



THE WEEE JUNGLE - the (electronic) urban mining



This activity has received funding from the European Institute of Innovation and Technology (EIT). This body of the European Union receives support from the European Union's Horizon 2020 research and innovation programme.

A stylized illustration of a tropical plant with large green leaves and a yellow vine, partially enclosed by a blue circular frame with a torn edge effect. The background is white.

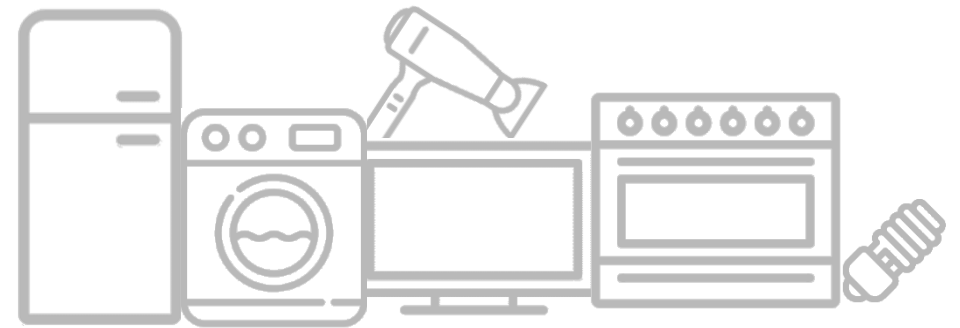
Introduction

What does EEE stand for?

Electrical &

Electronic

Equipment



EEE:

Equipment dependent on **electric currents** or **electromagnetic fields** in order to work properly

What does WEEE stand for?

Waste

Electrical &

Electronic

Equipment



WEEE:

is a EEE that has come to the
end of its “user-phase” → e-waste

The WEEE streams

C&F refrigeration and air-conditioning



LHA large household appliances



TV&Screens



SHA small household appliances



Lamps



A large, stylized graphic on the left side of the slide. It consists of a large white circle with a blue, torn-paper-like border. Inside the circle, there are green leaves and a yellow vine. The background of the slide is white.

The WEEE system

The legislative framework

Europe: European Directive 2012/19/EU on WEEE



Protects the environment and human health by preventing or reducing the production of WEEE.

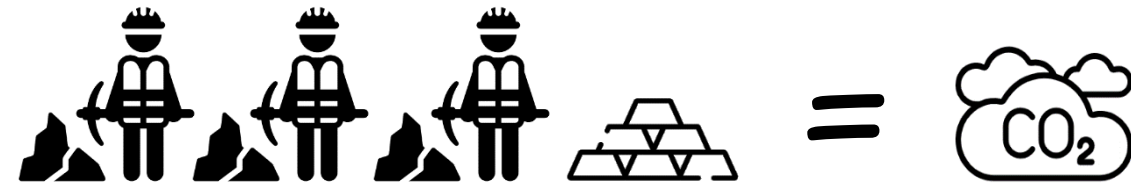
Italy: Legislative Decree no. 49 - 14/03/2014



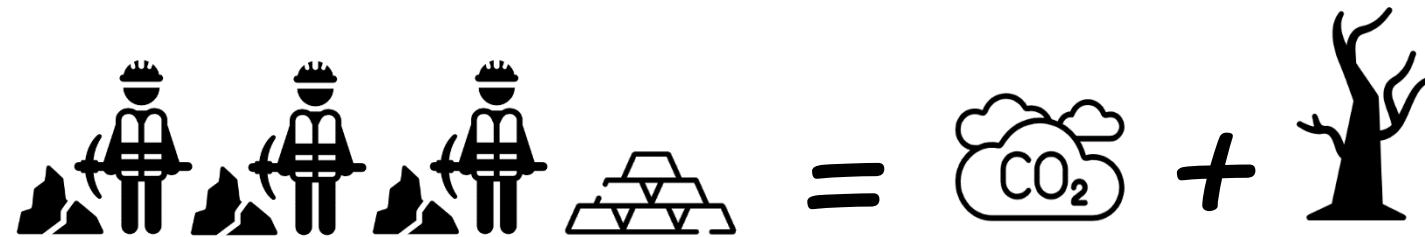
- Transposition of the European Directive
- Aims to reduce and avoid the negative impacts of EEE production and WEEE management.
- Defines Compliance Schemes, the “Centro di Coordinamento RAEE” (CdCRAEE) and collection targets.

When my... does not work anymore

If you keep it in a drawer, then...



If you throw it in the trash, then...



How should I get rid of...?

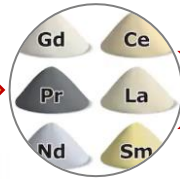
Story I: REMO



LINEAR ECONOMY



MINING ACTIVITIES



PRODUCERS
(Es. Samsung / Apple)



RETAILERS



Story 2: ROMOLO



MUNICIPAL COLLECTION POINT



WEEE TREATMENT PLANT



- Gd
- Ce
- Pr
- La
- Nd
- Sm

SMELTER



PRODUCERS
(Es. Samsung / Apple)



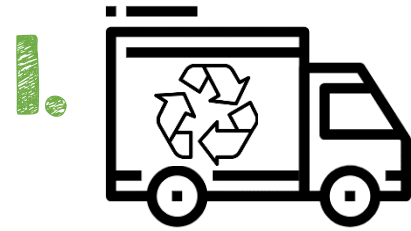
RETAILERS



CIRCULAR ECONOMY



How to properly dispose of my...



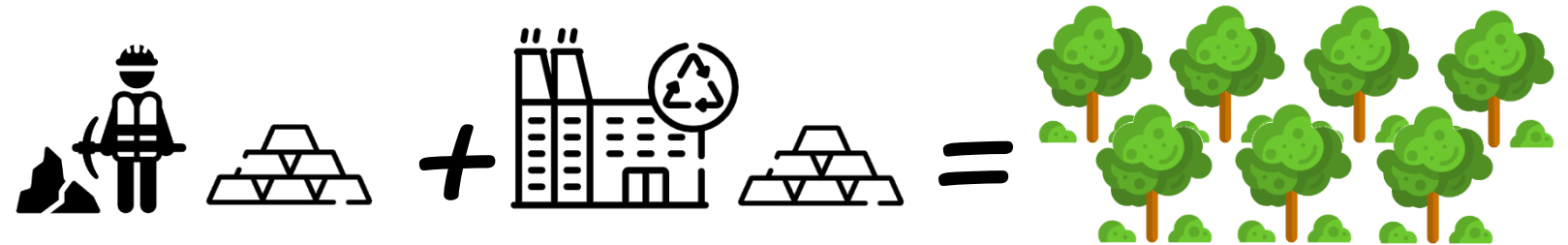
Municipal
collection service



Municipal
collection points



Retailers

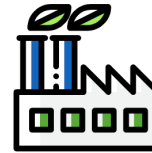


Who will take care of my... ?



