

Components and materials of WEEE and their recovery

Modul 1 – Science and Engineering



Department of Civil, Environmental and Mechanical Engineering DICAM

Green Process Engineering Research Group «GPEG»



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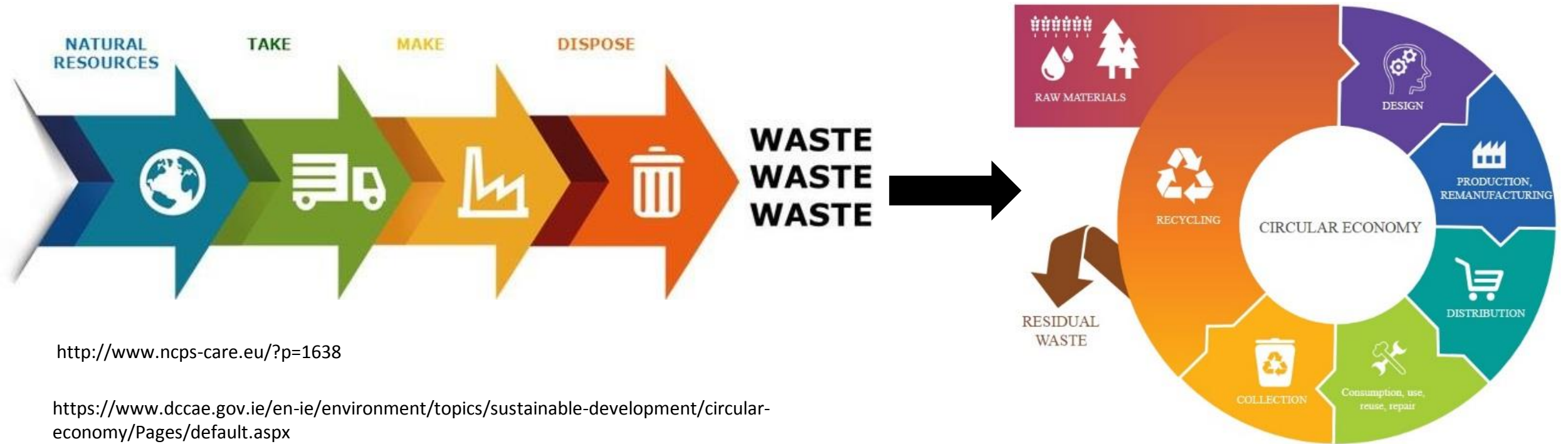


Giulia Ischia



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From the model «Take-Make-Dispose» to «Circular Economy»



<http://www.ncps-care.eu/?p=1638>

<https://www.dccae.gov.ie/en-ie/environment/topics/sustainable-development/circular-economy/Pages/default.aspx>

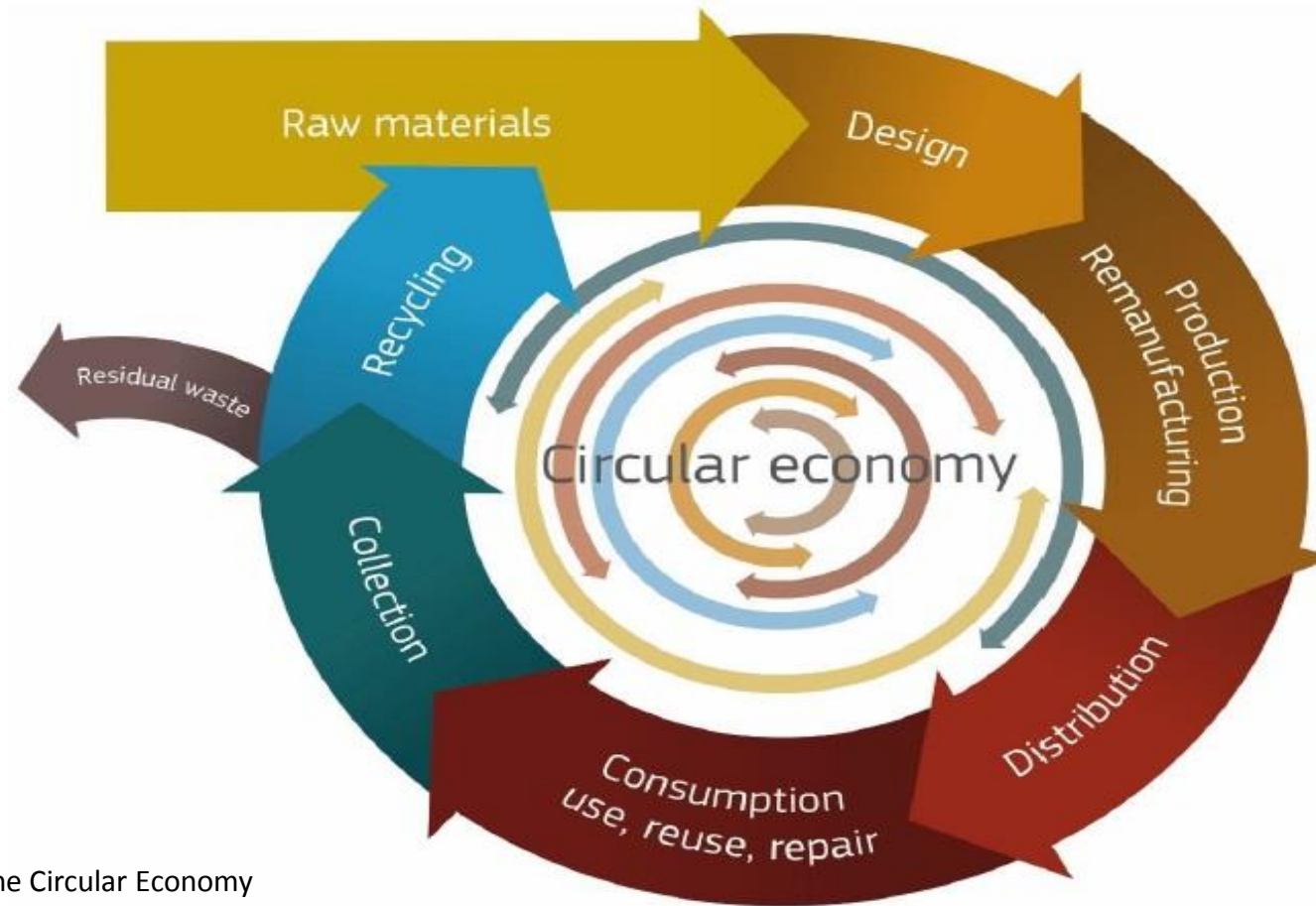


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Circular Economy: conceptual diagramm

The raw material comes back to the production system



Report on Critical Raw Materials and the Circular Economy
<https://ec.europa.eu/docsroom/documents/27327>



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The 5 R of waste management: reduce, reuse, recycle, re-collection and recover



- 1 **REDUCE** Waste reduction's at its origin: politics and choices of individual citizen
- 2 **REUSE** Repair, reinvent and relocate products and goods that are still reusable
- 3 **RECYCLE** Re-enter a secondary resource in the production cycle in the role of first resource
- 4 **RE-COLLECTION** Separate collection, through the separation of the waste produced, by materials categories' and packaging.
- 5 **RECOVER** Energy valorization (electrical and thermal energy recovery)

<https://www.econote.it/2014/08/28/le-5-r-dei-rifiuti/>



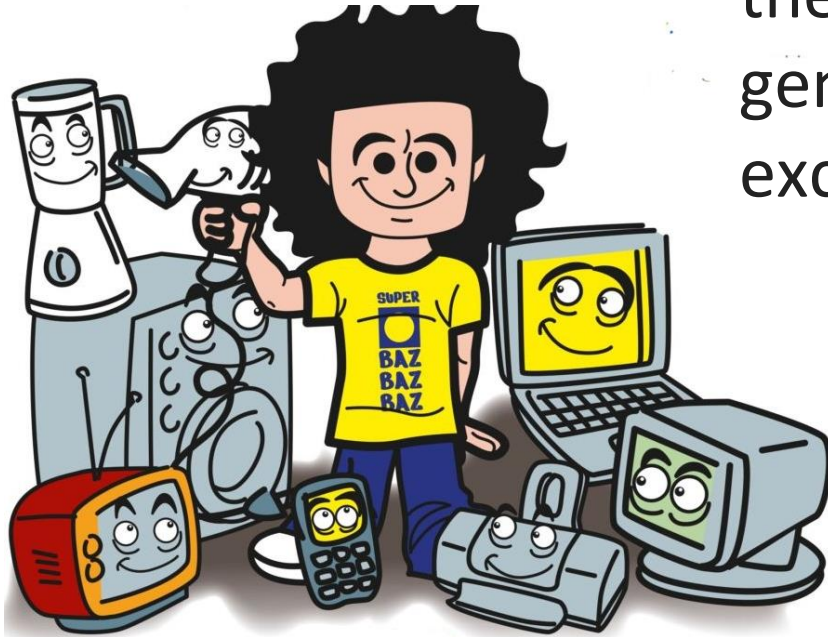
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EEE: (electrical and electronical equipment)

The AEE are devices that depend on electricity for their correct operation, both as users and as generators, designed to operate at voltages not exceeding 1000 V



WEEE: (wastes from electrical and electronic equipments)



WEEE are wastes from electrical and electronic equipments, ie all those EEE that the owner wants to dispose of due to obsolescence, breakdown, inactivity, etc.

End users, manufacturing companies, WEEE collection and recovery centers are the main actors in the correct disposal of this wastes.

European Regulation principle “**the polluter pays**”.

The collection target to which European countries must aim by the end of 2019 is: 65% of the average weight of EEE placed on the market in the previous three years.

<https://www.lentepubblica.it/wp-content/uploads/2015/02/RAEE.jpg>

https://www.cdcaee.it/GetHome.pub_do




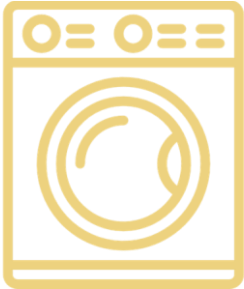

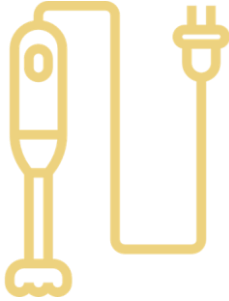

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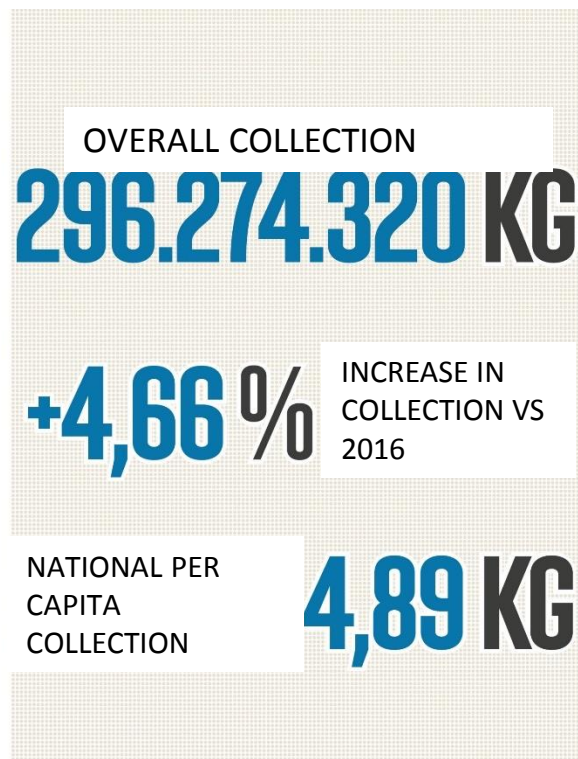
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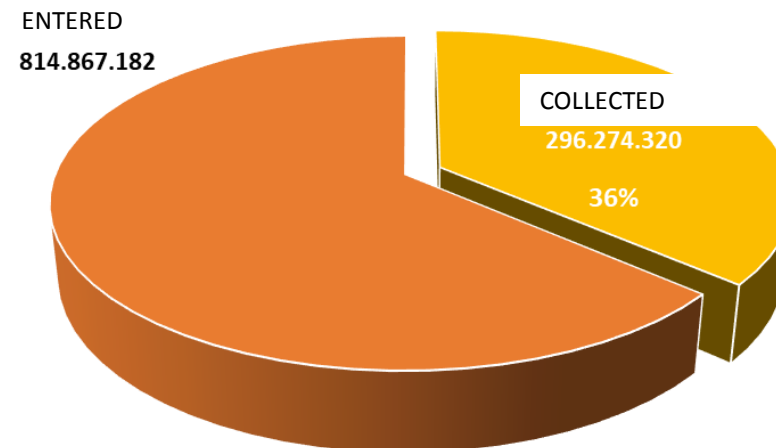
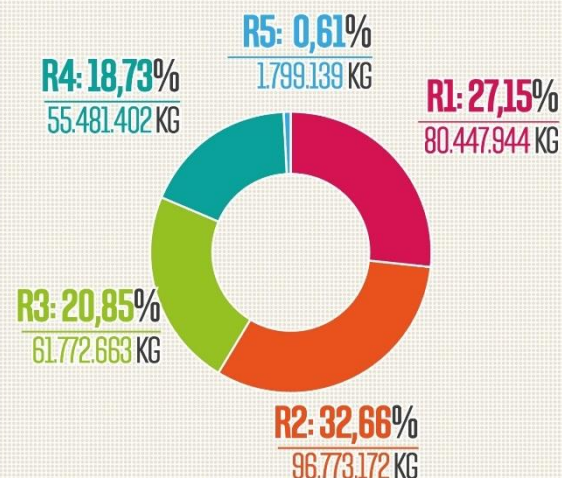
Categories of WEEE

WEEE differ from each other for the raw materials they are made of and in the use they had before becoming waste.

