A Tool to Evaluate Used Electronic Flows for the United States

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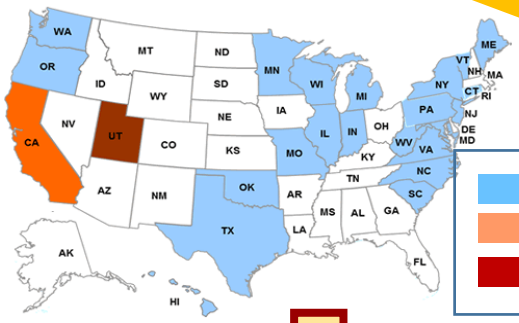
E-waste

Domestic management
Treatment depends on state regulations

Export to developing countries



- Producer responsibility law
- Consumer law
- Manufacture education law

Recycling

Landfilling

Incineration

Open burning

Acid extraction

Land disposal

Source: Greenpeace, Basel Action Network, www.bbc.com/news/world-europe-108

Source: Greenpeace, Basel Action Network,

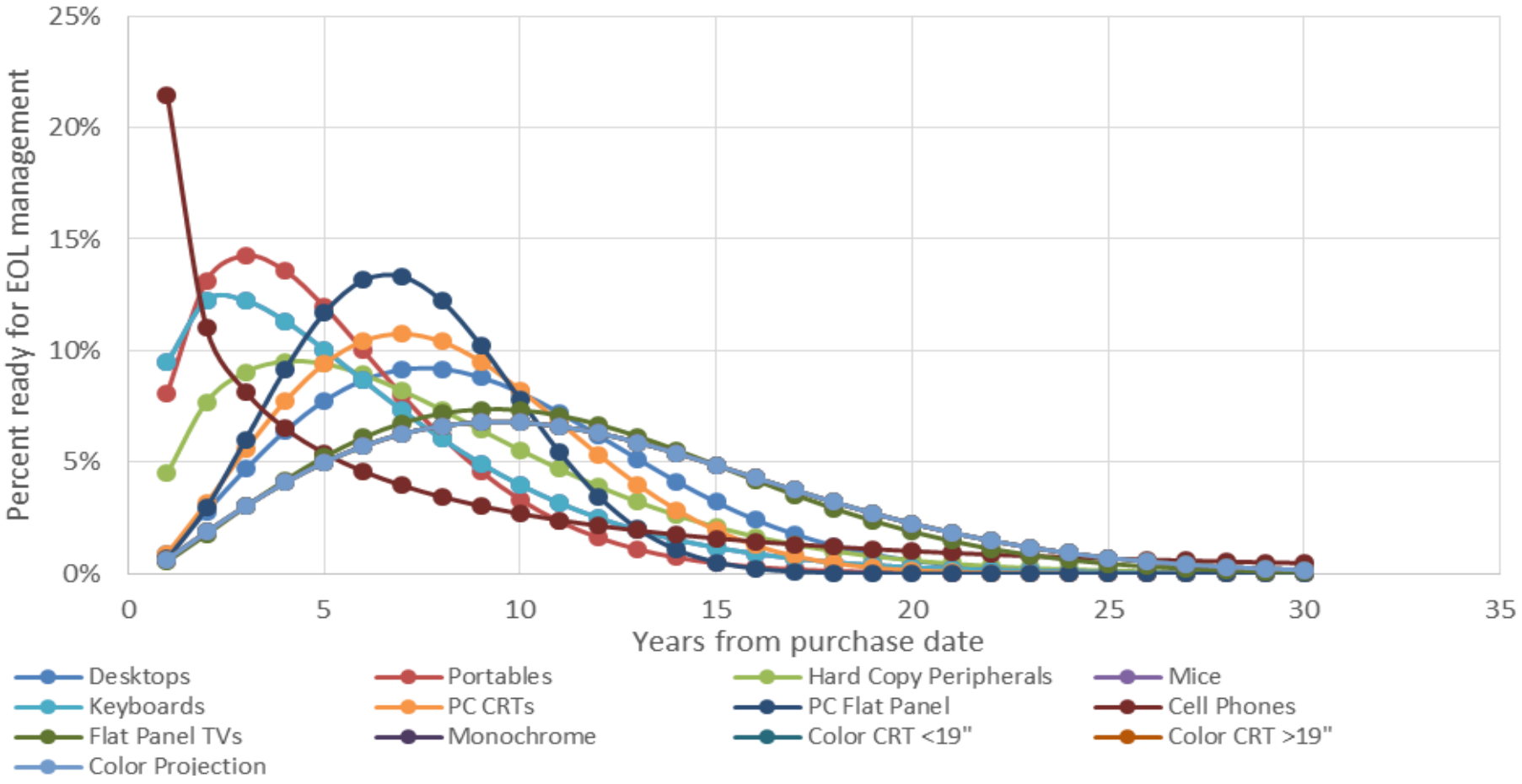
Source:http://www.epa.ohio.gov/dmwm/Home/Incinerators.aspx

www.bbc.com/news/world-europe-108

Source:www.flickr.com/photos/cogdog/9090732482

Source:www.documentscotland.com/portfolio/e-wasteland/

Percentage of Products Ready for End-of-life Management after Each Year of Sale



Alternative Disposition of Electronics Planning Tool (*ADEPT*)

- The ADEPT Tool is an Excel-based tool which evaluates the generation of used or disposed electronic items from nationally representative sales data.
- The state-level - National sales are disaggregated to a state level using state shares of national GDP.
- Does not account for specific state policies or actual state-level sales.
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  - specific state policies or actual state-level sales.
  - flows of disposed materials between states are not in the accounting

