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Estimation of Mobile Phone and Computer Waste: A Case Study of Kashmir University, Hazratbal

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ABSTRACT- Electrical and electronic equipements are classified as devices that operate on electrical current and electromagnetic fields. These EEE are transformed into WEEE after reaching the end of their useful lives. The usage of electrical and electronic equipment has expanded quickly, and because of their shorter lifespans, a lot of e-waste is produced globally. WEEE production reached 44.7 Mt in 2016 and would reach 52.2 Mt by 2021. The amount of elements in e-waste, including lead, chromium, arsenic, cadmium, and others, makes it dangerous for both the environment and living things. Only the estimation of mobile phones and personal computers at the University of Kashmir in J&K is the focus of this study. For that reason, I anticipate e-waste creation using a modified exponential equation and utilized the end-of-life model as a basis model to estimate current e-waste generation. At the University of Kashmir, a questionnaire survey was undertaken to learn how consumers dispose of their electronic devices once they have served their purpose. The typical life lengths of electronic devices (such as mobile phones and personal computers) have upper and lower bounds in two scenarios, respectively. The study's findings indicated that, in the case of mobile phones, the total amount of garbage created for 2021 will be close to 313.88 units and might reach as high as 561.57 units by 2025. The total amount of garbage produced under the lower limit is projected to be 358.15 units in 2021 and to rise to 599.05 units by 2025. Similar to PCs, the total waste created by PCs will increase up to 551.08 units by 2025, from 298.52 units in 2021. The total amount of garbage produced under a reduced restriction, however, was 325.72 units in 2021 and will rise to 581.84 units by 2025. As a result, enough infrastructures should be in place to handle the volume of trash that is produced, and this assessment can serve as a basis for politicians to express timely concern and take appropriate action to route e-waste from its user to disposal.

KEYWORDS- E-waste Generation, Kashmir University, Mobile Waste, Electrical And Electronic Equipment's.

I. INTRODUCTION

Electrical and Electronic Waste (EEE) has become a part of mankind's rich way of life as a result of rapid improvement in the fields of research and innovation, financial development, and enhanced way of life. Since they have become a necessary part of our lives, there has been a significant increase in the use of electrical and electronic hardware. The absence of spare bits of old and obsolete goods and the availability of revamped new items with more capabilities and gadgets at a reasonable cost are the reasons behind EEE's exceptional growth. As a result, purchasing new products is more beneficial and profitable than repairing and updating old ones. Electronic garbage, sometimes known as E-waste, has become a huge concern all over the world. Electronic devices that have outlived their usefulness fall under this category. One of the fastest-growing components of the present waste water system is electronic product trash. The amount of e-waste has grown significantly during the past few decades. E-waste includes items like computers, televisions, washing machines, mobile phones, air conditioners, and refrigerators, to name a few[2]. The worldwide WEEE age amount in 2014 was 42 Mt, with 12 Mt generated in Africa and 16 Mt produced in Asia, with an annual increase rate of 4 to 5 percent, according to Balde et al. [5]. According to the study, the MENA area produced 2.4 Mt of WEEE, with an average of 8 kg/person/year ranging from 0.9 kg to 17.2 kg/person/year. 19 nations in the area, totaling over 400 million people, were mentioned in the study[28]. Sales of electronics are growing significantly in emerging nations. The useful life of electric and electrical items are over. They become outdated (EOL) when they no longer meet the demands of their original users. If not properly managed, the dangerous and poisonous components included in e-waste can cause asset loss, as well as significant environmental and financial problems. In order to address the removal and treatment of e-waste and improve the financial, environmental, and social advantages for the many parties concerned, developed nations have implemented regulations and mandates[3]. The WEEE Order (European Commission-WEEE Directive, 2003), which promotes e-waste reuse, recovery, and repurposing while also requiring landfill collection reduction measures, and the Restriction of Unsafe Compounds (ROHS) order, which forbids the use of dangerous and hazardous substances in electronic device[20].

