



La gestione del ciclo dei rifiuti elettronici. Quali prospettive per l'economia circolare

The management of the e-waste cycle. Perspectives for the Circular Economy

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Agenda



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- 1 Some definitions and concepts
- 2 WEEE as a complex problem
- 3 Waste Hierarchy - Prevent the WEEE generation
 - Recycle option
 - Reuse-Repair
 - Ecodesign
- 4 Reduction of illegal E-waste traffic
- 5 Reduction of impact on environment and human health
- 6 Recovery and extraction of value
 - Weee system/regulation in EU
 - Results from the Italian case study

circular economy - Concepts

slowing, closing, narrowing loops

- 1) **Slowing resource loops** (i.e. reuse): Through the design of long-life goods and product life extension (i.e. service loops to extend a product's life, for instance through maintenance, repair) the utilisation period of products is extended, resulting in a slowdown of the flow of resources.
- 2) **Closing resource loops** (i.e. recycle): Through recycling, the loop between post-use and production is closed, resulting in a circular flow of resources.
- 3) **Resource efficiency or narrowing resource flows**, aimed at using fewer resources per product.Resource efficiency is not aimed at the cyclic use of products and materials, Different from slowing resource loops, as it does not influence the speed of the flow of products and does not involve any service loops (e.g. repair).

Bocken et al 2015

Circular Economy Principles

(Ellen Mac Arthur Foundation)



Waste = Food. In living systems, there is no waste. One species' waste become food for another species. We can reduce waste by redesigning products so they can be reused or disassembled at the end of the life. Products and materials are kept at their highest values all times

Build resilience through diversity. The nature model explains that living systems are diverse and many different species help to support the ecosystem against shocks. Companies, nations and economic systems can use diversity to build resilience and resources

Use renewable energy. The Circular Economy is about many actors working together, creating effective flows of both material and information, with everything increasingly powered by renewable energy

Think in systems. Looking at the connections between ideas, people and places to create opportunities for people, planet and profit.

[Adapted from Weetman, 2017, p.18]

Circular Economy Building blocks (Ellen Mac Arthur Foundation)



Circular economy design. Product and system design need a new approach, to enable product reuse, recycling and “cascading”. This requires advanced skills, information, methodologies. Design should aim for durability, easy EoL reuse, product/materials sorting or separation; look for potential by-products and waste”uses

New, innovative business models. Replace existing BM, seize new opportunities. Mayor companies can drive CE into the mainstream by their scale and vertical integration. Ideas, materials and products will come from disruptors and start-ups. Well known brand and large companies can inspire other players

Reverse Cycles. New material and product cascades and the final return of material to the soil or back into the production system need careful thinking and new approaches: logistics, storage, risk management, power generation, effective and efficient collection, sorting, treatment, reducing leakage of materials.

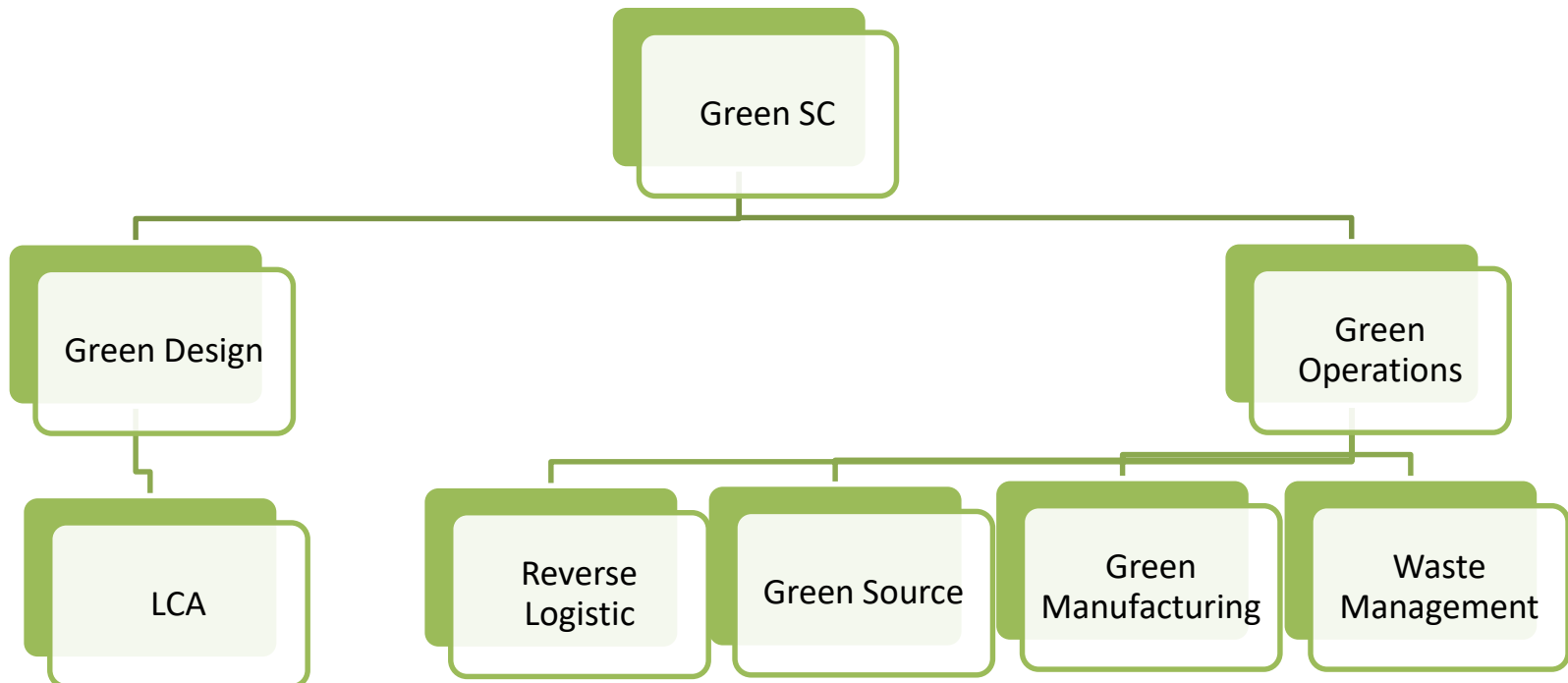
Enablers and favourable system conditions. New or revised market mechanisms can encourage widespread reuse of materials and higher resource productivity. (e.g.; incentives, suitable international environmental rules, access to financing). These can be supported by policymakers, educational system, opinion leaders.

[Adapted from Weetman, 2017, p.19]

Green Supply Chain Management



A Green SC has to consider all those activities that concern the entire life cycle products management, considering also their return reuse or recycling..



GREEN SCM



The Green Design - A design aimed at reusing, recycling and reducing waste, energy consumption, use of risky and dangerous materials.

The **Life-cycle analysis (LCA)** is an important tool of the Green design. It measures all resources used for production process (Srivastava, 2007).

Gungor and Gupta (1999): LCA "examines and quantifies energy and materials used and waste, assessing impact of the product on environment."

The Green Operations refers to all strategic and operational aspects related to (Srivastava, 2007) :

- 1.Green sourcing** regards the purchase of all materials, parts of products or products from suppliers, subcontractors, service providers, which respect environmental criteria
- 2.Green Manufacturing** aims to improve the efficiency of resource use in order to reduce toxic substances, waste pollutants and to limit the use of energy.
- 3.Waste Management** involves collection, transportation, removal, processing of materials considered waste, in order to reduce consumption resources and pollution prevention
- 4. Reverse Logistic:** all those operations aimed to ensure the return of materials or EoL products from customers to producers/suppliers, to recycle, reuse or recondition them (Stock, 1998).

The role of the REVERSE SC



The **Reverse Supply Chain** can be defined as the effective and the efficient management of those activities required to retrieve a product from a customer and either recover value from its treatment or dispose of it.

From the CE perspective, **RSC and RL** are necessary approaches to “close the loops” of EOL products. Both **aim to**:

- (i) support a more sustainable socio-economic development,
- (ii) focus on environmental, economic and ecological aspects and on the proper management of used product, waste and EOL, and so on
- (iii) Involve several similar activities: repair, refurbishing, recycling, disposal cycles

Indeed, Reverse Supply Chain

- i) Is made a variety of activities not necessarily only logistical and service activities, but also manufacturing and processing;
- ii) it is central not only the management of RL cycle, but coordination of a variety of people, capital goods and activities;
- iii) efficiency and effectiveness of end of life product management depends on relations between actors operating in it.

The role of the REVERSE SC



RSC is made by five key processes

- 1. Product acquisition:** costumers return product to the reseller;
- 2. Reverse Logistics:** includes all activities that allow to recover products or wastes, namely transportation, storage, distribution and inventory management.
- 3. Inspection and disposition:** tests and controls to determine quality level of returned products and to choose appropriate recovery
- 4. Recondition:** all those activities that let to repair, re-use, recover, recycle, remanufacture
- 5. Distribution and sales:** firms have a need to identify right market where to sell treated products

(Guide and Wassenhove, 2002; Prahinski, 2006; Blackburn, 2004)

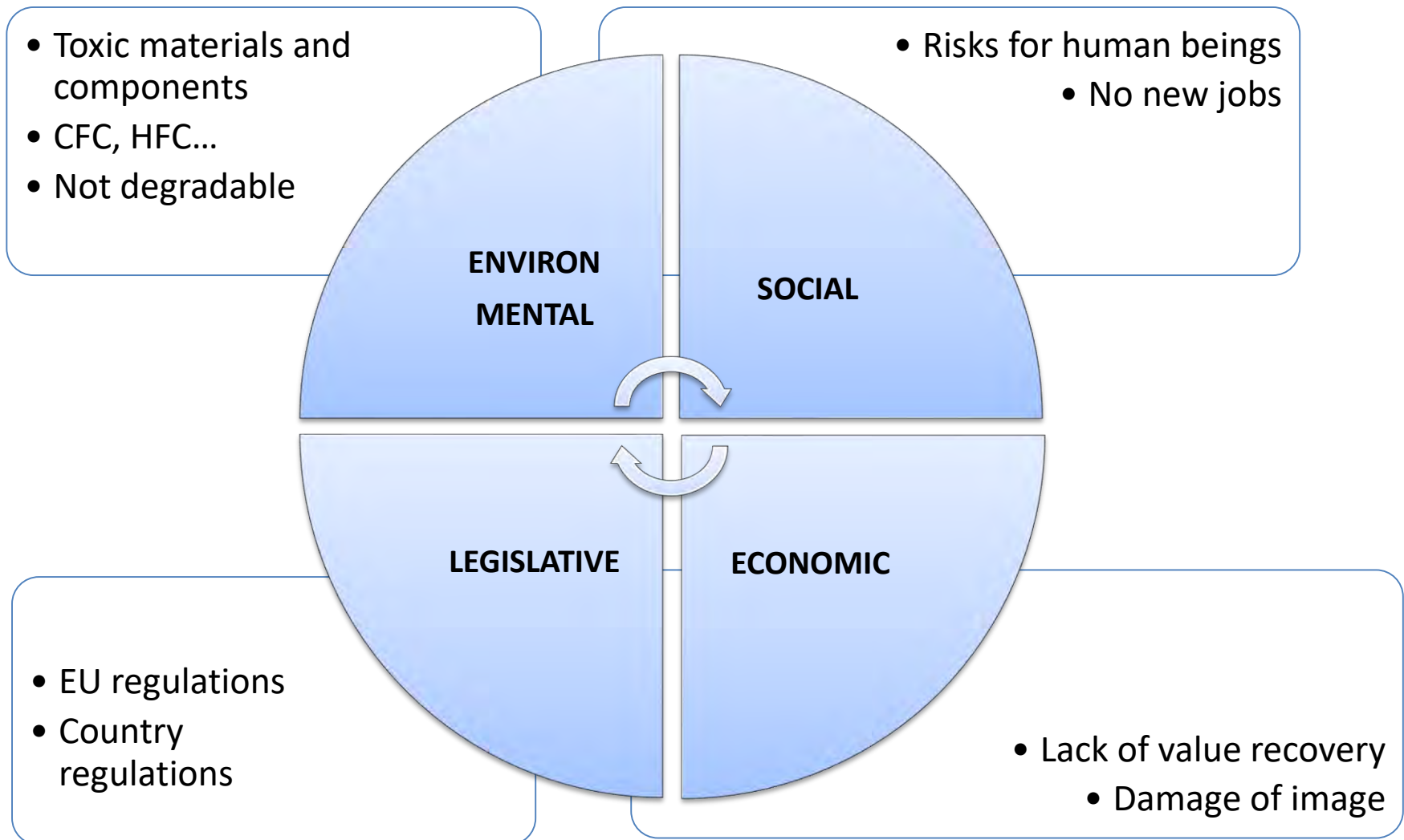
The RSC and the WEEE



The Reverse Supply Chain represents appropriately the waste management cycle of the *electrical and electronic equipment*.



The WEEE: in the traditional linear system



The WEEE: a complex problem



Waste of any equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields. This term includes all components, subassemblies and consumables which are part of the product at the time of discarding (Dir. 2002/96/EC).

“In UE Weee is one of the fastest growing waste streams, at 3-5% per year”

- among the more quoted sentence in the e-waste literature!
- three times faster than average waste.

About 90% of this waste is still land filled, incinerated or recovered without any pre-treatment (Savage, 2006) → very critical data.

2013: UE, about 50% ends up in landfills, incinerated or dispersed

2013: Italy: over 60% of WEEEE generated ends up in landfills or dispersed

In both cases the treatment process works (90% is recovered) →

The WEEE: from complex problem to opportunities



WEEE includes different substances, some recyclable such as, ferrous metals, non-ferrous metals, glass, plastics and other materials.

- Iron and steel are the most common materials found in EEE (48%). Plastics are the second largest component (21%).
- Non-ferrous metals, including precious metals (13%) among which (Widmer et al., 2005 and Ongondo et al, 2011).
- Other substances, such as mercury, sulphur, cadmium, lead, chromium, may cause serious damages to the environment and risks to human health.

Moreover WEEE contain high levels of embodied carbon due to resource extraction, production and transportation processes (Allwood et al, 2012; Norman et al., 2016).

Essential to manage WEEE in a proper way.

