RawMaterials Hub
Regional Center Southern Italy

EIT RawMaterials Winter School
“Waste Electrical and Electronic Equipment”

26th - 30th October 2020
Time: 15.00 - 17.00
On-line event: CONNECT®

27th October 2020, h 15:00 - 17:00

"Electric and Electronic Waste: Assessing the Environmental Benefits from Circular Management"

Prof. Sergio Ulgiati - Università degli Studi di Napoli Parthenope, Naples

INTRODUCTION

The growing market demand for electrical and electronic products has generated a rapid WEEE increase in recent years.

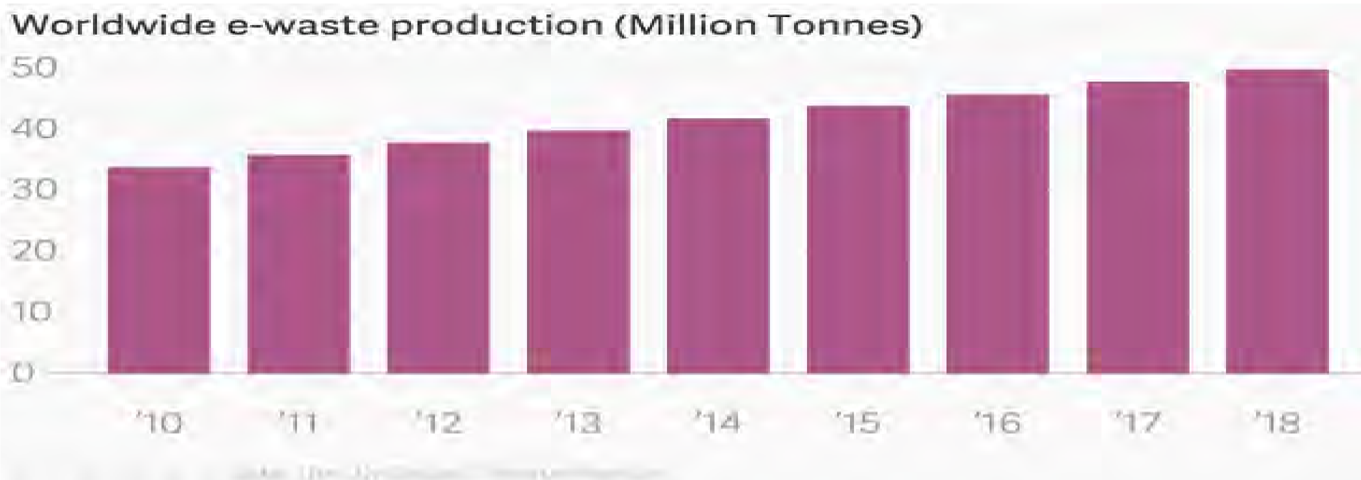


Figure 1: worldwide e-waste production (https://atlas.qz.com/i/atlas_4kEr0ieY@2x.png)

Waste Electric and Electronic Equipments (WEEE) also are a valuable “mine” of industrial materials that can be re-introduced into the production chains, allowing to minimize related environmental burdens.

Waste has the potential to become a valuable resource, thus allowing to save virgin materials and fossil energy sources, by means of reusing and recycling of existing products.

Production of computer and other similar devices (tablets, smart phones) is increasing worldwide, changing lifestyles, industrial processes, consumption patterns, cultural and communication opportunities.

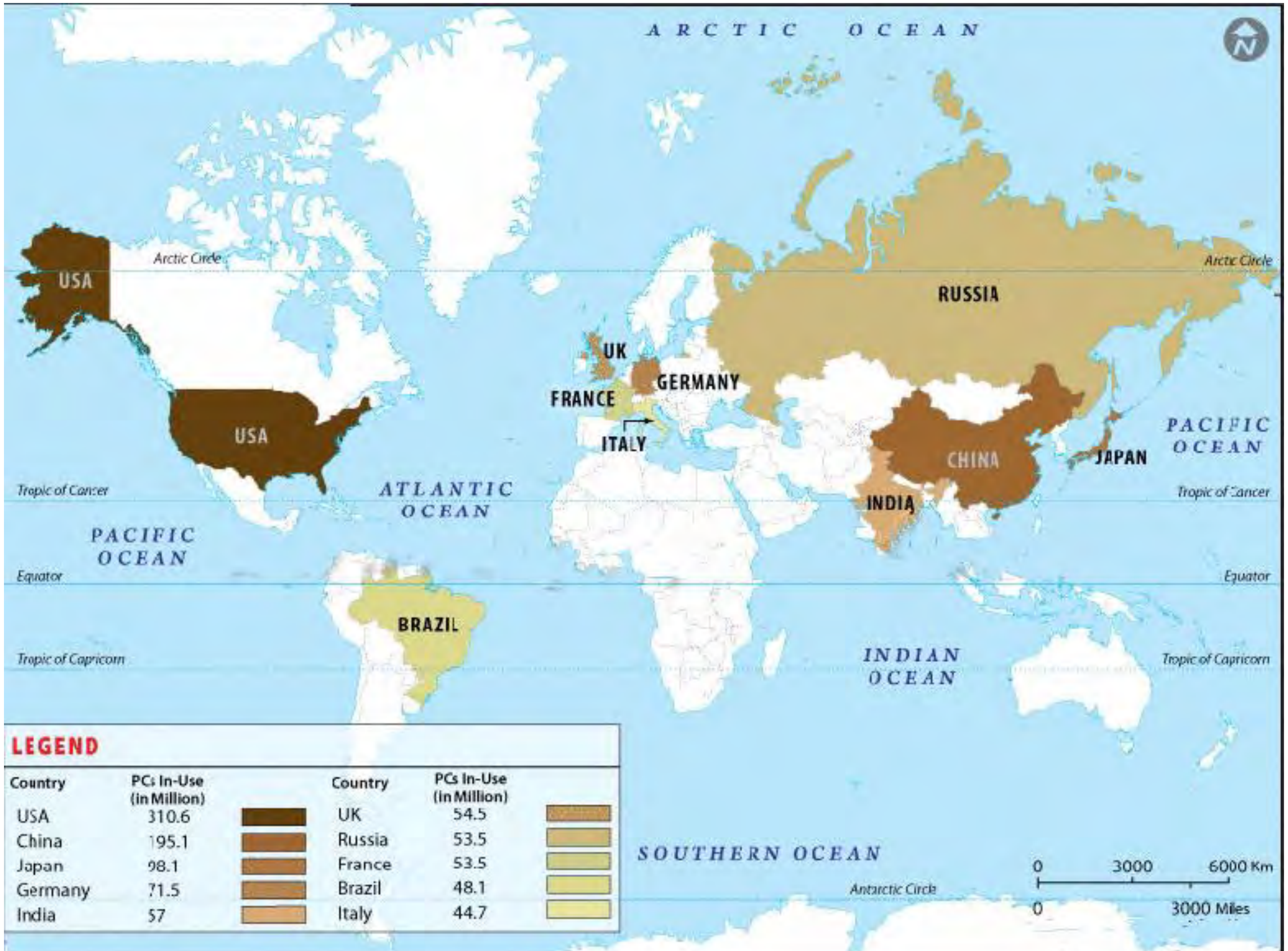
Fast replacement driven by markets makes life span of computers very short (planned obsolescence?)

End-of-life management of computers and other WEEE (Waste Electric and Electronic Equipments) is very complex, due to large number and typology of components and materials.

European Union (EU) has released a large number of directives , to promote:

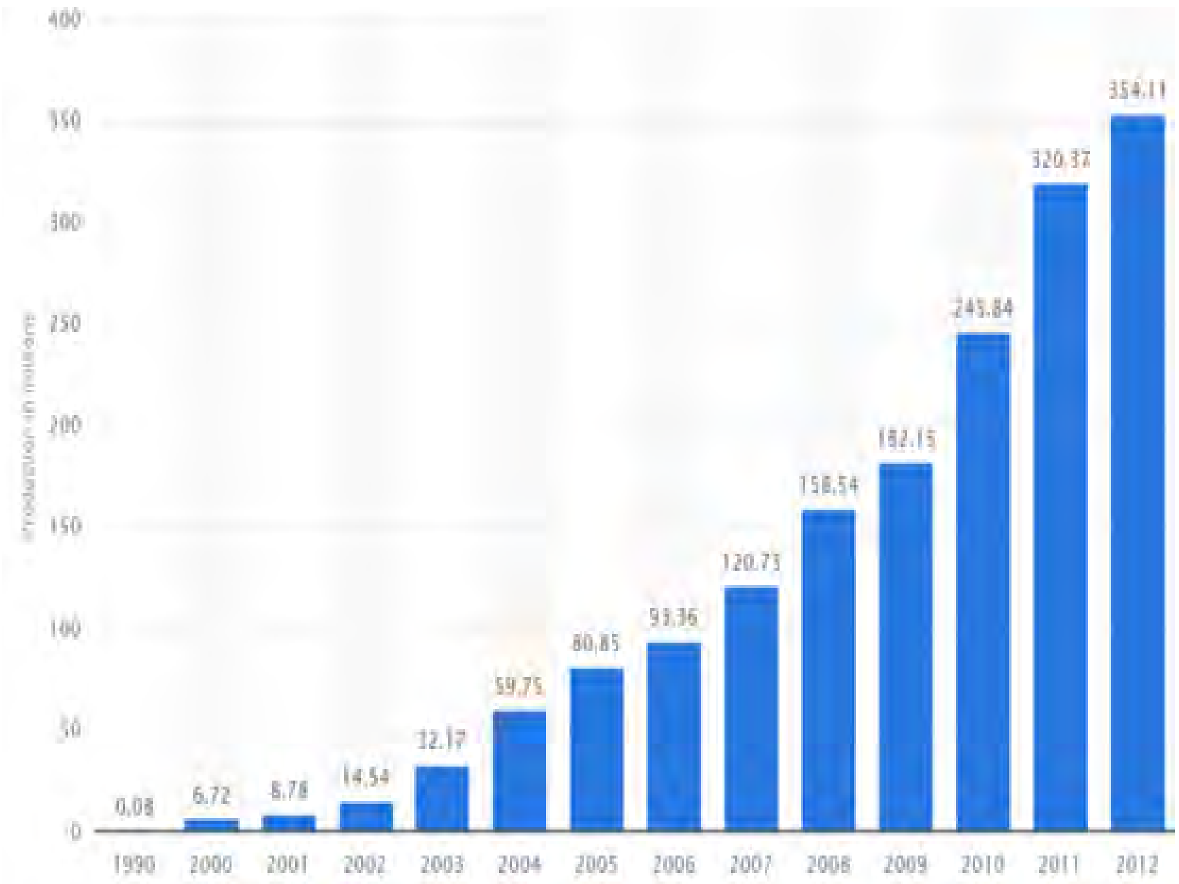
- *Restriction of hazardous substances in production*
- *Collection of dismissed PCs*
- *Recycling and disposal*


PCs use places China in 2^{nd} and Italy 10^{th} position all over the world.



Top Ten countries with highest number of PCs

PC production in China grows exponentially…



Computer production in China from 1990 to 2012

Electronic waste also increase…

Guiyu (China)

Guiyu (China)

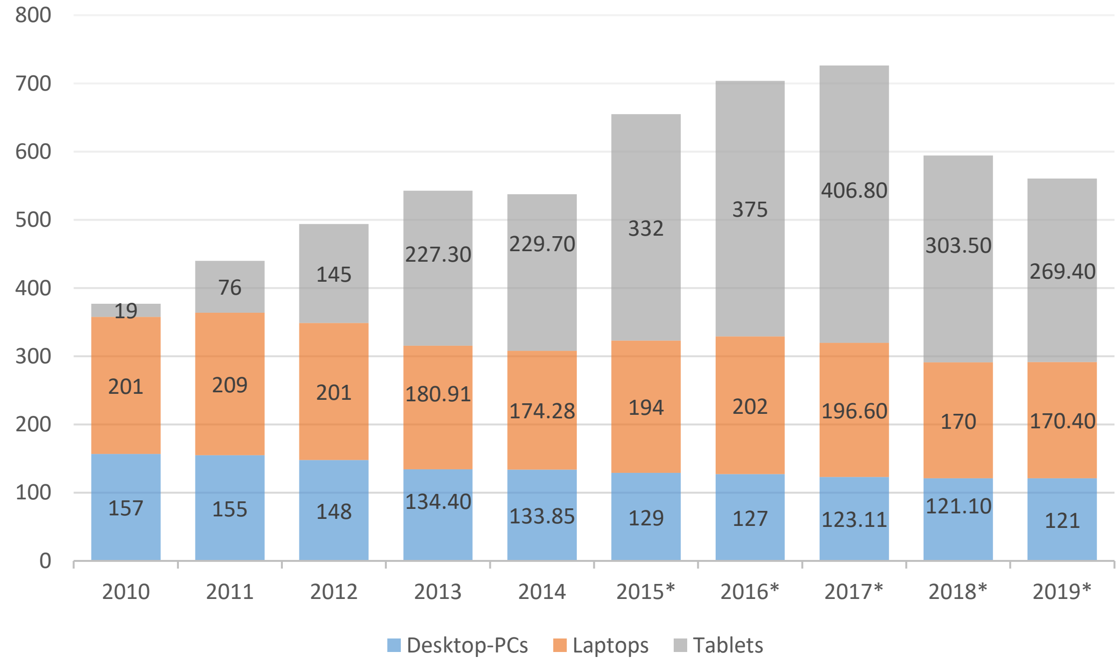
what are the environmental consequences of this uncontrolled electronic waste production and how is it possible to prevent it?

Agbogbloshie (Ghana)

Agbogbloshie (Ghana)

A problem and a challenge

The growing market demand for electrical and electronic equipments (EEE) has generated a rapid increase in recent years, although a decrease is expected in the next years.



Global shipments of tablets, laptops and desktop PCs 2010-2019, Source: http://www.idc.com

WEEE also are a valuable "mine" of industrial materials that can be re-introduced into the production chains, allowing to minimize related environmental burdens.

Resources, Conservation and Recycling 116 (2017) 124–136

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Full length article

Energy and eMergy assessment of the production and operation of a personal computer

Antonio Puca [a,b], Marco Carrano [b], Gengyuan Liu [a,c,*], Dimitri Musella [b], Maddalena Ripa [b], Silvio Viglia [b], Sergio Ulgiati [a,b,c]

[a] State Key Joint Laboratory of Environment Simulation and Pollution Control, School of Environment, Beijing Normal University, Beijing 100875, China
[b] Department of Sciences and Technologies, Parthenope University of Naples, Centro Direzionale—Isola C4, 80143 Naples, Italy
[c] Beijing Engineering Research Center for Watershed Environmental Restoration & Integrated Ecological Regulation, Beijing 100875, China


TECNO

LCA of a personal computer

Life Cycle Assessment of a Personal Computer and its Effective Recycling Rate

Byung-Chul Choi, Hang-Sik Shin, Su-Yol Lee and Tak Hur, Int J LCA 11 (2) 122 – 128 (2006)

LCA of an Ecolabeled Notebook – Consideration of Social and Environmental Impacts Along the Entire Life Cycle.

