



SmART Cities and Waste Research
Workshop: *Urban Waste Streams & Flows*

**Electronic waste – an emerging global
environmental and health challenge in
the 21st century**

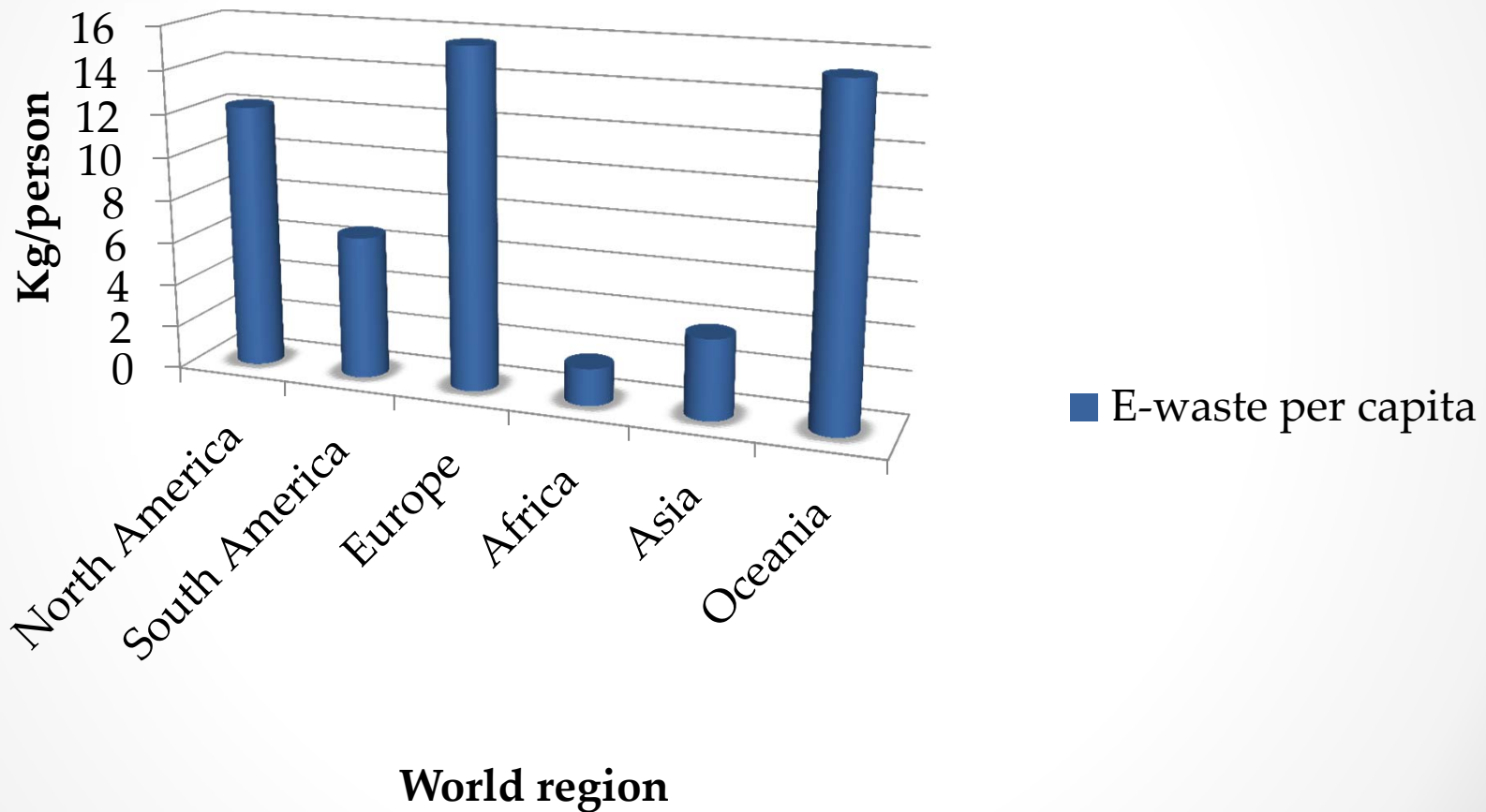
Diane Purchase



Out with the old ...



E-waste generated per capita in 2014



Source: United Nations University-Institute for the Advanced Study of Sustainability. 2015

