Material Flow Analysis and E-Waste Circularity

Eric Williams
Rochester Institute of Technology

July 18, 2024

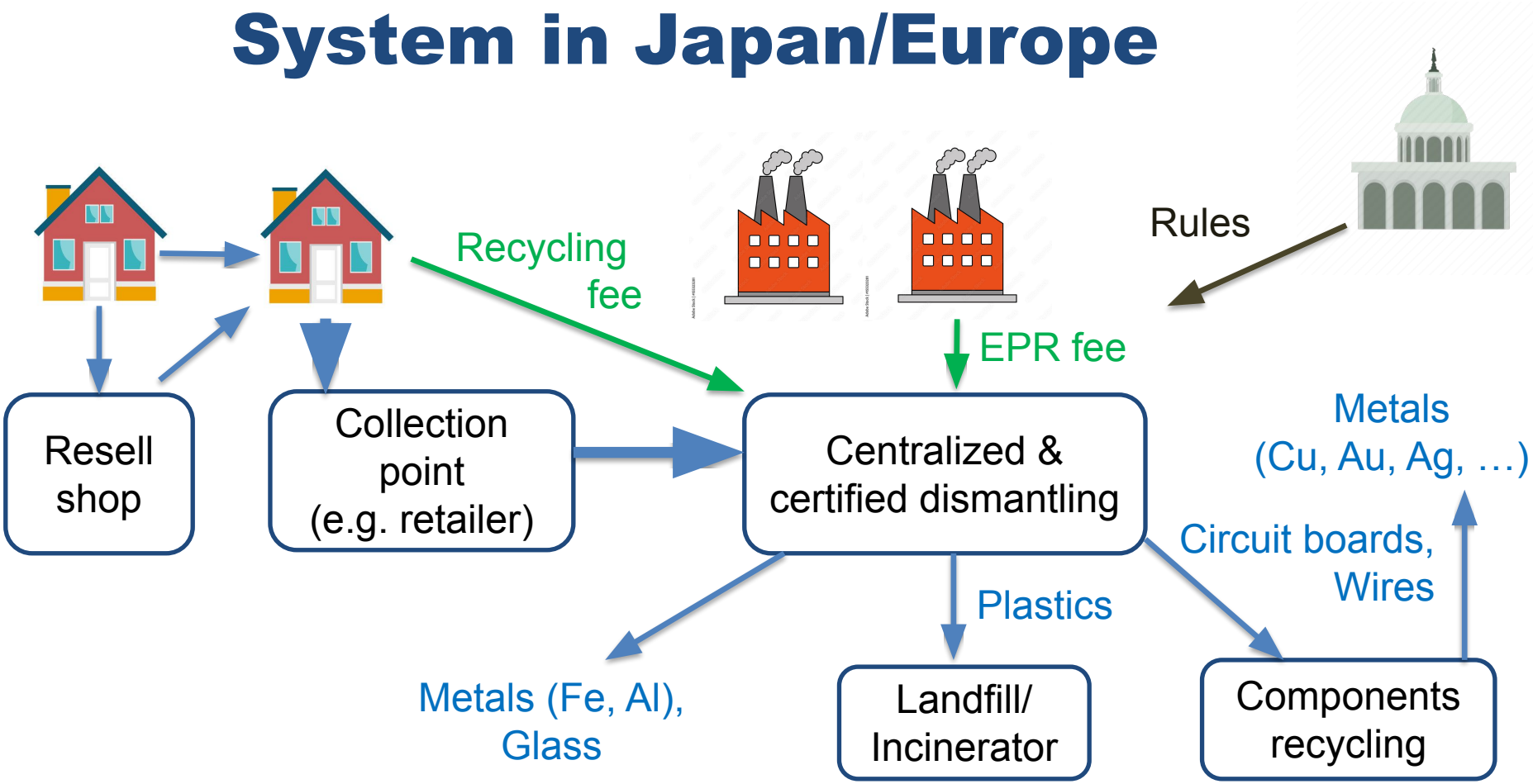
Roadmap

1. **Context**
   a) Circular economy
   b) End-of-Life systems – formal and informal
   c) Policy questions
   d) Quantitative analysis – Material flow and other analysis
2. **Project research**
   a) Method
   b) Review of flow data for end-of-life electronics in ASEAN
   c) Interview with informal sector
   d) Economic analysis of electronics recycling
3. **Conclusions**