2005

Estimation of the
ICT devices
generating waste

An average family
disposes about 68
devices in 20 years

2020: today this
value can be
considered under-
estimate

Product	Approx. replacement frequency (years)	No. per Household	Tot. replaced over 20 Yrs. ^a
Cell phone ^b	2	2	20
Computer ^{c,d}	3	1.5	10
Television ^c	8	2.6	7
Compact Disc Player ^{c,e}	6	2	7
Printer ^{c,d}	4	1.4	7
PDA, Palm pilot, or MP3 player ^c	6	1	3
VCR/DVD ^c	5	1.7	7
Cordless telephone ^c	7	1.5	4
Answering Machine ^c	6	1	3
Estimated total number of units over 20 years:	68		

(Cairns, 2005)

The WEEE: from complex problem to opportunities - Re-cycle option



Apple case study

Recovery rate about 96%



PRECIOUS METALS:

- 9 g COPPER
- 11 g IRON
- 24 mg GOLD
- 250 mg SILVER
- 9 mg di PLATINUM

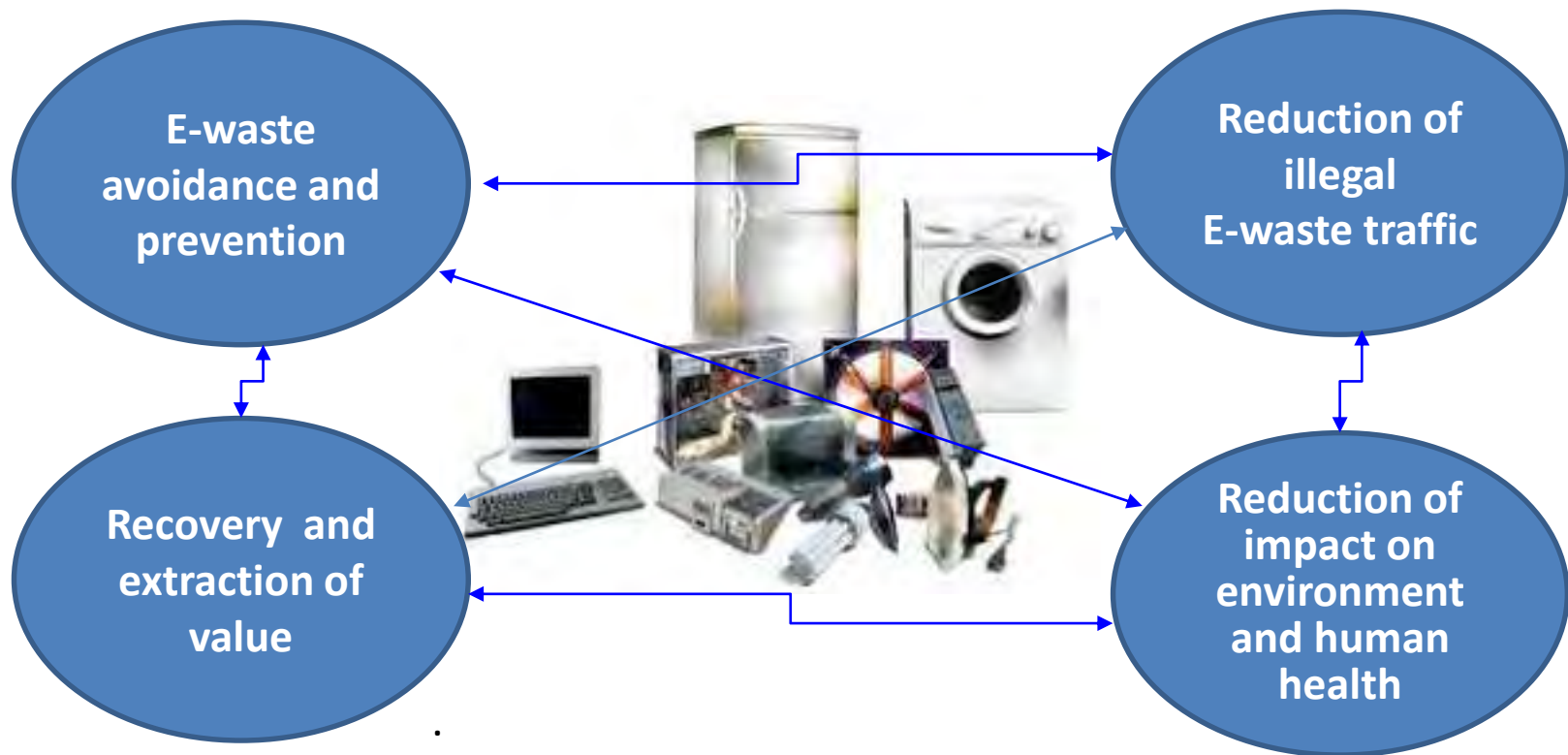
RARE EARTHS (about 2 g)

PLASTICS (about 65 g)

ESTIMATED ANNUAL SAVING

117 MILLION EUROS

How to observe Weee management in CE perspective

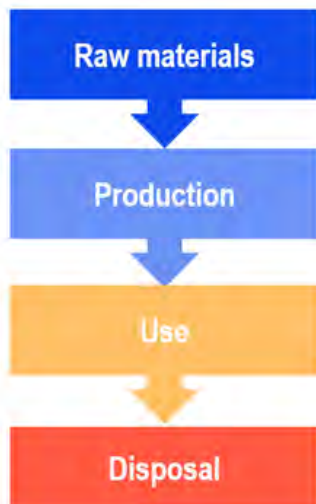


How to observe Weee management in CE perspective



The transition to circular economy

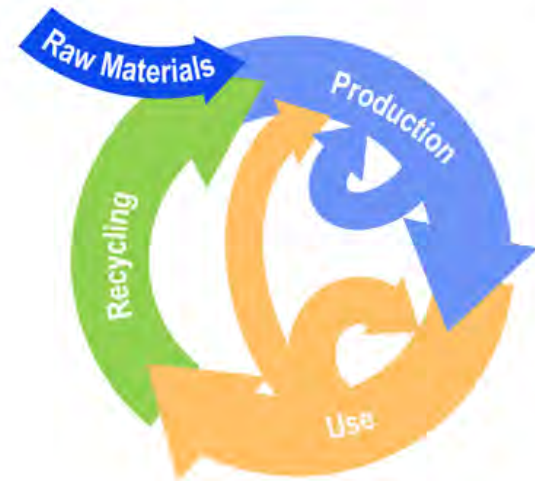
Linear economy



Recycling economy

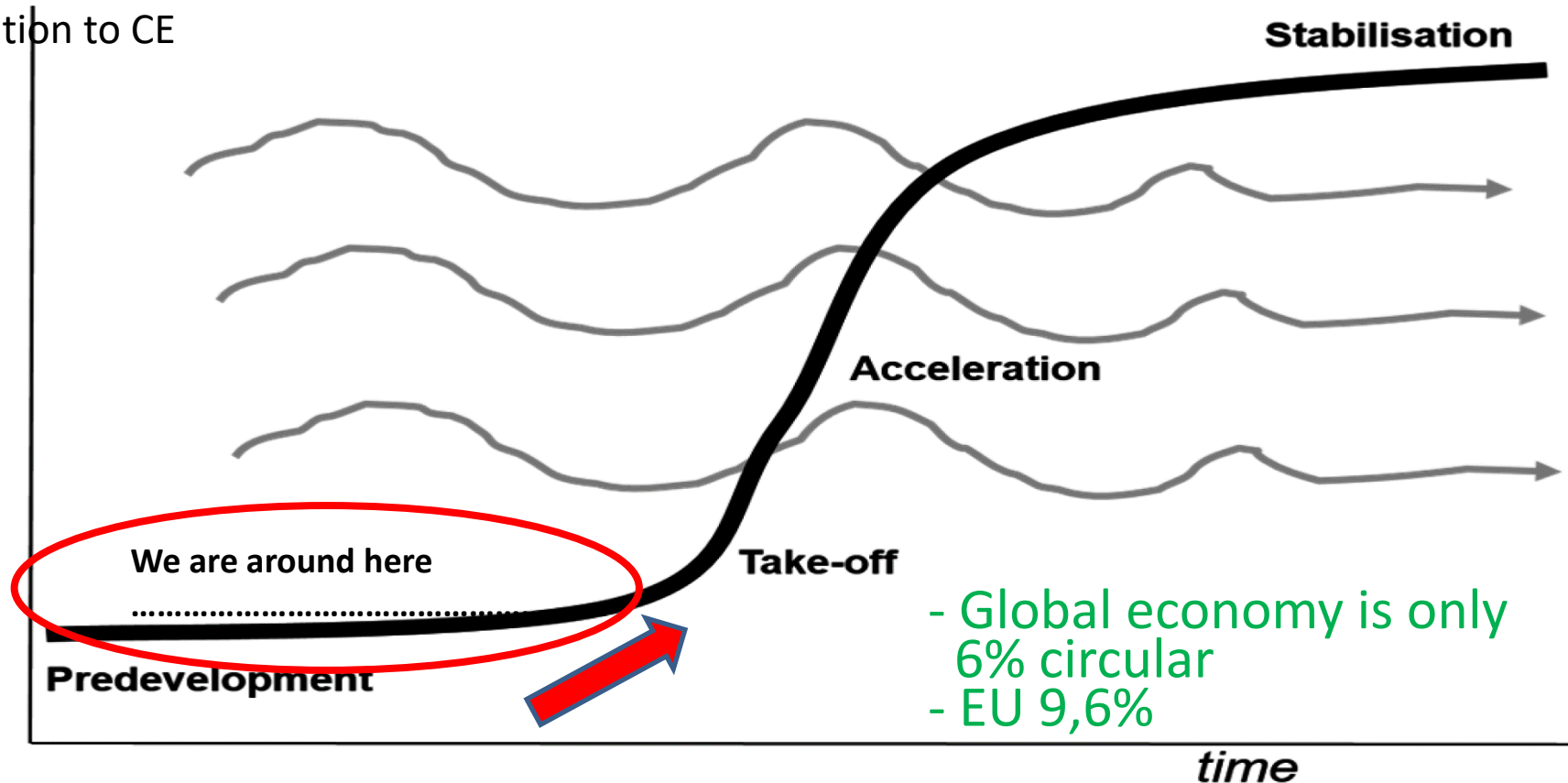


Circular economy



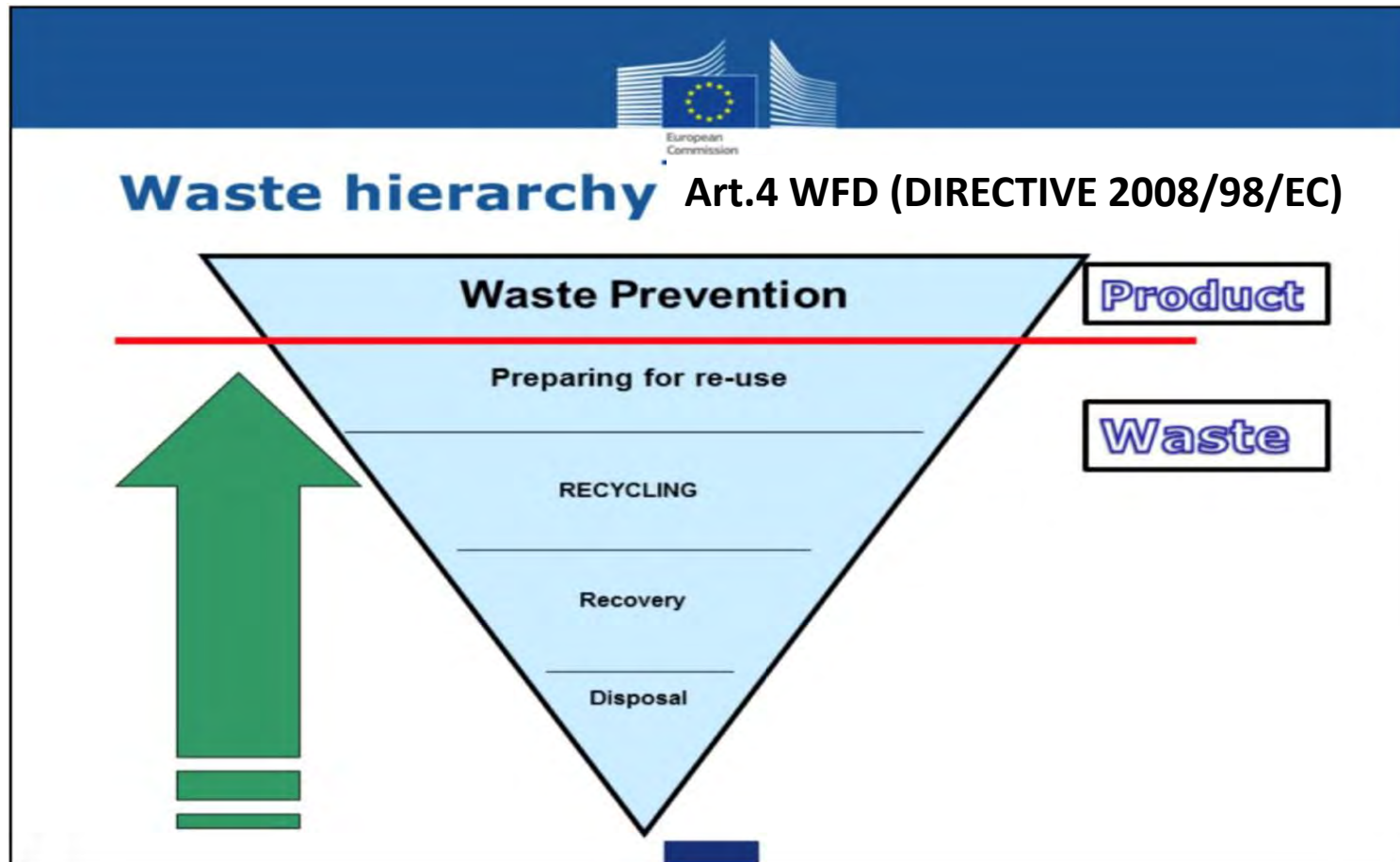
Transition to circular economy. (the trend).

Phases of
societal
transition to CE



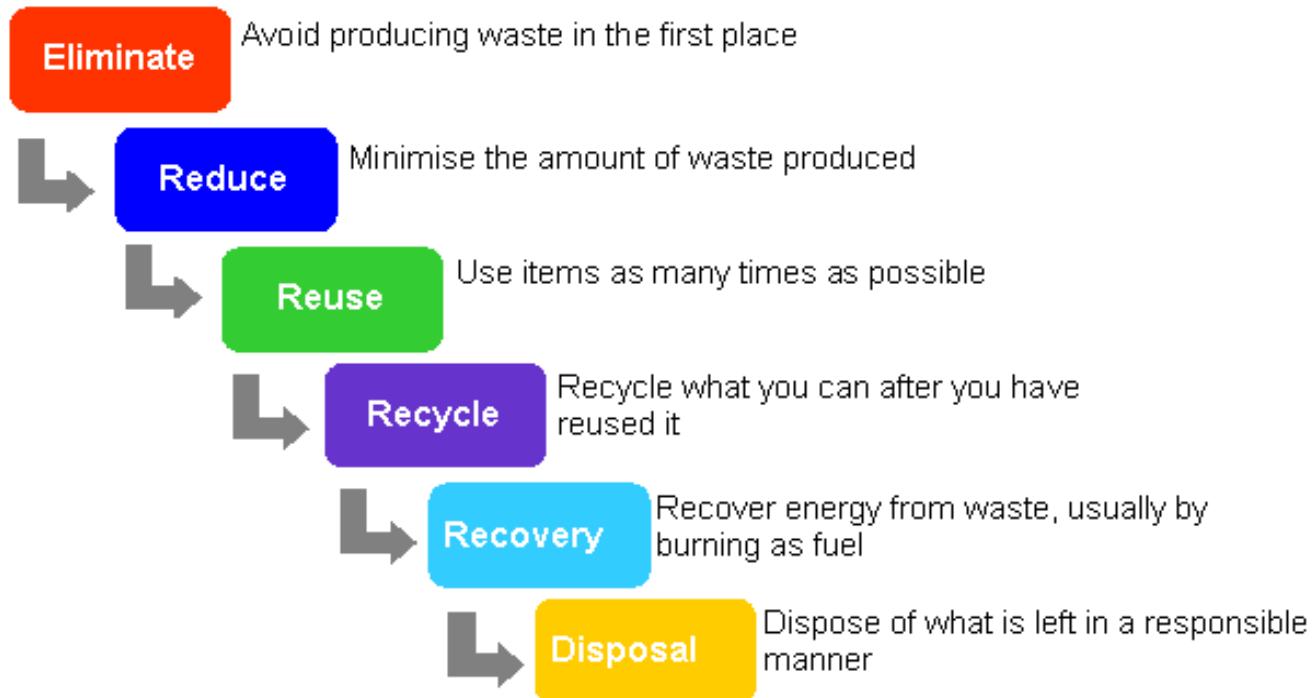
Fonte: Bosmans and Rotmans, 2016

Prevent the WEEE generation



Prevent the WEEE generation

Most Favoured Option



Least Favoured Option

Source: Welsh Government

Prevent the waste generation: directions to follow

GOING UP TO THE TOP OF WASTE HIERARCHY

- ❖ Support the process of adopting an eco-design for sustainability
- ❖ Develop the repair services system / market
- ❖ Develop the second-hand market (and the regulatory system)
- ❖ Solicit the system of consumer preferences
- ❖ Support and disseminate business models for the Circular economy (the role of startup companies)
- ❖ Support the development of scientific and professional skills
- ❖ Support IT development and solutions
- ❖ Support development of social and virtuous behavior

Weee Re-use option



EU Waste Framework Directive – Preparation for re-use definition

“checking, cleaning or repairing operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing”.