<p>R1</p> <p>refrigerators, freezers and air-conditioners</p>  <p>(dangerous)</p>	<p>R2</p> <p>washing and cooking appliances, extractor hoods and water- heaters</p>  <p>(non dangerous)</p>	<p>R3</p> <p>TVs and VDUs</p>  <p>(dangerous)</p>	<p>R4</p> <p>small appliances and IT, consumer electronics and lighting devices</p>  <p>(dangerous and non dangerous)</p>	<p>R5</p> <p>light sources</p>  <p>(dangerous)</p>
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COLLECTION IN THE 5 CATEGORIES
LA RACCOLTA NEI 5 AGGROPPAMENTI



COLLECTION % 2017 RESPECT TO THE ENTRY OF 2016

COLLECTION 2017 [kg]

https://www.cd craee.it/GetPage.pub_do?id=2ca980954c369c25014ce55c67350385

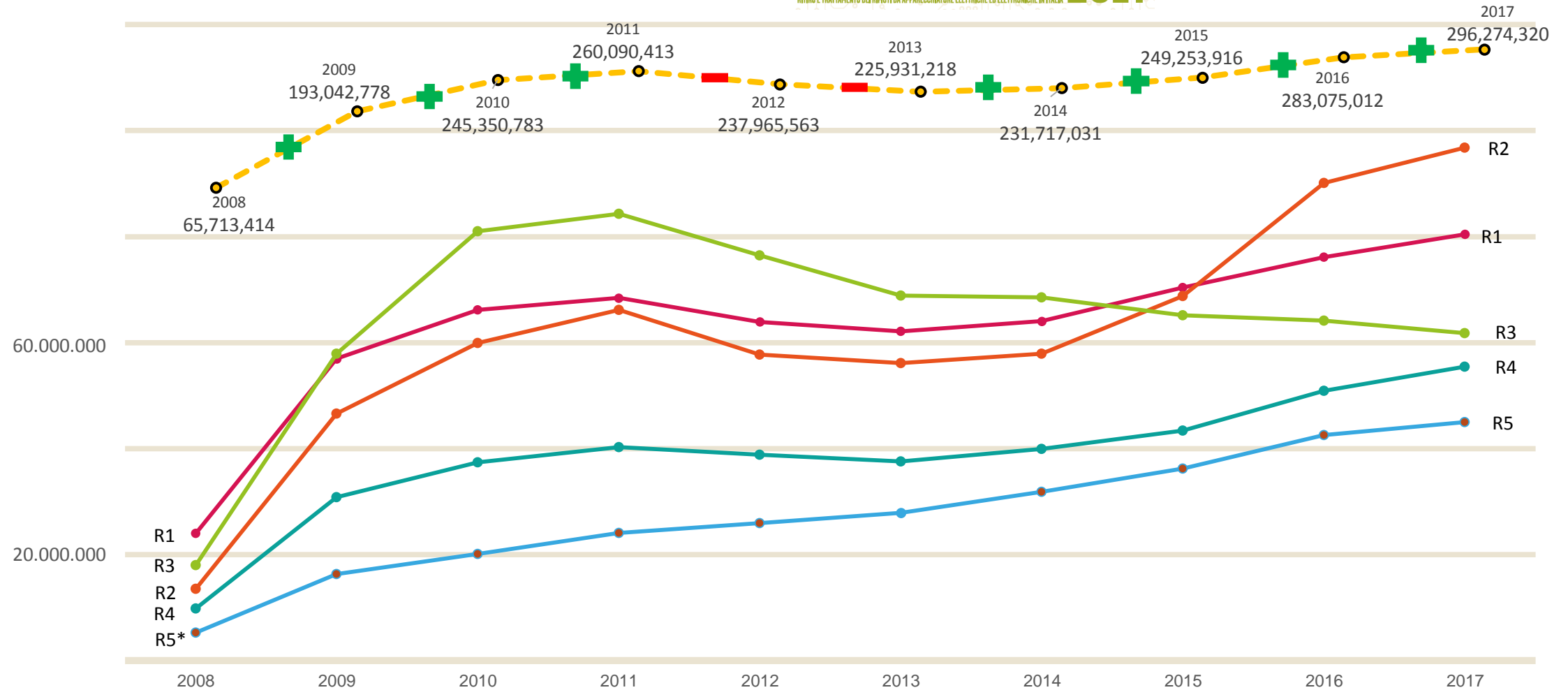


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Collection trend in the last 10 years [kg]

https://www.cdcrree.it/GetPage.pub_do?id=2ca980954c369c25014ce55c67350385

RAPPORTO ANNUALE 2017
RITIRO E TRATTAMENTO DEI RIFIUTI DA APPARECCHIATURE ELETTRICHE ED ELETTRONICHE IN ITALIA



*valore moltiplicato per 5



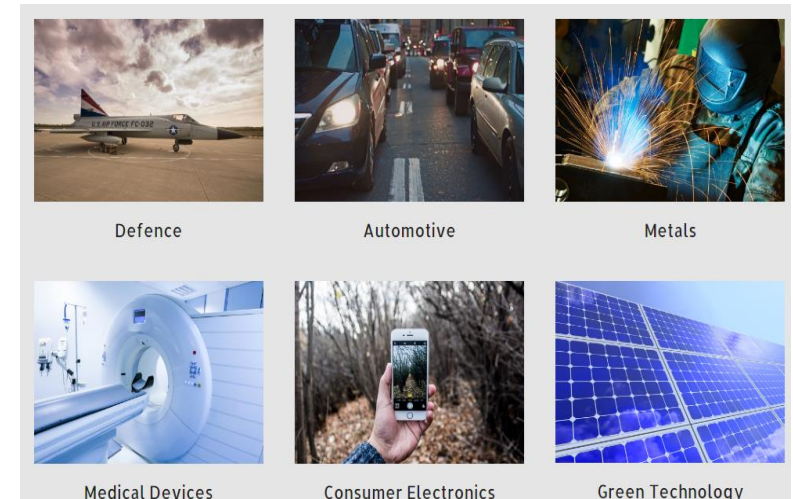
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Why the WEEE recovery's is important

- Materials componing WEEE are not biodegradable
- Risk of enviromental pollution
- Exhaustible natural resources
- Critical raw materials



<http://www.sudpress.it/rifiuti-crocetta-potremo-requisire-bellolampo-orlando-emergenza-frutto-di-un-governo-inadeguato/>



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What is a landfill?

Why shouldn't WEEE be abandoned?

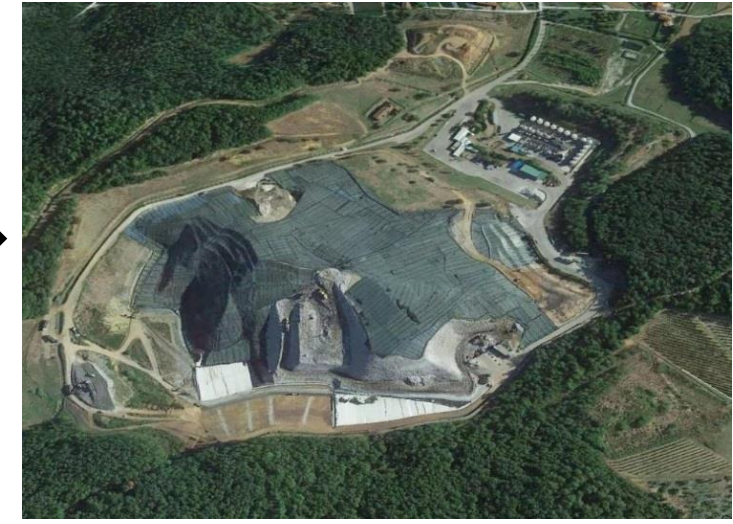
Realization phase



Operational phase



Closing phase



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Realization phase

<http://www.pisatoday.it/cronaca/visita-enrico-rossi-discarda-peccioli-25-luglio-2019.html>



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Operative phase



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<https://canavesenews.it/news/comital-volpiano-annullato-tavolo-regione-domani-lincontro-decisivo-al-ministero-del-lavoro-roma/>

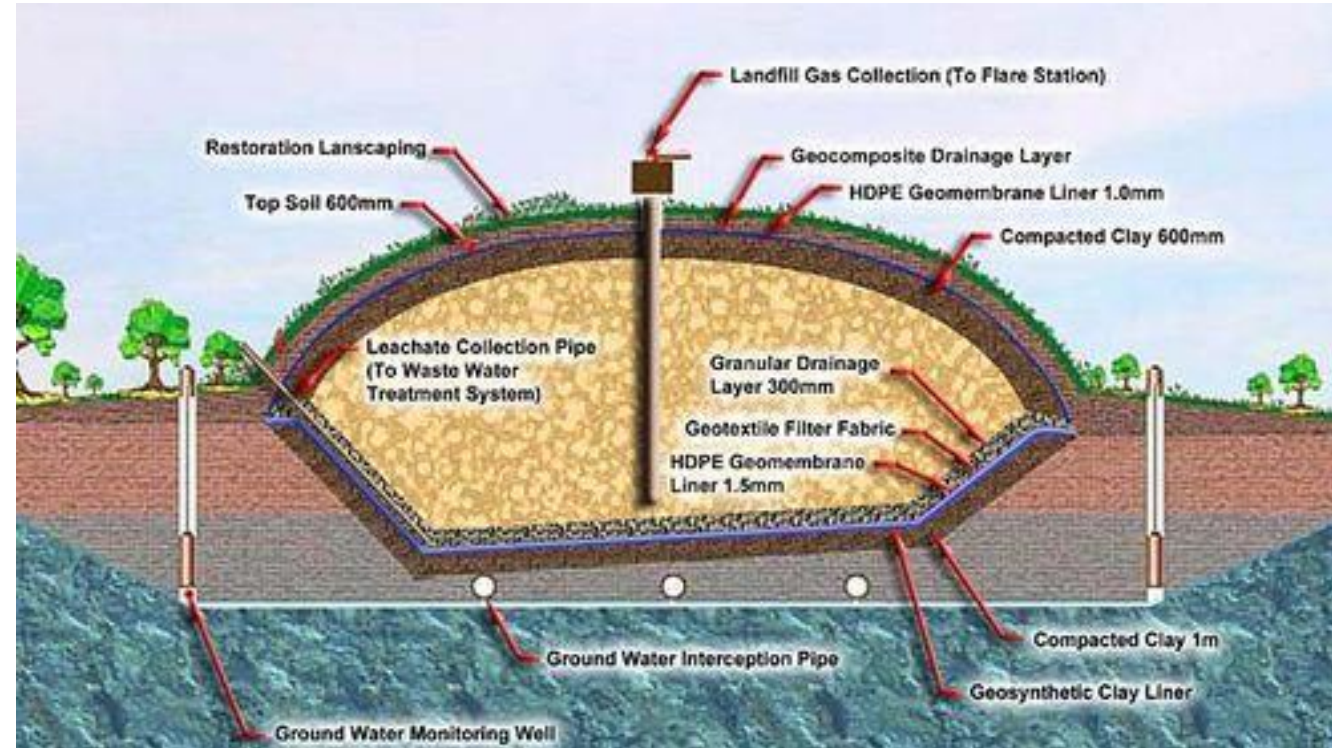
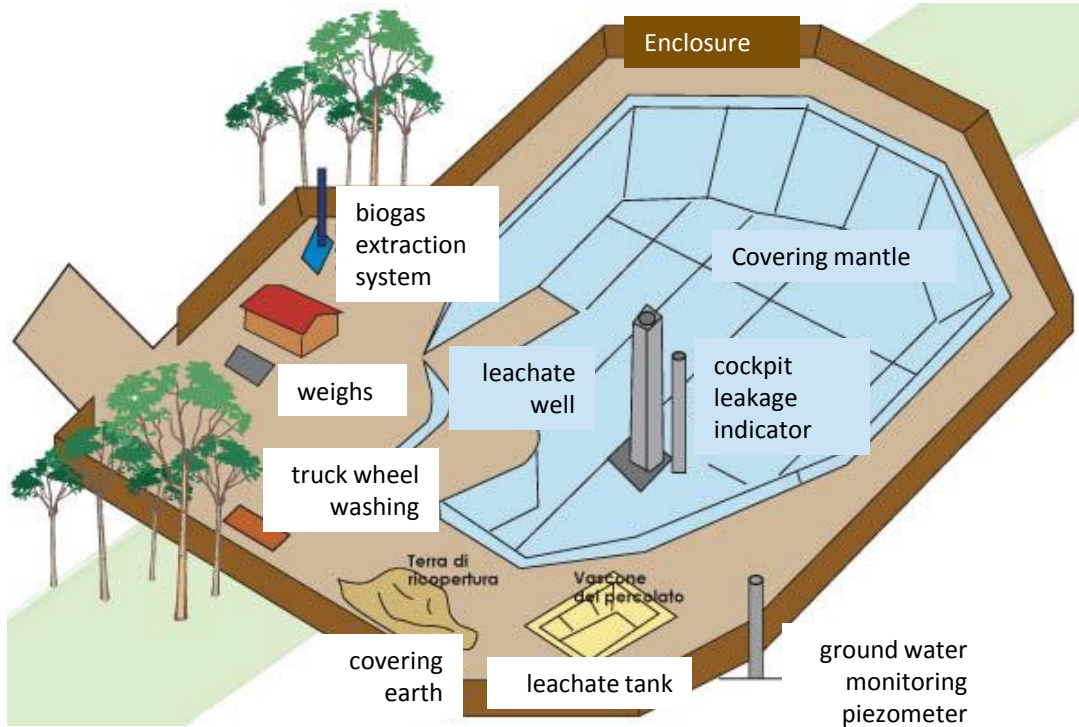
Closing phase