Since e-waste is a complicated movement involving a variety of devices, the paper facilities focus on the example of Information and Communication Technologies (ICTs) and particularly the paper recycling facilities centre on the example of Information and Communication Technologies (ICTs), particularly its fundamental component, such as computers, because e-waste is a complicated movement involving a variety of devices (PCs)[10]. Depending on the evaluation method and the information available in each case, life expectancy can be determined in a variety of ways. Due to the development of ICT devices and the steadily declining life expectancy of that class of devices, ICT waste has grown to be a significant contributor to both the purchase and a large amount of e- garbage. With the exception of other industrializeds nations like the United States, Germany, Brazil, China, and Japan, India is the country with the highest e-waste generation rates; nevertheless, the recycling rate in India is the lowest at only 2% per year of the country's e-waste production[23]. Because it is a market for investors from other affluent nations, India produces a significant amount of electronic trash. The creation of electronic garbage in India would reach 5.2 Mt by 2020, predicts ASSOCHAW (Associated Chambers of Commerce of India)[4]. Due to the lack of a system in place to collect it, e-waste is a huge issue in India. If the regulations outlined in the 2016 E-waste Management Rule were followed, more than 2% of India's yearly e-waste production would be recycled, which would be a poor implementation of the policy. India's official recyclers are not provided any incentives, which is the second problem. If they were given certain incentives, more e-waste would be formally recycled. There hasn't been any progress in India's e-waste recycling since the government doesn't offer incentives to these official recyclers and instead imposes further pressure by imposing a 12 percent GST on them. Infrastructural e-waste recycling is likewise receiving relatively little investment[24[. E-waste disposal and collection are not handled by any system. Thus, we must not only develop policies but also implement them as soon as feasible if we are to safeguard both our human resources and the environment. A sizable amount of e-waste is also produced in Jammu and Kashmir. There was reduced e-waste output in the most recent decade, 2009–2010. It was estimated that 492.5 tonnes of e-waste were produced. On the other hand, since 2010, technology has advanced significantly, making the internet widely available. Consequently, there has been a sharp increase in the e-waste creation curve.[9]

Study Area: The study area for my dissertation is Kashmir University Which has a campus area of 247 acres. The institute is divided into three parts- Hazratbal campus, Naseem bagh campus and Mirza bagh campus . Outside and inside the campus there are residential buildings for the faculty.

I designed a Google Forms questionnaire for my research, which is restricted to mobile devices and personal PCs. The questionnaire asks the following questions:

At first, the queries are social and demographic in nature. The age, location, education, and several members of the campus are all listed in this section.

The queries were designed to gather data on personal computers (laptops and desktops) and cell phones. The questions were picked with the purpose of estimating existing and prospective waste in Kashmir University.

The questions were also intended to gauge the degree of understanding and accountability for the proper disposal of electrical waste.

II. METHODOLOGY

A. End-of-Life Model

In this approach, the sources, paths, intermediates, and final destinations are all described. It is also called as EOL since the material may be examined utilising this e-waste destiny. The fate of WEEE will be represented by this model, along with the several flows that might result in options for EOL and the different intermediate activities that must take place before EOL. To estimate the creation of e-waste that will reach its EOL options, lifetimes related with each process must be reached before those options can be used.

B. Relevant Process for the Development of the EOL Model

To create an end-of-life model, MFA must be conducted according to specific guidelines.

Selection of equipment: The tools are selected depending on the objectives of the study, its extent, and the calibre of the human and financial resources available to MFA. The tools used in this study are the most prevalent and may be found in every house. Therefore, laptops and mobile devices are considered.

Relevant Flow and Process: With this knowledge, I can determine the typical lifespan of the electrical device. It is necessary to create a model that is both straightforward and trustworthy in order to represent the actual scenario of waste flow in the real world. When new electronic items reach their end of life, they can be reused, stored, repurposed, or landfilled. The questionnaire will aid in the investigation of the routes taken by the selected equipment to achieve end-of-life status, as well as the time spent by EEE in each phase.

There are users who can use the selected EEE without fixing it (LN), users who can use it after repairing it (LRe), and users who can store it (LS). This is also referred to as the end-of-life of EEE and is determined using surveys.

Determination of rate of mass flow: To comprehend this concept, we must first comprehend the word transfer coefficient (TC). When a process has many outputs, this phrase is utilised. As a result, TC stands for the rate of product flow, which indicates the percentage of time it takes to move from one process to another.As shown in fig 1.