Manufacturers are responsible for the management of WEEE.
And they do it by establishing:

COMPLIANCE SCHEMES



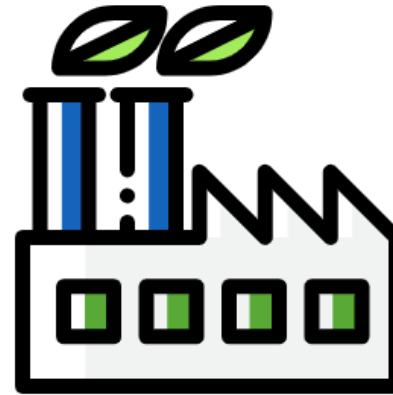
TRANSPORT TREATMENT

In Italy, **ERION** is the largest Compliance Scheme.

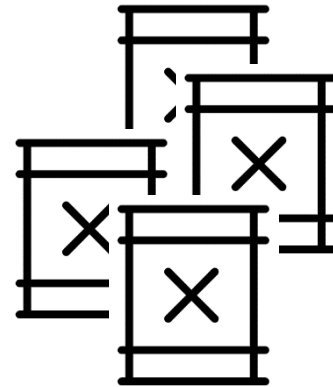
A circular frame on the left side of the slide contains a vibrant illustration of a jungle scene. It features various green leaves, including a large monstera leaf, and a yellow vine with a spiral pattern. The background within the circle is white, and the frame itself has a blue, torn-paper-like border.

What can be achieved from WEEE recycling?

WEEE treatment: overview



Hazardous substances removed



Energy recovery
Material recycling
Residues disposal

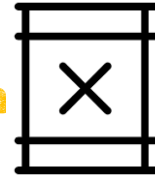
Valuable fractions collected



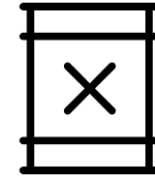
Secondary Raw Materials

Hazardous substances → RISKS

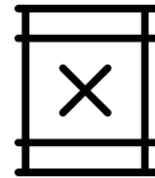
CFC/HC
[chlorofluorocarbon
hydrocarbon]



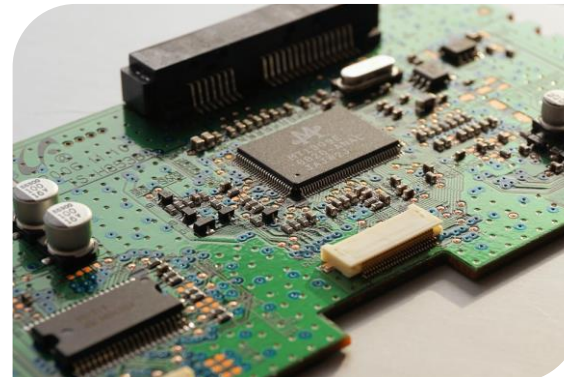
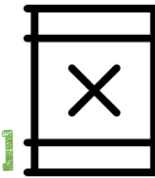
OILS



Batteries
[Pb, Cd, Hg, Cr⁶⁺]



PCBs
[Printed Circuit Boards]

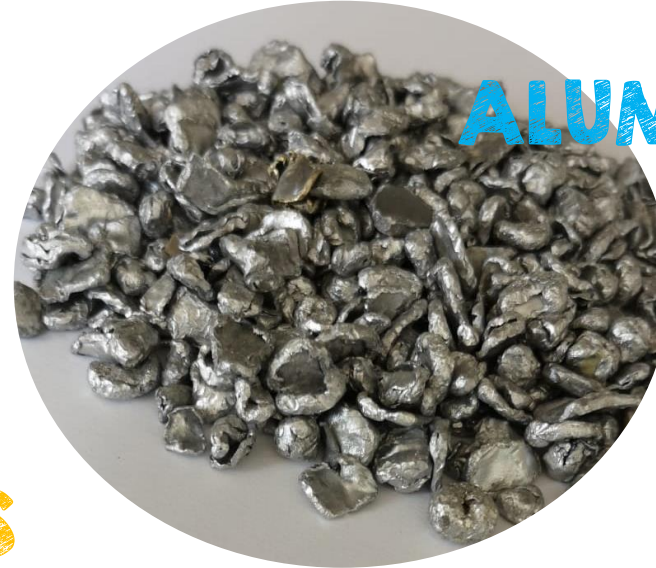


Separated
and
properly
secured

Valuable components → SUCCESS



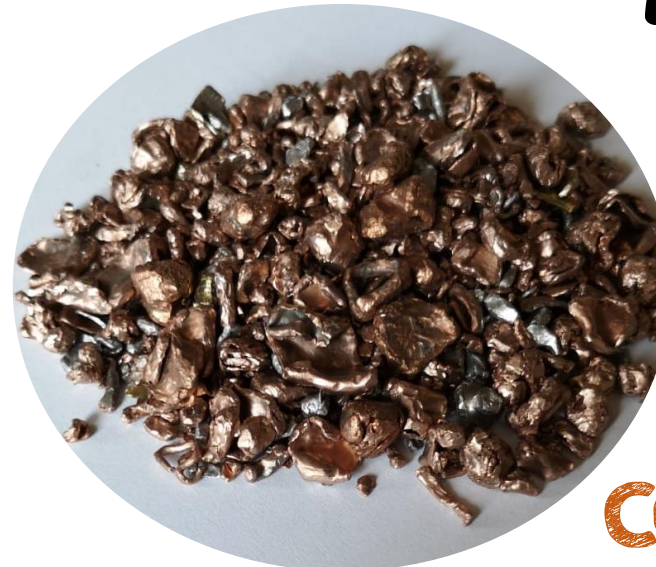
PLASTICS



ALUMINUM



IRON



COPPER

+

Critical Raw Materials (CRMs)