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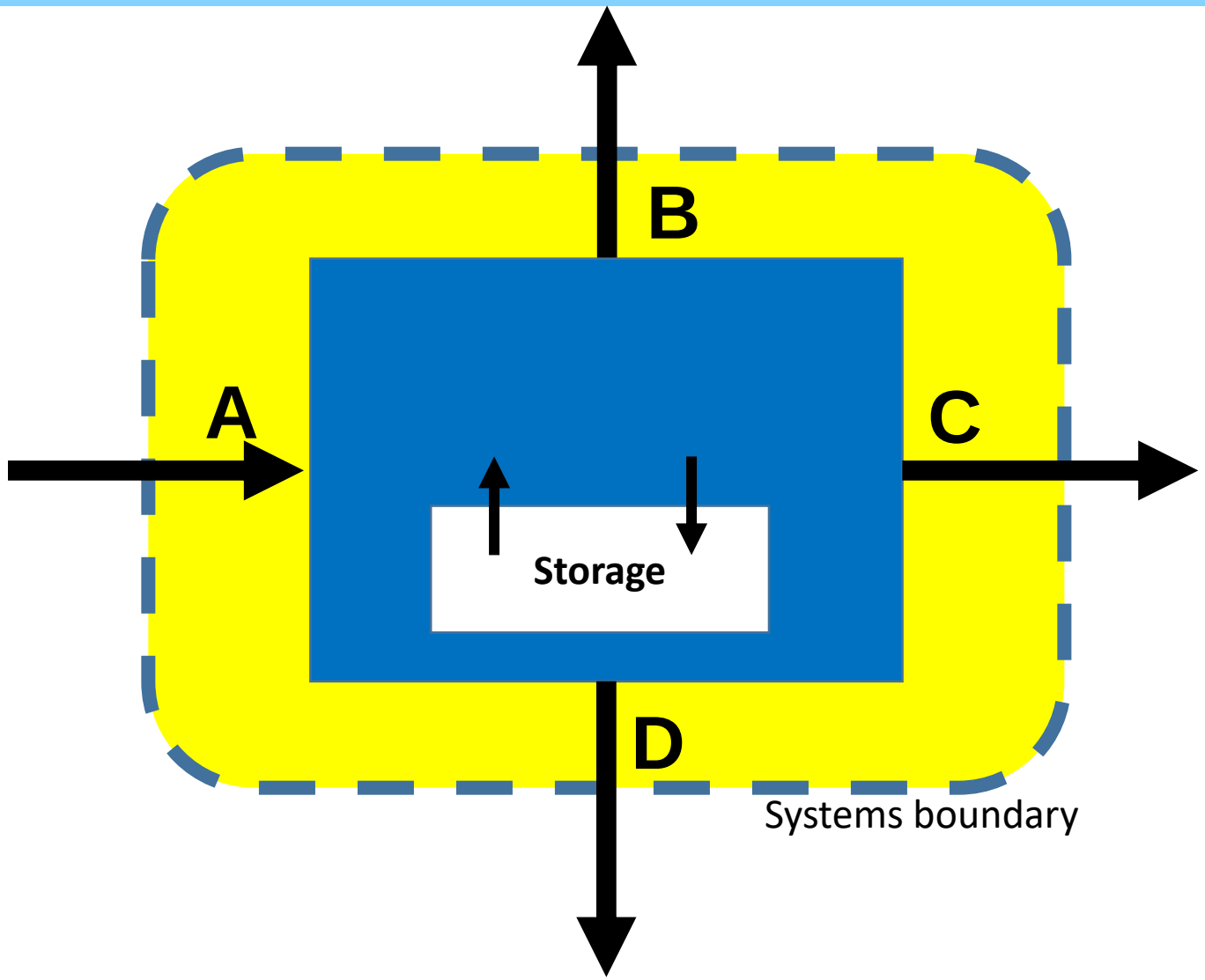
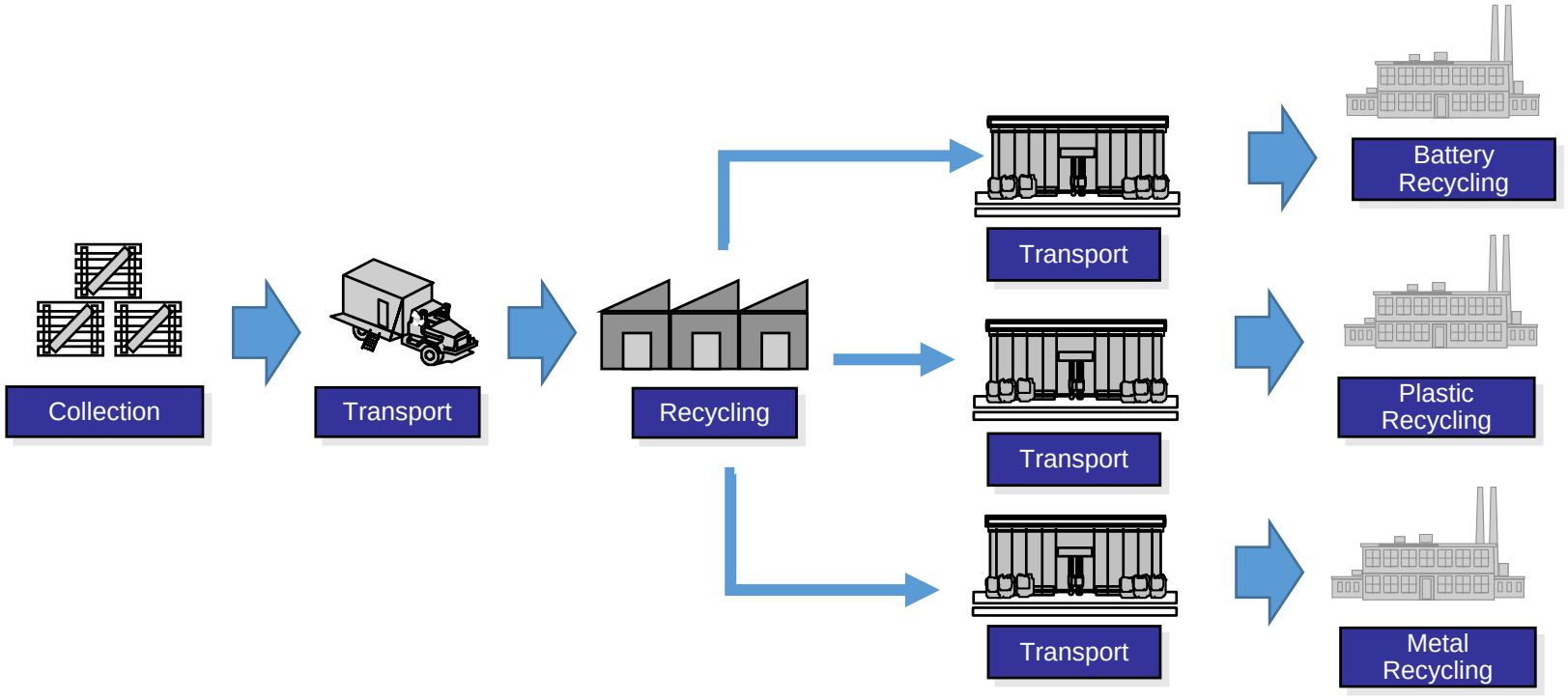
Material Flow Analysis