Table 2: Obstacles vs. Drivers for re-use and preparation for re-use

Obstacles for preparation for re-use	Drivers for preparation for re-use
<ul style="list-style-type: none">▪ Access to the waste streams by re-use facilities and quality of materials collected▪ Design of the products and availability of spare parts▪ Lack of appropriate logistics▪ Costs for municipalities▪ Resistance from producers▪ Consumer perception toward re-use▪ Legislative framework (no separate target on preparation for re-use)▪ Expertise required for preparation for re-use▪ Restrictions on trans-boundary shipments▪ Unfair competition (notably from re-use organisations which do not respect quality standards)	<ul style="list-style-type: none">▪ Quality control for re-use▪ Security standards▪ Open dialogue between manufacturers and re-use organisations▪ Commitment of local authorities towards re-use▪ Policies favouring social activities and funding▪ Marketing of second-hand products▪ Education for people involved in re-use and refurbishment

EC, 2015

Prevent the WEEE generation

75% of carbon emissions derive from the use of products and services (UK- Department for Environment, Food & Rural Affairs).

Over 80% of a product's environmental impact is generated in the Design phase

Adopt an appropriate regulatory system to develop sustainable design (Eco-design) to improve the processes of

- ☐ Dis-assembly (recovery of parts and components)
- ☐ Maintenance (prevent damages, performance loss, extend the life cycle)
- ☐ Inspection (prevent breakdowns)

Sustainability is 'the ultimate design brief'

Design will be the key feature in the next wave of sustainability.

(Chris Sherwin - designer for sustainability)

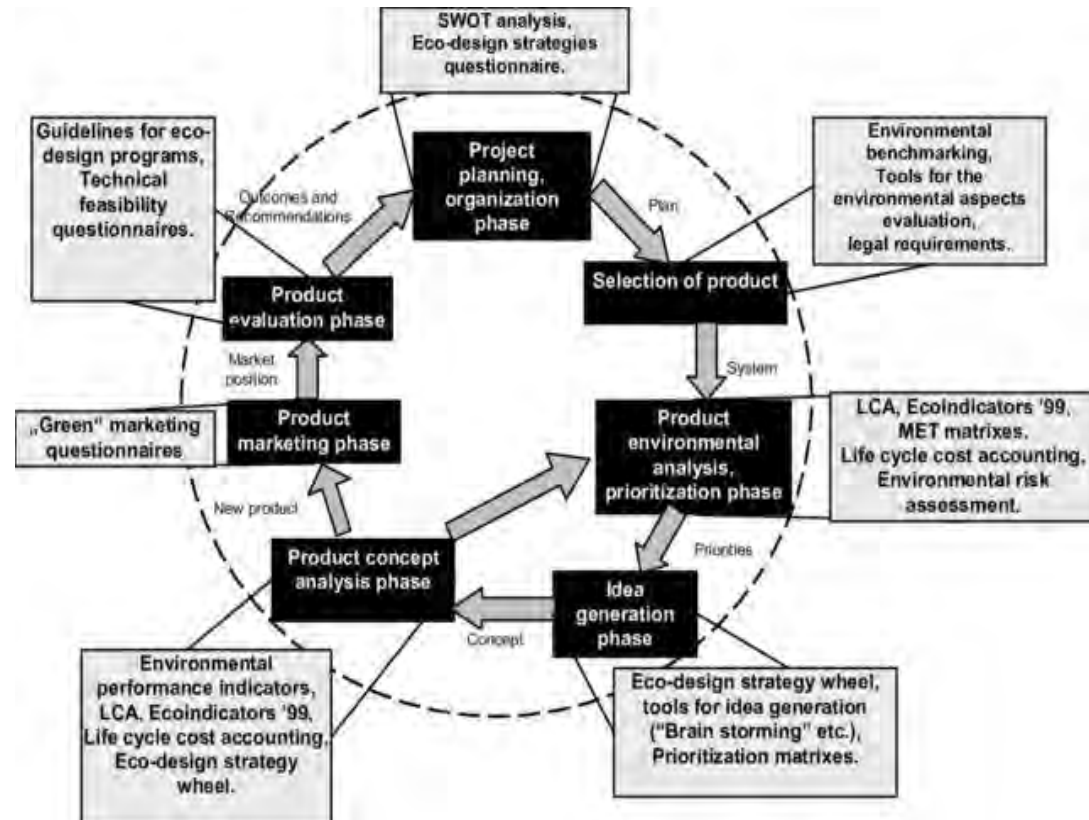
Prevent the WEEE generation

The role of Eco-design

Current EU regulation (Eco-design Directive)

Mandatory ecological requirements

- Energy labelling
- Materials use
- Water use
- Emissions
- Waste
- Recyclability
- **Reparability**



Gurauskienė, Varžinskas, 2006

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(Chris Sherwin - designer for sustainability)

New Eco-Design UE Directive

Repair Components



- ☐ Ease of disassembly
- ☐ Information disclosure
- ☐ Spare Part supply obligation (some groups only)

“Decisions made at the design phase greatly influence what happens during the use and end-of-life phases, not only in terms of energy consumption, but also in terms of life span, maintenance, repair, reuse, upgrade, recyclability and waste handling.”

Product groups

- Refrigerators
- Washing machines
- Dishwashers
- Electronic displays (including tv)
- Light sources & separate control gears
- External power suppliers
- Electric motors
- Refrigerators with a direct sales function
- Power transformers
- Welding equipment

https://ec.europa.eu/commission/presscorner/detail/en/QA_NDA_19_5889

New EU eco-design directive (Ease of disassembly)



COMMISSION REGULATION (EU) 2019/2020 of 1.10.2019

“..shall ensure that **light sources and separate control gears** can be replaced with the use of common available tools and without permanent damage to the containing product,

- ‘key components’ should be replaceable

New EU eco-design directive (Information sharing)



COMMISSION REGULATION (EU) 2019/2020 of 1.10.2019 for laying down ecodesign requirements [light sources and separate control gears](#)

Art.4

Manufacturers, importers or authorised representatives of containing products shall provide information about the replaceability or non-replaceability of light sources and control gears by end-users or qualified persons without permanent damage to the containing product. Such information shall be available on a free-access website. For products sold directly to end-users, this information shall be on the packaging, at least in the form of a pictogram, and in the user instructions

New EU- ecodesign directive

(Availability of spare parts)



*COMMISSION REGULATION (EU) 2019/2022 of 1.10.2019
laying down ecodesign requirements for [household dishwashers](#)*

Manufacturers, importers or authorised representatives of household dishwashers:

- shall make available to professional repairers at least the following spare parts, for at least seven years after placing the last unit of the model on the market: motors...printed circuit boards....
 - For others parts (door hinge and seals, drain filters, ...), for a minimum period of 10 years after placing the last unit of the model on the market;
 - shall ensure the delivery of the spare parts within 15 working days after having received the order;
 - In the case of main spare parts their availability may be limited to professional registered repairers
-
- 7 years minimum for [refrigerating appliances](#)
 - 10 years minimum for [household washing-machines and household washer-dryers](#)

Prevent the WEEE generation (policy elements)

Repair services

- ❖ Encourage independent repair services
 - ❖ Improve success rates (eco-design)
 - ❖ Information disclosure obligation
 - ❖ Obligation to supply spare parts (...)
-
- Regulation in progress (Further updates and improvements)
 - 3 yearly reviews (analysis, meetings, commissions, investigations)

Published reports

Push for methods positioned higher in the waste hierarchy
Need, but hard, to enforce product re-use rates

EU Scoring System on Reparability

- ❖ Part of the EC's action plan for the Circular Economy
- ❖ Aims to provide general criteria & product group specific criteria.
- ❖ Three product groups done so far (Laptop, vacuum cleaner, washing machine)

Parameter	Score [0-1] for priority part 1 (and weight)	...	Score [0-1] for priority part N (and weight)	Parameter Score [0-1]	Parameter Weight
#1 Disassembly depth / sequence	$S_{1,1} (\omega_1)$		$S_{1,N} (\omega_N)$	$S_1 = \frac{\sum_1^N \frac{S_{1,i} \omega_i}{\omega_i}}{\omega_i}$	W_1
#2 Fasteners	$S_{2,1} (\omega_1)$	...	$S_{2,N} (\omega_N)$	$S_2 = \frac{\sum_1^N \frac{S_{2,i} \omega_i}{\omega_i}}{\omega_i}$	W_2
#3 Tools	$S_{3,1} (\omega_1)$	...	$S_{3,N} (\omega_N)$	$S_3 = \frac{\sum_1^N \frac{S_{3,i} \omega_i}{\omega_i}}{\omega_i}$	W_3
#4 Disassembly time	$S_{4,1} (\omega_1)$	...	$S_{4,N} (\omega_N)$	$S_4 = \frac{\sum_1^N \frac{S_{4,i} \omega_i}{\omega_i}}{\omega_i}$	W_4
#5 Diagnosis support and interfaces	S_5	...	S_5	S_5	W_5
#6 Type and availability of information	S_6	...	S_6	S_6	W_6
#7 Spare parts	$S_{7,1} (\omega_1)$	...	$S_{7,N} (\omega_N)$	$S_7 = \frac{\sum_1^N \frac{S_{7,i} \omega_i}{\omega_i}}{\omega_i}$	W_7
#8 Software and firmware	S_8	...	S_8	S_8	W_8
#9 Safety, skills and working environment	$S_{9,1} (\omega_1)$	...	$S_{9,N} (\omega_N)$	$S_9 = \frac{\sum_1^N \frac{S_{9,i} \omega_i}{\omega_i}}{\omega_i}$	W_9
#10 Data transfer and deletion	S_{10}	...	S_{10}	S_{10}	W_{10}
#11 Password reset and restoration of factory settings	S_{11}	...	S_{11}	S_{11}	W_{11}
#12 Commercial guarantee	S_{12}	...	S_{12}	S_{12}	Not applied

EU Scoring System on Reparability

The proposed 4 Levels

1. “Potentially easy and quick disassembly”
2. “Possibility of disassembly with professional tools”
3. “Possibility of disassembly with proprietary tools”
4. “Product cannot be repaired”

Professional & Consumer repair distinction

- a. The scoring system sees consumer repair as highest achievable level
- b. Proposed eco-design directive changes mainly focus on professional repair
- c. What is the market value of going beyond legal requirements and to a higher level?

Directive/Regulations - Landmark

- a. Not part of EU Eco-Design directive changes
- b. Could be used in National Law implementation
- c. Could provide guideline in court cases
- d. Used as defense for being compliant
- e. Could be used as reference in court verdict

Spare Parts Market

- ❑ Problems with the current monopoly on repair services
- ❑ Independent repair shops can compete better with manufacturers
- ❑ Cooperation needed - Supply Part supply chains have to be set up
- ❑ Spare parts market has a high profit margin and growing revenue potential further down the life cycle
- ❑ With market size increase, aftermarket manufacturers might enter

The development of the repair and assistance services market

Shifting to the Automobile market model?

- ❖ Can the automobile car market model be a landmark?
- ❖ Diffusion of independent repair services and car parts
- ❖ Cars have a long life cycle associated with a lot of maintenance
- ❖ Over 90% of cars in the EU are recycled

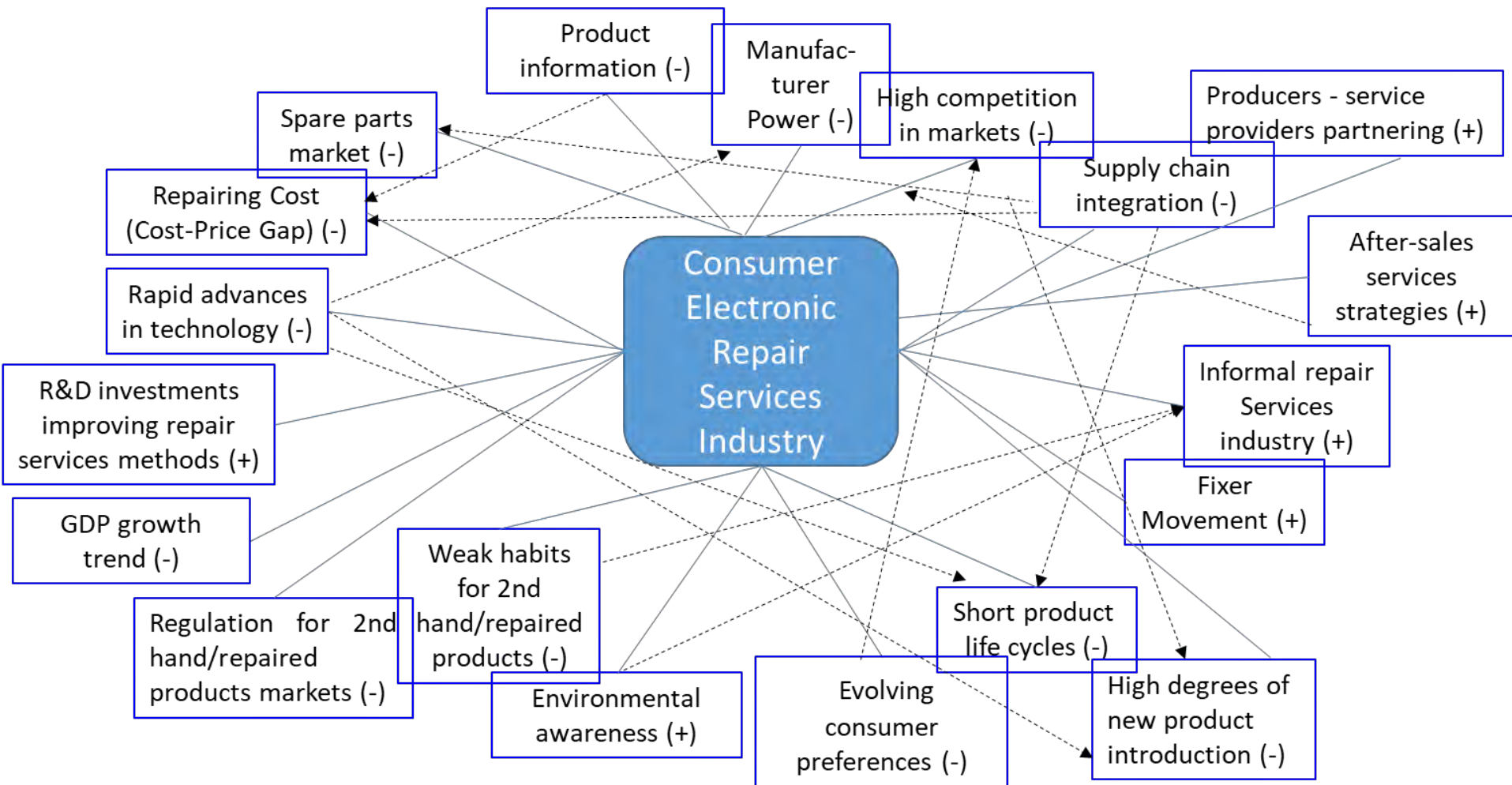
Goal

- ❖ Achieve a quick and easy replacement of critical parts of the product
(batteries, displays, keyboards,.....in smartphones, laptops, tablets ...)

