„Circular Economy“
Preduvjeti i (infrastrukturna) rješenja za izazove gospodarenja komunalnim otpadom

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- Znanstveno vijeće za zaštitu prirode i okoliša

Zagreb, 14.01.2025.

UNEP 2024: Global Waste Management Outlook 2024:

© 2024 United Nations Environment Programme: Global Waste Management Outlook 2024

Table 1: Waste management and its links to the Sustainable Development Goals

SUSTAINABLE DEVELOPMENT GOALS

Goal 1. No poverty: Waste workers in informal economies who have no health or social protections are vulnerable to exploitation and are paid only the material value of the materials they collect. Inclusive municipal waste management policies are most effective for addressing both poverty and pollution.

Goal 2. Zero hunger: While global hunger is increasing, one-third of all the food grown in the world is wasted. Hunger can be reduced by preventing food waste and redistributing excess food. Converting unavoidable food waste into compost can replenish depleted agricultural soils.

Goal 3. Good health and well-being: Communities without adequate municipal waste management services resort to dumping and open burning, both of which have significant negative health consequences, particularly for women and children.

Goal 4. Quality education: Waste management courses in tertiary and higher education are uncommon, resulting in a lack of professional technical capacity and a shortage of workers with appropriate skills and knowledge.

Goal 5. Gender equality: People's experience with waste and its management is gender-differentiated: e.g. household purchasing and domestic waste-generating activities, and levels of influence over community decision-making regarding waste collection services.

Goal 6. Clean water and sanitation: Pollutants leaching from dumpsites can contaminate freshwater sources and associated food chains. Meanwhile, combining municipal solid waste and container-based sanitation services can achieve economies of scale that make both services more attractive to investors.

Goal 7. Affordable and clean energy: Unavoidable food waste can be used to make biogas, a clean-burning renewable fuel that could be used to tackle energy poverty, including in off-grid communities.

Goal 8. Decent work and economic growth: The waste management and recycling sector is uniquely positioned to improve global resource efficiency, decouple economic growth from environmental degradation, and provide safe and decent work opportunities for all.

Goal 9. Industry, innovation and infrastructure: Decentralised waste management systems can attract private sector investment, encouraging innovation, entrepreneurship, domestic technology development, greater resource efficiency and increased employment opportunities, and reduce financial risks for governments and municipalities.

Goal 10. Reduced inequalities: Intragenerational and intergenerational inequalities must be addressed through developing waste and resource management systems; attention is required from all stakeholders because the transition to a more circular economy will not occur by default.

Goal 11. Sustainable cities and communities: Solid waste management is a basic utility service without which air quality and living conditions become degraded, leading to poor health and social discontent. To make cities and communities inclusive, safe, resilient and sustainable, universal access to municipal waste management services is essential.

Goal 12. Responsible consumption and production: Production and consumption patterns directly impact municipal waste generation. To reduce waste and prevent pollution, efforts are needed by companies, governments and citizens.

Goal 13. Climate action: Poorly managed waste generates a wide range of emissions that contribute to climate change, most significantly methane from landfills and dumpsites, and black carbon and a range of other emissions from the widespread practice of the open burning of waste.

Goal 14. Life below water: Understanding why and how land-based waste reaches the sea, and introducing mitigation measures, is essential. Urgent action is particularly required in the case of Small Island Developing States, which face a complex set of waste management challenges.

Goal 15. Life on land: The terrestrial environment continues to be the primary sink for waste, while rural communities face complex waste management challenges that if left unmanaged can significantly impact ecosystems and dependent livelihoods.

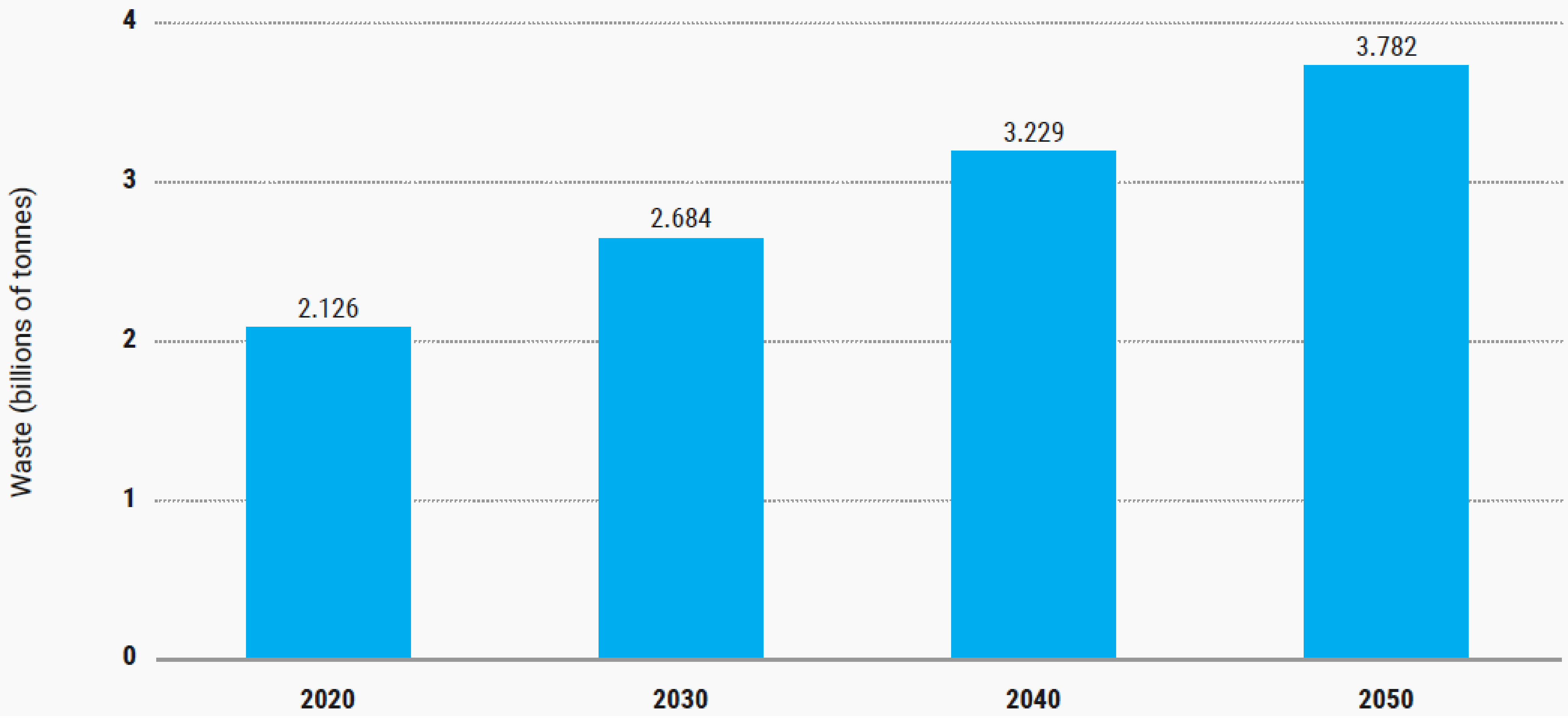
Goal 16. Peace, justice and strong institutions: The increasingly global nature of waste management calls for heightened international cooperation to build national capacity for the safe management of hazardous waste and to prevent its illegal trafficking.

Goal 17. Partnerships for the Sustainable Development Goals: Current investments in waste management are insufficient. Far higher investments will be needed in the future to cope with increasing waste generation and the accumulation of legacy waste. The return on investment for waste management needs to be realised to catalyse increased finance.

Source: United Nations Environment Programme 2023

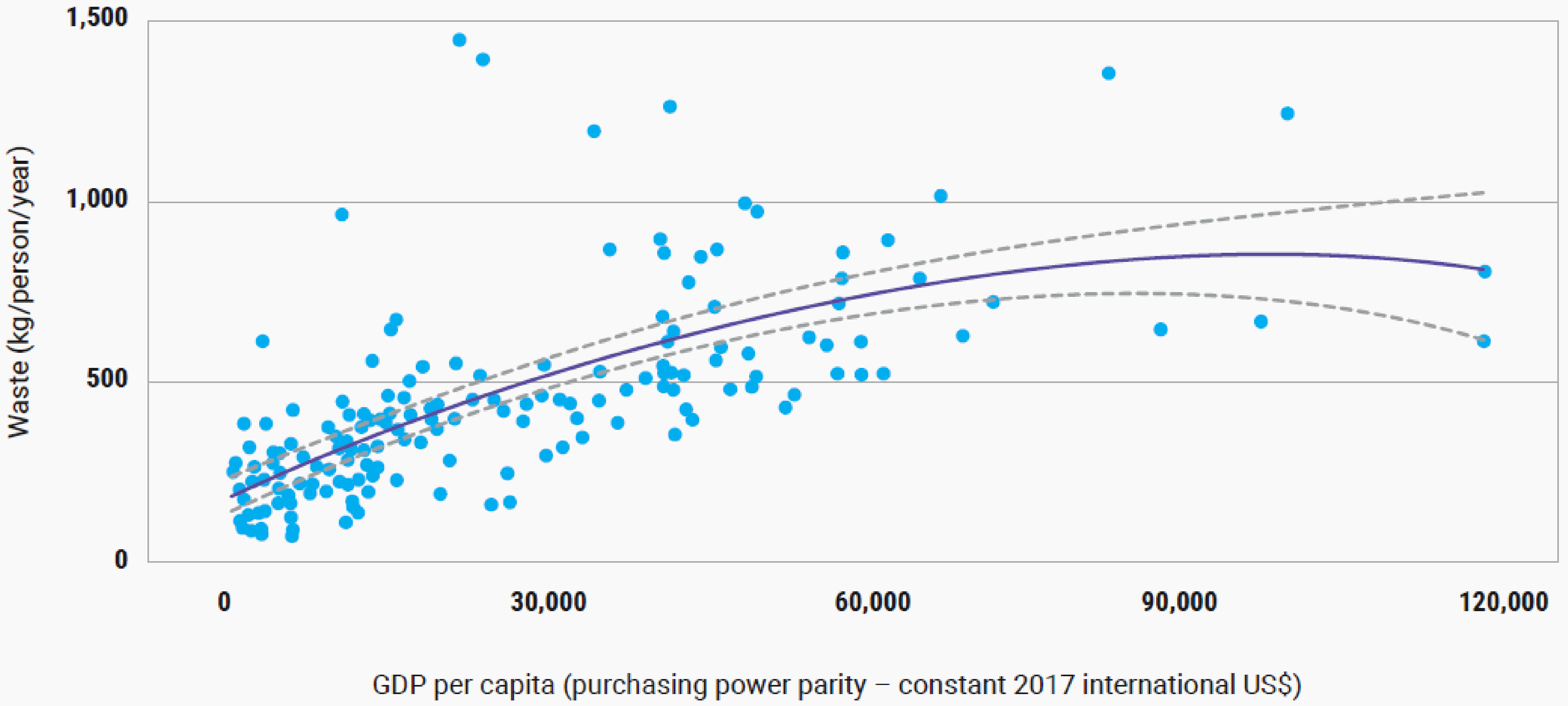
UNEP 2024: 3.8 billion tonnes of MSW by 2050

Figure 3: Projections of global municipal solid waste generation per year in 2030, 2040 and 2050 if urgent action is not taken.



