

# Dealing with e-waste

AN INTRODUCTORY LECTURE BY IAN WILLIAMS

E-Textiles Network: Manufacture and Sustainability of E-Textiles  
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# EEE (Electrical and electronic equipment)

## European Union (Directive 2012/19/EU) definition:

“equipment which is dependent on electrical currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1000 Volts for alternating current (AC) and 1500 Volts for direct current” (European Union, 2012)

# WEEE or “e-waste”

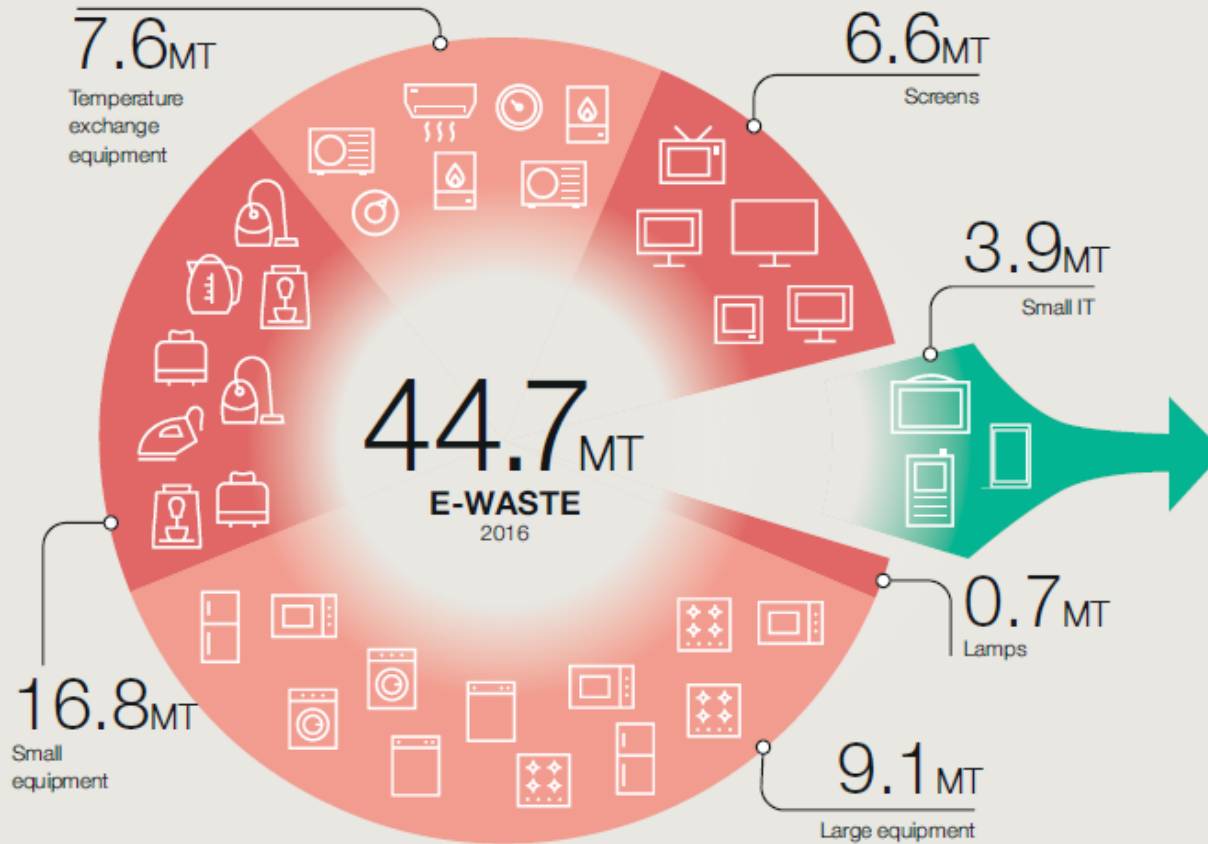
## **Anything with a plug, electric cord or battery**

- Complex mixture of materials + components
- Because of hazardous content & if not properly managed can cause major environmental / health problems
- Production of modern electronics requires use of scarce and expensive resources
- To improve environmental management of WEEE, to contribute to circular economy and enhance resource efficiency, improvement of collection, treatment & recycling of electronics at EoL is essential

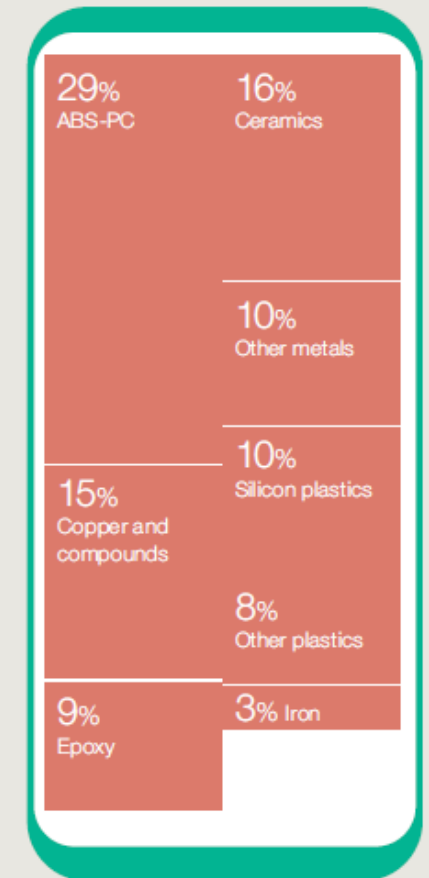


**Modern society involves consumption**

# WHAT IS E-WASTE?



What's in a typical mobile phone?

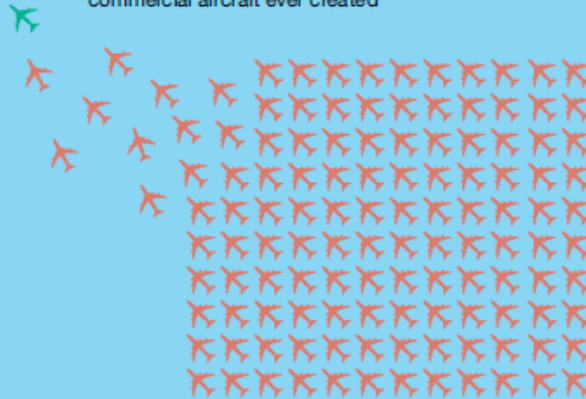


# HOW MUCH E-WASTE DO WE GENERATE EVERY YEAR?

We produce 50 million tonnes of e-waste a year that is the equivalent of....