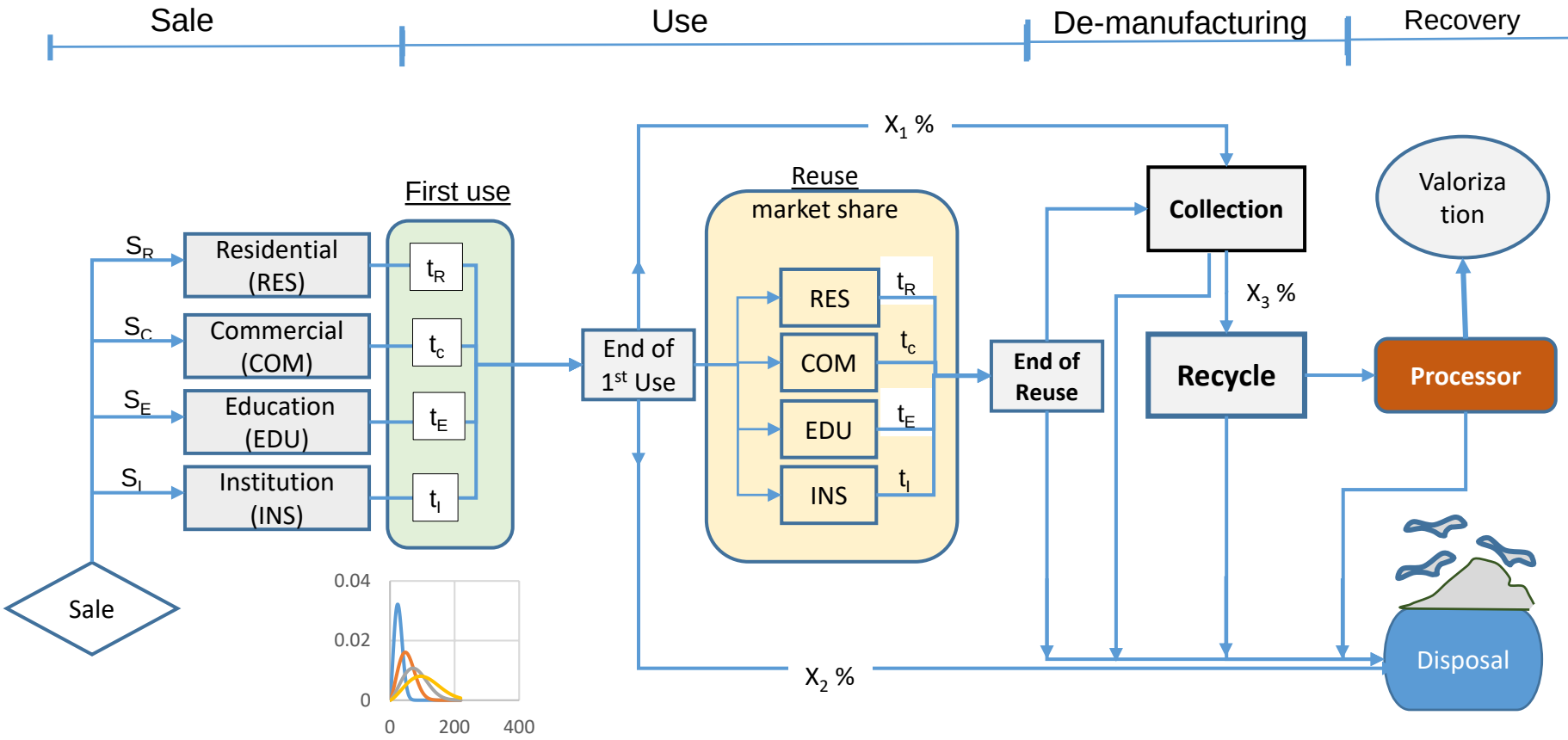
General Assumptions

- Waste may be sent directly to landfill during each stage in the flow or through the recycling chain.
- At each step in the recycling chain (i.e., collectors to recyclers), there is a fixed materials extraction efficiency applied to all products.
- For example, the default efficiency parameter from collectors to recyclers is 85%. This means that 85% of materials continue to recyclers and the remaining 15% goes to landfill.
- These efficiency parameters can be adjusted in the Control Panel's Behavior tab. These incremental movements of product and material weight to landfill is cumulative.
- The Total E-Waste Disposal for landfill is the cumulative waste disposed, for a given year, across each of these steps
- Material composition for each product is static across years. This assumption is based on a laboratory study by the Rochester Institute of Technology (Babbitt et al., 2017).