Challenges of E-waste

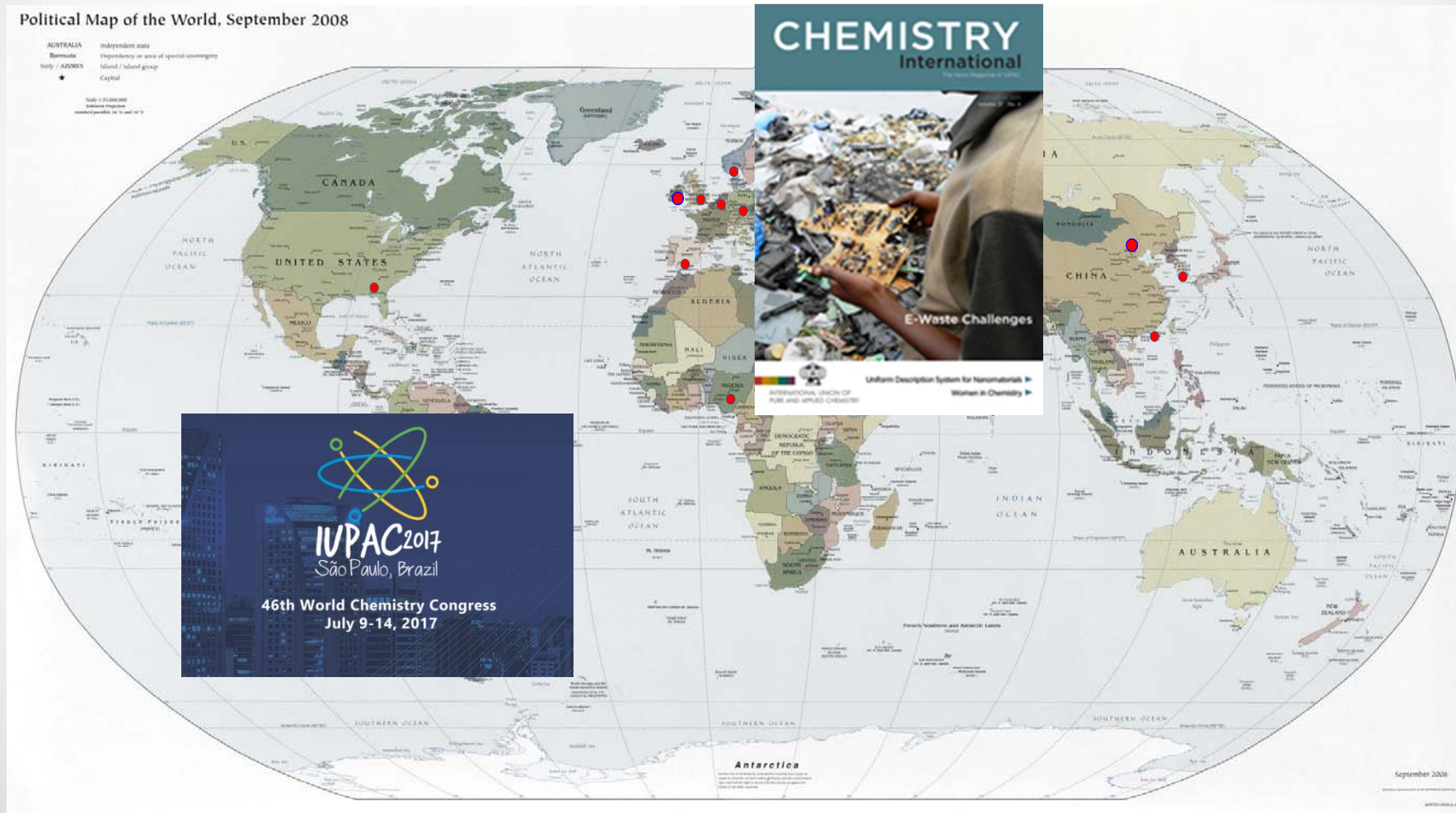


- Chemical nature and global distribution?
- Environmental and health impact?
- Risk management?
- Management strategy?