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How a landfill works: what the dangers are!



http://www.crati.it/por_calabria/Sito/Pannello10/Discariche.html

<http://www.geotecnologie.unisi.it/corsinew.php?act=det&wat=0&id=1901>



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The WEEE and their recovery

<https://www.youtube.com/watch?v=hB2DzYB4Tt0>



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What is my old pc made of?

Personal Computer



What materials

**Material
properties**

**How to recover
materials**

**What are the most
important
materials and why**



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What is my old pc made of? Materials and their properties

Personal Computer



Material	Content %	Material	Content %	Material	Content %
Plastic materials	22,9	Tantalum	16×10^{-3}	Silver	19×10^{-3}
Lead	6,4	Indium	2×10^{-3}	Antimony	9×10^{-3}
Aluminum	14,2	Vanadium	2×10^{-4}	Chrome	$6,3 \times 10^{-3}$
Germanium	2×10^{-3}	Beryllium	$15,7 \times 10^{-3}$	Cadmium	$9,4 \times 10^{-3}$
Gallium	1×10^{-3}	Gold	$1,6 \times 10^{-3}$	Selenium	$1,6 \times 10^{-3}$
Iron	20,5	Europium	2×10^{-3}	Radium	1×10^{-3}
Tin	1	Titanium	$15,7 \times 10^{-3}$	Platinum	$0,1 \times 10^{-3}$
Copper	6,9	Ruthenium	$1,6 \times 10^{-3}$	Mercury	$2,2 \times 10^{-3}$
Barium	$3,2 \times 10^{-2}$	Cobalt	$15,7 \times 10^{-3}$	Silicon (glass)	24,9
Nickel	0,9	Palladium	3×10^{-4}		
Zinc	2,2	Manganese	$31,5 \times 10^{-3}$		



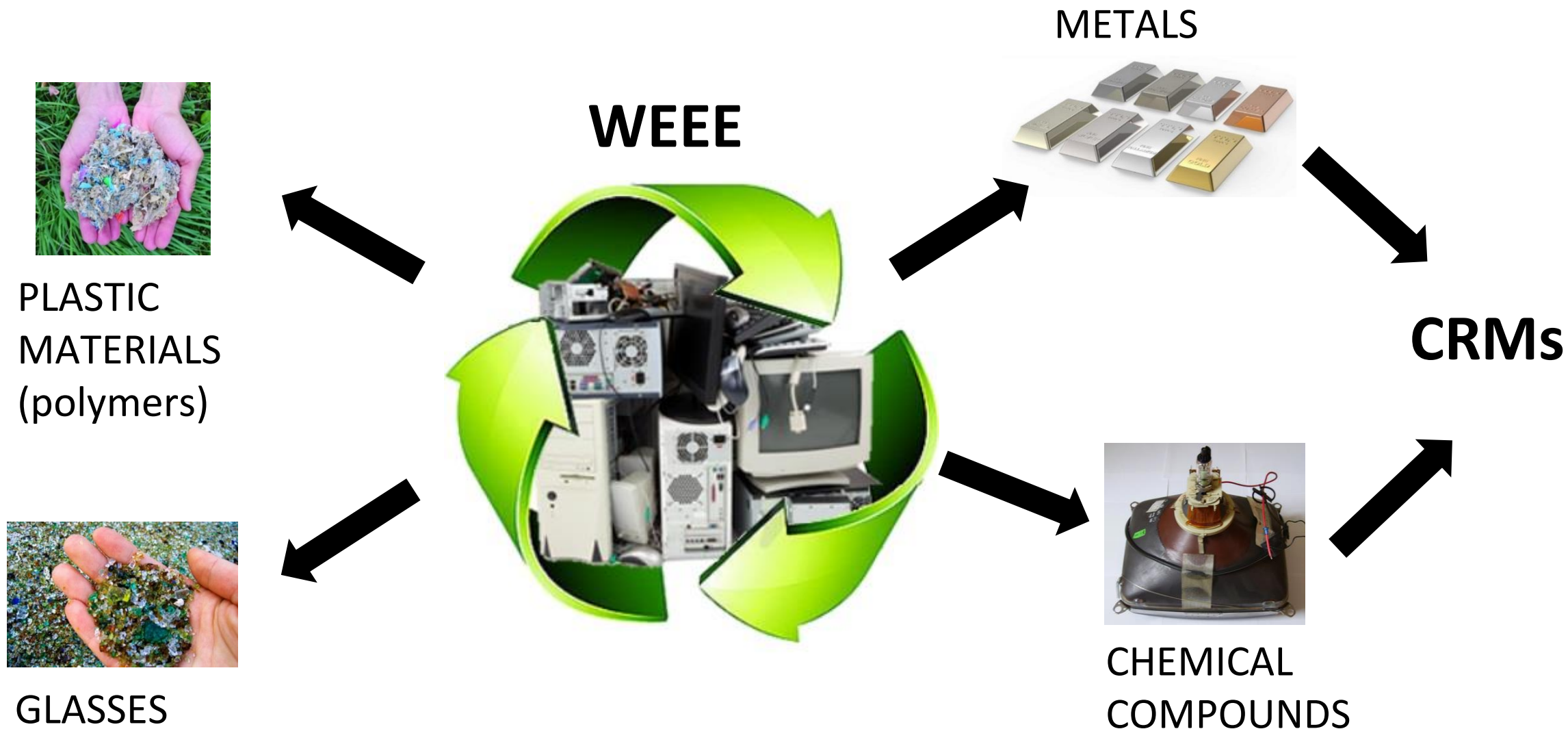
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Materials present in WEEE



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Periodic Table of the Elements

<div> <div>1</div> <div>Alkali Metal</div> <div>Alkaline Earth</div> <div>Transition Metal</div> <div>Basic Metal</div> <div>Semimetal</div> <div>Nonmetal</div> <div>Halogen</div> <div>Noble Gas</div> <div>Lanthanide</div> <div>Actinide</div> <div>18</div> </div>																	
1 H hydrogen 1.008	2 He helium 4.003																
3 Li lithium 6.94	4 Be beryllium 9.012															5 B boron 10.81	6 C carbon 12.01
7 Na sodium 22.99	8 Mg magnesium 24.31															9 Al aluminum 26.98	10 Si silicon 28.09
11 K potassium 39.10	12 Ca calcium 40.08	13 Sc scandium 44.96	14 Ti titanium 47.88	15 V vanadium 50.94	16 Cr chromium 52.00	17 Mn manganese 54.94	18 Fe iron 55.85	19 Co cobalt 58.93	20 Ni nickel 58.69	21 Cu copper 63.55	22 Zn zinc 65.39	23 Ga gallium 69.72	24 Ge germanium 72.64	25 As arsenic 74.92	26 Se selenium 78.96	27 Br bromine 79.90	28 Kr krypton 83.79
37 Rb rubidium 85.47	38 Sr strontium 87.62	39 Y yttrium 88.91	40 Zr zirconium 91.22	41 Nb niobium 92.91	42 Mo molybdenum 95.96	43 Tc technetium (98)	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs cesium 132.9	56 Ba barium 137.3	57-71 Lanthanide Series	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.9	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.5	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 208.98	84 Po polonium (209)	85 At astatine (210)	86 Rn radon (222)
87 Fr francium (223)	88 Ra radium (226)	89-103 Actinide Series	104 Rf rutherfordium (261)	105 Db dubnium (268)	106 Sg seaborgium (266)	107 Bh bohrium (270)	108 Hs hassium (277)	109 Mt meitnerium (278)	110 Ds darmstadtium (281)	111 Rg roentgenium (282)	112 Cn copernicium (285)	113 Nh nihonium (286)	114 Fl flerovium (289)	115 Mc moscovium (289)	116 Lv livermorium (293)	117 Ts tennessine (294)	118 Og oganeson (294)
			57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium (145)	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.2	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.0	71 Lu lutetium 175.0
			89 Ac actinium (227)	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium (237)	94 Pu plutonium (244)	95 Am americium (243)	96 Cm curium (247)	97 Bk berkelium (247)	98 Cf californium (251)	99 Es einsteinium (252)	100 Fm fermium (257)	101 Md mendelevium (258)	102 No nobelium (259)	103 Lr lawrencium (262)

<http://topnotchteacher.com/periodic-table-of-the-elements-chart-magnetic/>



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The Metals

- Definition of metallic material, what are its properties?
- Differences between common metal and noble metal
- What is the passivation of a metal or alloy?
- In what form are they commonly found in nature? What are the sources?

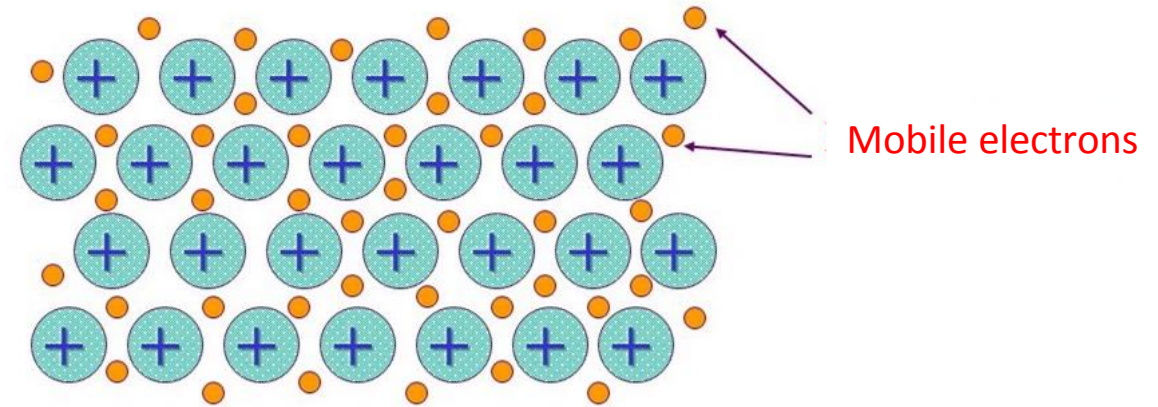


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Metallic materials

Simplifier model of the metal bond

Lattice of cations immersed in a «sea» of mobile electron



Metallic materials

1. Mechanical resistance
2. Electrical and thermal conductivity
3. Ductility

The bonds are delocalized in the whole crystal and the valence electrons are not tied to a particular atom but can move freely from one atom to another



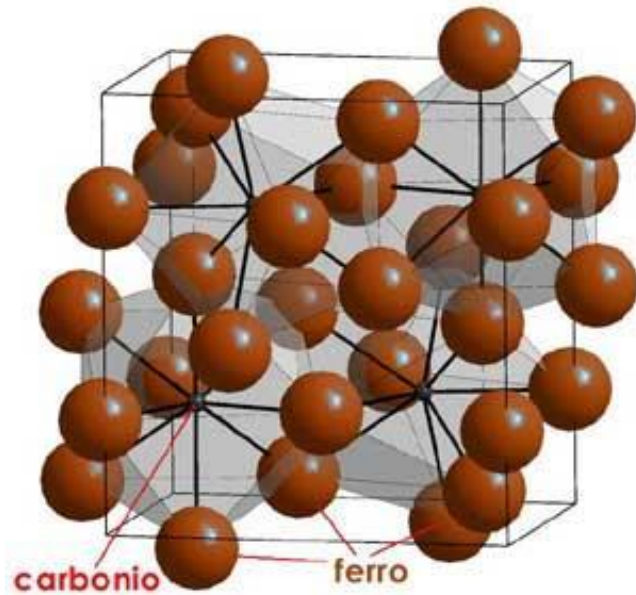
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Metallic materials and alloys

An alloy is a combination, in solution or in mixture, of two or more elements, of which at least one is a metal and the resulting material has metallic properties different from those of the relative components.