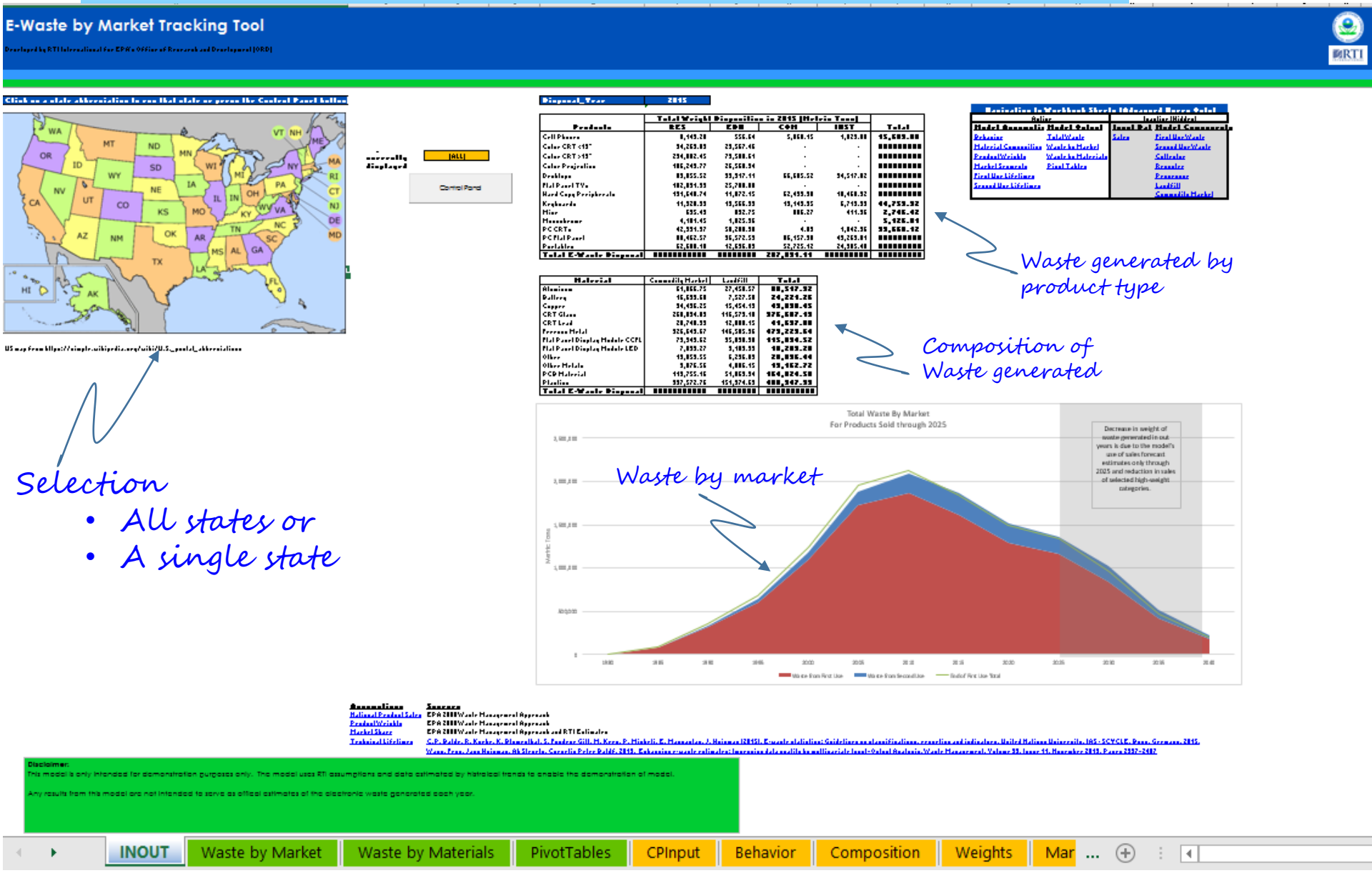
Conceptual depiction of end-of-life material flows



E-waste Stock – Flow – EoL Supply Chain Model



E-Waste Tracking Tool for US – Interface Page



Products & Materials

Products

- Cell phones
- Color Crt <19”
- Color CRT >19”
- Color Projection TVs
- Desktops
- Flat Panel TVs
- Hardcopy Peripherals
- Keyboards
- Mice
- Monochrome TVs
- PC CRTs
- PC Flat Panel CRTs
- Portables

Materials

- Aluminum
- Battery
- Copper
- CRT Glass
- CRT Lead
- Ferrous metal
- Flat Panel Display Module CCFL
- Flat Panel Display Module LED
- Other Metals
- Printed Circuit Board Materials
- Plastics

Source of Assumptions

- Assumptions are based on:
  - Literature
  - Prior research
  - Industry standards, and
  - Anecdotal evidence from stakeholder interviews and conversations
  - The user may adjust assumptions and parameters to appropriately match their specific information, assumptions, and needs

.