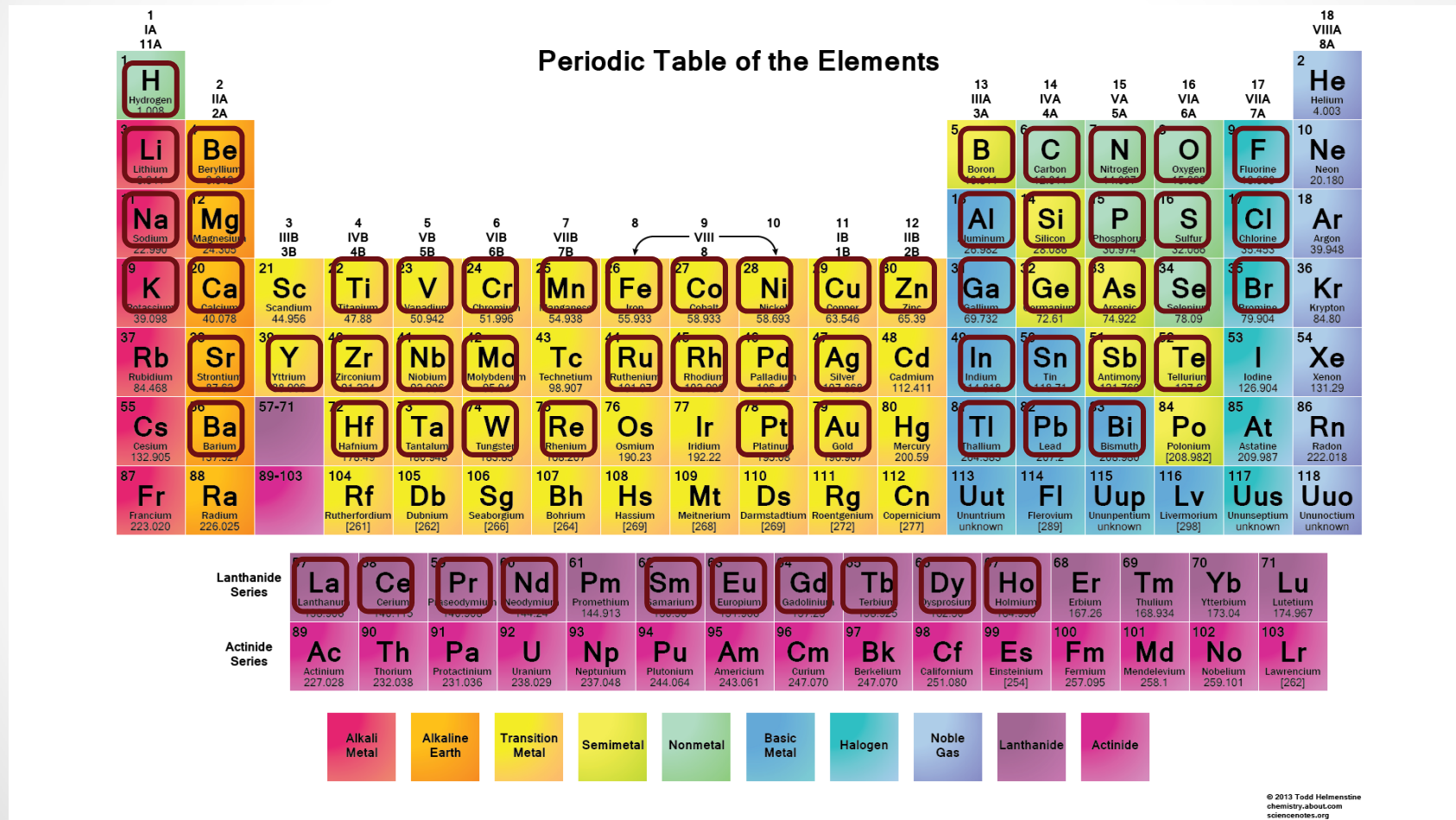


**Recommendations for
management approach**

The International Union of Pure & Applied Chemistry E-waste Project



Example - Elements typically found in a mobile phone



This periodic table does not take into account in what quantities and concentrations the elements have been used (only the smallest impurities are excluded). Neither does it take into account the form the element in question has been used in.

Examples of hazardous chemicals in E-waste

Heavy metals and metalloids

- e.g. barium, mercury, aluminium, chromium, copper
- e.g. arsenic

Brominated flame retardants

- e.g. hexabromocyclododecane (HBCDD), polybrominated diphenyl ethers (PBDE)

Plastics

- e.g. bisphenol-A, polychlorinated biphenyls (PVC)