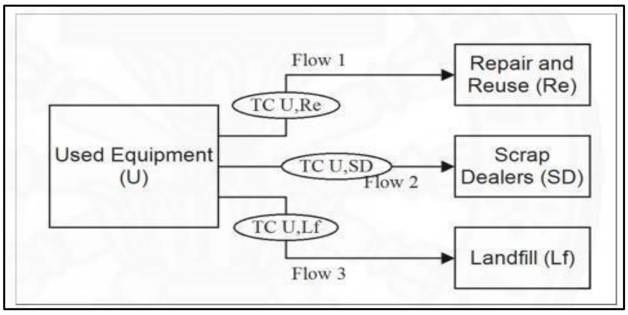

Figure 1: displaying the various flows following the use of new equipment

It is up to the user to determine what to deal with the old phone after having a new smartphone or PC for LN years (U). The TCs are determined based on how consumers dispose of waste during each step. URE denotes used mobile phones that are being repaired and then reused. USD denotes the temporary storage of equipment before it is sold to scrap dealers, as well as a variety of other end-of-life options. ULF denotes equipment that has been taken to the landfill for final disposal.

Assessment of total mass flow: In order to create the best fit curve for the complete range of e-waste returning to its EOL in year Y, to Sales numbers are first used. To calculate the sales data, or the entire variety of EEE offered for sale, an equation might be utilised. It is said that YE(Y) = ae ^{bx}.

Where YE represents the entire amount of electronic equipment that is released onto the market in the anticipated year (Y), and a and b represent the regression curve's constants.[27]

Since the garbage produced in each given year (Y) will eventually approach different EOL alternatives Therefore, it is necessary to add TC for each flow and to alter the life spans for each processing run and is given by:

$$y_{E,i}(Y_p) = TC... * TC.... * .... * ae^{b(Y_p - Y_B - LifeSpans)}$$

Where YE,i denotes the percentage of e-waste from a certain flow that reaches EOL,

Sales for the base year are denoted by YB, and YP is the forecast year for which we wish to estimate.

Sensitivity Analysis: The estimation and creation of e-waste are influenced by two variables: TC and life lifetime. As long as the predicted time is still in effect, TC is defined by disposal behaviour. Utilizing the consumer's usage habits, which may be determined via a pre-developed questionnaire, it is possible to determine the lifespan of electronic equipment. The confidence interval can be calculated using a 95% confidence level as follows:

$$C.I. = \bar{L}_N \pm t_{\alpha/2} \frac{S_{\bar{L}_N}}{\sqrt{n}}$$

Assuming sample mean of LN, as $\bar{L}$ N

S $\bar{L}$ N, is the sample's standard deviation, and n is the total number of observations.

A crucial value for the level of significance, t2 , is calculated from the t-distribution

at n-1 degrees of freedom.

This formula may be used to calculate the CI of LN, LRe, and Lst for computers and mobile devices. As a result, there will be upper and lower life span restrictions. A strategy is created based on these two categories.

III. RESULTS AND DISCUSSION

A. Results

The findings from data acquired from the University of Kashmir in jammu and kashmir are presented in this chapter. For this purpose The findings from data acquired from the University of Kashmir are presented in this chapter. ose, I received 114 responses to the questionnaires I provided to University residents, and I assessed the amount of e-waste generated and disposal characters based on these responses.

User experience is utilised to calculate the life spans of specific equipment via a questionnaire, and different confidence intervals are generated for different procedures based on that.As shown in table no. 1 range of an electrical device's typical life.

Table 1: The range of an electrical device's typical life

Equipment	Duration of new equipment's life (LN)	Lifetime following repair (LRe)	Durability of transient storage (LSt)
Mobile Phones	2.41 ± 0.14	1.39 ± 0.03	2.25 ± 0.45
Personal Computers	6.25 ± 0.22	4.45 ± 0.14	3.45 ± 0.53

Calculating the amount of mobile devices that are considered e-waste:

To comprehend the pattern and projection of e-waste in the future, it is essential to have historical national statistics data. The statistics department's website and the Indian Customs Department's website were used to collect the data. These are the sales numbers for mobile phones.

Since the data that are now accessible are national data, but I am estimating for Kashmir University, which needs to be modified because there aren't any local data, and regression is needed for future estimation, which is derived from the current data. The best curve fit is utilised to generate the curve using this data. Curves of many kinds are possible, including exponential, linear, logarithmic, power, polynomial, and others. The equation and R2 value are the result of exponential regression, which in this instance offers the best possible curve fit.

