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Circular Economy Impact Assessment

Electrical and Electronic Equipment Sector

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CENTAR ZA VISOKE EKONOMSKE STUDIJE

This impact assessment was prepared by the Center of Advanced Economic Studies (CEVES), led by Danijela Bobić with a team composed of Marko Danon and Marija Suzić. Impact assessment was conducted for three sectors: plastic packaging, electrical and electronic equipment, and HORECA. Authors of particular reports are named on the front page. The views expressed in it represent solely CEVES' views. The content of this publication does not necessarily reflect the views of the GIZ.

This report benefited from comments by participants at consultative meetings, as well as from bilateral meetings with stakeholders.

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List of abbreviations

BAU – Business as usual

CEVES – Center for advanced economic studies

EBITDA – Earnings before interest, taxes, depreciation and amortization

EEE - Electrical and electronic equipment

E-waste – WEEE

FTE – Full time equivalent

GVA – Gross value added

Kt – kiloton

NMS – New Member States of the EU (excluding Cyprus and Malta)

SEPA – Serbian Environmental Protection Agency

SORS – Statistics Office of the Republic of Serbia

WEEE – waste electrical and electronic equipment

EXECUTIVE SUMMARY

Collection and processing of e-waste have been steadily increasing in Serbia in recent years – in 2018 alone, it attained approx. 33 kt, which is three times higher than in 2012. The increase of this sector in the previous period also has significant environmental and economic effects. This quantity of waste is collected by a large number of individual and registered collectors and processed by a certain number of large recycling companies. The entire sector of collection and processing formally employs approx. 500 workers, but it is possible that there are another 5-6 thousand individual collectors, which, as it seems, collect the bulk of the waste.

By tackling inefficiencies in collection network and by improving institutional capacities to development of circular economy in WEEE, further intensive development of this sector is possible, which would have favourable environmental and economic effects. CEVES estimates that the introduction of circular economy in this sector might make room for increase of processing towards 77 kt of waste until 2030, which would create additional 1,200 jobs with formal and decent employment, as well as EUR 160 mln in GVA, cumulative between 2019 and 2030.

There may be additional positive effects, which were out of the scope of the present study. More effects plausibly stem from this process and may be considered for further research and analysis. We paid much focus on inefficiencies in collection network, but we are certain that much potential for improvement – and additional jobs and GVA – exists in capacities for post-recycling processing.

INTRODUCTION

Electrical and electronic equipment (EEE) sector is rapidly expanding on a global scale. The electronics revolutionized the world and electrical and electronic equipment became ubiquitous. The quantity of placements on EU-28’ market totalled cca 11 million tonnes in 2014, over two times more than in 1980, of which most was contributed to by sales of large and small household products. At the same time, combined population of these countries rose by a mere 13% suggesting an increasing reliance on electronic equipment by general population.

At the same time electronic waste equipment is surging, incurring a high environmental cost. As sales increase and average lifespan decreases, e-waste streams are soaring – globally 30-50 million tonnes are disposed annually, with an estimated growth rate of 3-5% (Cucchiella et al, 2015). As much of the EEE’ components are made of toxic materials – such as lead, zinc or nickel, surge in this waste stream has a high environmental cost. If not properly treated after disposal, incinerated or landfilled, the toxic components can seep into groundwater, and affect biosphere. The population exposed to potentially hazardous substances through inappropriate and unsafe management practices is increasing – and impacts may include foetal loss, premature births, low birthweight, and congenital malformations; abnormal thyroid function and thyroid development; neuro-behavioural disturbances; and genotoxicity (Goldizen et al, 2013).

Introduction of circular economy can mitigate these adverse effects. Increase in EEE sales and related increase in WEEE flows is unlikely to be reversed. Introduction of circular economy can be a part of solution – as it can help extend product lifespans and increase recovery of material (Aguilar-Barajas et al, 2019), unlike the traditional ‘’take, waste, dispose’’ model. This has numerous positive outcomes. Firstly, increased reuse of products can lead to a decrease in manipulation of toxic materials by humans, and to decline in their disposal in environmentally unsafe ways. Secondly, setting up a network of collection and recycling centres implies increased direct and indirect job creation and capital expenditures. Thirdly, much of the landfilled or incinerated materials could alternatively have an economic value, if properly reused. For instance, small household appliances may be composed of more than 50% in steel, iron, copper or aluminium components, smeltable for subsequent use. Large household appliances are made of up to 20% of concrete, reusable in construction. Some 10% of cooling and freezing equipment is made of PUR foam, which can emit heating energy. According to some studies, global estimated value of raw materials present in electronic waste is approximately EUR 55 bn annually (Balde et al, 2017).

We aim to assess potential impacts of introduction of circular economy in Serbian EEE sector. Serbian EEE sales follow global trends. Total imports of EEE rose by an average of 2-3% between 2004 and 2018, or from cca USD 1 bn in 2004 to USD 1.3 bn in 2018, plausibly driven by gradually increasing standards of living. This suggests that e-waste followed the global trend, and it is a clear motivation for the study.

This analysis is structured in three sections, described as follows. The first section presents the methodological approach. In the second section, we briefly outline the current EU and national legislative frameworks, which is followed by our estimate of recent and current levels of physical flows of WEEE in Serbia and EU-28, culminating in in-depth overview of the local WEEE cycle, and detailed explanations of financial and physical flows between key stakeholders within the cycle.

PART 1. METHODOLOGICAL APPROACH

This impact assessment quantifies the potential for creation of jobs (social aspect) and GVA (economic aspect), which could stem from an increased e-waste recycling rate. In order to process increased waste quantities, the entire system needs to be improved, while additional workers need to be employed. These elements incur operational and capital costs, but generate revenues, thus creating direct and indirect economic and social impacts.

This methodology has been developed by CEVES team and has built on previous studies of which we draw particular attention to Hogg et al (2017) and European commission (2014). This study contributes to existing body of research by providing a relatively updated and refreshed position on the issue, as well as an analysis focusing solely on Serbia's situation[1].