1a) Circular Economy

- Core idea: extract maximal value from resources by symbiosis and reuse hierarchy: reduce > reuse>recycling
- Environmental impacts of making electronics is high, thus large benefits from lifespan extension, also social benefits (digital divide)

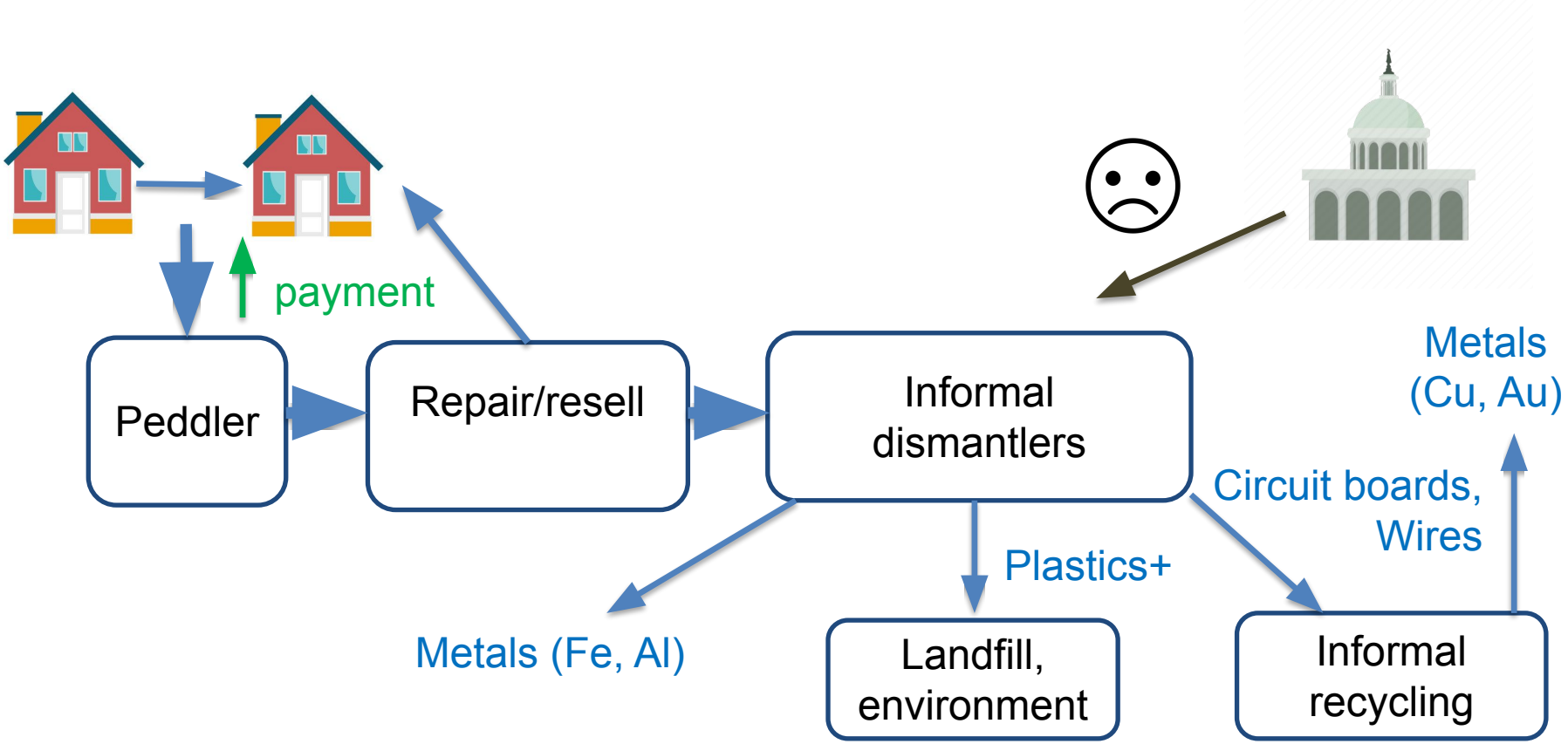
1b) End-of-First-Life Electronics System in Japan/Europe