Lead Glass

- e.g. Lead

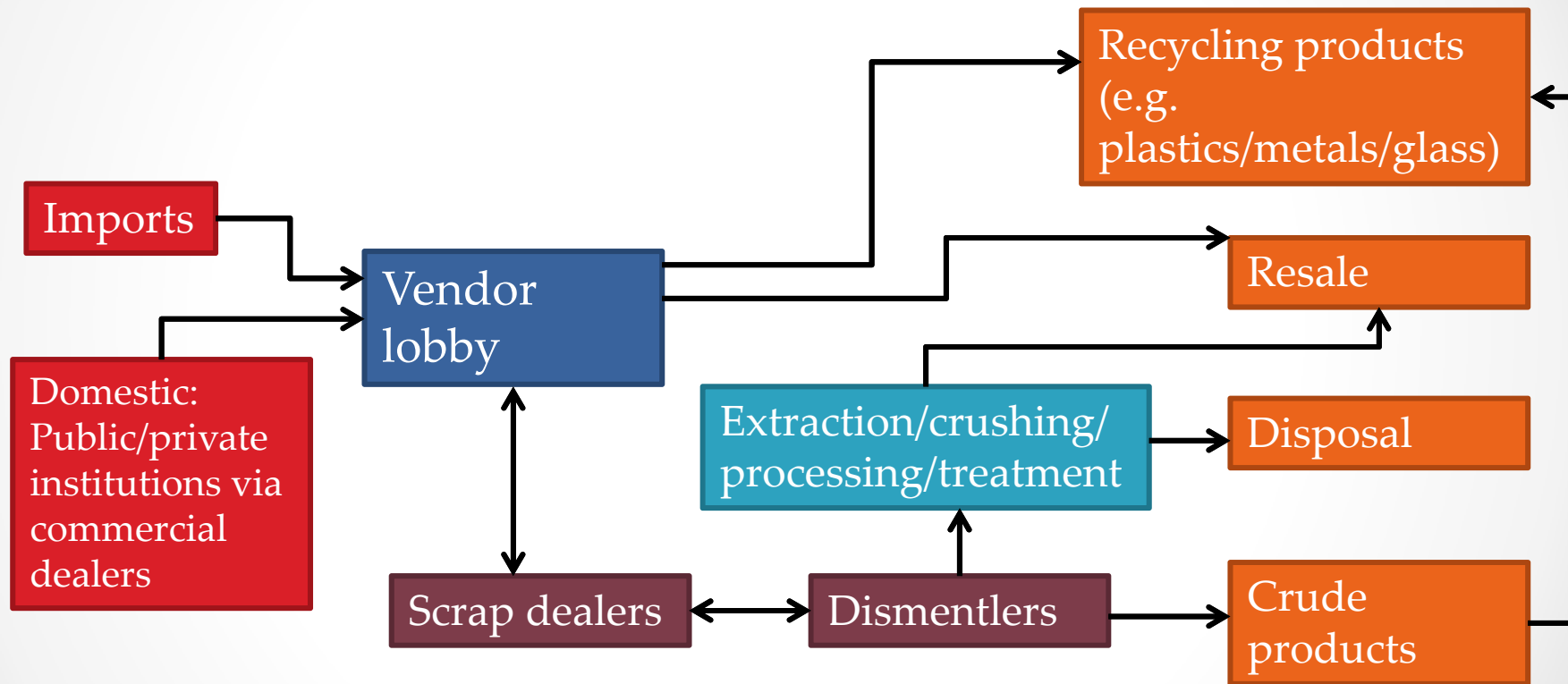
Treatment of E-waste

Dismantling
and pre-
processing

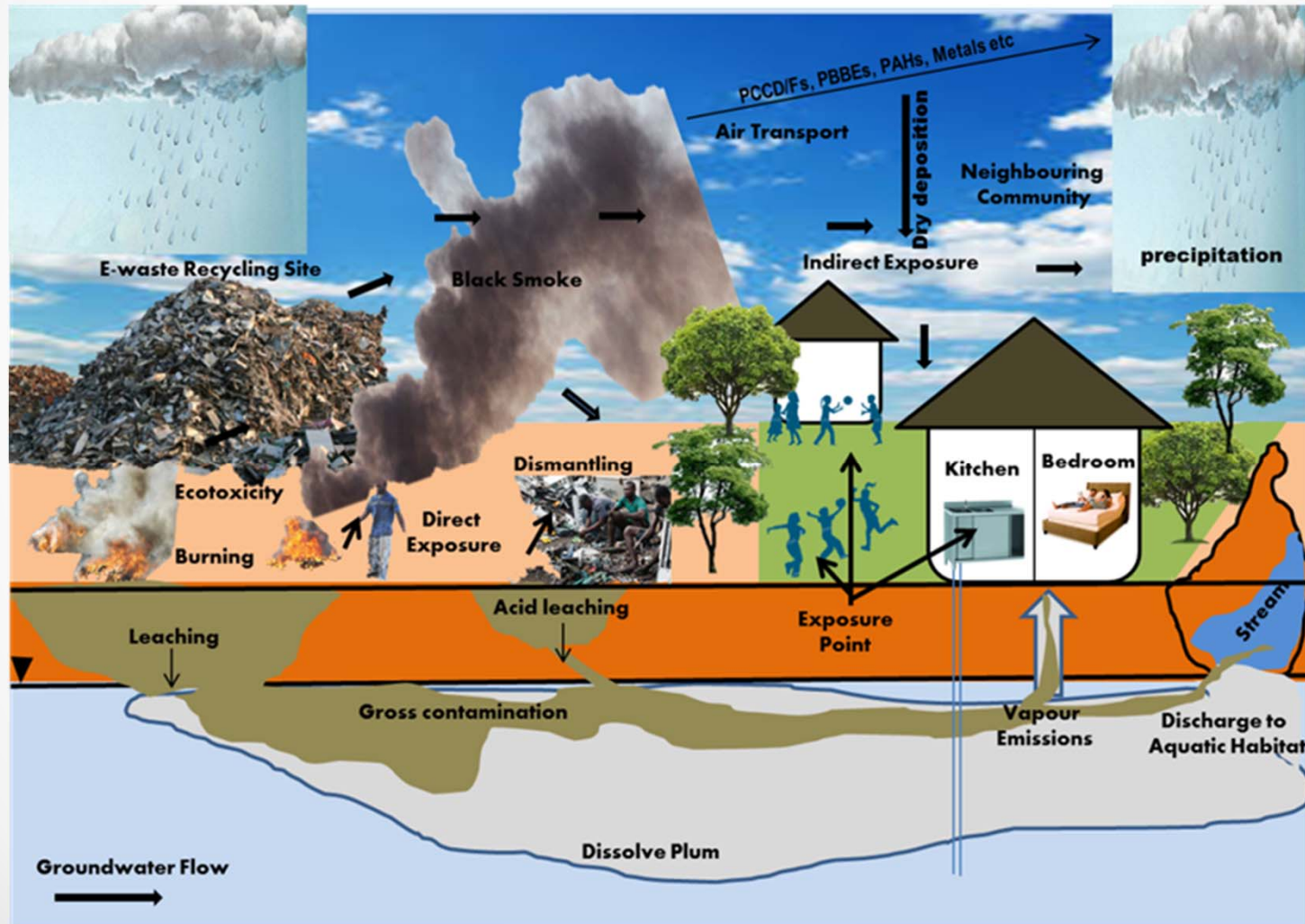
Recycling of
metal contained
E-waste

Recycling of E-
waste plastics

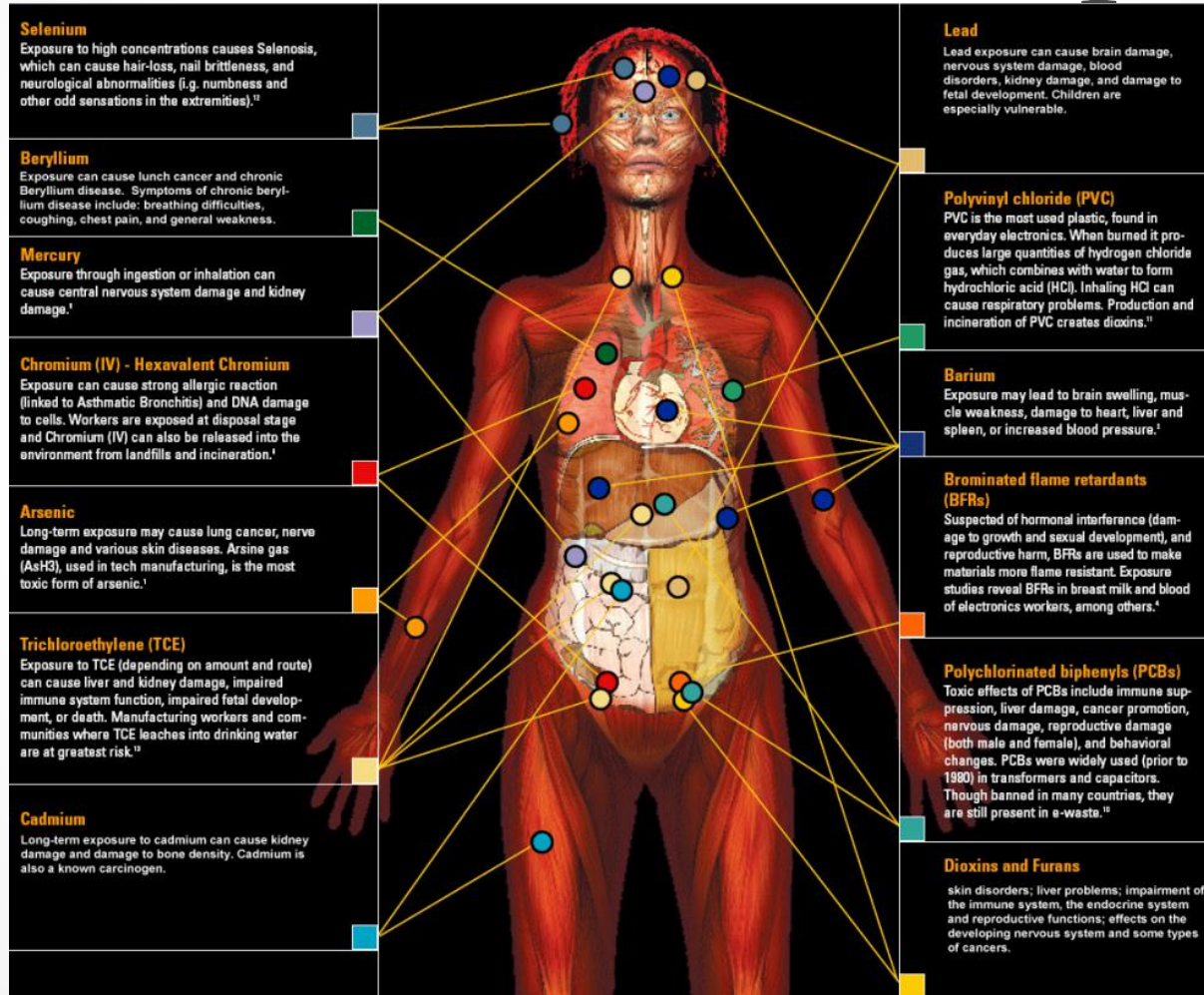
Example - Trade chain practice in India



Conceptual model of a typical E-waste recycling site in Nigeria



