



A Tool to Evaluate Used Electronic Flows for the United States

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Disclaimer

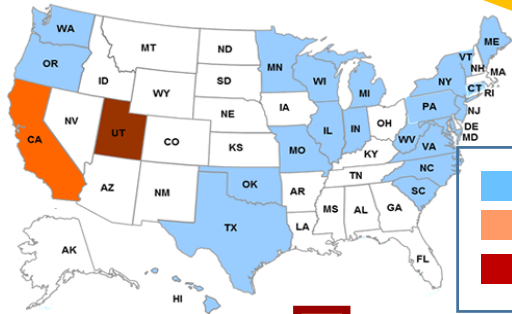
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E-waste

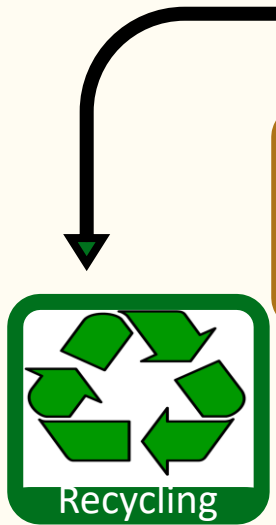
Domestic management
Treatment depends on
state regulations



**Export to
developing countries**



■ Producer responsibility law
■ Consumer law
■ Manufacture education law



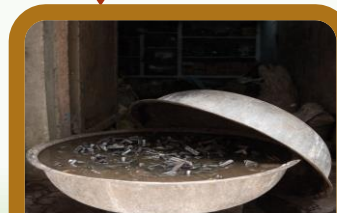
Landfilling



Incineration



Open burning



Acid extraction



Land disposal

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

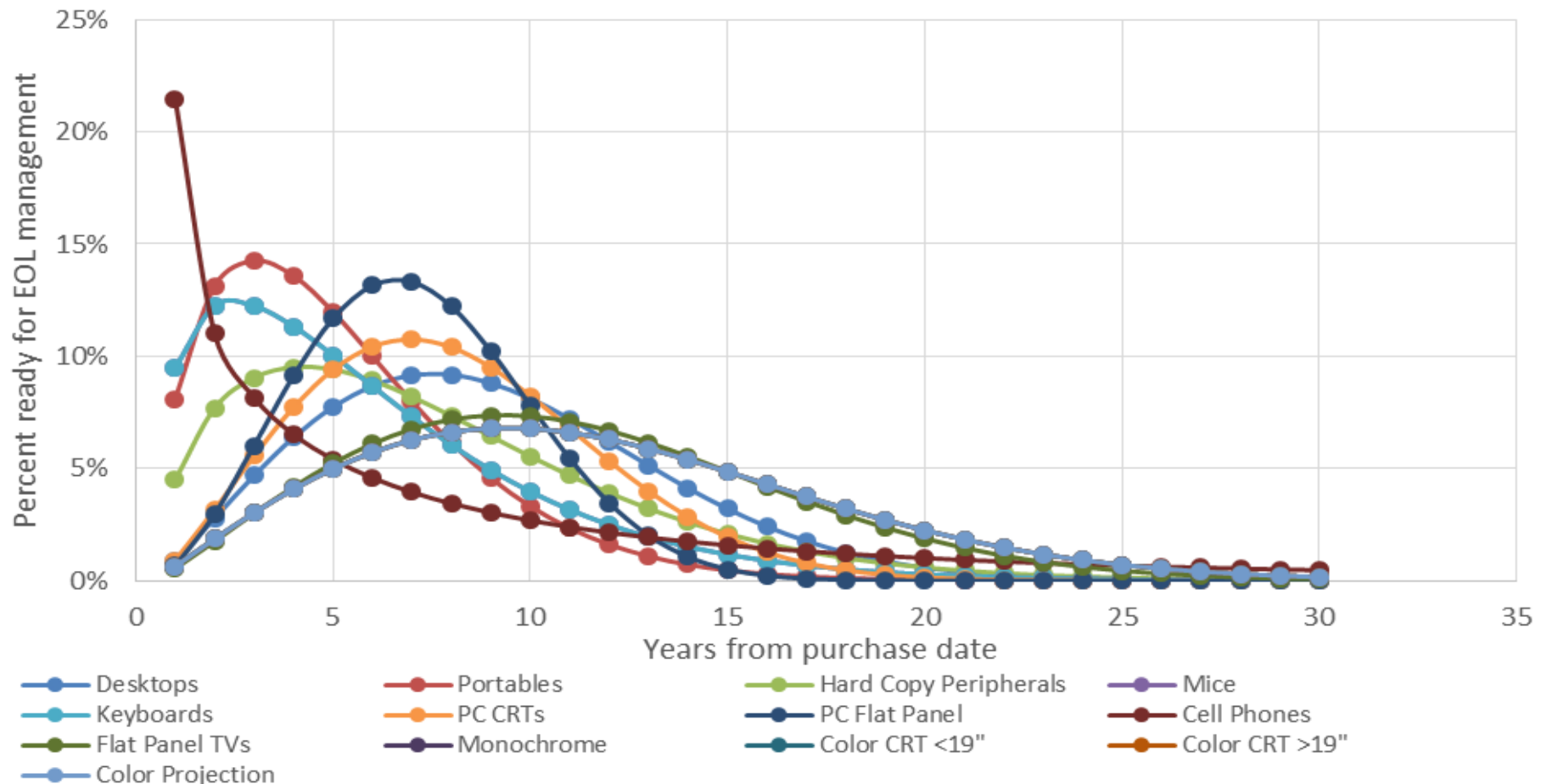
Source: Greenpeace, Basel Action Network,
Source: <http://www.epa.ohio.gov/dmwm/Home/Incinerators.aspx>