Steel: Alloy Fe-C

Mild Steel: C < 2%

Cast Iron: C > 2%

http://www.brunoacciai.it/tecniche_materiali/acciaio_caratteristiche.php



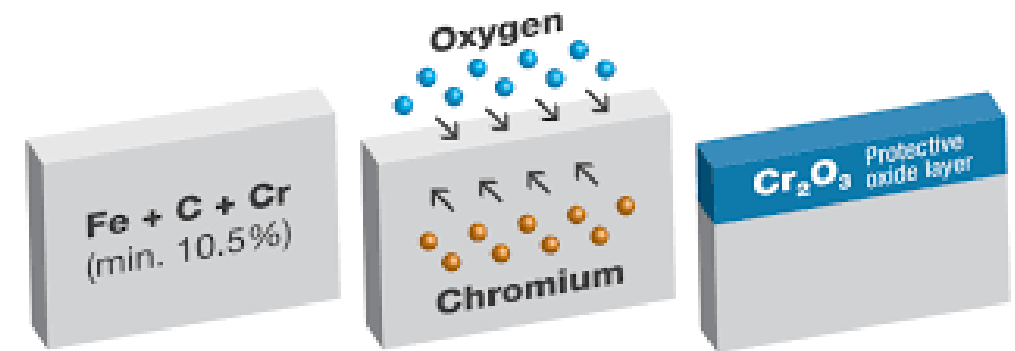
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Steel: INOX

AISI (*American Iron and Steel Institute*),

AISI 304 - Cr (18%) Ni (10%) C (0,05%);

AISI 316 - Cr (16%) Ni (11.3/13 %) Mo (2/3 %)



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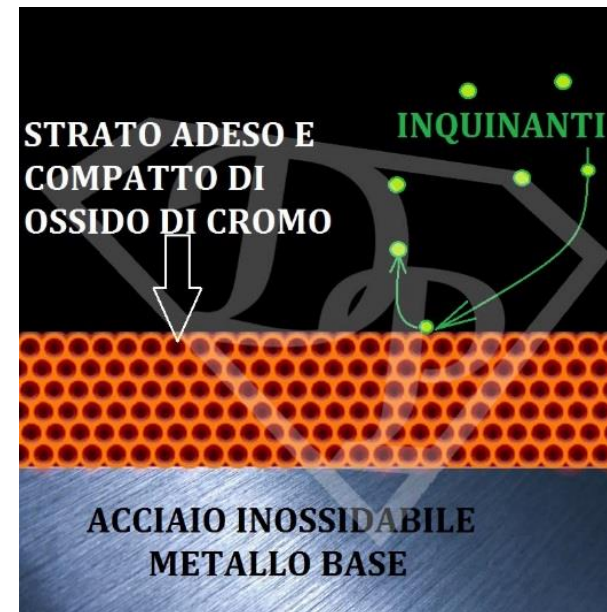
Corrosion and passivation of metals

Corrosion: uncontrolled oxidation with the formation of a porous and non-adhered oxide layer.

Passivation: controlled oxidation of metal with the formation of a thin layer of adherent and non-porous metal oxide.



Non- passivated metal



Passivated metal



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Corrosion of metals



What happens to my phone when it falls into the water?



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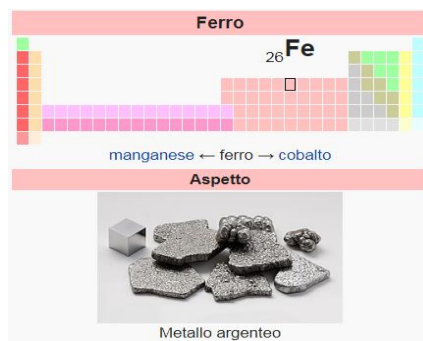
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Classification of metals: common metals

Periodic table of the Elements

Iron (Fe)



pf 1538 °C,
 $E_{\text{redox}} = -0.41 \text{ V}$
 40 €/t

Aluminum (Al)



pf 660 °C,
 $E_{\text{redox}} = -1.66 \text{ V}$
 1.7 €/kg

Elements																																																																							
1 H Hydrogen																																																																							
3 Li Lithium	4 Be Beryllium																	5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon																																																
11 Na Sodium	12 Mg Magnesium																	13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon																																																
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton																																																						
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon																																																						
55 Cs Cesium	56 Ba Barium	57 La Lanthanum	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon																																																						
87 Fr Francium	88 Ra Radium	89 Ac Actinium	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium																																																															



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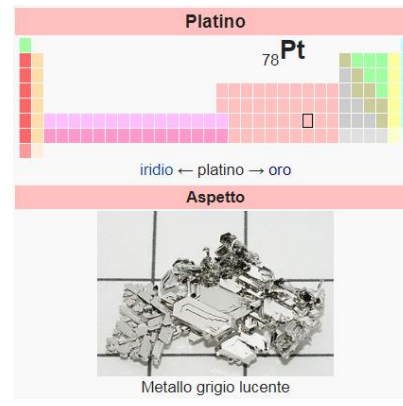


Gold (Au)



pf 1069 °C,
 $E_{\text{redox}} = 1.69 \text{ V}$
 34.8 €/g

Platinum (Pt)



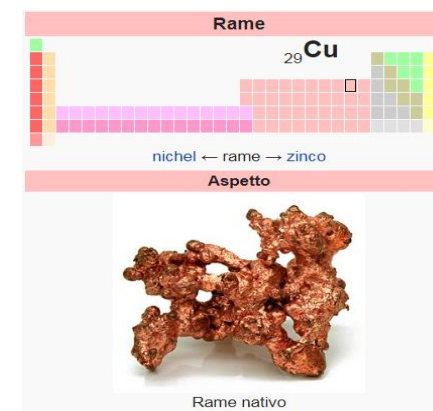
pf 1768 °C,
 $E_{\text{redox}} = 1.19 \text{ V}$
 24.8 €/g

Silver (Ag)



pf 981 °C,
 $E_{\text{redox}} = 0.80 \text{ V}$
 0.4 €/g

Copper (Cu)



pf 1084 °C,
 $E_{\text{redox}} = 0.34 \text{ V}$
 5.4 €/kg

Periodic table of the Elements

Elements

1 H Hydrogen																	2 He Helium				
3 Li Lithium	4 Be Beryllium															5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium															13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton				
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon				
55 Cs Cesium	56 Ba Barium	57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium	72 Hf Hafnium				
87 Fr Francium	88 Ra Radium	89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium	104 Rf Rutherfordium				

Lanthanide series

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
58	59	60	61	62	63	64	65	66	67	68	69	70	71
140.12	140.91	144.24		150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.05	174.97

Actinide series

Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
90	91	92	93	94	95	96	97	98	99	100	101	102	103
232.04	231.04	238.03	237.05	244.06	243.06	247.07	247.07	251.08	252.08	257.10	258.10	259.10	262.10

Noble Metals

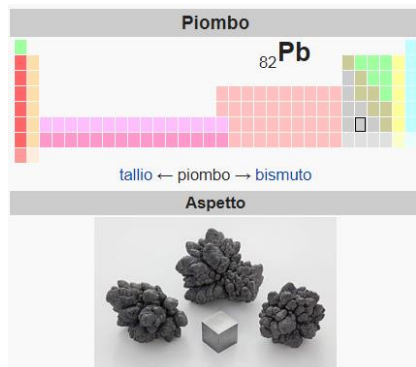


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Lead (Pb)



pf 327 °C,

Mercury (Hg)



pf – 38 °C,



Other metals

Periodic table of the Elements

Elements

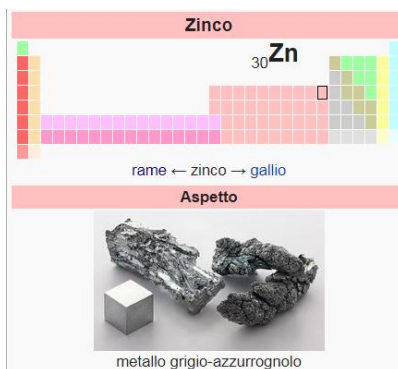
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3 Li Lithium	4 Be Beryllium																	5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium																	13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton						
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon						
55 Cs Cesium	56 Ba Barium	57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium							
87 Fr Francium	88 Ra Radium	89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium							

Cadmium (Cd)



pf 594 °C,

Zinc (Zn)



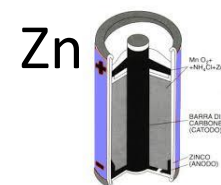
pf 693 °C,
 $E_{\text{redox}} = -0.77 \text{ V}$

Lithium (Li)



pf 454 °C,

Li



Ni/
Cd



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Connecting matters

Metals: mineral sources



Magnetite (Fe_3O_4)

<https://www.minieredicalamita.it/capoliveri-miniere/cuore-terra.html>



Bauxite (ricco in $\text{Al}(\text{OH})_3$)



Chalcopyrite (CuFeS_2)



<https://itimoni.it/america/viaggio-in-cile-e-isola-di-pasqua/>



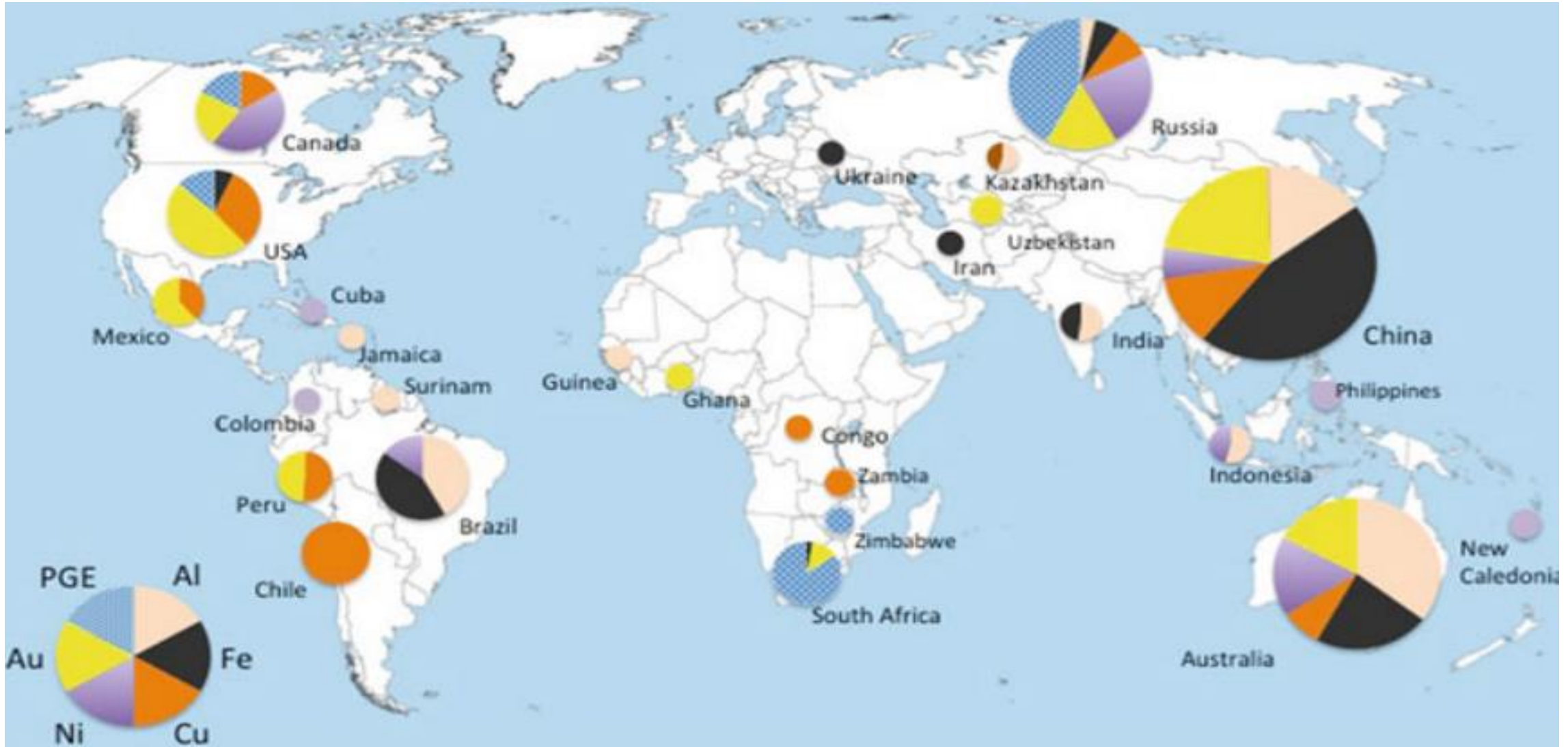
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Global distribution of metals