Potential health impacts

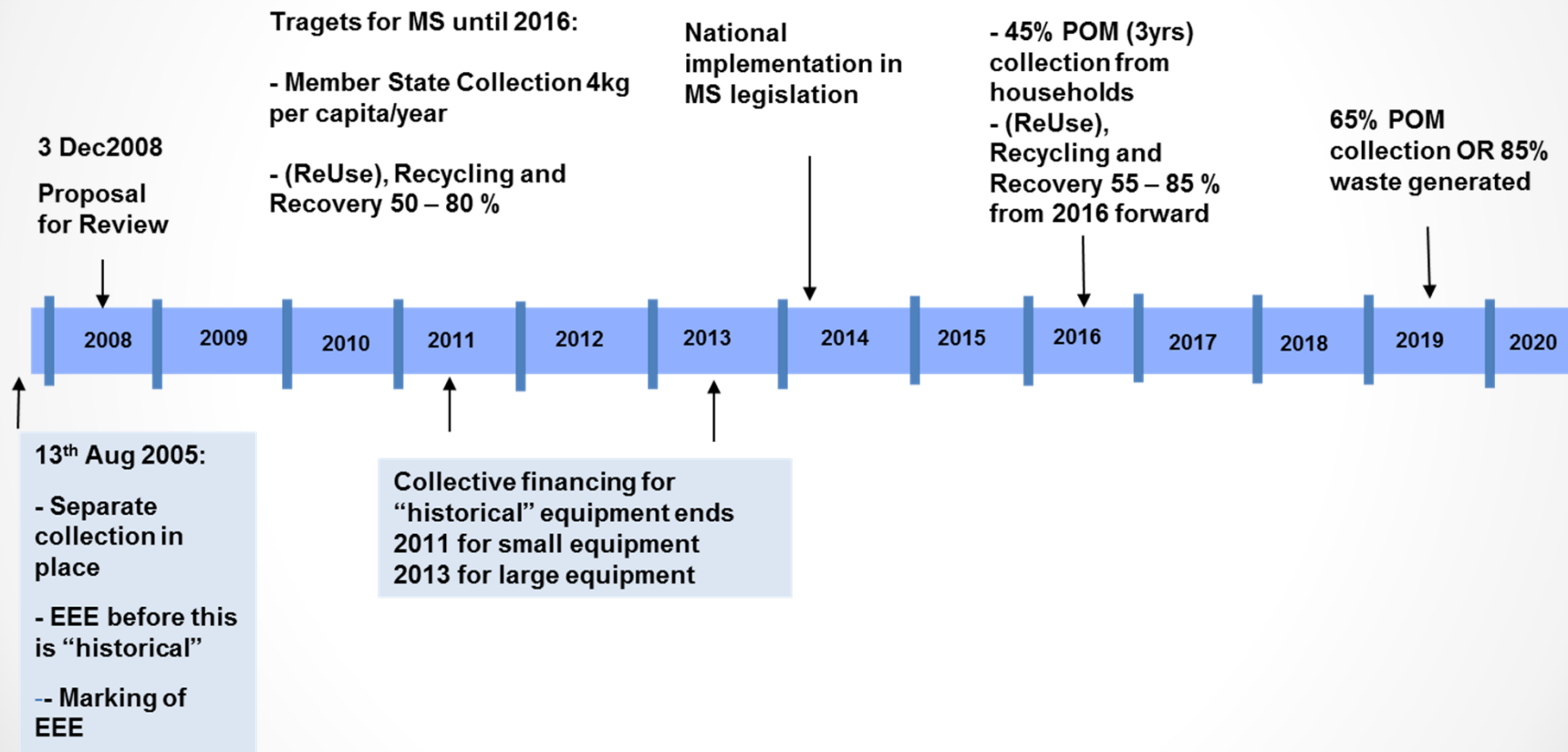


Source: <http://ewise.co.nz/the-impact-of-ewaste/>

Key legal framework

- **Basel Convention**
- **Waste Shipment Regulation (WSR)**
- **Restriction of Hazardous Substances Directive (RoHS)**
- **Extended Producer Responsibility (EPR)**
- **Directive on Waste Electrical/Electronic Equipment (WEEE)**