Problems

- ❖ Difficulty for imports from non-EU countries and purchases by individual consumers
- ❖ Adoption of more stringent quality requirements for the material being repaired
- ❖ Addressing the costs of generating and managing information
- ❖ Logistics management problems for the timing of supply of spare parts

Factors affecting the Consumer Electronic Repair Services Industry



The Consumer Electronic Repair Services Industry in Italy



Codice Ateco	Imprese	Fatturato (000 €)	Valore della produzione (000 €)	Margine operativo lordo (000 €)	Acquisto di beni e servizi (000 €)	Costi del personale (000 €)	Occupati
95	24.945	2.400.861	2.160.203	463.231	1.450.916	452.245	44.684
95.1	4.883	1.118.789	973.716	142.480	721.794	252.341	12.657
95.11	3.471	790.527	681.355	121.178	498.787	169.543	8.551
95.12	1.412	328.262	292.361	21.302	223.007	82.798	4.106
95.2	20.062	1.282.072	1.186.487	320.751	729.122	199.904	32.027
95.21	1.752	163.086	154.251	41.691	94.745	25.997	3.177
95.22	3.236	409.387	375.384	75.256	268.032	62.979	6.838

95.1	<u>RIPARAZIONE DI COMPUTER E DI APPARECCHIATURE PER LE COMUNICAZIONI</u>
95.2	<u>RIPARAZIONE DI BENI PER USO PERSONALE E PER LA CASA</u>

Initiatives support the business for reused products

- ❑ In 1997 the city of Vienna promotes initiatives / guides for the repair and reuse of EEE and in 1999 it launches an online platform for the direct exchange of used EEE
- ❑ In 1994 the municipality of Munich printed a brochure with addresses of repair shops and in 1997 organized a Repairwork-day (2/3 of the devices were easily repairable)
- ❑ Initiatives and best practice are diffused in, Belgium, Czech Republic, UK, Sweden, Wales, Romania, France,
- ❑ Some surveys highlight the low propensity to purchase second-hand products (0.75% of citizens in Spain) or to repair products (10% in Spain never repaired)
- ❑ The EU estimates that 1/3 of the products arriving at the Recycling Centers are reusable and could be resold on the used market
- ❑ Share of Re-used EEE as % of POM (2015)
UK 1,1; Germany: 0,9; France: 0,5; Italy: n.a.; Spain 0,2
- ❑ Share of reused as% of recycled
UK 3,7; Germany: 2,6; France: 1,8; Italy: n.a.; Spain 1.0

Prevent the waste generation: business models

Razor and Blade Model

Sell cheap, earn on spare parts/repair service

Extended Warranties/Insurance

Sell maintenance, assistance and repairs ahead of breakdown

Discourage independent repair services

Independent repair initiatives

- Repair shops (small lab companies)
- Repair café. Free meeting places. They're all about repairing things together
 - The goal is to transmit the “repair” abilities to the customer, completely free of charge.
 - The Repair Café circuit boasts over 1,500 operating points, spread all over the world.
 - Città della Scienza - Repair Café@Napoli - Città della Scienza



Prevent the waste generation: business models

Sustainable Product Services System (SPSS) model

- The producer is the owner of the product and the consumer buys the services
- Pay as you go / Pay Per Usage : Service package by Xerox; Enel-Ariston washing services,.....
- The producer has an interest in extending the product and materials life cycle, while intensifying the use of the product and minimizing the use of resources consumed (leasing model)
- Discourage independent repair services

Sharing model (collaborative consumption)

- Focused on the sharing of resource among consumers
- Decoupled from ownership.
- Pay as you go / Pay Per Usage.
- Intensive utilisation (exploitation) of underutilized resources, emission reduction.
- (eg: Apartments/Airbnb, Car/Blablacar, Uber...)

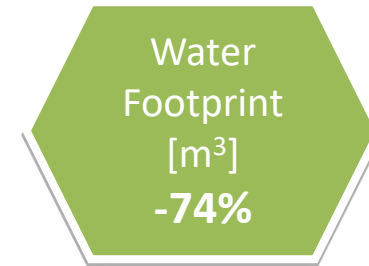
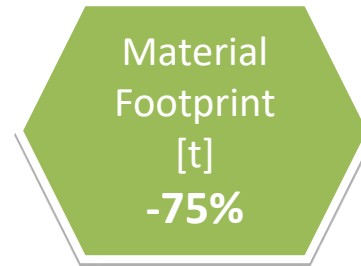
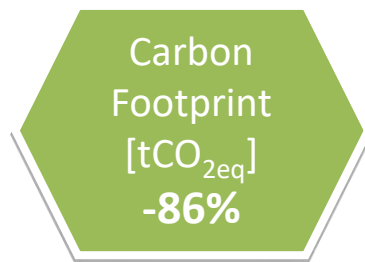
How to observe WEEE management in CE perspective



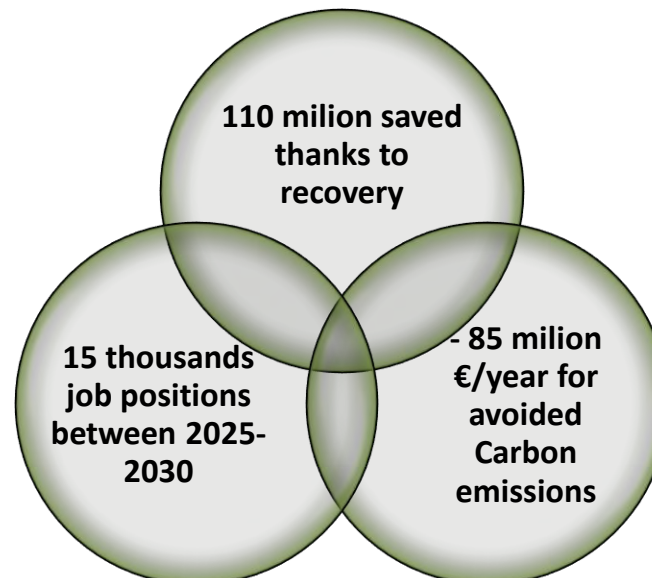
The WEEE: from complex problem to opportunities



- **Environmental benefits**



- **Economic and social benefits**



Fonte dati: Croci, Colella 2017

Impact of the Italian WEEE system -2018

MODELLO 1 - SISTEMA RAEE ITALIANO - 2018	GJ	t CO ₂ eq
TRASPORTI	1.538.256	563.202
TRATTAMENTO RAEE	377.372	42.253
RICICLO INDUSTRIALE	5.496.778	388.316
VALORIZZAZIONE ENERGETICA E SMALTIMENTO	-313.158	187.873
PRODUZIONE SEMILAVORATI	6.317.687	301.082
EMISSIONI DA CFC	-	3.837.740
TOTALE	13.416.935	5.320.466

Impact of the Italian WEEE system -2018 – Ecodom performance

MODELLO 2 - SISTEMA RAEE ITALIANO CON PRESTAZIONI ECODOM - 2018	GJ	t CO ₂ eq
TRASPORTI	1.710.623	631.119
TRATTAMENTO RAEE	401.592	43.815
RICICLO INDUSTRIALE	6.289.588	445.792
VALORIZZAZIONE ENERGETICA E SMALTIMENTO	-598.059	117.243
TOTALE	7.803.744	1.237.969

Source: Ecodom - 2018

Savings of over 5,613,191 GJ and 4,082,497 tons of CO₂e.

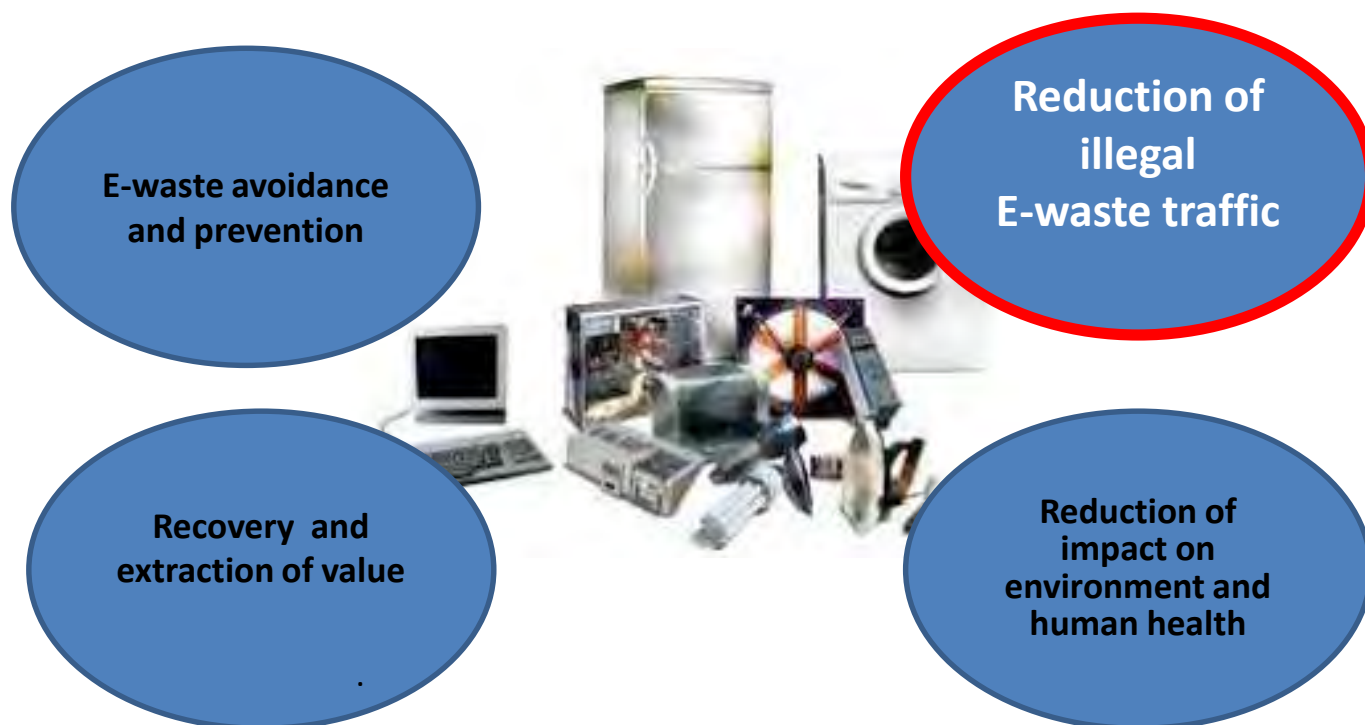
The impact of Weee on the environment

In EU – WEEE recycle avoid 2.9 millions of tonnes of CO2 equivalent and the related correct disposal of chlorofluorocarbon gas (used in fridges and, previously, in aerosols).

In Italy - in 2015, RAEE recycle prevented the emission of 550.000tonnes CO2 equivalent (Green Economy Report, Remedia)

Frost&Sullivan put the WEEE recycling market revenue in Europe at around EUR 1 billion, expecting it to reach EUR 1.5 b by 2020.

How to observe Weee management in CE perspective



Weee - illegal trade

WEEE is the waste streams with the highest number of violations

Percentuale del tipo di reati



Destinazione dei rifiuti e violazioni



Waste violations

Waste types	N°
Metalli	324 (13%),
Carta	175 (7%).
Plastica	330 (13%),
RAEE	364 (14%)
Parti di automobili	224 (9%)
RDF	14
Rifiuti dom e urbani misti	60
Legno	74
Pneumatici	111
Altro non pericoloso	85
Altro pericoloso	62
Tessile	50
Non specificato	504
Cavi	18
Vetro	13
Rifiuti edili	68
Rifiuti verdi	0
Pannelli filtrati non pericol	5
Ceneri e scorie non pericol	8
Cibo e olio commestibile	12
Batterie	60

Fonte: SWEAP project (Shipment of Waste Enforcement Actions Project) 2020 - www.Impel.eu (European Union Network for the Implementation and Enforcement of Environmental Law)

The impact of Weee on the environment (illegal trade and unsafe treatment)



**Hazardous e-waste recycling in
Agbogbloshie, Accra, Ghana**



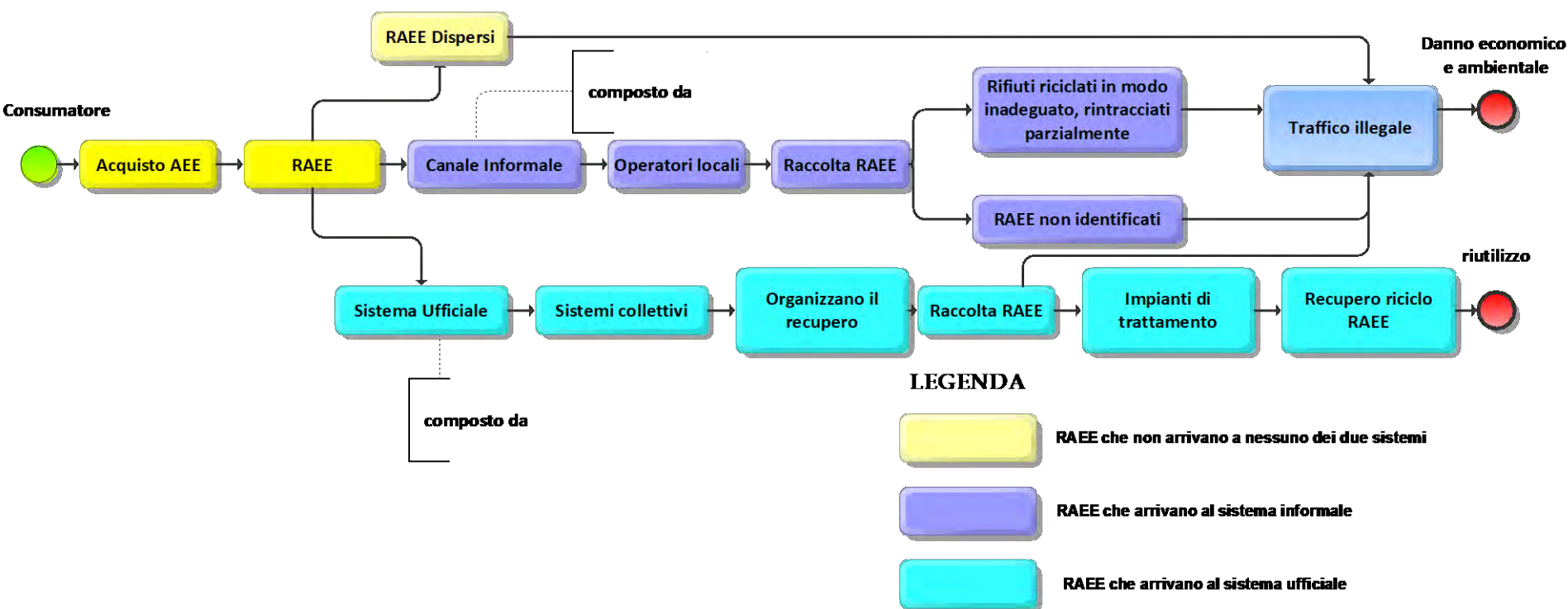
Ghana, Philippines, China, Nigeria....

A long list in Vaccari et al, 2019

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6539380/>

WEEE SYSTEM

(dispersed , informal and official channel)



WEEE SYSTEM

(dispersed , informal and official channel)

....a total of 53.6 million tonnes (Mt) of electronic waste was produced worldwide in 2019 with a 21% increase in just five years. Not only that, only 17.4% of this waste (classified as WEEE) was collected and recycled. This means, they explain, “that gold, silver, copper, platinum and other high-value recoverable materials valued conservatively at \$ 57 billion - more than the gross domestic product of most countries - have mostly been dumped or burned instead of being collected for treatment and recycling ”.

