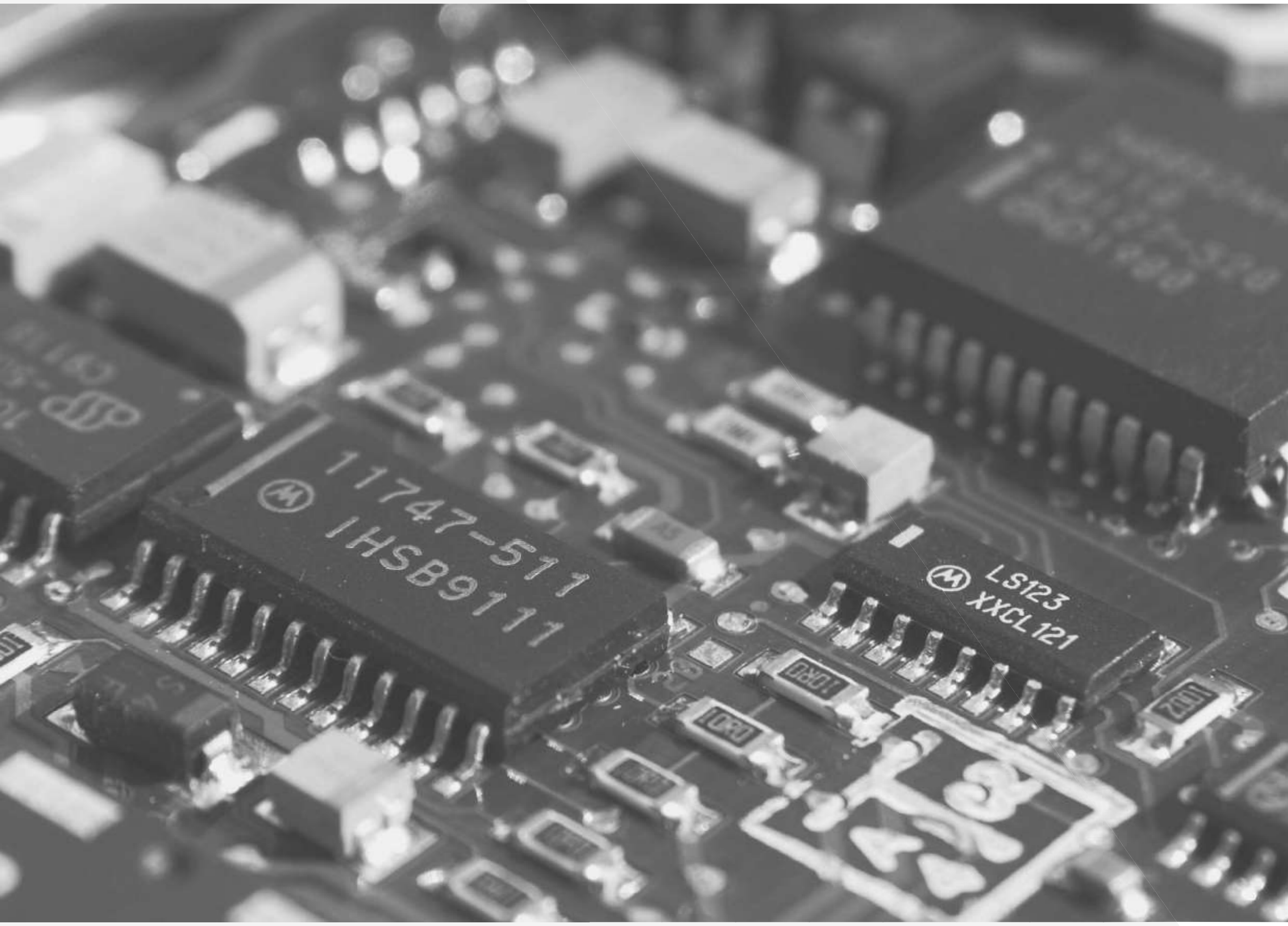
PROJECT DATARE

FINAL REPORT

NOVEMBER - 2021



PROJECT
DATARE

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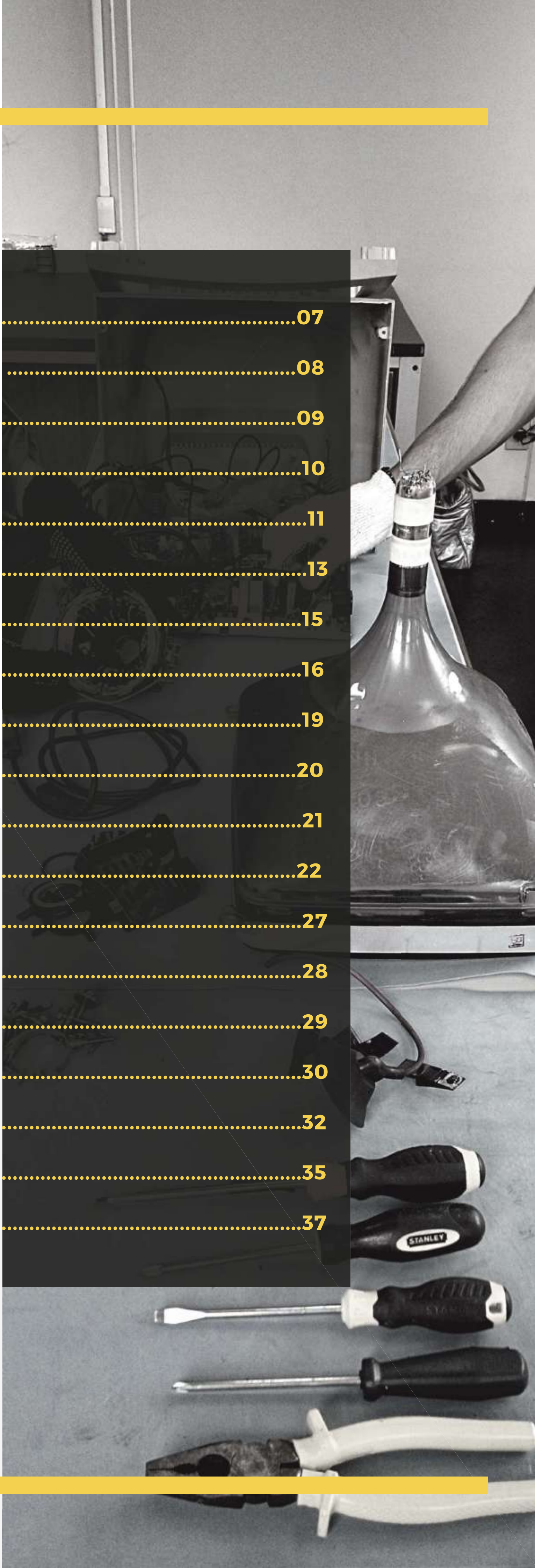


MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÕES
PÁTRIA AMADA BRASIL GOVERNO FEDERAL

PRESENTATION

The management of waste electrical and electronic equipment (WEEE or e-waste) in Brazil is regulated by Federal Law No. 12.305/2010 (Brazil, 2010a) and Federal Decree No. 7.404/2010 (Brazil, 2010b), which comprise the National Policy on Solid Waste (PNRS). In February 2020, Decree No. 10,240 (Brazil, 2020) was published, establishing the goals and deadlines for the collection and disposal of this category of waste in the country. Together, these regulatory instruments enabled the consolidation of guidelines and motivated the establishment of new business models for e-waste management in Brazil.

However, the lack of data on recycling companies, the volume of e-waste generated, as well as the location and potential for consolidation of the reverse logistics system represented the main obstacles to the definition of strategies and targeted public policies.

In 2020, a new edition of the Global E-Waste Monitor (Forti et al., 2020) was published, from which it is estimated that the per capita generation of WEEE in Brazil is equivalent to 10.2 kg per inhabitant, a volume that totals a generation of 2.1 million tons of e-waste in 2019. With no other parameter available to provide the order of magnitude of these values, the R3MINARE team proposed a research that could shed light on the subject and hence allow a closer analysis of the eco-industrial park available for the management of e-waste, as well as evaluate the generation indicators.

Thus, the Project DATARE (2021-2020) emerged, coordinated by the Centre for Mineral Technology (CETEM), with the collaboration of agents active in the segment. The Project DATARE survey reached 379 companies operating in the management of e-waste in the country, being 67% in the Southeast region, 18.2% in the South and only 3% in the North region, clearly showing the unequal distribution of the eco-industrial park. More than 1.7 million tons of electrical and electronic equipment were placed on the market in the base year of 2018, representing about 6.7 kg per inhabitant per year, for the evaluation carried out from the values identified for 45% of the equipment listed in the decree, as the object of the implementation of the reverse logistics system.

The results highlight both the challenges and the potential of circularity in the management of e-waste in the country and may come to contribute to the consolidation of integrated systems, symbiotic and aligned with best practices.

CENTRE FOR MINERAL TECHNOLOGY - CETEM

CETEM is the only public research center dedicated exclusively to mineral technology, aiming to innovate and develop technology for the mineral-metallurgical sector.

The main research themes at CETEM are focused on chemical, mineralogical and technological characterization, mineral processing, extractive metallurgical processes for rocks, ores and industrial minerals, as well as the development and application of environmental technologies.

NUMBERS

- 43 years
- 21 laboratories
- 4 pilot plants
- Library
- 60,000 m² / 21,000 m² built area
- Over 324 collaborators
- 90% PhD researchers

43 years

CETEM has been operating for 43 years as the only public research center dedicated exclusively to mineral technology in Brazil