- ## Scope of the study

This research was conducted within a specific scope, focusing on the impact assessment of increased recycling of e-waste in the period from 2019 to 2030. Further details are provided as follows:

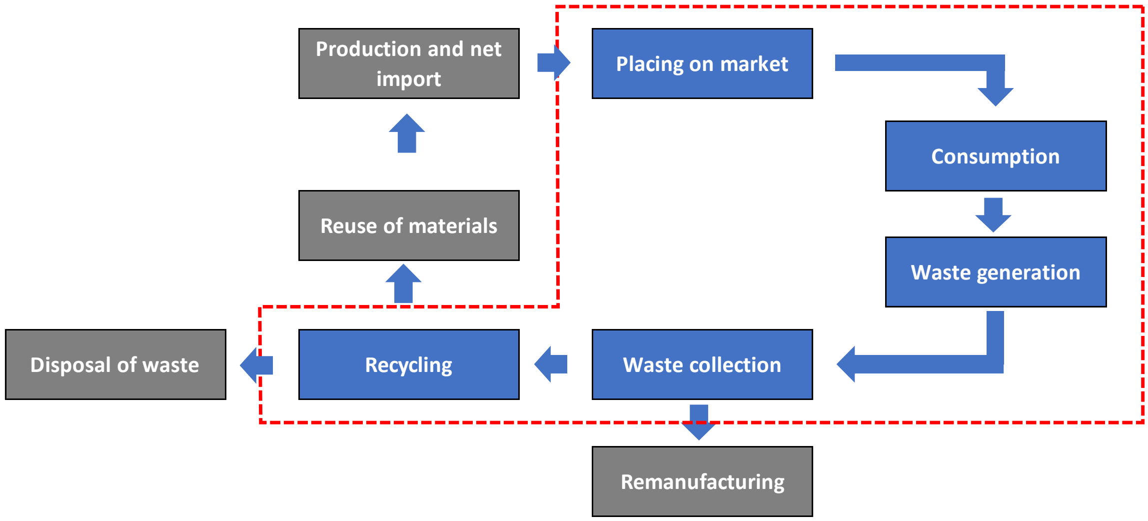
Table 1. Scope of the study

Topic	Scope/Description
WEEE types	Basis: European Commission' Directive 2012/19/EU, categorizing the EEE in 10 groups in the transitional period between 2012 and 2018 and in 6 groups after August 2018. Throughout this analysis, we rely on the former, as this one is still used in the Serbian regulatory framework.
Players	Focus on analysis of collection and recycling companies.
Recycling targets	According to EC' Directive 2012/19/EU - 65% of the average weight of EEE placed on the market or alternatively 85% of WEEE generated
Timeframe	2018 as reference year and 2019-2030 as forecast period
Geographical scope	Focus of the study: Serbia, benchmarked against the set of CEE countries, namely: Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia
Key indicators	Economic indicators: profitability and GVA Social indicators: jobs
Value chain segments covered	A part of the cycle starting with placements of the products and ending with the recycling. This study does not consider parts concerning production and net imports of the products, remanufacturing and post-recycling activities, Graph 1.

Source: CEVES estimate

[1] The two latter analyse WEEE flows in several countries, including Serbia

Graph 1. Conceptual WEEE cycle



Source: CEVES estimate

- ## Description of the model

We quantify the impact of increased recycling on job creation and value added in related sectors. In the first step, our model evaluates current and future physical streams of products put on market, waste generation and collection of waste. In the second step, it calculates how many additional jobs, revenues and costs the treatment of additional physical flows require, by using a set of estimated and assumed coefficients.

Current physical streams are benchmarked, and future ones are forecast. Current physical streams of e-waste in Serbia are largely estimated based on benchmarks by countries at similar development level, and in smaller part on official data, while we forecast the data for period until 2030 based on expectation of slow and partial Serbia’s convergence to EU-28 standards of living.

Associated labour, costs and revenue coefficients are estimated based on interviews with recyclers. Waste recyclers are central to the model – a small number of companies recycle almost entire e-waste in Serbia, while being supplied by a very heterogeneous group of registered and unregistered suppliers. Thus, we relied on interviews with key recyclers[2] – which process approx. 85-90% of WEEE – to obtain labour, costs and revenue coefficients which are associated with increased physical streams.

For the fully detailed description of the approach, please refer to Section IV.

- ## Scenarios

Two models branch out of the reference year 2018. Our approach posits two scenarios for the period 2019-2030, which effectively represent lower and upper boundary, depending on the level of improvements in e-waste collection rates, against the reference year 2018. More precisely, these scenarios are:

[2] Such as E-reciklaža, SET or Božić i sinovi

- **First, a Business-as-usual (BAU) scenario** which implies that current state of waste management practices will not be changed along the observed period. This means that the current rate of waste collection – which we estimate at 50% of total waste generated or 32% of products put on market – will remain unchanged along the observed period.
- **Secondly, a Target scenario** which implies reaching the EU Directive – set collection and recycling targets – meaning to reach 85% of total waste generated or 65% of products put on market – until 2030. In order to add more nuance to the analysis, we created three sub-scenarios within the Target scenario, with each one reaching the same collection level, but with different structure of suppliers.

  For more information, please refer to Section III.

PART 2. CURRENT STATE

WEEE recycling in Serbia has been gaining ground in recent years by going from 1.5 kg per capita in 2012 (11 kt) to 4.7 in 2018 (33 kt), but it still remains much below EU’s 7.4 kg per capita. Much of the collection of raw materials in Serbia is performed by numerous individual or registered collectors, while recycling activity is highly concentrated in a small number of local companies.

1. EU and National targets

EU generates significant amounts of e-waste, but is at global forefront of recycling. EU as a whole generates relatively high levels of e-waste, as elevated standards of living allow for higher stocks of electronic equipment in households and enterprises. As illustration, while the global e-waste generation amounted to 6 kg per inhabitant (Balde et al, 2018), it reached as much 20 in EU-28. However, while merely 1.2 kg per capita is collected and recycled properly at global scale, in Europe it tops approx. 8 kg per capita.

European recycling activity is supported by stringent common regulation. According to Balde et al (2018), only 66% of global population is covered by at least a simple e-waste legislation, while this ratio is 100% in EU-28, as well as most accession countries. Moreover, not only that EU regulation is widespread, but it is also more stringent than in other countries. For instance, the US does not have federal environmental laws that govern disposal of e-waste, leaving the federal states no overarching principle to follow or regulation to apply – half of the US states have no e-waste laws of any kind (link: https://www.ewaste1.com/why-does-europe-have-stronger-e-waste-recycling-than-the-usa/).