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Metals: the sources of copper

Chalcopirite



Bornite



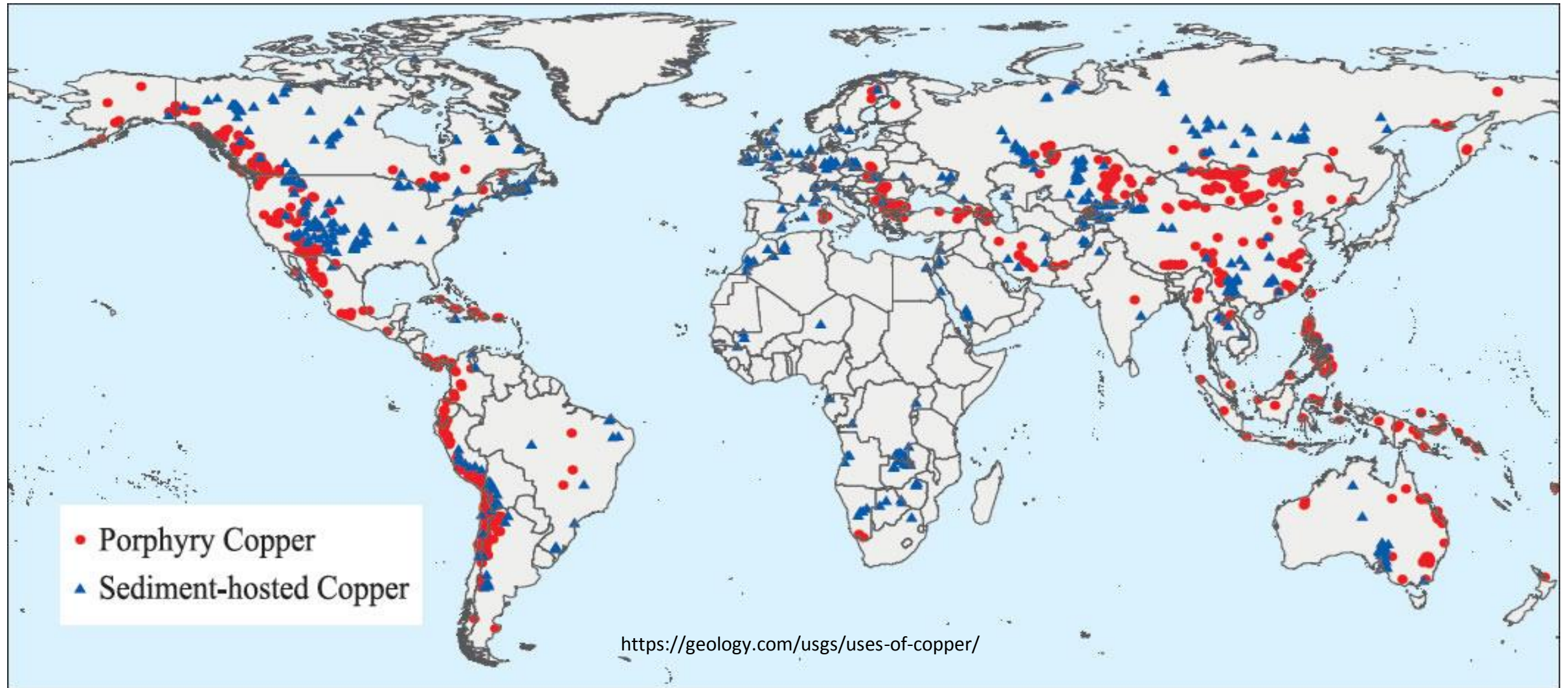
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Global distribution of copper



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Copper mines

<https://www.youtube.com/watch?v=Z-kfODjpB7M>

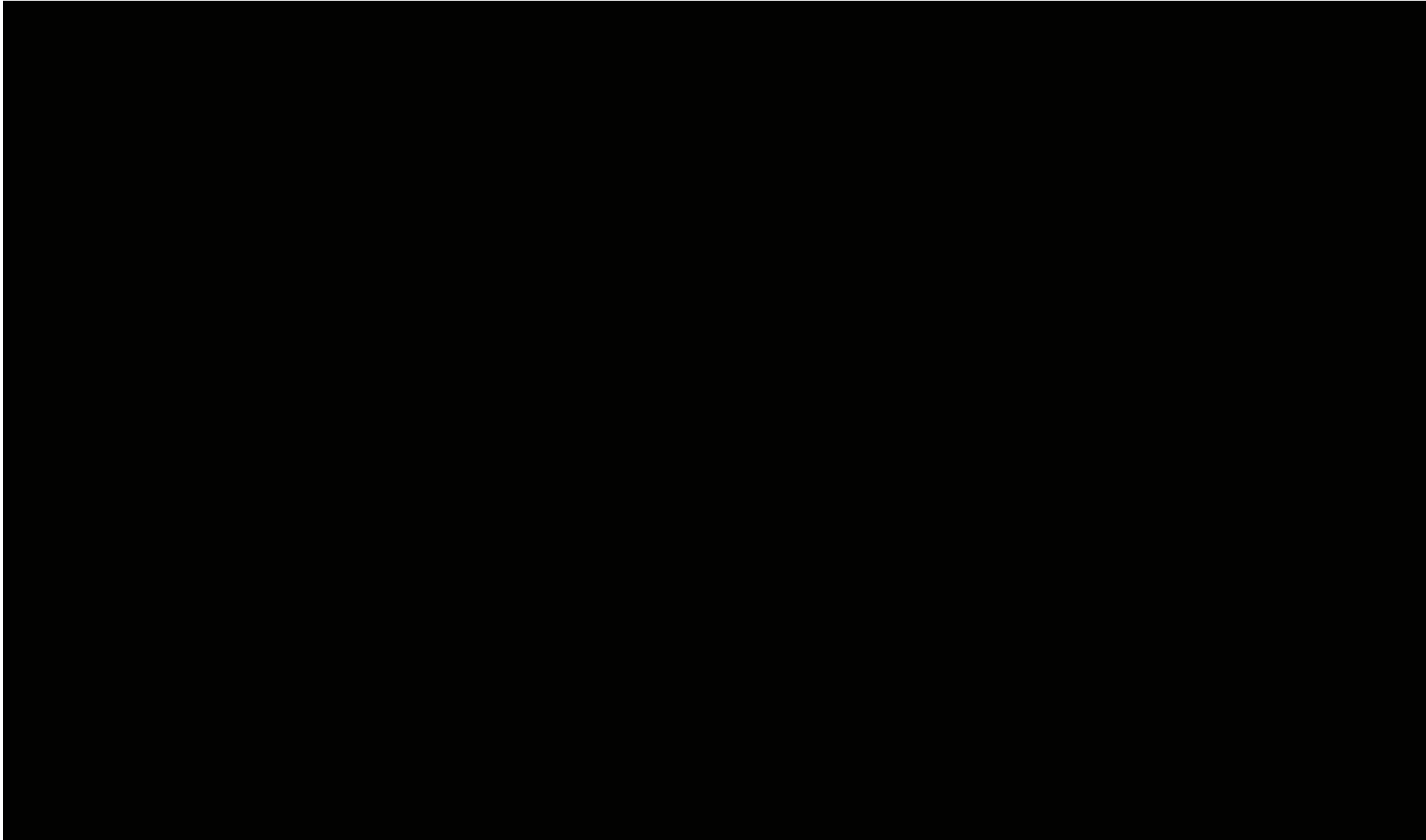


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Copper mines

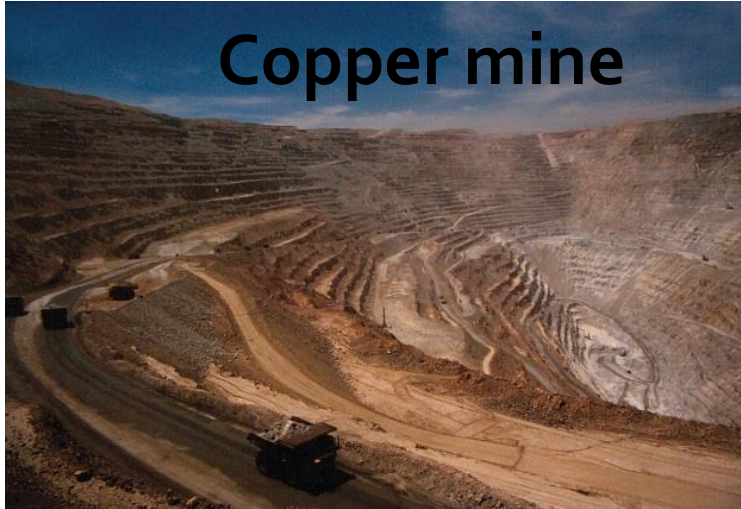
<https://www.youtube.com/watch?v=Z-kfODjpB7M>



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From traditional mine to urban mine



- Extraction of copper
- Crushing and grinding
- Flotation
- Concentration
- Roasting
- Casting and conversion
- Thermal refining
- Electrolytic refining

To Mine or not To Mine?



- Collection of WEEE
- Copper recovery from WEEE
- Casting
- Thermal refining
- Electrolytic refining



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Polymeric materials

WEEE



Grinding of plastics



Polymeric materials
(Plastics)

<https://www.eco-mind.it/portfolio-articoli/rifiuti-raee/>

<https://www.ecoambientesud.it/raee.html>



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Polymers

- What is a polymeric material?
- Natural and synthetic polymers, sources and examples
- What is it mean for Thermoplastic, Thermosetting and Rubber?
- Amorphous and crystalline polymer?
- Definition of composite materials
- Recovery and valorization of polymeric materials



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Polymers - definitions

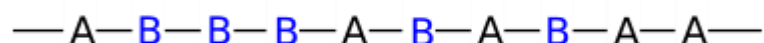
A polymer is a macromolecular or a molecule substance with a high molecular weight, consisting of the repetition of a large number of identical or different (co-polymer) repetitive units, linked together by covalent bonds.