Ciroth, A./Franze, J., ISBN 978-1-4466-0087-0. Berlin 2011

PC production and use process

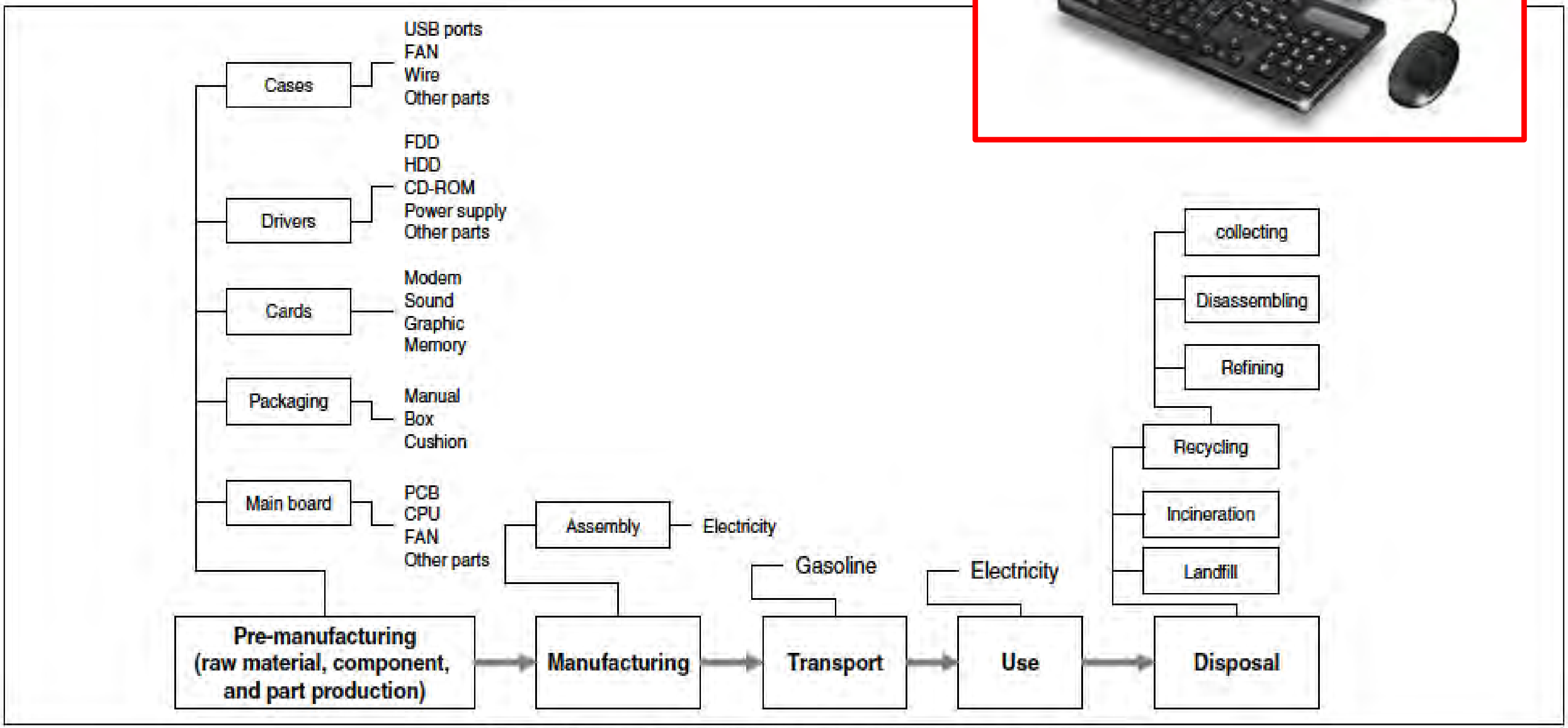
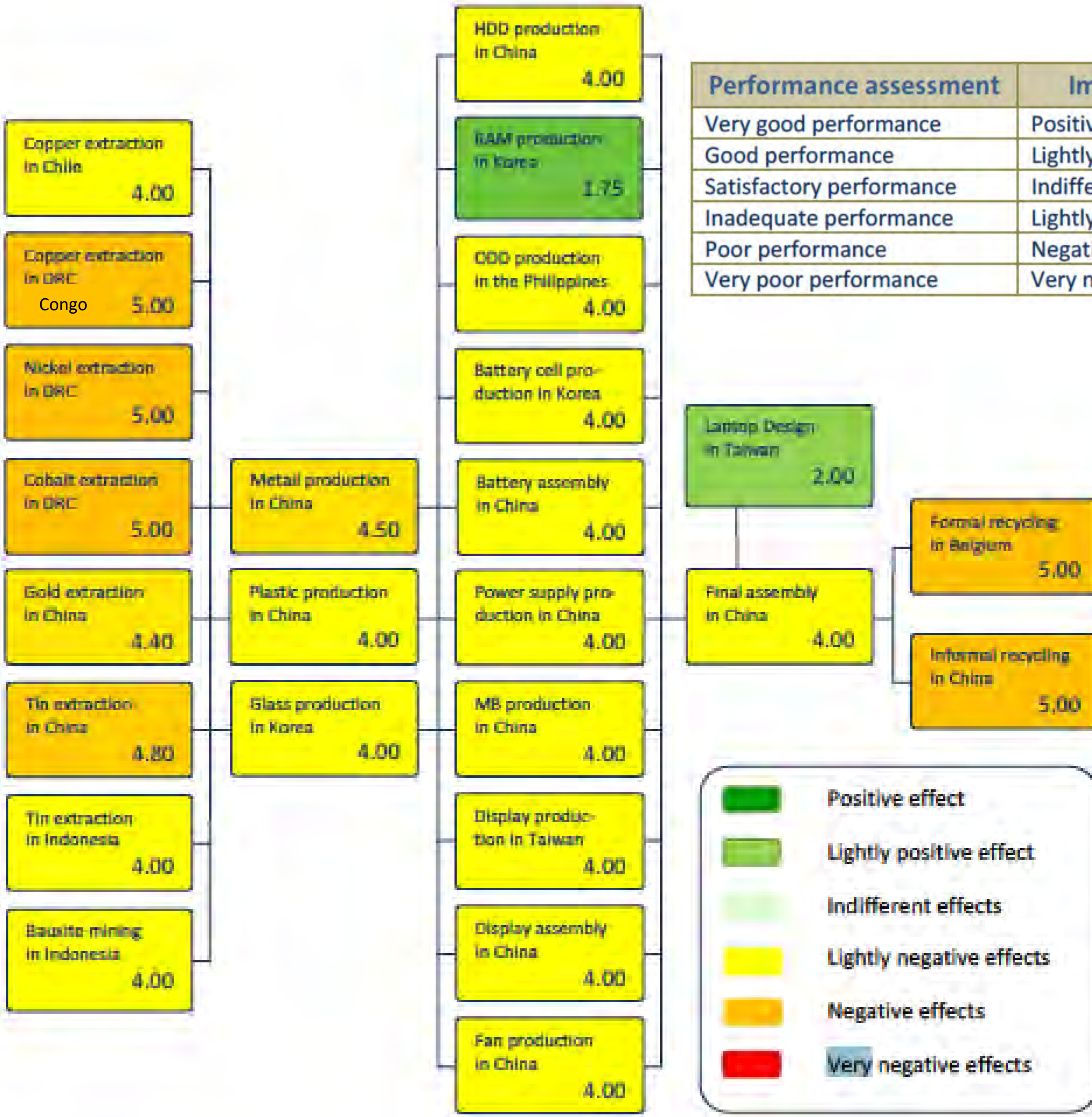


Fig. 1: Personal computer life cycle assessment structure



Performance assessment	Impact assessment	Colour	Factor
Very good performance	Positive effect		1
Good performance	Lightly positive effect		2
Satisfactory performance	Indifferent effect		3
Inadequate performance	Lightly negative effect		4
Poor performance	Negative effect		5
Very poor performance	Very negative effect		6

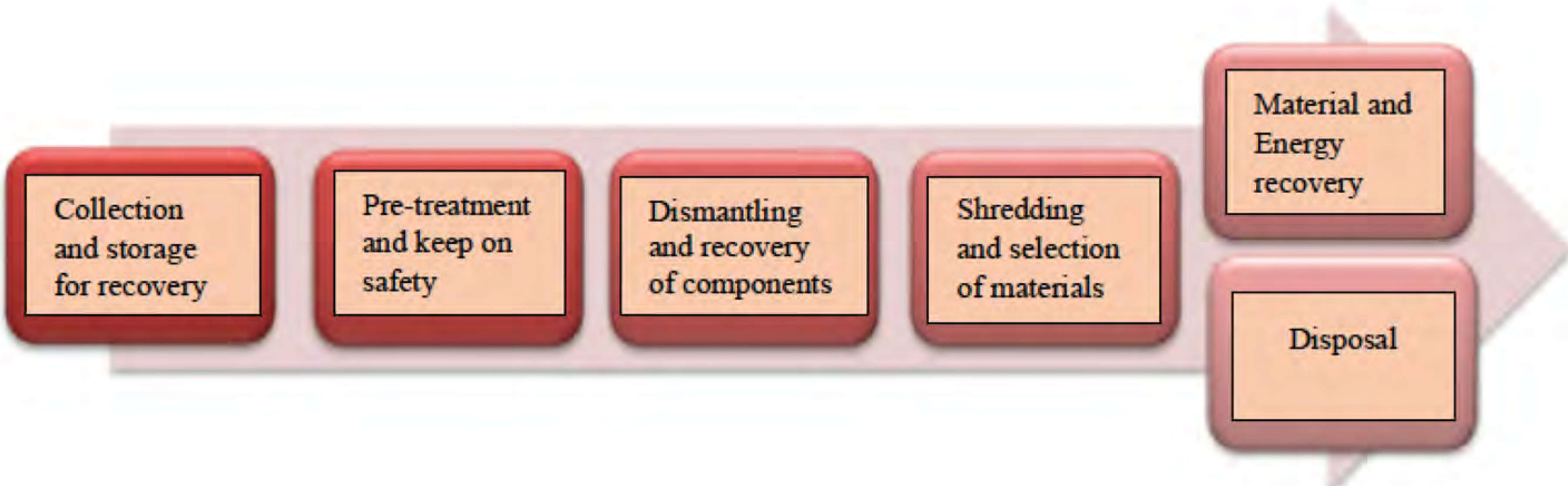
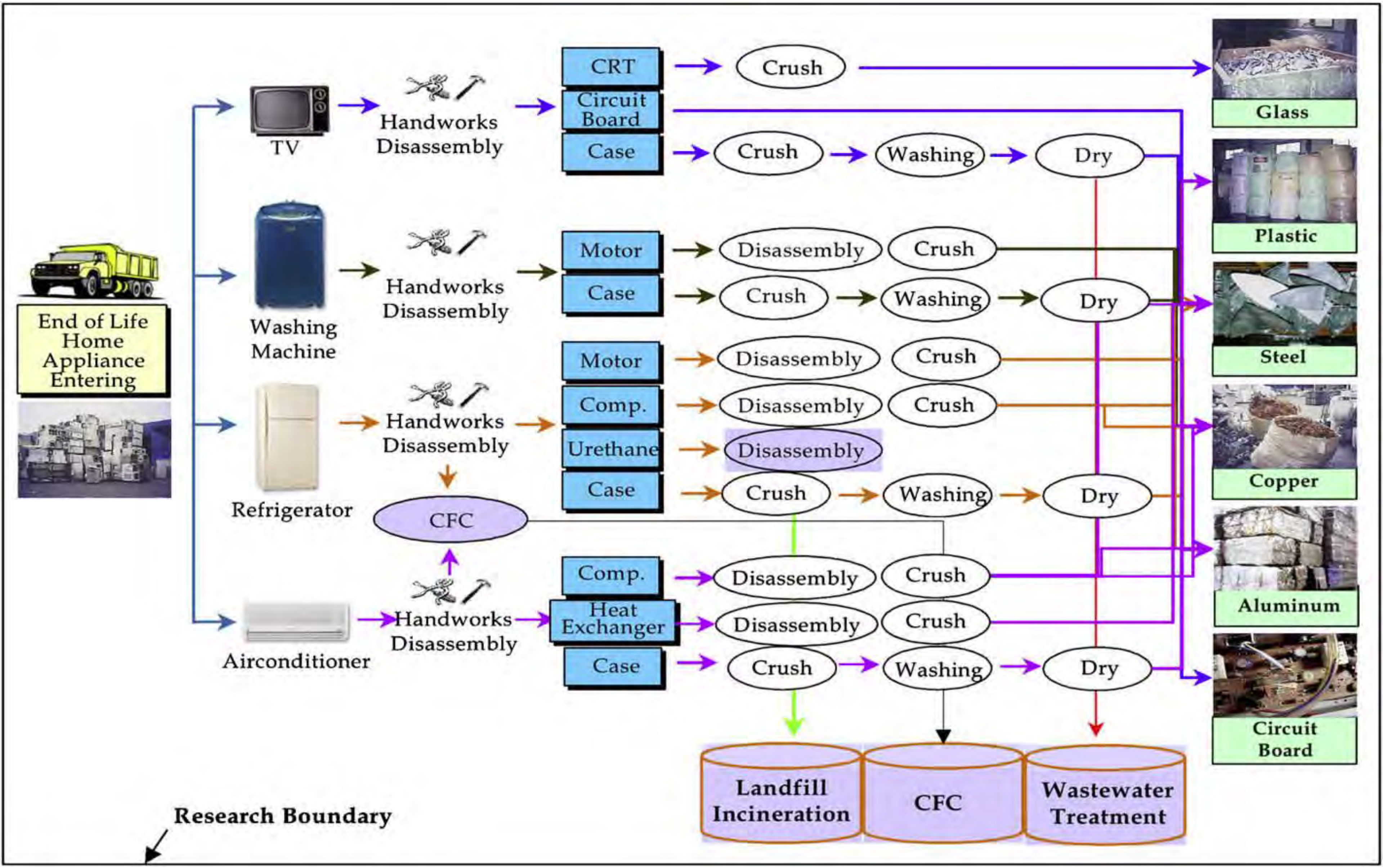
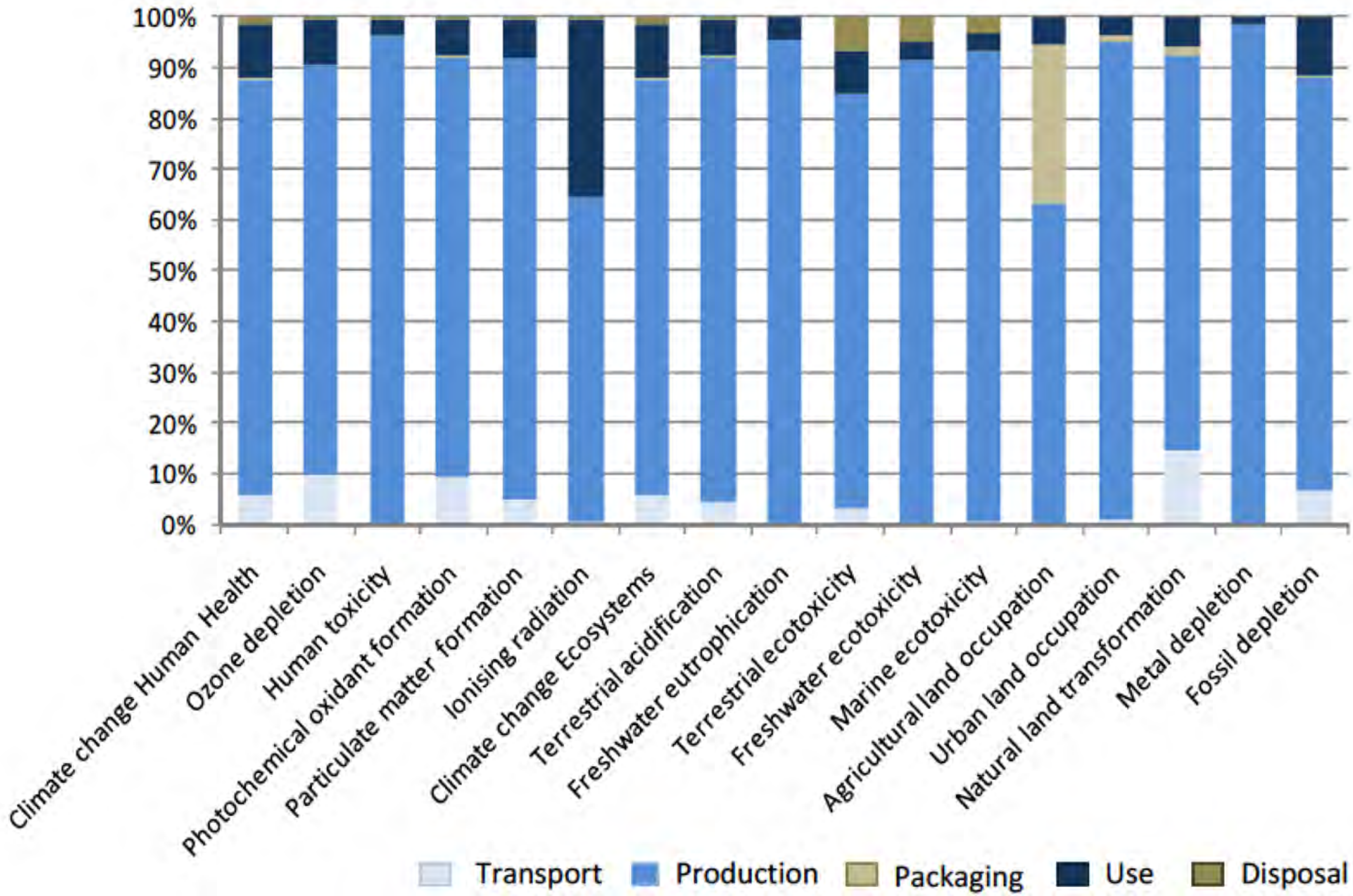