Y= 423990e0.1286x

The Ministry of Statistics and Program Implementation claims that, Hazratbal town has 0.042 percent of Indian families with mobile phones, which means that around 0.042 percent of all mobile phones are shipped to Hazratbal market. Nearly 10.8% of all mobile phones in Hazratbal are placed in Kahmir University, resulting in the updated equation:

Y= 19.23219e0.1286x{0.042% x 10.8% x 423990=19.23219}

Calculating the amount of mobile phones that are produced as e-waste:

Case 1(Upper Limit): LN= 2.53 years, LRe= 1.42 years, LSt= 2.70 years

As shown below in table no. 2 volume of discarded mobile phones produced for case1:

Table 2: Volume of discarded mobile phones produced for case1

Using the EOL option	2021	2022	2023	2024	2025
Stored in Home	123.6043	141.7155	161.1624	183.2688	208.420
Landfill	19.0464	21.6726	24.6449	28.2253	31.2172
Scrap dealers	41.6347	47.3485	53.8463	61.236	69.6398
Shops	128.5851	171.548	195.0905	221.8637	252.3112

Case 2 (Lower Limit): LN = 2.28 years, LRe= 1.33 years, LSt= 1.77 years as shown in table 3

Table 3: Volume of discarded mobile phones generated for case2

EOL Option Taken	2021	2022	2023	2024	2025
Stored in House	129.0666	146.7812	166.9236	189.8314	215.8830
Landfill	21.2342	24.1483	27.4623	31.2312	35.5172
Scrap dealers	45.4208	51.6541	58.7430	66.8046	75.9724
Shops	162.4286	184.7193	210.0693	238.8983	271.6836

Equation used for PCs $Y= 440618e^{0.1752x}$

Based on data from the Ministry of Statistics and Program Implementation, the Hazratbal town contains 0.095 percent of all Indian families with a personal computer, which means that around 0.095 percent of all personal computers are supplied to the Hazratbal market.

Nearly 6.03 percent of Hazratbal's PCs are assigned to Kashmir University, resulting in the amended equation:
$Y= 25.24080\ e^{0.1752x}$ {0.095% x 6.03% x 440618= 25.2408}

Calculating the creation of e-waste using PC units:

Case 1(Upper Limit): LN=6.48 years, LRe= 4.60 years, LSt= 3.99years As described in below table 4.

Table 4: Quantity of waste PCs for Case1

EOL OptionTaken	2021	2022	2023	2024	2025
Stored in Home	112.6054	132.5152	150.4152	169.3352	187.2451
Landfill	50.4562	68.3662	86.2762	104.1862	121.0962
Scrap dealers	45.2090	63.1190	81.029	98.939	116.849
Shops	90.2509	108.1609	126.0709	143.9809	161.8909

Case 2 (Lower Limit): LN = 5.99 years, LRe= 4.31 years, LSt= 2.90 years As shown in table 5.

Table 5: Quantity of waste PCs for case2

EOL Option Adopted	2021	2022	2023	2024	2025
Stored in House	121.2462	137.3162	153.3862	169.4562	185.5262
Landfill	54.9635	71.0335	87.1035	103.1735	119.2435
Scrap dealers	51.2398	66.3098	82.3798	98.4498	114.5198
Shops	98.2762	114.3453	130.4162	146.4862	162.5562

IV. DISCUSSION

A. Mobile Phones

Case 1: In the year 2021, there will be 124.60 mobile phones kept as trash in the home. Similarly, 19.0564 mobile phones are abandoned and dumped in landfills annually. A total of 41.6347 mobile phones have been delivered to recyclers. In total, 128.5851 mobile phones are brought back to retailers. E-waste is rising by around 13.49 percent year, reaching an estimated

561.57 units in 2025, up from 313.88 units in 2021, according to the computation of total e- waste generation cited above.

Case 2: In the year 2021, 129.0676 mobile phones will be disposed out as trash. Similar to this, there are 21.2342 units of abandoned and disposed-of mobile phones in landfills. 45.4208 mobile phones in total have been submitted to garbage dealers. Stores get 162.4286 units of returned mobile phones. E-waste is growing at a rate of around 12.06 percent each year, according to the above computation of the total amount produced, and will reach 599.0562 units in 2025, up from 358.1512 units in that year.1.