Directive on WEEE is the cornerstone of the EU approach, relying on constantly increasing stringiness of regulatory requirements. Regulation is governed by overarching Directive on WEEE (2012/19/EU), published initially in 2003, expanded in subsequent years, with last amendments being implemented in 2012. It encourages an eco-friendlier product design and focuses on adequate collection and recycling practices, by relying, inter alia, on constantly increasing mandatory targets. The ‘’moving’’ targets required collection of at least 4 kg per capita annually until 2015, minimum collection rate of 45% of total e-product sales until 2019, and either a minimum collection rate of 65% of total products put on market *or alternatively* 85% of total waste generation, from 2019 onwards. It should be noted that some countries have exceptionally high collection rates, either because of very advanced collection practices (such as 66% of total electronic products put on market in Sweden in 2016), or due to very high levels of historic e-waste (pushing the ratio to more than 90% in Bulgaria).

2. WEEE quantities in Serbia

Placements at domestic market

Official data plausibly underestimate Serbian placements on market. The Serbian Environmental Protection Agency (SEPA) reported[3] approx. 50-60 kt placed on market over the period 2012-2017. This is less, compared to the actual recycling levels (cca 150 kt in same period), to the level estimated by the Strategy of waste management for period 2010-2019 (86 kt of *new equipment sold annually*) and to data provided by other countries. To illustrate this, official data indicate that placements at local market amounted to less than 1.5 kg per capita in 2017, against as much as 21.7 kg at level of EU-28, and somewhat lower in NMS countries, such as 18 in Poland, 17 in Czechia, or 16 in Romania or in Bulgaria[4]. Although Serbia’s GDP per capita does indicate relatively lower levels of living standards, such discrepancy in sales of electronic products is untenable. This underlines the need for an alternative estimation of placements on market as the critical departure point in the model.

CEVES estimates that placements on Serbian market plausibly reached 14.4 kg per capita in 2018. By applying levels of placements on markets of countries with similar level of development on Serbia’s population, we concluded that total placements of electronic and electric equipment on Serbian market amounted to cca 100 kt, or 14.4 kg per capita in 2018.

CEVES estimates that Serbia disposed of 9.3 kg per capita in electronic waste, while 4.7 kg per capita were collected and processed in 2018. By applying historical WG/POM[5] ratio on Serbia’s placements on market, we concluded that total e-waste generated in 2018 reached 65 kt, or 9.3 kg per capita. This level is relatively high, and it is supported by decreasing life expectancy of products, but also, particular for Serbia, by seemingly high stocks of old and obsolete equipment in households[6]. A part of this waste, which is estimated by CEVES to 33 kt or 4.7 kg per capita, was adequately collected and provided to recyclers in 2018.

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[3] Products which become special waste streams in the Republic of Serbia

[4] In 2014, according to Apparent consumption methodology, used by the European Commission

[5] A ratio calculated as Waste generation divided by Products put on market. For a more thorough methodological clarification, please refer to Appendix 1: Methodology details

[6] Strategy of waste management for period 2010-2019 estimates that each year 30 kt of waste is generated but there is another 40 kt of historical waste at various landfills, warehouses and garages.

Table 2. WEEE streams estimate

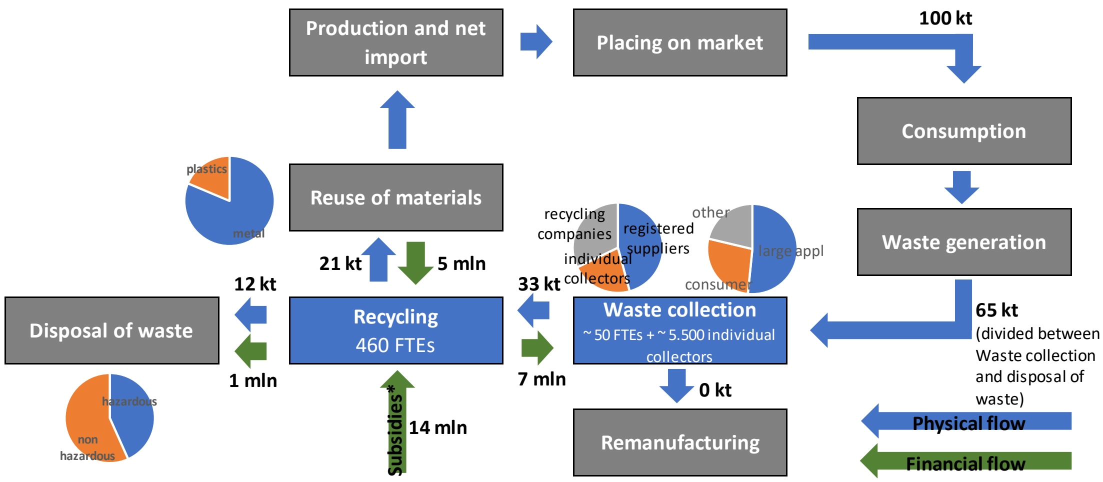
Indicator	2012	2013	2014	2015	2016	2017	2018
WEEE placed on market							
SEPA (kt)	7	6	7	8	10	11	13
CEVES estimate (kt)	89	85	90	96	99	100	101
WEEE waste generated							
CEVES estimate (kt)	55	53	56	60	61	63	65
WEEE processed							
WEEE processed (kt)	11	19	21	27	37	34	33
Serbia (kg per capita)	1.5	2.7	2.9	3.9	5.2	4.9	4.7
EU 28 (kg per capita)	5.4	5.6	5.6	6.2	7.4		

Source: SEPA, Eurostat, CEVES estimate

3. Sector’s value chain and players within

WEEE value chain is characterized by interplay between collectors and recyclers, as visualized by Graph 2. The basis of the WEEE value chain consists of a very heterogeneous group of collectors – including both registered and individual ones. SEPA (2019) reports that in 2018 some 33 kt of WEEE were processed, and plausibly in entirety by the recyclers, which are concentrated in a very small number of companies and represent the heart of the value chain. We show in the Graph below a stylized model of the interlinkages between recyclers, collectors and related stakeholders. The data used in the Graph below relates to 2018, and has been in large part been estimated by CEVES, based at SEPA official data for previous years, interviews with the 3 largest recycling companies (which account for cca 90% of total WEEE processing), in-depth analysis of the 2017 financial reports of the 5 largest recycling companies (cca 95% of processing), as well as literature review.