Data Projections

- Projections of future sales and sales growth are made via simple linear projections.
- The values of these projections can be edited by the user to address additional scenarios.

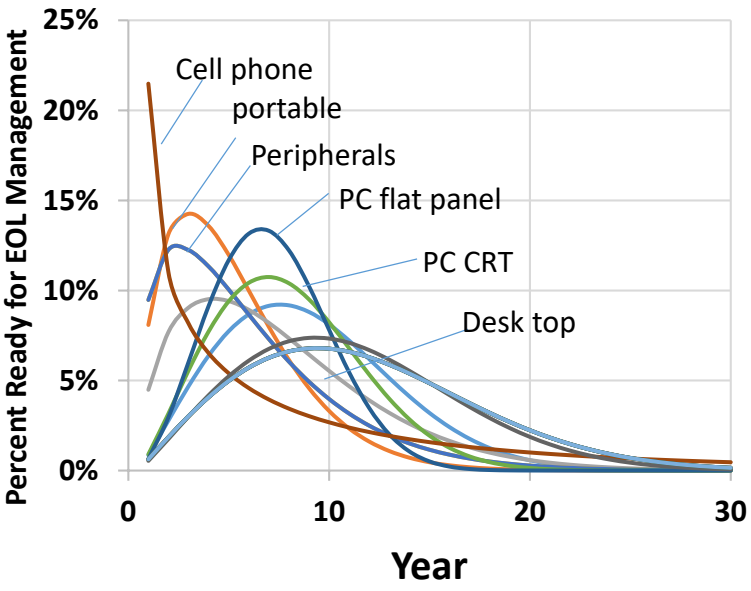
Weibull distributions to product lifetimes

$$\text{e-waste (t)} = \sum_{i=0}^{t \le T} Sales_t \cdot \left[\left(1 - e^{\left(\frac{T-t}{\beta}\right)^{\alpha}}\right) - \left(1 - e^{\left(\frac{(T-t)-1}{\beta}\right)^{\alpha}}\right)\right]$$

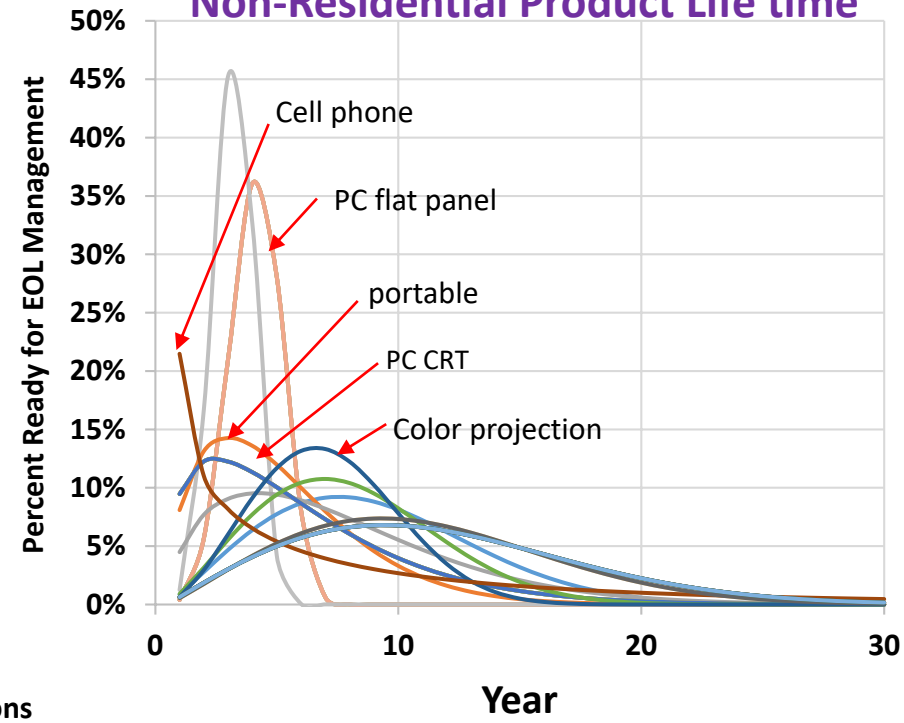
Where: t = Year when the product was sold
T = Year when e-waste was generated
$Sales_t$ = Industry sales for year t
β = Weibull distribution scaling factor
α = Weibull distribution shape factor.

Lifetime depends on the type of product and economic sector

Residential Product Life time



Non-Residential Product Life time



Sources: Baldé et al., 2014; U.S. EPA, 2011, and Authors calculations

Operational Assumptions

- Assumptions are designed to be changed within the Control Panel. Any assumption initially presented to the user in the Control Panel can be adjusted

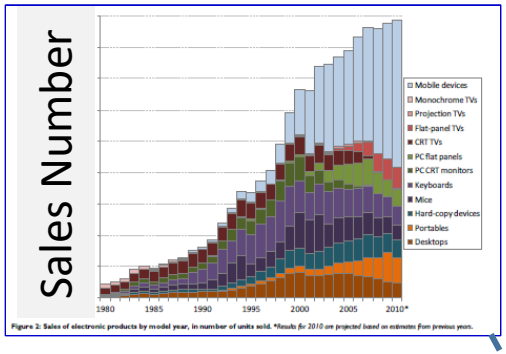
- Run Model buttons for the various assumptions tabs are available within the Control Panel.
  - Clicking those buttons will run the ADEPT with the updated assumptions but not close the Control Panel, permitting the user to make incremental changes to various assumptions without losing all assumption changes.
  - Closing the Control Panel after running the ADEPT, utilizes the red close button in the top right corner or the Run Model button on the General tab.