UNEP 2024: higher GDP means increased MSW generation

Figure 1: Relationship between gross domestic product (GDP) and waste generation in most recent year available between 2010 and 2020



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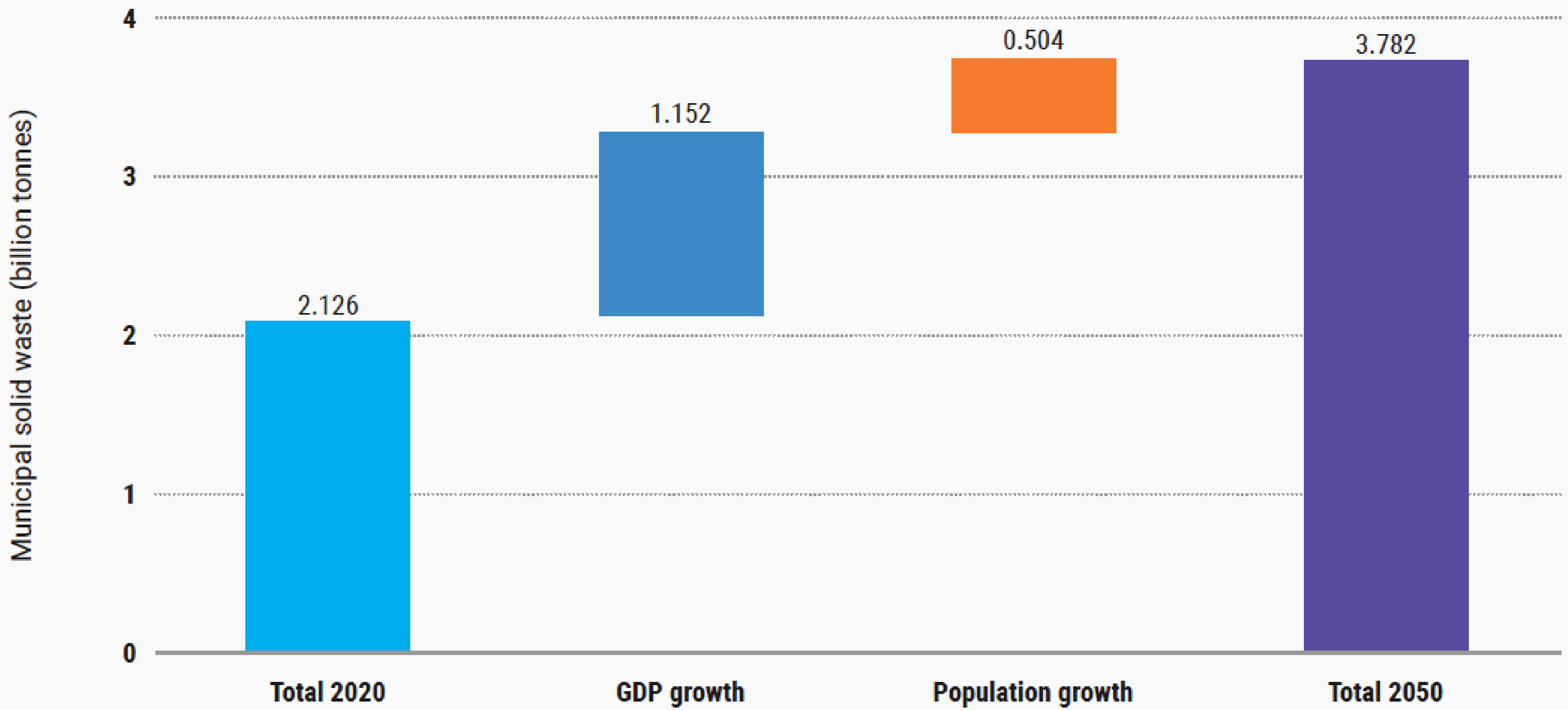
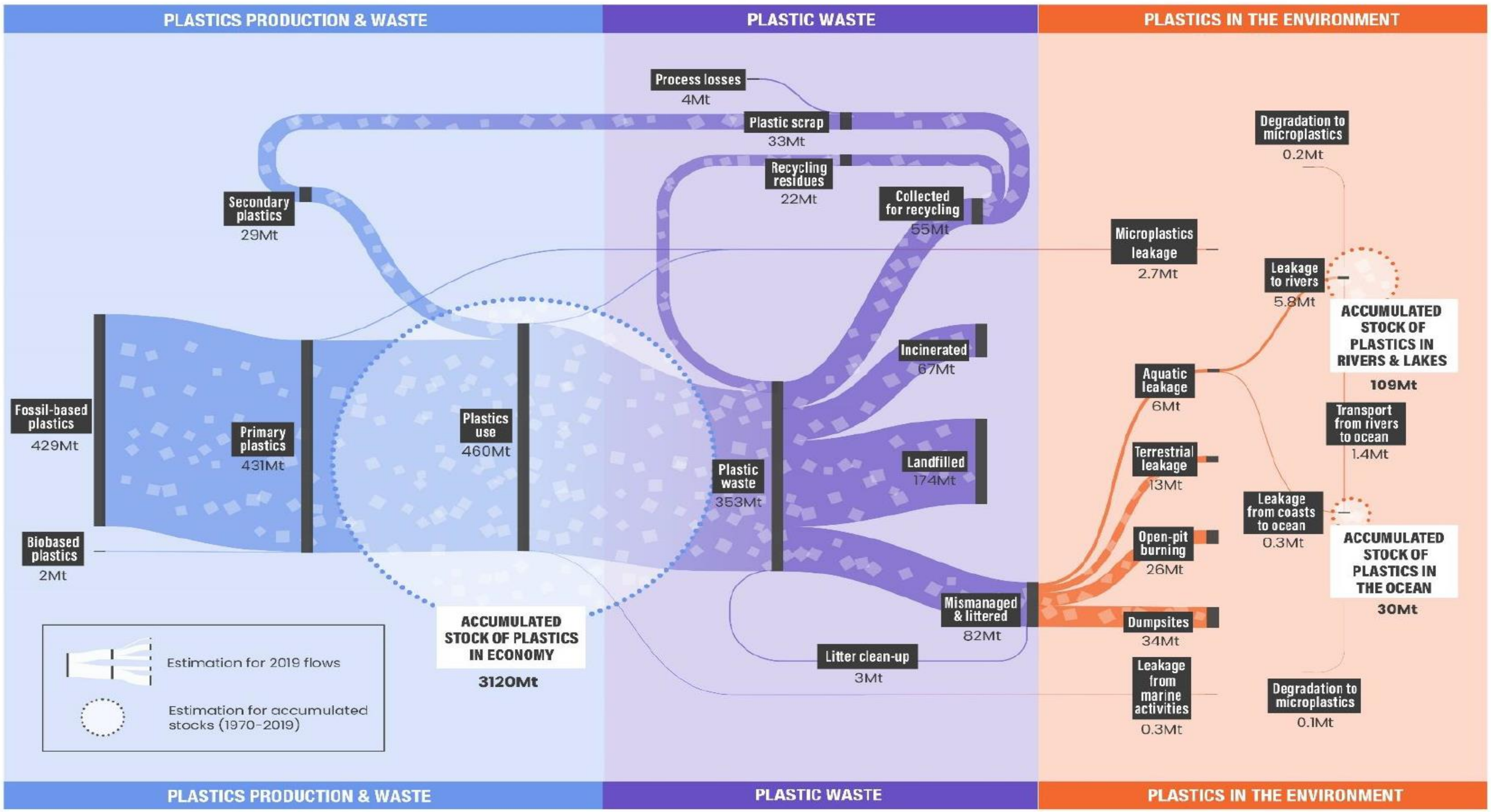
UNEP 2024: 2/3 of add. waste amount from GDP growth

Figure 4: Contribution of gross domestic product growth and population growth to the projected increase in global municipal solid waste generation in 2050.



Global Plastics Outlook 2022:
Global Plastic waste => 9% recycled

Figure 1.1. Only 33 million tonnes (Mt), or 9% of the 353 Mt of plastic waste, was recycled in 2019



Source: OECD Global Plastics Outlook Database, https://doi.org/10.1787/c0821f81-en.

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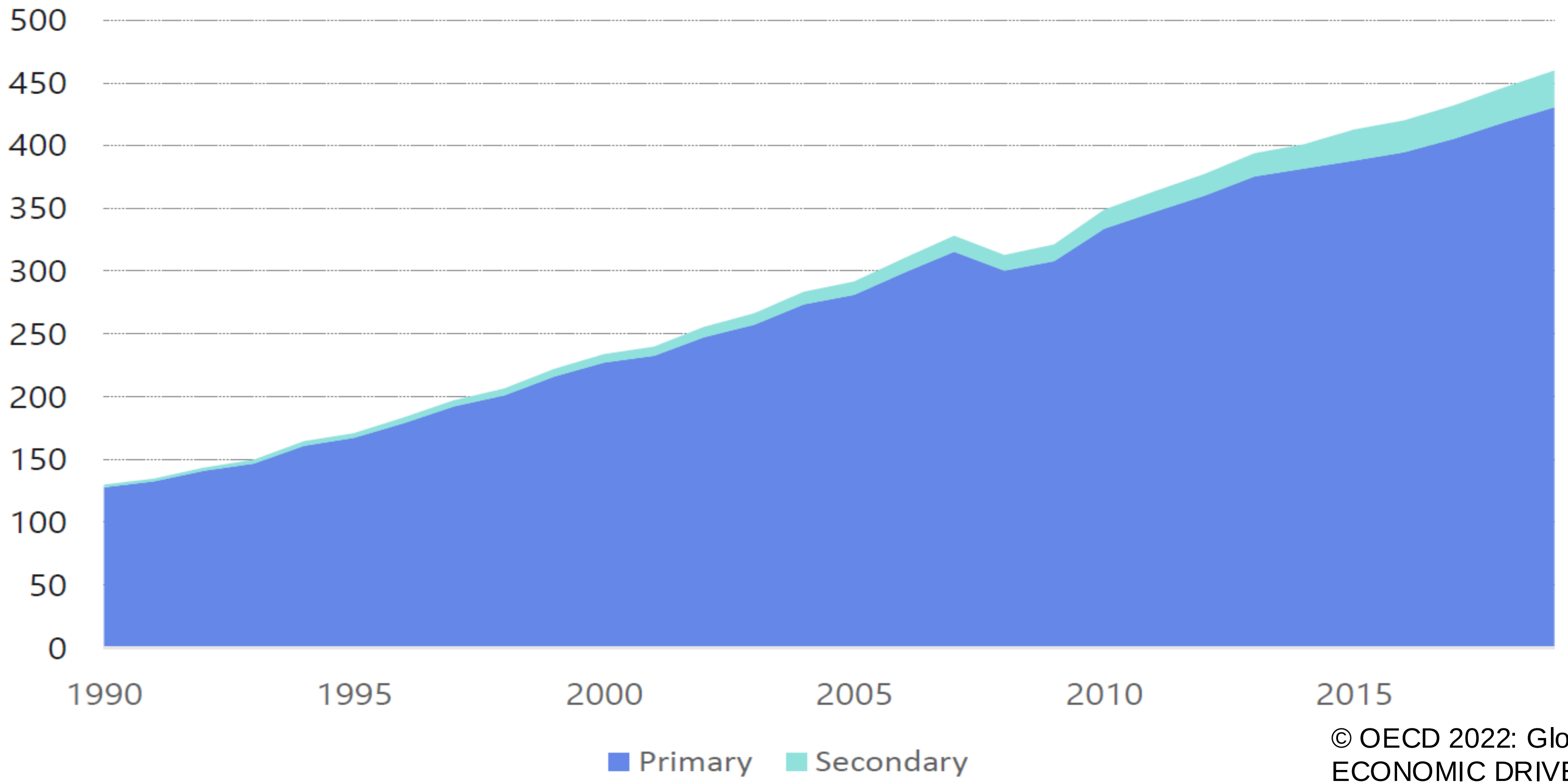
Global Plastics Outlook 2022:
Global Secondary Plastics => 6% of total plastics