125,000

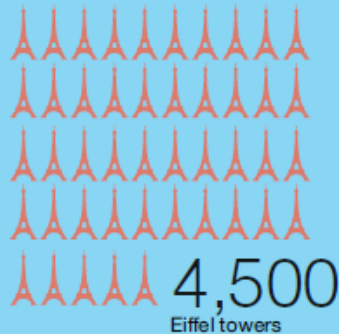
jumbo jets which is more than all the commercial aircraft ever created



It would take Heathrow Airport in London up to six months, day in and day out, to clear that many aircraft from its runways.

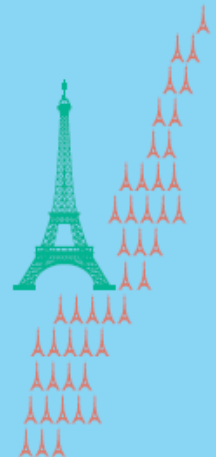


This is an equivalent of almost 4,500 Eiffel towers.

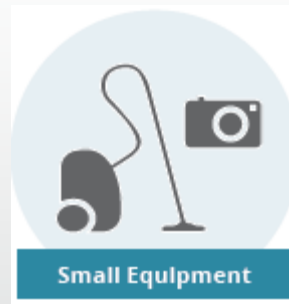
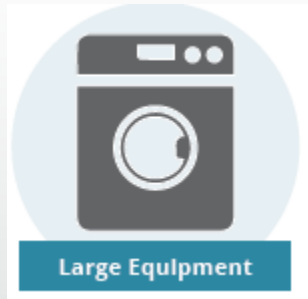
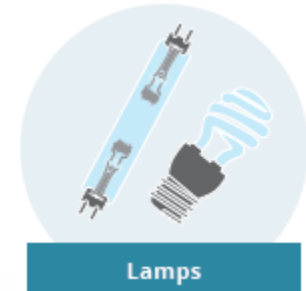
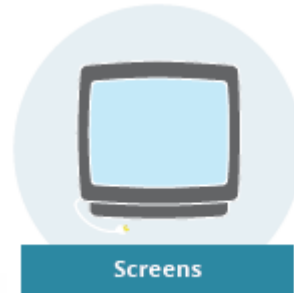
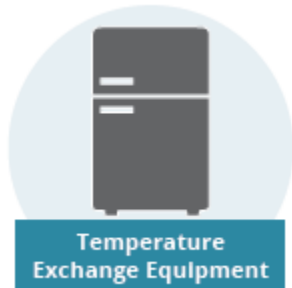


Jam them all in one space, side by side, and they would cover an area the size of Manhattan.

the size of  
Manhattan



# WEEE categories



# WEEE (or e-waste)

- Unavoidable, huge waste management challenge for developed and developing countries
- Annual growth rate of 4-5%
- WEEE generated in “throwaway societies” via:
  - i) Market forces (e.g. technological advances or fashion)
  - ii) Consumer behaviour
  - iii) Product features (e.g. material composition, condition, or reusability)
  - iv) Lack of infrastructure/services to collect WEEE
- Challenge to promote slower rate of consumption and to increase reuse of EEE

# Evolution of the radio



- Steady technological advances
- Relatively slow evolution of product with long lifetime
- Slow change in complexity, number of elements in product and number of users
- Relatively minor consequences for waste management
- Move from analogue to digital radio

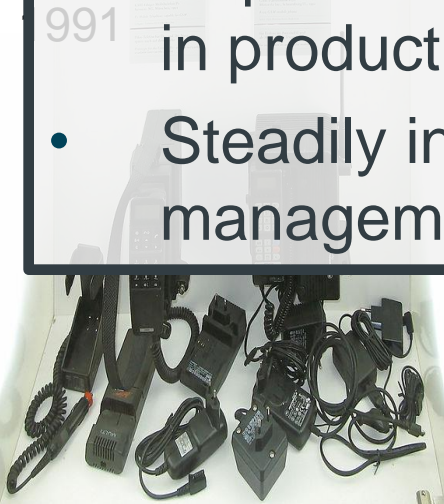


# Evolution of mobile phones



2011

- Rapid technological advances
- Rapid evolution of product and functionality with increasingly short lifetime
- Rapid increase in complexity, number of elements used in product and number of users
- Steadily increasing consequences for waste management



2007



2019

# Results: Evolutionary Timelines

## 1. Evolution

**1800s:**  
Since 1861 electric low and incandescent and Oliver compressed prototypes in 1895, the

## 2. Evolution

**1927:**  
The first 'neon lamp' that  
**1930s:**  
The first 'elect' (B&W) televis

## 3. Evolution

**1980s:**  
HDTV technol  
VCR, players  
shift to CD pl  
revolutionise  
(Monaghan, 2

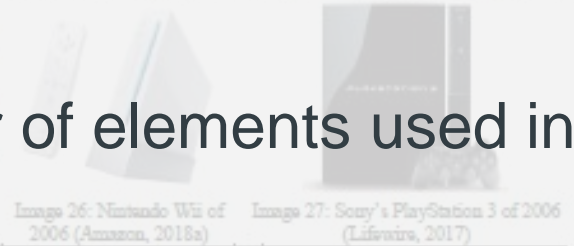
**1960:**  
Mattel launched its  
game system, with  
than the VCS, with  
NBA Basketball, 1  
first video game  
microprocessor.  
(Miller, 2005; Pol

**The 5<sup>th</sup> generat**  
**1989:**  
NEC's TurboGrafi  
marked the beginn  
generation of gam  
the first console to  
player attachment.

**1996:**  
Nintendo release  
game system, the  
incorporating a 6  
brunch was huge  
units sold in the  
(Miller, 2005; Pe

**Towards the 8<sup>th</sup> Generation of Game Consoles (2005-Present)**  
Currently there are 3 major competitors in the market: Microsoft's Xbox series, Sony's PlayStation series and Nintendo.