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

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

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

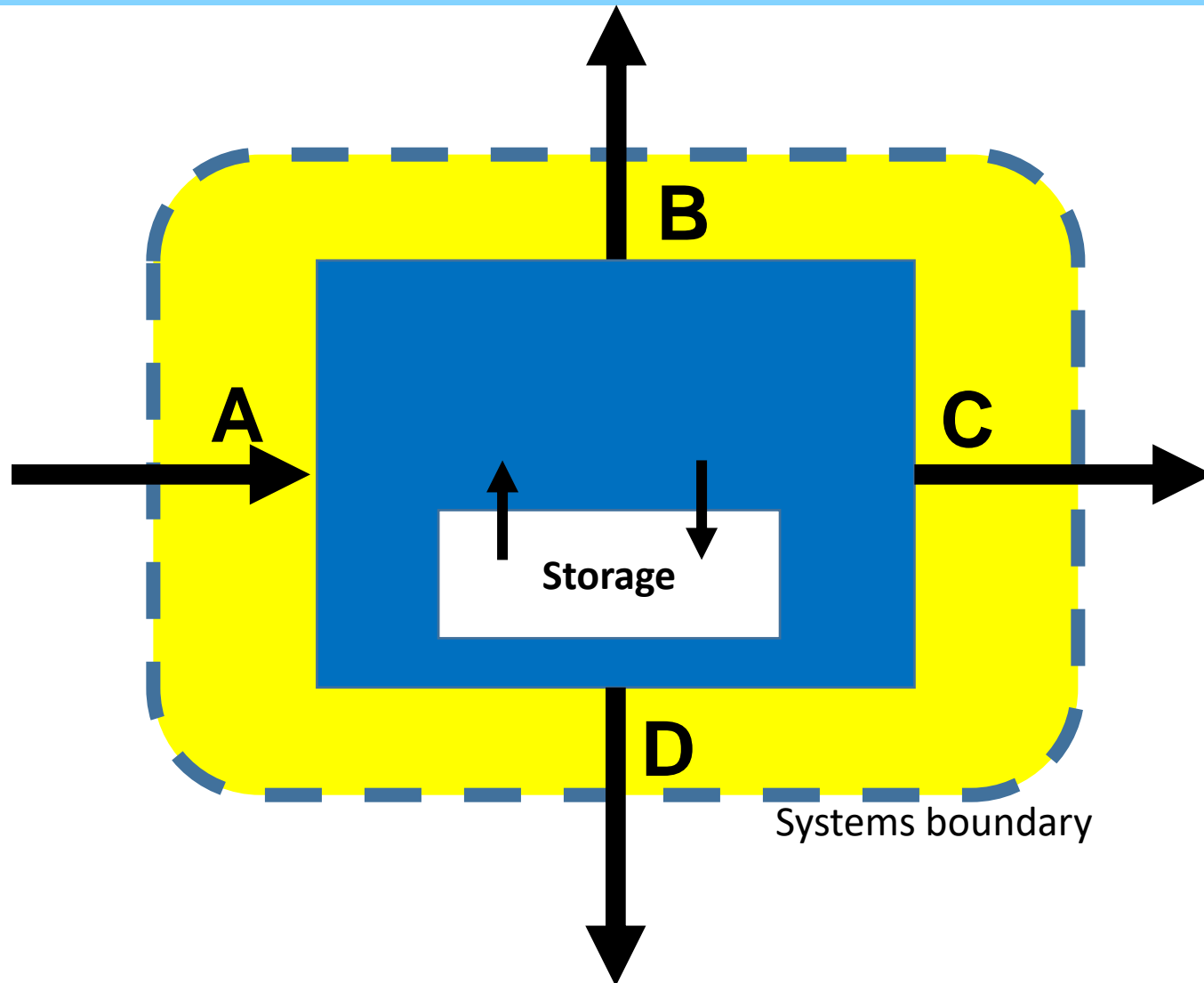
Percentage of Products Ready for End-of-life Management after Each Year of Sale



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.
- Does not account for:
 - specific state policies or actual state-level sales.
 - flows of disposed materials between states are not in the accounting