WEEE directive in EU "take-back" regulation



POM (3yrs) = put on market during previous 3 years

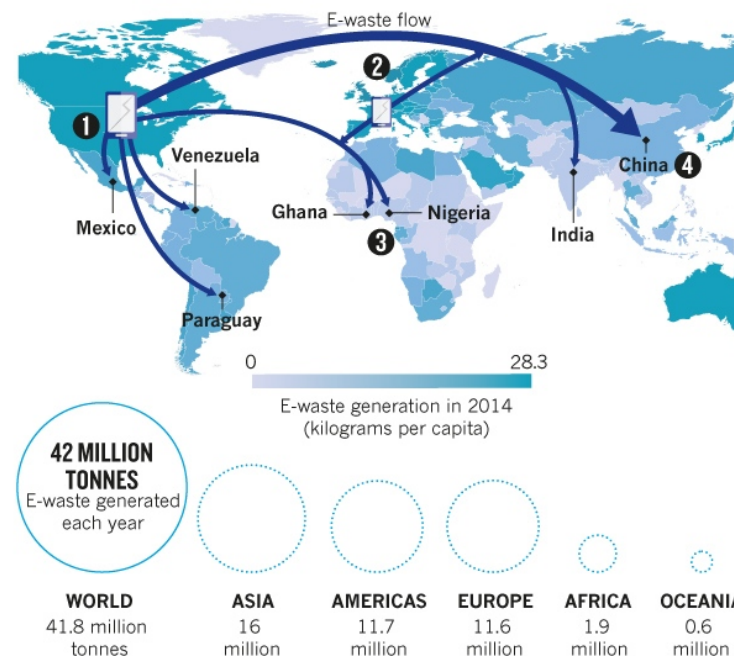
Challenges in the implementation of regulations and policy

- **Different implementation**
 - harmonized policy ≠ harmonized implementation
 - temporal & cultural dimension about waste
 - political unwillingness to regulate corporations too strictly
- **Difficult implementation**
 - Finding illegal trade = needle in haystack (risk assessment)
 - Requires expertise (not present with all agencies)
 - Limited resources
 - Information with different agencies
 - Different agencies with different goals
- **Prosecution & Sentencing:**
 - demanding investigative work
 - slow prosecution
 - low fines
- **Transnational trade: different jurisdictions, awareness, economics**

The known legal flow of E-waste

UNFAIR FLOW

Most electronic waste from developed countries ends up in poor nations that lack regulation. China processed around 70% of the world's e-waste in 2012; the rest goes to India and other countries in eastern Asia and Africa, including Nigeria.



- 1 The United States produces the largest total amount of e-waste per year, at 7.1 million tonnes.
- 2 Norway generates the most e-waste per person, at 28.3 kg per capita.
- 3 African nations produce little e-waste, with Equatorial Guinea creating most (10.8 kg per capita).
- 4 China ranks second for total e-waste generation (6 million tonnes), but low relative to its population size (4.4 kg per capita).

... and the illegal dark trade



Source: <http://www.sustainelectronics.illinois.edu/policy/international.cfm> [accessed 7th September, 2016]

E-waste as a criminogenic market?

- **Case of Ghana:**
 - Different priorities/concerns (no legislation on e-waste)
 - Massive informal collection & recycling
 - Local consumption of new/second hand products

'You can make money by "recycling" e-waste in poorer environmental and social conditions, since this provides you the precious metals with lower labour costs' (Corporate respondent 13).

Bisschop, L. (2015). Governance of the illegal trade in e-waste and tropical timber: case studies on transnational environmental crime. Green Criminology Series, Ashgate Publishing. (ISBN 978-1-4724-1540-0)

There's more to governance than government

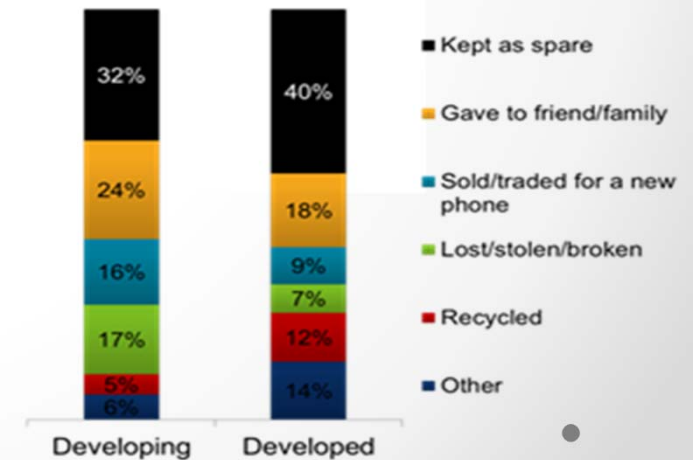
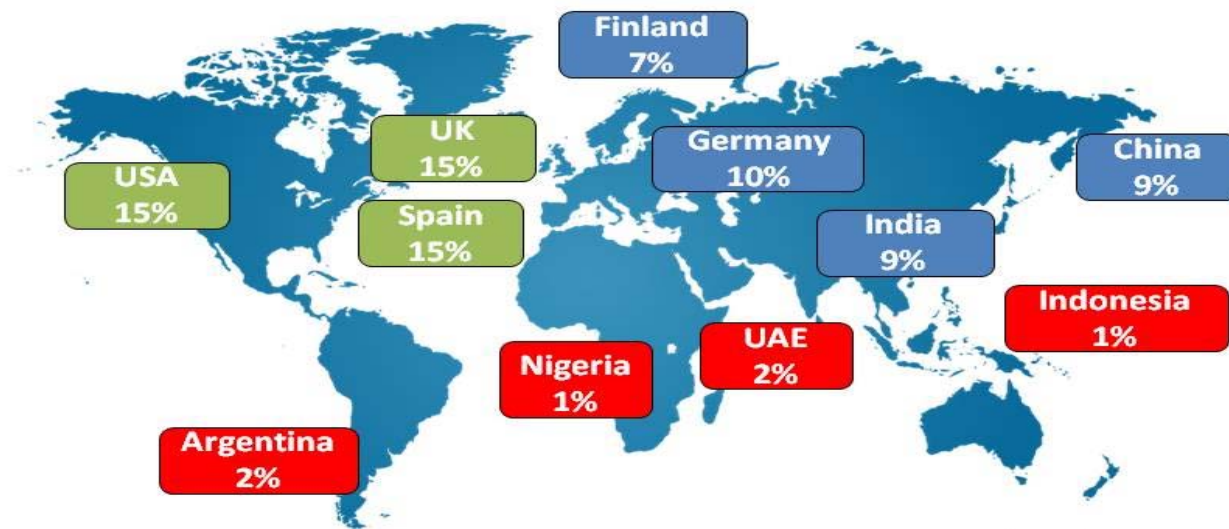
- Cross border circulation is a key for a successful business
- Harmonized rules are needed to facilitate economically sustainable solutions
- The differences in waste from various product groups should be respected
- Rules should be well defined and justified and not be used as trade barriers
- A formal global protocol on E-waste trading
- Strengthen domestic regulations
- Encourage transfer of knowledge on processing and recycling technology from developed to developing countries
- Producers' and Consumers' responsibilities