Global E-waste Monitor 2020 – United Nations

WEEE SYSTEM

(dispersed, informal and official channel)

The screenshot shows a web browser window displaying the la Repubblica website. The browser's address bar shows the URL: repubblica.it/economia/diritto-e-consumi/diritto-consumatori/2019/10/14/news/altroconsumo_pedina_i_rifiuti_elettronici_il_40_finisce_in_man_i_sbagliate-238508053/. The website header includes the la Repubblica logo, navigation links (MENU, CERCA), and subscription options (ABBONATI, QUOTIDIANO, ACCEDI). The main section is titled "Economia" with a search bar. Below the header, there is a navigation bar with links: HOME, MACROECONOMIA, FINANZA, LAVORO, DIRITTI E CONSUMI, AFFARI&FINANZA, OSSERVA ITALIA, CALCOLATORI, GLOSSARIO, LISTINO, and PORTAFOGLIO. The article title is "Altroconsumo 'pedina' i rifiuti elettronici: il 40% finisce in mani sbagliate" by Federico Formica. The article text states: "L'associazione ha nascosto un trasmettitore Gps in 200 elettrodomestici consegnati alle municipalizzate o ai negozi di elettronica, scoprendo che in molti casi i dispositivi non vengono smaltiti nel modo corretto". The article is dated 14 OTTOBRE 2019 and was published over a year ago. The FTSE MIB index is shown as 19.058, down 1.18%. The Windows taskbar at the bottom shows the date 26/10/2020 and time 14:21.

la Repubblica

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Economia

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Altroconsumo “pedina” i rifiuti elettronici: il 40% finisce in mani sbagliate

Federico Formica

L'associazione ha nascosto un trasmettitore Gps in 200 elettrodomestici consegnati alle municipalizzate o ai negozi di elettronica, scoprendo che in molti casi i dispositivi non vengono smaltiti nel modo corretto

14 OTTOBRE 2019 PUBBLICATO + DI UN ANNO FA 2° MINUTI DI LETTURA

Quando diamo indietro il vecchio elettrodomestico in cambio di quello appena comprato o lo portiamo all'isola ecologica del nostro Comune, siamo convinti di fare una buona azione anzitutto per l'ambiente. La realtà, però, è che non sempre è così.

FTSE MIB
19.058 -1,18%

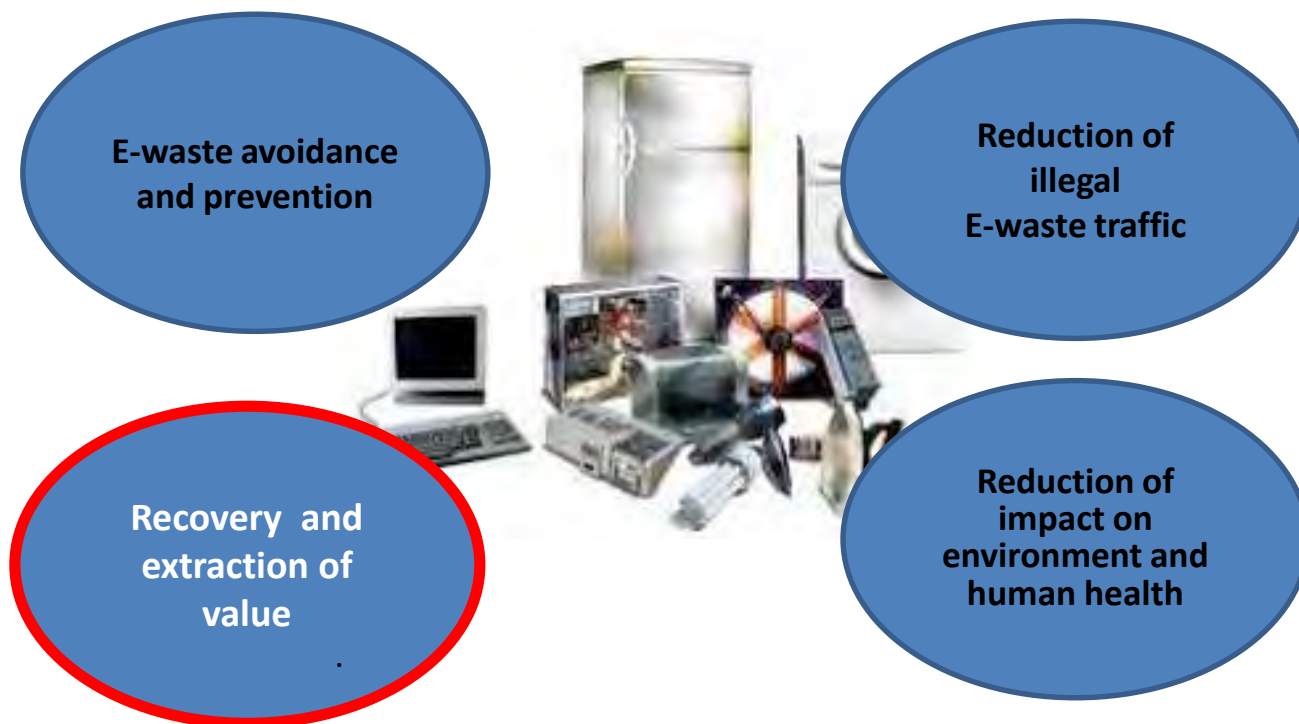
Global E-waste Mo...pdf

Scrivi qui per eseguire la ricerca

Mostra tutto

14:21
26/10/2020

How to observe Weee management in CE perspective



Weee Re-cycle option

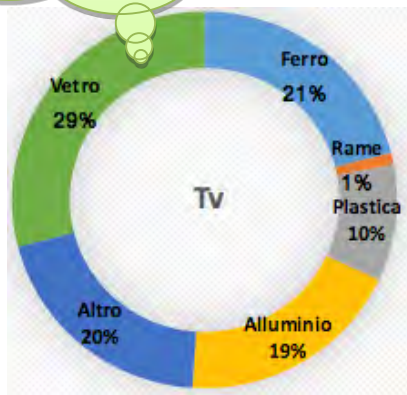


Secondary raw materials

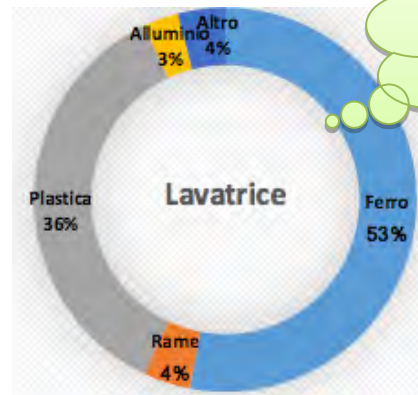
in Italy 39% is
happy to buy

in Europe 45% is
happy to buy

From the glass
of 30 TV you get
70 m2 of tiles



A bicycle is
obtained from 5
washing
machines



Precious metals in WEEE

The EU (2010) has proposed a list of “potentially critical raw materials” (materials subject to exhaustion to resource depletion) which includes: Silver, Gold, Bismuth, Cobalt, Copper, Palladium, Antimony, Tin, Berilliumo, Gallium

Table 1 Average concentration of precious metals in printed circuit boards from different equipment types (literature review)

<i>Reference</i>	<i>Equipment type (origin of the printed circuit board)</i>	<i>Silver (g/t)</i>	<i>Gold (g/t)</i>	<i>Palladium (g/t)</i>	<i>Platinum (g/t)</i>
Angerer et al. 1993	Audio and video equipment	674	31		
Huisman et al. 2007*	Radio set	520	68	8	
Huisman et al. 2007*	DVD player	700	100	21	
Angerer et al. 1993	Personal computer	905	81		
Hagelüken 2006	Personal computer	1000	250	110	
Huisman et al. 2007*	Personal computer	1000	230	90	
Keller 2006	Personal computer	775	156	99	
Kramer 1994	Personal computer	600	300		
Legarth et al. 1995	Personal computer	700	600	100	40
Art 2008	Computer keyboard and mouse	700	70	30	0
Huisman et al. 2007*	Computer CRT Monitor	150	9	3	
Huisman et al. 2007*	Computer LCD Monitor	1300	490	99	
Huisman et al. 2007*	Printer	350	47	9	
Ernst et al. 2003	Telephone	2244	50	241	
Ernst et al. 2003	Mobile telephone	3573	368	287	
Hagelüken and Buchert 2008	Mobile telephone	5540	980	285	7
Huisman et al. 2007*	Small IT and telecommunication equipment	5700	1300	470	
Hagelüken 2006	TV set—CRT-Monitor	280	17	10	
Huisman et al. 2007*	TV set—CRT-Monitor	1600	110	41	
Huisman et al. 2007*	TV set—LCD-Monitor	250	60	19	

*Combination of data from different sources

Rare-Earth elements in WEEE

List of 17 REE: *cerium (Ce), dysprosium (Dy), erbium (Er), europium (Eu), gadolinium (Gd), holmium (Ho), lanthanum (La), lutetium (Lu), neodymium (Nd), praseodymium (Pr), promethium (Pm), samarium (Sm), scandium (Sc), terbium (Tb), thulium (Tm), ytterbium (Yb), yttrium (Y)*.

REEs are critical due to their importance in a number of applications, including a number of green technologies, but, primarily, because of the high supply risks arising from the dependence on a single source (China).

At a global level, the demand for rare earth oxides in 2008 was estimated at around 120 000 tonnes, expected to increase up to around 170 000 – 200 000 tonnes in 2014.

Since the 1990s China has been producing roughly 90% of the world's supply of REEs.

Globally, an estimated 20-50 mln metric tonnes of e-waste is generated annually, containing a plethora of technologically relevant REEs. This makes WEEE a rich source of REEs as some metals have been estimated to be more concentrated in WEEE than in primary ores.

Most REEs entering EU are already embodied in components manufactured outside the EU.

Data from the most UNEP Report (2011) shows that in the last decade the level of recycling REE was very limited (<1%).

EU support for R&D in the recycling of REEs → Technology advances in WEEE REEs Extraction

Precious elements in a SmartPhone

https://www.vice.com/en_us/article/433wyg/everything-thats-inside-your-iphone

iPhone 6, 16GB model

Element	Chemical Symbol	Percent of iPhone by weight	Grams used in iPhone	Average cost per gram	Value of element in iPhone
Aluminum	Al	24.14	31.14	\$ 0.0018	\$ 0.055
Arsenic	As	0.00	0.01	\$ 0.0022	\$-
Gold	Au	0.01	0.014	\$ 40.00	\$ 0.56
Bismuth	Bi	0.02	0.02	\$ 0.0110	\$ 0.0002
Carbon	C	15.39	19.85	\$ 0.0022	\$-
Calcium	Ca	0.34	0.44	\$ 0.0044	\$ 0.002
Chlorine	Cl	0.01	0.01	\$ 0.0011	\$-
Cobalt	Co	5.11	6.59	\$ 0.0396	\$ 0.261
Chrome	Cr	3.83	4.94	\$ 0.0020	\$ 0.010
Copper	Cu	6.08	7.84	\$ 0.0059	\$ 0.047
Iron	Fe	14.44	18.63	\$ 0.0001	\$ 0.002
Gallium	Ga	0.01	0.01	\$ 0.3304	\$ 0.003
Hydrogen	H	4.28	5.52	\$-	\$-
Potassium	K	0.25	0.33	\$ 0.0003	\$-
Lithium	Li	0.67	0.87	\$ 0.0198	\$ 0.017
Magnesium	Mg	0.51	0.65	\$ 0.0099	\$ 0.006
Manganese	Mn	0.23	0.29	\$ 0.0077	\$ 0.002
Molybdenum	Mo	0.02	0.02	\$ 0.0176	\$ 0.000
Nickel	Ni	2.10	2.72	\$ 0.0099	\$ 0.027
Oxygen	O	14.50	18.71	\$-	\$-
Phosphorus	P	0.03	0.03	\$ 0.0001	\$-
Lead	Pb	0.03	0.04	\$ 0.0020	\$-
Sulfur	S	0.34	0.44	\$ 0.0001	\$-
Silicon	Si	6.31	8.14	\$ 0.0001	\$ 0.001
Tin	Sn	0.51	0.66	\$ 0.0198	\$ 0.013
Tantalum	Ta	0.02	0.02	\$ 0.1322	\$ 0.003
Titanium	Ti	0.23	0.30	\$ 0.0198	\$ 0.006
Tungsten	W	0.02	0.02	\$ 0.2203	\$ 0.004
Vanadium	V	0.03	0.04	\$ 0.0991	\$ 0.004
Zinc	Zn	0.54	0.69	\$ 0.0028	\$ 0.002
TOTAL		100%	129 grams		\$ 1.03

THE ONE DEVICE
THE SECRET HISTORY OF THE IPHONE

BRIAN MERCHANT
LITTLE BROWN, AND COMPANY

Rare-Earth elements in WEEE

Recycling and recovery of REEs is part of a **broader approach** towards addressing a possible REE supply challenge.

Binemmans et al (2013) propose that a threefold approach should be adopted including

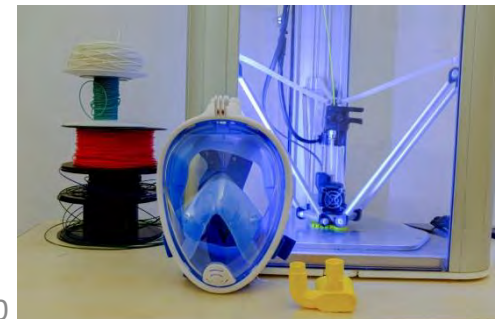
- A. substitution of critical rare earths by less critical metals when possible,
- B. investment in sustainable primary mining from old or new REE deposits and,
- C. technospheric mining;
 - C1) direct recycling of pre-consumer manufacturing REE scrap/residues;
 - C2) urban mining of post-consumer (often complex multi-material) End-of-Life products (Schüler et al., 2011; Brunner, 2011);
 - C3) landfill mining of historic (and future) urban and industrial waste residues containing REEs (Jones et al., 2012)