Figure 1.3. Secondary production is growing, but makes up only six percent of total plastic production

In million tonnes (Mt), 1990-2019



Source: OECD Global Plastics Outlook Database, https://doi.org/10.1787/c0821f81-en.

StatLink https://stat.link/gwun3o

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Sadržaj

- Cirkularna Ekonomija i (pred)uvjeti
- Use case „Plastika & Sortirnice“
- Use case „Smart Waste Factory & Digitalizacija“
- Use Case „Reciklaža kroz energetsku oporabu“
- Use Case „Energetska oporaba“
- Zaključci

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FEAD 2022.: Razvoj EU „otpadne“ legislative kao temelja za gospodarenje sirovinom i energijom

- **1973.:** Nakon Stockholmske konferencije (1972.), **prva velika konferencija UN-a usmjerena na međunarodnu pitanja zaštite okoliša, prvi Okolišni Akcijski program (Environmental Action Programme)** navodi načela i ciljeve politike zaštite okoliša Zajednice. Fokusirao se na povezivanje okoliša s gospodarstvom razvoj i dobrobit europskih građana.
- **1975.: Koncept „otpada“ definiran je po prvi put u prvoj Europskoj okvirnoj direktivi o otpadu (75/442/EEC),** kao „svaka tvar ili predmet koji posjednik odlaže ili je dužan odložiti u skladu s odredbama nacionalnog zakona na snazi“. To je bio temelj budućeg zakonodavstva o otpadu, **usmjerenog na uspostavljanje kontrole opasnosti i zaštitu okoliša i zdravlja ljudi.**

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FEAD, 2022: From Circular Economy to the fight against climate change – 40th Anniversary of the European Waste Management Association, 2022.

- **2008.**: Revidirana je **Okvirna direktiva o otpadu (Direktiva 2008/98/EZ)** kojom se uspostavlja obvezujuća **„hijerarhija otpada“ u pet koraka**. Također su uvedeni bitni koncepti, kao što su **nusproizvod i ukidanje statusa otpada („end-of-waste“)**, kako bi se razlikovao otpad od neotpada, kao i **proširena odgovornost proizvođača**. Revizijom iz 2008. godine prvi je put odgovornost za gospodarenje otpadom stavljena na **„izvornog proizvođača otpada“**, osim nositelja, kao što je to bilo u prethodnim verzijama. **Takva odgovornost proizvođača već je ugrađena u Direktive o ambalaži i ambalažnom otpadu (PPWD), o otpadnim vozilima (ELV), otpadnoj električnoj i elektroničkoj opremi (WEEE) i o baterijama, te stavlja financijsku i organizacijsku odgovornost za upravljanje postkonzumnim proizvodima i ambalažom na proizvođača, za jačanje ponovne uporabe i sprječavanje, recikliranje i drugu oporabu otpada.**

  Ova revizija također je uključivala **kvantitativne ciljeve za pripremu za ponovnu upotrebu i recikliranje otpada** u državama članicama EU. Kako bi se u potpunosti dosegnulo ciljano europsko društvo recikliranja, također je bitno da takvi reciklirani proizvodi imaju izlaz i potražnju na tržištu. Obavezni reciklirani sadržaj u proizvodu prvi je put uveden u zakonodavstvo EU-a 2019.

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FEAD, 2022: From Circular Economy to the fight against climate change – 40th Anniversary of the European Waste Management Association, 2022.

- **2015: Prvi Akcijski plan kružnog gospodarstva ...**
- **2016: Pariški sporazum postavio je globalni okvir za zaštitu klime**
- **2018: EU je usvojila Strategiju za plastiku. Do 2030. sva plastična ambalaža stavljena na tržište EU-a mora biti ponovno upotrebljiva ili lako reciklirajuća..**

  Revizijom Direktive o odlagalištima ograničava se udio komunalnog otpada koji se odlaže na odlagališta na 10% do 2035. godine.
- **2019: Europski Zeleni Plan (EGD) – plan za održivost gospodarstva EU-a;**

  Direktiva o jednokratnoj korištenoj plastici (SUP Direktiva (EU) 2019/904) prvi put obvezni reciklirani sadržaj u proizvodima (!) => PET boce 25% do 2025. etc.
- **2020: Uredba o taksonomiji (!) => paket poreza**
- **2021: "Paket Fit for 55" => klimatske, energetske, prometne i porezne politike**
- **2024: Europska Direktiva o korporativom izvještavanju o održivosti => transparentnost i transformacija poslovanja u održivosti + ekološki standardi**

FEAD, 2022: From Circular Economy that the fight against climate change – 40th Anniversary of the European Waste Management Association , 2022.

RH- uvjet za sirovine & energiju do 2035./2040.

- **ZGO; Članak 54. (1) Ciljevi gospodarenja otpadom propisuju se radi poticanja prelaska na gospodarstvo** koje je u većoj mjeri kružno i u kojem se što dulje zadržava vrijednost proizvoda, materijala i resursa, a stvaranje otpada se svodi na najmanju moguću mjeru
- **Komunalni otpad:** **recikliranje** **≥ 65%** do **2035. godine**.
  odlaganje **< 10% do 2035. godine**
- **Neopasni građevni otpad**: ≥ 70% do 2035. godine
- Plastični proizvodi za jednokratnu uporabu: **90% odvojeno sakupiti** radi recikliranja do 2029.
- **PET boce** trebaju sadržavati **≥ 25% reciklirane plastike** od 2025. godine; 30% od 2030.
- **Otpadna ambalaža: ≥ 70% mase** ukupne otpadne ambalaže do 2030. + specifični ciljevi za pojedine vrste ambalaže

„Landfill tax“ u RH

– 30,00 eura za 2025. godinu

– 35,00 eura za 2026. godinu

– 40,00 eura za 2027. godinu

– 45,00 eura za 2028. godinu

– 50,00 eura za 2029. godinu i nadalje.

Uredba o jediničnoj naknadi za odlaganje otpada

VLADA REPUBLIKE HRVATSKE

2259

Na temelju članka 100. stavka 6. Zakona o gospodarenju otpadom (»Narodne novine«, br. 84/21. i 142/23. – Odluka Ustavnog suda Republike Hrvatske), Vlada Republike Hrvatske je na sjednici održanoj 28. studenoga 2024. donijela

UREDBU

O JEDINIČNOJ NAKNADI ZA ODLAGANJE OTPADA

Članak 1.

Ovom Uredbom propisuje se jedinična naknada za obračun naknade za odlaganje otpada.

Članak 2.

(1) Jedinična naknada za obračun naknade za odlaganje jedne tone svake vrste otpada postupkom D 1, D 5 ili D 12, koji su propisani Dodatkom I. Zakona o gospodarenju otpadom iznosi:

– 30,00 eura za 2025. godinu

– 35,00 eura za 2026. godinu

– 40,00 eura za 2027. godinu

– 45,00 eura za 2028. godinu

– 50,00 eura za 2029. godinu i nadalje.

(2) Iznimno od stavka 1. ovoga članka, jedinična naknada za obračun naknade za odlaganje otpada iznosi 0,00 eura za:

– otpad odložen na odlagalištu koje je u okviru centra za gospodarenje otpadom i

– otpad koji sadrži azbest i koji je odložen na posebne plohe (kazete) na odlagalištima otpada.

Članak 3.

(1) Sredstva prikupljena naplatom naknade za odlaganje otpada koristi Fond za zaštitu okoliša i energetsku učinkovitost (u daljnjem tekstu: Fond) za financiranje gradnje i unaprjeđenje infrastrukture za gospodarenje otpadom i recikliranje otpada te na odgovarajuće obrazovne i informativne aktivnosti.

(2) Sredstva prikupljena naplatom naknade za odlaganje otpada, Fond može koristiti, uz prethodnu suglasnost Vlade Republike Hrvatske, za financiranje pripreme, provedbe i razvoja programa i projekata gospodarenja otpadom i sličnih aktivnosti u području očuvanja, održivog korištenja, zaštite i unaprjeđenja okoliša.

(3) Sredstva prikupljena naplatom naknade za odlaganje otpada ne mogu se koristiti za gradnju novih ploha odlagališta i produljenje vijeka trajanja postojećih odlagališta.

Članak 4.

Ova Uredba objavit će se u »Narodnim novinama«, a stupa na snagu 1. siječnja 2025.

Klasa: 022-03/24-03/126
Urbroj: 50301-05/14-24-3
Zagreb, 28. studenoga 2024.

Predsjednik
mr. sc. Andrej Plenković, v. r.

Dio NN: Službeni

Vrsta dokumenta: Uredba

Izdanje: NN 137/2024

Broj dokumenta u izdanju: 2259

Stranica tiskanog izdanja: 7

Donositelj: Vlada Republike Hrvatske

Datum tiskanog izdanja: 29.11.2024.

ELI: /eli/sluzbeni/2024/137/2259

ISPIŠI PDF

Prikaz na čitavom ekranu

Abfallverwertungstechnik & Abfallwirtschaft

Austria's Circular Economy Strategy 2022 & Vision 2050

Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

"The long-term goal of the Austrian federal government is to reform the Austrian economy and society into a comprehensive sustainable circular economy by 2050."

digitised

Austria on the path to a sustainable and circular society

The Austrian Circular Economy Strategy

CIRCULAR MATERIAL USE RATE

- **GOAL 3. Increasing the circularity rate to 18 % by 2030**
- **DE: 13,4%**
- **EU27: 12,8**
- **SI: 12,3%**
- **AT: 12,0 %**
- **HR: 5,1%**

The CIRCULARITY RATE refers to the percentage of materials and resources used in the economy that originate from recycling.