Making E-waste management sustainable

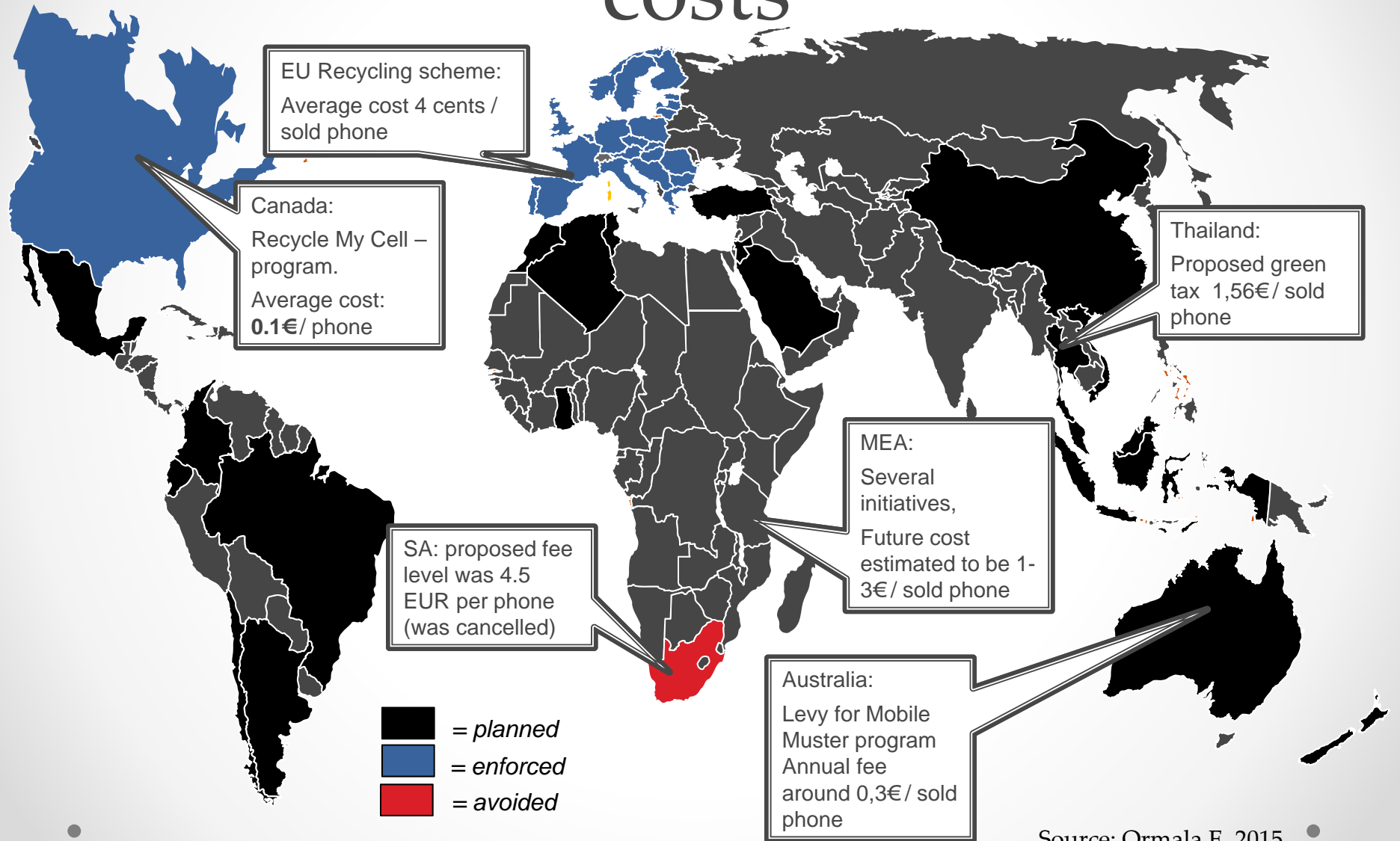
- Less wasteful consumption
- Circular economy
- Cleaner production & smaller material footprint
- Reverse logistics credits
- Life cycle analysis to identify environmentally sound end-of-life option
- Better treatment and disposals
- e-waste valorization