B. Personal Computers (Laptops/Desktops)

Case 1: There are 112.6053 PCs in total that are kept on hand as garbage for the year 2021. Similar to PCs, 50.4562 units of PCs are discarded and dumped in landfills each year. There have been 45.2090 computers sent in total to recyclers. 90.2509 units of PCs are returned to stores. E-waste is growing by about 15.91 percent annually, reaching an estimated 551.0814 units in 2025, up from 298.5214 units in 2021, according to the calculation of total e-waste creation.

Case 2: The number of PCs held in-house as waste for the year 2021 is 121. 2462 units. Similarly, the number of PCs discarded and transported to landfills is 54.9635. The total number of computers dispatched to junk merchants is 51.2398. PCs are returned to stores in 98.2762 units. According to the aforementioned calculation of total e-waste creation, e-waste is increasing by around 16.07 percent every year, resulting in approximately 581.8457 units in 2025, up from 325.7257 units in 2021.

V. CONCLUSION

The end-of-life model is especially effective and accurate for calculating electronic waste creation. If correct data is available, it can result in greater accuracy and be used internationally while taking into consideration data collection limitations. The equipment's typical lifespan is the foundation of the model. Knowing the user's disposal practises is important for lifespan (use, re-use, recycle, landfill). The study discovered that the movement of people into the area, which is used for product sales, and the first user's treatment of the electronic equipment after it has fulfilled its function are the two factors that have the most impact on estimates of e-waste. It goes without saying that the quantity of electrical waste created will grow exponentially as technology develops.The study's findings can be used to develop proper waste disposal management. Furthermore, trustworthy data should be readily accessible to allow policymakers to view accurate results and put up a system that is suitable for the collecting, recycling, and landfilling of used electronic equipment. Similar to this, the evaluation potential may be expanded to include specific benefits of item shipments to India, taking into account factors like population growth, economic development, and changing consumer and social attitudes about disposing of outdated electronics. For a more accurate indicator, it would be possible to analyse how long each individual electronic item will last in its reused and stored phases separately.

REFERENCES

[1] Alavi, N., Shirmardi, M., Babaei, A., Takdastan, A., Bagheri, N., 2015, "Waste electrical and electronic equipment (WEEE) estimation: A case study of Ahvaz City, Iran", Journal of the Air & Waste Management Association, Vol.65, Pages 298-305.

[2] Araújo, M.G., Magrini, A., Mahler, C.F., Bilitewski, B., 2012, "A model for estimation of potential generation of waste electrical and electronic equipment in Brazil", Waste Management, Vol.32, Pages 335-342.

[3] Arena, U., Gregoria, F.D., 2014, "A waste management planning based on substance flow

[4] analysis", Resources Conservation and Recycling, Vol.85, Pages 54-66.

[5] Borthakur, A., Sinha, K., 2013, "Generation of electronic waste in India: Current scenario, dilemmas, and

stakeholders”, African Journal of Environmental Science and Technology, Vol.7, Pages 899-910.

[6] Chawla, P., Jain, N., 2012, “Estimation of Wastes Generated from Obsolete Personal Computers in India”, International Journal of Scientific & Engineering Research, Vol.3, Issue 7.

[7] Deng, W.J., Giesy, J.P., So, C.S., Zheng, H.L., 2017, “End-of-life (EOL) mobile phone management in Hong Kong households”, Journal of Environmental Management, Vol.200, Pages 22-28.

[8] Deshpande, P.C., Philis, G., Brattebo, H., Fet, A.M., 2020, “Using Material Flow Analysis (MFA) to generate the evidence on plastic waste management from commercial fishing gears in Norway”, Resources, Conservation, and Recycling: X, Vol.5, 100024.

[9] Duman, G.M., Kongar, E., Gupta S.M., 2019, “Estimation of electronic waste using optimized multivariate grey models”, Waste Management, Vol.95, Pages 241-249.

[10] Dwivedy, M., Mittal, R.K., 2010, “Estimation of future outflows of e-waste in India”, Waste

[11] Management, Vol.30, Pages 483-491.

[12] Guo, X., Yan, K., 2017, “Estimation of obsolete cellular phones generation: A case study of China”, Science of the Total Environment, Vol.575, Pages 321-329.