Graph 2. Detailed overview of WEEE cycle



Source: CEVES estimate

* Estimated amount of premia, subsidies, grants, donations and similar items, earmarked for recyclers of electric and electronic waste, as a part of special waste flows, through process of public competition, and based on provisions set out by the Law on budget and Regulation on amount and conditions for allocation of incentives

The bulk of WEEE is collected by numerous individual and registered collector companies. Out of the 33 kt of WEEE collected in 2018, we assume that 45% was provided to recyclers by registered collectors, as the interviews suggest. Registered collectors are very heterogeneous and numerous, and often employ very low headcounts. This suggests that most of the supply to the recyclers is actually – possibly - bought from the individual collectors. Individual collectors also directly supply WEEE to recyclers – according to the interviews, their direct supply of raw materials may top as much as 22% of total. This means that individual collectors supply up to 70% of the total input to the recyclers. At the basis of interviews with recyclers and review of literature[7], we assume that there may be around 5.5 thousand of such individual collectors. The remainder of 32% of WEEE raw materials is supplied by recyclers' themselves. This largely includes collection from households and enterprises based at individual or collective contracts, and in a smaller part from contracts with vendors of equipment (i.e. activities such as ‘’New for old’’).

Most of collected WEEE are large household appliances and TV sets. A bit more than half of collected WEEE in 2018 was related to large household appliances, such as refrigerators, dishwashers or washing machines, as suggest the interviews. 27% is related to consumer equipment such as TV sets of audio&video equipment. Another 8% are the Electrical and electronic tools; and IT & telecommunication equipment each. The remaining 5% of WEEE is dispersed across other equipment, such as lamps, automatic dispensers or toys. The prevailing share of large household appliances can be explained by low marginal costs of transport and treatment, and high share of marketable recycled materials – such as scrap iron.

[7] See Ilić and Protić (2013).

Overwhelming majority of collected WEEE is recycled by a small number of large recycling companies. The recycling sector in Serbia is highly concentrated. There are somewhat more than 20 companies with a license as on end 2017. Out of this, top 4 companies recycled cca 85-90% of WEEE. Currently, local recyclers employ cca 460 workers, of which 400 in administration and operations (out of which most in disassembly), and another 60 in transport, storage and logistics.

Only a part of materials obtained from recycling can be sold, the rest requiring disposal costs. The WEEE is transformed in recycled materials, of which a part is marketable and sold as raw material (such as scrap metal), and a part is non-marketable (hazardous or non-hazardous) and incurs a disposal-related cost. Out of the 33 kt of WEEE treated in 2018, we assume that cca 50% of total refer to scrap metal parts, as the interviews suggest. These materials are sold at commodity prices to the numerous scrap metal traders, or to steel mills, copper smelters, etc. Another 12% refers to various types of plastics, which too can be sold in major part. The rest of materials incur disposal costs. Indeed, 18% of total weight is glass, of which at least one half is the hazardous lead glass mainly from discarded CRT TV sets. PUR foam and polystyrene - 5-6% - is usually given to cement companies for their energy intake. Another 5-6% is concrete, mainly from washing machines, which is given to construction companies. Finally, the rest is composed of various types of materials requiring disposal, of which some, such as Freon or waste dust from cathode ray tubes incur very elevated costs and are often discarded abroad.

Revenue from sales of recycled materials are smaller than costs of material, but state subsidies cover the gap. According to CEVES' estimate of 2018 recycling sector consolidated income statement, the sector has spent approx. EUR 7 mln in material purchases, EUR 1 mln in disposal costs, and has received 5 mln in sales of marketable materials. On the other hand, entire sector of recycling of special waste streams, including WEEE among others, benefits from incentives in amount of cca EUR 18 mln according to the Budget laws from previous years. Most of this amount, or cca EUR 13-14 mln is usually earmarked for the WEEE recyclers, in line with the Regulation on amount and conditions for allocation of incentives.

Table 3. Estimate of consolidated income statement of WEEE recycling sector in 2018

	Indicator	Amount in EUR mln	Share in revenues /costs
A	**Revenues**	**18.6**	**100%**
1	Premia, subisidies, grants, donations	14.0	75%
2	Sales of materials	4.6	25%
B	**Costs**	**13.2**	**100%**
3	Material costs	6.7	51%
4	Wages gross	4.2	32%
5	Fuel	1.0	8%
6	Amortization	0.3	2%
7	Other costs (i.e. disposal costs)	1.0	8%
C (A-B)	**Operative result***	**5.5**	
D (C+4+6)	**GVA**	**9.9**	

Source: CEVES estimate

* Operative result comes from core operations of a business, and does not include all costs, such as interest or taxes. This said, operative result may differ from net result

Actual output of recyclers seems to be only half the size of installed capacity. Although the entire sector recycled cca 33 kt in 2018, total capacities are at around 70-75 kt according to interviews with recyclers. This said, an increase in collection rate would not require immediate capital expenditures by neither one of largest companies but would rather require new job openings.

PART 3. CIRCULAR ECONOMY IMPACT ASSESSMENT

Improvements in collection system are essential for effective introduction of circular economy. An improved collection rate and a better collection structure – meaning a smaller share of WEEE collected and supplied by individual collectors – requires a better collection network. This includes among other, door-to-door collection, construction of recycling yards and collection sites or more intense activity of vendors. We considered the effect of construction of a network of collection stations[8] - or recycling yards – incurring effects through 1) capital investment employing local construction workers and material, 2) employment of full-time workers in these stations, but also leading to 3) lower unitary costs of raw materials for recyclers. This assumption allows to factor in higher development effects of collection stations. Although their massive construction may lead to decrease in number of individual collectors, it certainly implies more ‘’green jobs’’[9]. Based on inputs for such objects explained by Karigl et al (2017), and the interviews, we assumed the construction of up to cca 100 small (~100 m2) collection stations.

