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Ministero dell'Ambiente e della Sicurezza Energetica

Bando per il cofinanziamento di progetti di ricerca finalizzati allo sviluppo di nuove tecnologie per il recupero, il riciclaggio ed il trattamento dei rifiuti di apparecchiature elettriche ed elettroniche (RAEE).

SMART PCBs Sustainable Materials Recycling Technology for Printed Circuit Boards

2002-2022: 20 YEARS OF E-WASTE REGULATION IN THE EU AND THE EVOLUTION OF WORLDWIDE RECYCLING TECHNOLOGIES AND PRACTICES

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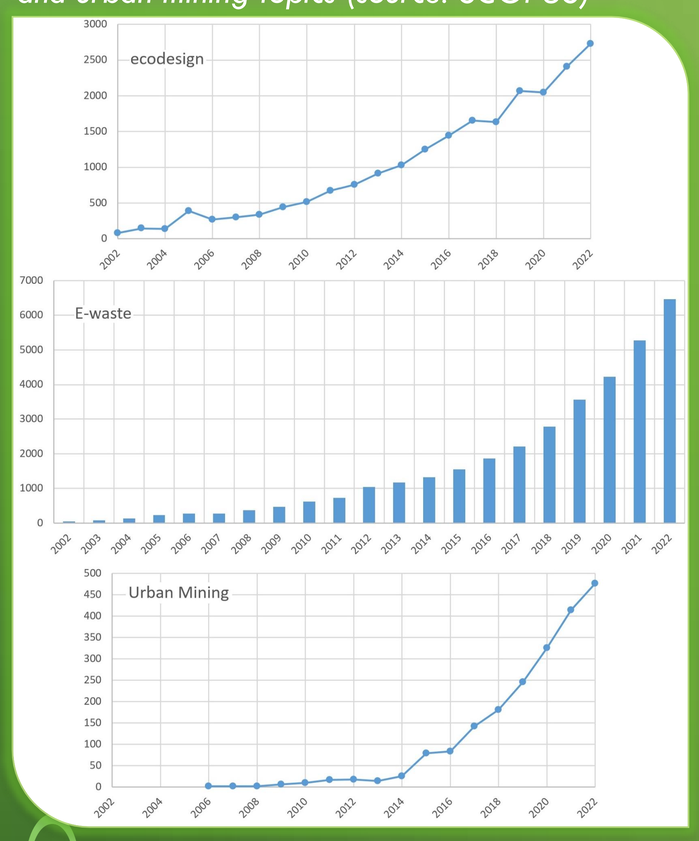
The work presented here aims to highlight the progress being made in e-waste recycling over the last 20 years, identifying key parameters for a more sustainable approach to safeguard human health and the environment, and how to improve at the global level in this field to move towards the Sustainable Development Goals of United Nations - Agenda 2030.

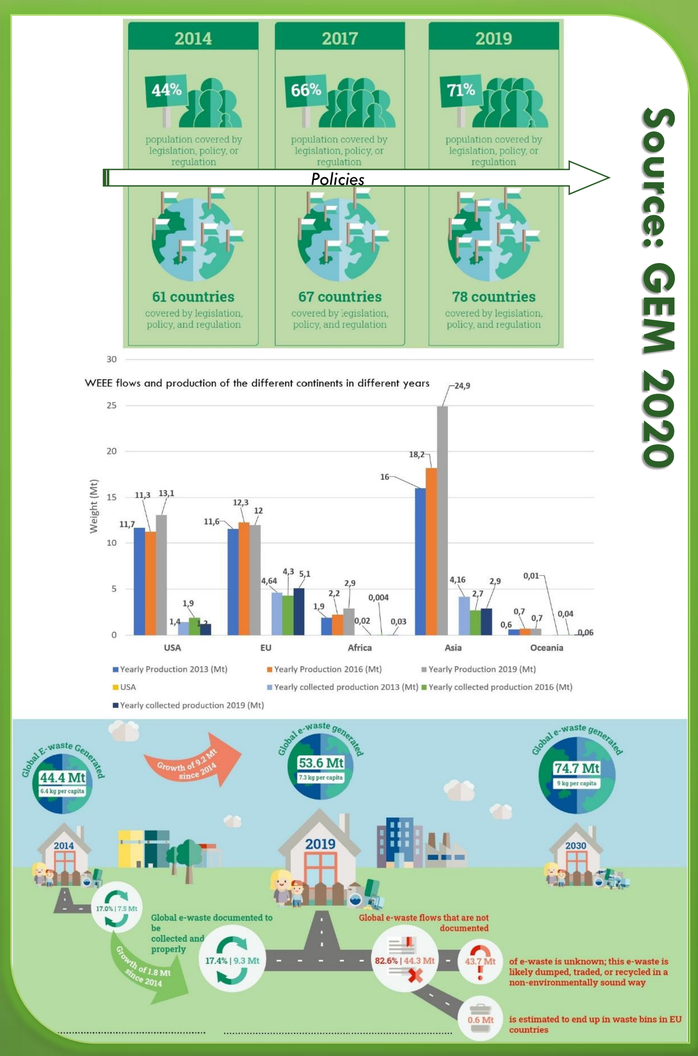
Electrical and Electronic Equipment (EEE) are integral to our daily life. In recent decades it has largely contributed to improving the quality of life, providing different benefits and opportunities in a variety of sectors: from energy, transport, health, and security, to school/education. Population growth and consumer demand are driving manufacturing and fueling raw material consumption. With rapid technological obsolescence, countries have to face an increasing accumulation of e-waste.[1]