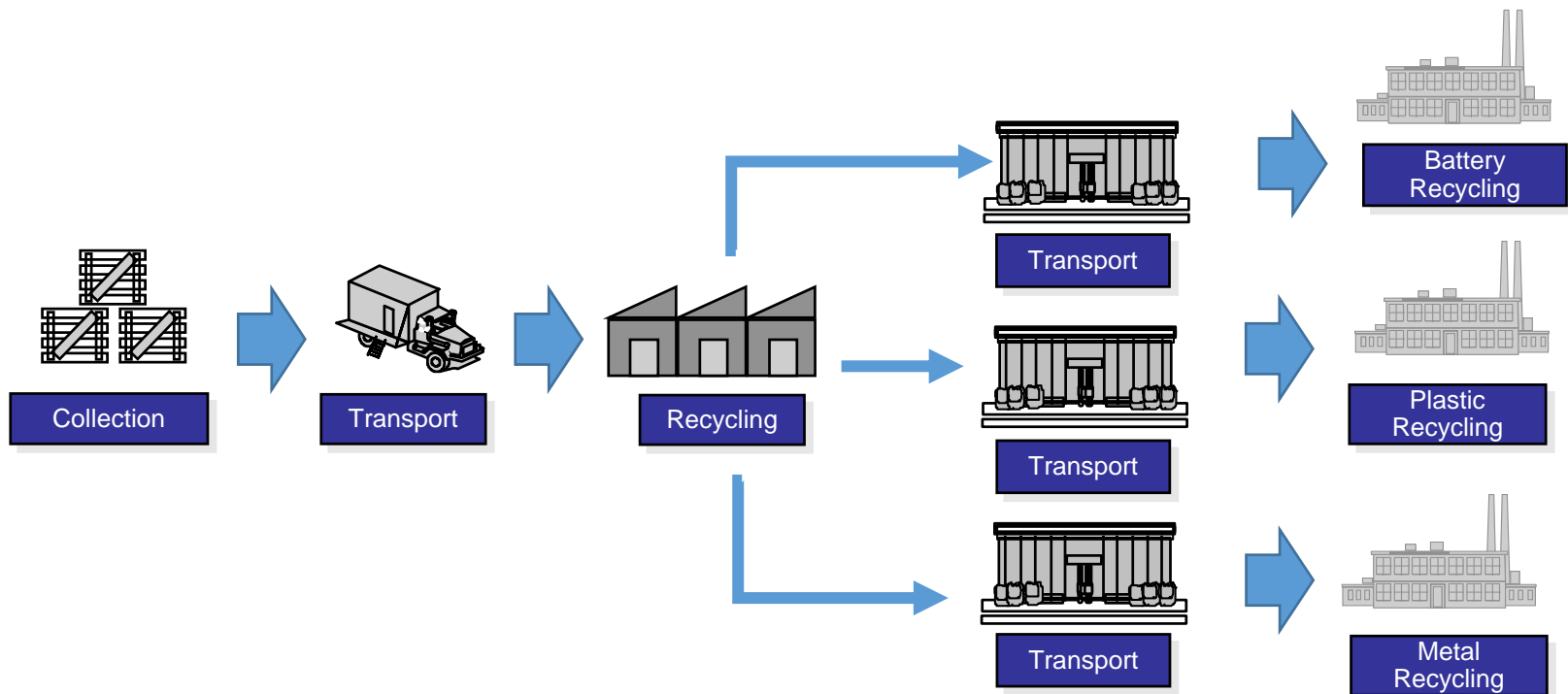
Material Flow Analysis



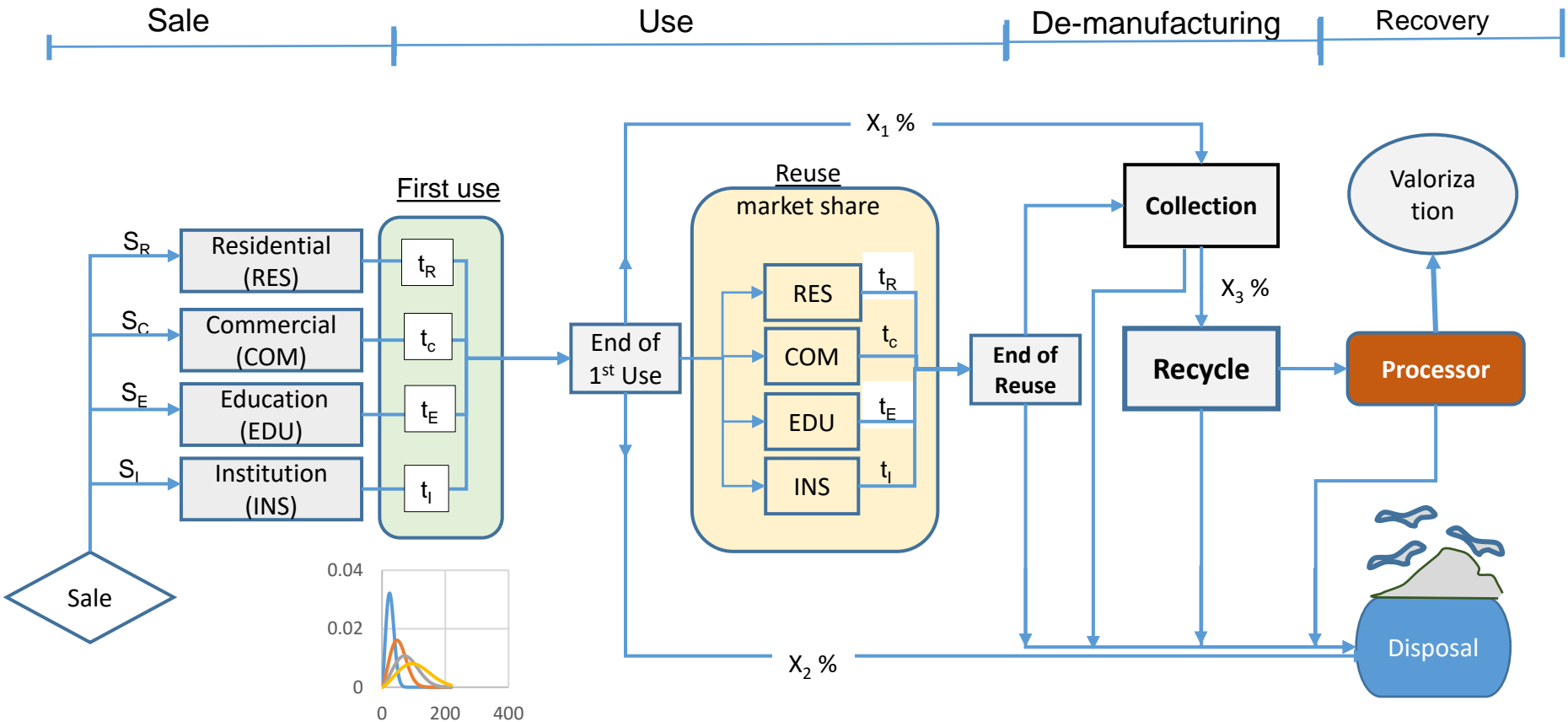
General Assumptions

- 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

E-Waste by Market Tracking Tool

Developed by RTI International for EPA's Office of Research and Development (ORD)



Click on a state abbreviation to see that state or press the Control Panel button



US map from https://simple.wikipedia.org/wiki/US_state_abbreviations



Disposal_Waste 2025				
Products	Total Weight Disposition in 2025 (Metric Tons)			
	ECS	EDB	CMS	TOTAL
Cell Phones	8,143.28	555.64	5,858.15	14,557.07
Color CRT <15"	34,263.83	23,587.45	-	57,851.28
Color CRT >15"	234,882.45	73,588.54	-	308,470.99
Color Projection	185,243.77	25,588.54	-	210,832.31
Desktops	83,855.52	35,517.11	55,885.32	175,257.95
Flat Panel TVs	182,851.33	25,788.88	-	208,640.21
Hard Copy Peripherals	151,438.74	14,872.15	52,453.38	218,764.27
Keyboards	11,328.33	12,558.33	15,143.33	39,029.99