The model is based on two distinct scenarios. In order to take these specificities into consideration, our model develops two distinct scenarios, with their key difference being the expected collection rate in 2030. While the first, Business as usual scenario foresees the collection rate unchanged until 2030, the Target scenario expects the rate to reach the level of 85% of total weight placed on market, as requests the EC Directive 2012/19/EU. A more detailed overview of the scenarios is provided as follows:

Business as usual (BAU) scenario implies no improvements in the current system – the collection rate would remain near current levels of 50% of waste generation by 2030. Almost 70% of WEEE supply would keep being collected by individual collectors, who are relatively underproductive, while working in precarious conditions. This scenario holds the price of raw materials constant along the observed period, as the collection would remain dominated by individual collectors, who are relatively cost ineffective.

Target scenario implies improvements in the current system with collection rate gradually converging to the 85% of generated waste, a mark set out by the EU Directive 2012/19/EU. However, the economic and social impacts may vary in function of the way the collection rate target is met, and this is why we develop three sub-scenarios, as follows:

- **Target sub-scenario 1 (T1)**: share of individual collectors in total supply remains unchanged (~70%), with a modest improvement in system of collection. This sub-scenario implies that price of raw materials for recyclers would remain constant along the observed period.

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[8] For instance, Karigl et al (2017) propose a collection network consisting, among other, civic amenity sites and stationary collection sites of e-waste.

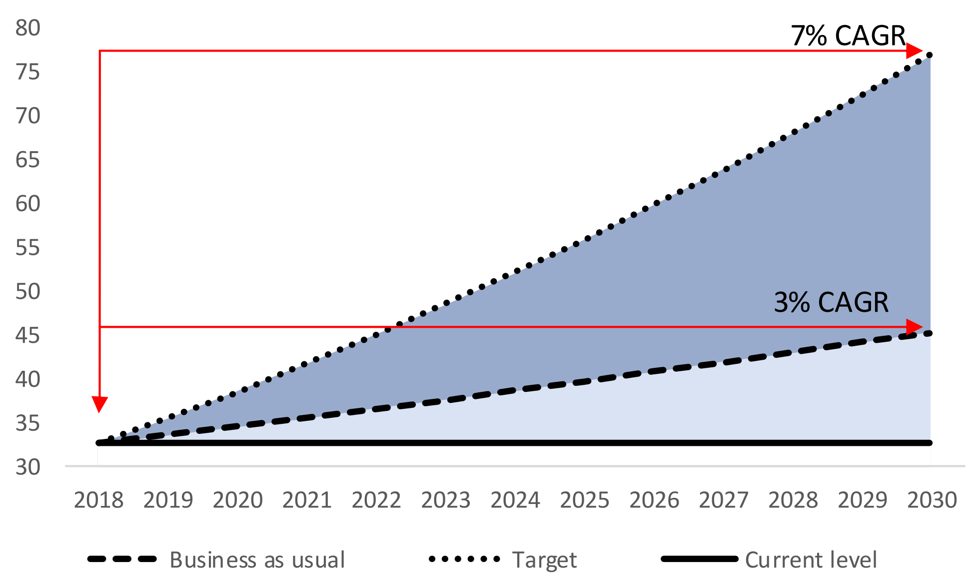
[9] Those defined by ILO as decent jobs that contribute to preserve or restore the environment (https://www.ilo.org/global/topics/green-jobs/news/WCMS_220248/lang--en/index.htm)

- **Target sub-scenario 2 (T2)**: share of individual collectors in total supply reduced to 33%, with a moderate improvement in system of collection. This sub-scenario implies that cost of raw materials for recyclers would gradually decrease to half of the current price of raw materials by 2030, as collection network gradually improves, through widening of collection station network.
- **Target sub-scenario 2 (T2)**: share of individual collectors in total supply reduced to 17%, with a significant improvement in system of collection. This sub-scenario implies that cost of raw materials for recyclers would gradually decrease to quarter of price of raw materials by 2030, as collection network gradually improves, through widening of collection station network.

4. Impact on collected and recycled quantities

By 2030, recycled quantity of waste would increase to 45 kt in BAU scenario, and to 77 kt in Target scenarios, with varying levels of social and economic impacts. If the collection rate remains near current levels of 50% of waste generation by 2030, as outlines the BAU scenario, the recycled quantities would increase from current 33 kt to 45 kt in 2030 (Graph 3). In this case, recycling activity and associated additionally employed headcount would only modestly increase, and social and economic footprints would be minimal. If the collection rate moves towards 85% in 2030, as detailed in Target scenarios, the quantities would increase towards 77 kt. The social and economic impacts vary in these cases in function of structure of collected WEEE – by moving from modest in T1 to significant in T3. This means that the highest positive social and economic effects are expected to be made in T3, in which the predominant share of WEEE is collected in collection stations.

Graph 3. BAU vs Target: Waste recycled quantities (in kt)



Source: CEVES estimate

In reality, it is most likely that a variation of these four scenarios would occur. The result depends on system efficiency in place, but also on willingness of all relevant stakeholders to participate, including the citizens, businesses, public and civil sectors. This all means that a specific variation of these four scenarios would most likely put the recycled amount of WEEE in area between 45 kt and 77 kt.

5. Impact on job creation

CEVES estimates that introduction of circular economy could create between 179 and 1,192 new jobs in formal employment by 2030, while the FTEs in individual collection may vary between cca 1,000 and 4,300. The extent of impact depends on improvements made in the collection system.

Recycling companies could increase headcount between 181 and 632 by 2030, which only depends on quantities of recycled WEEE. If that the actual output of 33 kt is twice below the full capacity, then the labour is the key input in recycling sector’s production function. As we hold average productivity of workers constant in our model, our scenarios forecast an increase of recycling workers to be proportional with recycled quantities. A rise from 33 kt to 45 kt in BAU scenario, might create 181 new jobs by 2030, of which 25 in transport and logistics, and the rest in operations and administration, Table 4. Target scenarios in this respect have no differences, as inputs provided by various types of WEEE suppliers are assumed homogeneous for recyclers. Thus, in T1, T2 and T3 there could be 632 new jobs, of which 89 in transport and logistics and 544 in recycling and administration.