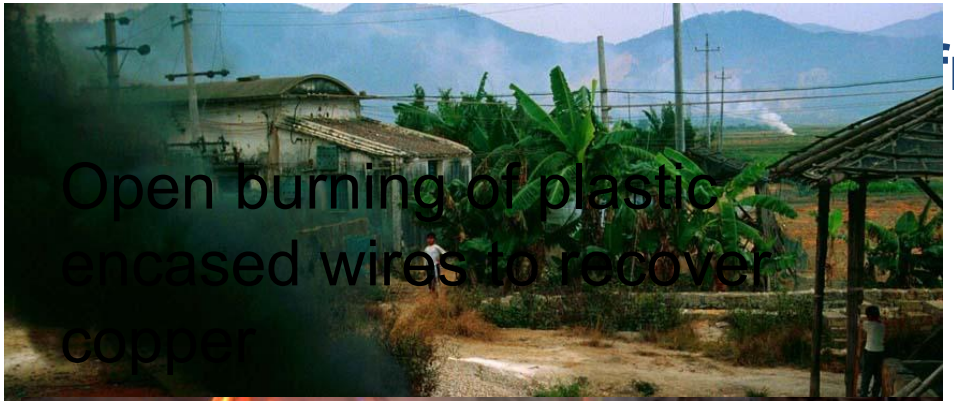
Extended Producer Responsibility (EPR)

- **The idea:** Make manufacturers responsible for collection and recycling.
- **The dream:** Manufacturers will become motivated and design better for environment
- **The reality** (as usually implemented for electronics): Just a financing mechanism for a centralized recycling, no incentivize to redesign. Hides recycling costs behind higher prices instead of explicit fees. Politically appealing, but ….

1b) End-of-First-Life Electronics System in many developing nations



rom informal recycling



Open burning of plastic encased wires to recover copper

Circuit boards treated with acid, cyanide to recover copper and gold

Pros and Cons

Formal Japan/Europe System

Pros:

- Safe and efficient recycling

Cons:

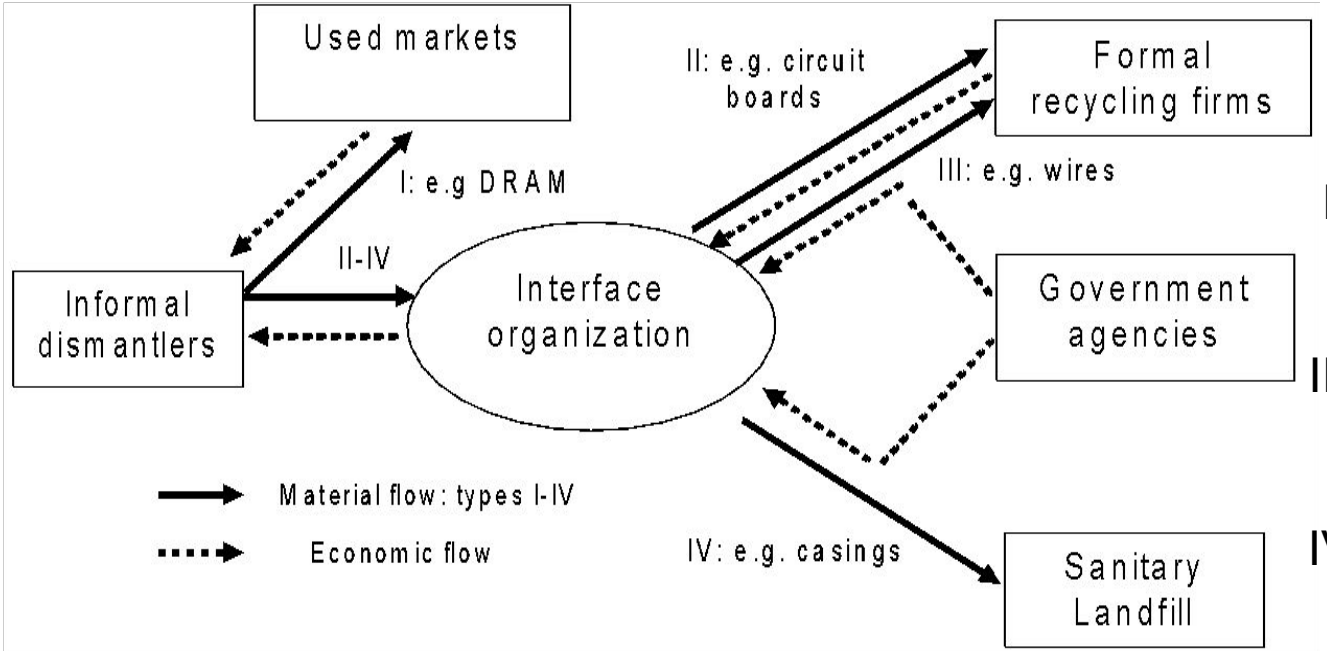
- Consumer pays $ (recycling fee or higher prices from EPR)
- Less reuse (focus on materials recycling)

1c) Policy questions for much of ASEAN

- How to address informal sector?
  - Formalize/cooperate, Ban, Outcompete
- How for pay for formal recycling?
  - Recycling fee, EPR, from general taxes
- How to get people to turn in devices?
  - Peddler purchase, collection points (e.g. at stores)
- What flows domestic versus international?
  - Major circuit board recycling facilities in a few countries, not ASEAN.

1c) How to cooperate with informal sector?

One approach - Interface organization: pay informal sector to channel to formal sector:



Part types:

I. No formal sector needed
II. Formal sector recycling profitable
III. Subsidy needed to recycle formally
IV. Needs landfilling

1d) Supporting decisions with data/analysis

Questions relevant to policy design:

- How much end-of-life electronics now and in future ? (for reuse versus for recycling)
- What prices does the informal sector get at each stage (if cooperating/competing)?
- How much will different reuse/recycling systems cost?

Quantitative analysis can inform these questions

(many challenges in data availability)

1d) Types of analysis to inform e-waste policy

- Material flow analysis – what are flows within nation of end of life devices, reuse markets, landfills?
- Economic analysis – What are revenues and costs for different stages and approaches to collect/repair/dismantle/recycle?
- Social analysis – What issues need to be addressed to collaborate w/ informal sector?