The recovery rate

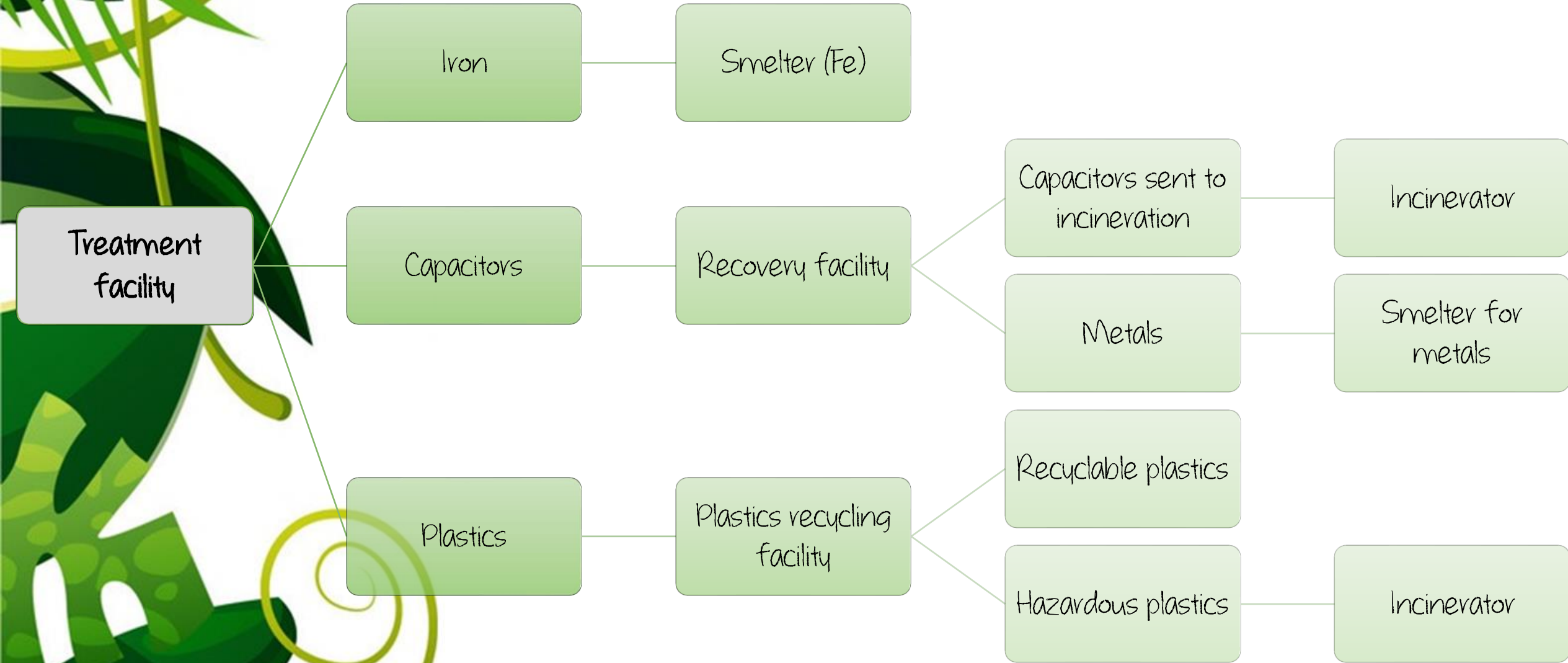
RECOVERY = MATERIAL RECOVERY + ENERGY RECOVERY = MR + EV

Example of energy **recovery**: the polyurethane sent to incineration is burnt
→ the heat generated is used to produce electric power and to heat water.

REUSE AND RECYCLING = MATERIAL RECOVERY = MR

Example of **recycling**: the iron extracted from refrigerators' treatment is sent to smelters to become “new” iron.

Recovery rate: PROCESS FLOW



The recovery rate

What the legislator ask for?

We must look at Directive 2012/19/EU of the European Parliament

Minimum targets applicable by category from 15 August 2018 with reference to the categories listed in Annex III:

- (a) for WEEE falling within category 1 or 4 of Annex III,
 - 85 % shall be recovered, and
 - 80 % shall be prepared for re-use and recycled;
- (b) for WEEE falling within category 2 of Annex III,
 - 80 % shall be recovered, and
 - 70 % shall be prepared for re-use and recycled;
- (c) for WEEE falling within category 5 or 6 of Annex III,
 - 75 % shall be recovered, and
 - 55 % shall be prepared for re-use and recycled;
- (d) for WEEE falling within category 3 of Annex III, 80 % shall be recycled.

For example, for WEEE falling within **category 1 or 4** it is required:

$RM + VE = 85\%$ $RECOVERY = MATERIAL RECOVERY + ENERGY RECOVERY = MR + EV$

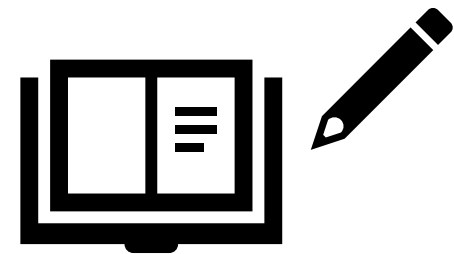
$RM = 80\%$ $REUSE AND RECYCLING = MATERIAL RECOVERY = MR$

Recovery and disposal

Example:
category R1

Components	Material Recovery	Energy Recovery	Incineration	Landfill Disposal
Aluminum	3.10%			
Other metals	0.60%			
CFC / HC			0.60%	
Capacitors			0.00%	0.00%
Wood	0.50%			
Ferrous metals	61.20%			
Oils	0.40%			0.00%
Plastics	13.90%	0.20%	0.00%	0.30%
Polyurethane	0.30%	11.90%		1.90%
Copper	2.20%			
Non-hazardous wastes		0.10%	0.00%	1.70%
Hazardous wastes				0.00%
Glass	1.10%			0.00%
Total	83.30%	12.20%	0.60%	3.90%

TIME TO EXERCISE



Recovery and disposal

Declaration

Cooling and freezing R1

Aluminum Smelter S.A.

Dear ESEE Education,

Hereby it is stated that 100% of the aluminum we received from you was processed for the production of aluminum bars.

Best Regards

/CEO

Aluminum Smelter S.A.