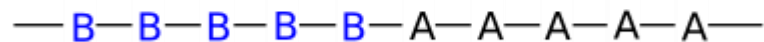
1 **Linear polymer Homo-polymer (one type of repeat unit)**



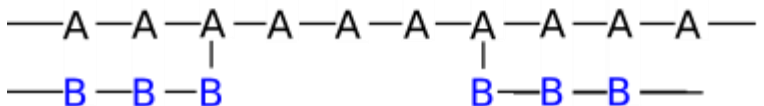
2 **Linear polymer Co-polymer (at least two repeat units)**



3 Linear polymer Co-polymer (random)



4 Linear polymer Co-polymer (blocks)



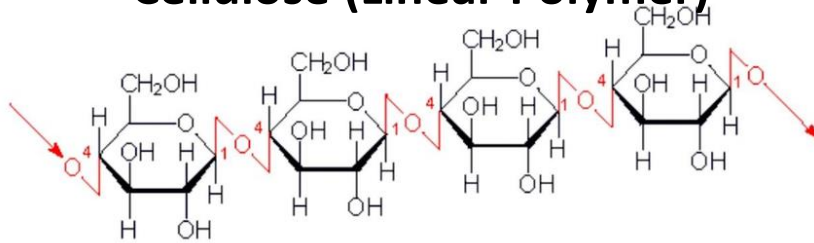
5 Linear polymer Co-polymer (graft)

<https://it.wikipedia.org/wiki/Polimero>

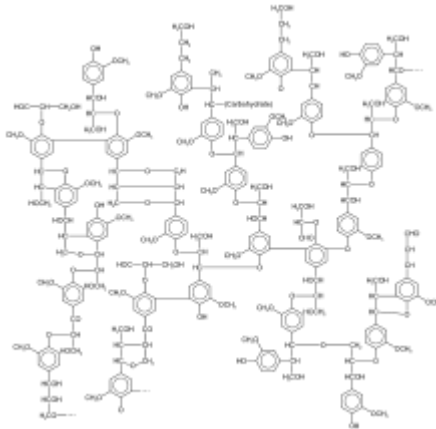
Natural and synthetic polymers

Natural Polymers

Cellulose (Linear Polymer)

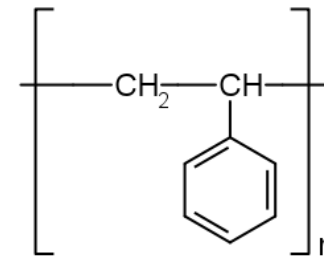


Lignin (Cross-linked polymer)

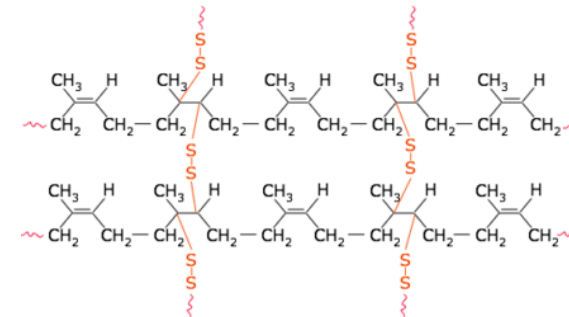


Synthetic Polymers

polystyrene (Linear Polymer)



Polybutadiene (Cross-linked polymer)



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Polymers: the sources

The thermoplastic polymers such as polyethylene and polypropylene are synthesized by addition of the respective monomers: ethylene and propylene which derive from mineral and oil.

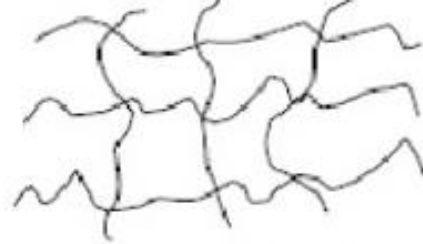


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Amorphous and crystalline polymers



Linear polymer



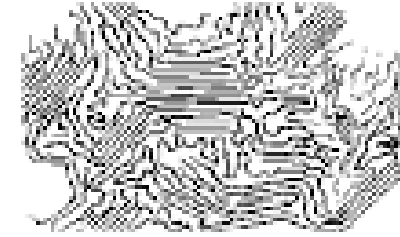
Cross-linked polymer



Branched polymer



Amorphous structure (random)



Semi – crystalline structure



Structure with thermosetting cross-links



High Density Polyethylene HDPE



Low density Polyethylene LDPE



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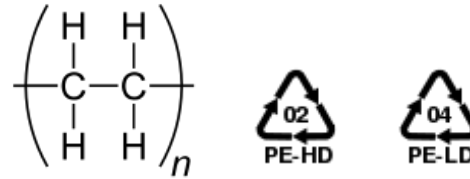
Supported by:



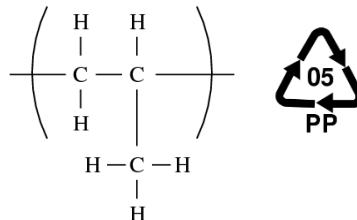
Thermoplastic polymers

Thermoplastic polymers are fuses and therefore can be melted and reshaped

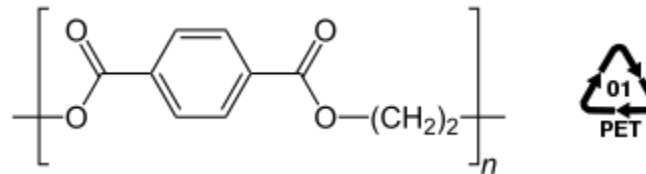
PE polyethylene



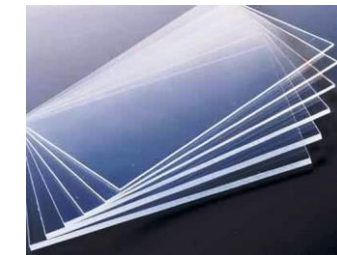
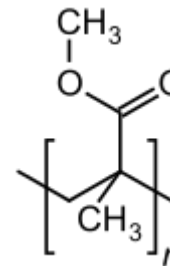
PP polypropylene



**PET
polyethylenetereftalato**



PMMA polymethylmetacrylato (plexiglass)



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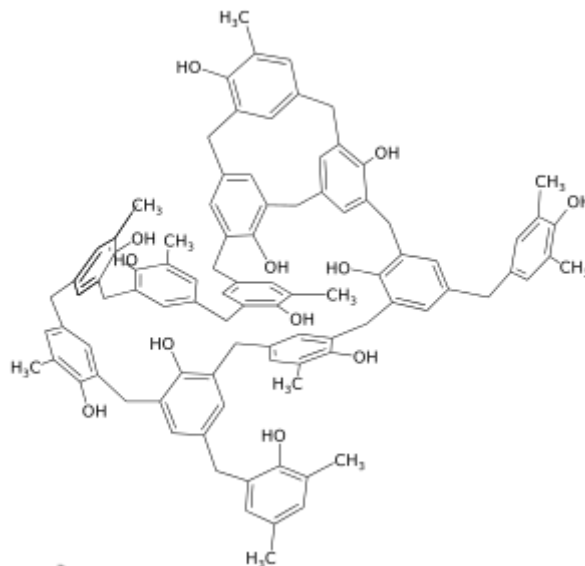


RawMaterials
Connecting matters

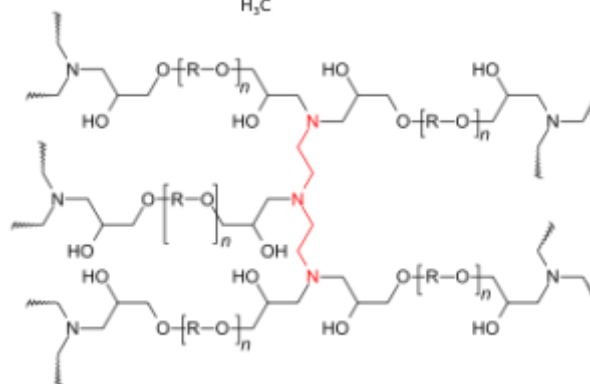
Thermosetting polymers

Thermosetting polymers are non-fusible crosslinked compounds with high mechanical, thermal and chemical properties. However they undergo decomposition at high temperatures.

Bakelite (fenolic resin)



Epoxyn Resin



Composite materials

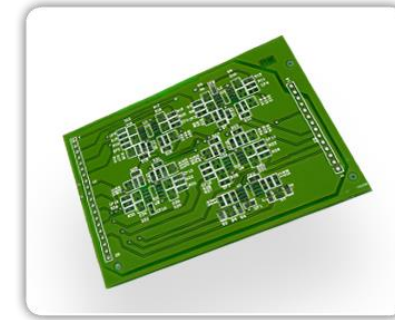
Composite materials consist of more materials that together give an object with high mechanical and chemical characteristics. An example is the fiberglass carbon fiber composite material carbon fibers and epoxy resin



Fiberglass fabric



Phthalic resin



PCB Plate



Fiberglass carbon fiber



Phthalic Resin



Advanced electronic components



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Polymers: collection, recycling and valorization

WEEE Collection and separation of plastics



Object in recycled plastic



Thermovalorization



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WEEE – glasses and chemical compounds (Critical Raw Materials)

WEEE- Monitor

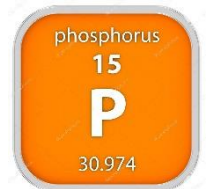


Cathode ray tube

<https://www.qsl.net/ik1hgi/472khz/impedenza.htm>



GLASSES



Rare Earth

Phosphorous

<https://www.regionieambiente.it/ritiro-e-trattamento-dei-raee/>

The rare earths, the phosphorus and other materials such as europium and red phosphorus, but also other rare earth chemical compounds, are used in cathode ray tubes and liquid crystal displays.

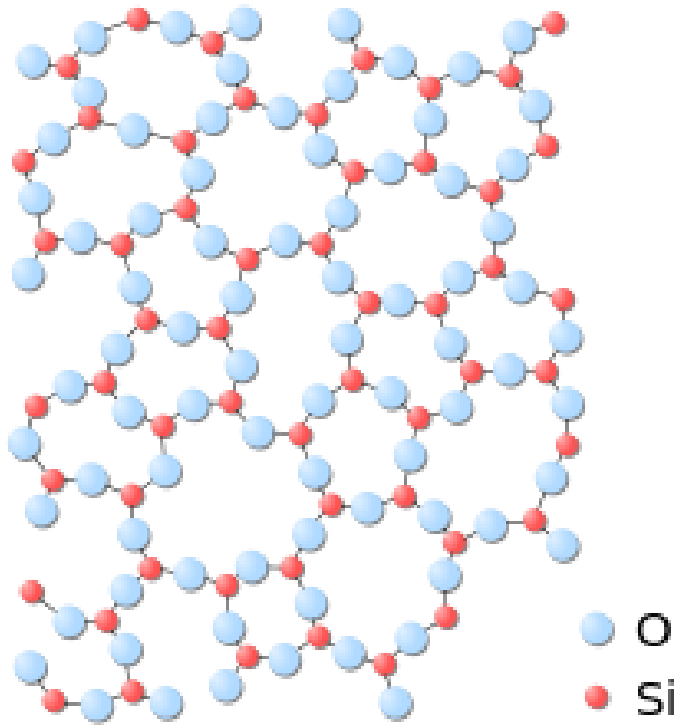
These elements are among those indicated as critical raw materials



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The Glass

The glass is a subcooled liquid that appears as an amorphous solid or a substance in which atoms have not arranged in a crystal lattice.



Special glass PYREX



Boron is added in the form of borax ($\text{Na}_2\text{B}_4\text{O}_7$) or boric acid (H_3BO_3) to improve thermal and electrical characteristics (PYREX).



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The Glass - recycle

Glass can be recycled an unlimited number of times without any alteration. In the recycling process, to obtain high quality glass, the different types of glass must be separated to avoid the presence of unwanted additives.



<https://www.ecofocus.it/2016/01/da-vetro-rinasce-vetro/>

<http://www.elysglass.com/glassIdeas.asp>



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RawMaterials
Connecting matters

European Commission Publishes New Critical Raw Materials List – 27 CRMs Confirmed



On 13 September 2017, the European Commission published a Communication on its long-awaited 2017 list of Critical Raw Materials (CRMs), which features 27 raw materials and updates the 2014 list. The primary purpose of the list is to identify the raw materials with a high supply-risk and a high economic importance to which reliable and unhindered access is a concern for European industry and value chains.

Following an objective methodology the list provides a factual tool for trade, innovation and industrial policy measures to strengthen the competitiveness of European industry in line with the renewed industrial strategy for Europe, for instance by:

- **identifying investment needs which can help alleviate Europe's reliance on imports of raw materials;**
- **guiding support to innovation on raw materials supply under the EU's Horizon 2020 research and innovation programme;**
- **drawing attention to the importance of critical raw materials for the transition to a low-carbon, resource-efficient and more circular economy**

It is hoped that the list will help incentivize the European production of critical raw materials through enhancing recycling activities and when necessary to facilitate the launching of new mining activities.

The new list features 27 raw materials: Antimony, Beryllium, Borates, Cobalt, *Coking Coal, Fluorspar, Gallium, Germanium, Indium, Magnesium, Natural Graphite, Niobium, Phosphate Rock, Silicon Metal, Tungsten, Platinum Group Metals, Light Rare Earths and Heavy Rare Earths, Baryte, Bismuth, Hafnium, Helium, Natural Rubber, Phosphorus, Scandium, Tantalum, and Vanadium.

*it is important to note that Coking Coal is considered a borderline case. Although it narrowly misses the economic importance threshold, for the sake of caution, coking coal is kept on the list of critical raw materials for the EU and thus included in the table. However, it will be phased out from the next list should it fail to meet the criteria in full.