Figure 4. The life cycle of WEEE. Source: EcoR'it, 2017.



Kim, J., Hwang, Y., Park, K., 2009. An assessment of the recycling potential of materials based on environmental and economic factors; case study in South Korea. Journal of Cleaner Production 17: 1264–1271.


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Climate change Human Health
Ozone depletion
Human toxicity
Photochemical oxidant formation
Particulate matter formation
Ionising radiation
Climate change Ecosystems
Terrestrial acidification
Freshwater eutrophication
Terrestrial ecotoxicity
Freshwater ecotoxicity
Marine ecotoxicity
Agricultural land occupation
Urban land occupation
Natural land transformation
Metal depletion
Fossil depletion
Transport
Production
Packaging
Use
Disposal

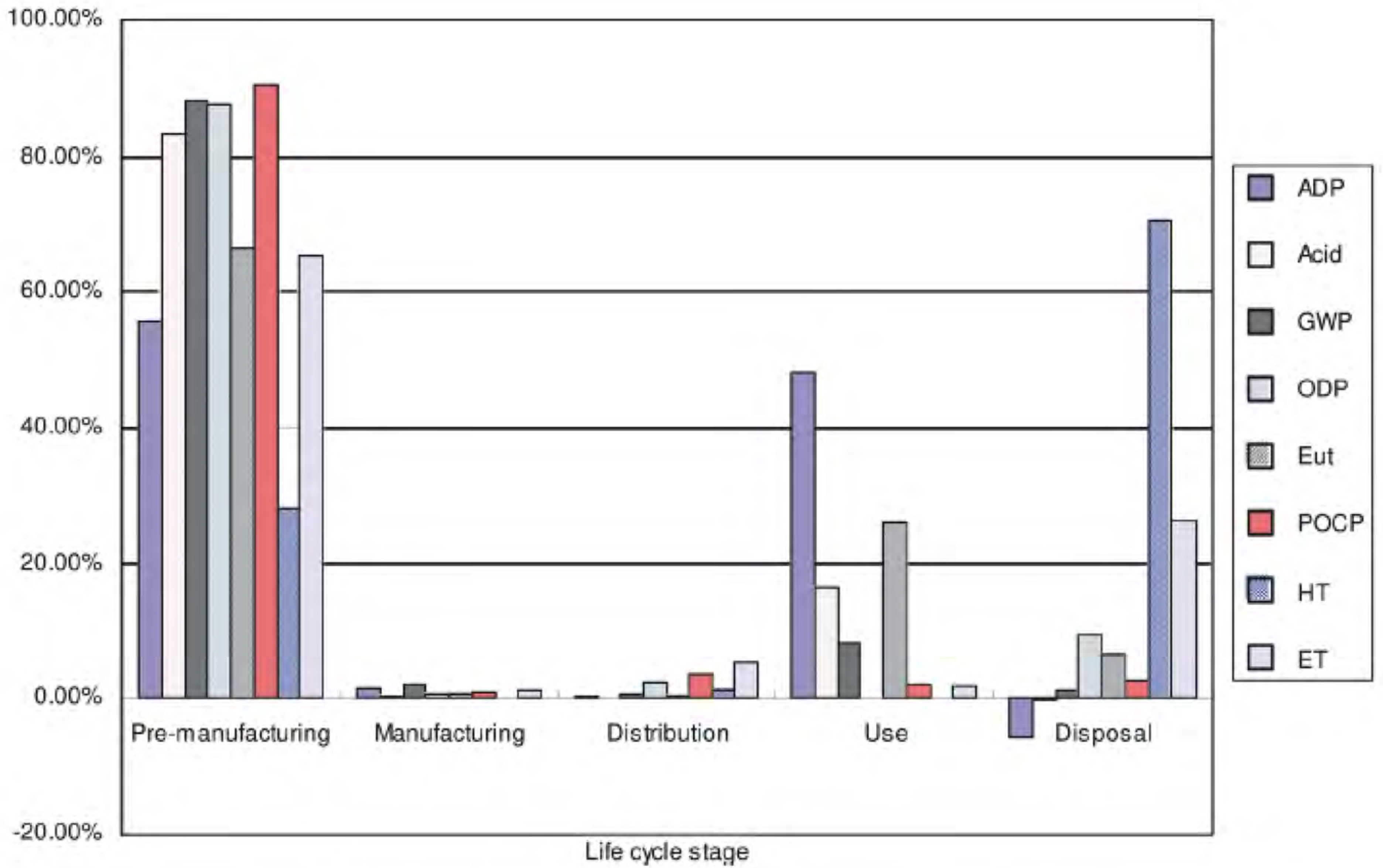


Fig. 2: Environmental impact assessment result for a personal computer

Table A1
Embodied Energy Analysis of the production and operation of a desktop PC.

Desktop PC		Using primary materials and nonrenewable electricity mix		Using secondary materials and renewable electricity mix	
Inventory	Amount (g)[a]	Energy intensity (MJ/g)[a]	Embodied Energy (MJ)	Energy intensity (MJ/g)[a]	Embodied Energy (MJ)
Materials					
Copper	186.00	0.06	10.96	0.02	2.98
Aluminum	825.00	0.16	132.65	0.03	23.93
Iron	7360.00	0.05	351.77	0.01	36.80
Steel	104.00	0.10	10.52	0.01	0.94
Tin	12.00	0.34	4.14	0.05	0.58
Brass	5.00	0.07	0.34	0.04	0.10
Plastic materials	2988.09	0.10	298.81	0.03	95.62
Glass	813.00	0.02	16.26	0.01	8.94
Microcomponents					
Internal clock nickel battery	3.00	0.26	0.78	0.08	0.24
Led	0.37	16.81	6.15	15.77	5.77
Capacitors	79.31	0.44	34.55	0.20	15.95
Inductors	69.49	0.12	8.49	0.11	7.94
Microchips	16.83	6.20	104.31	2.98	50.09
Printed Wiring Board	322.40	2.78	896.27	0.86	278.45
Cables	399.00	0.11	41.95	0.04	14.81
Diodes	1.77	9.45	16.71	1.93	3.42
Resistances	7.30	0.44	3.21	0.03	0.25
Reflecting glass surfaces	33.00	0.02	0.66	0.01	0.36
Polarizers	41.00	0.02	0.82	0.01	0.41
Transistors	35.10	0.35	12.45	0.04	1.40
Connectors	140.54	0.06	9.11	0.06	8.00
Magnets	60.10	0.03	1.80	0.03	1.80
Assembly					
Electricity for assembly (kWh)[a]	56	8.57	479.92	0.29	16.24
Final product					
Mass of assembled computer	13502.29				
Cumulative energy demand			2442.65		574.95
Oil equivalent (kg)[a]			58.16		13.69
Five year operation					
Electricity for 5 year operation (kWh)[a]	505.00	8.57	4327.85	0.29	145.95
Oil equivalent (kg)[a]			103.04		3.47
CO_2 emissions					
		Conversion factor (kg_{CO2eq}/kg_{oileq})	CO_2 release (kg_{CO2eq})	Conversion factor (kg_{CO2eq}/kg_{oileq})	CO_2 release (kg_{CO2eq})
Total CO_2 eq emission		3.2	515.85	3.2	54.9

[a] Unit of electricity input flow is kWh; unit of energy intensity of electricity is MJ/kWh; unit of oil equivalent is kg.

Table 3
Embodied Energy Analysis of the production and operation of a laptop PC.

Laptop PC		Using primary materials and nonrenewable electricity mix		Using secondary materials and renewable electricity mix	
Inventory	Raw Amount (g)*	Energy intensity (MJ/g)*	Embodied Energy (MJ)	Energy intensity (MJ/g)*	Embodied Energy (MJ)
Materials					
Copper	65.21	0.06	3.84	0.02	1.04
Aluminum	414.77	0.16	66.69	0.03	12.03
Iron	287.5	0.05	13.74	0.01	1.44
Steel	97.3	0.1	9.84	0.01	0.88
Tin	1.1	0.34	0.38	0.05	0.05
Brass	39.51	0.07	2.67	0.04	1.74
Plastic materials	616.69	0.1	61.67	0.03	19.73
Glass	255.4	0.02	5.11	0.01	2.81
Microcomponents					
Internal clock nickel battery	3	0.26	0.78	0.08	0.24
Capacitors	30.1	0.44	13.11	0.2	6.05
Inductors	35.35	0.12	4.32	0.1	3.48
Led	0.37	16.81	6.22	15.77	5.84
Microchips	25.7	6.2	159.3	2.98	76.49
Printed Wiring Board	297	2.78	825.66	0.86	256.52
Cables	205	0.11	21.55	0.04	7.22
Diodes	8	9.45	75.59	1.93	15.45
Dynamo	32	0.07	2.21	0.02	0.52
Resistances	2.17	0.44	0.95	0.02	0.05
Reflecting glass surfaces	43.2	0.02	0.86	0.01	0.48
Polarizers	27.63	0.02	0.55	0.01	0.28
Transistors	24.13	0.35	8.56	0.04	0.96
Connectors	33.71	0.06	2.19	0.03	0.86
Alloys	50	0.08	4	0.03	1.5
Magnets	33.11	0.05	1.58	0.01	0.17
Lithium battery	282	0.44	124.34	0.14	39.98
Miscellaneous materials	40	0.35	14	0.12	4.8
Assembly					
Electricity for assembly (kWh)[a]	43	8.57	368,51	0,29	12.43
Final product					
Mass of assembled computer (g)	2949.95				
Cumulative energy demand (MJ)			1798,24		468.21
Oil equivalent (kg)[a]			42.82		11.15
Five year operation					
Electricity for 5 year operation (kWh)[a]	226	8.57	1936.82	0.29	65.54
Oil equivalent (kg)[a]			46.11		1.56
CO_2 emissions (production and five year operation)					
		Conversion factor ($kg_{CO2\,eq}/kg_{oil\,eq}$)	CO_2 release ($kg_{CO2\,eq}$)	Conversion factor ($kg_{CO2\,eq}/kg_{oil\,eq}$)	CO_2 release ($kg_{CO2\,eq}$)
Total CO_2 equiv emission		3.2	284.6	3.2	40.7

[a] Unit of electricity input flow is kWh; unit of energy intensity of electricity is MJ/kWh; unit of oil equivalent is kg.

Energy, emergy and emission performance indicators per FU

This table is a huge source of information, showing the investment referred to the computer production and use phase.

Performance parameters of production and use processes, for both laptop and desktop PCs over BAU and RAR assumptions

Investigated computer	Embodied Energy (MJ)						CO_2 emissions ($kg_{CO_2\ eq}$)						Emergy (sej)					
	Total Embodied Energy	E.E. per phase		Unit E.E.			Total CO_2 emissions	CO_2 per phase		Unit CO_2 release			Total emergy	Emergy per phase		UEV		Data Power
		Production	Use	MJ/ $kg_{computer}$	MJ/ hr_{use}	MJ/FLOPS		Production	Use	kg_{CO_2eq}/ $kg_{computer}$	kg_{CO_2eq}/ hr_{use}	$kg_{CO_2\ eq}$/ FLOPS		Production	Use	sej/kg	sej/hr_{use}	sej/FLOPS
*BAU Desktop PC**	6770.5	2442.6	4327.8	180.9	0.74	5.03E-07	515.8	186.1	329.7	13.8	0.06	3.83E-08	1.40E+15	4.46E+14	9.56E+14	3.30E+13	1.54E+11	9.18E+04
RAR Desktop PC	720.9	574.9	145.9	42.6	0.08	1.18E-07	54.9	43.8	11.1	3.2	0.01	9.01E-09	2.72E+14	1.41E+14	1.30E+14	1.04E+13	2.97E+10	2.90E+04
*BAU Laptop PC**	3735.1	1798.2	1936.8	609.6	0.41	4.71E-07	284.6	137.0	147.5	46.4	0.03	3.59E-08	6.17E+14	1.89E+14	4.28E+14	6.41E+13	6.76E+10	4.95E+04
RAR Laptop PC	533.7	468.2	65.5	158.7	0.06	1.23E-07	40.7	35.7	5.0	12.1	0.004	9.34E-09	1.05E+14	4.65E+13	5.83E+13	1.58E+13	1.15E+10	1.22E+04

The added value of calculating emergy performance indicators is that emergy captures the process of resource generation, and the environmental support to generating minerals, water, and ecosystem services.