Table 4. CEVES estimate of impact on job creation

Indicators	Baseline 2018	Value in 2030				Change 2030 vs 2018			
		BAU	T1	T2	T3	BAU	T1	T2	T3
Total WEEE recycled (kt)	32.6	45.3	77.0	77.0	77.0	12.7	44.4	44.4	44.4
Total jobs	**2,346**	**3,314**	**5,596**	**3,726**	**2,782**	**969**	**3,250**	**1,380**	**437**
Total formal jobs	**502**	**681**	**1,263**	**1,549**	**1,694**	**179**	**761**	**1,047**	**1,192**
Total informal jobs	**1,844**	**2,633**	**4,333**	**2,177**	**1,088**	**790**	**2,490**	**333**	**-755**
Recycling	**465**	**645**	**1,097**	**1,097**	**1,097**	**181**	**632**	**632**	**632**
Transport and logistics	65	91	154	154	154	25	89	89	89
Recycling	399	555	943	943	943	155	544	544	544
Collection	**1,881**	**2,666**	**4,482**	**2,589**	**1,634**	**785**	**2,601**	**708**	**-247**
Collection sites	0	18	83	231	305	18	83	231	305
Logistics	37	14	65	182	241	-23	28	144	203
Individual collectors	1,844	2,633	4,333	2,177	1,088	790	2,490	333	-755
Construction	**0**	**3**	**17**	**40**	**51**	**3**	**17**	**40**	**51**

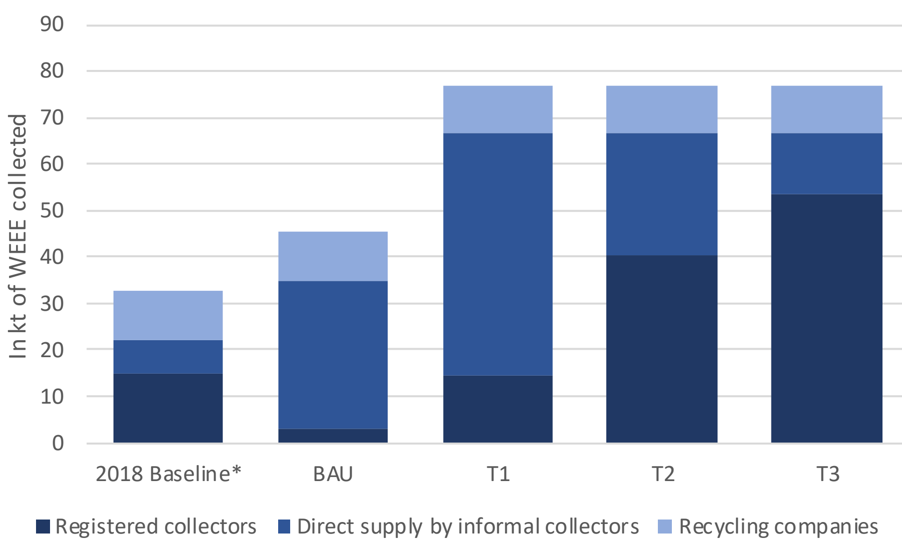
Source: CEVES estimate

Even though it might seem that T1 would provide an ample employment, we believe it is unlikely to happen and it is less desirable as it relies on poor working conditions in unsafe environment. There are currently cca 5.500 of individual collectors[10], working in labour intensive way and often in precarious conditions, including unsafe collection and treating processes. They are estimated to supply cca 70% of total WEEE supply, and in BAU and T1 we assume this share to remain constant by 2030. This means that most of the increase of collected quantities between 2018 and 2030 would be administered by individual collectors and

[10] In reality, seemingly a significant portion of these individual collectors is not specialized solely in WEEE. To control for this effect, we divide number of persons engaged in individual collection by 3, in order to translate this level in a relevant number of full-time equivalents (FTEs).

that increased recycling will not guarantee full social benefits. In this respect, given that T1 scenario foresees that the collected quantities would be more than twice larger by 2030, it would require additional cca 7.5 thousand individual collectors – which is possibly untenable bearing in mind the limitedness of pool of these workers. For this reason, materialization of the T1 scenario is possibly less likely than other scenarios and should be considered predominantly for illustrative reasons. Moreover, although BAU and T1 seem to provide ample employment, they favour precarious over ‘’green’’ jobs, i.e. those that provide decent work conditions and whose processes and products are environmentally friendly. This means that we consider BAU and T1 as developmentally and environmentally less desirable scenarios, in comparison with T2 and T3.

Graph 4. Structure of employment in WEEE value chain



Source: CEVES estimate

* In 2018, entire amount sold by regular collectors to recyclers is assumed to be initially collected by individual collectors

T2 and T3 forecast less jobs, but of significantly higher quality. In T2 and T3, individual collectors’ share in WEEE collection is smaller – gradually drops to 34% and 17% respectively by 2030. This means that in both scenarios, most of the increase in waste collection is expected to be administered by the group of more productive and regulated registered collectors – such as registered companies or public utility companies. As most of the increase in waste collection is expected to go through the network of collection stations, it would require massive construction of collection stations – namely of 77 in T2 and 102 in T3. Furthermore, their construction may facilitate access to households, and thus increase collection from citizens, which is currently an untapped potential[11]. All in, the effect of such increase in collection would be at least threefold: 1) additional 144 to 203 workers in transports, logistics and administration in registered collectors; 2) 231 to 305 new jobs in collection stations, and 3) 40-51 new jobs in construction of new collection stations. Such employment also has higher employment

[11] According to Karigl et al (2017): ‘’It can be assumed that no regular collection system for WEEE from households and small businesses exists for the moment and that a relevant part of WEEE from households is collected by individual collection activities’’

multipliers, than in case of BAU or T1, given the increased consumption in other sectors of the economy.

6. Impact on gross value added

Introduction of circular economy could help expand the economy by EUR 162 mln cumulatively between 2019 and 2030, which is EUR 26 mln more than if the system remained unchanged.

Recyclers might generate approx. EUR 146 mln in GVA cumulatively between 2019 and 2030. Recycling companies will remain in centre of WEEE value chain and as such will continue to generate most of the value added within this sector. Recycling sector’s GVA would rise from the level of EUR 10 mln in 2018 to a level between EUR 11 mln in 2030 in our BAU scenario and EUR 10-18 mln in T1, T2 and T3, Table 5. Our models foresee that the development of collection network would have beneficial effects for recyclers’ profitability, as they would gradually lead to decrease in unitary cost of materials.