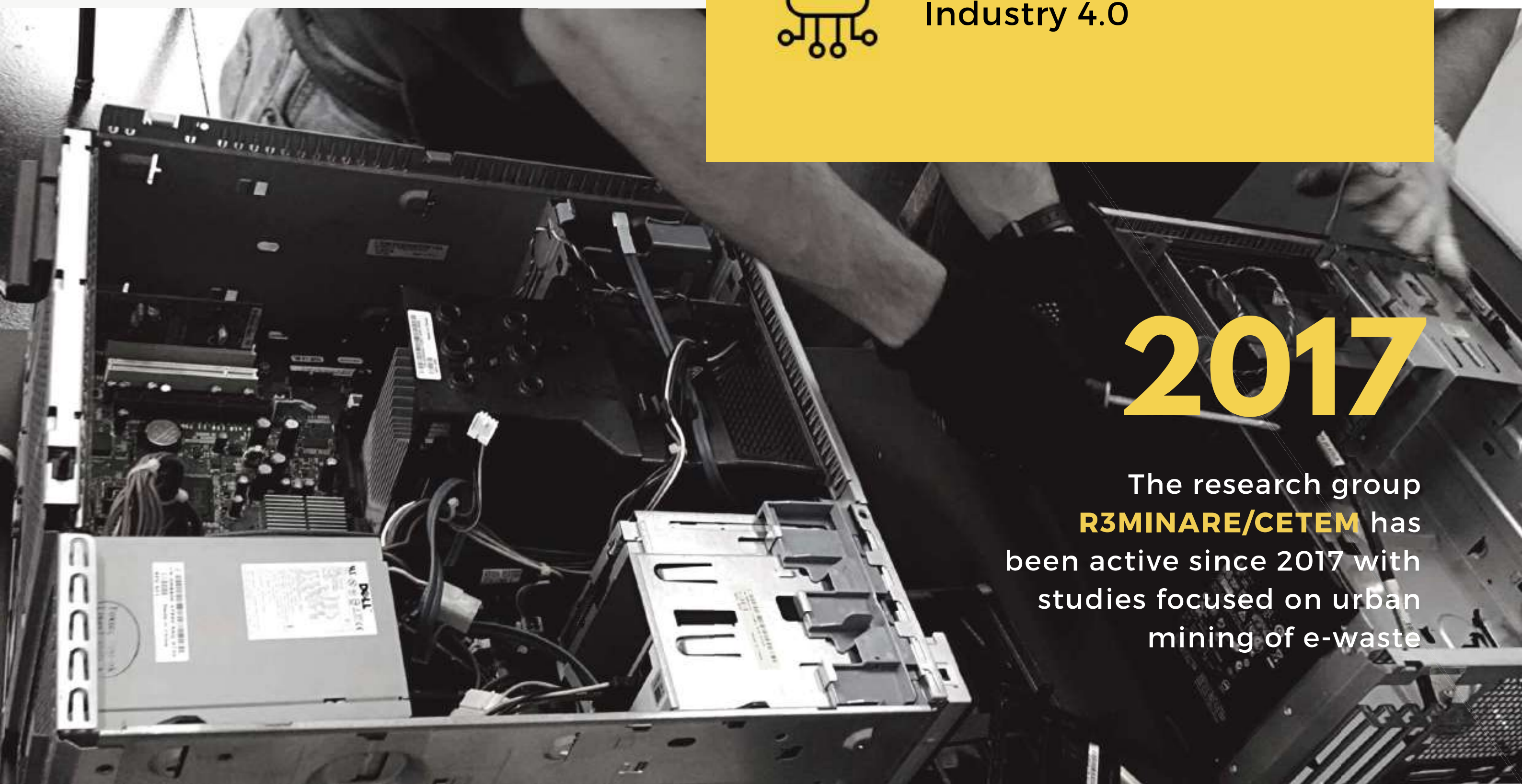
R3MINARE

The research group of the Centre for Mineral Technology (CETEM/MCTIC) came about from the initiative of studies applied to Urban Mining of Waste Electrical and Electronic Equipment from mid-2017.

R3MINARE brings as objectives to contribute, within the premises of the Circular Economy, with researches in the scientific-technological field and development of projects focused on Urban Mining of e-waste to identify the potential for recovery and reinsertion of secondary raw materials and critical materials in the production chain.

The researches conducted by R3MINARE is related to the following main thematic points:

- Circular economy
- E-waste management
- E-waste urban mining
- Solutions in E-waste Reverse Logistics
- Industry 4.0



2017

The research group **R3MINARE/CETEM** has been active since 2017 with studies focused on urban mining of e-waste

CIRCULAR ECONOMY

Circular Economy is an integrated, restorative and regenerative model for anthopic systems. This approach includes the reduction or elimination of waste through optimized cycles of products, components, materials, and services, keeping them at their highest utility and value, as "nutrients" for the technical and biological cycles. A successful circular economy contributes to all three dimensions of sustainable development (Korhonen et al., 2018).

E-waste valorization strategies

RETHINK: Restructure production processes and ways of consuming.

REDUCE: Reduce discarded volumes or more efficient manufacturing processes that use fewer natural resources and materials.

REVERSE LOGISTICS: System of collection and return of electrical and electronic products discarded by consumers and disposed of in an environmentally correct manner, according to legal requirements.

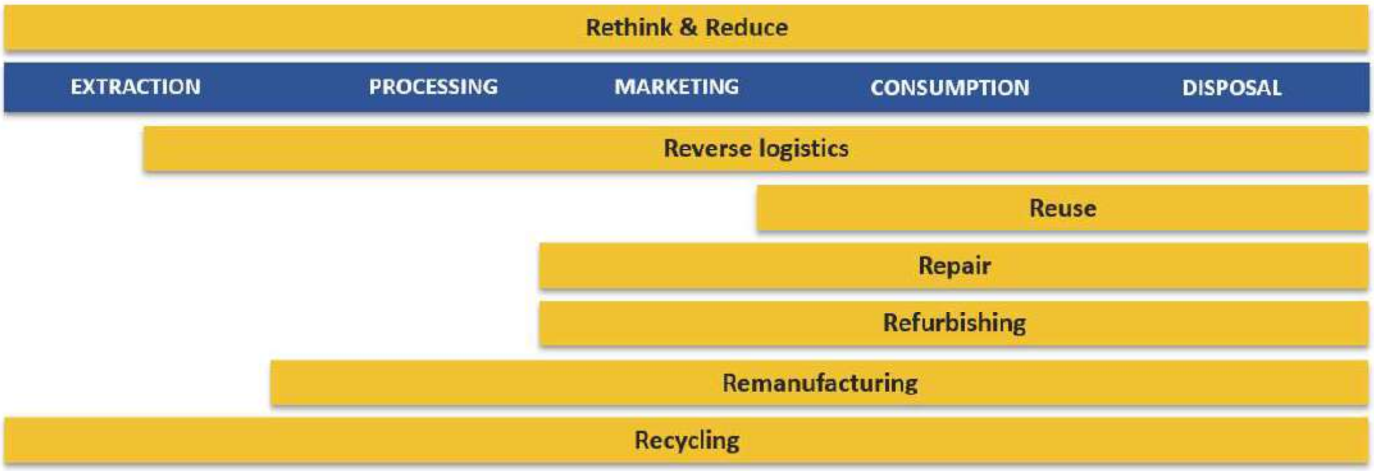
REUSE: Solution for increasing the useful life of electrical and electronic products.

REFURBISHING: Processes that transform e-waste into parts and pieces, inputs or raw materials, without obtaining new products.

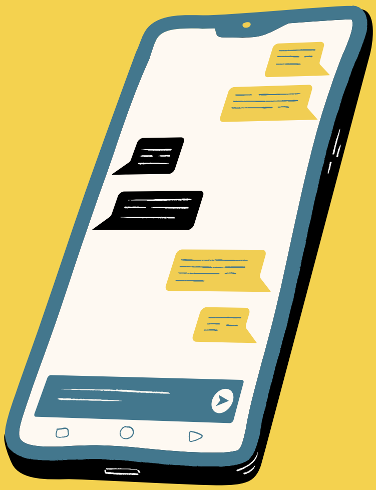
REPAIR: Maintenance process to increase the useful life of products.

REMANUFACTURING: The use of functional parts and components of discarded products for future reconditioning processes into new products.

RECYCLING: Physical-chemical transformation of the original materials from the residues for the recovery of materials and elements contained therein.



ELECTRONIC WASTE

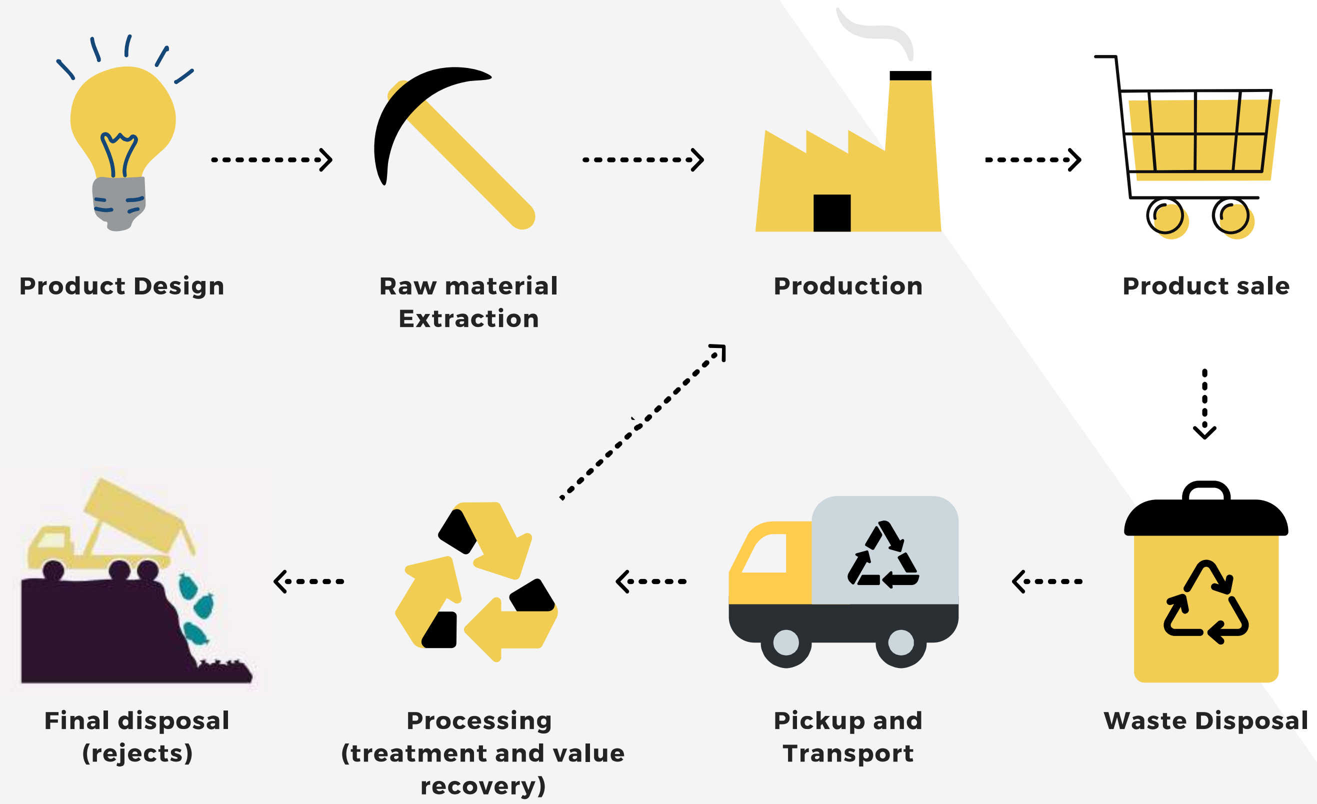


Equipment for which operation depends on electric currents with a maximum rated voltage of 240 volts.

8 Categories of e-waste:

1. **Large Household Appliances**
   Refrigerator, oven
2. **Small Household Appliances**
   Blender, fan
3. **Monitors**
   LCD, plasma, CRT
4. **IT & Telecomm**
   Cell phones,computers, mouse
5. **Wires & Cables**
6. **Batteries**
7. **Lighting**
8. **Photovoltaic Panels**

Electrical and electronics products' Life Cycle



E-waste value recovery chain

END OF LIFE

The product becomes obsolete or suffers some damage and is discarded by the consumer

DISPOSAL

The post-consumption electrical and electronic products can be disposed of at Voluntary Delivery Points (VDPs), campaigns or collected by the municipal waste collection systems

SORTING

E-waste is sent for sorting within organizations operating in reverse logistics, where they are separated by types to proceed to the treatment and value recovery lines

TREATMENT / VALUE RECOVERY

There are different metallurgy techniques used to perform the treatment and recovery of the value of e-waste. Of these, three major groups can be highlighted: (1) Pyrometallurgy; (2) Hydrometallurgy; (3) Biohydrometallurgy.