2005



2013

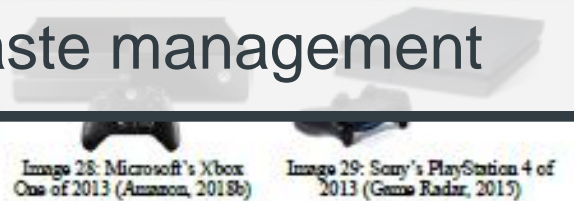


Image 30: Nintendo Switch gaming console of 2017 (Two Honest Guys, 2017)

- Very rapid technological advances
- Very rapid evolution of product and functionality with increasingly short lifetime
- Huge increase in complexity, number of elements used in product and number of users
- Very significant consequences for waste management

**Starophor**  
By mid-19  
introduced  
Speakers b

(Hall, 2011)

**Modern A**  
In the 2000  
instigated;  
speakers; s

(Wagner, 2

**1970s:**  
In 1972, West  
first LCD pane  
By 1973, TV s  
exponentially,  
being sold to n  
and 60s sets.

**1975-1976:**  
Betamax vide  
home recordi  
introduced (In  
(Television Hi  
2005, 2016)

(Bogner, 2011)

**Chromecast**  
(Television H  
(Williams, 20

**2010-Present**  
After 2010, fl  
LCDs), comp  
panel "Smart"  
in high-defini  
USB device o

(Bogner, 2011)

**1978:**  
Magnavox laun  
game console kn  
more popular in E  
where it was mar

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(Miller, 2005; Pe

**1989:**  
Sega released the  
system in the US;  
Master System (o  
10) incorporating  
glasses for certain  
Nintendo released  
programmable las  
system, known as  
(Image 11); the tw  
best-selling video

(Miller, 2005; Pol

**Featured high-**  
**1995:**  
Sony released the  
system, the PlaySt  
incorporating a 32  
Backed by a large  
the console unres  
to become the leas  
system, selling m  
units worldwide.  
Nintendo launche  
starting console  
reality gaming (In  
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a 733MHz Pentii  
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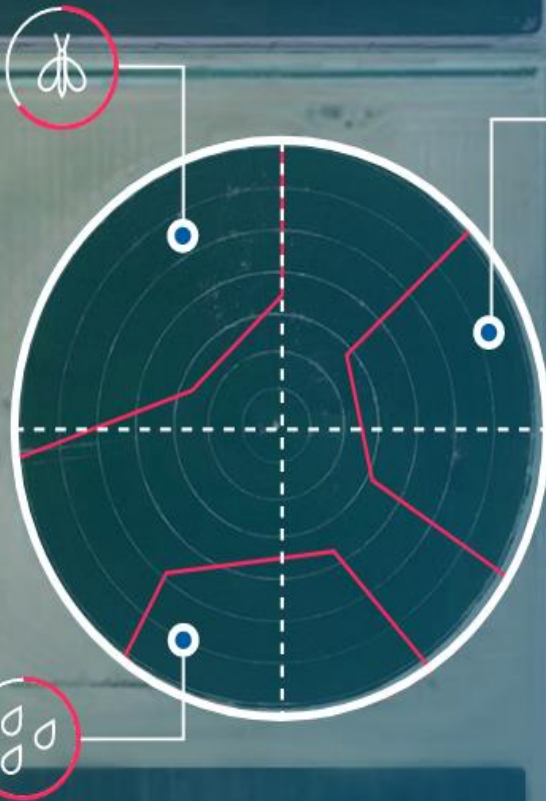
(Miller, 2005; Pe

(Image 24), which sold over 80 million units throughout its product lifecycle. Two updated models of the Xbox360 were released in 2010 and 2013 (Image 25) (Poh, 2017).

**2006:**  
Nintendo released the Wii game console (Image 26) selling more than 100 million units throughout its product lifecycle, popular due to its simplicity and ease of use. It was replaced in 2007 (Image 27) with sophisticated 60GB hard-drive capabilities and internet capabilities.

**2013:**  
Microsoft released the Xbox One console (Image 28) which sold approximately 30 million copies worldwide (Court, 2013). Sony released their 8<sup>th</sup> generation video game console, named PlayStation 4 (PS4; Image 29) (Court, 2013).