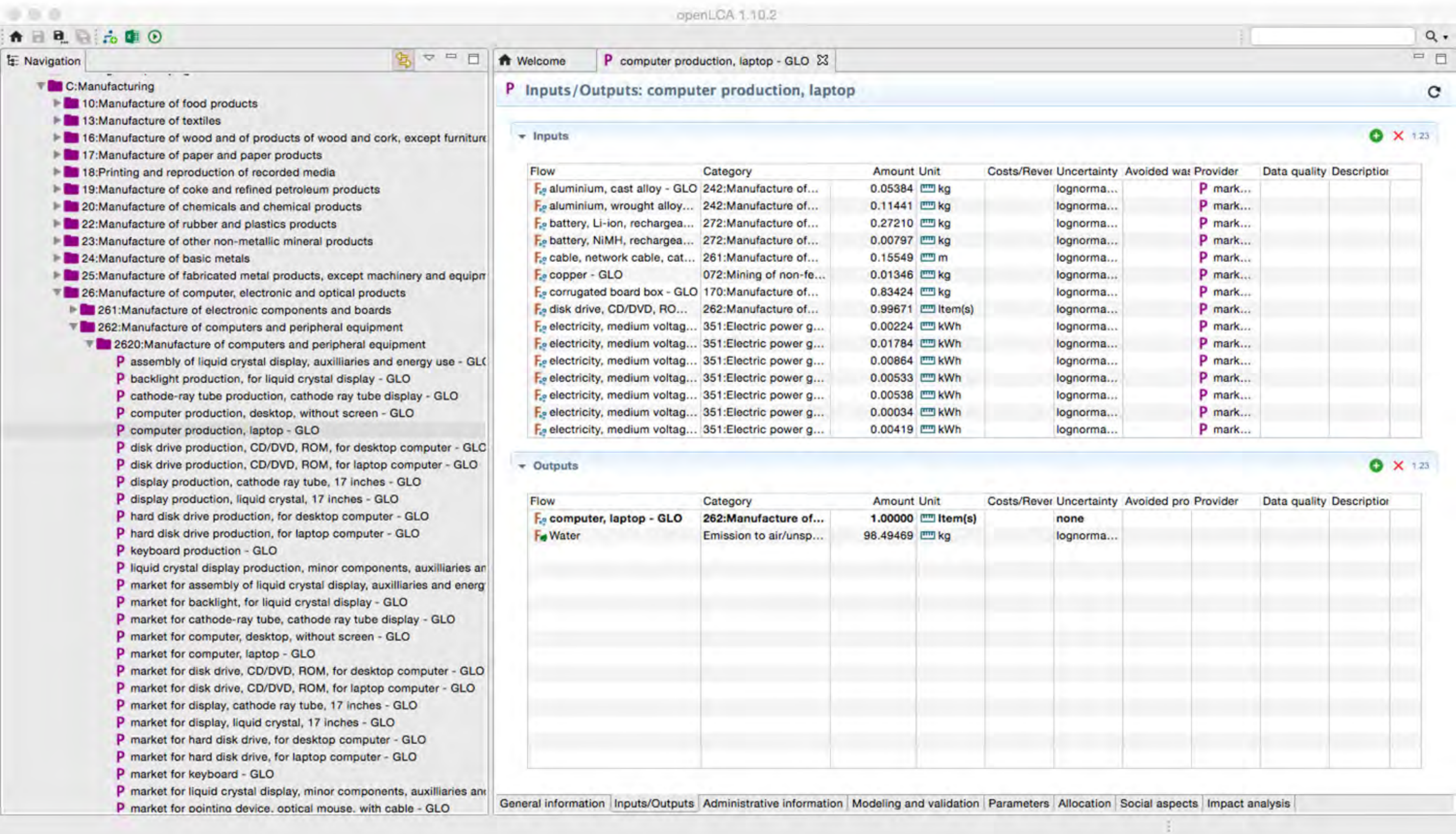
Note: FLOPS (**floating point operations per second**) indicates the computational ability of a computer (https://en.wikipedia.org/wiki/FLOPS)

LCA performance indicators per FU (kg, hour of use, FLOPS)

Performance parameters of production and use processes, for both laptop and desktop PCs over BAU and RAR assumptions

Investigated computer	**Freshwater eutrophication**					**Human toxicity**					**Terrestrial acidification**					**Metal depletion**				
	Production	Operation use	Impact/ $Kg_{computer}$	Impact/ hr_{use}	Impact/ FLOPS	Production	Operation use	Impact/ $Kg_{computer}$	Impact/ hr_{use}	Impact/ FLOPS	Production	Operation use	Impact/ $Kg_{computer}$	Impact/ hr_{use}	Impact/ FLOPS	Production	Operation use	Impact/ $Kg_{computer}$	Impact/ hr_{use}	Impact/ FLOPS
*BAU Desktop PC**	1.97E-07	3.18E-08	1.46E-08	2.51E-11	4.05E-17	1.01E-07	1.34E-08	7.48E-09	1.25E-11	2.08E-17	5.70E-09	5.24E-09	4.22E-10	1.20E-12	1.17E-18	4.61E-08	2.58E-09	3.41E-09	5.33E-12	9.49E-18
RAR Desktop PC	3.22E-08	1.30E-09	2.39E-09	3.67E-12	6.63E-18	6.70E-08	1.23E-09	4.96E-09	7.48E-12	1.38E-17	2.15E-09	2.50E-10	1.59E-10	2.63E-13	4.42E-19	1.59E-08	2.78E-10	1.18E-09	1.77E-12	3.27E-18
*BAU Laptop PC**	2.15E-07	1.43E-08	7.29E-08	2.51E-11	5.63E-17	4.54E-08	6.05E-09	1.54E-08	5.64E-12	1.19E-17	6.20E-09	2.36E-09	2.10E-09	9.38E-13	1.62E-18	3.67E-08	1.16E-09	1.24E-08	4.15E-12	9.61E-18
RAR Laptop PC	1.79E-08	5.86E-10	6.07E-09	2.03E-12	4.69E-18	1.44E-08	5.53E-10	4.88E-09	1.64E-12	3.77E-18	4.90E-10	1.12E-10	1.66E-10	6.60E-14	1.28E-19	5.95E-09	1.24E-10	2.02E-09	6.66E-13	1.56E-18

Note: FLOPS (**floating point operations per second**) indicates the computational ability of a computer (https://en.wikipedia.org/wiki/FLOPS)


openLCA 1.10.2
Navigation
C:Manufacturing
10:Manufacture of food products
13:Manufacture of textiles
16:Manufacture of wood and of products of wood and cork, except furniture
17:Manufacture of paper and paper products
18:Printing and reproduction of recorded media
19:Manufacture of coke and refined petroleum products
20:Manufacture of chemicals and chemical products
22:Manufacture of rubber and plastics products
23:Manufacture of other non-metallic mineral products
24:Manufacture of basic metals
25:Manufacture of fabricated metal products, except machinery and equipm
26:Manufacture of computer, electronic and optical products
261:Manufacture of electronic components and boards
262:Manufacture of computers and peripheral equipment
2620:Manufacture of computers and peripheral equipment
assembly of liquid crystal display, auxilliaries and energy use - GLO
backlight production, for liquid crystal display - GLO
cathode-ray tube production, cathode ray tube display - GLO
computer production, desktop, without screen - GLO
computer production, laptop - GLO
disk drive production, CD/DVD, ROM, for desktop computer - GLO
disk drive production, CD/DVD, ROM, for laptop computer - GLO
display production, cathode ray tube, 17 inches - GLO
display production, liquid crystal, 17 inches - GLO
hard disk drive production, for desktop computer - GLO
hard disk drive production, for laptop computer - GLO
keyboard production - GLO
liquid crystal display production, minor components, auxilliaries an
market for assembly of liquid crystal display, auxilliaries and energ
market for backlight, for liquid crystal display - GLO
market for cathode-ray tube, cathode ray tube display - GLO
market for computer, desktop, without screen - GLO
market for computer, laptop - GLO
market for disk drive, CD/DVD, ROM, for desktop computer - GLO
market for disk drive, CD/DVD, ROM, for laptop computer - GLO
market for display, cathode ray tube, 17 inches - GLO
market for display, liquid crystal, 17 inches - GLO
market for hard disk drive, for desktop computer - GLO
market for hard disk drive, for laptop computer - GLO
market for keyboard - GLO
market for liquid crystal display, minor components, auxilliaries an
market for pointing device, optical mouse, with cable - GLO
Welcome
computer production, laptop - GLO
Inputs/Outputs: computer production, laptop
Inputs
Flow | Category | Amount | Unit | Costs/Rever | Uncertainty | Avoided was | Provider | Data quality | Descriptio
aluminium, cast alloy - GLO | 242:Manufacture of... | 0.05384 | kg | lognorma... | mark...
aluminium, wrought alloy... | 242:Manufacture of... | 0.11441 | kg | lognorma... | mark...
battery, Li-ion, rechargea... | 272:Manufacture of... | 0.27210 | kg | lognorma... | mark...
battery, NiMH, rechargea... | 272:Manufacture of... | 0.00797 | kg | lognorma... | mark...
cable, network cable, cat... | 261:Manufacture of... | 0.15549 | m | lognorma... | mark...
copper - GLO | 072:Mining of non-fe... | 0.01346 | kg | lognorma... | mark...
corrugated board box - GLO | 170:Manufacture of... | 0.83424 | kg | lognorma... | mark...
disk drive, CD/DVD, RO... | 262:Manufacture of... | 0.99671 | Item(s) | lognorma... | mark...
electricity, medium voltag... | 351:Electric power g... | 0.00224 | kWh | lognorma... | mark...
electricity, medium voltag... | 351:Electric power g... | 0.01784 | kWh | lognorma... | mark...
electricity, medium voltag... | 351:Electric power g... | 0.00864 | kWh | lognorma... | mark...
electricity, medium voltag... | 351:Electric power g... | 0.00533 | kWh | lognorma... | mark...
electricity, medium voltag... | 351:Electric power g... | 0.00538 | kWh | lognorma... | mark...
electricity, medium voltag... | 351:Electric power g... | 0.00034 | kWh | lognorma... | mark...
electricity, medium voltag... | 351:Electric power g... | 0.00419 | kWh | lognorma... | mark...
Outputs
Flow | Category | Amount | Unit | Costs/Rever | Uncertainty | Avoided pro | Provider | Data quality | Descriptio
computer, laptop - GLO | 262:Manufacture of... | 1.00000 | Item(s) | none
Water | Emission to air/unsp... | 98.49469 | kg | lognorma...
General information
Inputs/Outputs
Administrative information
Modeling and validation
Parameters
Allocation
Social aspects
Impact analysis

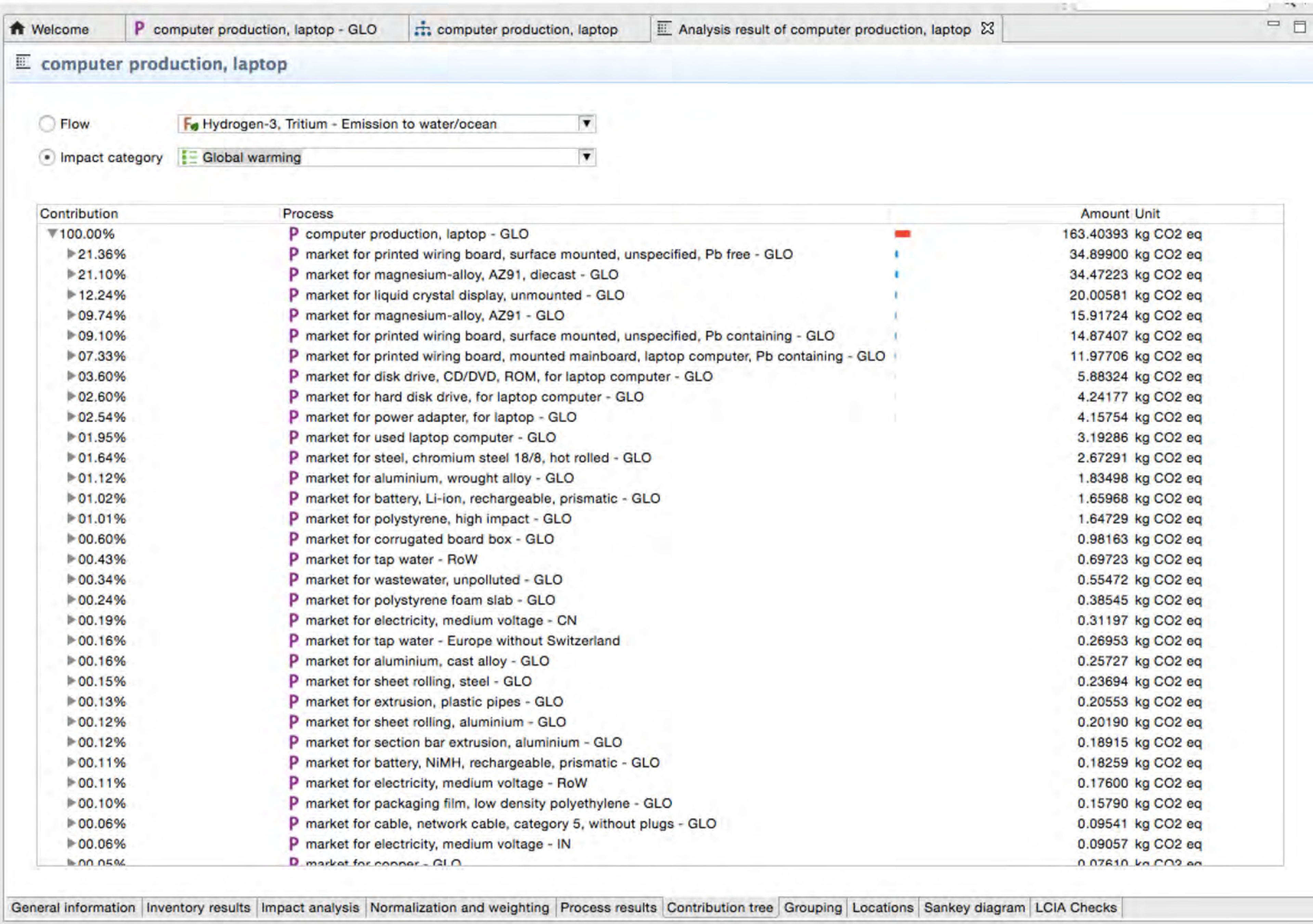
Welcome | P computer production, laptop - GLO | computer production, laptop | Analysis result of computer production, laptop

computer production, laptop

Impact analysis: ReCiPe 2016 Midpoint (H)