(Weee) Re-cycle option

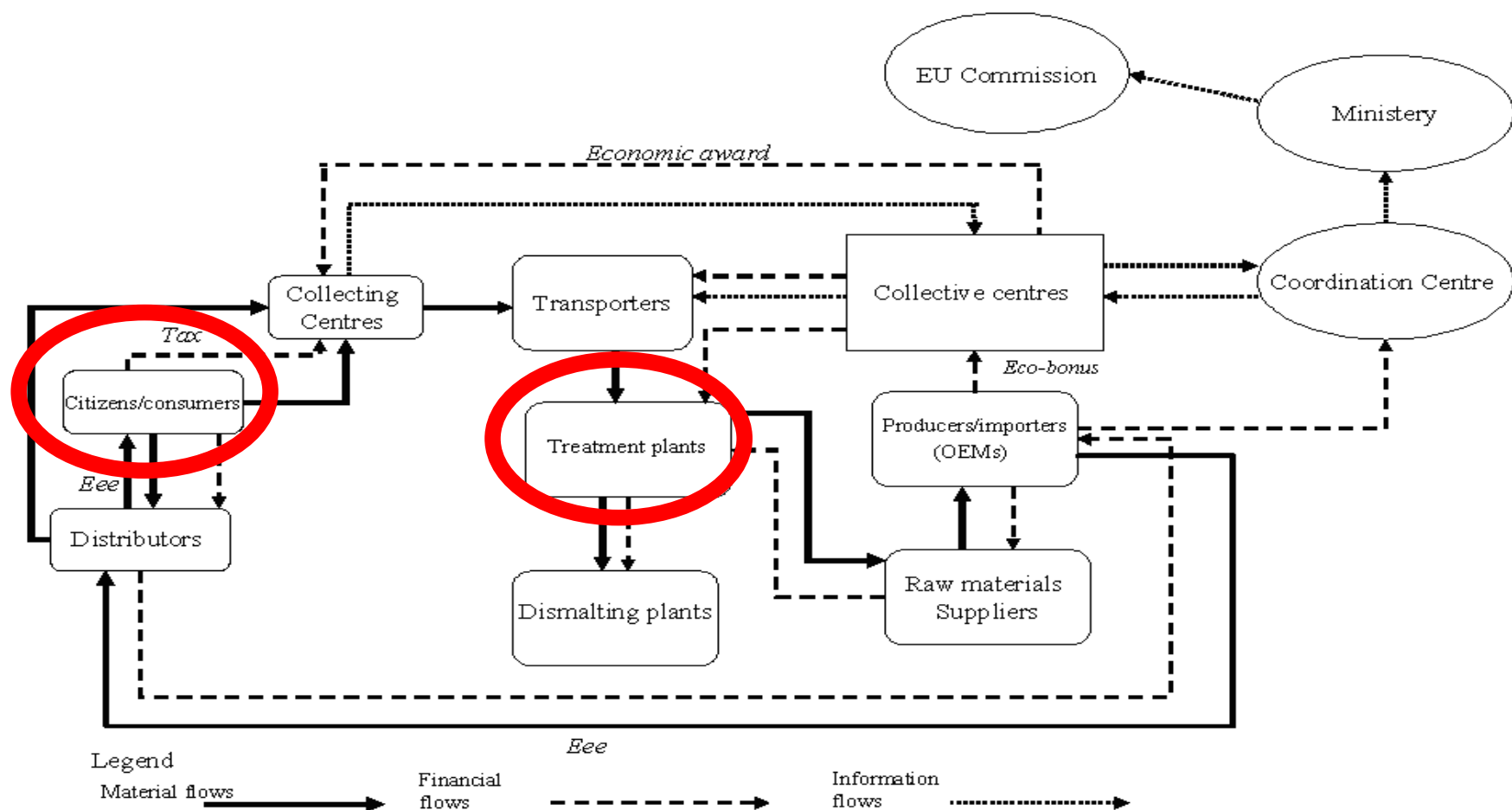


ReMade consegna valvole in 3D all'Asl Napoli 2 Nord

<https://www.dalsociale24.it/re-made-consegna-valvole-in-3d-allasl-napoli-2-nord/>



The flows of reverse supply chain of WEEE

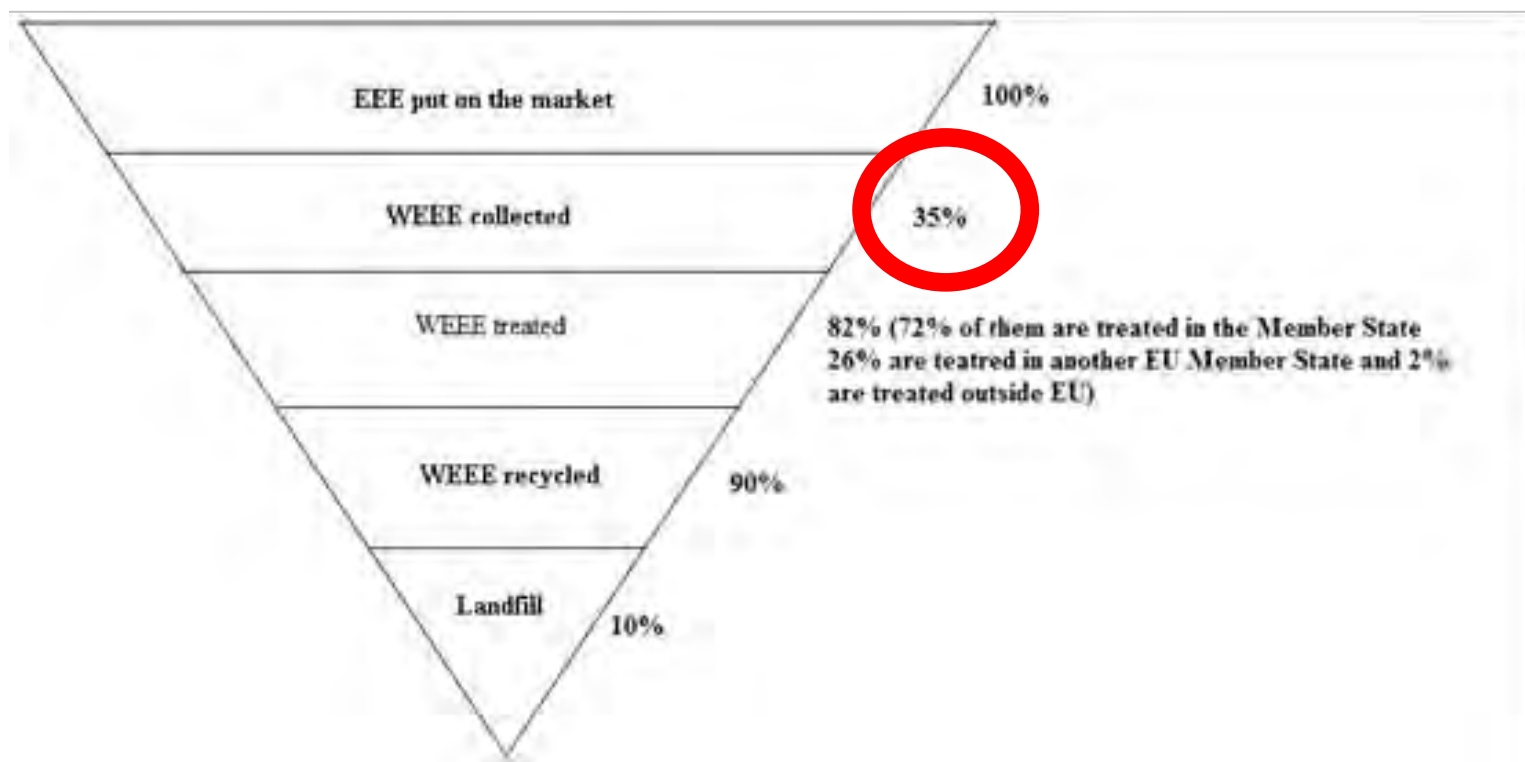


Moccia et al 2012.

Analysis of data about Weee

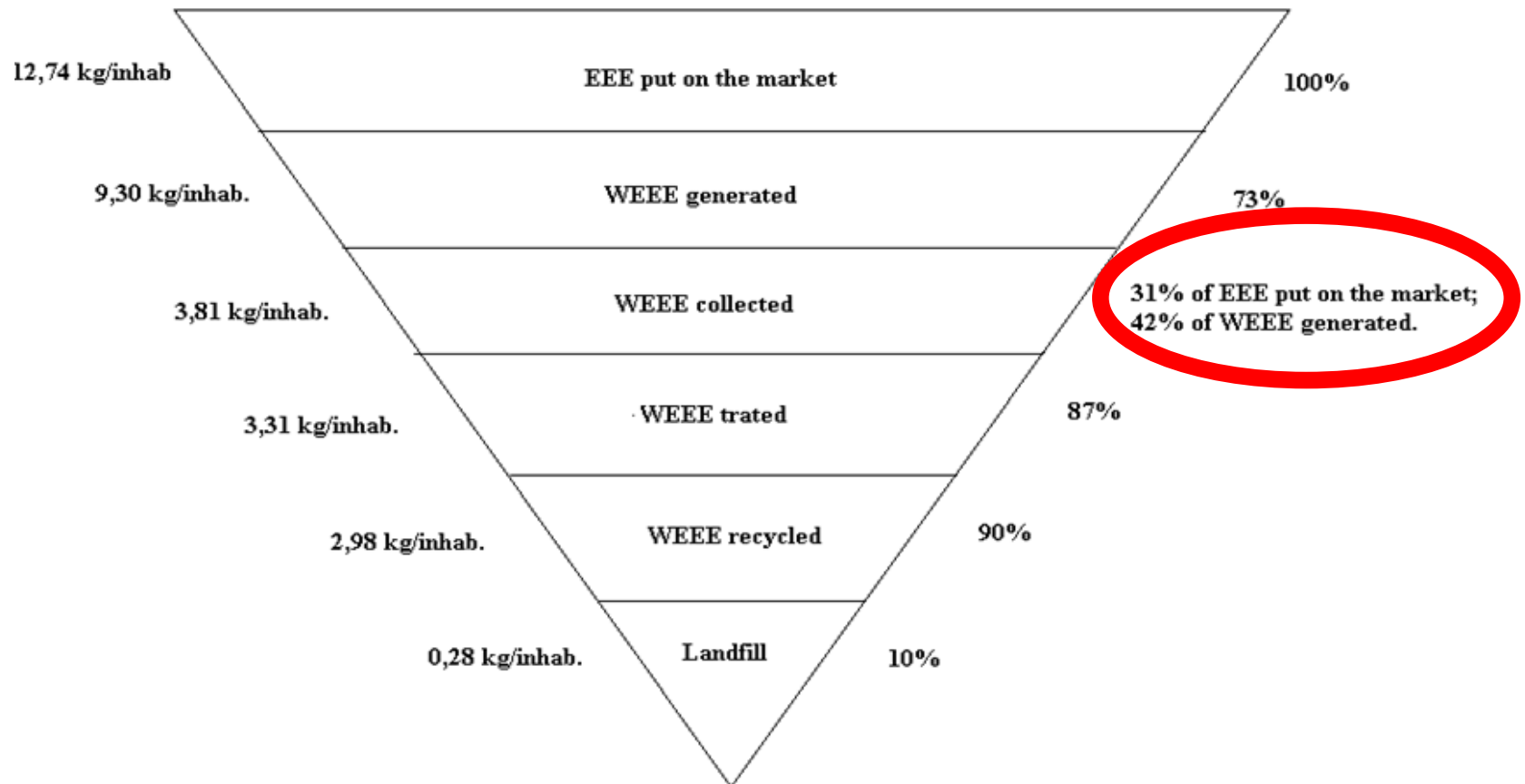
Indicator	Meaning
Total EEE Put on Market (unit kg/inh)	Represents the size of the national e-goods market.
Weee formally collected (KG per capita)	Represents the the amount of e-waste that is collected by the formal take-back system.
Weee return rate: $\frac{\text{Weee collected (kg per capita)}}{\text{EEE put on the market (kg per capita)}}$	Indicates the effectiveness the formal collection systems and (indirectly) of the UE Weee Directives
$\frac{\text{Weee collected (kg per capita)}}{\text{Weee generated (kg per capita)}}$	It indicates the effectiveness performance of the formal Weee collection system
$\frac{\text{Weee treated (kg per capita)}}{\text{Weee collected (kg per capita)}}$	It indicates the effectiveness of formal Weee treatment plants system
$\frac{\text{Weee recycled and reused (kg per capita)}}{\text{Weee treated (kg per capita)}}$	It indicates the efficiency of formal Weee treatment plants and effectiveness of formal Weee management system as a whole

The impact of WEEE on the environment (EU): the waste hierarchy



Source: our elaboration on Eurostat data

The impact of Weee on the environment (ITA): the waste hierarchy



In Italy 60-70% of WEEE slips out the legal system

Source: our elaboration on CDC RAEE, 2015

Virtual Winter School on WEEE - ENEA - October 26 2020

The WEEE: from complex problem to opportunities



To prevent/reduce WEEE and to promote the reuse, recycling and other forms of recovery...



EU Directives aim to involve all the operators along the WEEE Management System in order to:

- minimize the waste disposal processes
- minimize the leakage of hazardous substances
- maximize the reuse and recycling of EEE components and materials

The EU WEEE regulation



WEEE
Directive
2002/96/CE

WEEE
Directive
2012/46/EU



Decree
n.151/2005

Decree
n.49/2014

- Make more responsible the EEE producers
- Creation of take back schemes where consumers (should) return their WEEE free of charge.
- «One for One» and «One for Zero» principles
- Definition of new target for EU countries

The EU WEEE collection targets (2005-2019)



Year	Until 21 dic. 2015 (Dir.2002/96)	From dic. 2016 to 2018 (Dir.2012/19)	From 2019 (Dir.2012/19)
Collection targets	4 kg of households Weee per inhabitant (Kgpc)	Minimun collection rate: 45% of the total weight of the WEEE defined as a % of average weight of the EEE POM (placed on the market) <i>(about 8 kgpc)</i>	65% of the total weight of the WEEE defined as a % of average weight of the EEE POM (placed on the market) <i>(about 12 kgpc)</i> (alternatively 85% of WEEE which has been generated).

The EU WEEE directives



2002/96/EC

1. Introduces *the responsibility of the producer (EPR); the one-to-one principle*, namely consumers can delivery their WEEE at a seller for free, but they have to buy another good belonged to the same category.
2. *definition of two collection systems*: National Collective System (coordinated) and Clearing House Model (competitive).

2012/19/EU

1. *Introduction of the one-to-zero principle*, namely consumers can delivery their WEEE at a seller for free, without buying another WEEE but it should be a small EEE.
2. *photovoltaic panels and other equipment with a useful life of more than 20 years are considered WEEE*

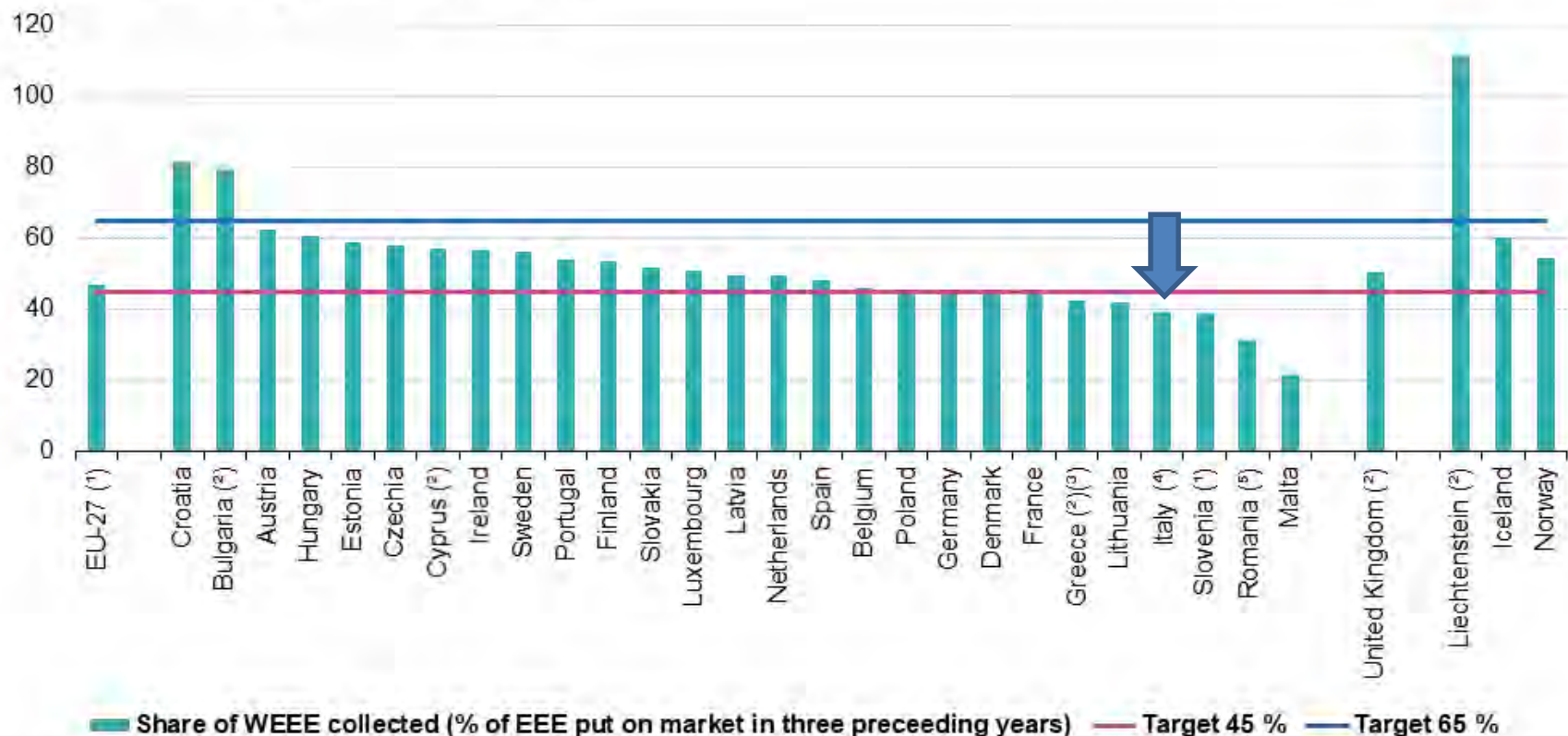
Take back schemes in EU countries

Country	Take Back Model
Austria	Clearing House
Belgio	Collective System
Cipro	Collective System
Rep.Ceca	Clearing House
Danimarca	Clearing House
Estonia	Clearing House
Finlandia	Clearing House
Francia	Clearing House
Germania	Clearing House
Grecia	Clearing House
Ungheria	Collective System
Irlanda	Collective System
Italia	Clearing House
Lettonia	Clearing House
Lituania	Clearing House
Lussemburgo	Collective System
Malta	NA
Paesi Bassi	Collective System
Polonia	Clearing House
Portogallo	Collective System
Slovacchia	Clearing House
Slovenia	Clearing House
Spagna	Clearing House
Svizzera	Collective System
UK	Clearing House