A shift of paradigm to move away from the unsustainable linear economic model to a circular approach is therefore essential to reduce the pressure of our limited natural resources and limit the environmental impact of waste landfill. In this context, visionary regulations have been promulged worldwide to change a concern into an opportunity.[2] Among them, EU Directives have been playing a pivotal role in driving the "green" revolution in this field promoting a new sensitivity and responsibility in industrial and social communities around the world, specifically related to:

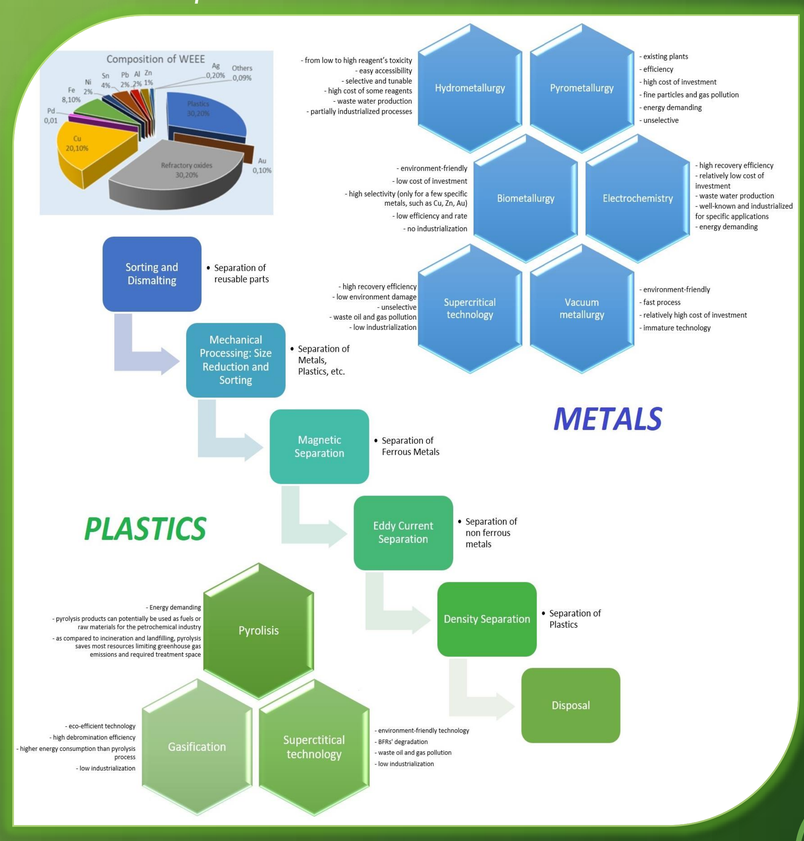
- **e-waste concept** → from an environmental issue to a valuable resource of secondary raw materials – *urban mines* - towards a circular economy [3]
- **worldwide e-waste regulations and policies** → established rules for protecting the planet and pursuing people's safety and prosperity [2]
- **eco-design and green processes** → responsibilities and request for innovation in products design and sustainability in treatments [4]
- **sustainability assessment** → Life cycle analysis (LCA) as a tool for checking the environmental performances of the new approaches [5]
- **dissemination, sensibilization, and initiatives** → implementation of suggestions and encouragements to achieve target goals

Trends on scientific production in ecodesign, e-waste and urban mining topics (source: SCOPUS)





Typical WEEE composition: pre-treatments and valorization processes



INDICES AND PRIORITIES FOR DECISION-MAKING PROCESSES

The last 20 years have been characterized by an increasing global effort to implement circular economy models in EEE production field. Multi-criteria decision methods have been adopted by most of the studies, where the relationship between e-waste generation and gross domestic product (GDP), as well as global e-waste generation and GDP demonstrated to be particularly sensitive.[6] Some examples are reported below:

Resource, Technology, Environment

Clusters with the highest scores in all three areas are prioritised for material collection and recovery in China.[7]

12 indicators in environmental, economic and social dimensions help to provide a better choice for e-waste reverse logistics routes in the metropolitan region of Rio de Janeiro in Brazil.[8]

Multi-criteria decision methods and a stepwise weight assessment ratio analysis

Socio-economic issues (e.g. e-waste awareness and tax incentives) are factors which demonstrated to enhance the urban mining of e-waste in India.[9]

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