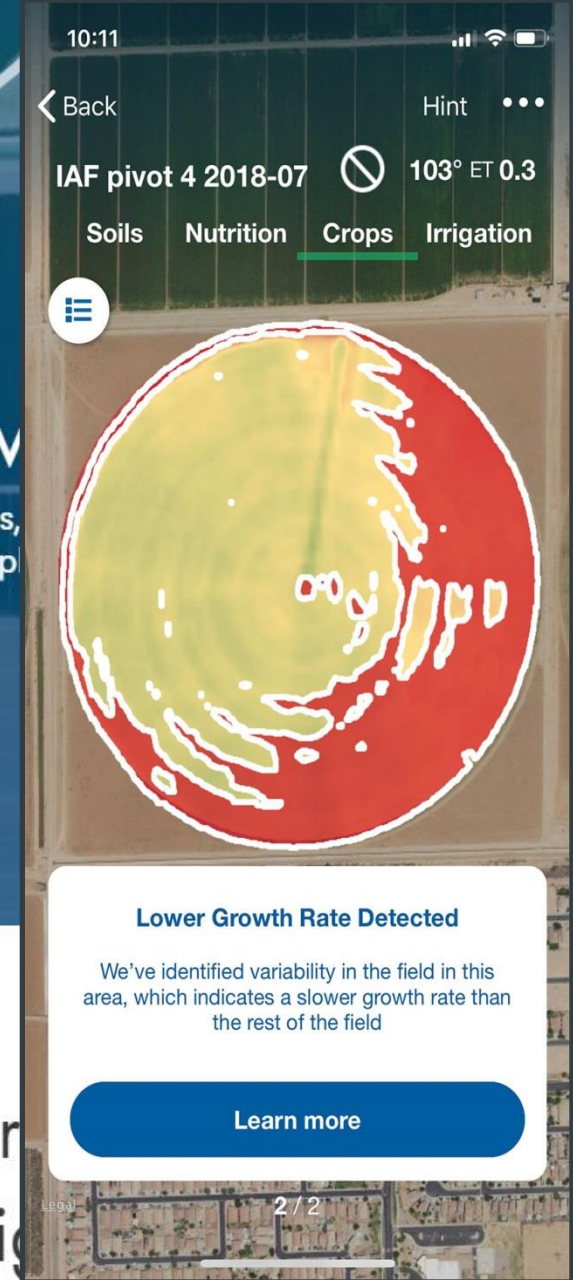
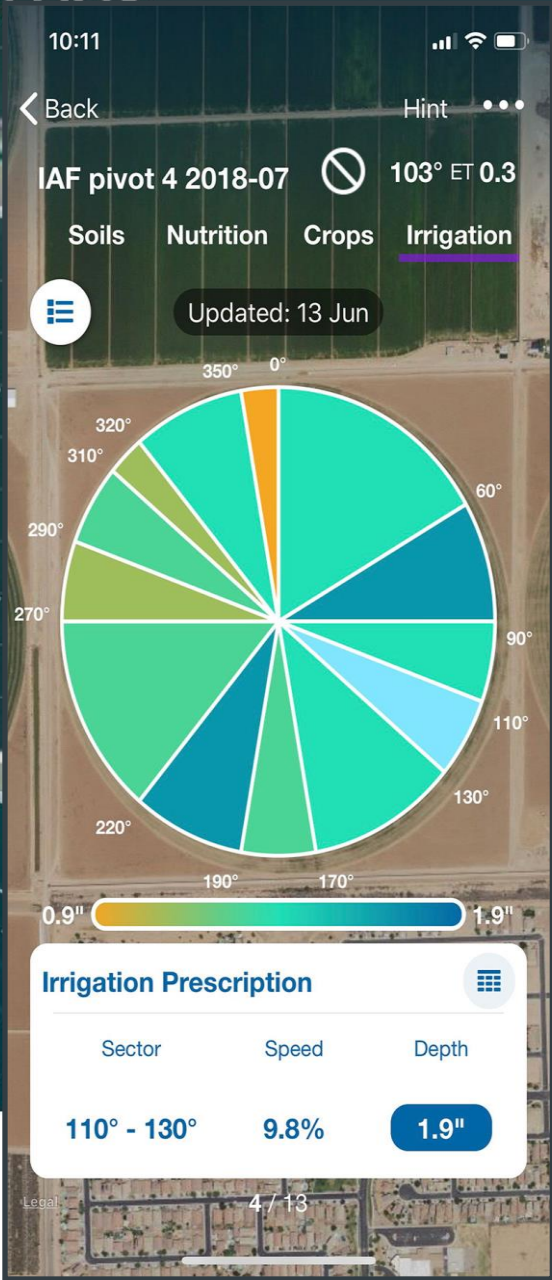
**2017:**  
Nintendo released their newest game console, the Switch (Image 30) acting as the first 'hybrid' console, which allows for both portable gaming through a 6.2-inch display, as well as home video gaming through its detachable hand-sets (Nations, 2017).



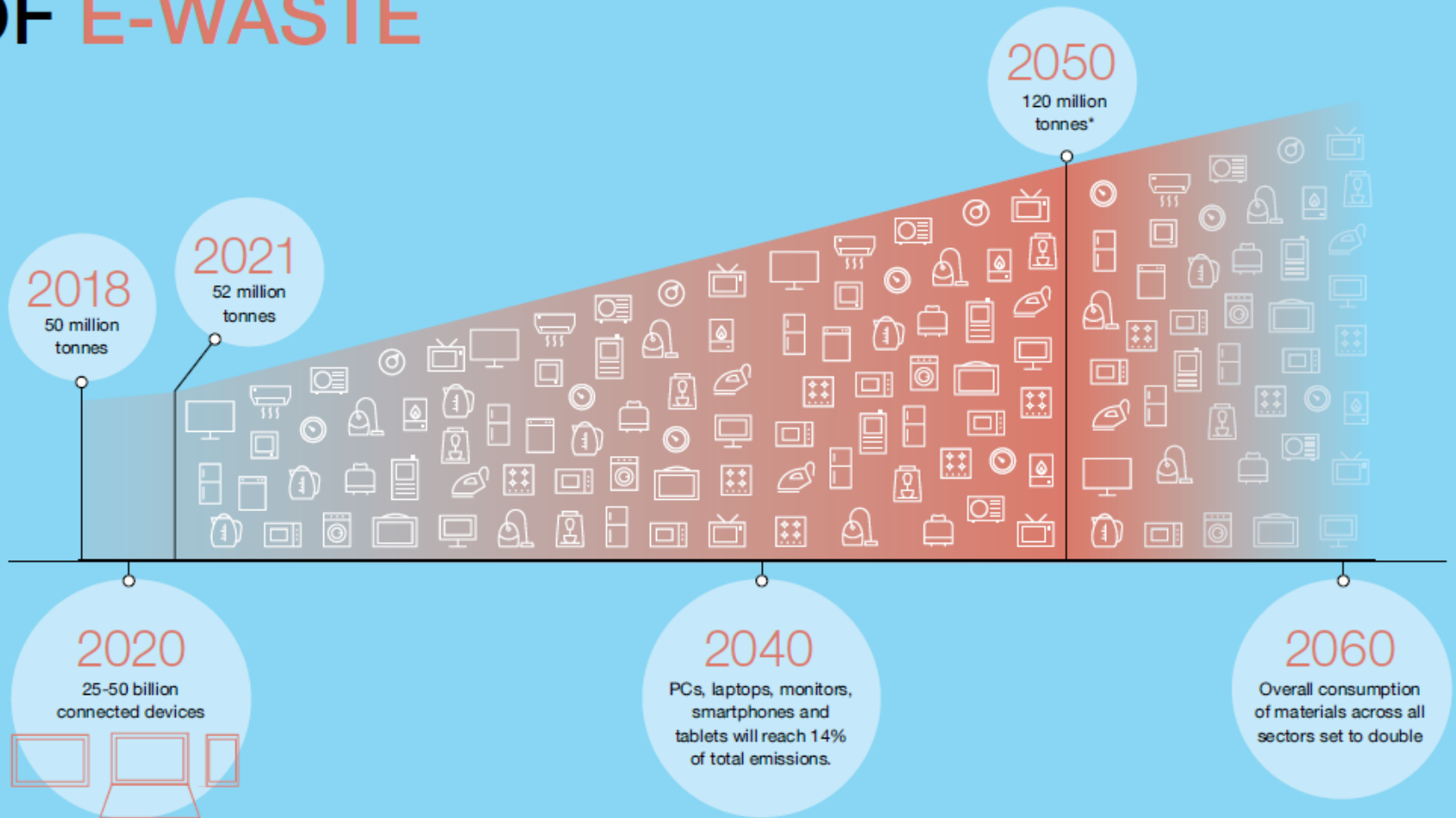
# Data-driven Farming

Grow more with less, using the world's 1st DIY farm management platform.