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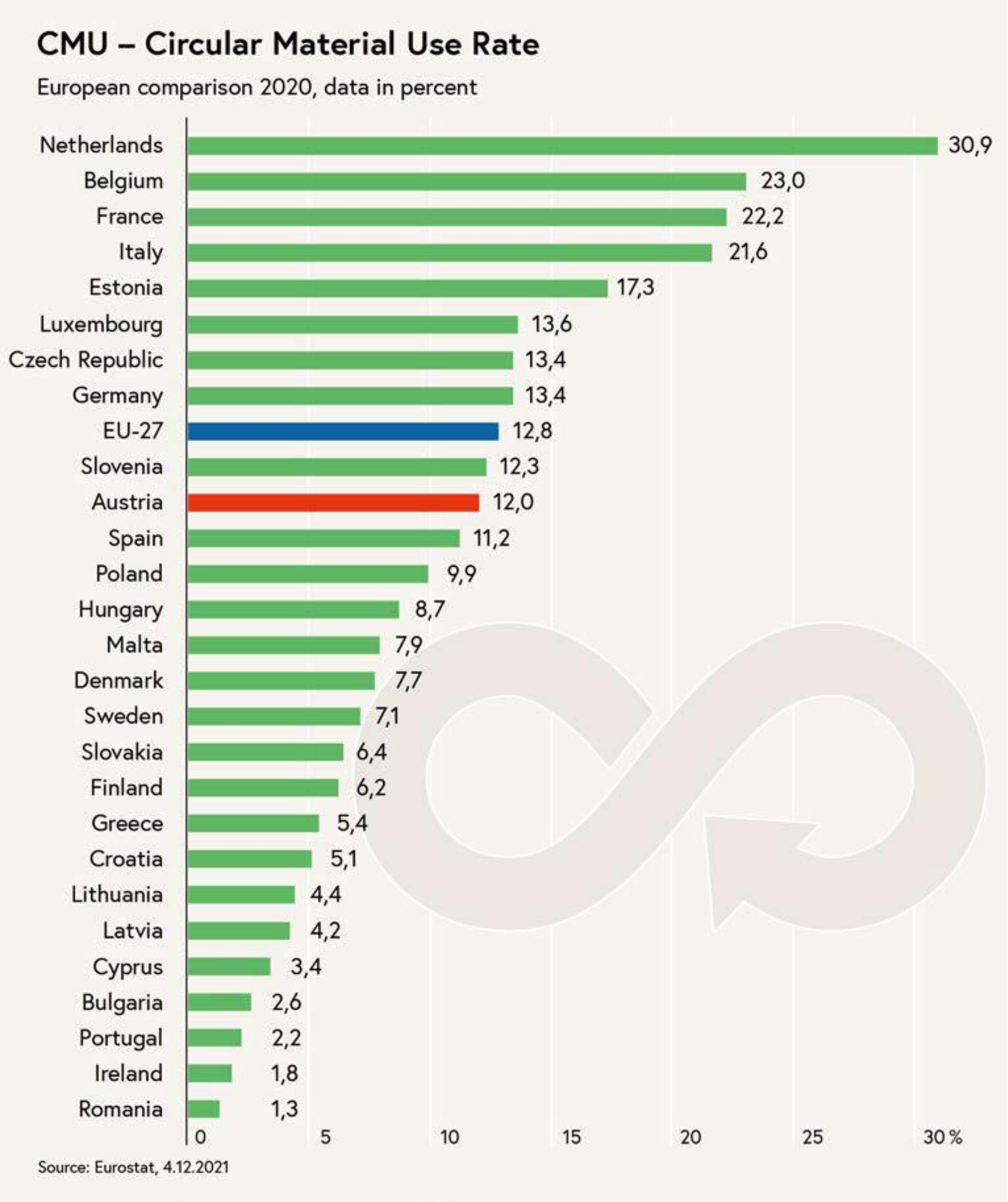
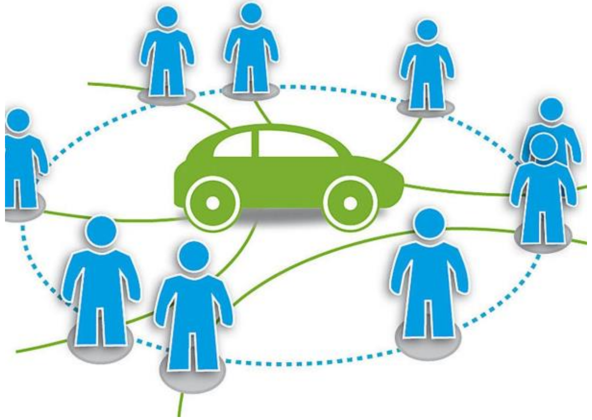
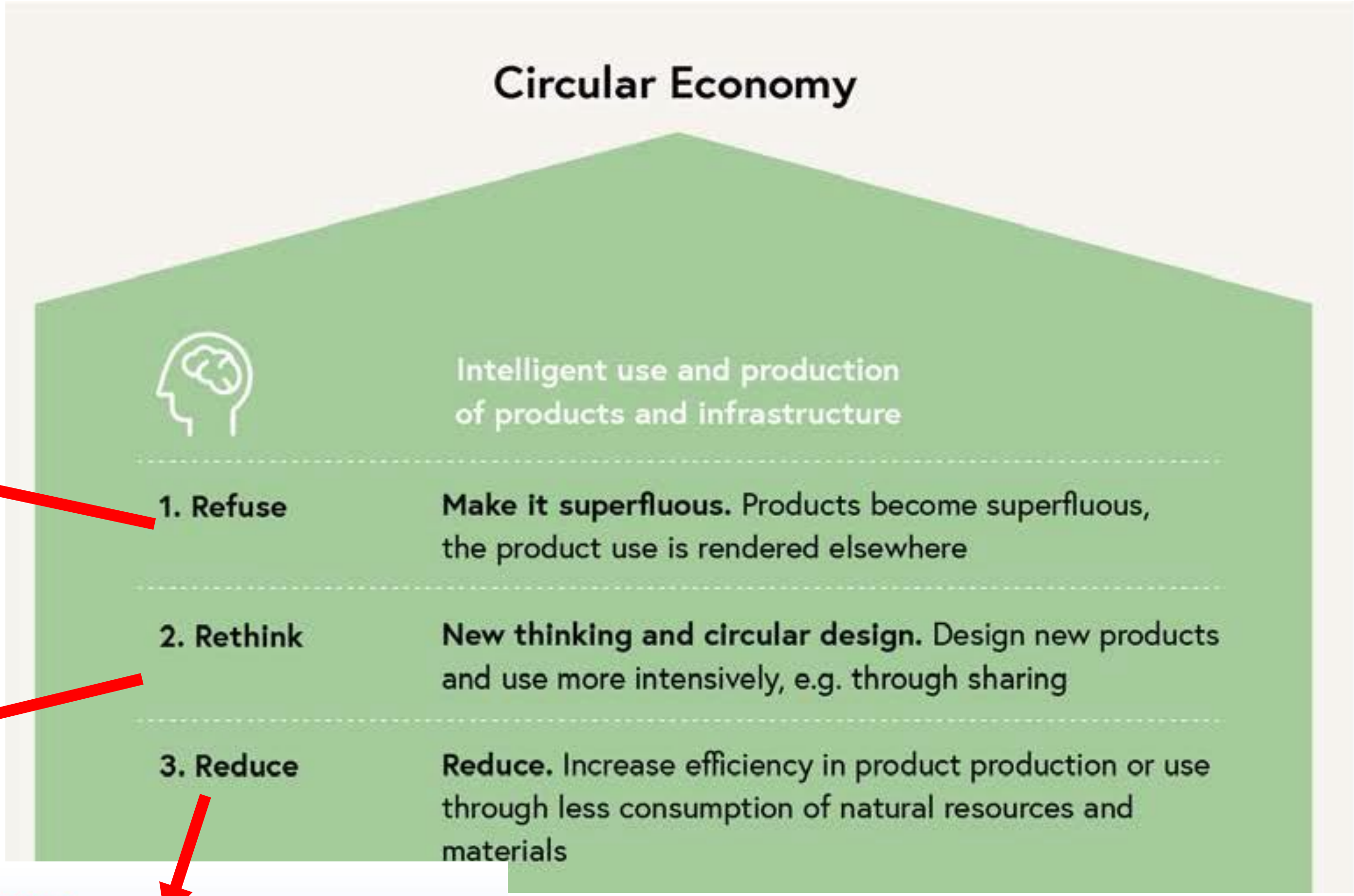


Refuse/Rethink/Reduce => Awareness contribution

- **Intelligent USE & PRODUCTION OF PRODUCTS and INFRASTRUCTURE**





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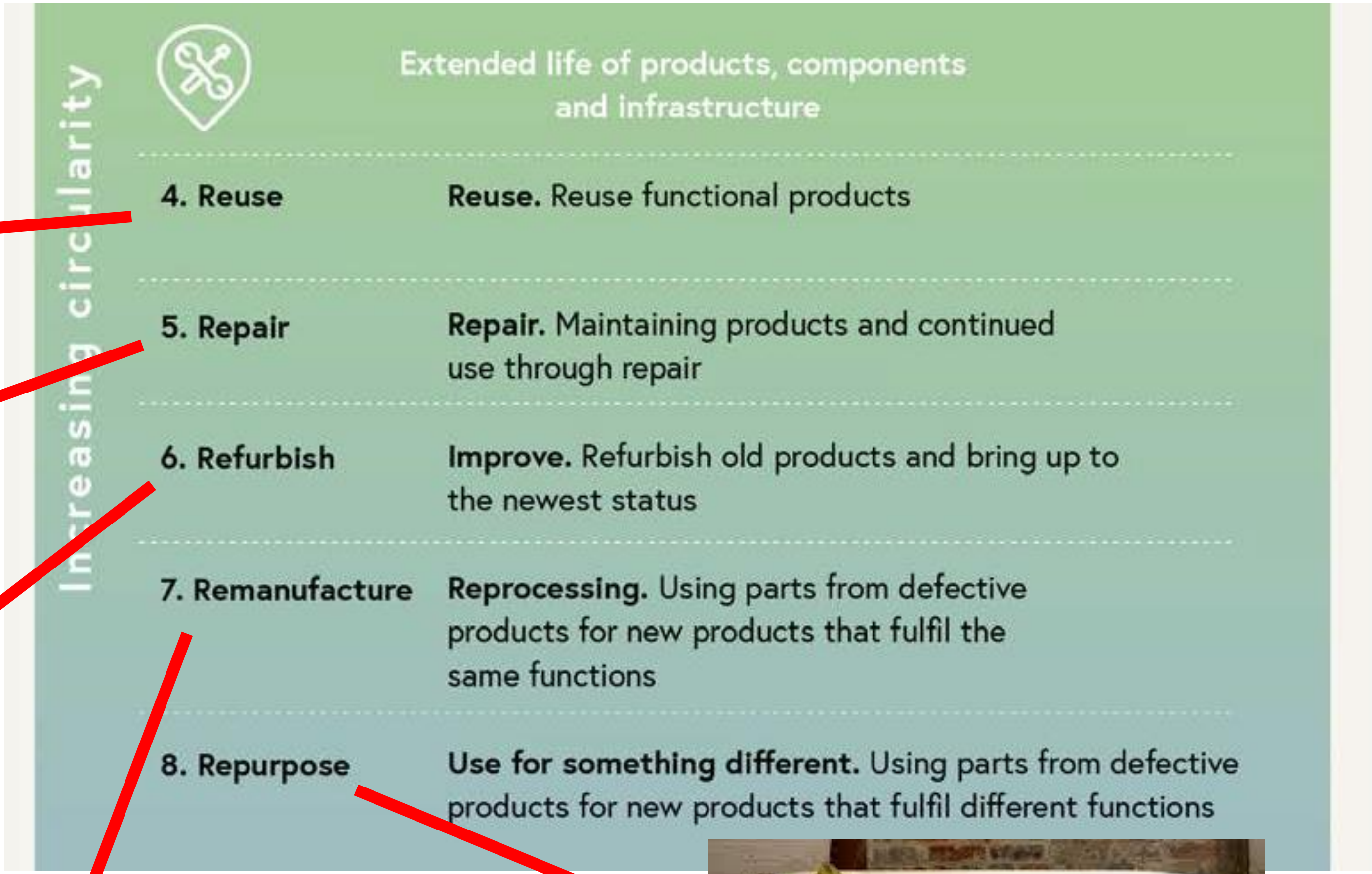
Reuse => Awareness contribution