<https://ec.europa.eu/transparency/regdoc/rep/1/2017/EN/COM-2017-490-F1-EN-MAIN-PART-1.PDF>



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Critical Raw Materials «CRMs» in WEEE

<https://youtu.be/03E1-GIhLQs>



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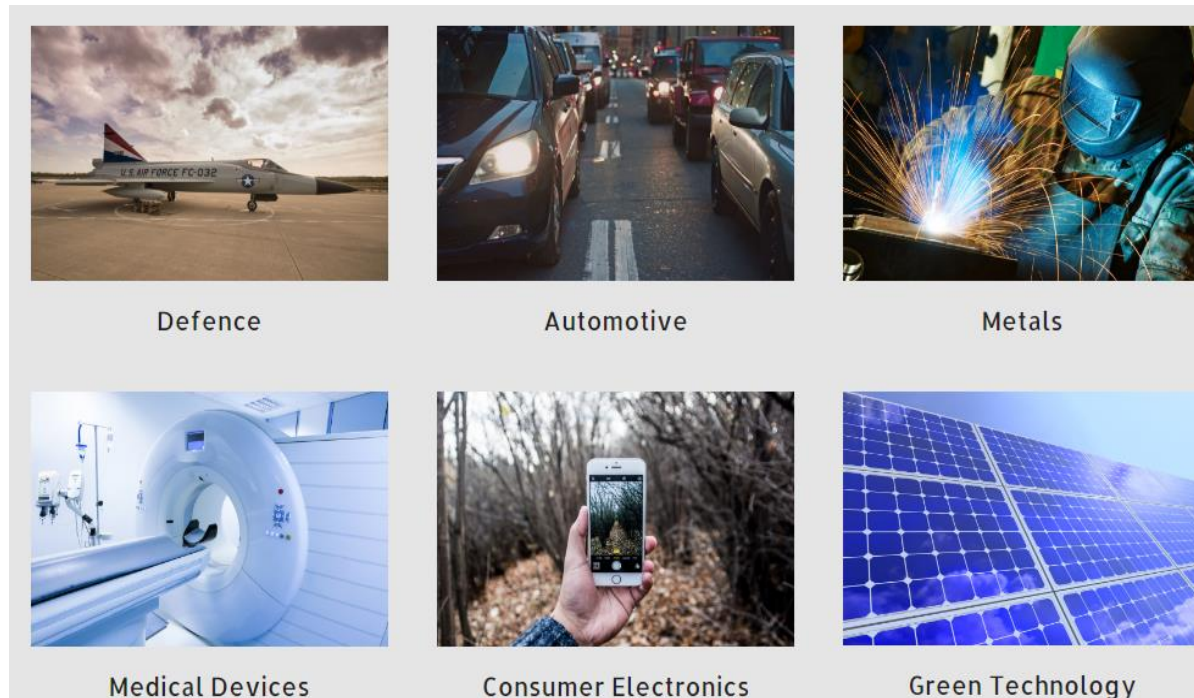
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Critical Raw Materials «CRMs»

In a specific document, the European Commission identifies the critical materials as materials that have a high strategic importance for their use in high-tech sectors, materials that are not replaceable and that present supply problems due to their reduced quantity and geopolitical problems which limit the possibility of retrieval.



1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uug	115 Uup	116 Uuh	117 Uus	118 Uuo



* Lanthanides

** Actinides

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr



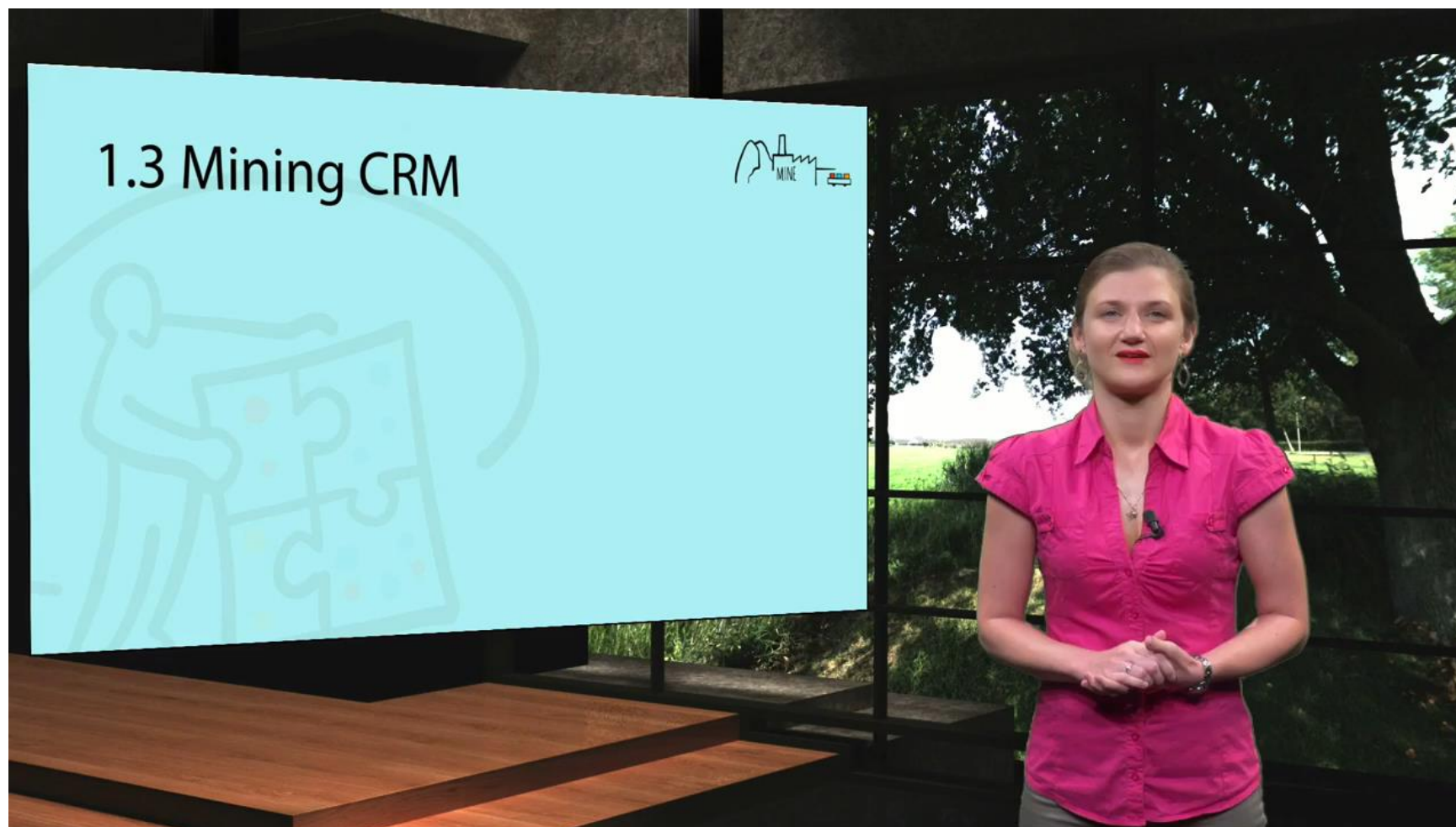
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Critical Raw Materials: supply problems

<https://youtu.be/tnkjWyJ5S4>



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Critical Raw Materials- The key factors

It is important to note that these raw materials are NOT classified as critical exclusively for the scares reserve but rather because:

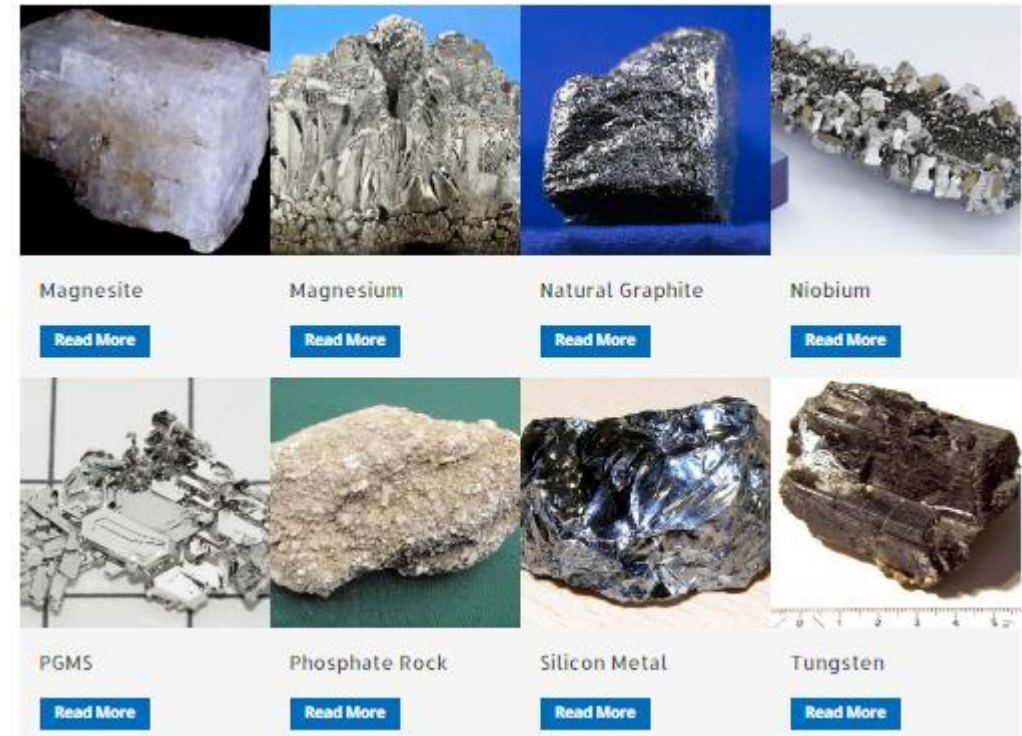
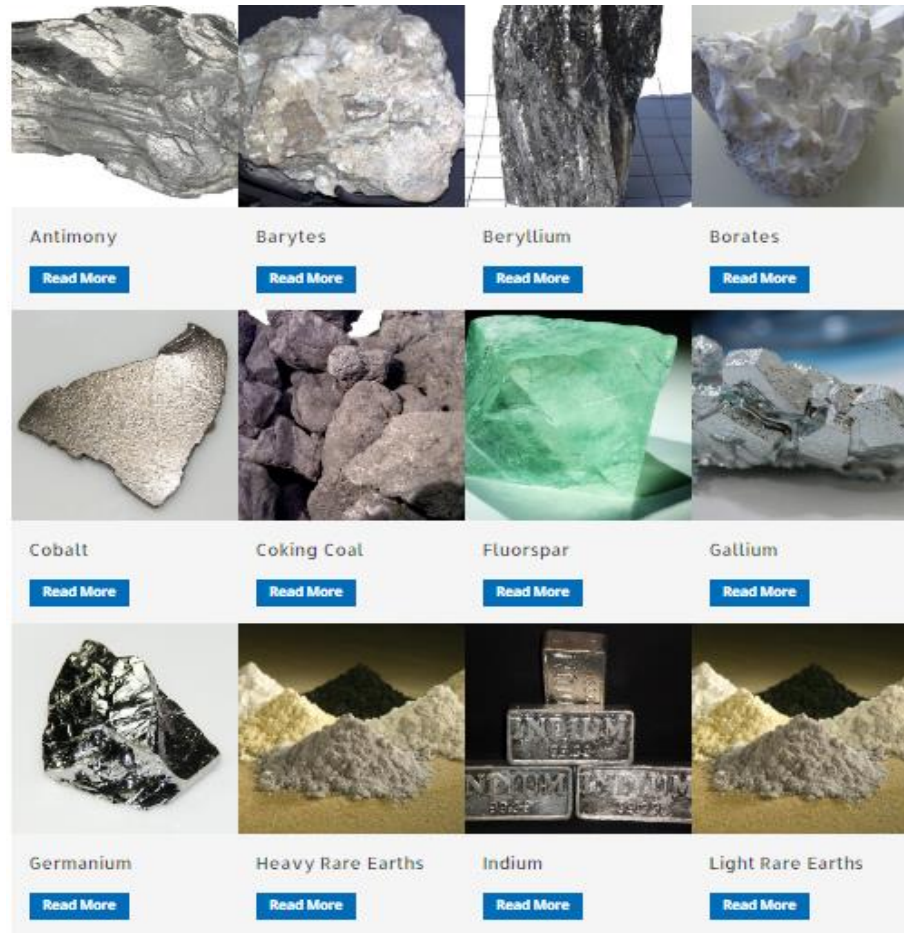
1. High economic importance for key factors of the European economy, such as electronics, environmental technologies, automotive sector, aerospace, defense, health and steel production
2. High supply risk due to high dependency and high concentrations of categories of these materials in specific countries
3. Lack of (possible) substitutes, due to the unique properties of these materials for existing and future applications.