Mice	635.43	832.75	886.27	2,354.45
Monitors	4,181.43	1,825.36	-	6,006.79
PC CRTs	42,351.37	18,288.38	4.83	60,644.58
PC Flat Panel	88,462.57	56,572.53	86,157.38	231,192.48
Peripherals	52,688.18	12,435.83	52,725.12	117,849.13
Total E-Waste Disposal	1,000,000.00	1,000,000.00	287,834.15	2,287,834.15

Material	Commodity Market	Landfill	Total
Aluminum	51,866.75	27,458.57	79,325.32
Battery	16,535.18	7,527.58	24,062.76
Copper	34,435.25	15,454.13	49,889.38
CRT Glass	268,834.83	116,573.18	385,408.01
CRT Lead	28,748.33	12,888.15	41,636.48
Fluorescent Bulb	525,643.57	145,585.35	671,228.92
Flat Panel Display Module CCFL	73,343.62	35,838.38	109,182.00
Flat Panel Display Module LED	7,839.27	5,183.33	13,022.60
Other	19,855.55	6,235.83	26,091.38
Other Metals	3,875.55	4,886.15	8,761.70
PCB Metals	149,755.16	51,863.34	201,618.50
Plastics	337,572.76	151,374.63	488,947.39
Total E-Waste Disposal	1,000,000.00	1,000,000.00	2,287,834.15