Example: Improve recycling behaviour-mobile phones



Source: Ormala E. 2015

Examples of E-waste recycling costs



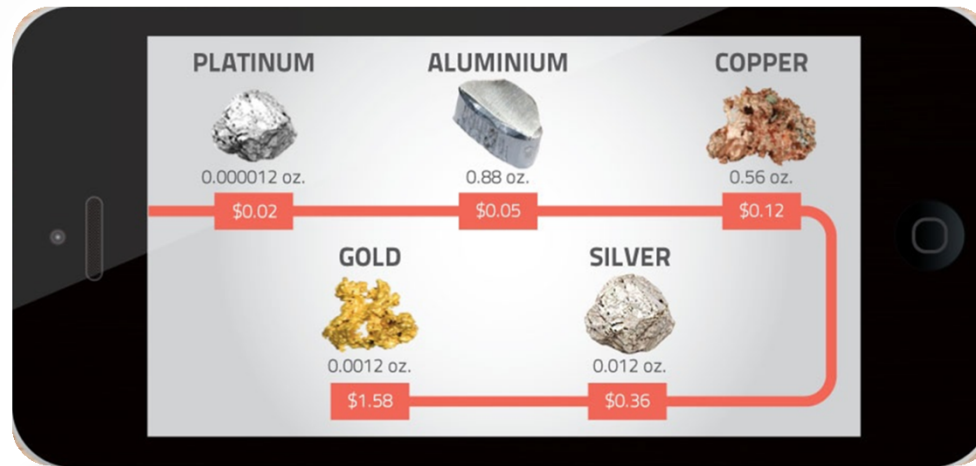
Examples - Advances in material science for cleaner production

- Synthesis of heteroarchitectures formed by graphene oxide, conductive polymers and manganese dioxide for low cost high performance supercapacitors
- High performance supercapacitors - polypyrrole nanotubes coated with $\text{Ni}(\text{OH})_2$ for
- Hybrid Materials for Hybrid Energy Storage – supercapacitor and batteries in one

Examples - Advances in recycling technologies for metals recovery

Recycling technology	State of recovery metals	Species and effect of recovery metals	Advantages of environmental and technological aspect
Pyrometallurgy	pure solid metals	almost all metals; high recovery rate	totally-commercial; owing some dust chamber and exhaust gas treatment plant
Mild extraction	solution	almost all metals; recovery rate related to the reagents and reaction condition	low toxicity; simple and easy accessibility; relative low environment damage
Biometallurgy	Solution	only for a few specific metals; considerable recovery rate for Cu, Zn, Au etc	environment-friendly; low cost of investment
Electrochemical	pure solid metals	only for specific metals; high recovery rate	high recovery efficiency; low cost of investment; mature technology
Supercritical	solid mixture of metals	almost all metals; high recovery rate	high recovery efficiency; low cost of investment; low environment damage
Vacuum metallurgy	solid single metal	only for high vapor pressure metals; high recovery rate	environment-friendly; short technological process

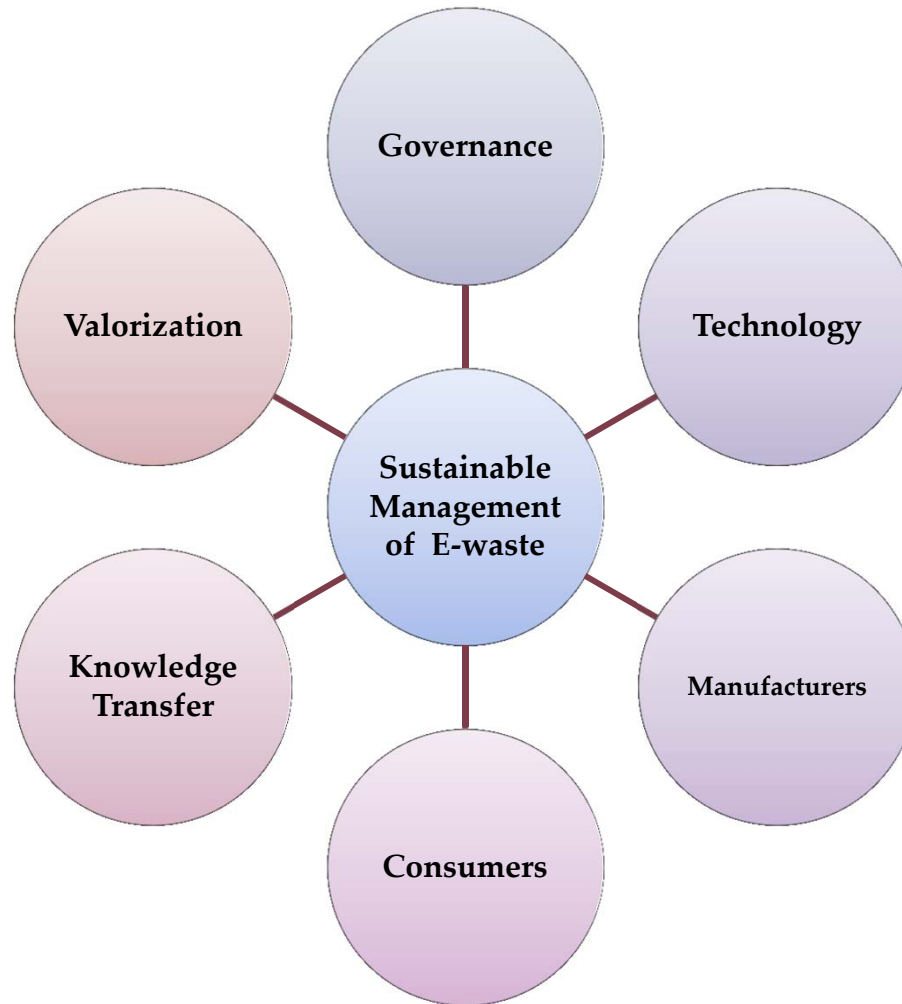
'There is no such thing as waste ...'



<http://www.electronicsspecifier.com/around-the-industry/do-you-have-a-goldmine-in-your-pocket>

- Also contains rare earth minerals
- From cathode-ray-tube funnel glass to zeolites
- Indium from LCD display
- From old printed circuit boards to Cu-Sn nanoparticles

Conclusion



The IUPAC e-waste task group

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