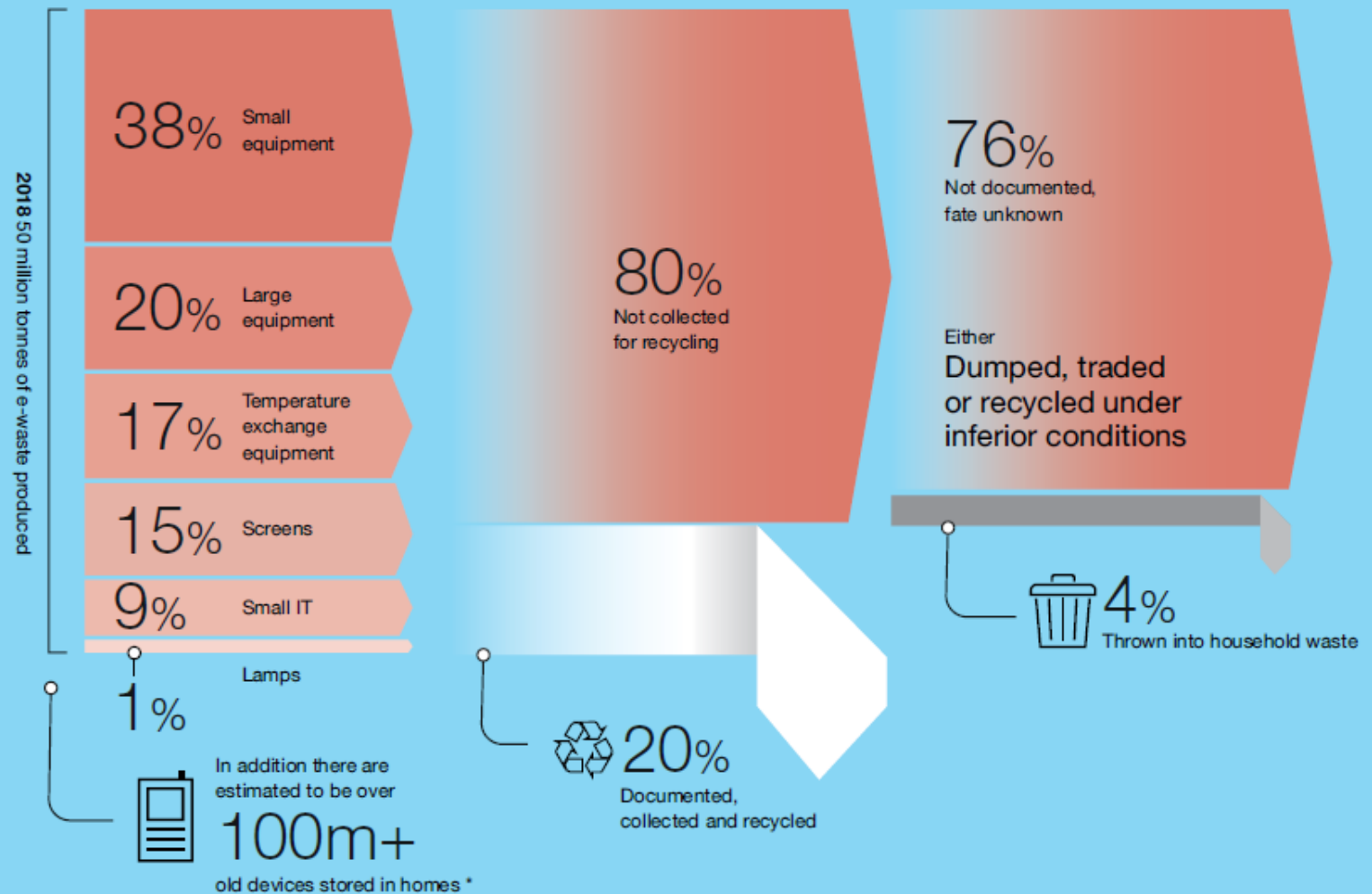
Delivering Instant Value Through  
Actionable, Impactful insights