Disposition in Worksheet Shows Estimated Waste Total			
Model	Material	Model	Material
Model A	Material A	Model B	Material B
Model C	Material C	Model D	Material D
Model E	Material E	Model F	Material F
Model G	Material G	Model H	Material H
Model I	Material I	Model J	Material J
Model K	Material K	Model L	Material L
Model M	Material M	Model N	Material N
Model O	Material O	Model P	Material P
Model Q	Material Q	Model R	Material R
Model S	Material S	Model T	Material T
Model U	Material U	Model V	Material V
Model W	Material W	Model X	Material X
Model Y	Material Y	Model Z	Material Z
Model AA	Material AA	Model AB	Material AB
Model AC	Material AC	Model AD	Material AD
Model AE	Material AE	Model AF	Material AF
Model AG	Material AG	Model AH	Material AH
Model AI	Material AI	Model AJ	Material AJ
Model AK	Material AK	Model AL	Material AL
Model AM	Material AM	Model AN	Material AN
Model AO	Material AO	Model AP	Material AP
Model AQ	Material AQ	Model AR	Material AR
Model AS	Material AS	Model AT	Material AT
Model AU	Material AU	Model AV	Material AV
Model AW	Material AW	Model AX	Material AX
Model AY	Material AY	Model AZ	Material AZ
Model BA	Material BA	Model BB	Material BB
Model BC	Material BC	Model BD	Material BD
Model BE	Material BE	Model BF	Material BF
Model BG	Material BG	Model BH	Material BH
Model BI	Material BI	Model BJ	Material BJ
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Model BO	Material BO	Model BP	Material BP
Model BQ	Material BQ	Model BR	Material BR
Model BS	Material BS	Model BT	Material BT
Model BU	Material BU	Model BV	Material BV
Model BW	Material BW	Model BX	Material BX
Model BY	Material BY	Model BZ	Material BZ
Model CA	Material CA	Model CB	Material CB
Model CC	Material CC	Model CD	Material CD
Model CE	Material CE	Model CF	Material CF
Model CG	Material CG	Model CH	Material CH
Model CI	Material CI	Model CJ	Material CJ
Model CK	Material CK	Model CL	Material CL
Model CM	Material CM	Model CN	Material CN
Model CO	Material CO	Model CP	Material CP
Model CQ	Material CQ	Model CR	Material CR
Model CS	Material CS	Model CT	Material CT
Model CU	Material CU	Model CV	Material CV
Model CW	Material CW	Model CX	Material CX
Model CY	Material CY	Model CZ	Material CZ
Model DA	Material DA	Model DB	Material DB
Model DC	Material DC	Model DD	Material DD
Model DE	Material DE	Model DF	Material DF
Model DG	Material DG	Model DH	Material DH
Model DI	Material DI	Model DJ	Material DJ
Model DK	Material DK	Model DL	Material DL
Model DM	Material DM	Model DN	Material DN
Model DO	Material DO	Model DP	Material DP
Model DQ	Material DQ	Model DR	Material DR
Model DS	Material DS	Model DT	Material DT
Model DU	Material DU	Model DV	Material DV
Model DW	Material DW	Model DX	Material DX
Model DY	Material DY	Model DZ	Material DZ
Model EA	Material EA	Model EB	Material EB
Model EC	Material EC	Model ED	Material ED
Model EE	Material EE	Model EF	Material EF
Model EG	Material EG	Model EH	Material EH
Model EI	Material EI	Model EJ	Material EJ
Model EK	Material EK	Model EL	Material EL
Model EM	Material EM	Model EN	Material EN
Model EO	Material EO	Model EP	Material EP
Model EQ	Material EQ	Model ER	Material ER
Model ES	Material ES	Model ET	Material ET
Model EU	Material EU	Model EV	Material EV
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Model FG	Material FG	Model FG	Material FG

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.

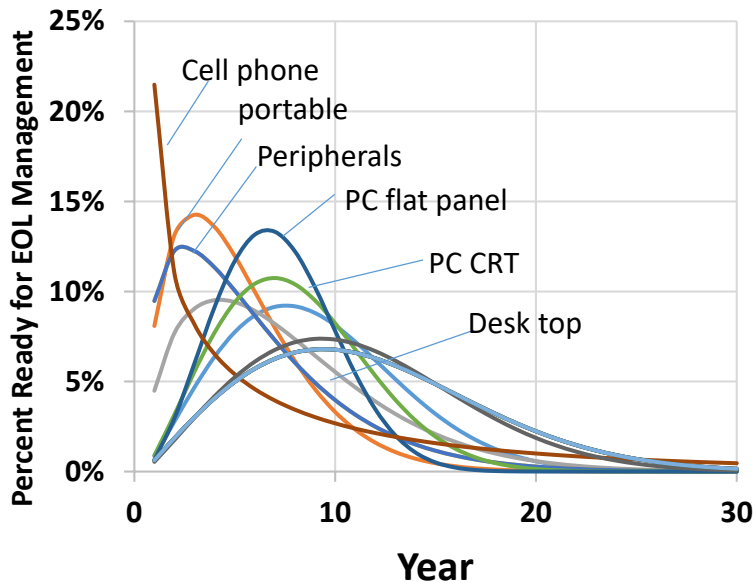
Weibull distributions to product lifetimes