Recovery and disposal

Solutions for R1 → cooling and freezing

R1 STREAM			Weight [kg]				Percentages [%]			
Components	Total weight [kg]		Material Recovery	Energy Recovery	Incineration	Landfill disposal	Material Recovery	Energy Recovery	Incineration	Landfill disposal
Aluminum	1,148,166	of which:	1,148,166				3.1%			
Other metals	97,927	of which:	97,927				0.3%			
CFC/HC	225,557	of which:	660	77	224,820		0.002%	0.0%	0.6%	
Capacitors	8,267	of which:			679	7,588			0.002%	0.02%
Wood	143,522	of which:	143,522				0.4%			
Oils	132,351	of which:	131,040			1,311	0.4%			0.004%
Plastics	5,484,440	of which:	5,425,860	49,545	270	8,765	14.6%	0.1%	0.001%	0.024%
Polyurethane	5,121,150	of which:	116,383	4,239,114	83,032	682,621	0.3%	11.4%	0.2%	1.837%
Copper	856,712	of which:	856,712				2.3%			
Glass	437,920	of which:	437,920				1.2%			
Non-hazardous wastes	1,113,831	of which:			9,663	1,104,168			0.026%	3.0%
Ferrous metals	22,373,682	of which:	22,373,682				60.2%			
Hazardous wastes	11,833	of which:				11,833				
TOTAL	37,155,358	of which:	30,731,872	4,288,736	318,464	1,816,286	82.7%	11.5%	0.9%	4.9%

EU MANDATORY TASK:

RECOVERY rate: 85%

RECYCLING rate: 80%

Recovery and disposal

Solutions for R3 → screen

R3 STREAM			Weight [kg]				Percentages [%]			
Components	Total weight [kg]		Material Recovery	Energy Recovery	Incineration	Landfill disposal	Material Recovery	Energy Recovery	Incineration	Landfill disposal
Aluminum	153	of which:	153				0.3%			
Other metals	635	of which:	635				1.1%			
Capacitors	46	of which:				46				0.1%
Wood	880	of which:	880				1.5%			
Ferrous metals	6,140	of which:	6,140				10.6%			
Plastics	9,554	of which:	9,289	1	250	14	16.0%	0.002%	0.4%	0.0%
Copper	4,701	of which:	4,701				8.1%			
Glass	18,621	of which:	18,621				32.1%			
Cone glass	15,545	of which:	8,950			6,595	15.4%			11.4%
Non-hazardous wastes	1,549	of which:		36	335	1,178		0.1%	0.6%	2.0%
Hazardous wastes	208	of which:				208				0.4%
TOTAL	58,032	of which:	49,369	37	585	8,041	85.1%	0.1%	1.0%	13.9%

EU MANDATORY TASK:

RECOVERY rate: 80%

RECYCLING rate: 70%

A circular frame on the left side of the slide contains a vibrant illustration of a jungle scene. It features various green leaves, a yellow vine, and a blue sky with white clouds. The frame has a rough, torn-paper edge effect.

CRMs

Critical Raw Materials

in WEEE

What are CRMs?

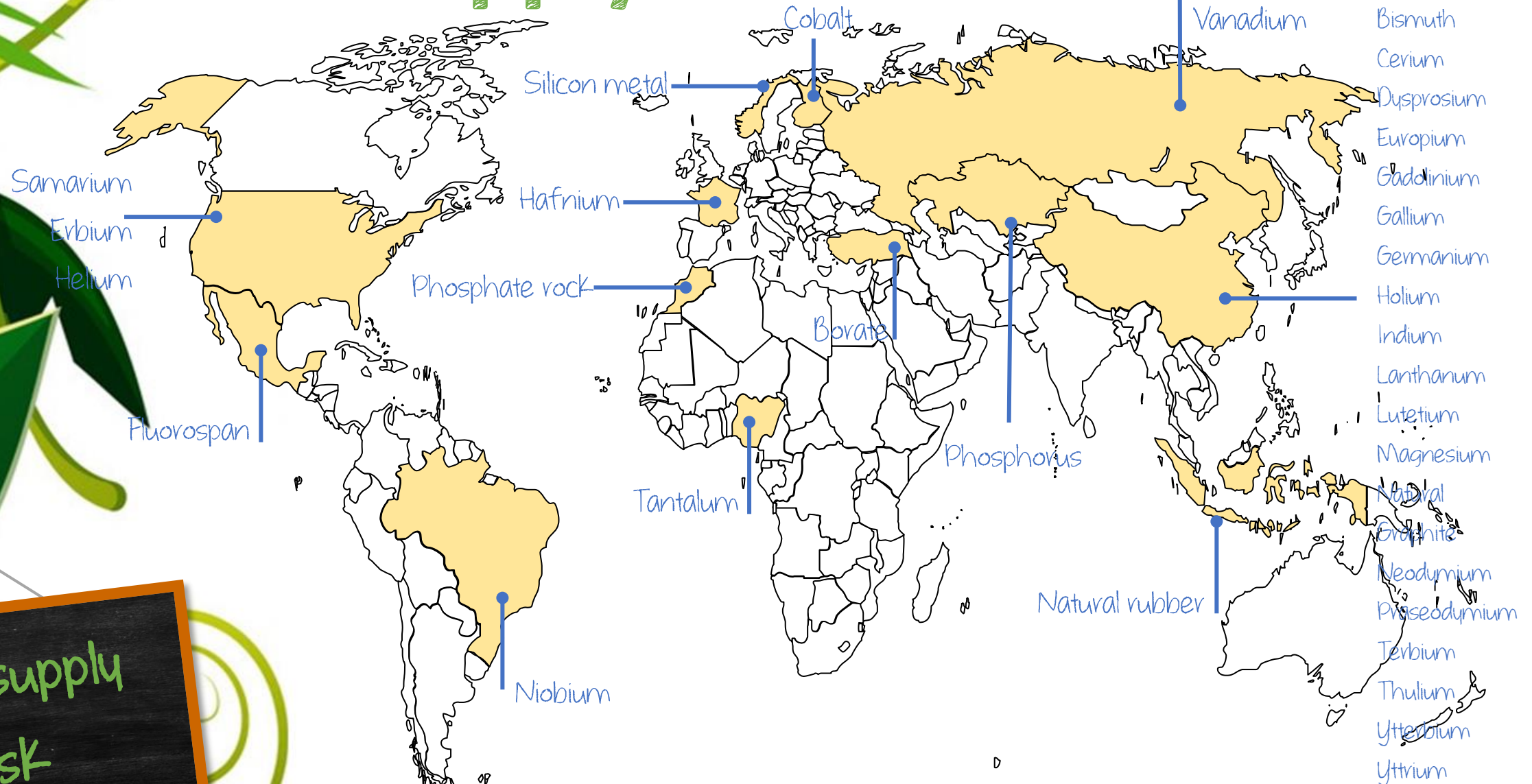
CRMs [=CRITICAL RAW MATERIALS] are raw materials classified by the European Commission as “**CRITICAL**”.