- **EXTENDED LIFE of PRODUCTS, COMPONENTS & INFRASTRUCTURE**



Extended life of products, components and infrastructure	
4. Reuse	**Reuse.** Reuse functional products
5. Repair	**Repair.** Maintaining products and continued use through repair
6. Refurbish	**Improve.** Refurbish old products and bring up to the newest status
7. Remanufacture	**Reprocessing.** Using parts from defective products for new products that fulfil the same functions
8. Repurpose	**Use for something different.** Using parts from defective products for new products that fulfil different functions

…

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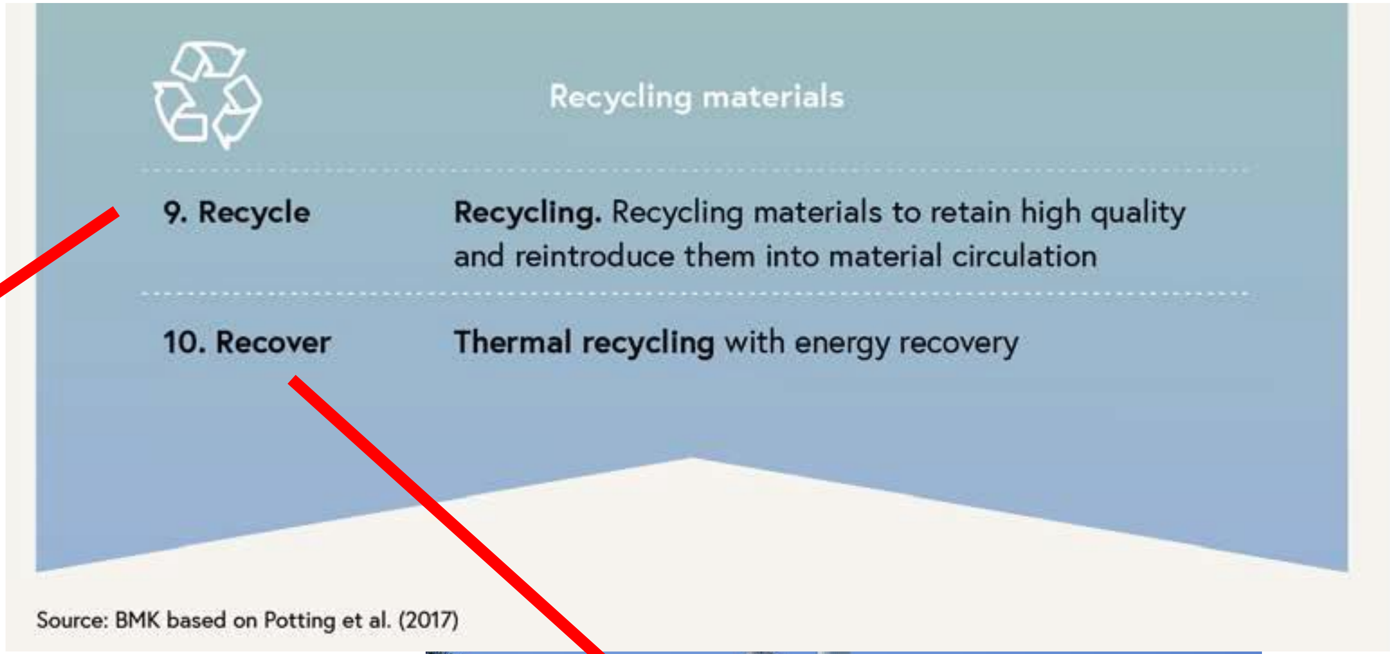
2 technical principles of Circular Economy

- **RECYCLING MATERIALS**

  & Thermal recycling with energy recovery



New WtE plant for pre-treated waste for high efficient energy production Norske Skog, Bruck/Mur, AT

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Recyclability is one of main requirements for CE

- **"Is the ability of a product to be recycled after separate collection and/or waste processing."**

- Recyclability is a **key to more environmentally friendly products** and a **more circular economy.**

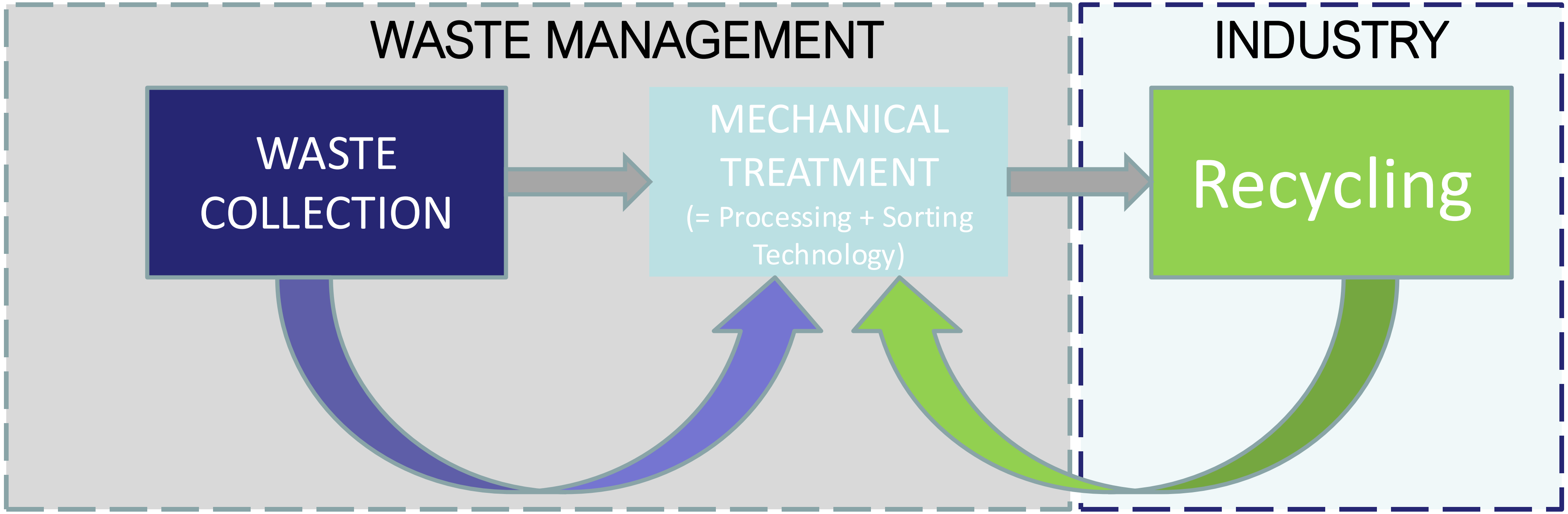
- Attention to **THEORETICAL, TECHNICAL AND REAL RECYCLABILITY** !!!

- **There are so many stupid products on the market that are not recyclable !**

Abfallverwertungstechnik & Abfallwirtschaft

Pomberger (2020): https://link.springer.com/article/10.1007/s00506-020-00721-5

Processing and Sorting technology as a link between waste collection and Recycling



Available quantities
Quality
Pollution/Dirt
Potential of recoverable fractions

(Secondary) Raw Material Market
Raw Material Prices
Quality Requirements

Recikliranje otpada ne odvija se unutar sektora gospodarenja otpadom, već u industriji koja zamjenjuje primarne sirovine odgovarajućim (kvaliteta & količina) sekundarnim sirovinama.

Sadržaj

- Cirkularna Ekonomija i (pred)uvjeti
- **Use case „Plastika & Sortirnice“**
- Use case „Smart Waste Factory &
- Use Case „Recikalaža kroz energetsku oporabu“
- Use Case „Energetska oporaba“
- Zaključci

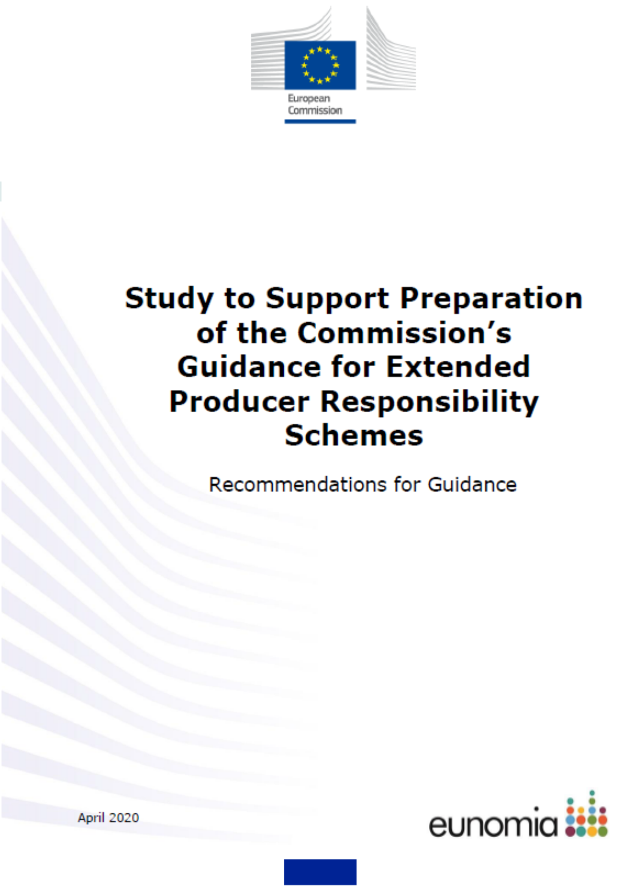
AVW Abfallverwertungstechnik & Abfallwirtschaft

CIRCULAR ECONOMY needs
Extended Producer Responibility (EPR)

- **Studija izrađena za Europsku Komisiju daje posebnu pažnju temi:**

  „Waste Management Costs to be Covered by the EPR Schemes“

https://op.europa.eu/en/publication-detail/-/publication/08a892b7-9330-11ea-aac4-01aa75ed71a1/language-en


European Commission

Study to Support Preparation of the Commission’s Guidance for Extended Producer Responsibility Schemes

Recommendations for Guidance

April 2020

eunomia

…Producers should bear the operational costs of collecting and managing the material they place on the market so that this material can be recycled…

=> „Full Cost Model“ => naknada treba pokriti sve troškove nastale za određenu vrstu materijala uzimajući u obzir ispunjenje svih zadanih ciljeva za tu vrstu otpada

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PRAVILNIK O AMBALAŽI I OTPADNOJ AMBALAŽI, PLASTIČNIM PROIZVODIMA ZA JEDNOKRATNU UPORABU I RIBOLOVNOM ALATU KOJI SADRŽAVA PLASTIKU (11.2023.)