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

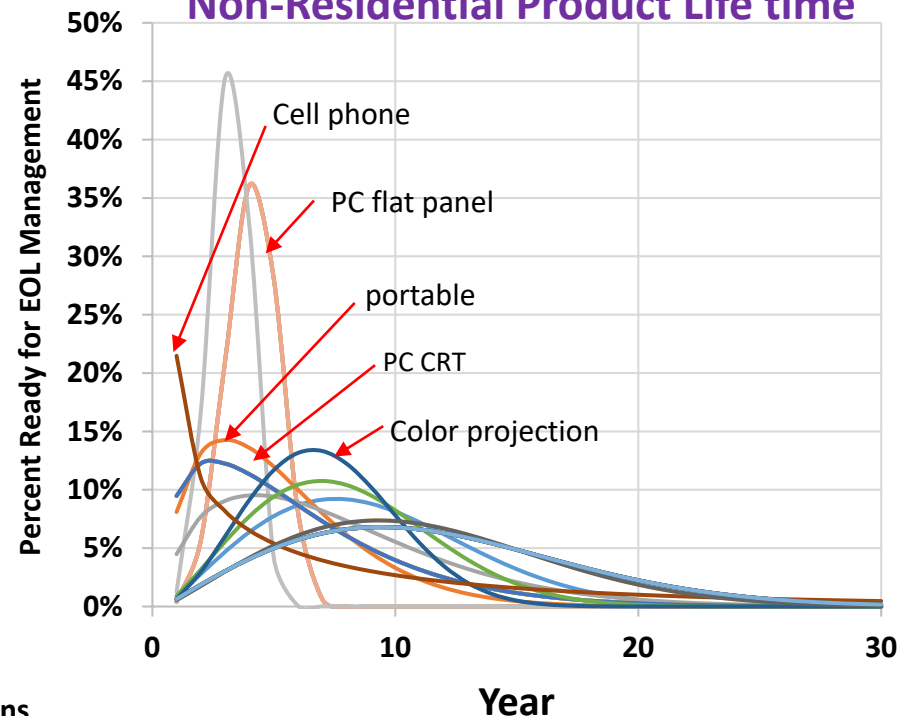
Where: t = Year when the product was sold
 T = Year when e-waste was generated
 Sales_t = Industry sales for year t
 β = Weibull distribution scaling factor
 α = Weibull distribution shape factor.

Lifetime depends on the type of product and economic sector

Residential Product Life time



Non-Residential Product Life time



Operational Assumptions

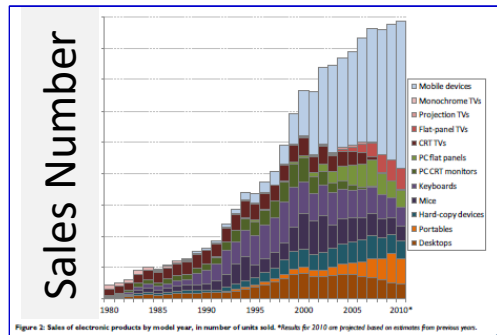
- Assumptions are designed to be changed within the Control Panel. Any assumption initially presented to the user in the Control Panel can be adjusted
- Run Model buttons for the various assumptions tabs are available within the Control Panel.
 - Clicking those buttons will run the ADEPT with the updated 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

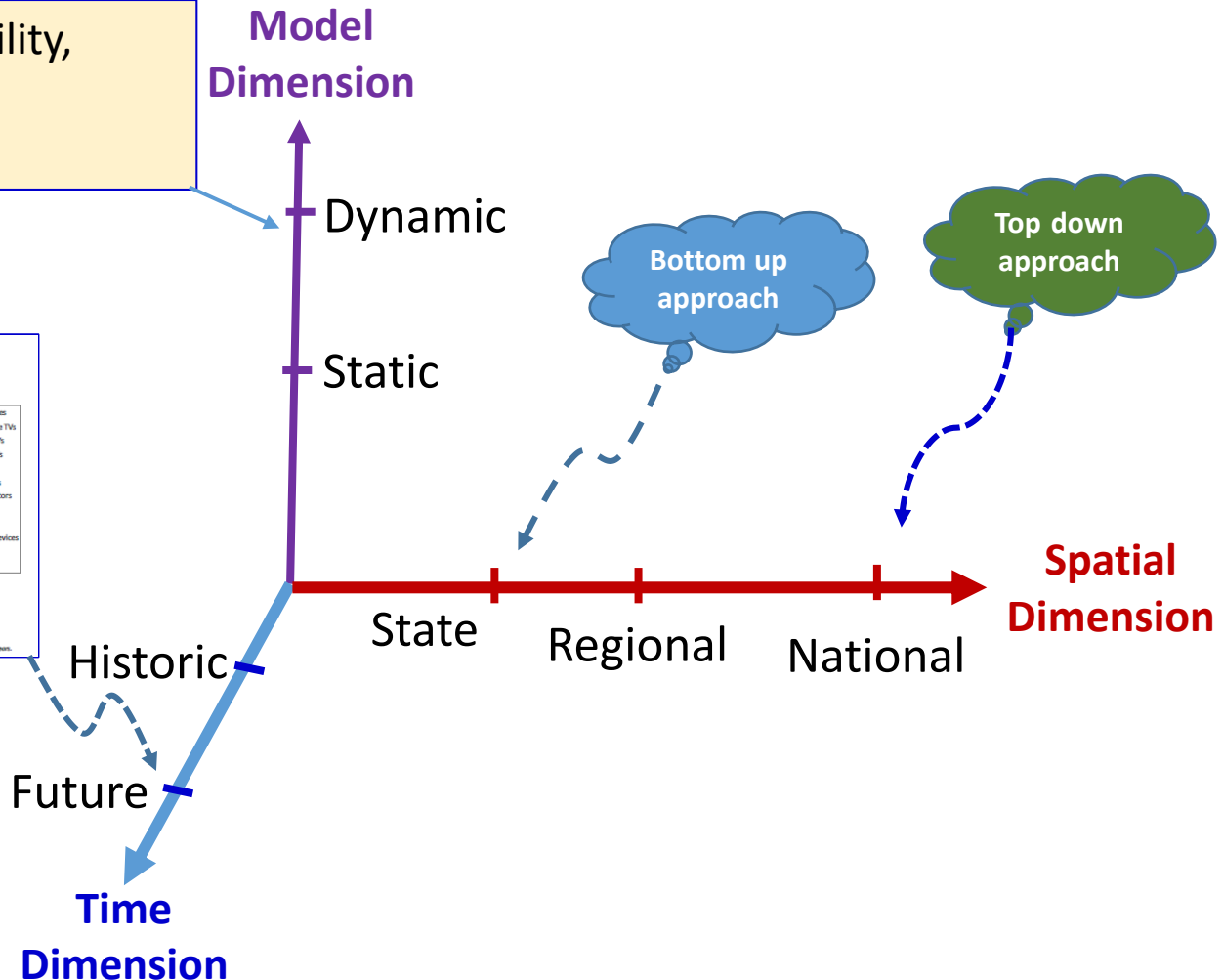
- Navigate to the sheet labeled INOUT. NOTE: The file may initially open in a non-editable mode and may cause features such as the Control Panel button to be non-responsive. Enable Content button will overcome any snares
- Click the abbreviation for the desired state on the map.
 - This opens the General 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