The main parameters used to determine the **criticality** for the EU Commission are:

- high economic importance to the EU;
- high risk associated with their supply.

In 2020, the European Commission published the **4th list of 30 CRMs**.

EU supply of CRMs



The supply risk

Countries accounting for the largest share of EU supply of CRM

CRMs - the list

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Lanthanide	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Actinide	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og
Lanthanide		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
Actinide		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

PGM Platinum Group metals
 LREE Light Rare Earth Elements
 HREE Heavy Rare Earth Elements

REEs ore deposits

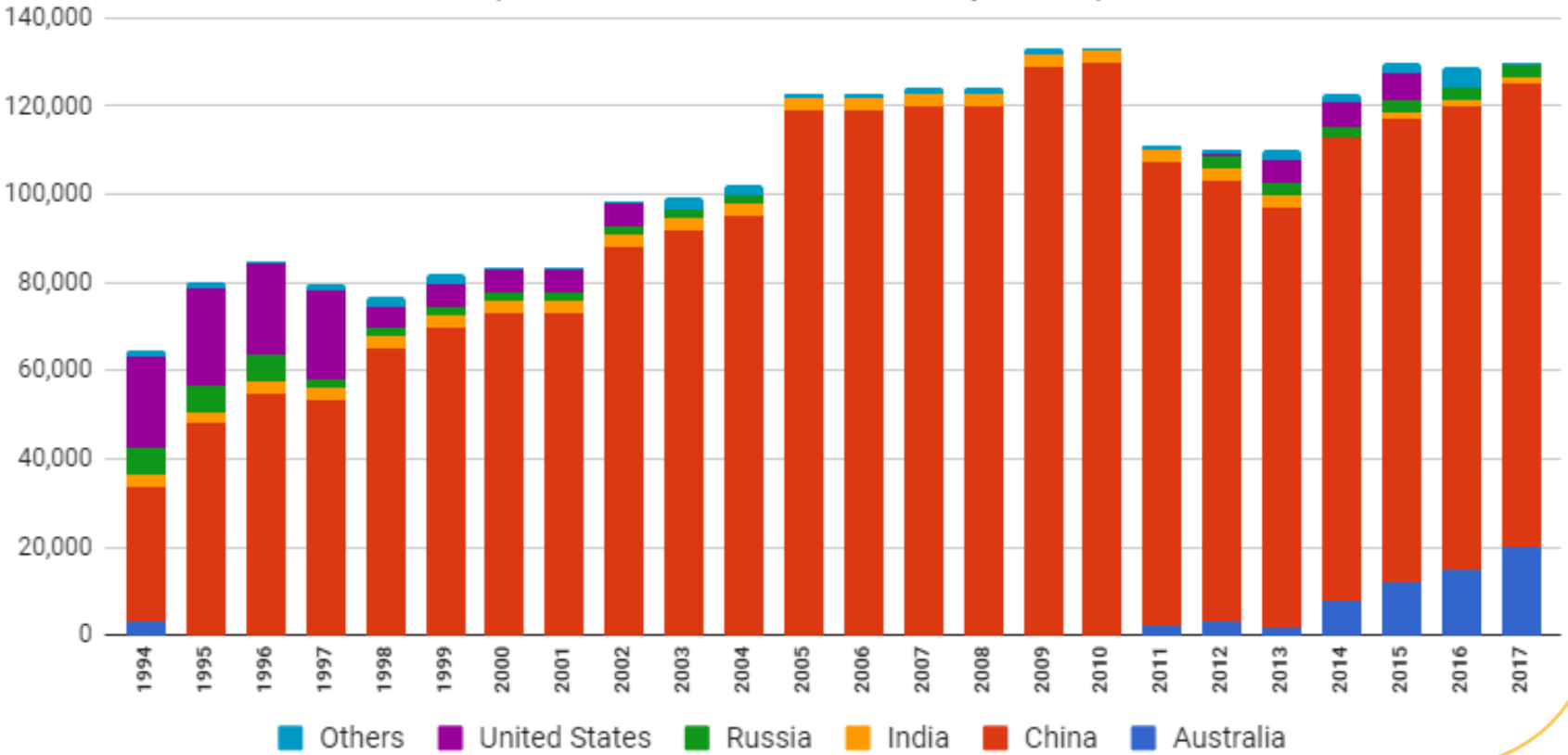


Despite many known REE deposits, the global supply of REEs is limited by the cost and complexity of exploring REE deposits and developing REE mines, including REE extraction and separation facilities.

REEs supply history

Rare Earth Element Production

(Metric tons - rare earth oxide equivalent)



PRODUCING COUNTRIES

- CHINA: more than 90%
- AUSTRALIA
- UNITED STATES
- RUSSIA
- INDIA

RARE EARTH ELEMENTS are in the list of CRITICAL RAW MATERIALS since 2014

Since 2010, new researches to look for new deposits of Rare Earth Elements developed. And new initiatives for recycling REEs from WEEE started.

CRMs in WEEE → think about

WEEE streams containing CRMs:



Displays

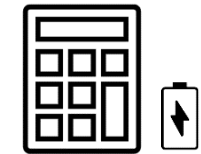
(typically LCD screens)



ICT



Consumer electronics




Small mixed WEEE
(including batteries)