Subgroup by processes ☑ Don't show < 1 %

Name	Category	Inventory result	Impact factor	Impact result	Unit
Freshwater ecotoxicity				66.22103	kg 1,4-DCB
Ozone formation, Human health				0.48658	kg NOx eq
Marine eutrophication				0.07350	kg N eq
Water consumption				1.41311	m3
Stratospheric ozone depletion				8.86211E-5	kg CFC11 eq
Freshwater eutrophication				0.39127	kg P eq
Terrestrial acidification				0.94900	kg SO2 eq
Human carcinogenic toxicity				19.86868	kg 1,4-DCB
Terrestrial ecotoxicity				1530.63605	kg 1,4-DCB
Global warming				163.40393	kg CO2 eq
Human non-carcinogenic toxicity				2154.00201	kg 1,4-DCB
Fossil resource scarcity				47.22801	kg oil eq
Fine particulate matter formation				0.43752	kg PM2.5 eq
Ozone formation, Terrestrial ecosystems				0.52219	kg NOx eq
Land use				2.28970	m2a crop eq
Marine ecotoxicity				92.80385	kg 1,4-DCB
Ionizing radiation				17.73861	kBq Co-60 eq
Mineral resource scarcity				5.30617	kg Cu eq



Welcome | computer production, laptop - GLO | computer production, laptop | Analysis result of computer production, laptop

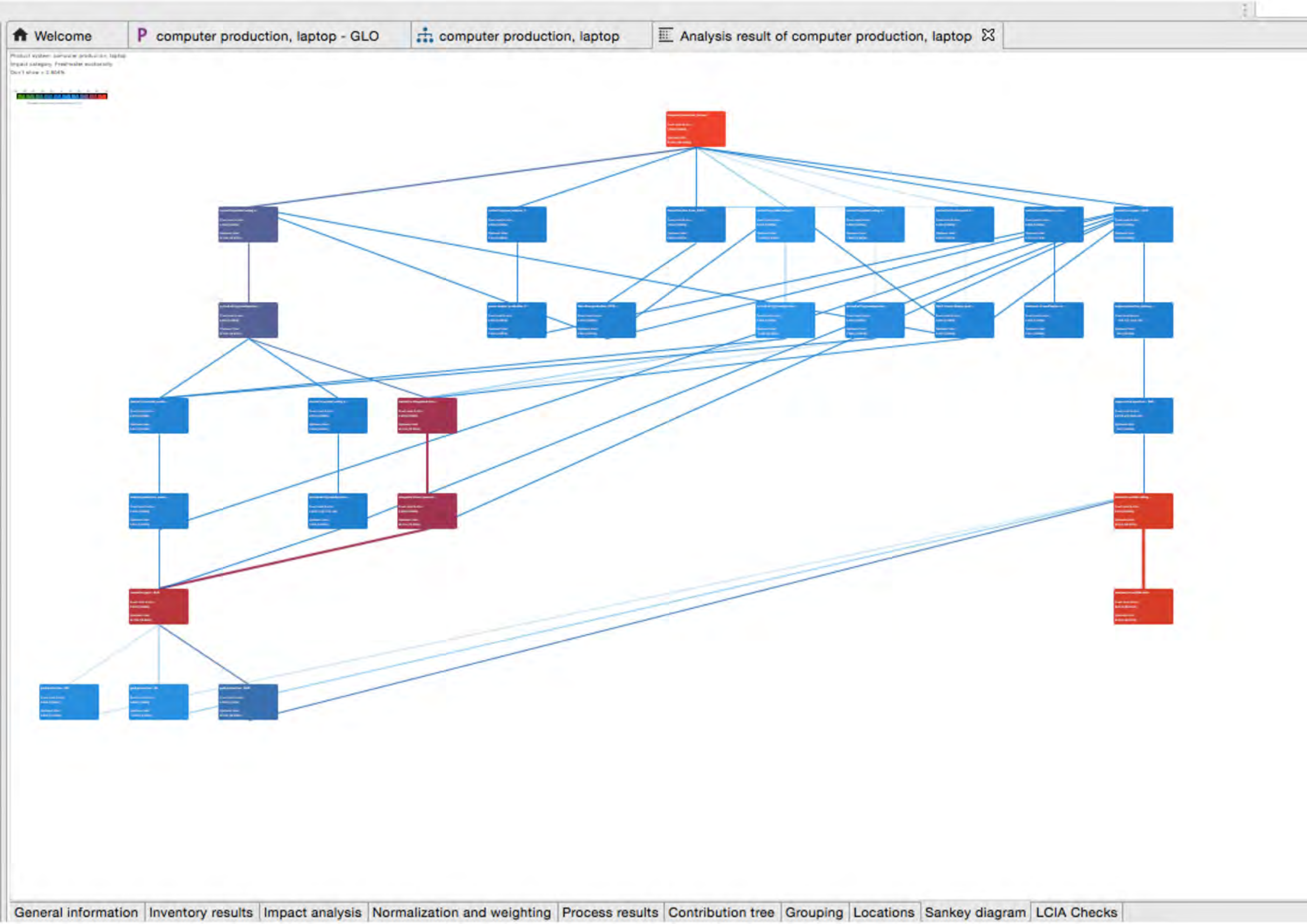
computer production, laptop

Flow: Hydrogen-3, Tritium - Emission to water/ocean

Impact category: Global warming

Contribution	Process	Amount	Unit
100.00%	computer production, laptop - GLO	163.40393	kg CO2 eq
21.36%	market for printed wiring board, surface mounted, unspecified, Pb free - GLO	34.89900	kg CO2 eq
21.10%	market for magnesium-alloy, AZ91, diecast - GLO	34.47223	kg CO2 eq
12.24%	market for liquid crystal display, unmounted - GLO	20.00581	kg CO2 eq
09.74%	market for magnesium-alloy, AZ91 - GLO	15.91724	kg CO2 eq
09.10%	market for printed wiring board, surface mounted, unspecified, Pb containing - GLO	14.87407	kg CO2 eq
07.33%	market for printed wiring board, mounted mainboard, laptop computer, Pb containing - GLO	11.97706	kg CO2 eq
03.60%	market for disk drive, CD/DVD, ROM, for laptop computer - GLO	5.88324	kg CO2 eq
02.60%	market for hard disk drive, for laptop computer - GLO	4.24177	kg CO2 eq
02.54%	market for power adapter, for laptop - GLO	4.15754	kg CO2 eq
01.95%	market for used laptop computer - GLO	3.19286	kg CO2 eq
01.64%	market for steel, chromium steel 18/8, hot rolled - GLO	2.67291	kg CO2 eq
01.12%	market for aluminium, wrought alloy - GLO	1.83498	kg CO2 eq
01.02%	market for battery, Li-ion, rechargeable, prismatic - GLO	1.65968	kg CO2 eq
01.01%	market for polystyrene, high impact - GLO	1.64729	kg CO2 eq
00.60%	market for corrugated board box - GLO	0.98163	kg CO2 eq
00.43%	market for tap water - RoW	0.69723	kg CO2 eq
00.34%	market for wastewater, unpolluted - GLO	0.55472	kg CO2 eq
00.24%	market for polystyrene foam slab - GLO	0.38545	kg CO2 eq
00.19%	market for electricity, medium voltage - CN	0.31197	kg CO2 eq
00.16%	market for tap water - Europe without Switzerland	0.26953	kg CO2 eq
00.16%	market for aluminium, cast alloy - GLO	0.25727	kg CO2 eq
00.15%	market for sheet rolling, steel - GLO	0.23694	kg CO2 eq
00.13%	market for extrusion, plastic pipes - GLO	0.20553	kg CO2 eq
00.12%	market for sheet rolling, aluminium - GLO	0.20190	kg CO2 eq
00.12%	market for section bar extrusion, aluminium - GLO	0.18915	kg CO2 eq
00.11%	market for battery, NiMH, rechargeable, prismatic - GLO	0.18259	kg CO2 eq
00.11%	market for electricity, medium voltage - RoW	0.17600	kg CO2 eq
00.10%	market for packaging film, low density polyethylene - GLO	0.15790	kg CO2 eq
00.06%	market for cable, network cable, category 5, without plugs - GLO	0.09541	kg CO2 eq
00.06%	market for electricity, medium voltage - IN	0.09057	kg CO2 eq
00.05%	market for copper - GLO	0.07610	kg CO2 eq

General information | Inventory results | Impact analysis | Normalization and weighting | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks


Welcome
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computer production, laptop
Analysis result of computer production, laptop
General information
Inventory results
Impact analysis
Normalization and weighting
Process results
Contribution tree
Grouping
Locations
Sankey diagram
LCIA Checks

Ecological Indicators 94 (2018) 37–51

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Ecological Indicators

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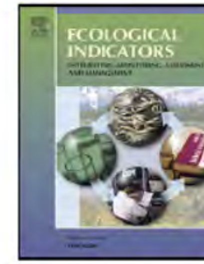


Sustainable urban electricity supply chain – Indicators of material recovery and energy savings from crystalline silicon photovoltaic panels end-of-life

Fabiana Corcelli [a], Maddalena Ripa [a,*], Enrica Leccisi [a], Viviana Cigolotti [b], Valeria Fiandra [b], Giorgio Graditi [b], Lucio Sannino [b], Marco Tammaro [b], Sergio Ulgiati [a,c]

[a] Department of Science and Technology, Parthenope University of Naples, Centro Direzionale – Isola C4, 80143 Naples, Italy
[b] ENEA, Italian National Agency for New Technologies, Energy and the Environment, Portici Research Centre, P. le E. Fermi, 1, Portici, 80055 Naples, Italy
[c] School of Environment, Beijing Normal University, 19 Xinjiekouwai St., Haidian District, 100875 Beijing, China

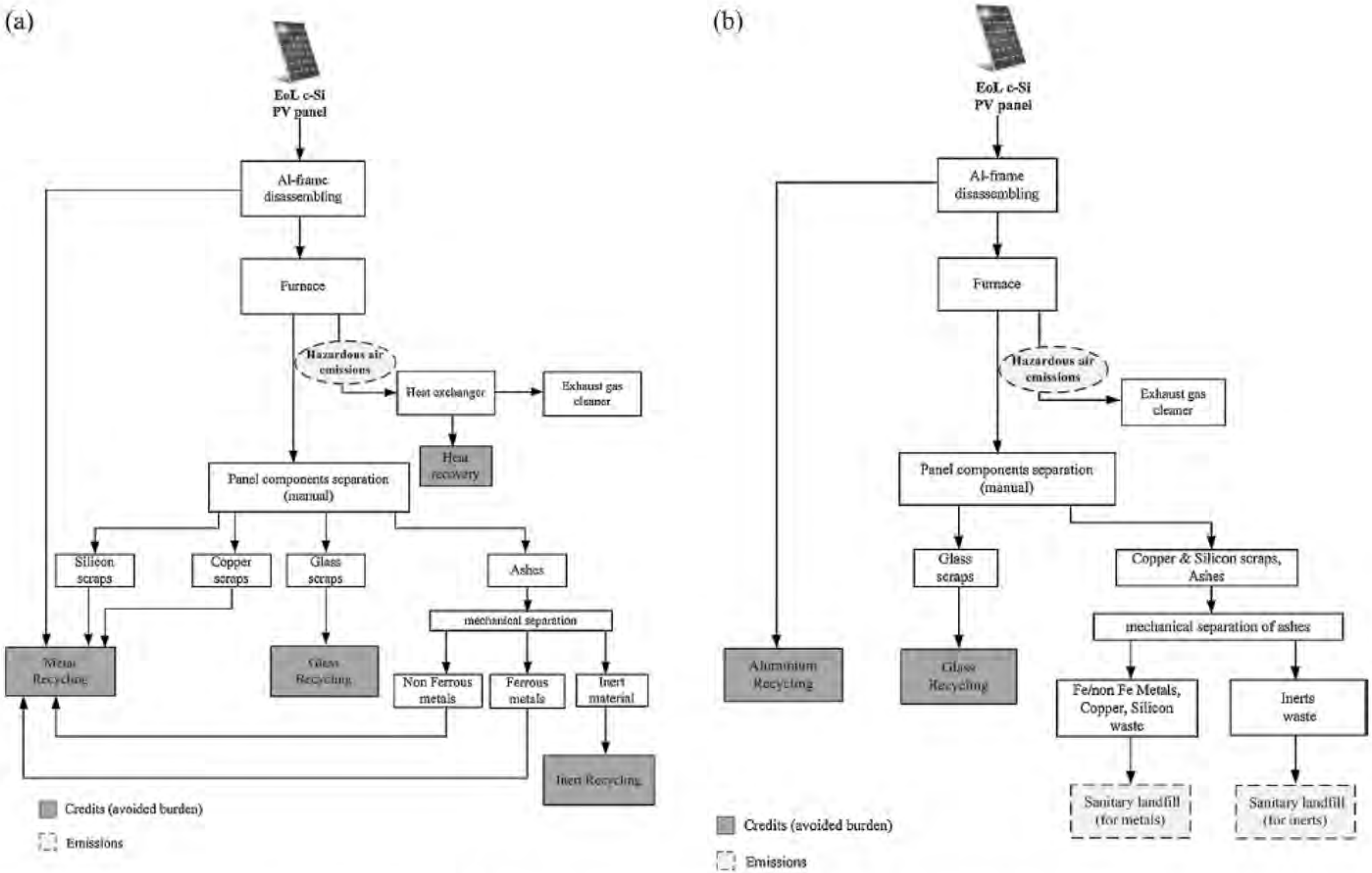
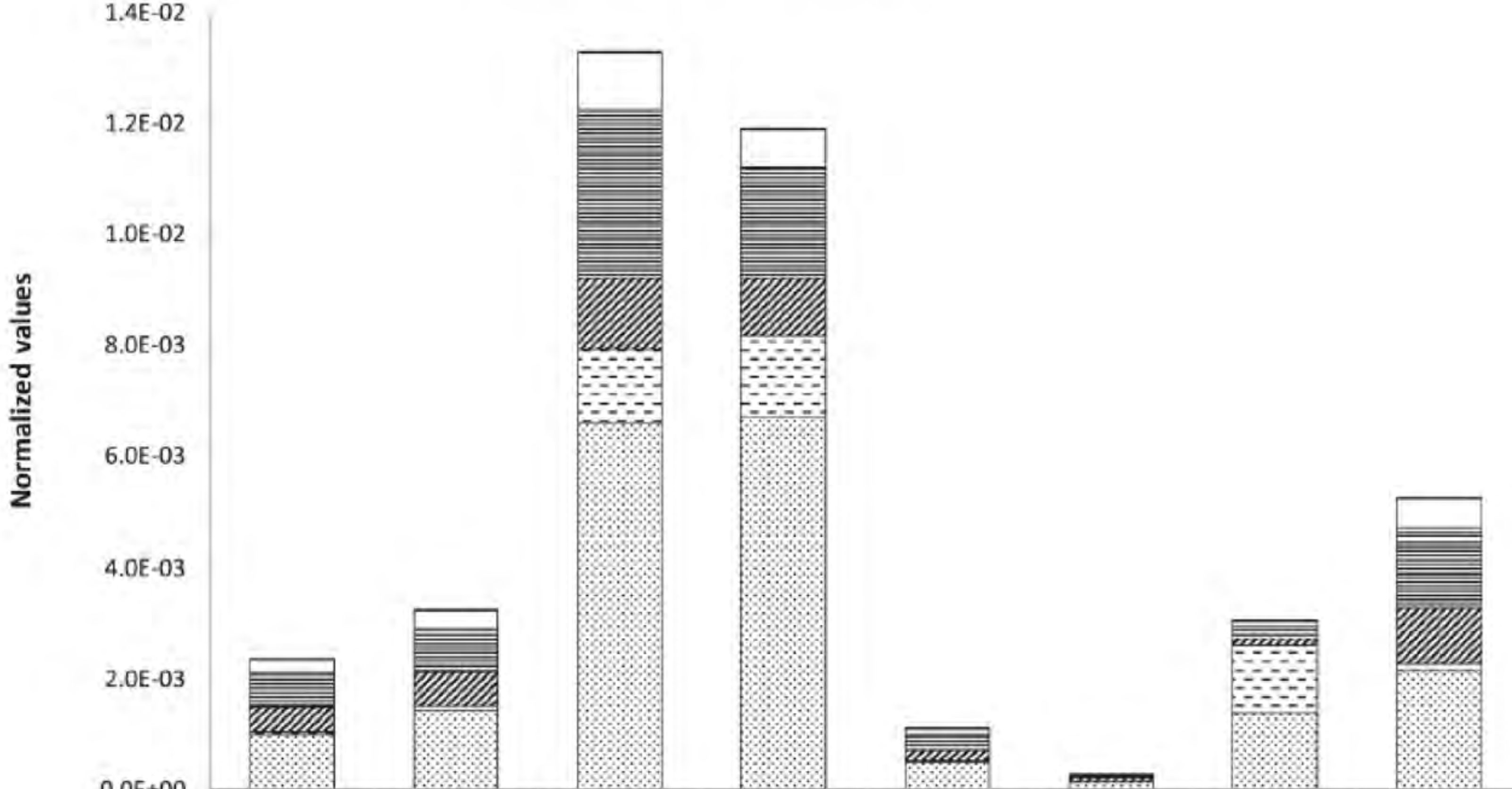


Fig. 1. (a) Flow chart of high-rate recovery scenario (HR). (b) Flow chart of low-rate recovery scenario (LR).