# THE FUTURE OF E-WASTE

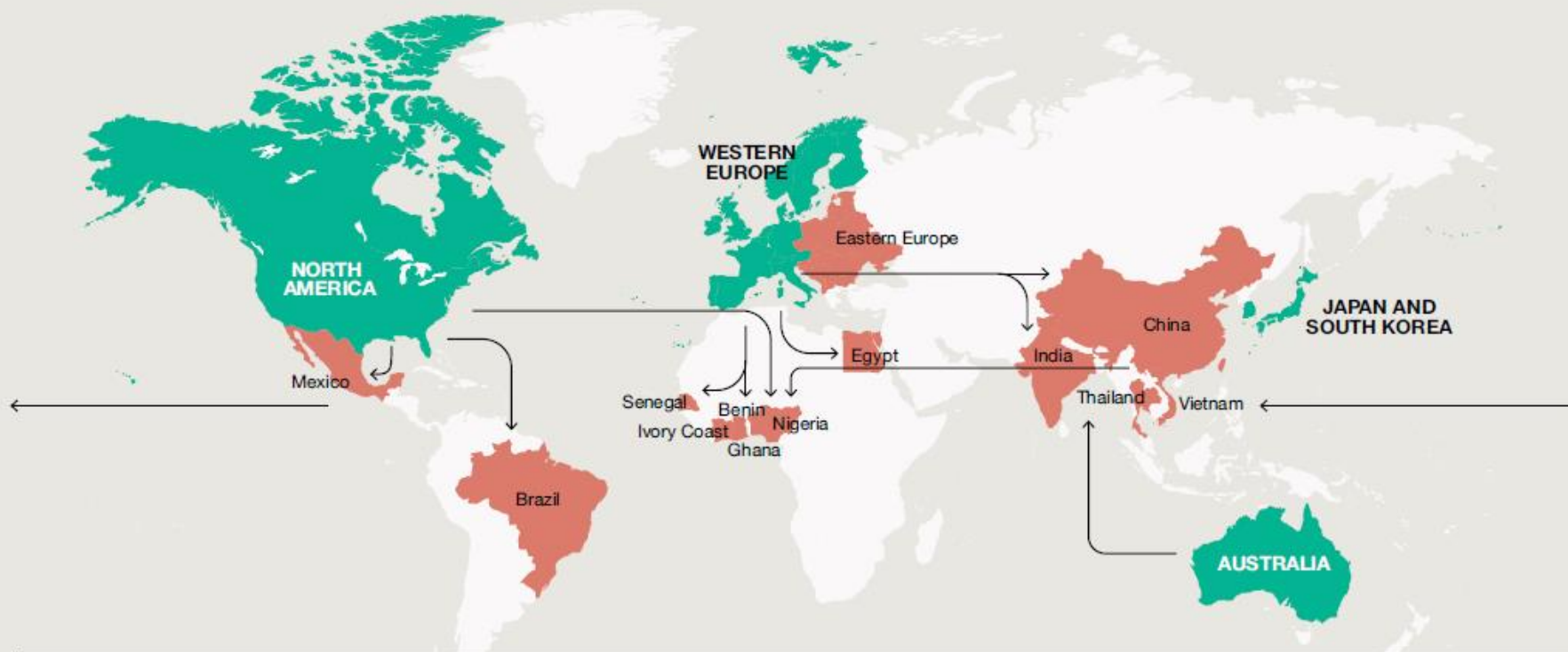


# GLOBAL E-WASTE FLOWS



# MAPPING OUT E-WASTE

- ◆ Regions sending e-waste
- ◆ Regions receiving e-waste
- ↪ Common routes for illegal shipments



Some of the highest and lowest e-waste generating nations E-Waste generated (kg per capita), 2016



# E-waste management

- Approach 1:
  - Documented and official collection in accordance to statutory requirements
  - Collection via municipal collection points, EEE producers and retailers or via dedicated pick-up arrangements
  - E-waste collected transported to specialised treatment facilities
  - Treated via processes (including manual disassembly, shredding and materials recycling) under controlled conditions to ensure environmentally sound manner of treatment

# E-waste management

- Approach 2:
  - Characterised by direct disposal of E-waste together with regular household waste (commingled waste)
  - Consumers dispose of E-waste together with non-segregated household waste
  - Comingled waste ends up landfilled or incinerated

# E-waste management

- Approach 3:
  - Involves unofficial collection of E-waste
  - Waste brokers and dealers
  - Outcomes include recycling of E-waste at specialist facilities, refurbishment or exportation to developing countries
  - E-waste in this scenario not officially documented, making generation and collected amounts difficult to track
  - Due to absence of legal requirements or framework E-waste management
  - Treatment not environmentally sound or may end up exported illegally

# E-waste management

- Approach 4:
  - Prevalent in developing countries
  - Involves informal collection of E-waste
  - Activities not regulated - absence, or no enforcement of legislation
  - Treatment methods basic and crude - open burning and acid leaching for metal extraction
  - Involves reuse, repair and cannibalising E-waste for parts, also occurs within Europe

# Impacts of e-waste



# Unregulated and Untreated, WEEE leads to Environmental Risks

The background image shows a dense pile of electronic waste (WEEE). Visible items include a Nokia mobile phone with a CE mark and barcode, various plastic casings, cables, and internal components. The scene is cluttered and represents a significant volume of discarded electronics.

- Substances contained in WEEE:
  - Greenhouse gases
  - CFCs
  - Metals
  - Flame retardants
- Can lead to risks for human health + the environment:
  - Global warming
  - Destruction of the ozone layer
  - Leakages from landfills into water and soil
  - Possible formation of new hazardous substances during incineration

Massive adverse environmental impacts in developing countries





“In its lifetime a typical microwave will use more power to illuminate its digital clock than it will use for actually cooking food”