SUSTAV PROŠIRENE ODGOVORNOSTI PROIZVOĐAČA KOJIM UPRAVLJA FOND

Članak 25.

(1) Fond upravlja gospodarenjem otpadnom ambalažom koja je neopasni otpad i ako se ispuni uvjet iz članka 11. stavka 2. ovog Pravilnika i otpadnom ambalažom koja je sukladno ovom Pravilniku opasni otpad.

(2) Fond je dužan ispuniti ciljeve u svezi ambalaže i u tu svrhu raspolaže otpadnom ambalažom, uključujući i otpadnu ambalažu koja je sakupljena u reciklabilnom komunalnom otpadu, provodi poslove za koje sukladno članku 105. Zakona osigurava nadoknadu troškova, te upravlja i osigurava funkcioniranje i učinkovitost sustava gospodarenja otpadnom ambalažom.


Ref. Ares(2023)2428990 - 04/04/2023

EUROPEAN COMMISSION
EUROSTAT

Directorate E: Sectoral and regional statistics
Unit E-2: Environmental statistics and accounts; sustainable development

Guidance for the compilation and reporting of data on packaging and packaging waste according to Decision 2005/270/EC

(Note: The Commission Delegated Decision on average loss rates is currently being finalised, future versions of this guidance will contain further details on the published legal act.)

Version of 30 March 2023

GUIDANCE of the EC: CALCULATION POINT: PLASTICS


EUROPEAN COMMISSION
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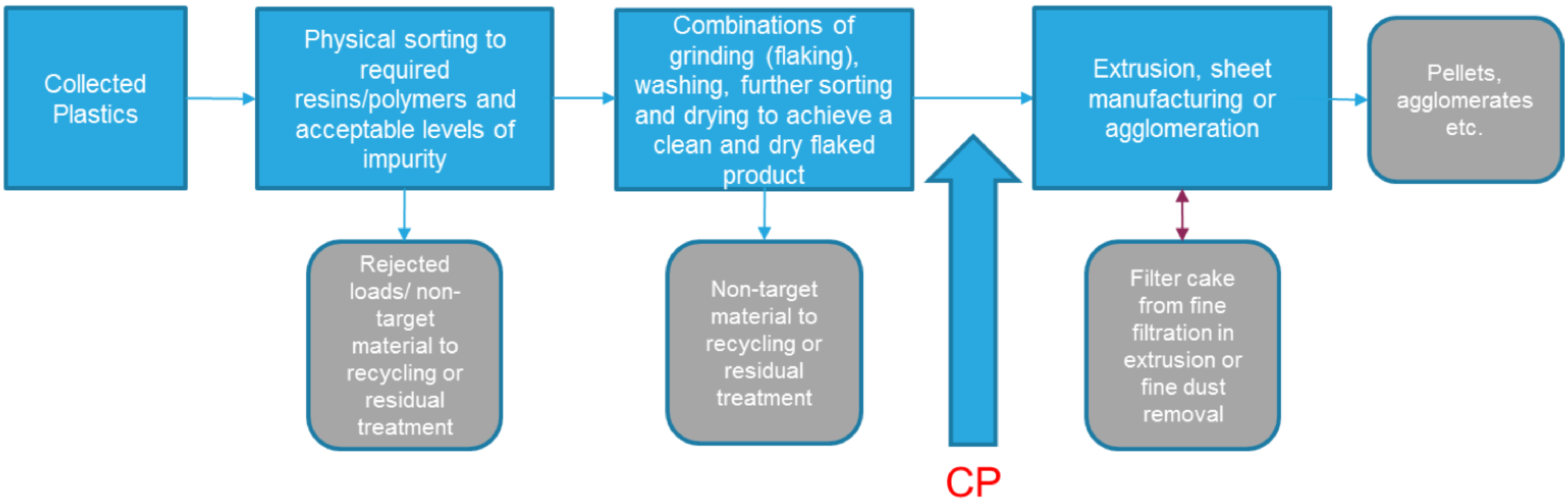
Version of 30 March 2023

- **50 % (2025) & 55% (2030)**

Figure A 1: Plastics calculation point



Abfallverwertungstechnik & Abfallwirtschaft

GUIDANCE of the EC: CALCULATION POINT: PAPER & C.


EUROPEAN COMMISSION
EUROSTAT
Directorate E: Sectoral and regional statistics
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Guidance for the compilation and reporting of data on packaging and packaging waste according to Decision 2005/270/EC

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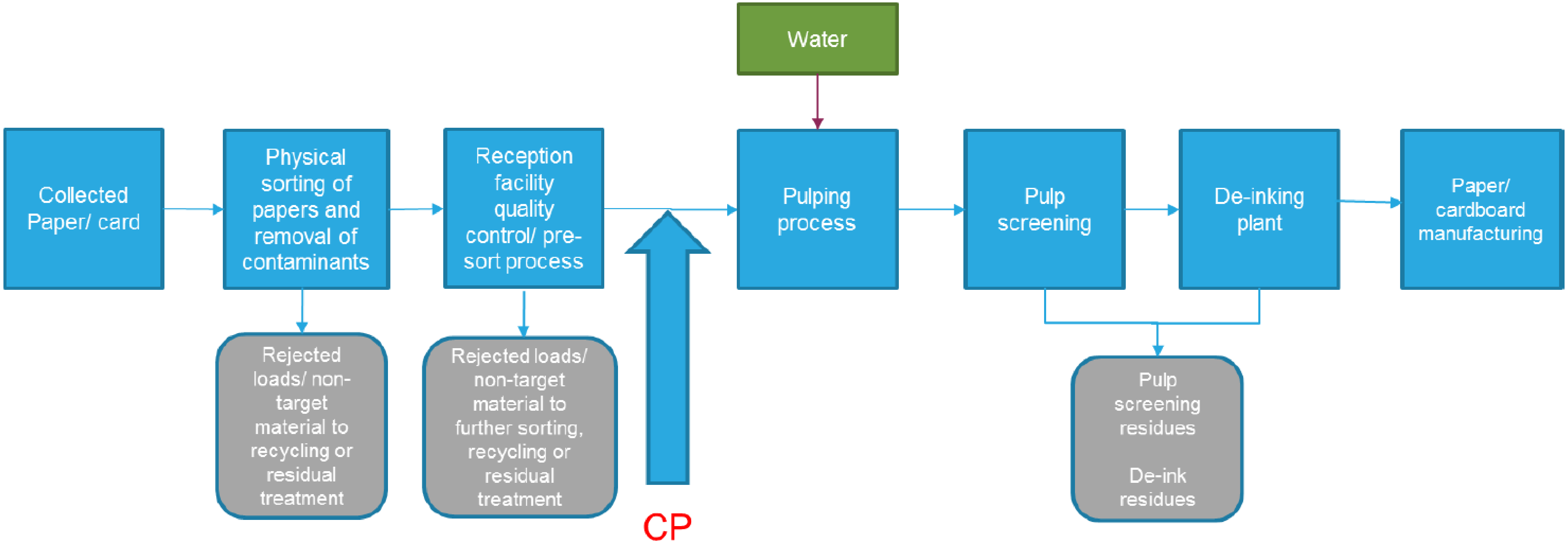
Version of 30 March 2023

- **75 % (2025) & 85% (2030)**

Figure A 2: Paper / cardboard calculation point



Abfallverwertungstechnik & Abfallwirtschaft

Cirkularna ekonomija je jedino ostvariva kada se osigura tržište za reciklate za proizvodnju novih proizvoda

Prognoza 2025.

+10 Mil. t/a

reciklata

https://recy gpor .eu/Archive/47349

RECIKLATI = SIROVINA

za nove PROIZVODE

=> **INDUSTRIJA je ključ**!

Nova sortirnica „TRIPLAST“ u AT, 2024: => kapacitet 100.000 t/a i 38 instaliranih NIR uređaja povezanih umjetnom inteligencijom

https://www.youtube.com/watch?v=gargo9q9iD8

https://triplast.at/

Sadržaj

- Cirkularna Ekonomija i (pred)uvjeti
- Use case „Plastika & Sortirnice“
- **Use case „Smart Waste Factory & Digitalizacija“**
- Use Case „Reciklaža kroz energetsku oporabu“
- Use Case „Energetska oporaba“
- Zaključci

ReWaste – COMET COMPETENCE CENTRES 2017-2025

COMET K-Projekt „ReWaste4.0“

Duration:	04/2017 – 03/2021
Partners:	8 Industry + 2 Scientific
Budget:	4,880,000 €
PhD Theses:	5 completed
M+B Theses:	12 + 12
PR Papers:	27
Conf. Contr.:	> 60
Staff:	119 people (82 m and 37 w)
Students:	39

COMET K-Projekt „ReWaste F“

Duration:	04/2021 – 03/2025
Partner:	14 Industry + 4 Scientific
Budget:	4,850,000 €
Post-Docs:	2 persons
PhDs:	4 persons
Students:	ca. 10 persons/a

Cooperations and Networking – Drivers of Innovation for Particle-, Sensor-, and Data-Based Circular Economy