Table 5b
LCI of the main output flows of the thermal treatment referred to a 1 m^2 of c-Si PV panel.

Output flows	Amount (kg/m^2 panel)[a]
HF	8.71E−04
NO	5.78E−06
NO_2	8.25E−07
CO	6.56E−05
CO_2	2.81E−04
VOC	4.32E−05
Hydrocarbons	2.34E−05
Al	8.60E−08
Cr	2.10E−09
Cu	1.76E−09
As	2.15E−10
Cd	4.42E−09
Pb	8.85E−08
Fe	8.20E−09
Sn	2.47E−07
Zn	3.16E−08
In	8.90E−10
Ba	1.37E−09
Ni	2.95E−10
Aluminum (frame)	3.29E+00
Glass	8.14E+00
Silicon (cell)	9.79E−01
Copper	3.62E−02
Inerts	3.81E−02
Non Fe-metals	1.66E−02
Fe-metals	2.27E−05
Heat from plastics	3.77E+01

[a] Except for electricity (where kWh is used) and heat (where MJ is used).



	GWP	TAP	FEP	HTP	POFP	TEP	MDP	FDP
Inert recovery	1.7E-08	1.0E-07	3.5E-08	3.3E-08	8.1E-08	1.2E-09	1.1E-08	3.6E-08
Heat recovery	2.3E-04	2.9E-04	1.0E-03	6.7E-04	1.1E-04	2.0E-05	9.6E-05	5.1E-04
Steel recovery	8.9E-10	1.4E-09	1.5E-08	5.3E-08	7.0E-10	9.6E-10	2.1E-09	2.1E-09
Silicon recovery	6.5E-04	7.9E-04	3.1E-03	2.0E-03	2.9E-04	5.5E-05	2.0E-04	1.4E-03
Glass recovery	4.1E-04	6.4E-04	1.3E-03	1.0E-03	1.9E-04	4.9E-05	1.2E-04	1.0E-03
Copper recovery	4.9E-05	7.2E-05	1.3E-03	1.5E-03	2.4E-05	8.3E-06	1.2E-03	1.1E-04
Aluminium recovery	1.0E-03	1.4E-03	6.6E-03	6.7E-03	5.0E-04	1.5E-04	1.4E-03	2.2E-03

Fig. 3. Normalized impacts of high-rate scenario, broken down into contributions from each single phase, with reference to 1 m^2 of c-Si PV panel treated.

ANNEX 5

Report on Waste Electrical and Electronic equipment (WEEE) Management and the Potential for Circular Options in the Metropolitan City of Naples

<u>China-Italy Bilateral Project</u>

"Analysis on the metabolic process of urban agglomeration and the cooperative strategy of circular economy"

CUP: I56C17000020002

Institution: Università degli Studi di Napoli "Parthenope"/ Parthenope University of Naples

Unit: Dipartimento di Scienze e Tecnologie / Department of Science and Technology

<u>**Project activities**</u>: Work Packages 2 and 3

<u>**Authors:**</u>

Patrizia Ghisellini, Silvio Cristiano, Remo Santagata, Francesco Gonella, Stefano Dumontet, Sergio Ulgiati

June 2019

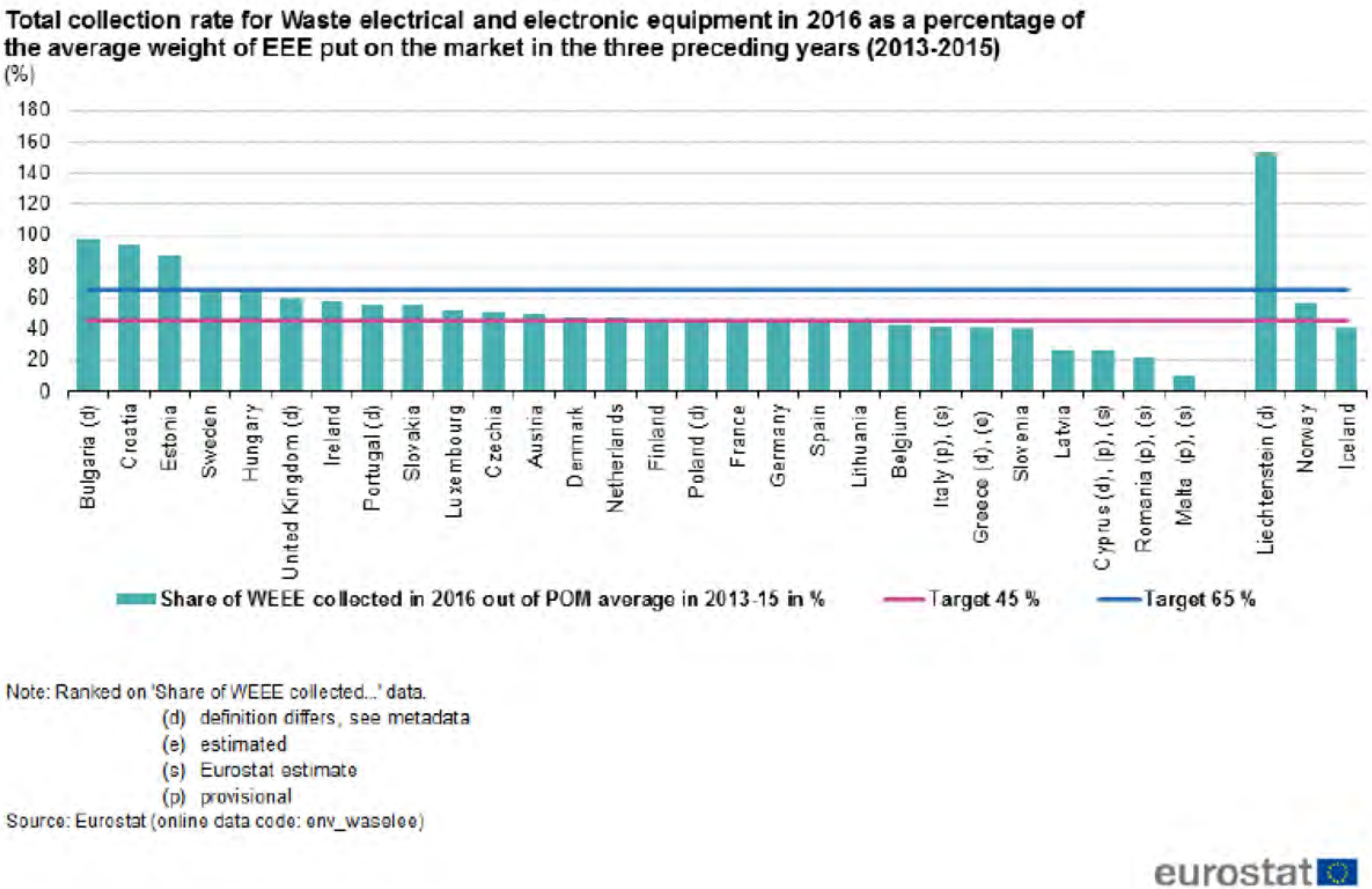


Figure 1. Total collection rate for Waste electrical and electronic equipment in 2016 as a percentage of the average weight of EEE put on the market in the three preceding years (2013-2015) (%). Source: EUROSTAT[11]

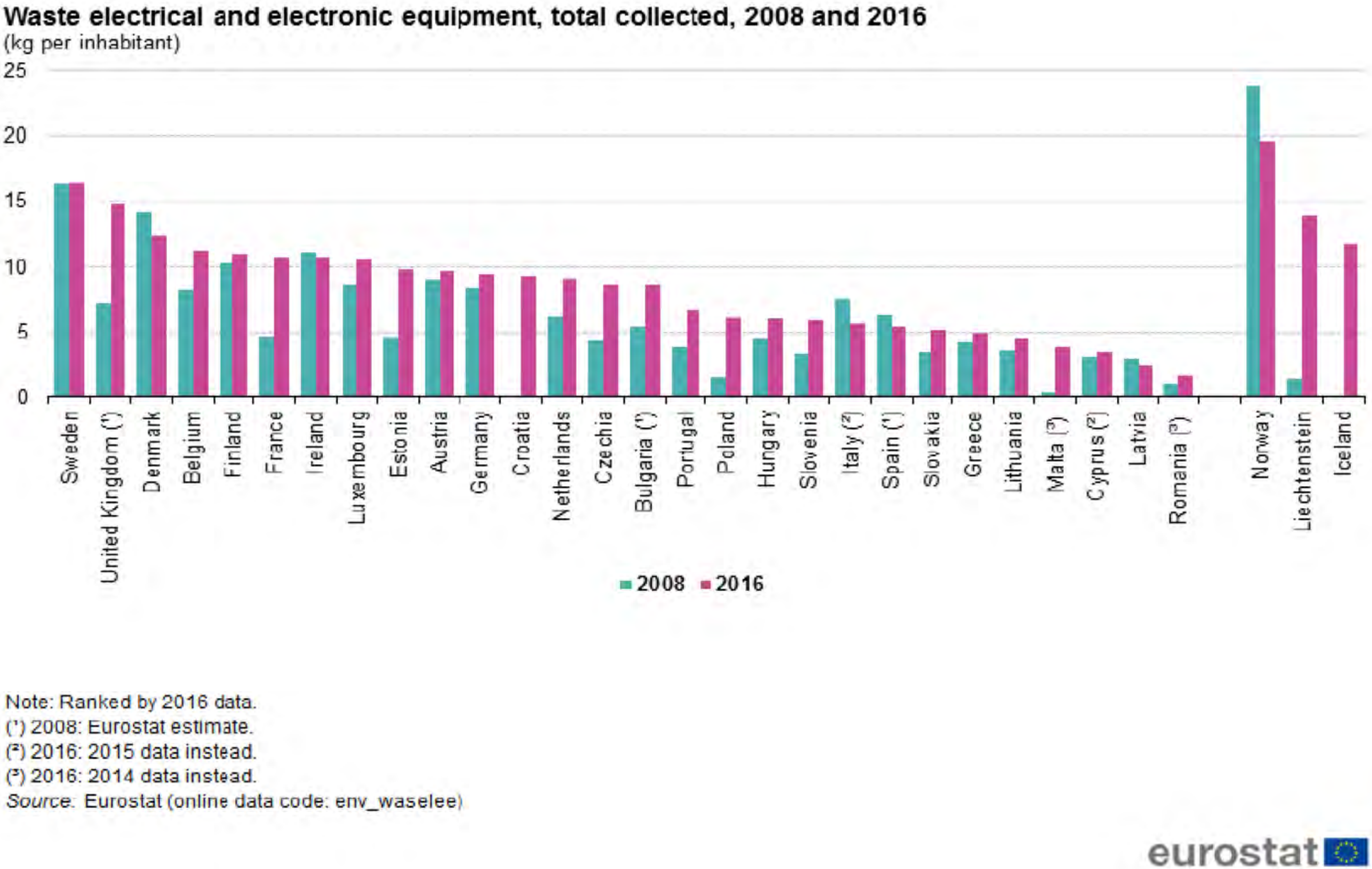


Figure 2. WEEE collection rates per capita (kg/per capita) in EU 28 in 2008 and 2016. Source: EUROSTAT[12].

The Ministerial Decree 185/2007 also defined that collection centres should classify WEEE into five categories as follows:

- "R1" Refrigerators and air conditioning systems;
- "R2" Large household appliances[18];
- "R3" TV sets and displays[19];
- "R4" Small household appliances, consumer electronics, office automation, computer appliances, lighting devices[20];
- "R5" Light sources (no incandescent lamps)[21];

Table 2. Materials and energy recovered from 1 tonne of WEEE across the different categories. Source: Biganzoli et al., (2015).

Recovered materials and energy	U.M.	heaters and refrigerators (R1)	large household appliances (R2)	TV and monitors (R3)		small household appliances (R4)	lighting equipment (R5)
				CRTs	FPDs		
ABS plastic	kg	-		112.5	156	-	-
Aluminium	kg	45.8	6.86	4	102	15.2	33.4
Chromium steel	kg	-	24.8*	-	-	-	-
Cobalt	kg	-	-	-	-	0.1	-
Concrete (grinded)	kg	-	96.0	-	-	-	-
Copper	kg	11.5	8.56	28.9	27.2	29.1	-
Electricity	kWh	2.08	14.6	11.4	21.5	675	-
Glass	kg	-	-	355	37.2	-	800
Gold	kg	-	0.00011	0.02	0.02	0.005	-
Lead	kg	-	0.011	1.48	1.33	1.70	-
Manganese powder	kg	-	-	-	-	0.005	-
Nickel	kg	-	0.022	3.11	2.77	1.04	-
Palladium	kg	-	0.00022	0.03	0.03	0.01	-
Particle board	m^3	0.016	0.0008	0.015	-	0.0009	-
Plasmix	kg	51.0	27.6	-	-	-	-
PMMA plastic	kg	-	-	-	32.9	-	-
PS plastic	kg	90.4	48.8	-	-	-	-
Silver	kg	-	0.004	0.53	0.48	0.18	-
Steel	kg	471	665	97	384	490	44.1
Thermal energy	MJ	4.67	15.9	16.4	20.2	1504	-
Electricity	kWh	2.08	14.6	11.4	21.5	675	-

*The value refers to the chromium steel scraps separated from the R2 category.