E-cycle Washington



90%
of residents have a
recycling location within
10 miles of their home



E-Cycle Washington
has expanded since 2009
and now includes tablet
computers, e-readers and
portable DVD players



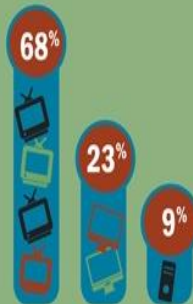
200,000,000 lbs
of electronics (computers, TVs, monitors) recycled



Recycled more than
13 million pounds
of lead and reduced pollution



Only **2%**
sent to landfill – the rest
recycled or reused



68% of collections
have been TVs,
23% monitors and
9% computers



Approximately **29%**
of computers are reused
through refurbishment or resale

Manufacturers have provided **\$47**
million dollars in electronics
recycling services at no cost to
local governments or consumers
(from January 2009 – July 2013)



No
toxic materials
exported to
developing nations



Created over **125 jobs** for independent collection, transportation
and processing enterprises across the state

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)

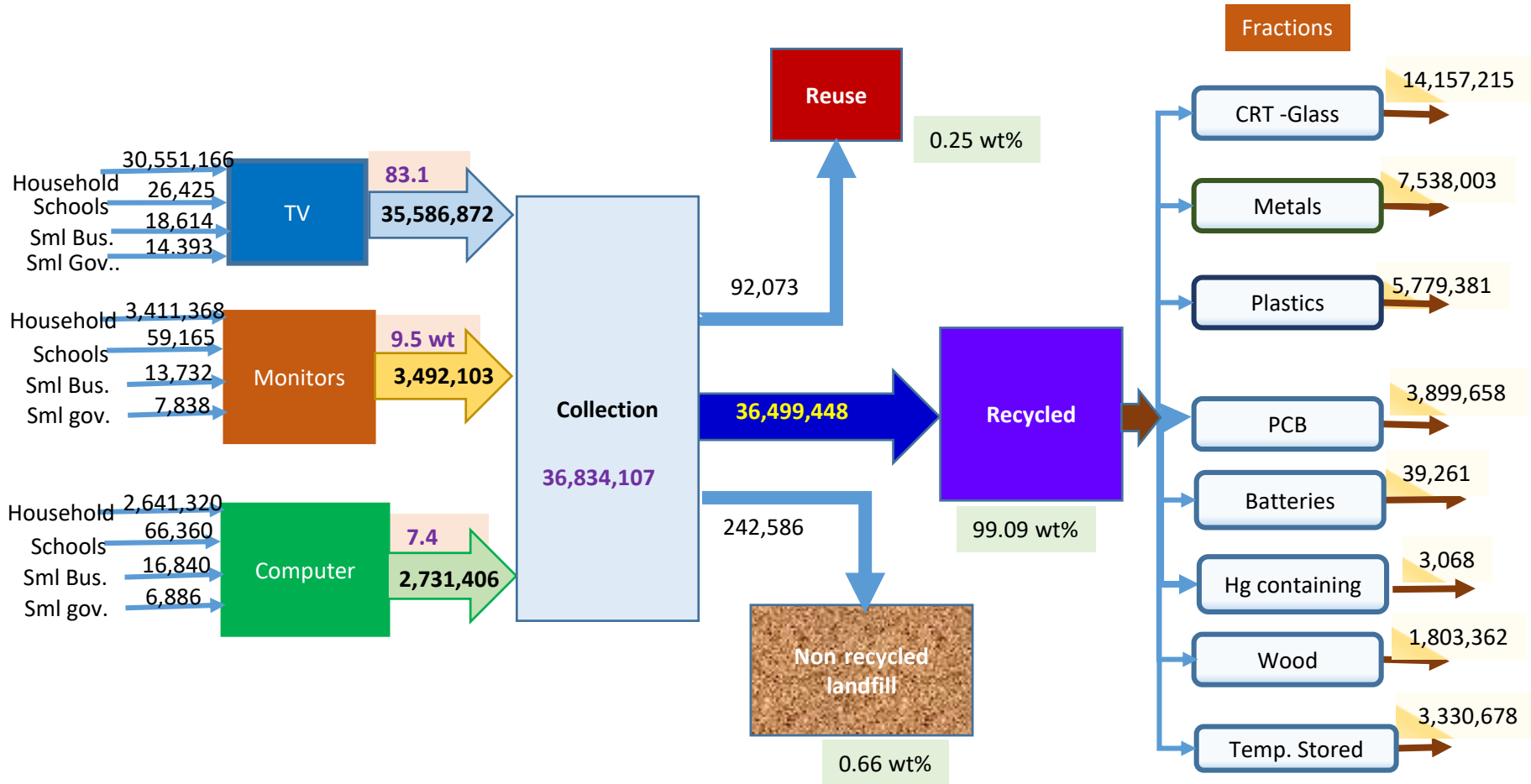
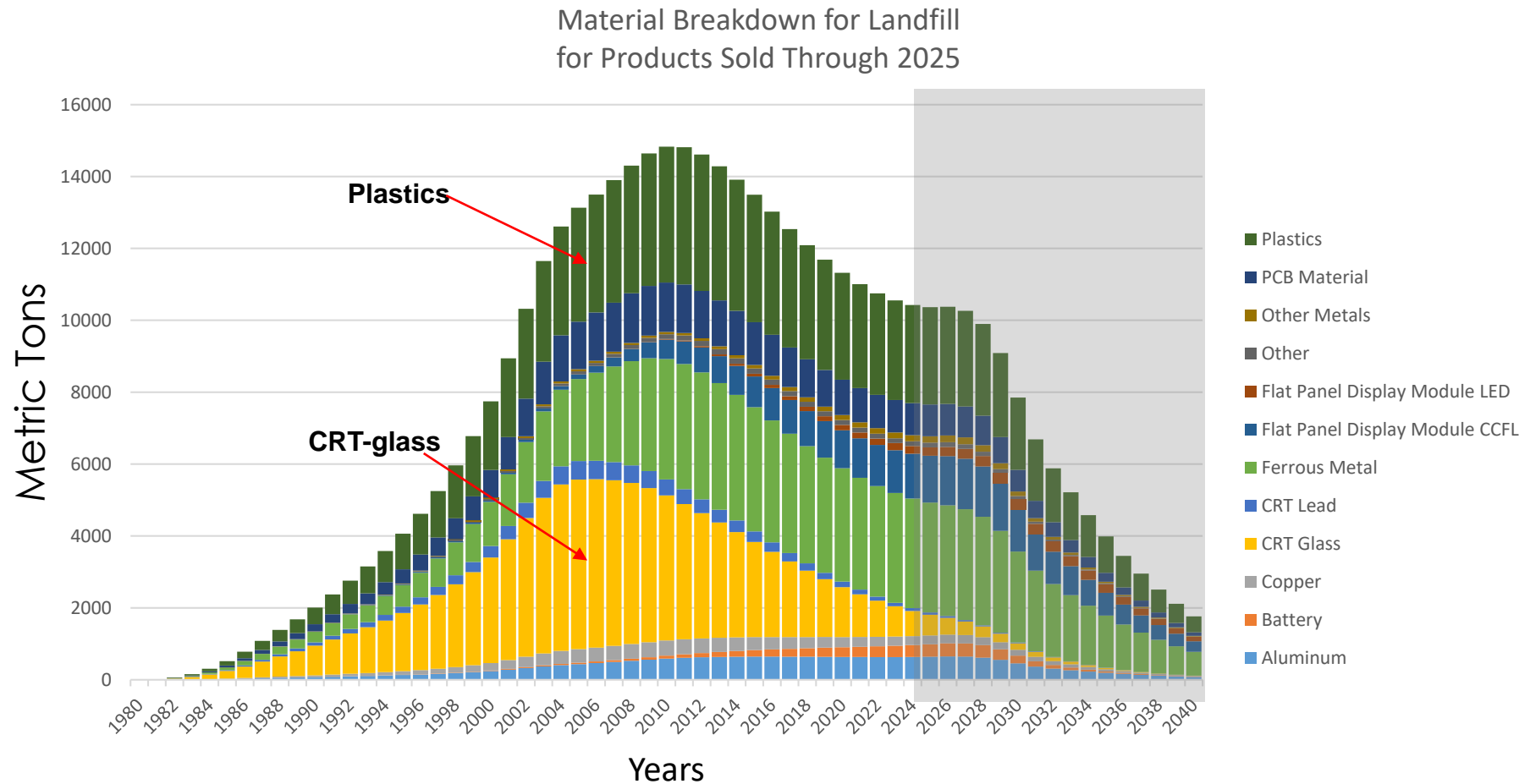


Figure 7

Model prediction of material breakdown of E-waste



USED AND RECYCLED ELECTRONICS FLOW DEVELOPMENT ROADMAP





Questions?