REGULATIONS

2010	2013	2017	2019	2020
Law No. 12,305/2010 Federal decree No. 7.404/2010	**MMA Call Notice (reverse logistics)**	**Federal Decree No 9.177/2017**	**Signing of the Sector Agreement for electro electronic products**	**Federal Decree No 10.240/2020**

2010: Brazilian Policy on Solid Waste (BPSW)

Reverse Logistics Systems (RLS) can be implemented by Terms of Commitment, Sectoral Agreements or via Regulations (decree, ordinance, etc)

2017: Isonomy in inspection and fulfillment of obligations for Reverse Logistics

Manufacturers, importers, distributors and traders that are not signatories to a sectorial agreement or a term of commitment signed with the Union are obliged to structure and implement RLS, considering the same obligations attributable to the signatories and adherents of a sectorial agreement signed with the Union

2020: Implementation of the Reverse Logistics System for electrical and electronic products

Mandatory for electrical and **electronic household products** and their components

Percentage to be collected and to be destined each year by RLS

YEAR 1	YEAR 2	YEAR3	YEAR4	YEAR5
2021	2022	2023	2024	2025
1%	3%	6%	12%	17%

Brasil (2020)

IBAMA NORMATIVE INSTRUCTIONS

Two normative instructions (IN) of the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) may apply to the management of electronic waste. IN no. 01/2013 on the regulation of the National Register of Operators of Hazardous Waste (CNORP) and IN no. 08/2021 which regulates Article 8 of Decree no. 10,240/2020 regarding the mandatory issuance of an Environmental Permit for the Transportation of Hazardous Products for the interstate transportation of discarded electrical and electronic products and e-waste. The latter uses the requirements of the implementation of the National System of Transport of Dangerous Products (SNTPP) regulated by Resolution No. 5,947/2021.

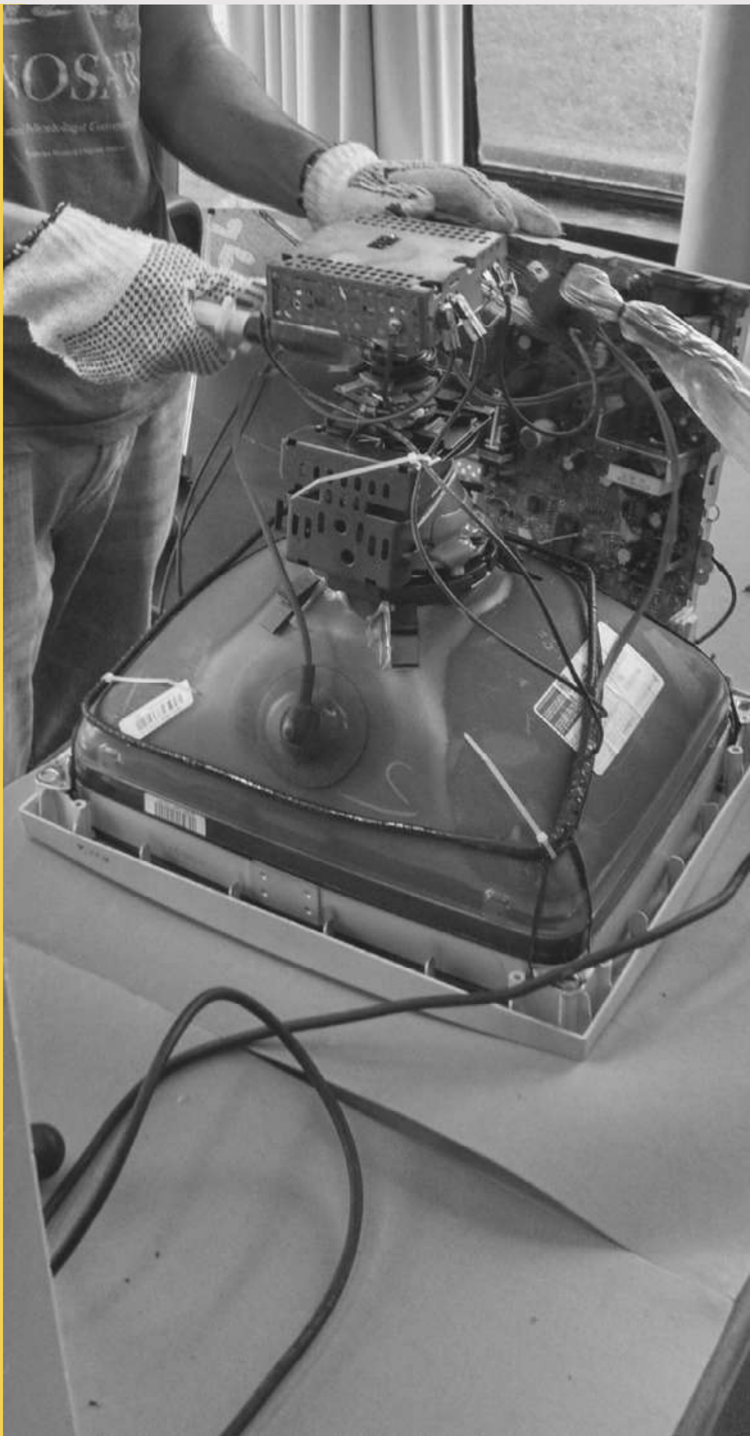
Hence, the SNTPP established in 2013, in compliance with Complementary Law No. 140/2011, which assigns to IBAMA the environmental control of interstate maritime and land transportation of hazardous products, replaces IN No. 05/2012.

IN 01/2013

Regulates the National Register of Operators of Hazardous Waste (CNORP) and defines the procedures related to the provision of information on solid waste, including rejects and those considered hazardous. The 19 generating activities are defined, as well as the transport, storage and destination categories. Among the activities, Category 5 is defined, which specifies the manufacture of batteries and chargers (code 5-1), electrical and electronic material and equipment for telecommunications and information technology as an electrical, electronic and communications material industry, (code 5-2) and manufacture of electrical and household appliances (code 5-3).

IN 08/2021

Regulates Article 8 of Decree 10.240/2020, establishing that when the transportation is of components classified as hazardous or hazardous waste, the carrier's registration in the National Register of Hazardous Waste Operators (CNORP) is mandatory. The generator or operator of hazardous waste must register in the Federal Technical Registry of Potentially Polluting Activities and/or Users of Environmental Resources CTF-APP in accordance with the Framework Technical Files (FTEs),



PROJECT DATARE

In general

The DATARE project has as its objective the survey of the set of companies that operate in the recycling of electrical and electronic products in Brazil.

The project considered the identification of companies, followed by the analysis of their particularities, considering the segment of activity, geolocation, as well as production capacity, infrastructure and compliance with legal requirements. The mapped companies were organized in SIS-DATARE, the database developed for the project.

The study advanced to identify the volume of electrical and electronic equipment placed on the market (PoM) from the base year 2018, used in Federal Decree No. 10.240/2020 for the implementation of the reverse logistics system for electronics in the country.

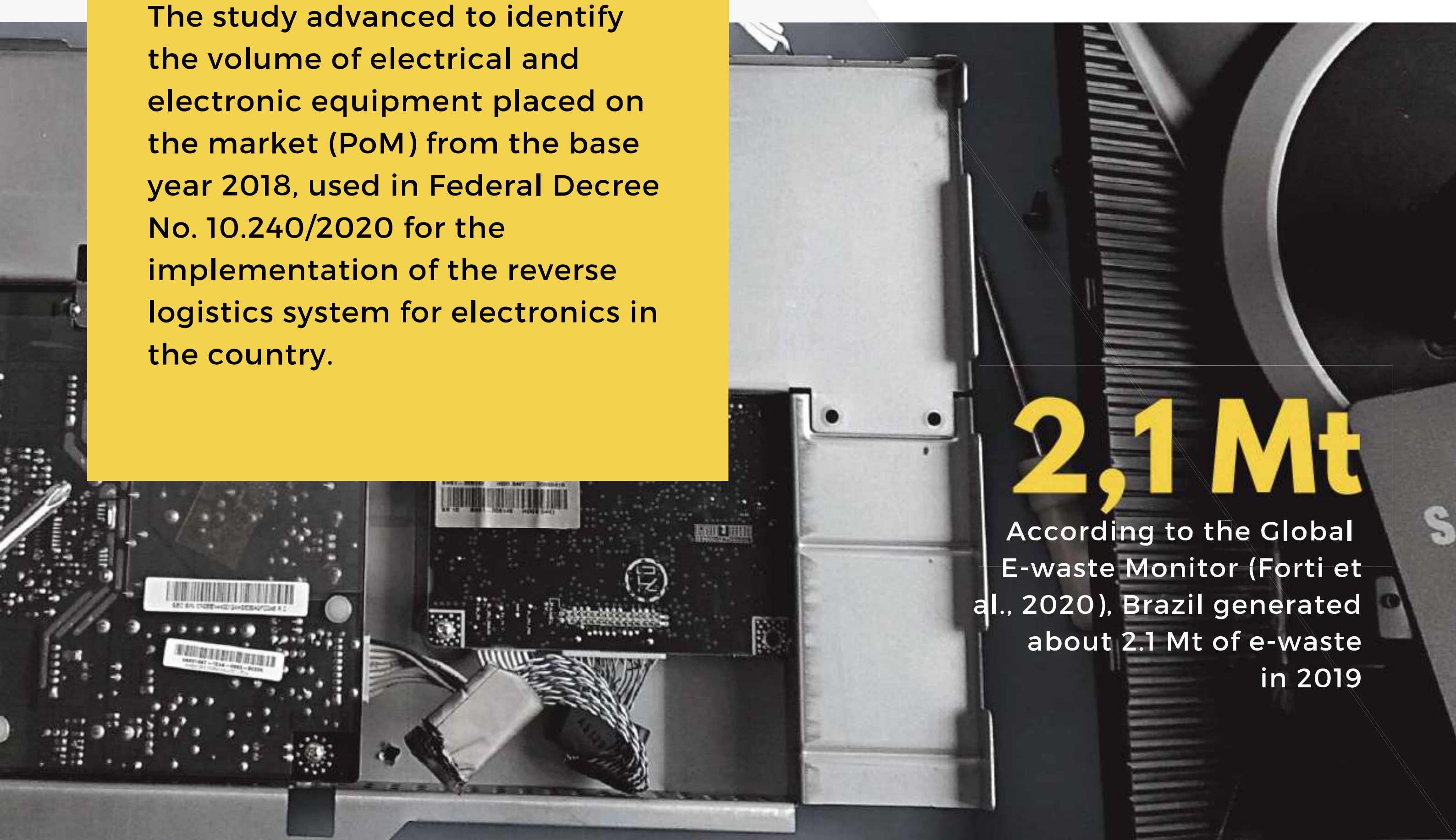
TIMELINE:
January 2020 - October 2021

BUDGET:
R$ 139,600.00

RESPONSIBILITY:
Centre for Mineral Tecnology CETEM/MCTI

FOCUS:
Urban mining and reverse logistics of e-waste in Brazil

MAIN RESULTS:
Identification, geolocation and analysis of the companies that perform the management of e-waste in Brazil in compliance with legal requirements, development of the SIS-DATARE database, as well as the calculation of the volume placed on the market in 2018. The project resulted in more than 20 scientific publications in the format of articles, e-books, book and manuals



2,1 Mt

According to the Global E-waste Monitor (Forti et al., 2020), Brazil generated about 2.1 Mt of e-waste in 2019

R3MINARE PUBLICATIONS

Articles

Xavier, L.H., Ottoni, M., Lepawsky, J., 2021. Circular economy and e-waste management in the Americas: Brazilian and Canadian frameworks. Journal of Cleaner Production 297, 15 May 2021, 126570. https://doi.org/10.1016/j.jclepro.2021.126570

Ottoni, M., Dias, P., Xavier, L.H., 2020. A circular approach to the e-waste valorization through urban mining in Rio de Janeiro, Brazil. Journal of Cleaner Production 261, 120990. https://doi.org/10.1016/j.jclepro.2020.120990

Xavier, L.H., Novais, M.P., Ottoni, M., Nascimento, H., 2021. Clustering Analysis of E-Waste Management in BRICS and G7 Countries. EnviroInfo 2021 Berlin, Germany.

Apolonio, L., Xavier, L.H., Ottoni, M., Araujo, R.A., Giese, E.C., 2021. E-Waste collection in the reverse logistics systems and case study in Rio de Janeiro, RJ, Brazil. 2021 IEEE 2nd SUSTAINABLE CITIES LATIN AMERICA CONFERENCE (SCLA 2021), Medellin, Colombia.