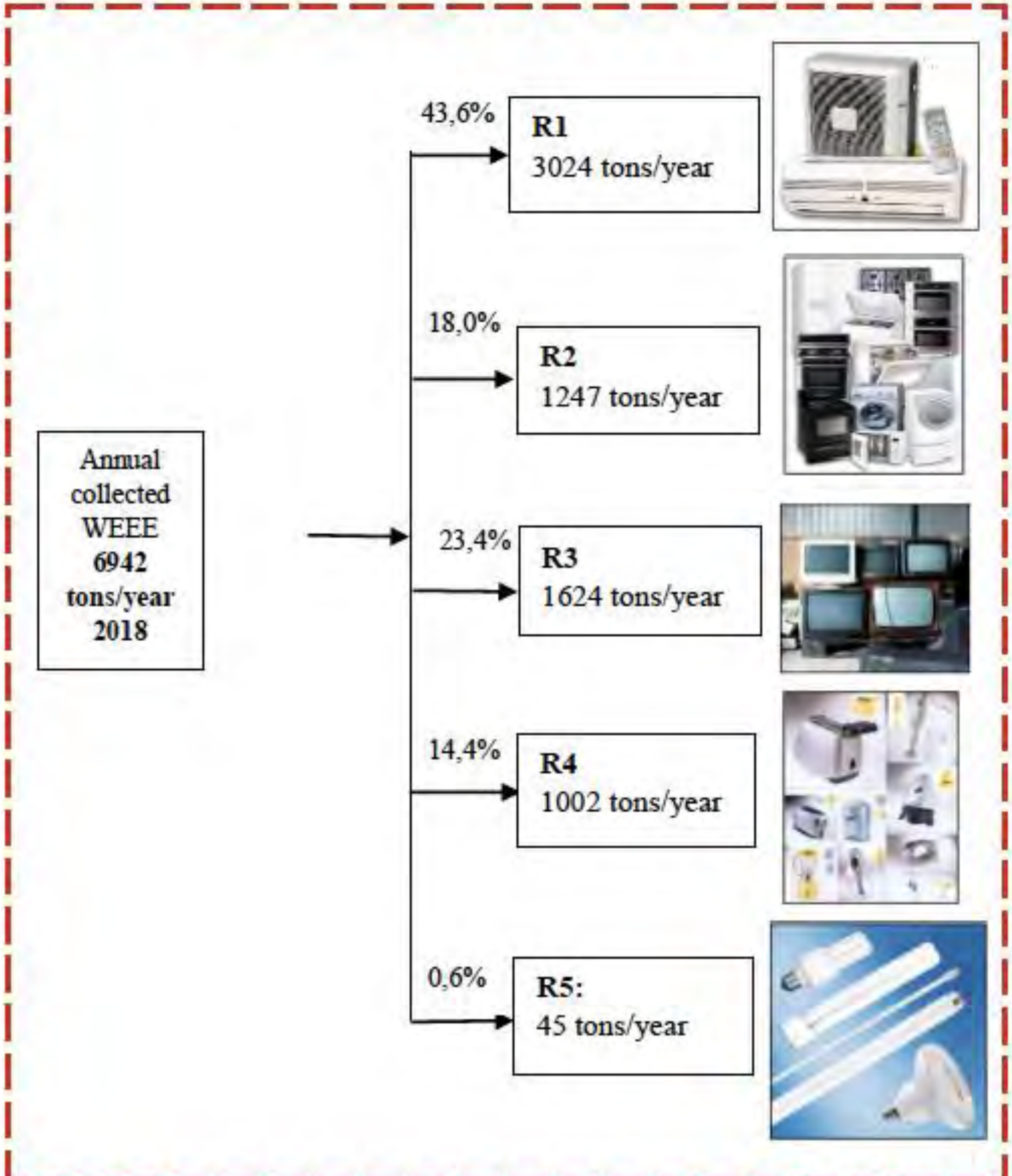


Figure 5. Annual amount of collected WEEE and its composition into the different groups of WEEE such as: Source of the data: Annual report of WEEE Coordination Centre, 2018.

WEEE recovery in the Metropolitan City of Naples

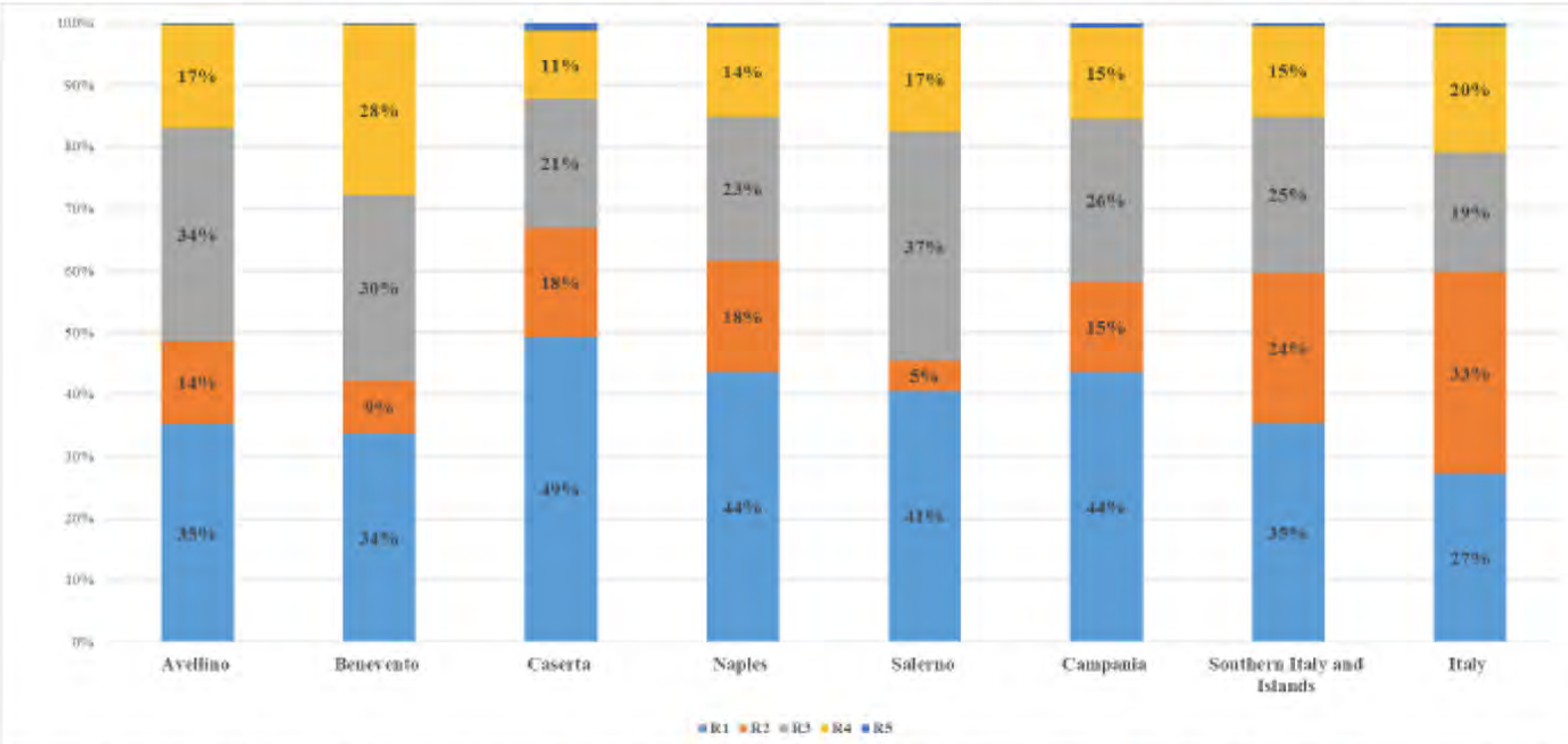


Figure 6. Share of WEEE category in the total amount collected at province and regional level. Source of the data: Centro Coordinamento RAEE, Rapporto annuale 2018.

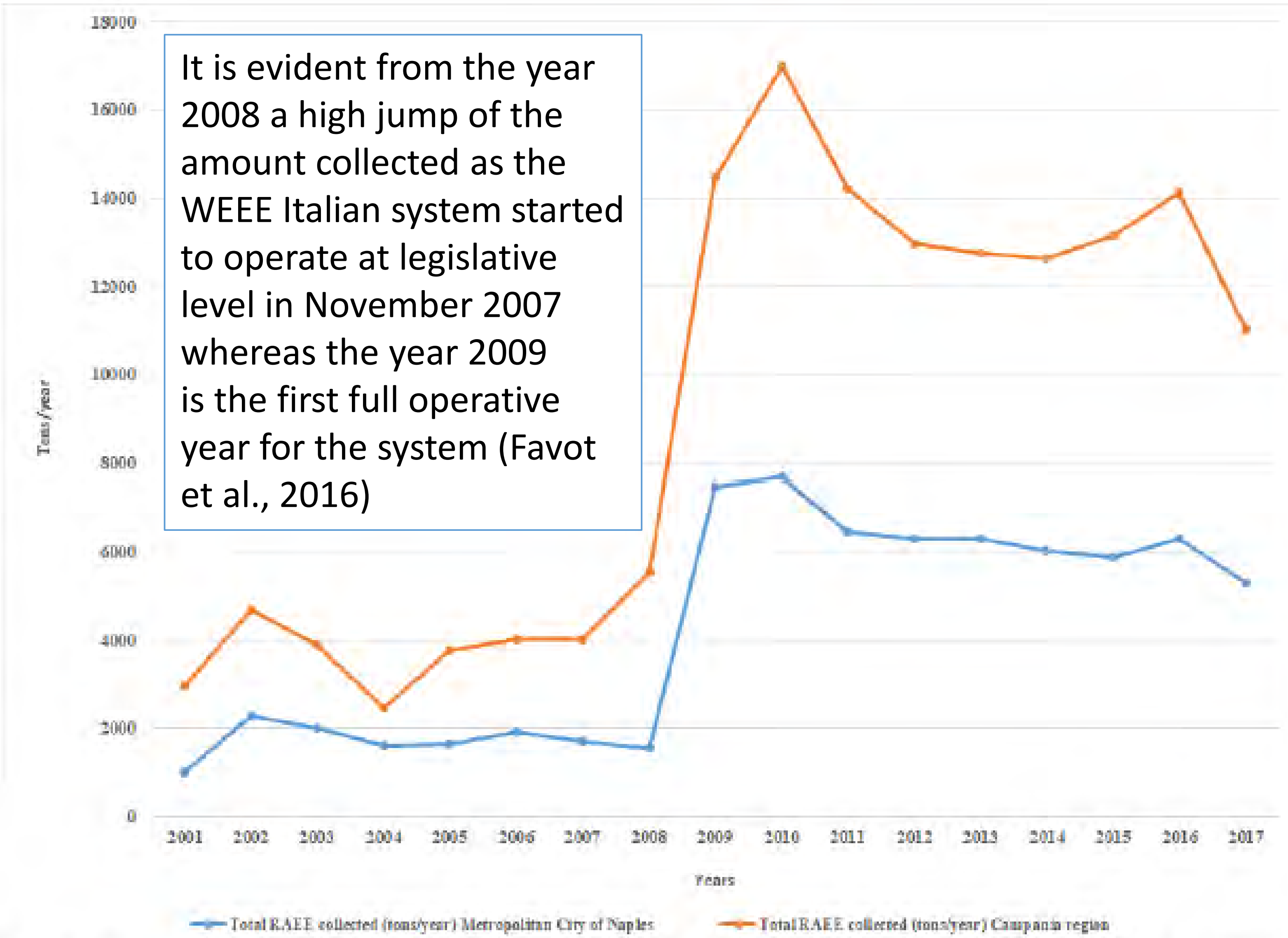


Figure 7. Evolution of annual amount of WEEE collected in the Metropolitan city of Naples and Campania Region. Source of the data: National Waste Cadastre by ISPRA.

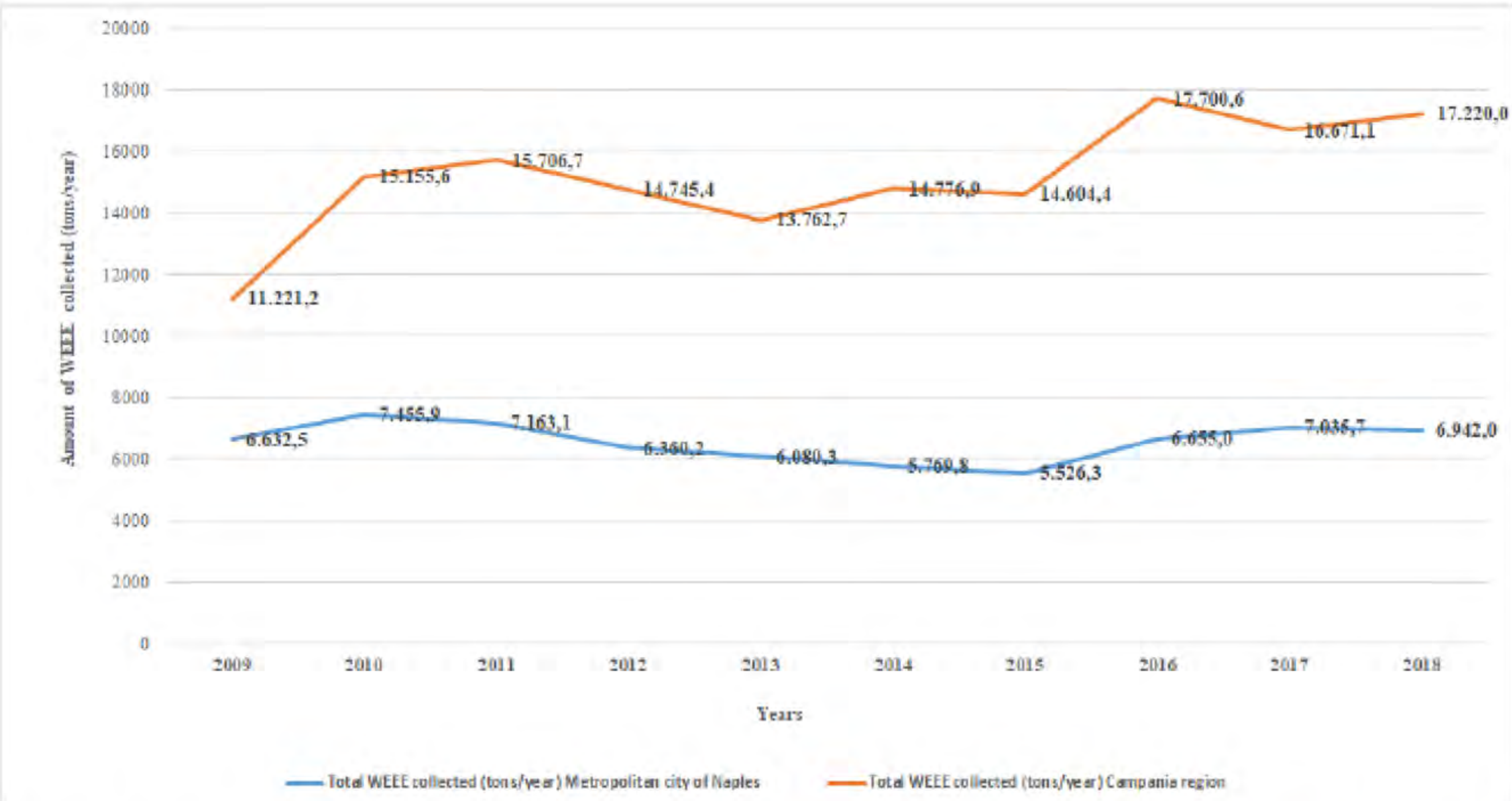


Figure 8. Trend of the amount of WEEE collected in Campania Region and Metropolitan City of Naples. Source of the data: Annual Reports by the WEEE Coordination Centre (https://www.cdcraee.it/GetHome.pub_do).