© Basel Action Network

# Household EEE Stock (Data BEL)

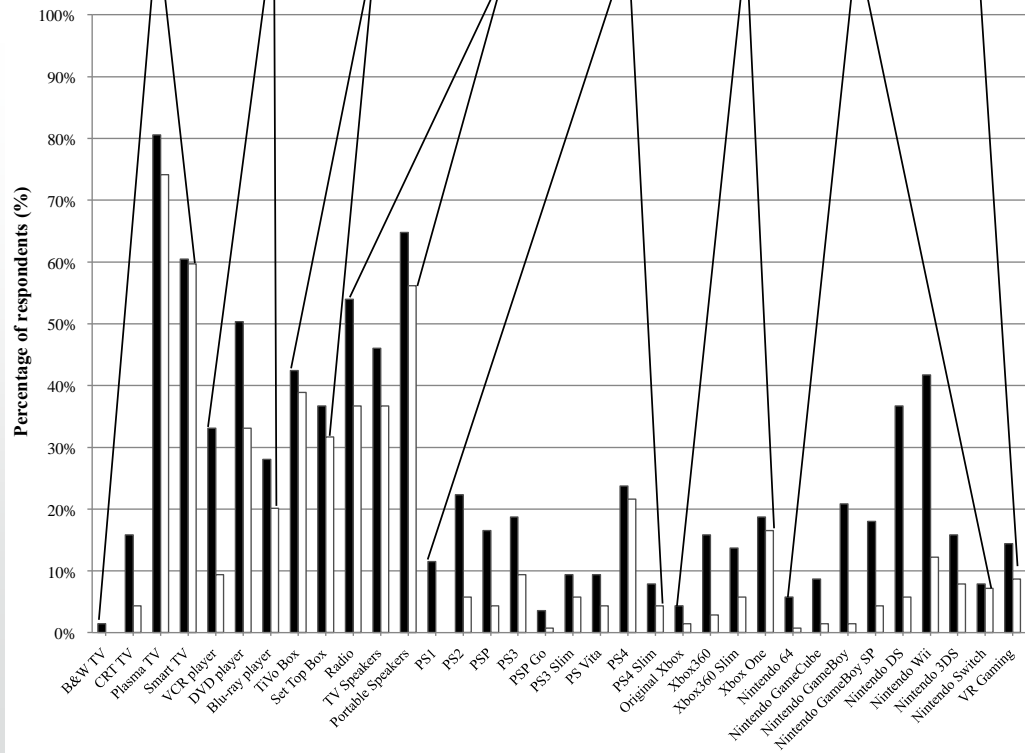
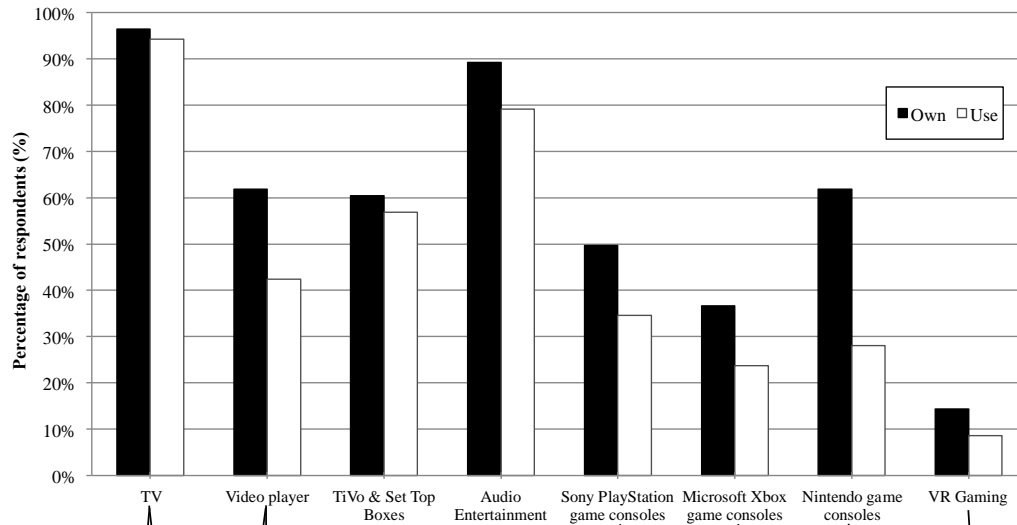


Total: 79 EEE + 47 Lamps/Luminaires per HH (B2C) // + 36 EEE per HH (B2B)