The divide in the EU WEEE collection

Total collection rate for waste electrical and electronic equipment, 2017

(% of the average weight of electrical and electronic equipment put on the market in the three preceding years (2015-2017))



⁽¹⁾ Eurostat estimate.

⁽²⁾ Definition differs.

⁽³⁾ Estimate.

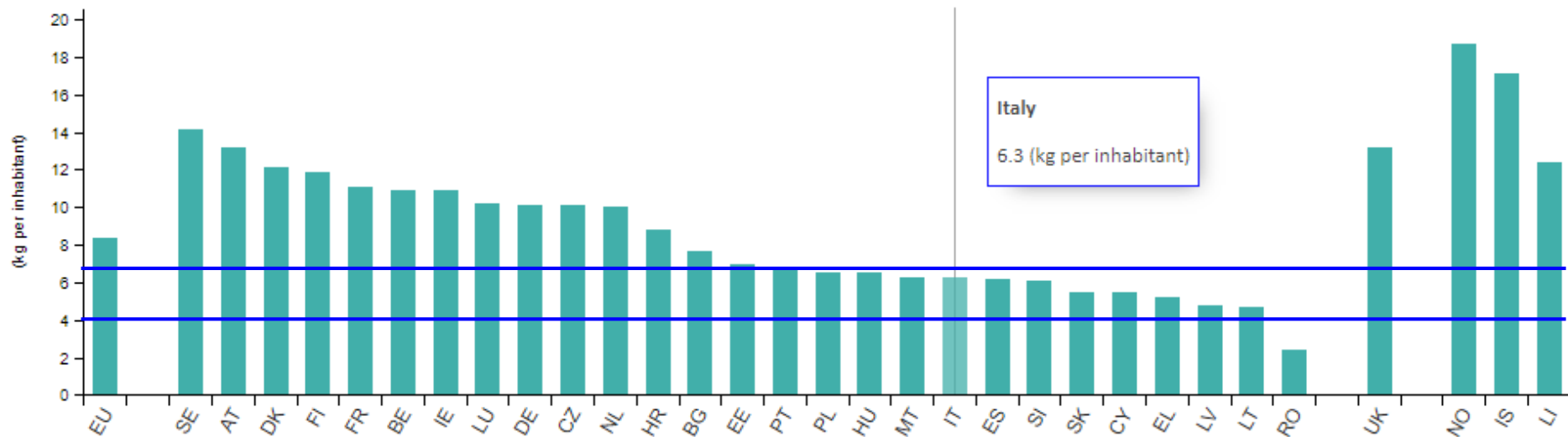
⁽⁴⁾ Data on collection 2015 instead of 2017; % of average weight of EEE put on the market 2013-2015.

⁽⁵⁾ Data on collection 2016 instead of 2017; % of average weight of EEE put on the market 2014-2016.

Source: Eurostat (online data code: env_waselee)

The divide in the EU WEEE collection (WEEE kg per capita)

Waste electrical and electronic equipment, total collected, 2017



2016 data: Romania.

EU total: estimated.

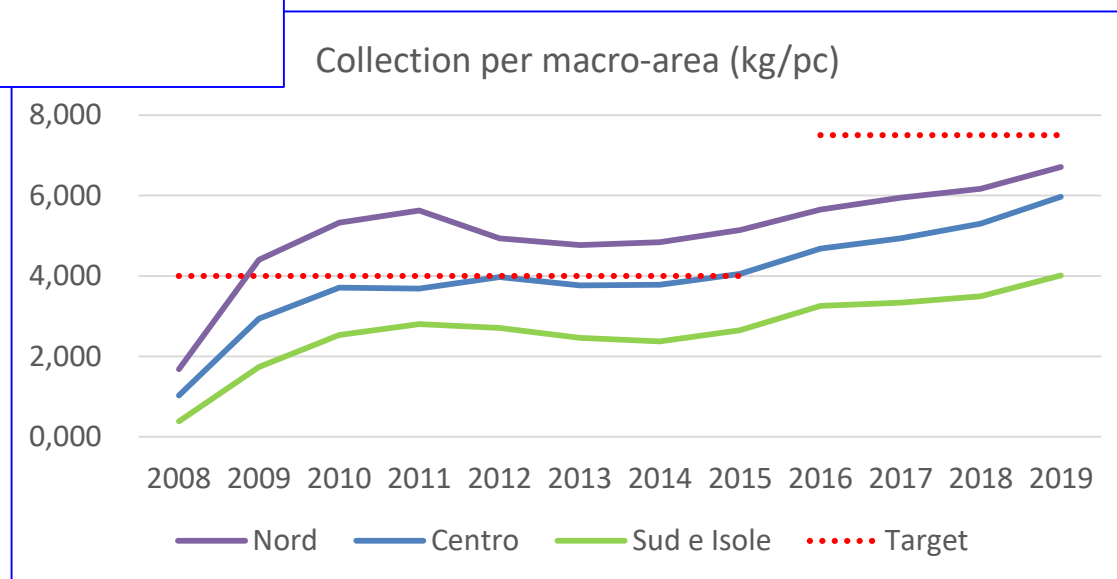
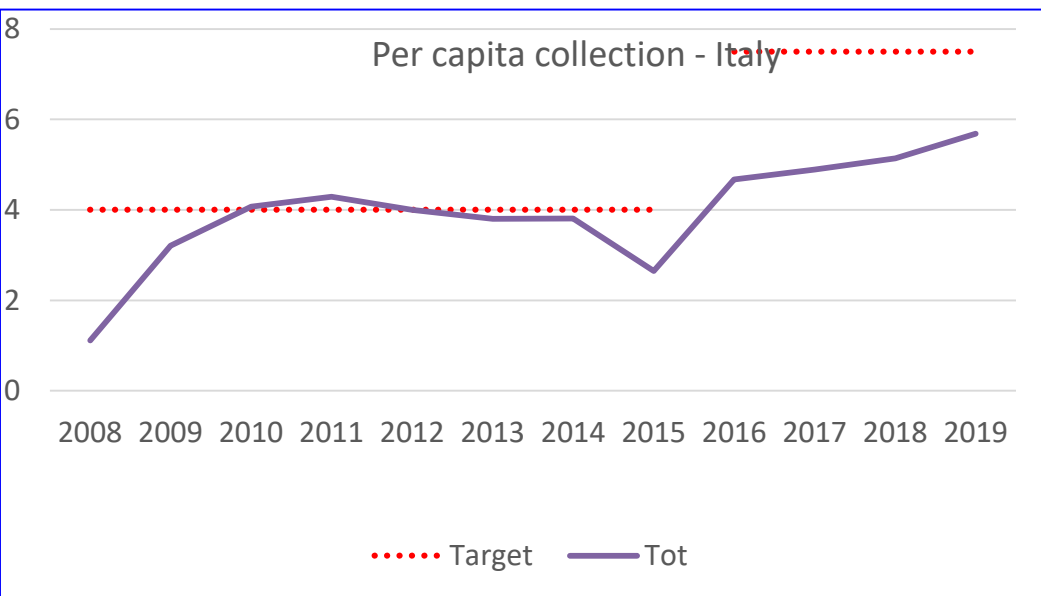
Countries are ranked in decreasing order by waste electrical and electronic equipment collected per inhabitant.

Source: Eurostat (online data code: env_waselee)

Weee collection in Italy (regions)



The divide in the Italian WEEE collection

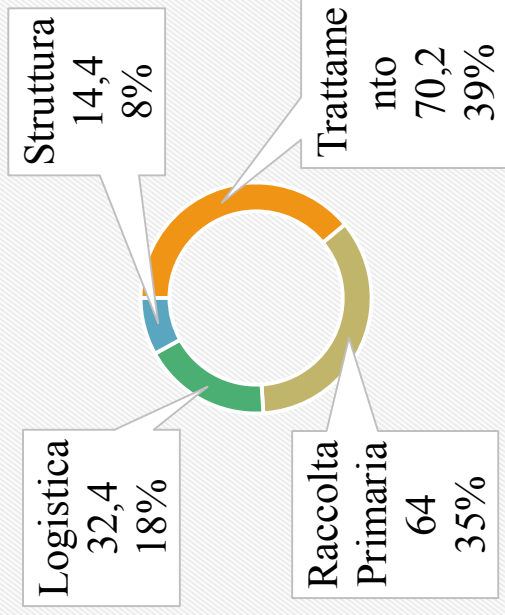


Italian official WEEE management system

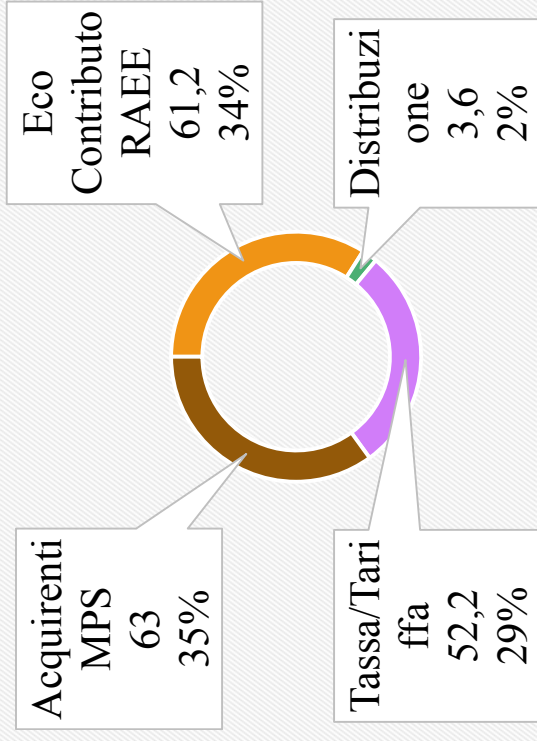
Cost – Revenue structure



Cost Structure



Revenue sources



milioni di €



Article

The Reverse Supply Chain of the E-Waste Management Processes in a Circular Economy Framework: Evidence from Italy

Raffaele Isernia ¹, Renato Passaro ², Ivana Quinto ^{3,*} and Antonio Thomas ²

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³ Department of Industrial Engineering, University of Naples Federico II, 80, Piazzale Tecchio, 80125 Naples, Italy

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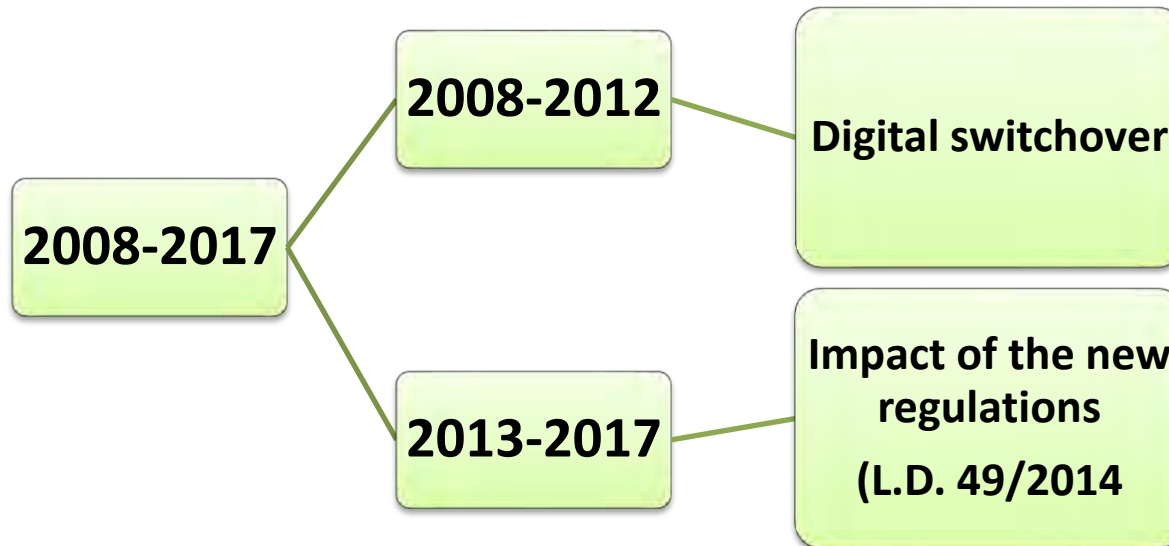
Received: 15 January 2019; Accepted: 16 April 2019; Published: 24 April 2019



Abstract: In the last several decades, Waste Electrical and Electronic Equipment (WEEE) reverse supply chain management has increasingly gained more attention due to the development of an environmental awareness, the rapid raise of e-wasted products and the EU regulations. In particular, although the new EU WEEE collection target has not been reached by many EU countries, several studies

The WEEE collection in Italy

An analysis of the Italian Weee Collection System



- DATA
- WEEE collection, pro capite
- Provincial Population (Istat)

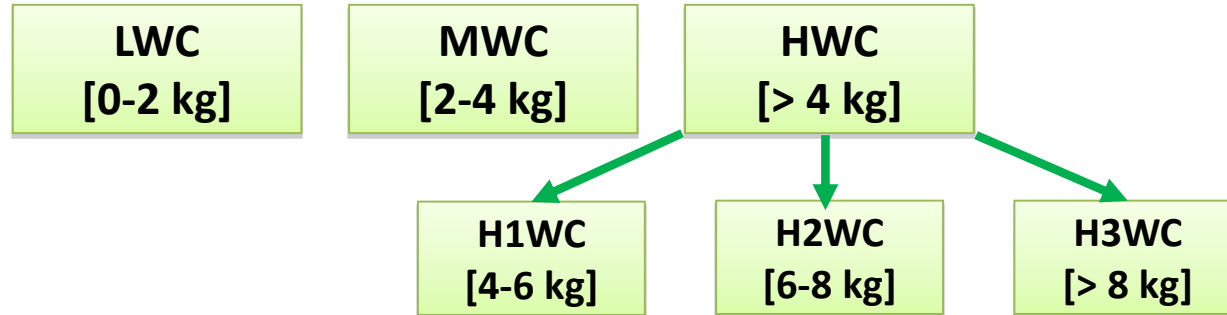
The Reverse Supply Chain of the E-Waste Management Processes in a Circular Economy Framework. R Isernia, R Passaro, I Quinto, A Thomas Sustainability 11 (8), 2430



Transition probabilities matrix

WEEE Collected

“Waste electrical and electronic equipment Collected” is the per capita WEEE collected at provincial level and it is expressed as Lower, Medium e Higher WEEE collected level.