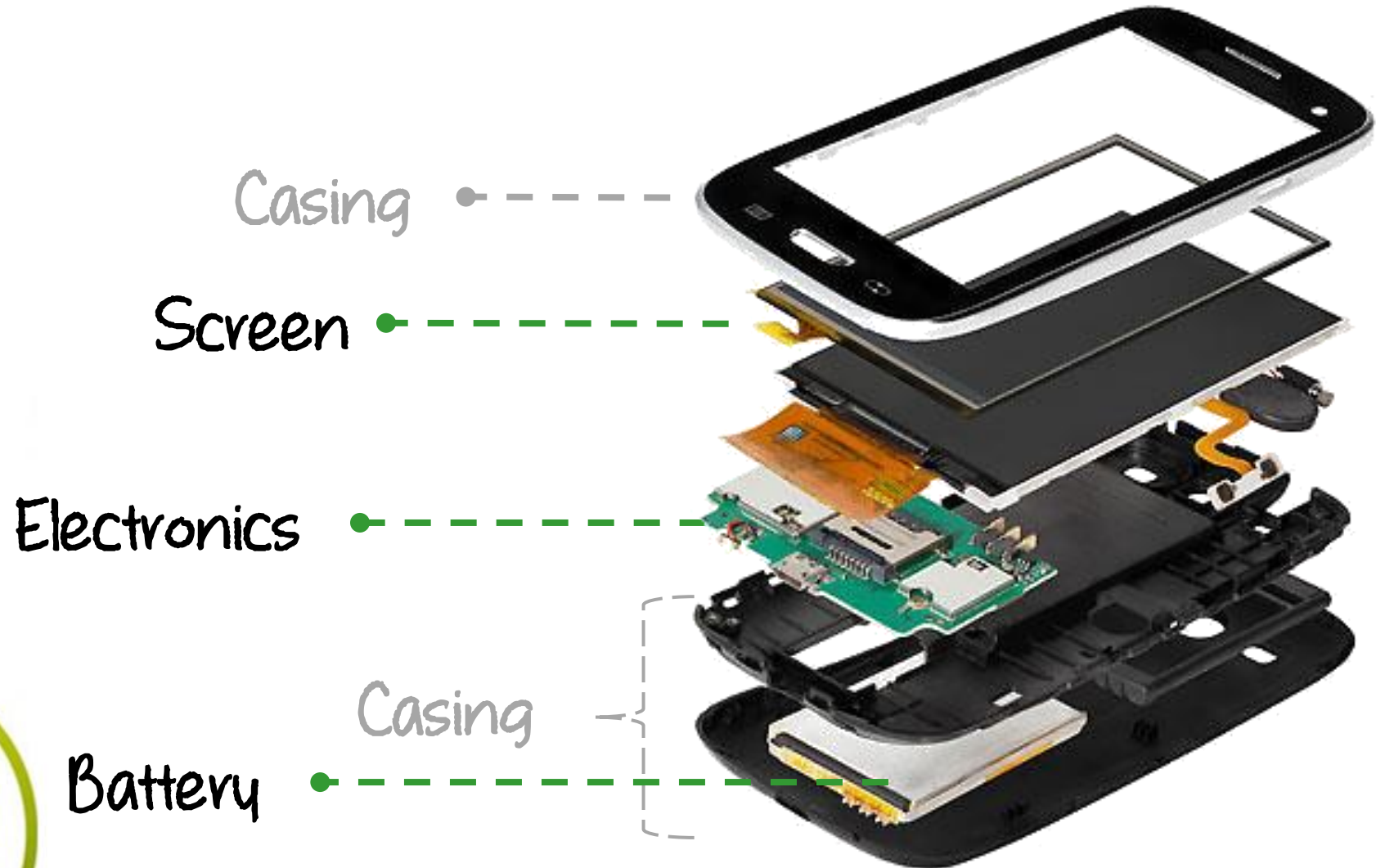
of WEEE is generated every year in the world...

... but only **20%** is properly managed

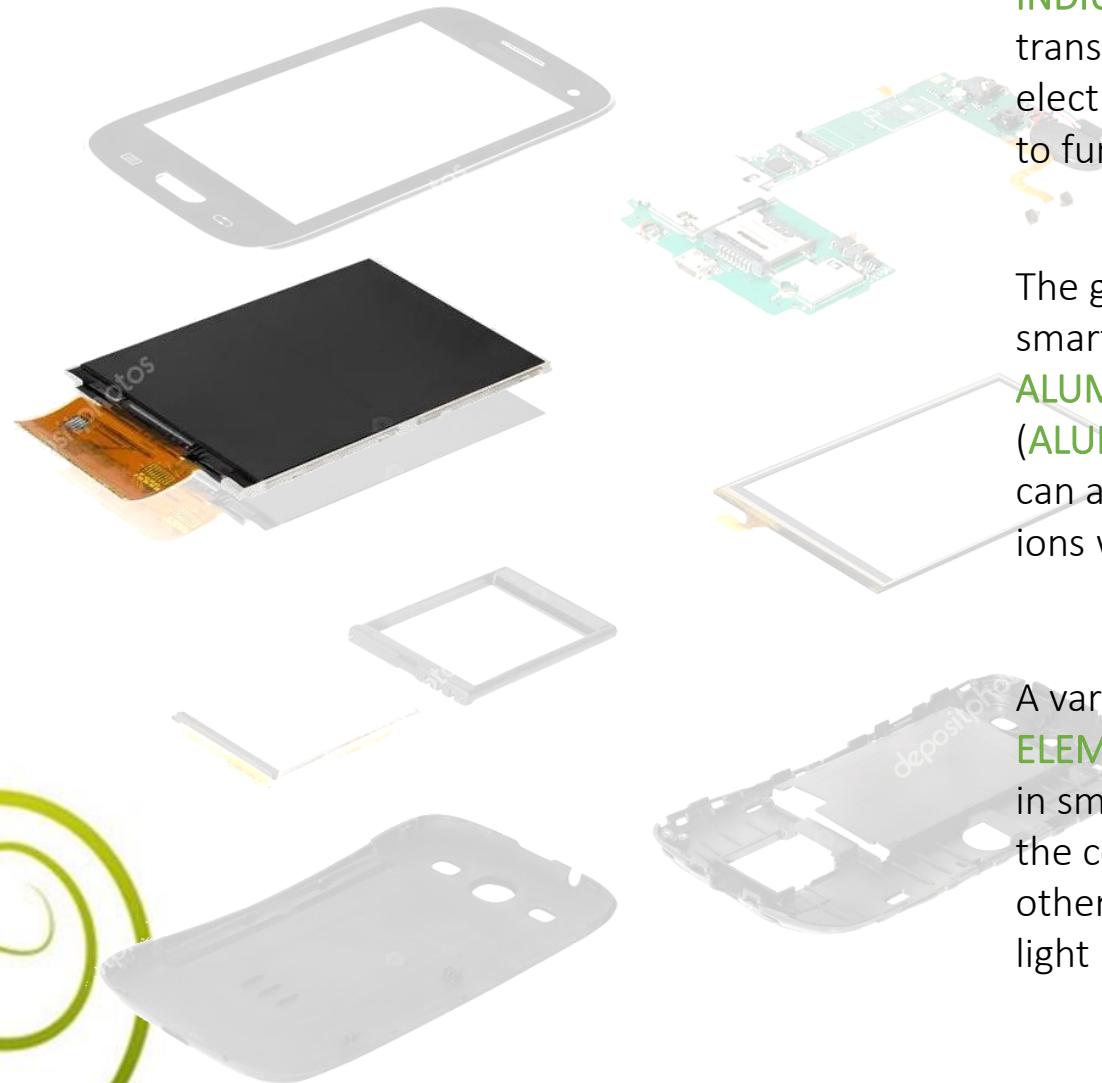
A stylized illustration of a jungle scene is framed within a large, light blue circular shape that has a torn, paper-like edge. The illustration includes various green leaves, a yellow vine, and a blue sky with white clouds.