Quick Start

- Navigate to the sheet labeled INOUT. NOTE: The file may initially open in a non-editable mode and may cause features such as the Control Panel button to be non-responsive. Enable Content button will overcome any snares
- Click the abbreviation for the desired state on the map.
  - This opens the General tab on the Control Panel for the selected state, which is highlighted in the Level of Analysis list.
  - The user can then select the year to be modeled, up to the year 2015.
- Alternatively, the Control Panel button can be selected on the INOUT screen.
  - Opens the Control Panel General tab and you can then select the state from the Level of Analysis list and select the year to be modeled.
- The Control Panel provides access to various tabs where the user can make changes to ADEPT assumptions as you see fit. Toggle buttons provided to either increase or decrease assumption input values or enter a value directly in the data field

Dimensions of Characterizing Flow of Used and Waste Electronics

- Accounts for flow variability, delays, accumulation.
- Forecasting possibilities



- Products change
- Volatile demand-supply

Model Dimension

Dynamic

Static

Bottom up approach

Top down approach

State

Regional

National

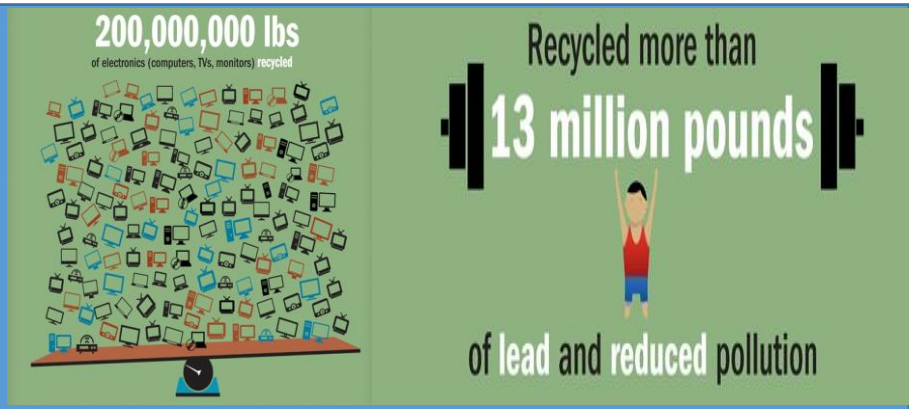
Spatial Dimension

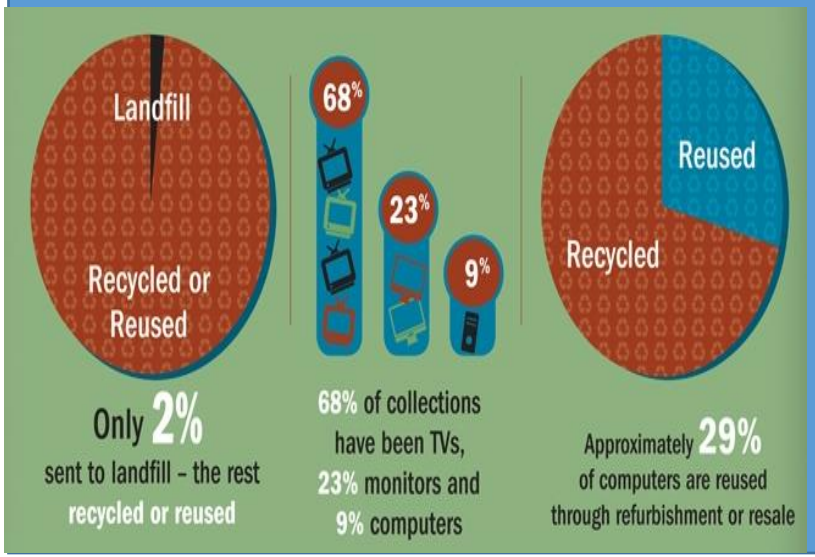
Historic

Future

Time Dimension

E-cycle Washington





Washington State of E-waste flow estimate

Disposal_Year	2015

Products	Total Weight Disposition in 2015 (Metric Tons)				Total
	RES	EDU	COM	INST	
Cell Phones	192.41	12.64	140.46	24.57	**370.08**
Color CRT <19"	2,128.51	532.13	-	-	**2,660.64**
Color CRT >19"	6,668.44	1,667.11	-	-	**8,335.56**
Color Projection	2,434.22	608.55	-	-	**3,042.77**
Desktops	1,928.01	2,306.24	1,597.07	825.35	**6,656.67**
Flat Panel TVs	2,449.52	612.38	-	-	**3,061.89**
Hard Copy Peripherals	3,104.05	260.53	1,496.66	250.63	**5,111.87**
Keyboards	267.42	320.30	311.28	158.65	**1,057.66**
Mice	16.41	19.66	19.08	9.73	**64.88**
Monochrome	88.41	22.10	-	-	**110.51**
PC CRTs	970.00	1,152.31	0.12	23.99	**2,146.41**
PC Flat Panel	1,899.94	2,280.66	2,063.39	1,035.49	**7,279.47**
Portables	1,502.27	302.82	1,262.56	597.86	**3,665.51**
Total E-Waste Disposal	**23,649.62**	**10,097.42**	**6,890.61**	**2,926.26**	**43,563.92**

Material	Commodity Market	Landfill	Total
Aluminum	1,433.47	644.40	**2,077.87**
Battery	399.60	180.19	**579.79**
Copper	805.13	361.33	**1,166.45**
CRT Glass	5,909.62	2,649.29	**8,558.91**
CRT Lead	653.33	292.89	**946.22**
Ferrous Metal	7,697.45	3,454.37	**11,151.81**
Flat Panel Display Module CCFL	1,903.77	854.71	**2,758.48**
Flat Panel Display Module LED	169.11	75.84	**244.95**
Other	328.04	147.62	**475.66**
Other Metals	215.93	97.21	**313.14**
PCB Material	2,648.43	1,189.03	**3,837.46**
Plastics	7,907.32	3,545.85	**11,453.17**
Total E-Waste Disposal	**30,071.19**	**13,492.73**	**43,563.92**