The HWC state is further subdivided into 3 secondary states: : H1WC, H2WC and H3WC



Transition probabilities matrix

Transition matrix method

Methodology to explain the probabilities of a state variable passing from one state to another in a given period of time.

MOVEMENTS MATRIX

	X_1	...	...	...	X_n	
X_1	a_{11}	...	...	...	a_{1j}	a_{1tot}
*	*	*	*	*	*	*
*	*	*	*	*	*	*
*	*	*	*	*	*	*
X_n	a_{i1}	...	...	...	a_{ij}	a_{itot}

a_{ij} number of movements from state i to state j

a_{itot} sum of the i^{th} row

PROBABILITY TRANSITION MATRIX

	X_1	...	...	...	X_n
X_1	p_{11}	...	...	...	p_{1j}
*	*	*	*	*	*
*	*	*	*	*	*
*	*	*	*	*	*
X_n	p_{i1}	...	...	...	p_{ij}

p_{ij} probability of state transition
 $a_{ij} / a_{i tot}$

Each element of the matrix represents the probability of moving from initial state (state at time t) to a new state at the end of the period (state at time $t + n$).

Values on the main diagonal represent a steady state condition: the probability of persisting in the same condition during the given unit of time.

The gross probability of transition from state i to state j is defined as the ratio of the number of provinces in state i at time t which are in state j at time $t + 1$, to the stock of provinces in the original state i at time t

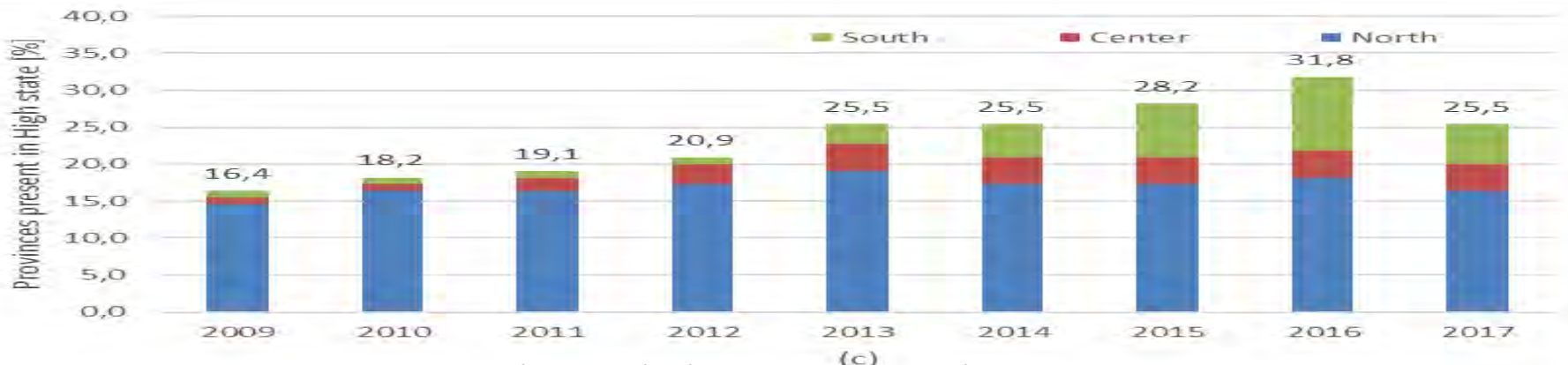
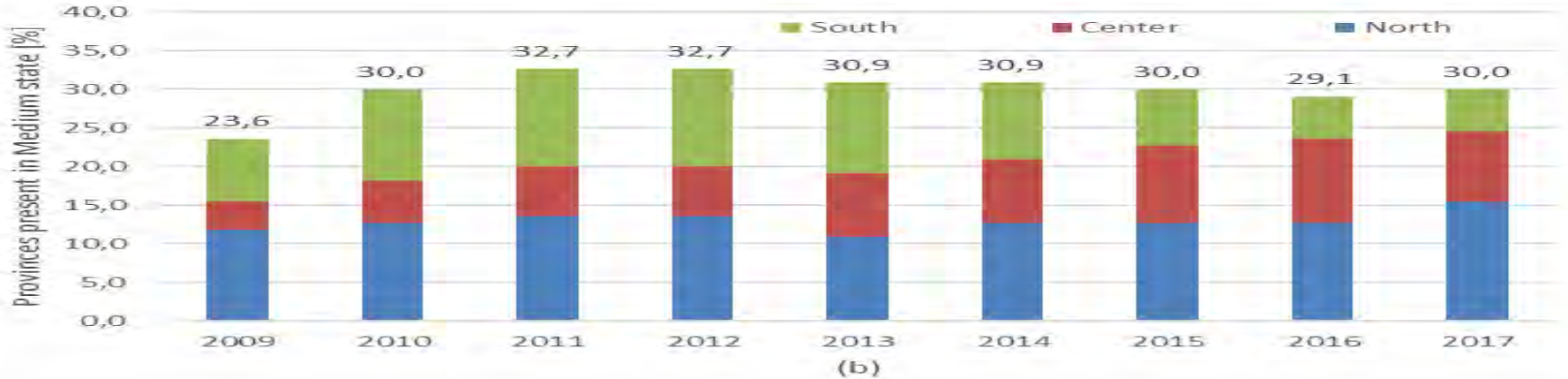
WEEE statistics by collection states, macro-area and years (2008–2017): % of provinces.

		Years									
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LWC(%)	North	28.2	1.8	0	0	0	0	0	0	0	0
	Central	20.0	5.5	2.7	2.7	2.7	0.9	1.8	1.8	0.9	0.9
	South	31.8	23.6	13.6	10.9	9.1	13.6	16.4	14.5	10.0	11.8
	Italy	80.0	30.9	16.4	13.6	11.8	14.5	18.2	16.4	10.9	12.7
MWC(%)	North	13.6	13.6	1.8	0	5.5	8.2	4.5	1.8	1.8	0.9
	Central	3.6	10.9	10.0	7.3	5.5	10.0	10.9	7.3	5.5	5.5
	South	1.8	6.4	12.7	13.6	17.3	13.6	10.9	10.9	12.7	10.9
	Italy	19.1	30.9	24.5	20.9	28.2	31.8	26.4	20.0	20.0	17.3
HWC(%)	North	0.9	27.3	40.9	42.7	37.3	34.5	38.2	40.9	40.9	41.8
	Central	0	7.3	10.9	13.6	15.5	12.7	10.9	14.5	17.3	17.3
	South	0	3.6	7.3	9.1	7.3	6.4	6.4	8.2	10.9	10.9
	Italy	0.9	38.2	59.1	65.5	60.0	53.6	55.5	63.6	69.1	70.0

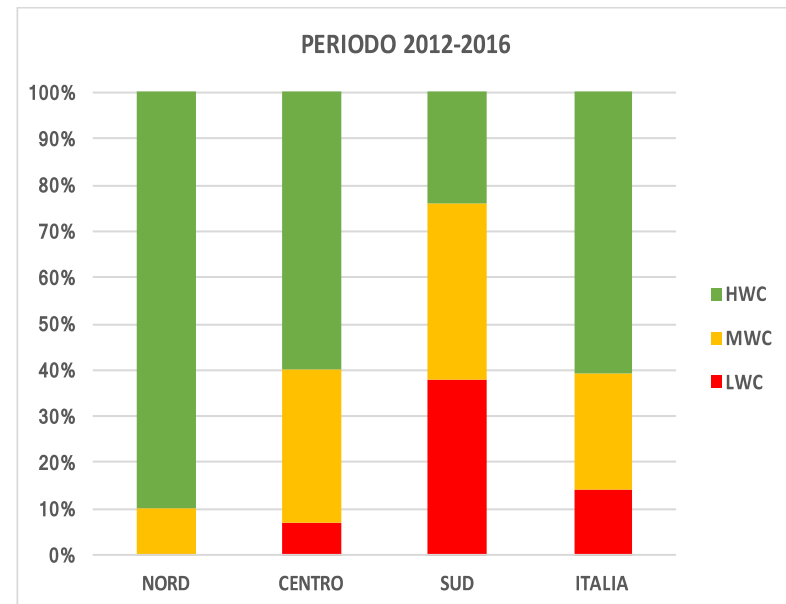
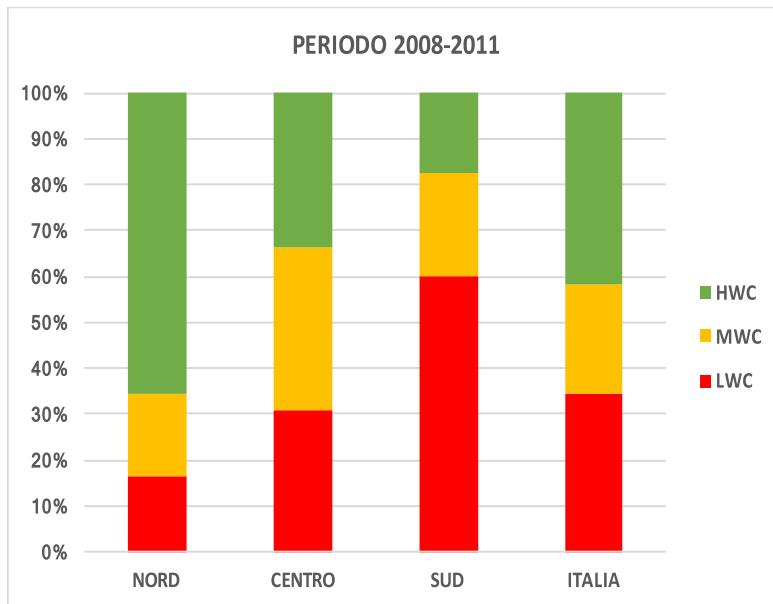
SOME RESULTS - 10 years after the introduction of the WEEE regulation system:

- 70% of provinces shows a relevant collection performance (HWC state).
- 17.3% and 10.9% of these provinces are respectively in Southern and Central Italy.
- Consistently, the % of provinces in LWC and MWC states at the end of the period is low and mainly concentrated in the South and Central area.
- Northern provinces progressively moved both from LWC (2008=28.2; 2017=0) and MWC (2008=13.6; 2017=0.9) to HWC state (2008= 0.9; 2017= 41.8).
- Trend of the HWC state: two different dynamics for the 3 areas. First increase for the period 2008–2012, then, after a slight decline, a second increase is registered in the period 2014–2017.
- 2008–2012; impact of the digital switchover, which involved the replacement of televisions sets and the increase of the R3 group of WEEE.
- 2014–2017: caused by the entry into force of LD 49/14 that re-imposed Directive 2012/19/EU and produced a new impetus on the collection process.

Distribution of WEEE Collection Centers by state and area (2009–2017)



Main results



- Disparity between Italian macro-areas and regions
- Non-homogeneous distribution of Collection centers: North 9, Center and South 5.
- Italy is far from the new objectives
- Molise and Valle d'Aosta exceed the targets.
- The Northern, Tuscan and Sardinia provinces are preparing to reach the new targets.
- The remaining southern provinces show a backwardness condition

Analysis on the spatial access to the recovery network for WEEE

Region (ID)	Scenario	No. of new located Collection Centers	Avg. distance [km]	Region (ID)	Scenario	No. of new located Collection Centers	Avg. distance [km]
Abruzzo (13)	AS IS	-	4.17	Molise (17)	AS IS	-	3.03
	$\gamma = 0.60$	0	4.17		$\gamma = 0.60$	0	3.03
	$\gamma = 0.70$	0	4.17		$\gamma = 0.70$	0	3.03
	$\gamma = 0.80$	10	3.59		$\gamma = 0.80$	2	2.83
Basilicata (14)	AS IS	-	3.35	Puglia (18)	AS IS	-	3.11
	$\gamma = 0.60$	0	3.35		$\gamma = 0.60$	1	2.91
	$\gamma = 0.70$	0	3.35		$\gamma = 0.70$	1	2.91
	$\gamma = 0.80$	5	2.99		$\gamma = 0.80$	5	2.57
Calabria (15)	AS IS	-	5.89	Sicilia (20)	AS IS	-	4.48
	$\gamma = 0.60$	9	4.98		$\gamma = 0.60$	4	4.21
	$\gamma = 0.70$	18	4.29		$\gamma = 0.70$	7	4.00
	$\gamma = 0.80$	32	3.57		$\gamma = 0.80$	21	3.45
Campania (16)	AS IS	-	2.35				
	$\gamma = 0.60$	0	2.35				
	$\gamma = 0.70$	1	2.28				
	$\gamma = 0.80$	5	2.17				

Average accessibility distance and number of located collection centers by region

G.Bruno, A.Diglio, R.Passaro, C.Piccolo, I.Quinto, paper under review, 2020.

Weee treatment plants in Italy - 2020

ITALIA

Localisation	Registered plants	Accredited plants (% of Registered plants)
Nord	854	30 (3,5%)
Centro	191	14 (7,3%)
Sud e Isole	225	13 (5,8%)
Totale	1270	57 (4,5%)

Description	% Registered plants per macroregion	% Accredited plants per macroregion
Nord	67,24	52,63
Centro	15,04	24,56
Sud e Isole	17,72	22,81

CAMPANIA

	Avellino	Benevento	Caserta	Napoli	Salerno
N. Plants in Campania	3	0	15	21	10

Weee treatment plants in Campania:(obstacles)



Plant	a) Secondary activity	b) Insufficient amount of WEEE	c) Lack of economic advantages	d) Neighbouring consolidate plants
A	X	X		
B				
C	X	X	X	
D	X		X	X
E	X	X	X	X
F		X	X	X
G		X		X
H		X		X

Econometric Model



Economic variables

EEE placed on the market
assigned on the basis of the
average income of Italian
households

Social variables

Participation in voluntary
activities during the year

Demographic variables

Italian Population (Istat)

Cultural variables

Number of graduates
(upper secondary
school) in 2017

**WEEE
Collection**

Econometric Model – Main results



Variables		Estimated coefficients	Standard Deviation
Cultural	X_3	0.831*	0.0296
Economic	X_2	0.142*	0.0419
Social	X_4	0.129*	0.0335
Demographic	X_1	0.0927*	0.0147
$\alpha=0.01$			

Econometric Model – Main Results



- Cultural factor plays an important role, while the demographic variable is less critical.
- Economic variable is not so crucial...it was not expected!
- Large metropolitan cities are classified as following:
 1. Milan: **BEST IN CLASS**
 2. Naples: **CRITICALITY**
 3. Rome: **WORST IN CLASS**

Conclusion



- Italy is very far from the new EU targets, specially Southern Italy.
- Strong disparity between Italian macro-areas and regions.
- Necessity to improve the spatial distribution of the network of Collection centers, in particular in the South of Italy.
- Cultural and social variables can play a key role to trigger the WEEE collection.



Thanks For The Attention

Any
question?



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