„ReWaste F“

Smart Digitalisation and Networking

ANDRITZ SIEMENS

Recycling System

RecycleMe

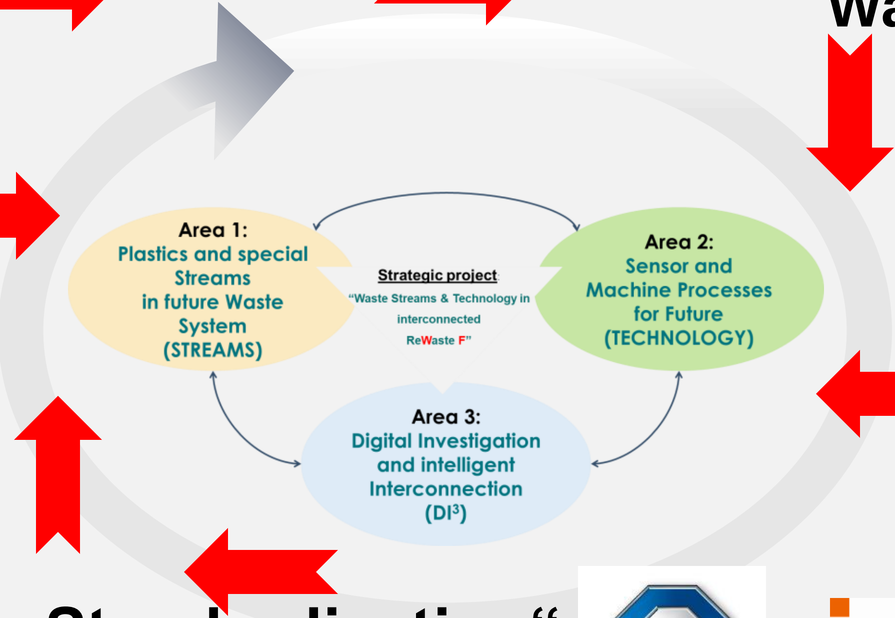
Waste Management & Treatment

Saubermacher müllex abfall container recycling

mayer Rohstoffe der nächsten Generation

Material Recycling

LAFARGE



Technology and Plants

REDWAVE KOMPTECH

Scientific Institutions

MONTANUNIVERSITÄT LEOBEN, KNOW Center, FH JOANNEUM University of Applied Sciences, RECENDT Research Center Non Destructive Testing

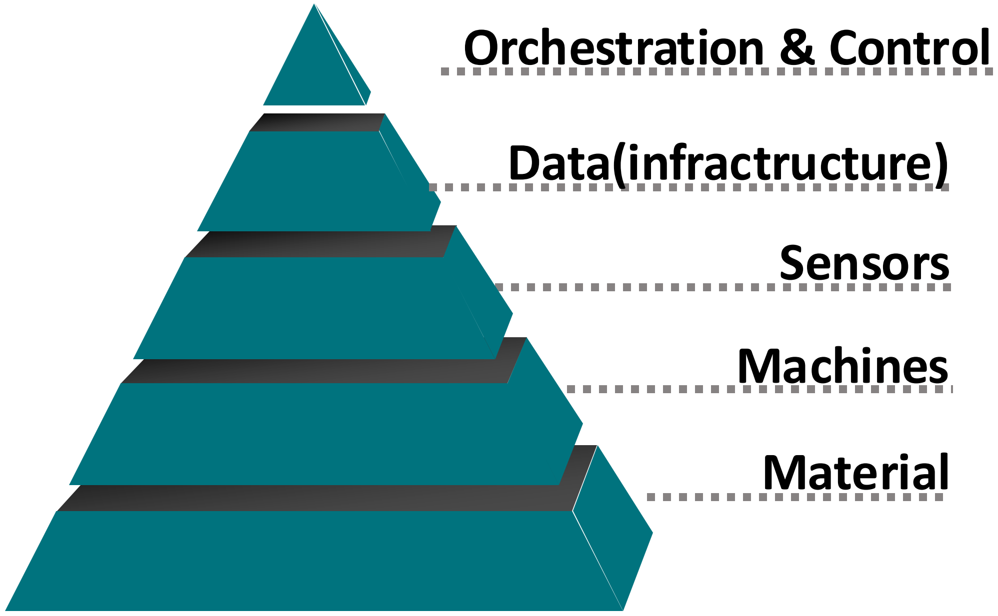
„Standardisation“

GREEN TECH CLUSTER, TÜV SÜD Landesgesellschaft Österreich, IFE Aufbereitungstechnik, EVK, IUT Ingenieurgemeinschaft Innovative Umwelttechnik GmbH

Abfallverwertungstechnik & Abfallwirtschaft

ReWaste F Prototype – Levels of R&D

Research Levels



Orchestration & Control

Individual Data Acquisition
Data Integration
Data Processing
Data-Based Calculations
Modeling
Machine control instructions …

Standardised Intelligent Networking and Modularity

=> **MTP = Module Type Package**

Determination and Implementation of Dynamic Control
=> Material Quality & Machine Control

=> SMART WASTE FACTORY DEVELOPMENT

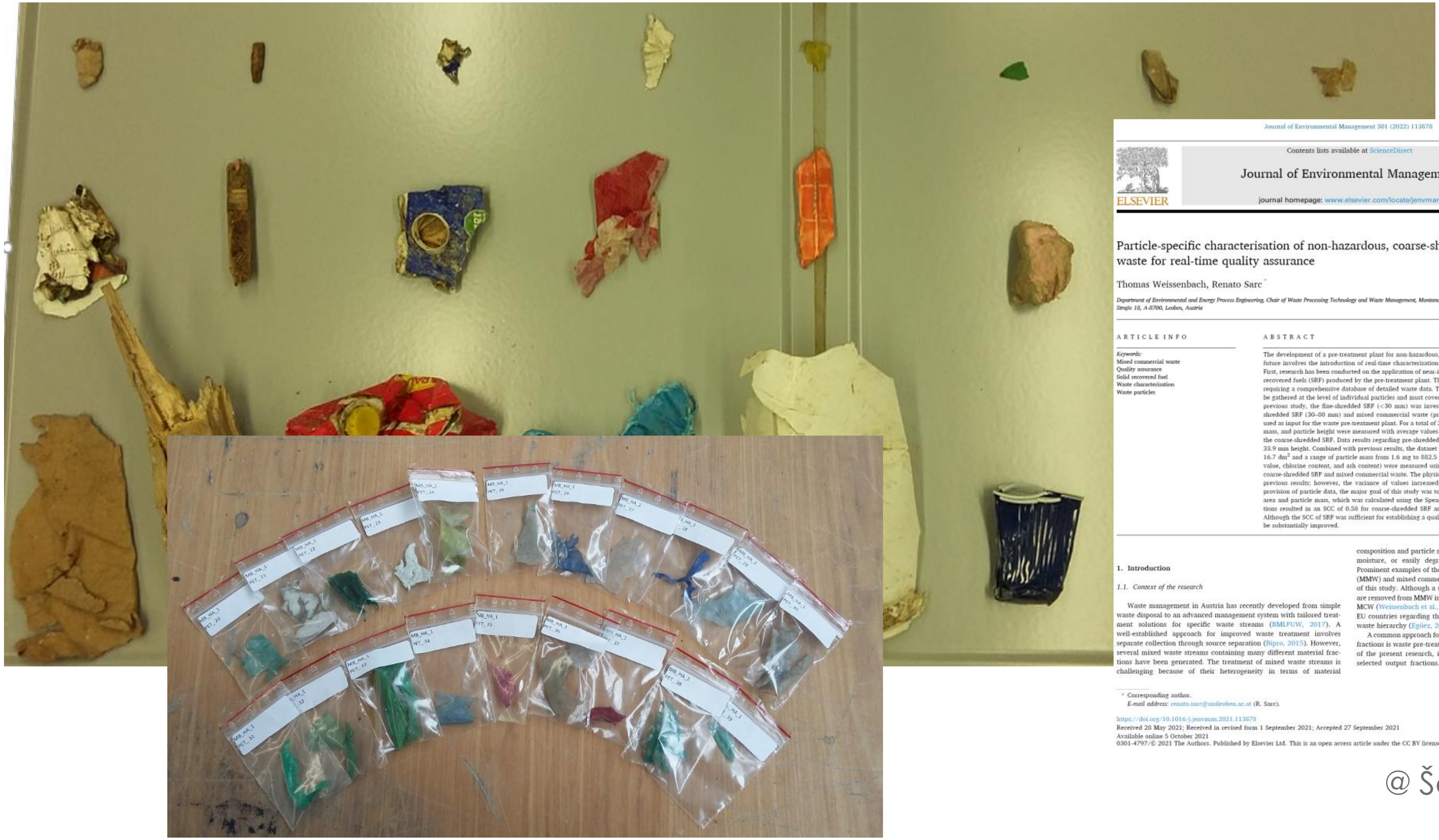
Development of a "Particle Database" – Linking "Traditional" Material Data with Sensor-Acquired Data

PCC Wood BCC PE PP PS PET PVC

Main Burner
< 30 mm
ca. **15,540 Particles**

Calciner
30 - 80 mm
ca. **1,080 Particles**

Input
80 – 500 mm
ca. **1,270 Particles**



Journal of Environmental Management 301 (2022) 113878

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Particle-specific characterisation of non-hazardous, coarse-shredded mixed waste for real-time quality assurance

Thomas Weissenbach, Renato Sarc *

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A R T I C L E I N F O

Keywords:
Mixed commercial waste
Quality assurance
Solid recovered fuel
Waste characterisation
Waste particles

A B S T R A C T

The development of a pre-treatment plant for non-hazardous, solid mixed waste into a smart waste factory for future involves the introduction of real-time characterisation of waste streams by applying sensor technology. First, research has been conducted on the application of near-infrared spectroscopy for quality assurance of solid recovered fuels (SRF) produced by the pre-treatment plant. The method is based on statistical analyses, thereby requiring a comprehensive database of detailed waste data. To ensure high-precision measurements, data must be gathered at the level of individual particles and must cover a broad spectrum of different particle types. In a previous study, the fine-shredded SRF (<30 mm) was investigated. The scope of this study includes coarse-shredded SRF (30–80 mm) and mixed commercial waste (pre-shredded to a maximum of 500 mm), which is used as input for the waste pre-treatment plant. For a total of 2346 particles, the projected particle area, particle mass, and particle height were measured with average values of 11.5 cm^2, 1.2 g and 10.4 mm, respectively, for the coarse-shredded SRF. Data results regarding pre-shredded waste input were 115 cm^2 area, 16.7 g mass and 33.9 mm height. Combined with previous results, the dataset covers a range of particle areas from 15.7 mm^2 to 16.7 dm^2 and a range of particle mass from 1.6 mg to 882.5 g. Additionally, selected fuel parameters (heating value, chlorine content, and ash content) were measured using laboratory analysis of composite samples from coarse-shredded SRF and mixed commercial waste. The physico-chemical results of the present study confirmed previous results; however, the variance of values increased, and more outliers were identified. Despite the provision of particle data, the major goal of this study was to determine the correlation between the projected area and particle mass, which was calculated using the Spearman's correlation coefficient (SCC). The calculations resulted in an SCC of 0.58 for coarse-shredded SRF and an SCC of 0.22 for pre-shredded waste input. Although the SCC of SRF was sufficient for establishing a quality assurance system, the SCC of input waste must be substantially improved.