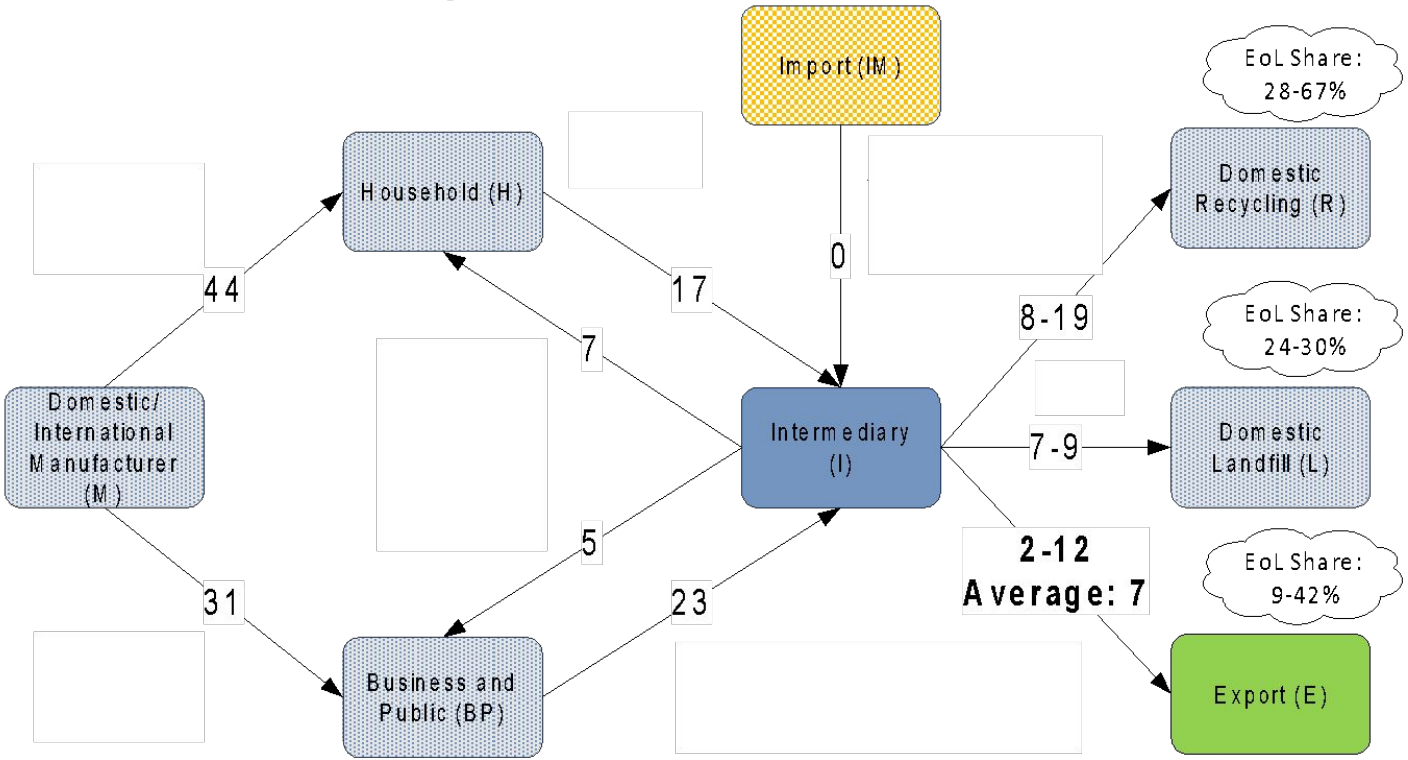
1d) Material flow analysis – What is it?

United States 2010 flows of new, used and waste personal computers.
(millions of units)

What do we learn?

- 27 million/year for recycling or export
- Recycling system only partly working
- 12 million/year reuse sales

Source: Kahhat and Williams (2012)



1d) How to estimate Material Flow – e.g. from households

I. **Sales + Lifetime**

- Find/buy data on annual sales of devices.
- Guess/measure lifetimes
- Calculate # of devices leaving home /year

Pros: cheap, leveraging available sales data

Cons: accuracy. Resale vs. recycle?

2. Research@RIT for sustainable end-of-life electronics in ASEAN

a) Assess state of knowledge of material flow analysis & state of policy
b) Interviews with informal sector workers
c) Economic/material analysis of reuse/recycling

2a) Assess state-of-knowledge of material flow analysis in ASEAN

Country	E-waste generation (1,000 tonnes)		
	2019	2015	Avg. Ann. Growth (%)
Brunei Darussalam	9	7	5.2
Cambodia	19	16	3.5
Indonesia	1620	745	17
Lao PDR	17	8	16
Malaysia	364	232	9.4
Myanmar	82	29	23
Philippines	425	127	27
Singapore	113	100	2.5
Thailand	621	419	8.2
Vietnam	257	115	17

- E-waste Monitor (UNITAR) data, uses sales + lifetime method
- E-waste = basically everything with a plug

What is known for end-of-life electronics?