Novais, M. P., Xavier, V.A., Xavier, L.H., Junseok, H., 2021. Modeling e-waste management data in smart cities, 2021 IEEE 2nd SUSTAINABLE CITIES LATIN AMERICA CONFERENCE (SCLA 2021), Medellin, Colombia.

Araujo, R., Cugula, J., Apolonio, L., Ottoni, M., Xavier, L.H., 2020. Spatial distribution analysis of e-waste voluntary delivery points (VDP) by Green eletron manager in São Paulo city (SP, Brazil), 5th Symposium on Urban Mining and Circular Economy, Venice, Italy.

Araujo, R.A., Ottoni, M., Xavier, L.H., 2020. Analysis of e-waste Voluntary Delivery Points (VDP) location in the city of Rio de Janeiro, Brazil. 5th Symposium on Urban Mining and Circular Economy, Venice, Italy.

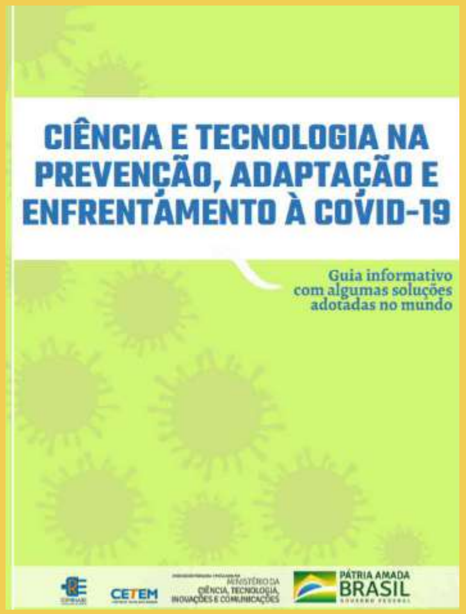
Cugula, J.S., Apolonio, L., Araujo, R., Ottoni, M., Xavier, L.H., 2020. E-waste hotspots and best routes analysis for reverse logistics in the city of São Paulo, Brazil. 5th Symposium on Urban Mining and Circular Economy, Venice, Italy.

Ottoni, M., Araujo, R., Xavier, L.H.,, 2020. Quantificação de pontos de entrega voluntária (PEVs) de resíduos de equipamentos eletroeletrônicos (REEE) na cidade do Rio de Janeiro. XI Forum Internacional de Resíduos Sólidos. Porto Alegre, RS. https://institutoventuri.org/ojs/index.php/FIRS/issue/view/11firs

Araujo, R., Cugula, J., Apolonio, L., Gomes, C.F., Ottoni, M., Xavier, L.H., 2020. ALOCAÇÃO DE PONTOS DE ENTREGA VOLUNTÁRIA DE RESÍDUOS DE EQUIPAMENTOS ELETROELETRÔNICOS NA CIDADE DE SÃO PAULO POR MEIO DE ANÁLISE MULTICRITÉRIO EM SIG. XI Forum Internacional de Resíduos Sólidos. Porto Alegre, RS. https://institutoventuri.org/ojs/index.php/FIRS/issue/view/11firs

Araujo, R., Ottoni, M., Xavier, L.H., 2020. PANORAMA DAS COOPERATIVAS DE CATADORES ATUANTES NA CIDADE DO RIO DE JANEIRO NO SEGMENTO DE RESÍDUOS DE EQUIPAMENTOS ELETROELETRÔNICOS. Forum Internacional de Resíduos Sólidos. Porto Alegre, RS. https://institutoventuri.org/ojs/index.php/FIRS/issue/view/11firs

E-books and Manuals



The e-books are free and can be downloaded directly from CETEM's website
https://www.cetem.gov.br/antigo/livros?start=50

Vídeos

Electronic Waste in Brazil

R3MINARE and COVID-19

3° IEWD - Part 1

3° IEWD - Part2

3° IEWD - Part 3

Retos y Oportunidades de las Universidades y Centros de Investigación

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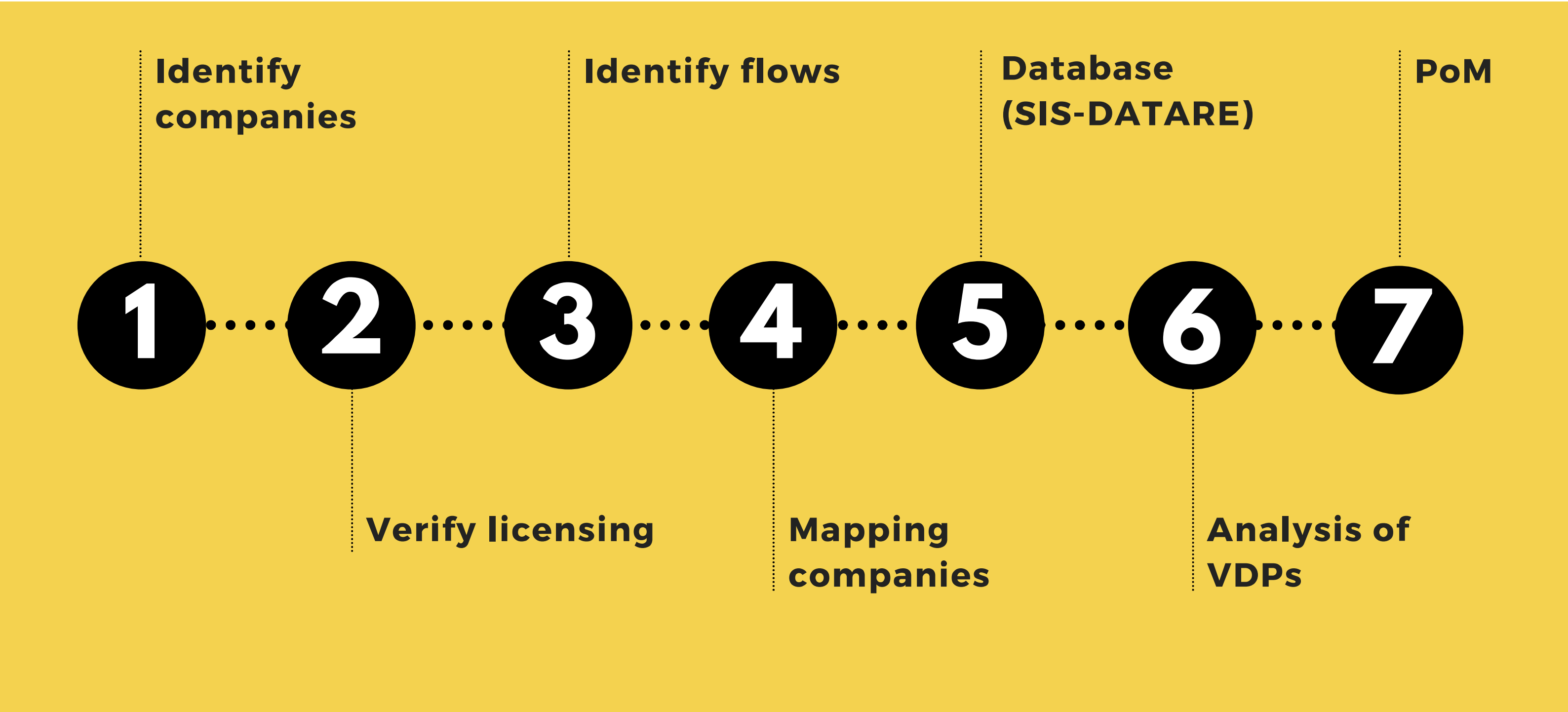
OUR METHODOLOGY



1 Identify companies

Active companies in the e-waste chain were identified from extensive research in websearch engines and by indication of stakeholders

2 Identify licensing

The qualification of the identified companies was verified through analysis of official public documents that prove their capacity and license to operate in the area (CNPJ, CNAEs, environmental licenses, fire department inspection certificate, and so on)

3 Identify flows

The identification of the materials flows, production processes and management practices of these organizations were done by online forms sent to the identified companies

4 Mapping companies

The identified companies were mapped in ArcGIS software for spatial analysis

5 SIS-DATARE

SIS-DATARE was developed as a database to store the information gathered about the companies

6 Analysis of VDPs

The spatial analysis in the Project DATARE was extended to the current and ideal distribution of Voluntary Points of Delivery (VDPs) of e-waste

7 PoM

The Volume Placed on the Market (PoM) in 2018 was calculated based on the values of exports, imports and production of electronics in Brazil

IDENTIFIED COMPANIES

Companies acting in the e-waste chain in Brazil

68 companies	93 companies	134 companies	379 companies
UnB	ABDI (2013)	Dias et al. (2018)	Project DATARE (2021)

DATARE Survey

TYPES OF ORGANIZATIONS:

379 Companies

43 Cooperatives and associations

5 NGOs and 12 computer recovery center (CRCs)

GENERAL DATA OF COMPANIES

230 parent company - 61

149 branch office - 39

66 with only CNAE 1° - 17%

Average capital share: 500K BRL

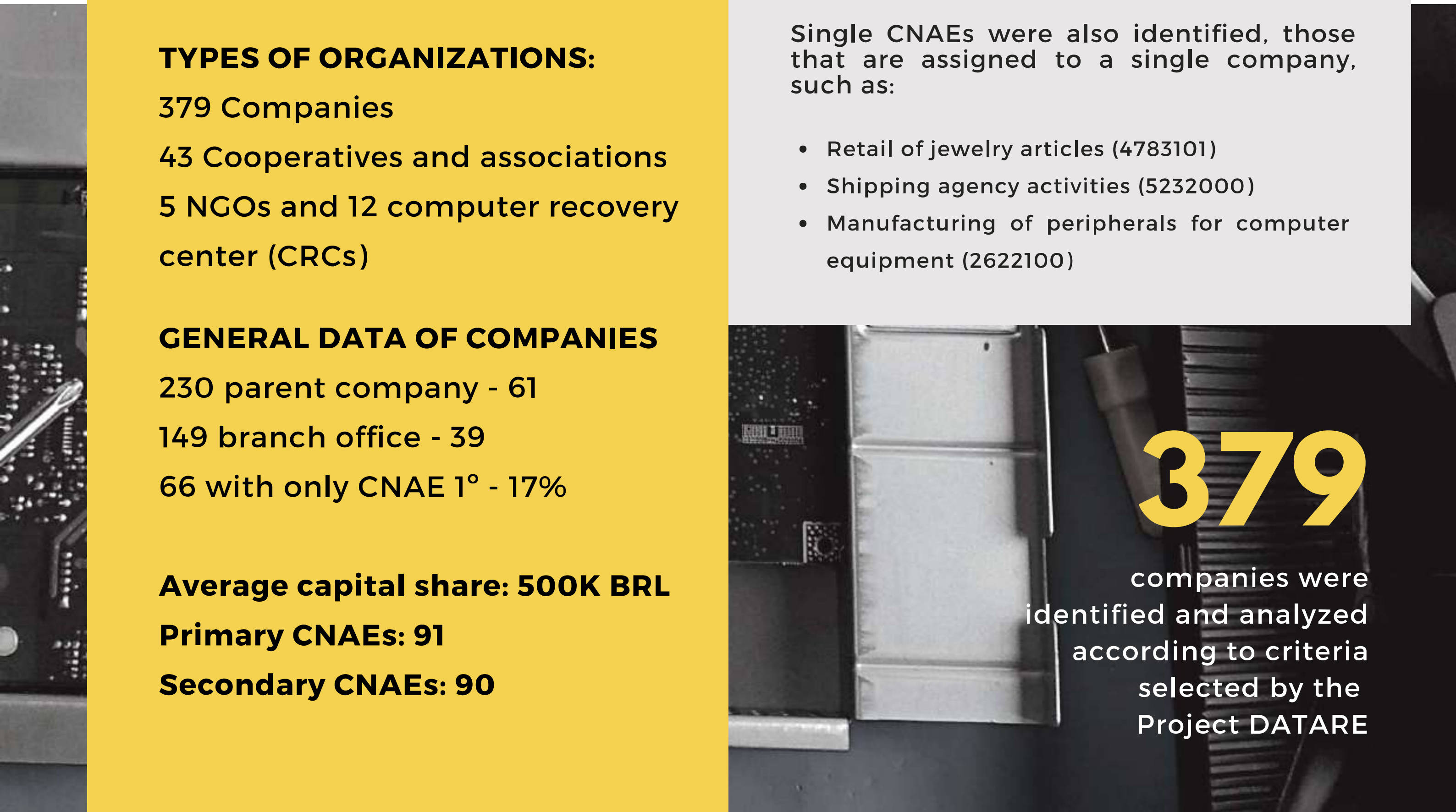
Primary CNAEs: 91

Secondary CNAEs: 90

Of the total CNAEs identified in the Project DATARE's survey, 24% were categorized as single CNAEs, i.e. 91 primary CNAEs for the 379 companies.