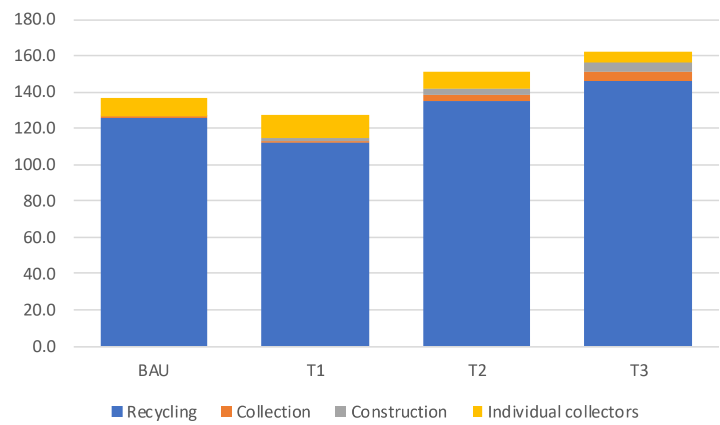
Table 5. CEVES estimate of impact on GVA

Indicators	Baseline 2018	Value in 2030				Cumulative 2019-2030			
		BAU	T1	T2	T3	BAU	T1	T2	T3
Total WEEE recycled (kt)	32.6	45.3	77.0	77.0	77.0	45.3	77.0	77.0	77.0
GVA (EUR mln)	**11.4**	**12.1**	**11.2**	**16.0**	**18.4**	**136.6**	**128.3**	**151.0**	**162.5**
Recycling	9.9	11.1	9.5	14.8	17.5	126.0	111.8	134.8	146.4
Collection	0.8	0.0	0.0	0.0	0.0	0.4	1.4	3.5	4.5
Construction	0.0	0.0	0.2	0.4	0.5	0.3	1.4	3.8	5.1
Individual collectors	0.7	1.0	1.6	0.8	0.4	9.9	13.3	8.9	6.5

Source: CEVES estimate

Improved waste collection in T2 and T3 allow for higher GVA creation, mostly due to multiplier effects. Due to differences in supply structure, BAU and T1 differ from T2 and T3. In the latter group, the registered collectors hold a dominant part of collection, and in the same time generate more GVA. For instance, for the same quantity of recycled waste, T3 makes EUR 12 mln more in GVA than T2 and EUR 34 mln more than T1 (cumulative between 2019 and 2030). This is related to multiplicative effects of construction and operation of collection stations. It includes increased wage mass in formal employment, purchase of construction (locally produced) material, and lower unitary cost of materials for recyclers. These multiplicative effects may include further additional positive GVA effects, which were not accounted for in scope of this analysis – for example, we didn’t calculate the effect of workers spending their wages in local shops. On the other hand, the GVA in individual collectors decreases from EUR 10 mln in BAU to EUR 7 mln in T3, due to their decreasing role in value chain, which goes linearly and monotonously from 70% in supply in BAU and T1 to 13% in T3.

Graph 5. Structure of GVA (in EUR mln)



Source: CEVES estimate

Construction companies would generate additional value of up to EUR 5 mln through construction of collection station network across country. Setting up the collection network of up to 100 small stations would have additional, indirect, effects on economy, which are basically twofold. Firstly, total capital expenditure on construction of such network would generate revenues of up to EUR 5 mln for local construction companies. Given the low complexity of such objects, we assume that this construction would not require any imported material, thus the domestic economy would benefit it in entirety. Secondly, the construction would employ up to 50 construction workers annually – providing additional impetus to economy through their wages.

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APPENDIX 1. METHODOLOGY DETAILS

The model is based on publicly available data obtained from official statistical sources (SORS, Eurostat) and interviews with recycling companies, as well as from relevant literature. In many cases, it was not possible to retrieve data from official sources. In these cases, we estimated the missing data based on assumptions retrieved from interviews with recyclers and review of relevant literature.

Departure point was to determine quantities of electronic and electric equipment currently put on Serbian market. As SEPA data plausibly underestimates the level, we used per capita levels of placements on markets in NMS markets, discounted by 15%, and multiplied by Serbia's population. In order to forecast future placements, we assumed a 1% annual growth rate, thus making sure that Serbia's per capita levels rise in mid-term towards levels currently held by more advanced NMS countries.

Furthermore, we assumed that waste generation currently amounts to approx. 60% of total placements on market, which is roughly at level of historical WG/POM ratio recorded at level of EU-28 in period between 1980 and 2014. As lifespan of products gradually decreases due to technology, while historical stocks of waste accrue, WG/POM ratio increases over time, and we assume it to reach 80% by 2030, which is a level currently recorded in some more advanced west European economies.

Mass of collected waste in our Target scenarios equals 85% of waste generated and 65% of equipment put on market, in line with Directive 2012/19/EU. The current amount of waste collected is taken from SEPA (2019), and it equals 50% of estimated waste generated in 2018. Our Business as usual scenario holds this rate constant along the observed period. Entire waste collected is assumed to be recycled within the same calendar year, and we assume that none of waste collected is remanufactured.

Table 6. Main technical assumptions used in determination of waste quantities

Coefficient	Amount
Collection rate in 2018 (in % of WG)	50%
Collection rate in 2030 (in % of WG)	85%
Remanufacturability ratio	0%
WG/POM ratio 2018	62%
WG/POM ratio 2030	80%

Source: CEVES

In order to translate the estimated current and future waste streams in jobs and GVA, we primarily relied on interviews with the largest recycling companies. We conducted in-depth interviews with the 3 largest companies (which account for 90% of recycling market) and analysed financial statements of 5 largest companies (95% of market) and obtained a set of coefficients. At basis of the interviews, as well as based on literature review, we concluded there are basically three groups of agents which require job and GVA quantification: recyclers, collectors and construction companies.