Case study: the SMARTPHONE

Its CONSTITUENTS



The SCREEN



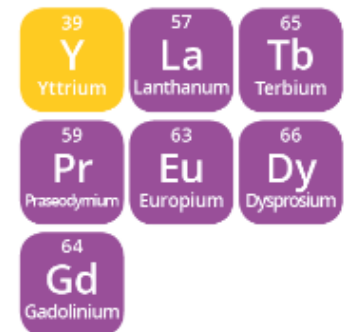
INDIUM TIN OXIDE is used in a transparent film that conducts electricity, allowing the screen to function as touch screen.



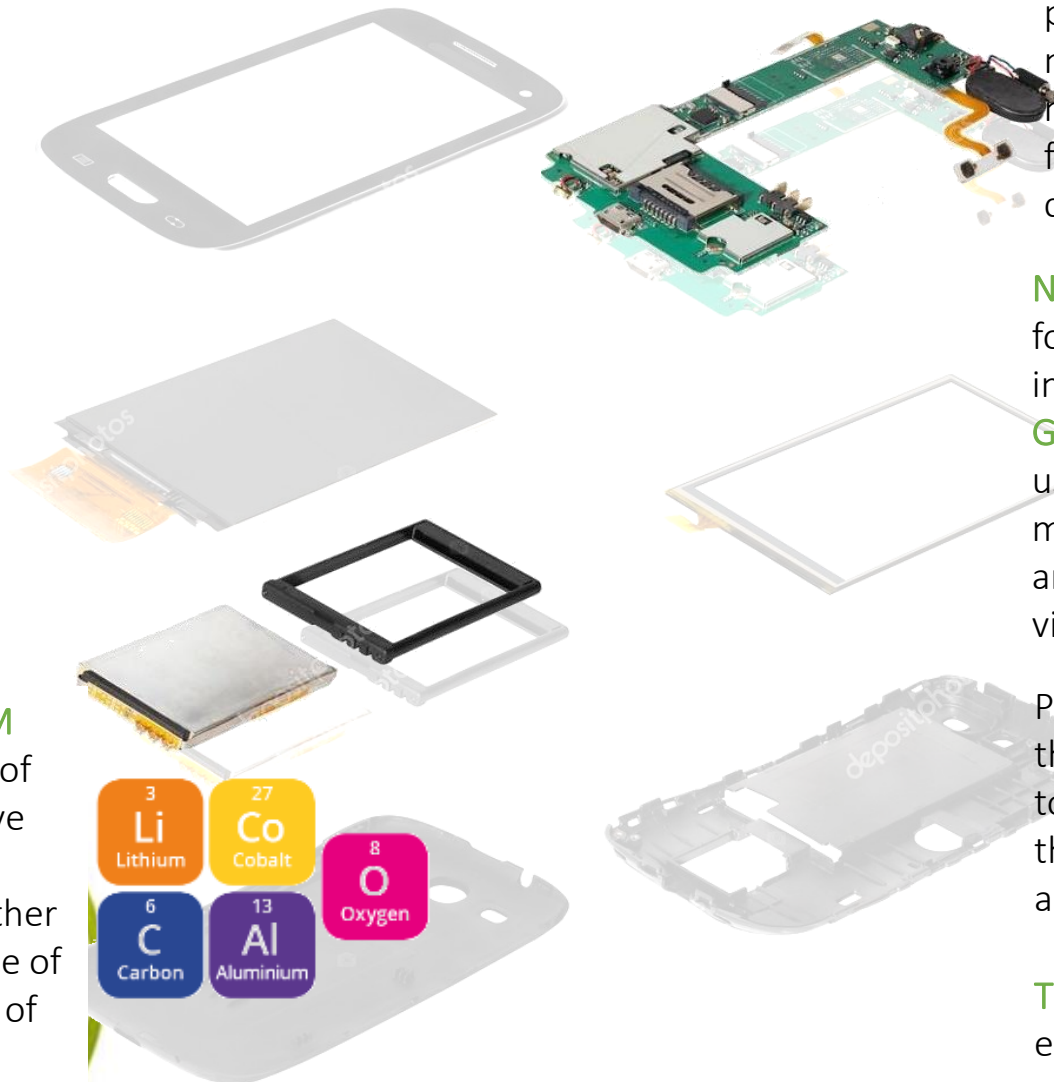
The glass used on majority of smartphones is an **ALUMINOSILICATE** glass (**ALUMINA+SILICA**). This glass can also contains **POTASSIUM** ions which help to strengthen it.



A variety of **RARE EARTH ELEMENT COMPOUNDS** are used in small quantities to produce the colours in the screen. Some others can be used to reduce UV light penetration into the phone.



ELECTRONICS and BATTERY



COPPER is used for wiring in the phone; **COPPER-GOLD-SILVER** are the major metals from which microelectrical components are fashioned. **TANTALUM** is the major component of micro-capacitors.

29 Cu Copper	47 Ag Silver
79 Au Gold	73 Ta Tantalum

NICKEL is used in the microphone and for electrical connections. **ALLOYS** including **PRASEODYMIUM**, **GADOLINIUM** and **NEODYMIUM** are used in magnets in the speaker and microphone. **NEODYMIUM**, **TERBIUM** and **DYSPROSIUM** are used in the vibration unit.

28 Ni Nickel	66 Dy Dysprosium	59 Pr Praseodymium
65 Tb Terbium	60 Nd Neodymium	64 Gd Gadolinium

Pure **SILICON** is used to manufacture the chip in the phone. It is oxidised to produce non-conducting regions, then other elements are added to allow the chip to conduct electricity.