Single CNAEs were also identified, those that are assigned to a single company, such as:

- Retail of jewelry articles (4783101)
- Shipping agency activities (5232000)
- Manufacturing of peripherals for computer equipment (2622100)



379

companies were identified and analyzed according to criteria selected by the Project DATARE

CNAE

From a set of more than 560 identified companies, those with inactive CNPJ, those that did not have a National Economic Activity Code (CNAE) equivalent to the segment intended by the research, as well as cooperatives, CRCs and NGOs were excluded. The identification of a total of 379 companies is not an exhaustive survey of the national eco-industrial park and, likewise, does not qualify companies as technically able to operate in the segment.

Even so, this research suggests questions for technical qualification as established in Article 13 of Decree 10,240/2020, such as:

((i) environmental licensing,

(ii) qualification by management companies or entities, and

(iii) compliance with the ABNT NBR 16.156:2013 and ABNT NBR 15.833:2018 standards. Keeping in mind that the operational criteria are established in the Basic Operational Manual.

The CNAE codes vary significantly for some companies in the same area of activity and do not always reflect the company's performance in e-waste management.

This aspect denotes the possibility of re-evaluating the availability of codes that reflect the areas of activity and, therefore, make it possible to specify the different solutions for the e-waste management in the country, even aiding in the development of regulatory instruments and incentive policies from the diagnosis of the performance of recycling companies.

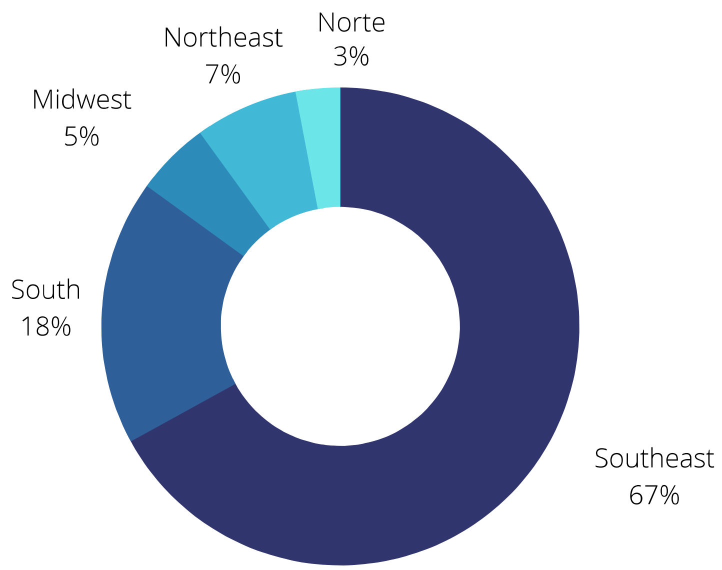
Some of the CNAE codes observed with greater incidence among the analyzed companies:

811400 - Collection of non-harzadous waste
4930202 - Land freight transport, except dangerous goods and moving, intercity, interstate and international
5211799 - Merchandise warehouses for third parties, except for general warehouses and furniture warehouses
3821100 - Treatment and disposal of non-harzadous waste
3822000 -Treatment and disposal of harzadous waste
3831901 - Aluminium scrap recovery
3831999 - Recovery of metalic materials, except aluminum
3832700 - Recovery of plastic materials
3839499 - Recovery of materials not specified previously

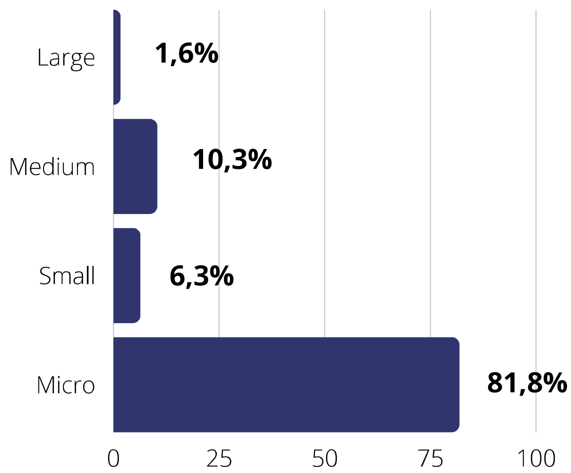
ECO-INDUSTRIAL PARK

A sample of companies that make up the eco-industrial park of value recovery from e-waste in Brazil was surveyed in the DATARE Project. The geospatial distribution of recycling companies in the national territory shows their concentration in the Southeast region (67%), coinciding with the greatest potential for the generation of electrical and electronic waste.

COMPANIES' SITES



COMPANIES' SIZES



SIZE OF IDENTIFIED COMPANIES ACCORDING TO BNDES CATEGORIZATION

MICRO - Up to 360 thousand BRL

SMALL - Up to 4.8 million BRL

MEDIUM - More than 4.8 million BRL
Lorene, GRI Koleta, Essencis, Cobremax, Indústria Fox, Umicore, Re-Teck, Metalúrgica Barra do Piraí, Harsco, Silcon, Geodis

LARGE - More than 300 million BRL
Stericycle and Flextronics

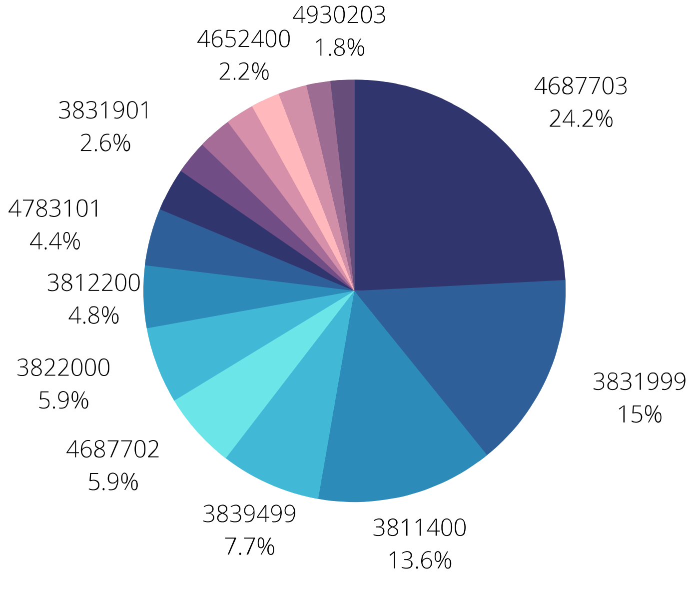
*** Large companies are manufacturing companies that also engage in repair, remanufacturing, or process secondary material.**

ECO-INDUSTRIAL PARK

The CNAE codes assigned to companies that operate in the management of electronic waste in the country can be an important indicator of the scope and priority of activities in this segment. It was verified the attribution of 1,279 CNAE codes for the 379 companies identified as acting in the e-waste management, representing an average of 3.4 codes per company. Of these codes, 207 represented single codes distributed between primary and secondary CNAEs. The frequency of the most recurrent codes for the analyzed companies are presented below. It can be seen that the wholesale of waste and scrap metal prevails in relation to the others and that most of them have a specific code, evidencing the diversity of primary CNAEs.

ANALYSIS OF THE 16 PRIMARY CNAE CODES WITH THE HIGHEST OCCURRENCE

CNAE	FREQUENCY	DESCRIPTION
4687703	66	Wholesale trade of waste and metal scrap
3831999	41	Recovery of metallic materials, except aluminum
3811400	37	Non-hazardous waste collection
3839499	21	Recovery of materials not previously specified
4687702	16	Wholesale trade of non-metallic waste and scrap, except paper and cardboard
3822000	16	Aluminum scrap recovery
3812200	13	Collection of hazardous waste
4783101	12	Retail trade of jewelry items
3832700	9	Recovery of plastic materials
3831901	7	Aluminum scrap recovery
4930202	7	Road freight transport, except for hazardous products, intercity, interstate and international
4687701	6	Wholesale trade of paper and cardboard waste
4652400	6	Wholesale trade of electronic components and telephony and communication equipment
4751201	6	Retail trade of computer equipment and materials
3821100	5	Treatment and disposal of non-hazardous waste
4930203	5	Road transport of hazardous products

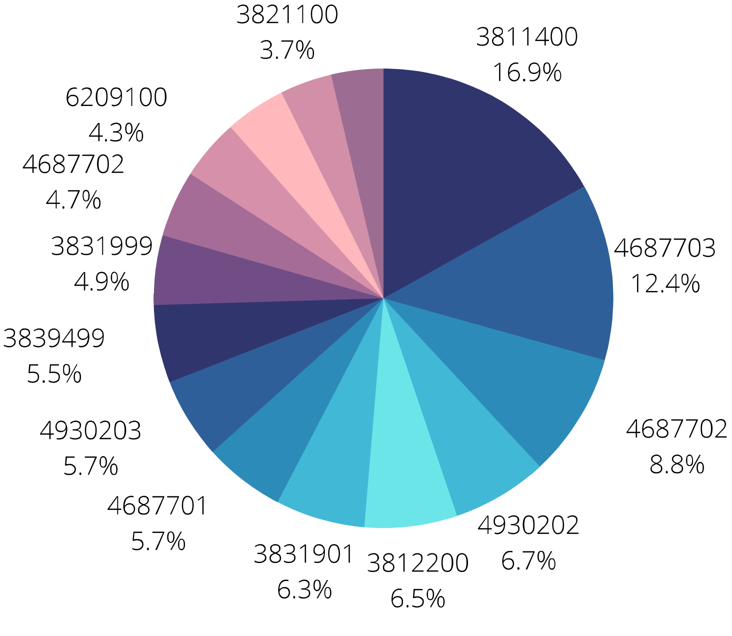


ECO-INDUSTRIAL PARK

The CNAE codes for the totality of the primary and secondary codes of the analyzed companies confirm the occurrence of the codes related to the collection of hazardous and non-hazardous waste, the wholesale trade of metallic and non-metallic waste and scrap, but raises to the third position, with 33 occurrences, the land cargo transportation, except for hazardous products.