- Total generation, sometimes from multiple sources
- Official exports of scrap (circuit boards, Cu, Al) from UN COMTRADE, e-waste from Basel

What is not known?

- Flows to and within informal sector
- Degree of reuse
- Flows to environment, landfills
- Unofficial imports and exports

2a) Assess state of end-of-life electronics policy

Nation	Collection	Recycling	Informal recycling ban
Brunei Darussalam	Informal & 2 government collection centers	Informal & reports of circuit board exports to Japan	No
Cambodia	Informal & pilot government system	Informal	No
Indonesia	Informal & formal pilot in Jakarta	Informal & formal facilities license via local government	No
Lao PDR	Informal only	Informal only	No
Malaysia	Informal & 121 govt. licensed collection centers	Informal & 35 licensed formal recycling companies	Yes
Myanmar	Informal only	Informal & some recycling companies handle e-waste	No
Philippines	Informal & pilot collection events & points	Informal & 28 licensed formal companies	No
Singapore	Informal & govt. contract firm w/ 600 collection points	Formal system mandated by government	Yes, but informal collection OK
Thailand	Informal (~99%) & local govt (~1%)	Informal & licensed facilities.	No
Vietnam	Informal, EPR funded system from 2024	Informal & 15 licensed firms,	No

Overall:

- Singapore has established policy
- Vietnam policy decided, starts soon
- Others: pilot activities and policies in various stages of development

2a) Assess state of end-of-life electronics policy

Import and Export Policy

International:

- UN Basel Convention governs international trade in waste
- E-waste is classified as hazardous, used electronics is not.
- Main convention requires notification of trade, Basel Amendment bans OECD and EU nations from exporting hazardous waste
- All ASEAN nations ratified main convention, 4 ratified amendment

Domestic policy

- Some ASEAN nations require government permit to export e-waste (e.g. circuit boards).

2b) Interviews with informal sector workers

- Goals:
  - Understand their working situation better
  - Understand what is needed for them to sell to formal sector (interface organization)
- Conducting 45 total interviews w/ informal sector (collection, repair, dismantling) in 5 ASEAN nations (Indonesia, Malaysia, Philippines, Thailand, Vietnam)

2b) Interviews : vignettes from initial interviews

“Gabriel” from Philippines

- Collects, repairs and dismantles TV, A/C, washing machine, fans
- Has a truck/cart, parks and team goes out to households
- Bothered by police for illegal parking and dismantling in public space
- Member of collective organization
- Cash day-of transactions only

2c) Economic/material analysis of reuse/recycling

- Built economic/material of recycling desktop and laptop computers in ASEAN
- Revenues: sales of steel, aluminium, circuit boards, copper wires.
- Costs: facility, wages, transport, purchases waste devices
- Result: W/out reuse, confirm that recycling is net cost. Results vary by location, but e.g. need recycling fee of 8$ for desktops, 2$ for laptops

3. Conclusions

Next for RIT research:

- Complete and analyze interviews.
- Economic analysis of recycling fees and circuit board aggregators
- Future work?: Survey of consumers to clarify household flows, prices paid by peddlers, degree to reuse vs. new.

3. Conclusions

Next for application:

- Synthesize economic and interview analysis to inform ongoing entrepreneur training.
- Engage with policy makers to support development with data/modeling
- Your ideas?

Thank you for your attention!

RIT Golisano Institute for Sustainability

RIT Saunders College of Business

Made possible with support from:

Eric Williams
exwgis@rit.edu