E-Cycle Washington State 2016
(weight in lb)

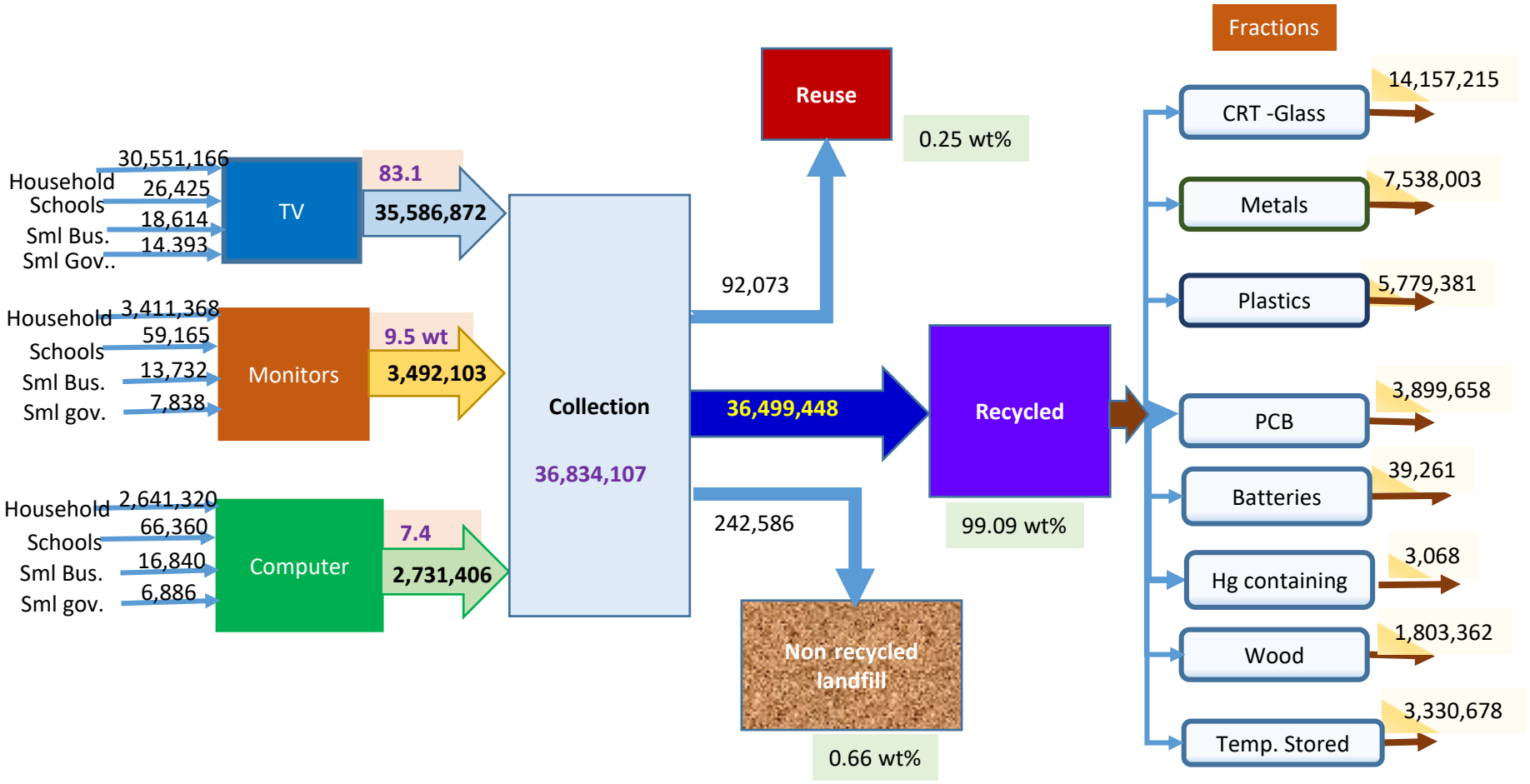
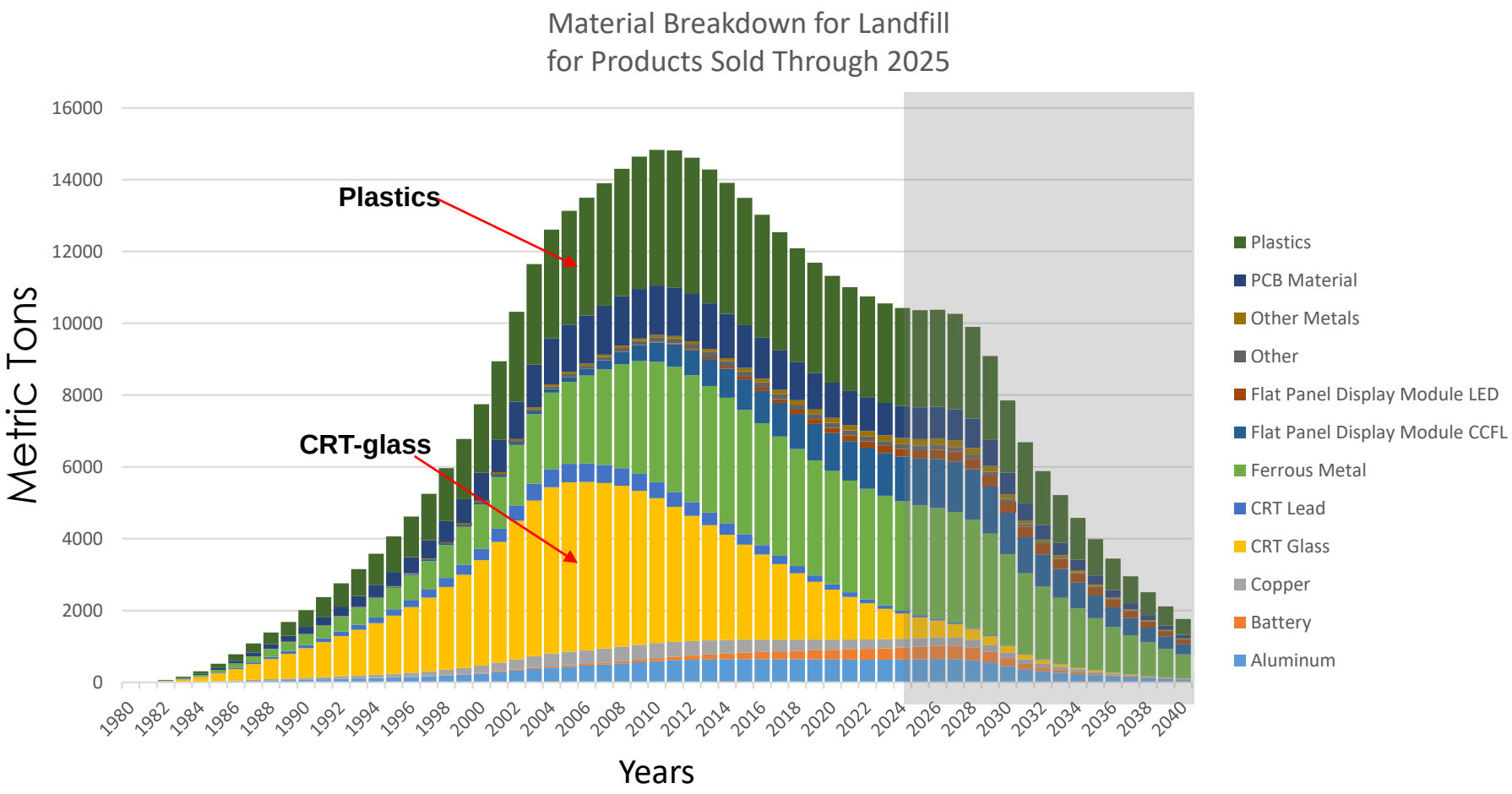
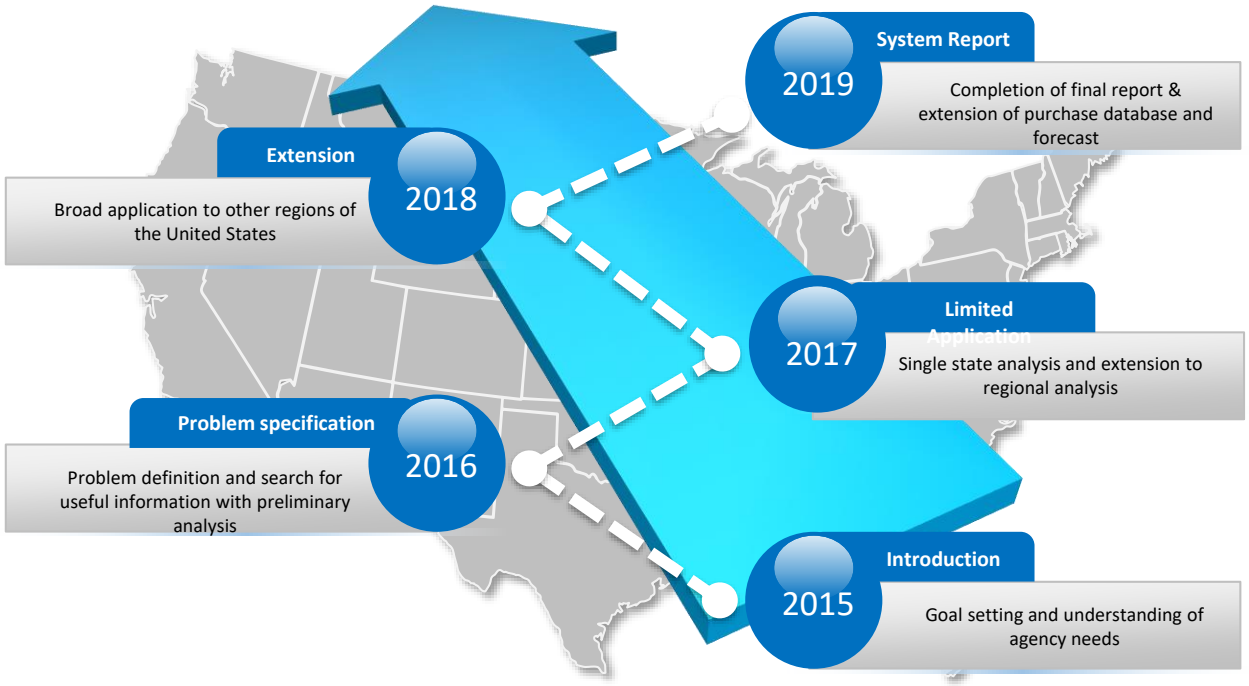


Figure 7

Model prediction of material breakdown of E-waste



USED AND RECYCLED ELECTRONICS FLOW DEVELOPMENT ROADMAP




questions?