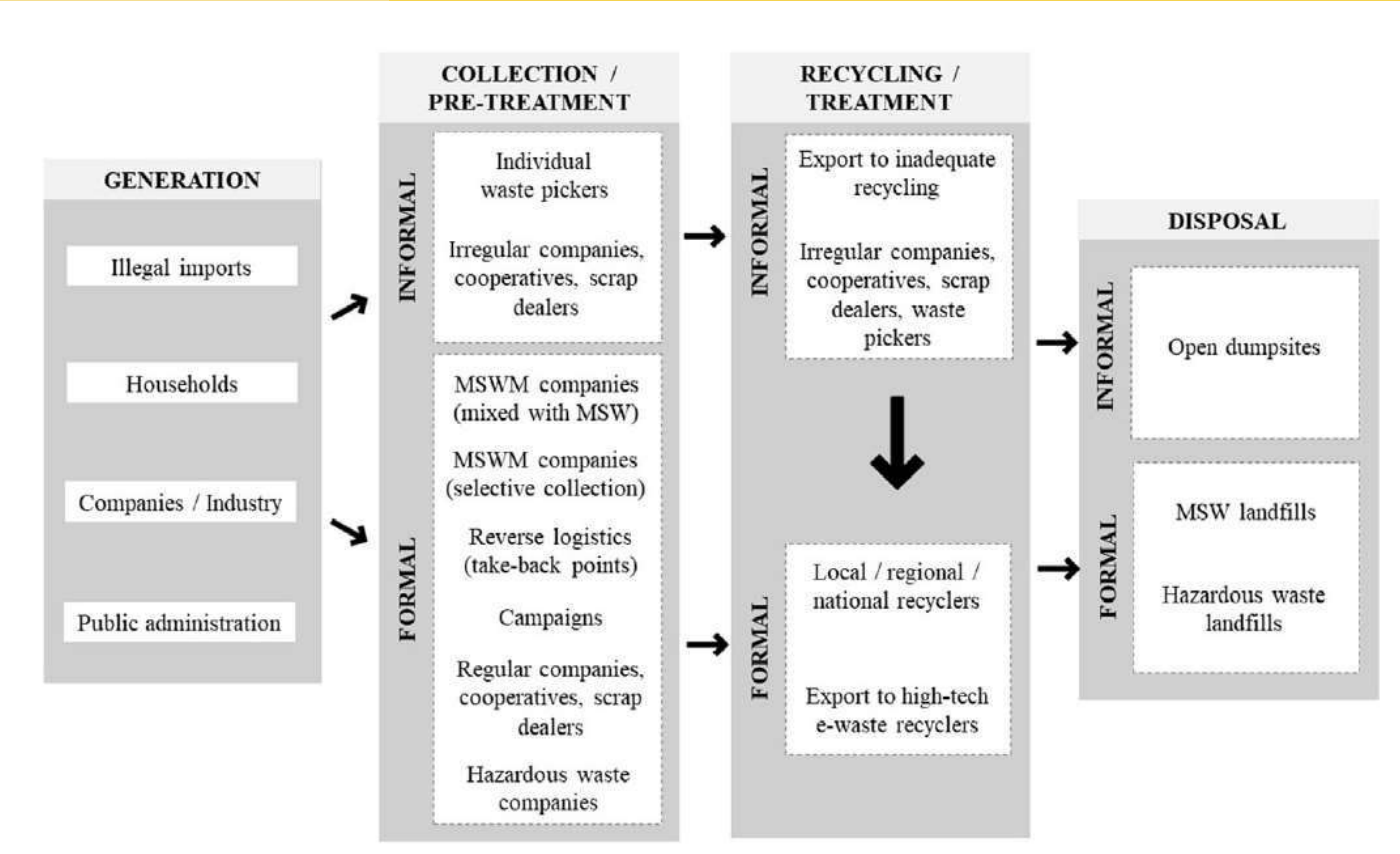
ANALYSIS OF THE 15 CNAE CODES WITH THE HIGHEST OCCURRENCE FOR THE SET OF PRIMARY AND SECONDARY CNAES

CNAE	FREQUENCY	DESCRIPTION
3811400	83	Non-hazardous waste collection
4687703	61	Wholesale trade of waste and metal scrap
4687702	43	Wholesale trade of non-metallic waste and scrap, except paper and cardboard
4930202	33	Road freight transport, except for dangerous goods, intercity, interstate and international
3812200	32	Collection of hazardous waste
3831901	31	Aluminum scrap recovery
4687701	28	Wholesale trade of paper and cardboard waste
4930203	28	Road transport of dangerous goods
3839499	27	Recovery of materials not previously specified
3831999	24	Recovery of metallic materials, except aluminum
4687702	23	Wholesale trade of non-metallic waste and scrap, except paper and cardboard
6209100	21	Technical support, maintenance and other information technology services
4930201	21	Road freight transport, except hazardous products and removals, municipal
3821100	18	Treatment and disposal of non-hazardous waste
7020400	18	Consulting and business management activities, except specific technical consulting



E-WASTE FLOWS

Ottoni and Xavier (2019) show that a huge portion of Brazilians (approximately 85%) keep at home their post-consume electronic devices instead of discarding them in the existing e-waste collection points. This is an important challenge to consider regarding the reverse logistics approach. The collection performance and the collected volumes are crucial for the efficiency of the entire system.

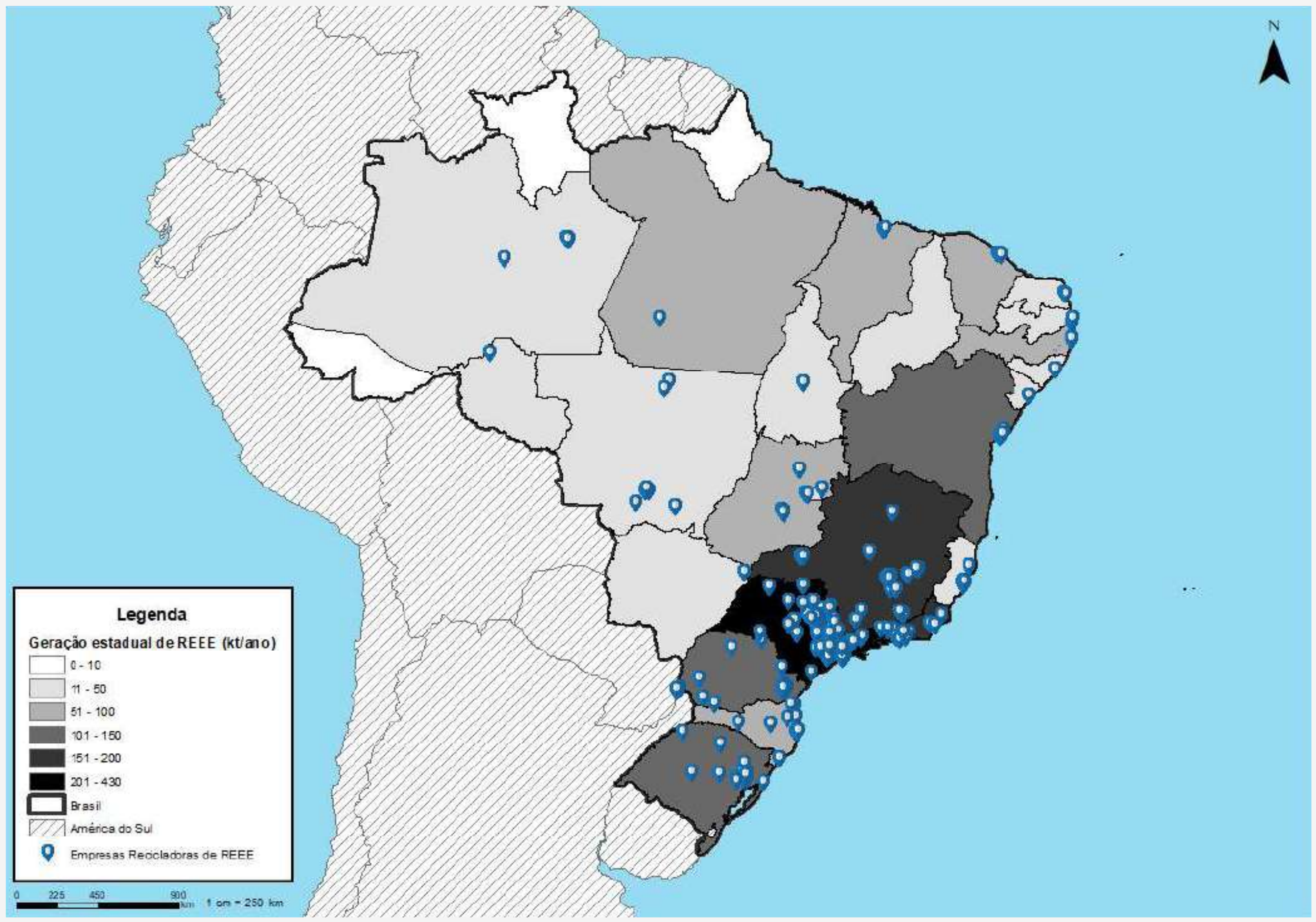


Framework of general formal and informal e-waste flows in Brazil (Xavier et al., 2021)

As presented in the diagram, both, the formal and informal flows work in coordinated activities since the discard of e-waste by the holders (consumers), flowing by the collection/pre-treatment steps, the recycling/treatment processes and reaching the disposal alternatives.

According to the value recovering along this framework, short cycles (reusing) or long cycles (recycling) are performed according to the circular economy principles. The importance of informal stakeholders are highlighted by manual operations that guarantee volumes and valuable sorting of materials.

GEOLOCATION OF E-WASTE COMPANIES



The states of São Paulo, Minas Gerais and Rio de Janeiro show the highest rate of e-waste generation due to population density.

On the other hand, Bahia has a significant generation. However, it does not have a significant enough amount of recyclers to meet the observed demand. The concentration of recyclers in capitals and along the coast was also a pattern verified for the Northeast of the country.

Another panorama is observed for the states of Mato Grosso and Goiás that present a more uniform distribution of identified recyclers, and a lower generation of electronic waste.

VOLUNTARY DELIVERY POINTS (VDP)

According to Article 48 of Decree No. 10.240/2020, it is established the location of at least one Voluntary Delivery Point (PEV) for every 25 thousand inhabitants in meeting the requirements for the implementation of the e-waste Reverse Logistics System (RLS). Thus, the decree itself presents in its Annex III the cities of São Paulo, Rio de Janeiro, Brasilia, Salvador, Fortaleza, Belo Horizonte and Manaus, the most populous in the country, exceeding 2 million inhabitants each.

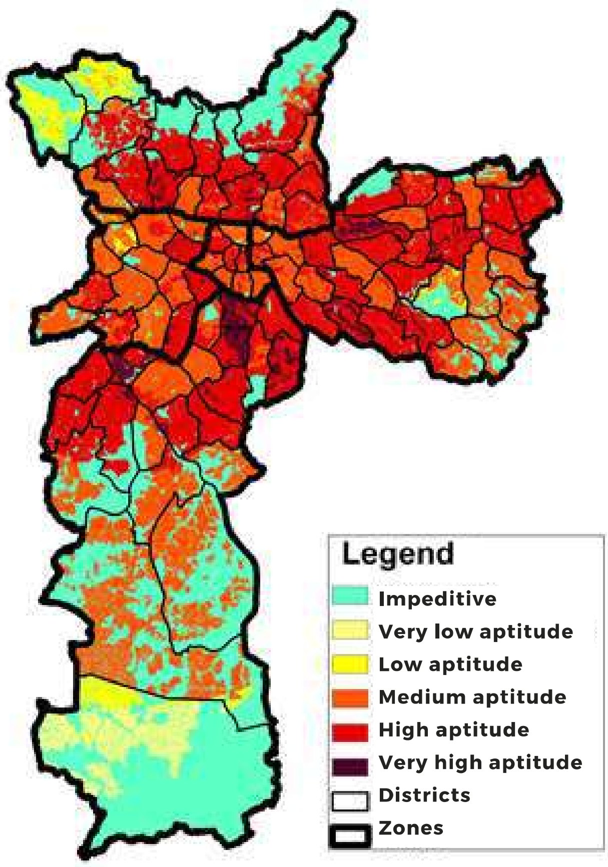
According to the decree, the state of São Paulo must have, by the end of 2021, at least 8 cities served by the RLS, while the states of Rio de Janeiro and Minas Gerais must each have 3 cities served in each one. The states of Bahia, Ceará, Espírito Santo, Goiás, Mato Grosso do Sul, Pernambuco, Paraná, Rio Grande do Sul, Santa Catarina and the Federal District must have at least one city served in each.