14 Si Silicon	8 O Oxygen	51 Sb Antimony
33 As Arsenic	15 P Phosphorus	31 Ga Gallium

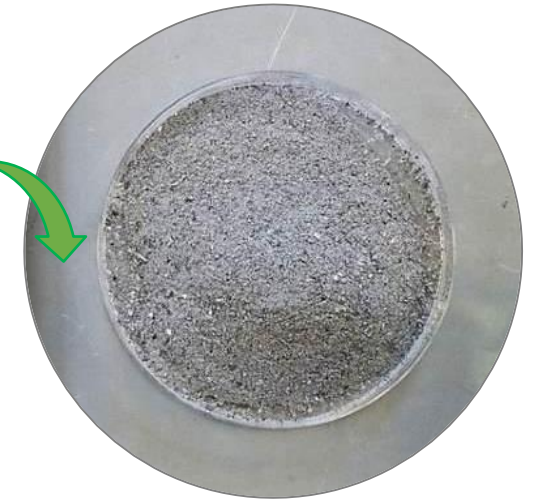
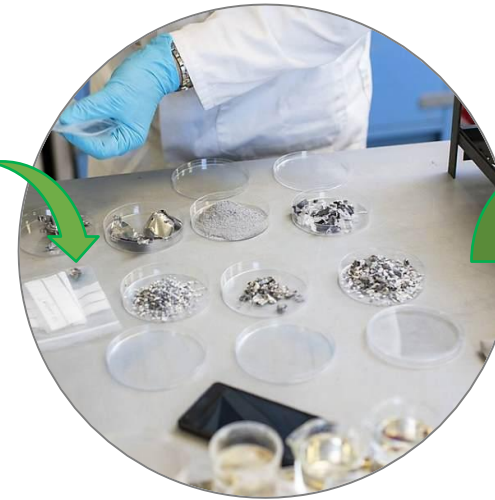
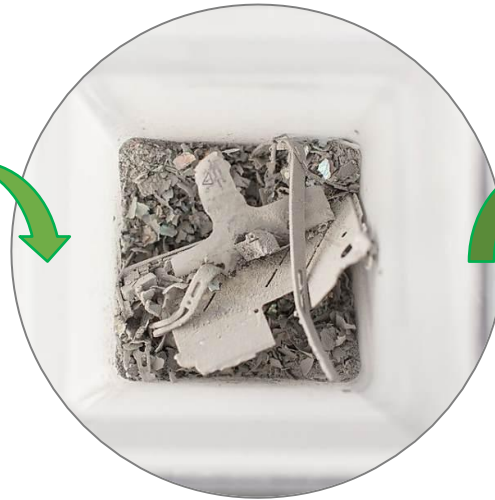
TIN and **LEAD** are used to solder electronics in the phone.

50 Sn Tin	82 Pb Lead
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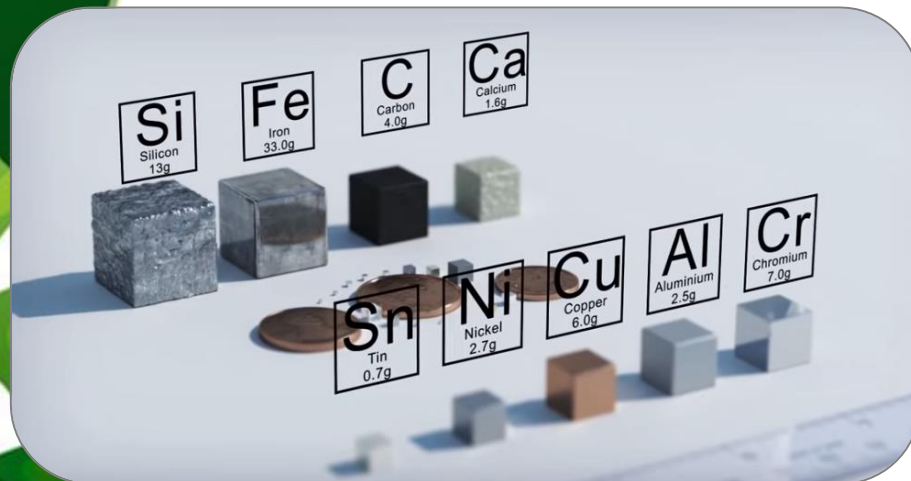
The majority of phones use **LITHIUM ION** batteries, which are composed of **LITHIUM COBALT OXIDES** as a positive electrode and **GRAPHITE** as the negative one. Some batteries use other metals, such as **MANGANESE** in place of cobalt. The battery's casing is made of **ALUMINIUM**.

3 Li Lithium	27 Co Cobalt	8 O Oxygen
6 C Carbon	13 Al Aluminium	

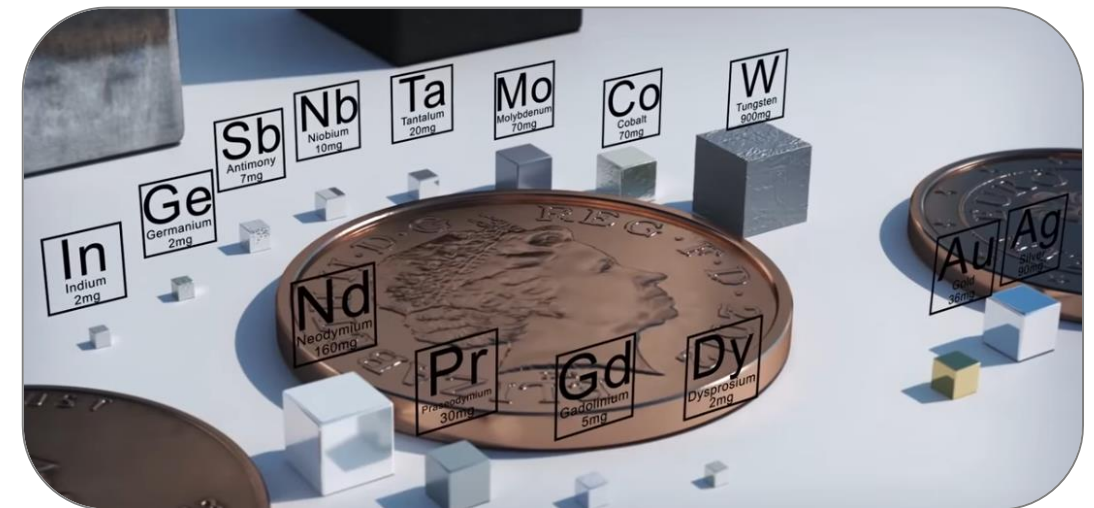
An EXPERIMENT @ Plymouth University



METALS CONTENT



RARE EARTH ELEMENTS CONTENT





Thanks for your attention!

 **Projects and Innovation Team**

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