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27 Critical Raw Materials

The European Commission in the last update of the list of Critical Raw Materials includes 27 materials including those listed below:



<http://criticalrawmaterials.org/>



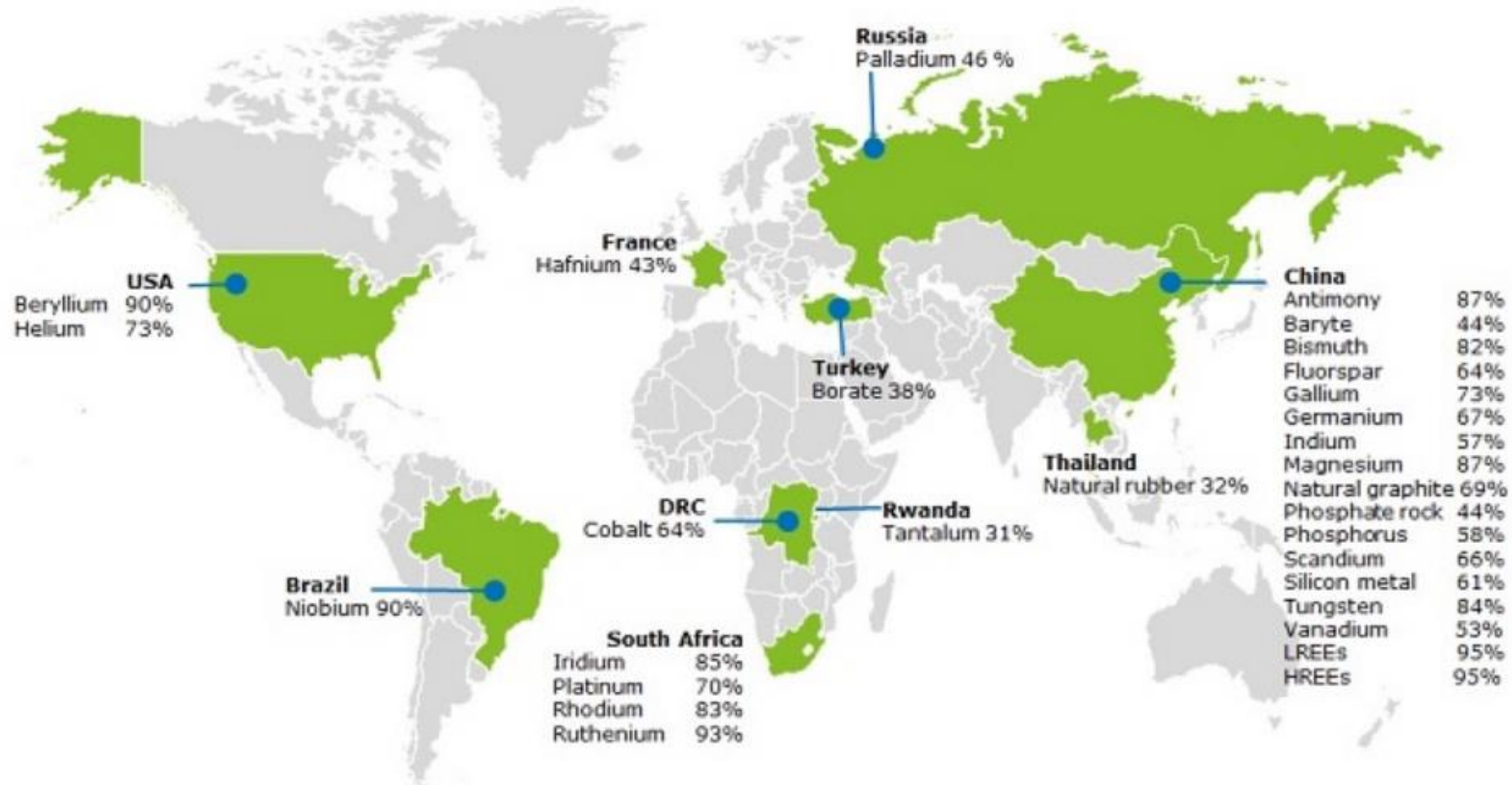
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Global Share of Critical Raw Materials

Countries accounting for largest share of global supply of CRMs



<http://criticalrawmaterials.org/>



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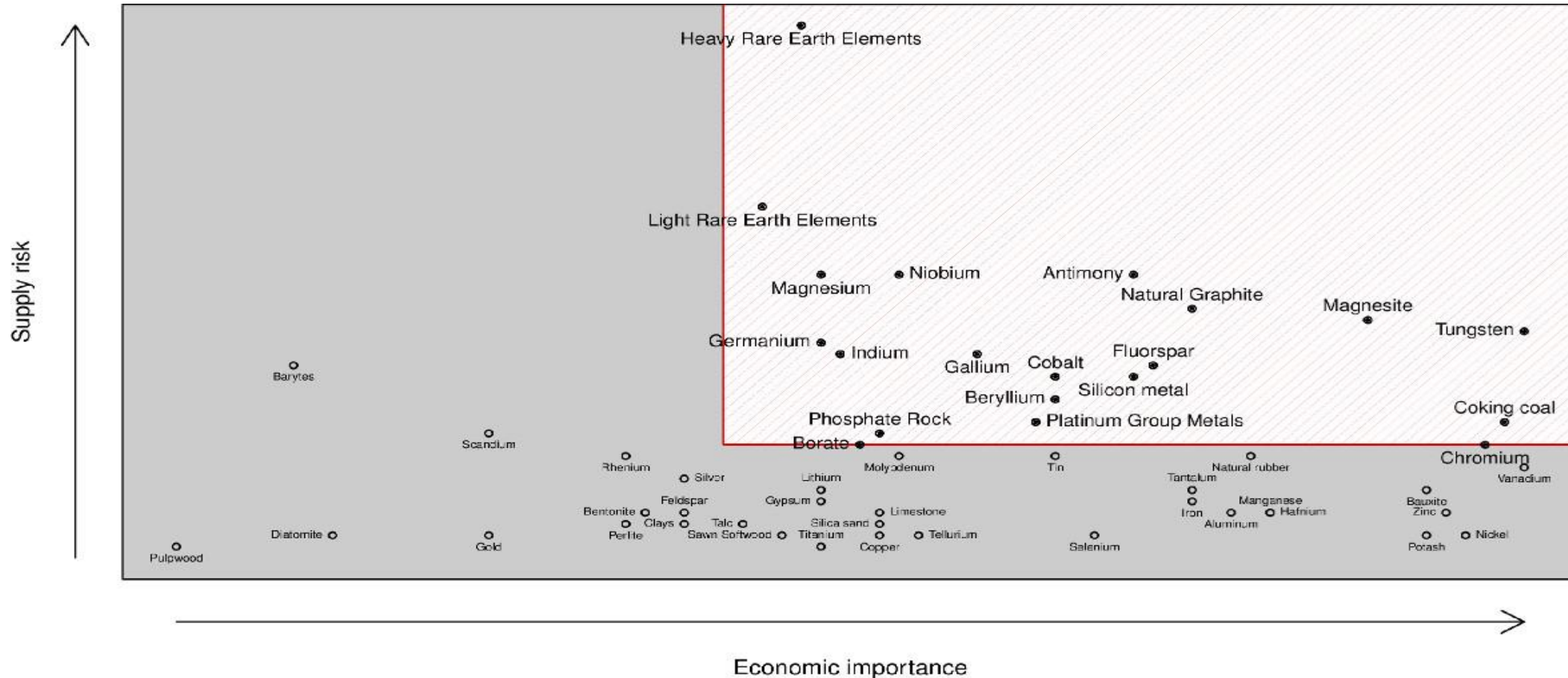
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Critical Raw Materials

Magnesium, Antimony, Phosphorus, Rare Earths (light and heavy etc. are among the most highly regarded raw materials)



<http://criticalrawmaterials.org/>



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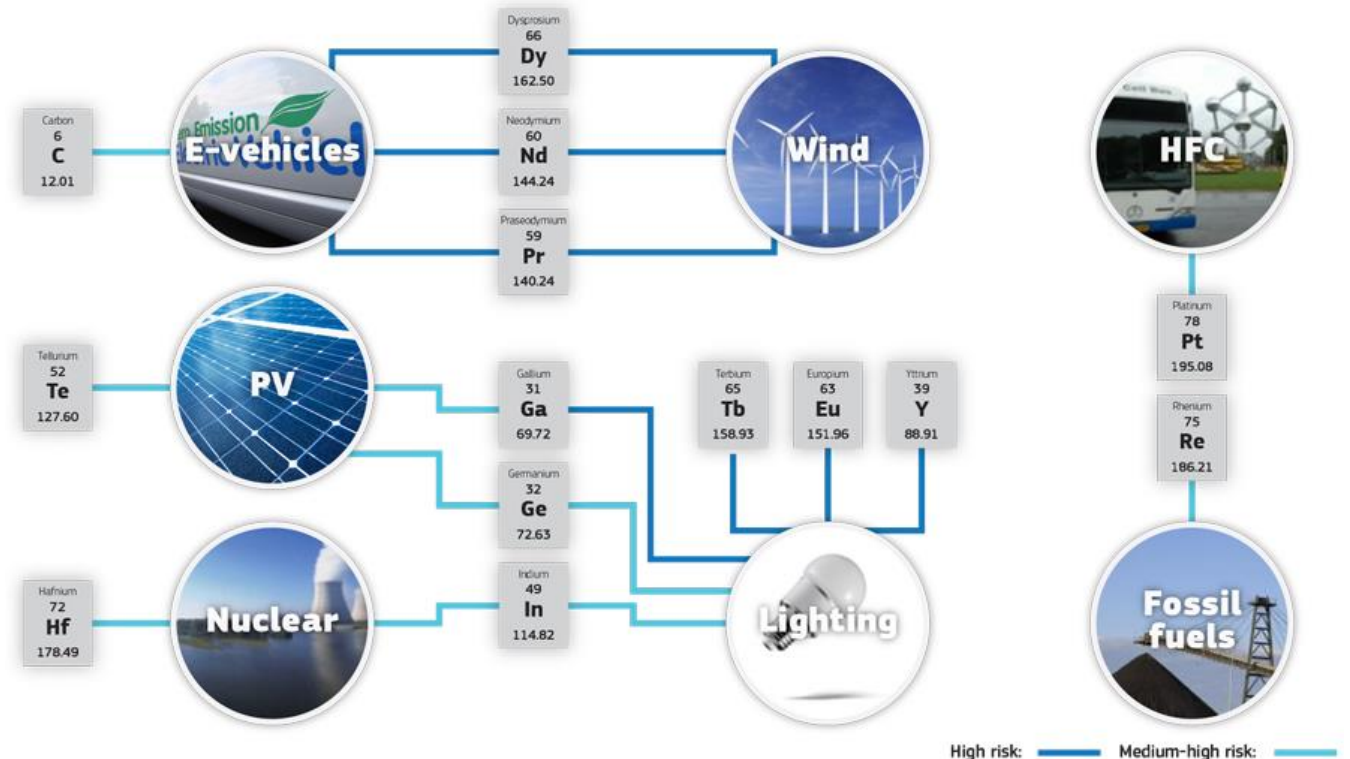
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Critical Raw Materials – Risk Rating and Technology Applications

Raw Material	Risk Rating	Associated Technology
Rare Earths: Dy, Pr, Nd	High	e-vehicles, wind
Rare Earths: Eu, Tb, Y	High	lighting
Gallium	High	lighting, solar
Tellurium	High	solar
Graphite	Medium-High	e-vehicles
Rhenium	Medium-High	fossil fuels
Hafnium	Medium-High	nuclear
Germanium	Medium-High	lighting
Platinum	Medium-High	fuel cells
Indium	Medium-High	solar, lighting, nuclear



<http://criticalrawmaterials.org/>



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The importance of the correct disposal of WEEE in SUMMARY

- **Recovery and saving of exhaustible raw materials and energy**



- **No emission of toxic substances in the environment**



- **The recovery and recycle of CRMs is of strategic importance for the European Union**



<https://www.habitante.it/habitare/living-e-tendenze/imparare-il-risparmio-energetico-e-ledilizia-sostenibile-un-nuovo-lavoro/>



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