As required by law, the cities of São Paulo, Rio de Janeiro and Brasília must have a number of PEVs equivalent to 480, 267 and 119 units, respectively.

Case study: City of São Paulo

As seen in the map (image to the right), the study for the allocation of VDPs in the city of São Paulo through multi-criteria analysis in GIS highlights the areas with the greatest potential for the installation and collection of e-waste (Araujo et al., 2020) .

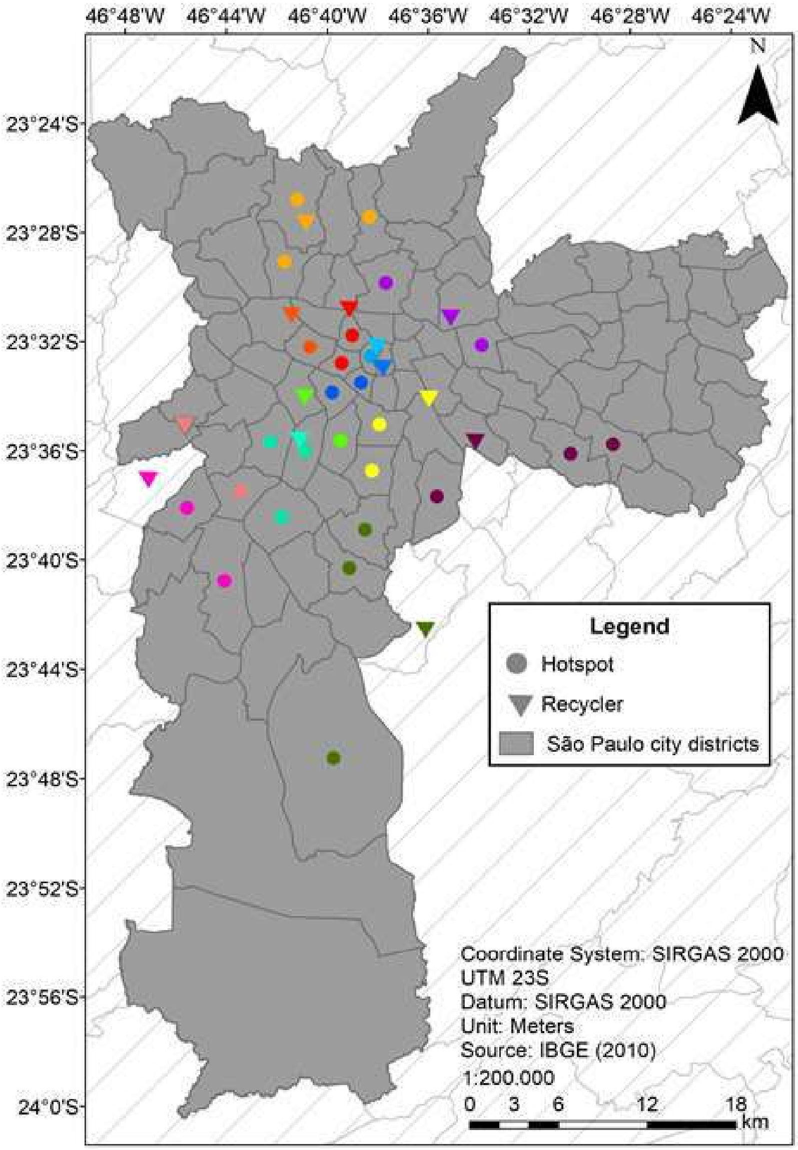
To define the best locations, 13 attributes and 40 sub-attributes were used in the analysis, considering, for example, generation potential, existence of transport network and population density. The method can be replicated in other states, showing the potential of cities in meeting legal requirements.



Aptitude of VDPs allocation in the city of São Paulo
Source: Araujo et al. (2020)

ROUTES TO REVERSE LOGISTICS

The analysis of the routes for the e-waste reverse logistics was possible due to the location of recyclers and the points of the highest concentration of e-waste generation, also called hotspots. The study identified 26 total e-waste hotspots in the city of São Paulo, mostly in the central and richest part of the city, along with the distribution of recyclers (Cugula et al., 2020)

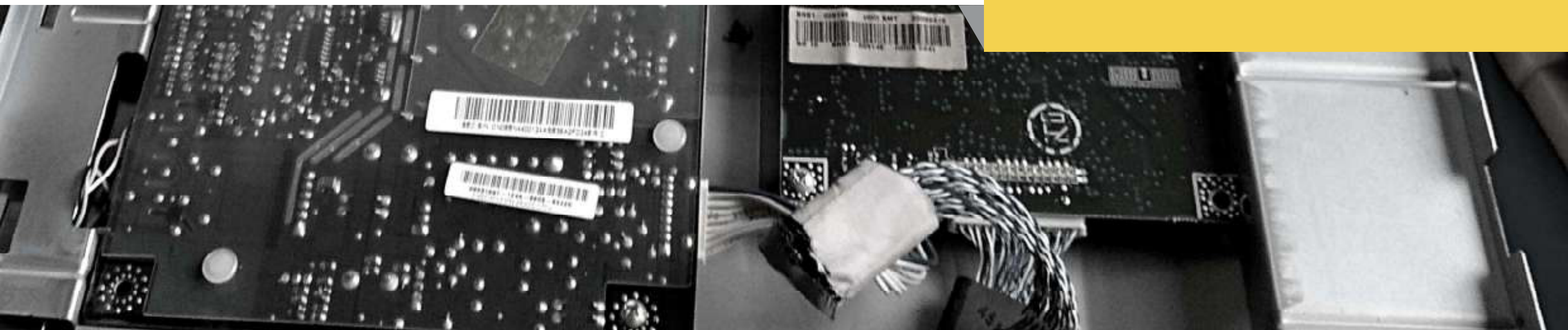


Identification of WEEE hotspots and recyclers in the city of São Paulo. Source: Cugula et al. (2020)

Case study: City of São Paulo

This study allowed the identification of the adherence between the generating points and the possibility of locating VDPs with the intention of directing the e-waste category to their respective processing points.

Future studies may also consider the processing potential and typology of materials to be recovered.



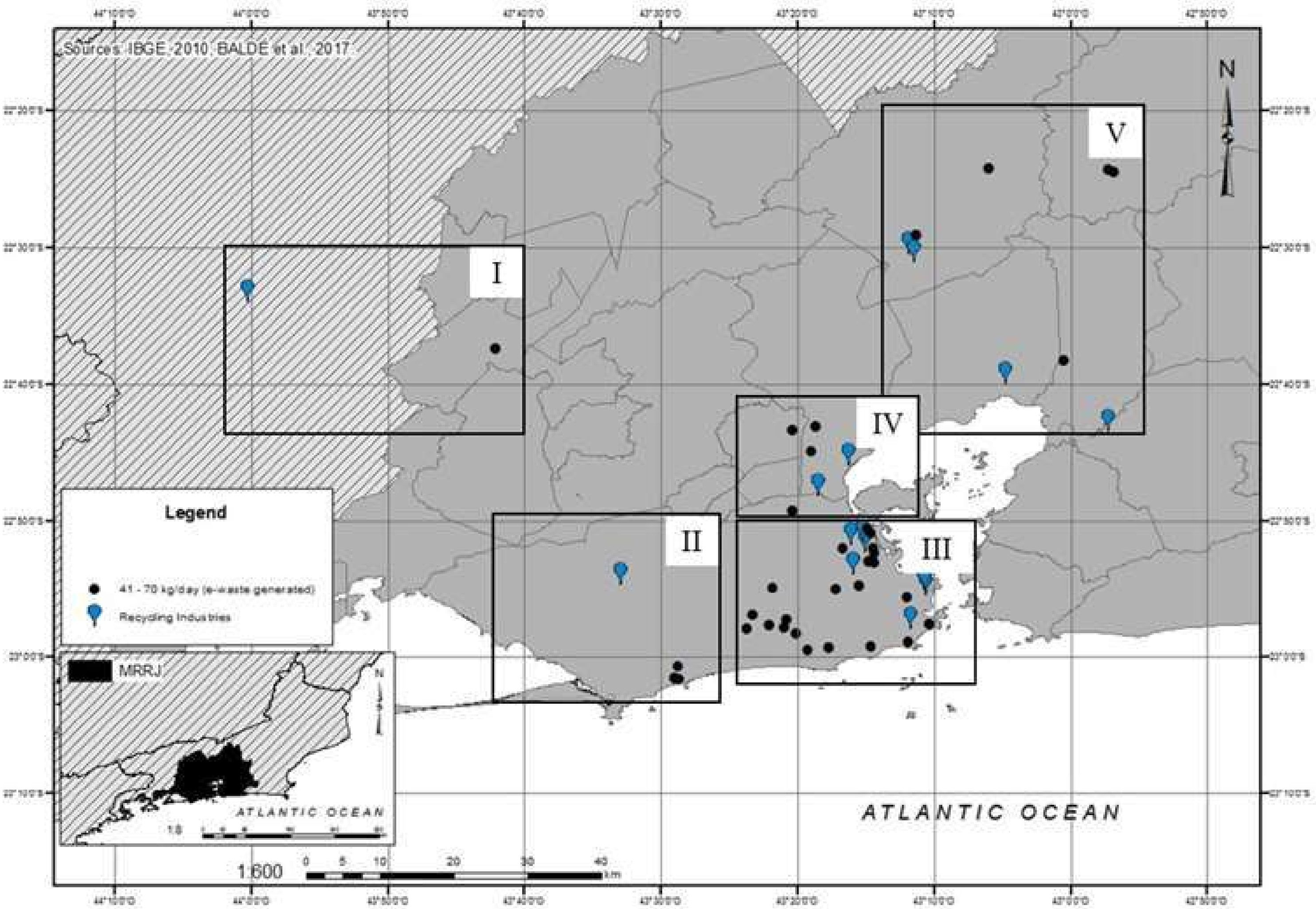
CLUSTERING

Case study:
Rio de Janeiro metropolitan region

The analysis of the location of companies acting in the management of electronic waste allowed for the identification of possible clusters due to the concentration of processing units and the generation of e-waste in the analyzed area.

In the figure below, five possible clusters are presented for the Metropolitan Region of Rio de Janeiro, RMRJ (Ottoni et al., 2020). As presented, regions I and II would have less adherence between areas with higher generation potential and the location of processing units. While regions III and IV would have a better distribution of processing units. Region V, in turn, has a greater distance from the processing units, requiring greater displacement and need for the installation of more PEVs for the consolidation of volumes to optimize routes and processing of the collected material.

Thus, the study highlights the need for differentiated strategies according to the distribution of the reclaiming units in space.