PROVINCES	COLLECTION PER CAPITA	CHANGE 2018/2017
AVELLINO	3,19	5,11%
BENEVENTO	3,02	17,19%
CASERTA	5,42	7,06%
NAPLES	2,24	-1,33%
SALERNO	2,38	3,94%
CAMPANIA REGION	2,96	3,29%
SOUTHER ITALY AND ISLANDS	3,54	5,55%
ITALY	5,14	4,84%

Table 3. Amount of WEEE collected per capita and percentage change in 2018 compared to 2017. Source of the data: Centro Coordinamento RAEE, Rapporto annuale 2018.

Waste Management 67 (2017) 222–231

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Waste Management

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E-waste collection in Italy: Results from an exploratory analysis

Marinella Favot *, Luca Grassetti

University of Udine Department of Economics and Statistics (DIES), Via Tomadini 30/A, 33100 Udine, Italy

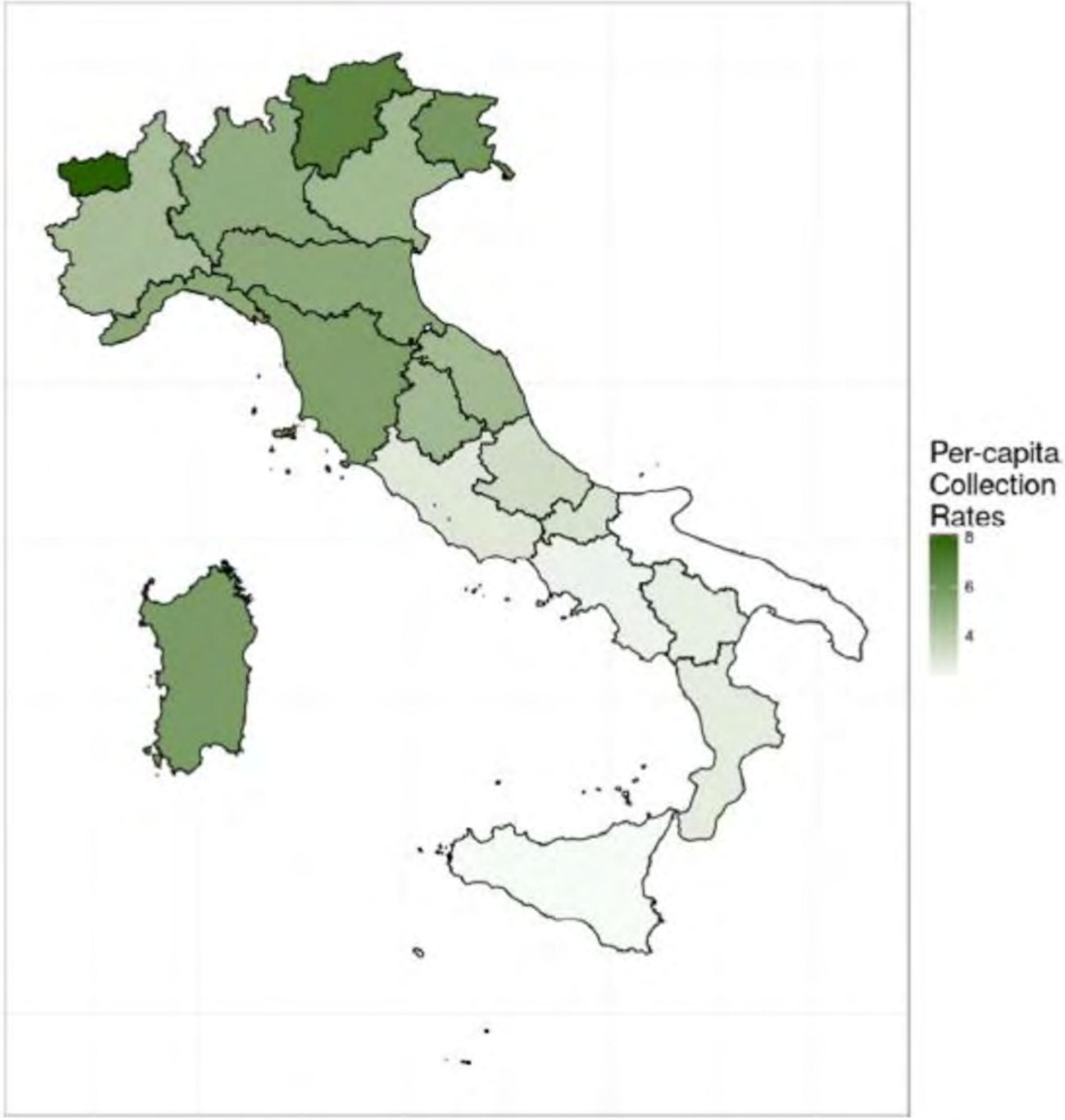

Fig. 2. The spatial distribution of per-capita collection rates (CR) in Italy (Year = 2015) CR: kg collected per inhabitant per year.

Come raggiungere la sede del seminario

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Centro Direzionale di Napoli
isola C4

Dalla stazione centrale (Piazza Garibaldi)
(In auto 3 min. - piedi 15 min)
da Piazza Garibaldi, girare a destra per Corso Novara
girare la prima a destra per Corso Meridionale
proseguire diritto per circa 500mt

Dalla stazione centrale (Piazza Garibaldi)
(Circumvesuviana - 5 min)
linea per Baiano
scendere alla prima fermata: Centro Direzionale

Dalle Autostrade (A1) - (A3)
Nel tratto E45 -- collegamento A1 (Milano-Napoli) - A3 (Napoli-Salerno) --,
si incrocia la S.S. 162 uscire a Centro Direzionale.

da Salerno, dopo la barriera di Napoli proseguire su E45
in direzione Roma (A1) ed uscire a Centro Direzionale.

da Roma, dopo la barriera di Napoli proseguire su E45
in direzione Salerno (A3) ed uscire a Centro Direzionale.

da Avellino, dopo la barriera di Napoli proseguire su E45
in direzione Salerno (A3) ed uscire a Centro Direzionale.

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Con il Patrocinio Morale di

COMUNE DI NAPOLI

Presentazione progetto "RE-BIT"

Una seconda vita per i computer!

REBIT

Install Party

Venerdì 23 maggio
ore 10:30/13:00
Atrio di ingresso Università Parthenope
Centro Direzionale (Isola C4) Napoli

dentroSalerno Cerca...

[Home](#) » [Senza categoria](#)

Napoli: RE-BIT, donati scuola pc non rottamati

Inserito da [DentroSalerno](#) on 20 maggio 2014 – 01:00 [No Comment](#)

Sarà presentato venerdì 23 maggio, alle ore 10.30 presso l'Università Parthenope di Napoli (Centro Direzionale, Isola C4) il progetto Re-Bit che mira a selezionare computer ancora utilizzabili per destinarli a scuole e biblioteche. Il programma dell'evento prevede alle ore l'intervento di saluto del Direttore del Dipartimento di Scienze e Tecnologie, Prof. Raffaele Santamaria, e del Direttore del Dipartimento di Ingegneria, prof. Vito Pascazio e del vice-sindaco e assessore all'Ambiente del Comune di Napoli Tommaso Sodano. La selezione dei computer utilizzabili presso la A&C Ecotech è già in corso da parte di studenti dell'Università Parthenope. Il giorno 23 maggio, in concomitanza il convegno presso l'Università Parthenope promosso da Legambiente Campania e dal consorzio Ecoem, si svolgerà un "Install Party", in cui ricercatori e studenti dell'Università Parthenope installeranno software open-source idoneo ad usi non professionali (scuole elementari, associazioni) per poi destinare i computer così rigenerati a scuole elementari del Comune di Napoli e a singole associazioni. In parallelo si svolgerà un'esposizione di oggetti artistici ottenuti mediante riciclo di parti di vecchi computer. Il progetto Re-Bit, patrocinato dal Comune di Napoli, è un'iniziativa promossa dall'Università Parthenope (attraverso il Dipartimento di Scienze e Tecnologie e il Dipartimento di Ingegneria

CONTATTI

Prof. Sergio Ulgiati

Dipartimento di Scienze e Tecnologie

Università degli Studi di Napoli "Parthenope", Centro Direzionale, Isola C4 – 80143 – Napoli

email:
sergio.ulgiati@uniparthenope.it

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REBIT

Una seconda vita per i computer!

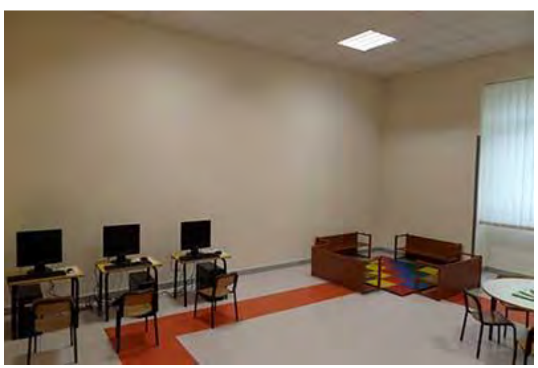
Social and Environmental Benefits

The REBIT project at Parthenope University

A reuse project has been implemented since 2014 up to 2018 in Campania region named REBIT. This project originated from a collaborative effort of Parthenope University, the City administration, the firm A&C Ecotech and the environmental association Legambiente.

REBIT project aims to reuse and recycling (**circular economy)**:

- Select and repair still usable computers;
- Decrease waste generation and increase resource saving;
- Minimize the existing digital divide.



REBIT 2015 at the junior School G.Pascoli of Naples (https://www.scienzeetecnologie.uniparthenope.it/REBIT-2015.html)

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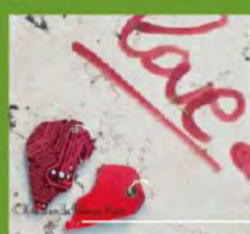

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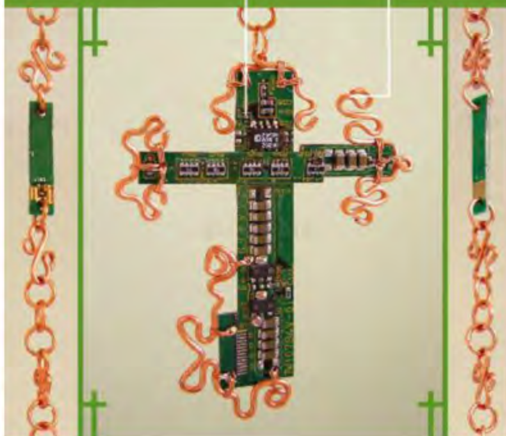


collana

cavi elettrici

connettori

terminali per bigiotteria

distanziatori con occhiello per bigiotteria

anello

resistenze

base per anello

collana

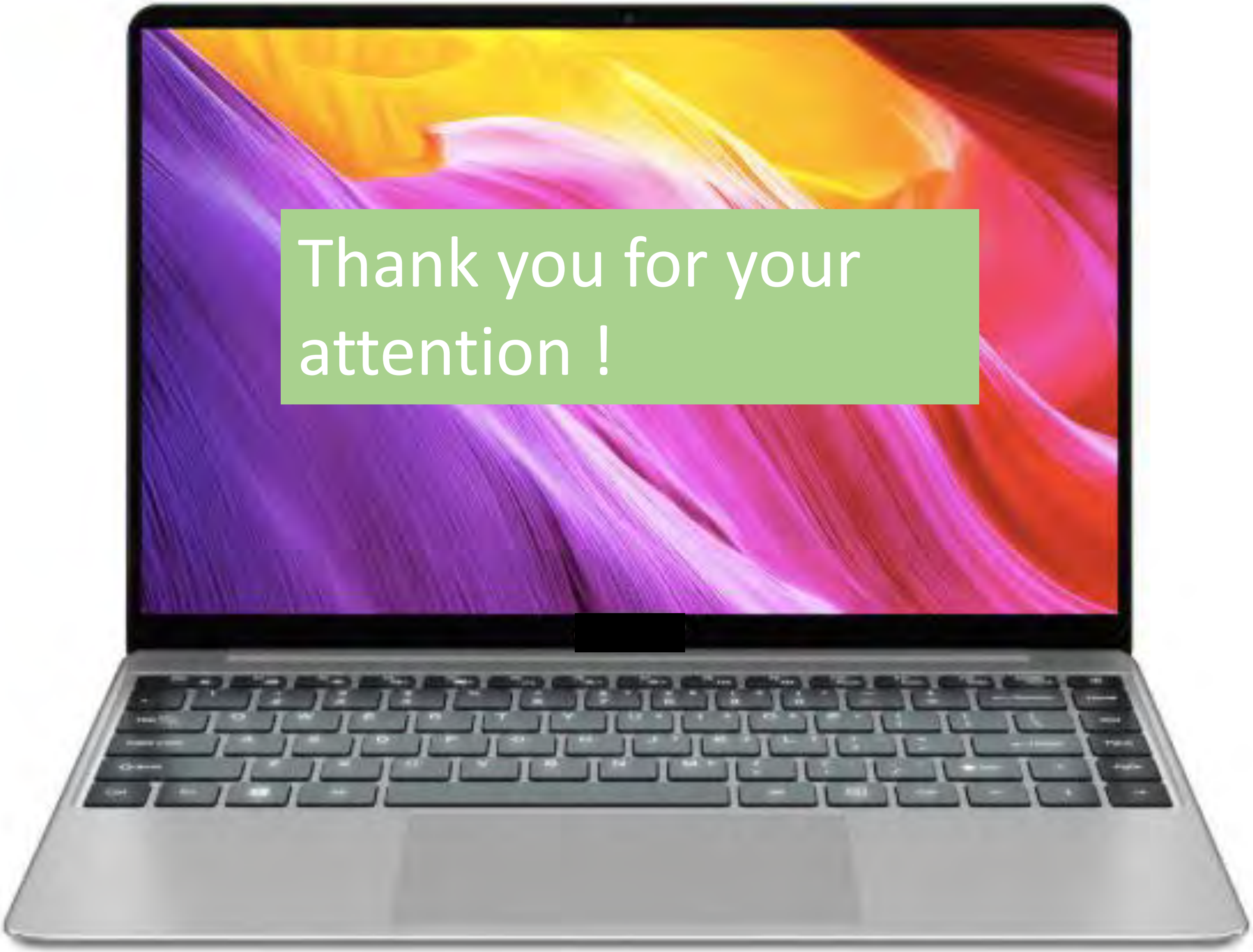
asse di testina di hard disk

griglia di altoparlanti

filo per bigiotteria

disco in vinile


Old Tech New Art


Thank you for your attention !