[13] Ikhlayel, M., 2016, “Differences of methods to estimate generation of waste electrical and electronic equipment for developing countries: Jordan as a case study”, Resources, Conservation and Recycling, Vol.108, Pages 134- 139.

[14] Iqbal, M., Nadim, A., Ahmed, A., Iqbal, S., 2020, “A Study on Present E- waste Scenario in Chattogram City, Bangladesh”, Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, Pages 3013-3022.

[15] Islam, M.T., Huda, N., 2018, “Application of Material Flow Analysis (MFA) in Electronic Waste (E-Waste) Management”, Proceedings, Vol.2, 1457.

[16] Islam, M.T., Huda, N., 2019, “Material flow analysis (MFA) as a strategic tool in E-waste management: Applications, trends and future directions”, Journal of Environmental Management, Vol.244, Pages 344-361.

[17] Jain, A., Sareen, R., 2006, “E-waste assessment methodology and validation in India”, J Mater Cycles Waste Management, Vol.8, Pages 40- 45.

[18] Kahhat, R., Williams, E., 2012, “Materials flow analysis of e-waste: Domestic flows and exports of used computers from the United States”, Resources, Conservation and Recycling, Vol.67, Pages 67-74.

[19] Kang, H.Y., Schoenung, J.M., 2006, “Estimation of future outflows and infrastructure needed to recycle personal computer systems in California”, Journal of Hazardous Materials, Vol.B137, Pages 1165-1174.

[20] Kim, S., Oguchi, M., Yoshida, A., Terazono, A., 2013, “Estimating the amount of WEEE generated in South Korea by using the population balance model”, Waste Management, Vol.33, Pages 474-483.

[21] Kiran, M., Shanmugam, P.V., Mishra, A., Mehendale, A., Sherin, N., 2021, “A multivariate discrete grey model for estimating the waste from mobile phones, televisions, and personal computers in India”, Journal of Cleaner Production”, Vol.293, 126185.

[22] Kumar, P., Shrihari, S., 2007, “Estimation and Material Flow Analysis of Waste Electrical and Electronic Equipment (WEEE) - A Case Study of Mangalore City, Karnataka, India”, Proceedings of the International Conference on Sustainable Solid Waste Management, Vol.5, Pages 148- 154.

[23] Li, B., Yang, J., Lu, B., Song, X., 2015, “Estimation of retired mobile phones generation in China: A comparative study on methodology”, Waste Management, Vol.35, Pages 247-254.

[24] Parajuly, K., Habib, K., Liu, G., 2017, “Waste electrical and electronic equipment (WEEE) in Denmark: Flows, quantities and management”, Resources, Conservation and Recycling, Vol.123, Pages 85-92.

[25] Petridis, N.E., Stiakakis, E., Petridis, K., Dey, P., 2016, “Estimation of computer waste quantities using forecasting techniques”, Journal of Cleaner Production, Vol.112, Pages 3072-3085.

[26] Pizarro, D.C., Barajas, I.A., Romero, D., Rodriguez, C.A., 2019, “Circular Economy in the Electronic Products Sector: Material Flow Analysis and Economic Impact of Cell-phone E-Waste in Mexico”, Sustainability, Vol.11, 1361.

[27] Rahmani, M., Nabizadeh, R., Yaghmaeian, K., Mahvi, A.H., 2014, Yunesian, M., “Estimation of waste from computers and mobile phones in Iran”, Resources, Conservation and Recycling, Vol.87, Pages 21-29.

[28] Saidan, M., Tarawneh, A., 2015, “Estimation of Potential E-waste Generation in Jordan”,

[29] Ekoloji, Vol.24, Pages 60-64.

[30] Tran, H.P., Schaubroeck, T., Nguyen, D.Q., Ha, V.H., Huynh, T.H., Dewulf, J., 2018, “Material flow analysis for management of waste TVs from households in urban areas of Vietnam, Resources, Conservation & Recycling, Vol.139, Pages 78-89.

[31] Wang, H., Gu, Y., Wu, Y., Zhang, Y.N., Wang, W., 2015, “An evaluation of the potential yield of indium recycled from end-of-life LCDs: A case study in China”, Waste Management, Vol.46, Pages 480- 487.

[32] Zeng, X., Ali, S.H., Li, J., 2021, “Estimation of waste outflows for multiple product

[33] types in China from 2010–2050”, Scientific Data, Vol.8, 15.