Recyclers and estimation of e-waste generation in the RMRJ. Source: Ottoni et al. (2020)

SIS-DATARE

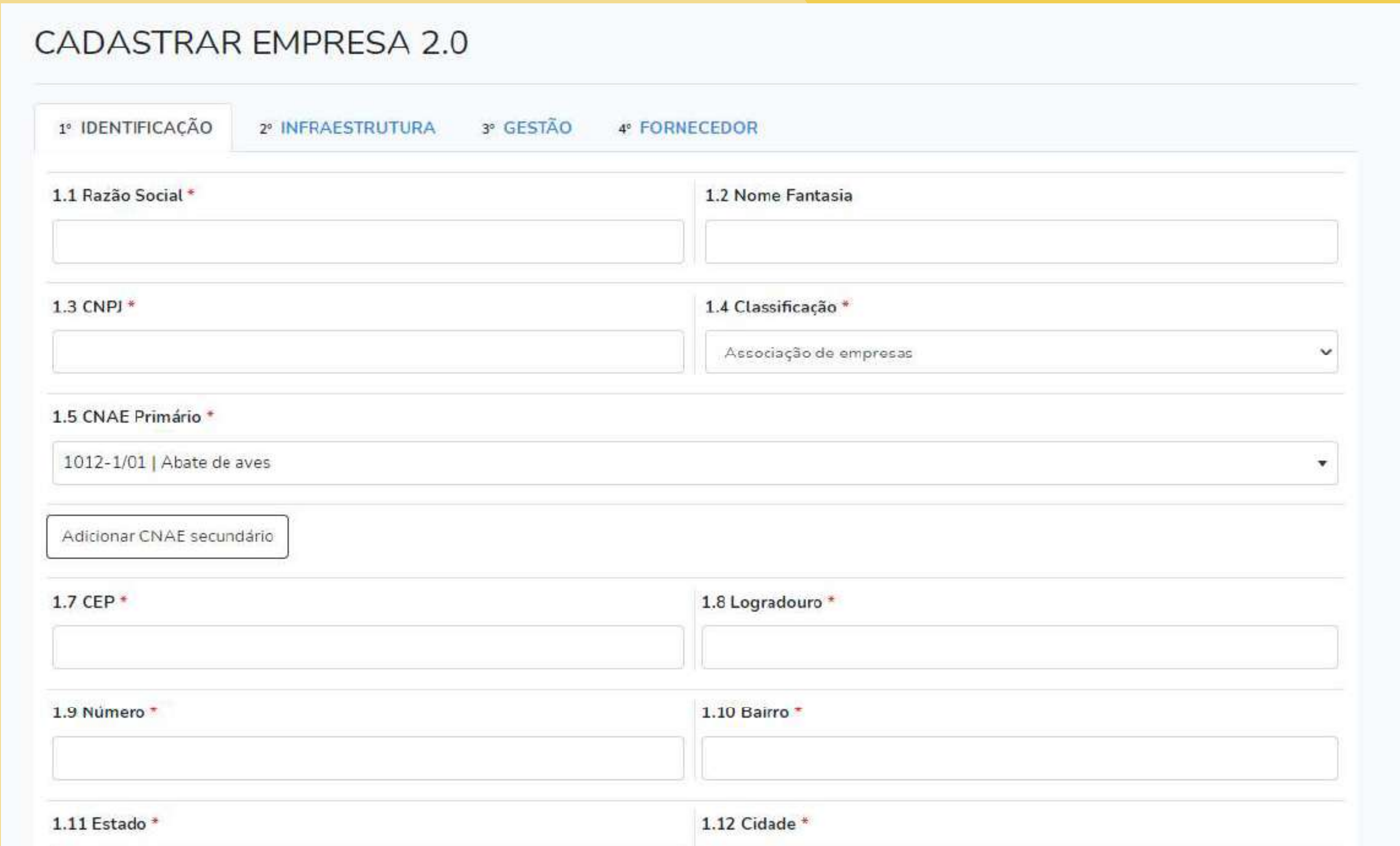
The Sis-DATARE system is one of the results of the Project DATARE developed throughout 2020 and 2021 by the Centre for Mineral Technology (CETEM).

Many entrepreneurs have become interested in operating in the reverse manufacturing segment, recycling, production and commercialization of secondary raw materials recovered from electronic equipment scrap. However, very little information has been made available on the subject.

Thus, the Sis-DATARE came to life from the demand for a consistent database to identify and evaluate the agents active in the management of waste electrical and electronic equipment in Brazil.

The Sis-DATARE system allows the search for registered companies and the verification of the company's status regarding the data provided to the Project DATARE.

The Sis-DATARE database contains the registry of companies active in reverse logistics of e-waste in Brazil in terms of their general information, infrastructure, management and suppliers.



VOLUME PLACED ON THE MARKET- POM

In Phase 1 of the implementation of the Reverse Logistics System (SLR), between February and December 2020, it was incumbent to create the Performance Monitoring Group (GAP), comprised of entities that represent manufacturers, importers, distributors and traders of electrical and electronic products nationwide to monitor and disseminate the implementation of SLR and detail the group's functions and activities in internal regulations.

The management of post-consumption electro-electronic equipment is significantly complex due to the diversity of products and the consumers' lack of knowledge about the destination channels. The targets established in Decree 10.240/2020 for the collection and e-waste disposal are based on the total volume of electronic products placed on the market (PoM) in Brazil.

POM and Decree No 10.240

The calculation of PoM must be performed for household products, using the weight in the base year 2018 as a reference. For this purpose, volume by weight targets were established for the e-waste collection and disposal, with staggered percentages, starting Phase 2 from the implementation of RLS with initial target of 1% (in 2021) of collection and disposal, moving on to 3% (in 2022), 6% (in 2023), 12% (in 2024), up to 17% (in 2025).

Decree No. 10,240/2020 establishes a list of 215 products as the target of reverse logistics in Brazil. However, after analyzing the list and comparing the items with the codes assigned for import and export (Siscori database of the Internal Revenue Service) and for production (IBGE database), a screening was performed with the elimination of 3 repeated items. Weights were found for 96 items on the list, of which 17 had a direct correlation with the IBGE code and the other 79 items were grouped into 26 IBGE codes.

PoM calculation

As references for the PoM calculation consolidated methodologies applied by European countries and disseminated by the United Nations University were used. The methods used production, import and export volumes as a basis.

PoM methodological approach

- Norden (2009): Method to measure the amount of WEEE generated
- Magalini et al. (2014): Study on collection rates of WEEE (European Commission)
- Baldé et al. (2017): Global E-Waste Monitor
- Forti et al. (2018): Statistics for E-Waste
- Forti et al. (2020): Global E-Waste Monitor
- United Nations University (UNU)

In the Project DATARE, the PoM (measured in tons, t) was calculated using the equation below:

PoM (t) = Production (t) + Import (t) - Export (t)

Placed on Market (PoM) calculation: step-by-step

PRODUCTS LIST
Decree No 10,240/2020
215 items

Verifying →

PRODUCTS LIST
(reordered)
187 items

PoM (t) = Production (t) + Import (t) - Export (t)

SIDRA / IBGE
207 codes

IBGE CODE
2XXX-2XXX

COMEX STAT / SISCORI / RECEITA FEDERAL IRS
111 NCM codes identified with weight values

NCM CODE
8XXX.XX.XX

Data were harmonized according to the description and categies

BASE YEAR 2018

Total imported: 475.661 tons

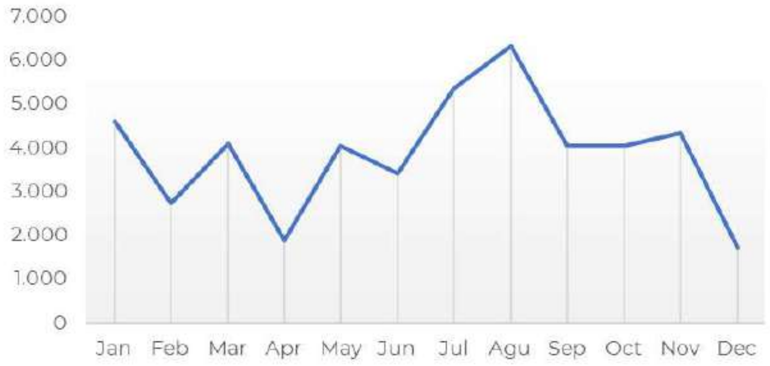
Total exported: 12.280 tons

Total production: 1.325.379 tons

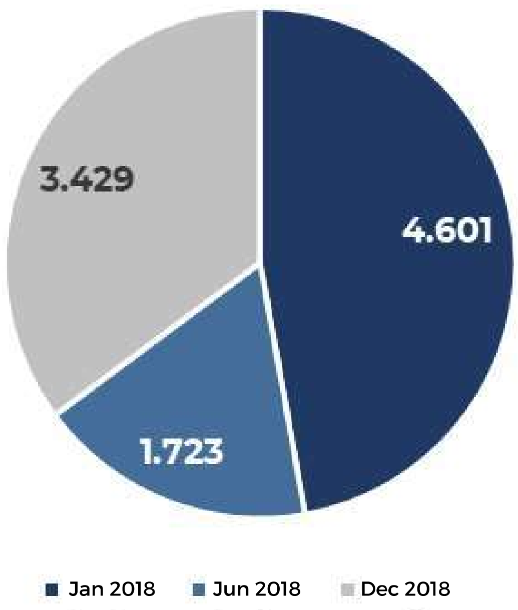
PoM = 1.788.760 tons
placed on market in base year 2018

IMPORTED ELECTRONICS IN BRAZIL (2018)

Volume of printed circuit boards imported in Brazil in 2018 (t)



Printed circuit boards import in weight (t/month)



From the analysis of the data provided by SISCORI, the export and import volumes for specific e-waste categories in Brazil can be identified.

The spreadsheets have extended data referring, for example, to the origin, volumes, import values and even the shipping costs. Such data allow comparison with international movement.

In 2018, 46,622 tons of printed circuit boards were imported in Brazil. For the month of January alone, an import value of US$ 37 million and a freight value of US$ 1.8 million. The boards were imported from 20 countries, with China accounting for over 95% of imports.

As the import of electronic equipment in Brazil significantly exceeds the exported volume, only imported volumes are an important indicator for estimating the e-waste generated in the country.

CONCLUSION

The management of e-waste represents a global challenge due to the potential risks and the market value of recoverable products and materials. In Brazil, e-waste management is regulated and the targets for the implementation of the reverse logistics system that began in 2021 should be completed in 2025.

The definition of the categories of the volume of electrical and electronic products placed on the market (PoM) is a fundamental requirement for the verification of collection and disposal targets in the country. Thus, this study sought to present forms of categorization of electrical and electronic equipment through the analysis of identification codes (IBGE and NCM), as well as to identify the PoM for these devices as a subsidy to meet the targets set for the implementation of the e-waste RLS in Brazil.

The analysis of CNAE codes for the categorization of companies that make up the eco-industrial park for the e-waste management is an issue that can impact the configuration of business models based on circular economy principles and the monitoring of the agents' performance. Therefore, this topic must be prioritized or reconfigured so as to enable the harmonization with the legal and regulatory requirements .

Challenges

- Limiting data availability
- Production companies protect data for strategic reasons
- Inconsistent databases
- Need for data harmonization

Opportunities

- Internationally validated methodology
- Validation of results
- Identification of the most viable segments/places (value and size)
- Identification of e-waste urban mining potential in Brazil

Eco-industrial Park Identification

- Quantification and qualification of the companies
- Analysis of the production potential and compliance with the legislation's targets
- Identification of the diversity of performance
- Contribution of integration / strengthening of activities

Georeferencing

- Urban mining siting analysis
- Clusters identification
- Analysis of the eco-industrial park's potential

Volume Placed on Market - PoM

- Points for harmonization of categories
- Clarity regarding legal requirements
- Identification of equipment groups from production
- Analysis of dispersion in relation to value (FOB) and volume (weight)
- Potential of urban mining in Brazil in economic values

Circular Economy

- Proposed content for regulation in the sector
- Identification of the degree of circularity in the segment

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