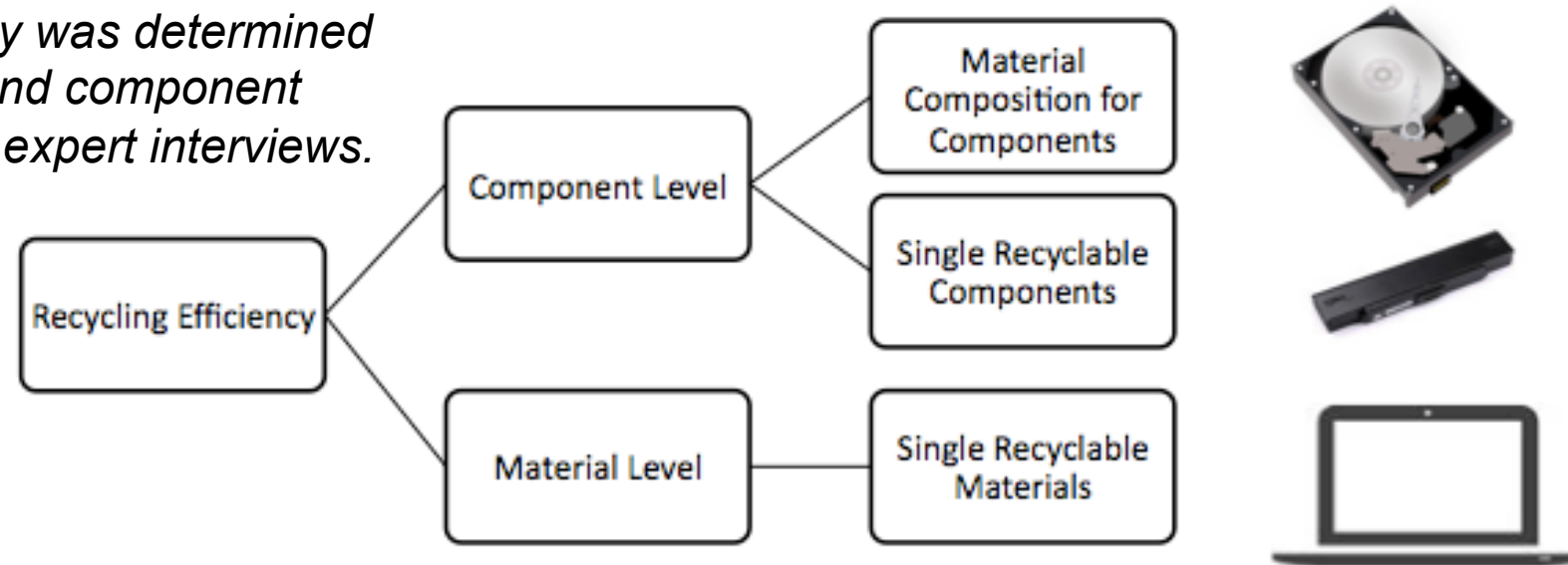


Components of Recyclability Calculator

- Bill of materials and percent composition of common products
- Recycling Efficiency at the component and material levels
- Scrap value of material recovered through recycling

Recycling Efficiency – Component and Material

Recycling efficiency was determined for each material and component from literature and expert interviews.



Example material composition of common computer components

	LCD Display ¹	Hard Disc Drive ²	Optical Drive ³
Weight	Reported (W_{LCD})	Reported (W_{HDD})	Reported (W_{OD})
Steel	33%	14%	33%
Aluminum (Al)	14%	84%	42%
Magnesium (Mg)	----	----	----
PC/ABS	3%	----	19%
Other Plastics	12%	----	----
PWB	23%	----	----

¹ Ecoinvent database
² Boyd, S., et al. (2010). Mobile-Hong-Chao Zhang (2005)
³ Ecoinvent study reference. Mobile assembly work (2005)

Mass and value based metric calculations

- Mass-based equation is the foundation of the calculator
 - Recyclable mass of each material and component as a percentage of total product mass

$$R_{cyc} = \frac{\sum \text{recyclable mass of each part}}{\text{Total product mass}} \times 100\%$$

- Combined component and material efficiency equation

$$R_{cyc} = \frac{\sum (m_{(i)} \times R_{eff(i)})_{component} + \sum (m_{(i)} \times R_{eff(i)})_{material}}{m_{total}} \times 100\%$$

- Scrap value calculation as a function of recycling efficiency

$$V_{cyc} = \sum V_i (R_{cyc})_i$$

Recyclability calculator user interface

- The approach presented here provides a consistent standard methodology for calculating mass-based recyclability of a product and accounts for the value recovered and how efficiently the product can be recycled.

Future Work

- Incorporate Design for Recycling criteria
- Integrate new component level data for additional products
 - Printed wiring board data by grade level and product type
- Research potential for including reuse and refurbishment potential at product and component levels

Acknowledgements