**Total Stock = 263 kg/inh.**

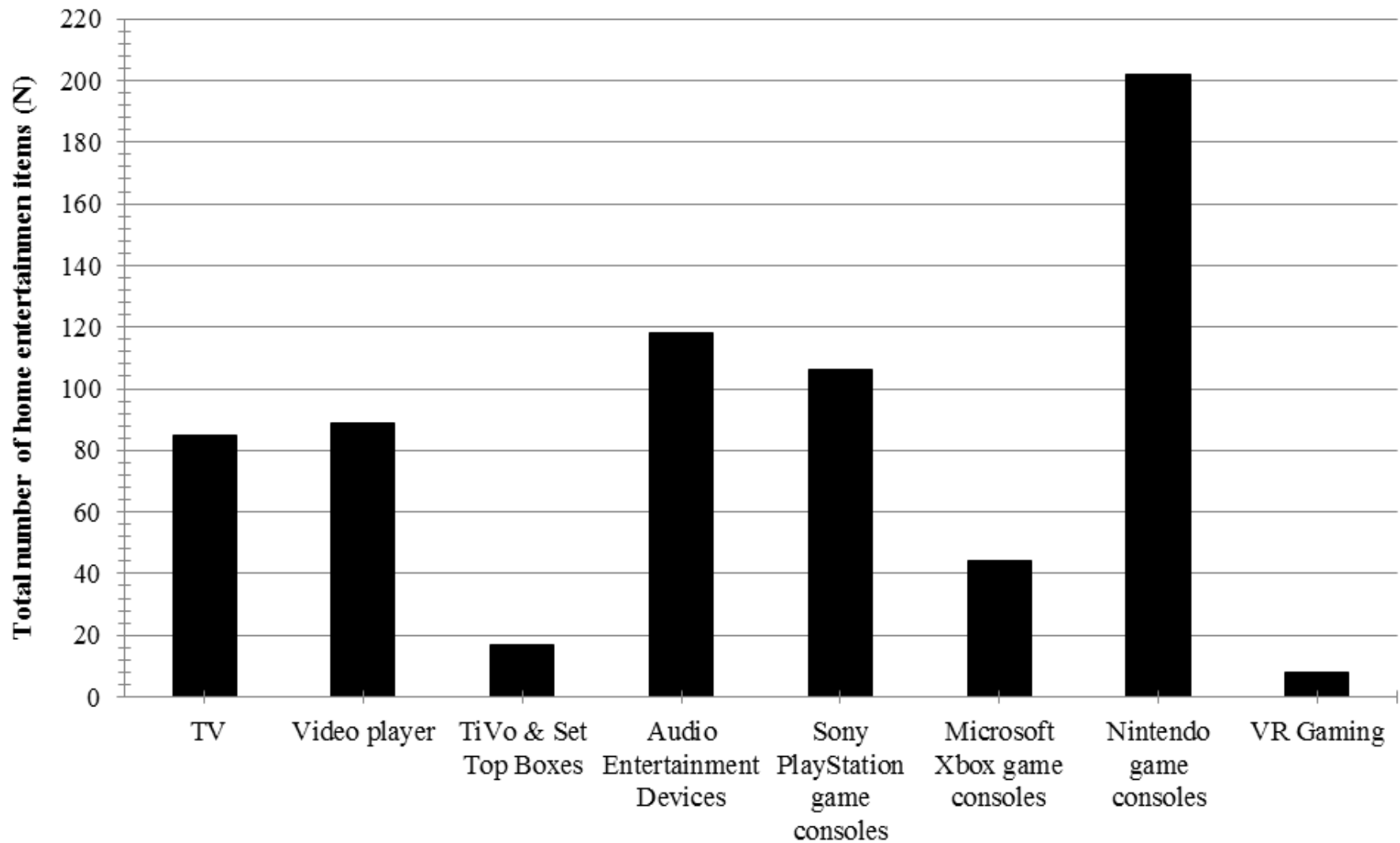
# WEEE Hoarding

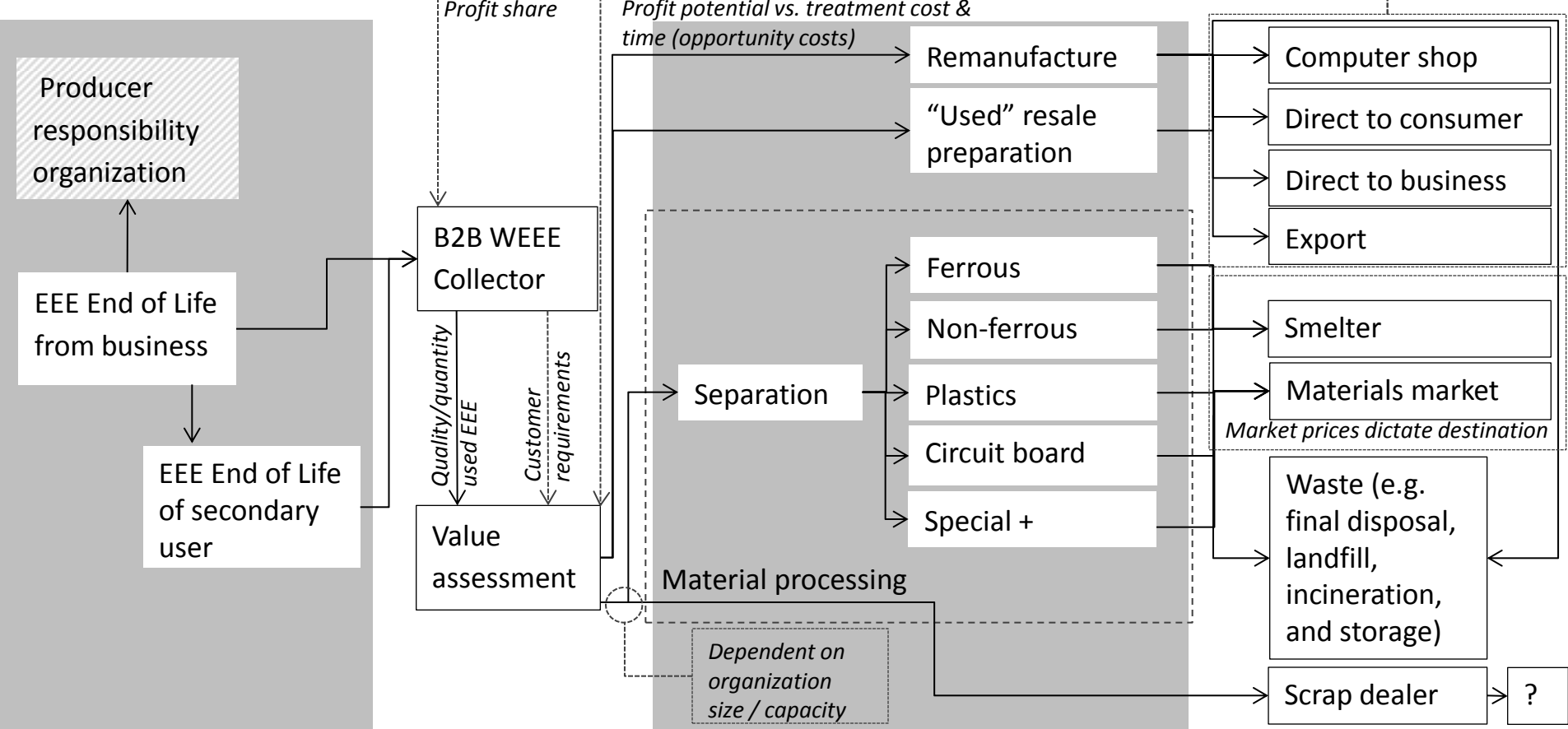
- Hoarding - consumers indefinitely store obsolete EEE that are no longer used or wanted
  - Major barrier to releasing exploitable materials into CE
- Average household in USA hoards 4.1 small and 2.4 large EEE in attic or basement
- Europe: hoarding common for (W)EEE with perceived residual value (monetary, functional, sentimental)
- Hoarded items currently unavailable (hibernating stocks) reduce exploitation potential of anthropogenic resources
- (W)EEE should be stockpiled/hoarded with intent of releasing it into CE to ensure access to DUM's stocks



Proportion of respondents owning and using at least one home entertainment electronic product in Southampton in 2018 (n=139).

Total number of home entertainment items hoarded by respondents (n=104).





Leakage into environment (water, air, soil)

Source                      Collection                      Treatment                      Destination

Legend

	Physical Flow+
	Drivers of physical flow
	Actor
	Out of scope

+ Where there is physical flow info or cash flow assumed present

Source: Peagram et al, 2014

Drivers of materials flow for business to business (B2B) WEEE from collection through treatment for reuse or recycling. Special+ includes unusual (one-off) or non-standard items. "Leakage into the Environment" is possible from every step, to simplify the illustration, the arrows are not plotted.



## We Need a WEEE Circular Economy!

- Resources within WEEE - plastics, glass, metals - recovered, reducing need for extraction of raw materials
- Modern high-tech EEE rich in metals + critical raw materials; large proportion of anthropogenic stocks
- Secondary resources may be exploited via urban mining
- Ideal locations for urban mining – Distinct Urban Mines - include urban hubs, localised populations, quantifiable anthropogenic (W)EEE stocks and material flows
- Material stocks - in-use and hibernating (hoarded or stockpiled) (W)EEE in society
- Material flows - involve reuse, recycling and discarding of EoL electronics

## Conclusions

- To ensure recovery of used EEE and WEEE, waste management efforts should:
  - Promote recycling and reuse through awareness campaigns on collection schemes for consumer electronics
  - Establish convenient and accessible used EEE and WEEE collection points to encourage regular (periodic) harvesting
  - Establish incentives to encourage reuse / recycling behaviour, with potential monetary incentives
  - Target recovery of items that take up more space in consumer households
  - Encourage faster reuse of EEE via donations to charities, relatives or friends in order to gradually stimulate consumers to view EoL WEEE differently

# Dealing with e-waste

THANK YOU FOR YOUR ATTENTION

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