Jobs in recycling sector were estimated as product of quantities of collected waste and workers required to process these quantities, as outline the following formula:

$$JR_n = WC_n * (C_{adm} + C_{rec} + C_{trans})$$

Where:

JRn – Jobs in Recycling in year n

WCn – Waste collected in year n

Cadm – Coefficient of tonnage which can be administered by 1 worker in administration annually (obtained in

Crec – Coefficient of tonnage which can be recycled by 1 worker in operations annually

Ctrans – Coefficient of tonnage which can be stored and transported by 1 worker in transport and logistics annually

Formal Jobs in collection sector were estimated, as outlines the following formula:

$$JC_n = WCRS_n * C_{rs} + (WCRS_n - WCIS_n) * C_{trans} + NCSn * Ccs$$

Where:

JCn – Formal jobs in Collection in year n

WCRSn – Waste collected and supplied by registered collectors[12] in year n

WCISn – Waste collected and supplied by individual collectors in year n.

Crs – Coefficient of tonnage which can be stored and transported by 1 administrative worker in registered collector companies annually

NCSn – Number of Collection stations in year n

Ccs – Assumed number of workers per collection station (based on assumption that a small working station necessitates only 1 worker per shift)

Individual Jobs (FTE) in collection sector were estimated, as outlines the following formula:

$$JCI_n = WCIS_n * C_{is} * 0.33$$

Where:

JCIn – Individual Jobs (FTE) in Collection in year n

Cis – Coefficient of annual tonnage which can be stored and transported by 1 individual worker who spends 2-3 hours daily in collecting WEEE

Jobs in construction sector were estimated as product of quantity of needed collection stations and assumed number of workers per station, as outlined:

$$\boldsymbol{JCNn = (WC_n - WC_{n-1}) * C_s * C_{ws}}$$

Where:

JCNn – Jobs in Construction of collection stations in year n

WCn – WCn-1 – Change of waste collection quantity in comparison with previous year

[12] For detailed overview of structure of supply of raw materials per type of supplier, please refer to Section 3.

Cs – Coefficient of tonnage which can be stored in one small 100 m2 large collection station per year

Cws - Coefficient of size of construction team per one construction station

Table 7. Main operative assumptions used in determination of number of jobs in recycling, collection and construction

Coefficient	Name of variable	Amount	Source
Crec	Recyclable tonnage by 1 worker p.a.	100	Interviews with recyclers
Ctrans	Transportable tonnage by 1 worker in logistics p.a.	500	Interviews with recyclers
Cadm	Administratble tonnage by 1 worker in administration p.a.	446	Interviews with recyclers
Crs	Collectable tonnage by 1 worker in registered collector p.a.	400	Interviews with recyclers
Cis	Collectable tonnage by 1 worker in individual collector p.a.	4.0	Interviews with recyclers
Ccs	Workers per 1 collection station	3	CEVES assumption
Cs	Tonnage of 1 collection station p.a.	525	Karigl et al (2017)
Cws	Size of team needed to construct 1 collection station	5	CEVES assumption

Source: CEVES

For quantification of GVA in the sector, we relied on interviews with 3 largest recyclers (90% of market) and on in-depth analysis of financial statements of 5 largest companies (95% of recycling market).

GVA in recycling sector was estimated as sum of EBITDA and wages in recycling sector, as specifies the following formula:

$$GVAR_n = (SUB + WRM_n * PS) - (WC_n * PP + V_n * FC * FP + WRN_n * DC)$$

Where:

GVARn – GVA in Recycling in year n

SUB – 2018 level held constant for the period between 2019 and 2030. According to the Budget law for 2020, incentives for all waste streams are increased towards EUR 30 mln, however as we still cannot forecast the structure of this spending, we used the last available level earmarked for EE recyclers.

WRMn – A part of recycled marketable materials

PS – Average sales price of recycled marketable materials, EUR per tonne

PP – Average purchasing price of WEEE, EUR per tonne[13]

[13] PP varies across scenarios in line with share of individual collectors – as the price of raw materials is assumed to converge to 0 when collected by registered collectors, public utility companies or recycling companies, through the network of established collection stations, while it would remain constant at 2018

Vn – Number of vehicles in year n

FC – Fuel consumption per vehicle, litres per 100 km

FP – Fuel price per litre, EUR

WRNn – Waste to be disposed in year n

DC – Average cost of disposal, EUR per tonne

GVA in registered collection sector was estimated as sum of EBITDA and wages in formal collection sector and in collection centres, as outlines the following formula:

$$GVAC_n = WCRS_n * PP - (WCRS_n * PP * 0.75 + NCS_n * CAPEX * IR) + AW * (JC_n + JCS_n)$$

Where:

GVACn – GVA in Collection in year n

CAPEX – Cost of construction of one collection station

IR – Annual interest rate on borrowing used to fund construction of collection stations, %

AW – Average wage, EUR monthly, gross

GVA in individual collection sector was estimated as sum of EBITDA in individual collection sector, as outlines the following formula:

$$GVAIC_n = WCIS_n * PP - WCIS_n * PP * 0.85$$

GVA in construction sector was estimated as sum of EBITDA and wages in construction activities needed to build the collection station network, as outlines the following formula:

$$GVACO_n = (NCS_n - NCS_{n-1}) * CAPEX$$

Where:

GVACOn – GVA in Construction in year n

NCSn-NCSn-1 – Number of collection stations built in year n

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prices when collected by informal collectors. This implies that the more developed collection networks allow for decrease of input prices for recyclers

Table 8. Main financial and economic assumptions used in determination of number of GVA in recycling, collection and construction

Coefficient	Name of variable	Amount	Source
SUB	Subsidy amount EUR mln	14	Financial statements 2017, Budget Law 2018, Ministry of Environmental protection (2019)
PS	Average selling price of recycled materials, EUR per tonne	225	Financial statements 2017, Interviews with recyclers
PP	Average purchase price of raw WEEE, EUR per tonne (2018)	205	Financial statements 2017, Interviews with recyclers
DC	Average cost of disposal of materials, EUR per tonne	87	Financial statements 2017, Interviews with recyclers
FC	Fuel consumption per vehicle, l per 100 km	35	Interviews with recyclers
FP	Fuel price, EUR per litre	1.0	Interviews with recyclers
IR	Average borrowing interest rate, %	5%	CEVES assumption, market overview
AW	Average wage, EUR monthly, gross	750	Interviews with recyclers

Source: CEVES