1. Introduction

1.1. Context of the research

Waste management in Austria has recently developed from simple waste disposal to an advanced management system with tailored treatment solutions for specific waste streams (BMLFUW, 2017). A well-established approach for improved waste treatment involves separate collection through source separation (Bipro, 2015). However, several mixed waste streams containing many different material fractions have been generated. The treatment of mixed waste streams is challenging because of their heterogeneity in terms of material composition and particle size, as well as their contamination with dust, moisture, or easily degradable substances (Küppers et al., 2018). Prominent examples of these waste streams are mixed municipal waste (MMW) and mixed commercial waste (MCW), the latter being the focus of this study. Although a significant proportion of recyclable materials are removed from MMW in Austria, a high percentage are still present in MCW (Weissenbach et al., 2019). Austria is among the best-performing EU countries regarding the management of waste according to the EU waste hierarchy (Egüez, 2021).

A common approach for separating mixed waste streams into useable fractions is waste pre-treatment plants. This treatment type is the focus of the present research, including the input waste stream MCW and selected output fractions. Typical fractions produced are recyclable

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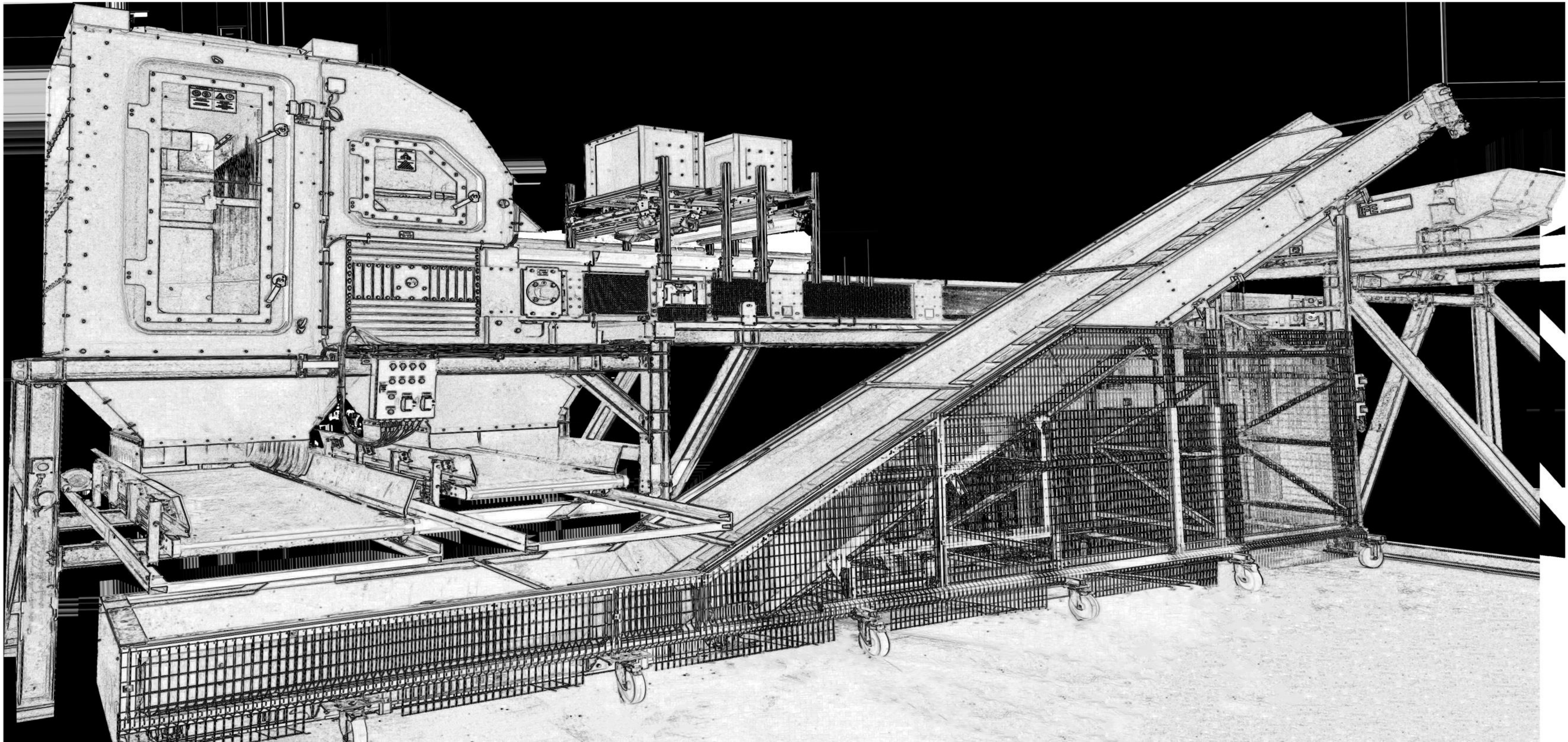
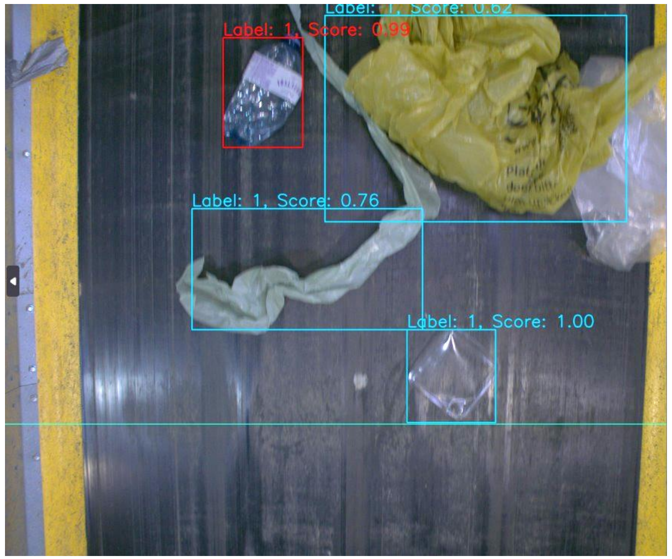
Available online 5 October 2021

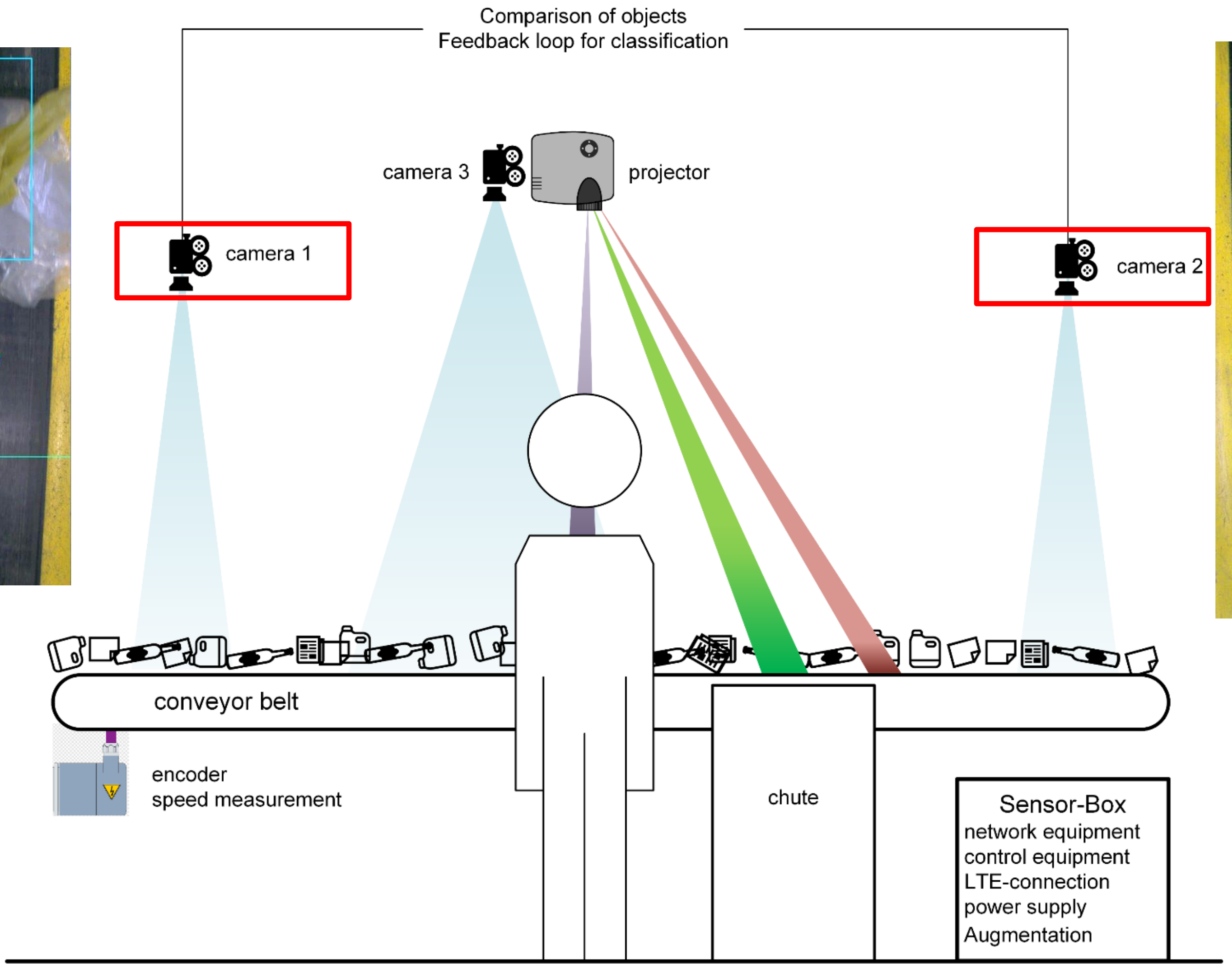

Aufgabe in
Zerkleinerer Aduro P

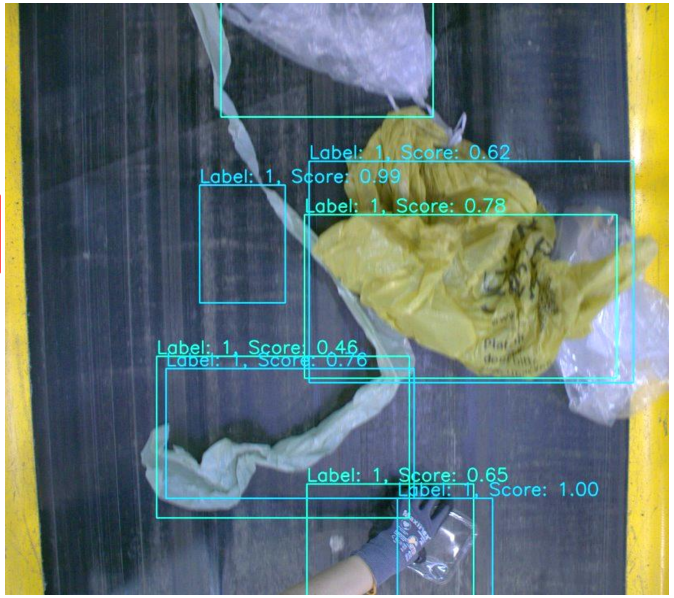
Real & Virtual Research Facility => DIGITAL Waste TWIN



recAIcle – Prototype & model training for AI-powered assistance system for manual waste sorting



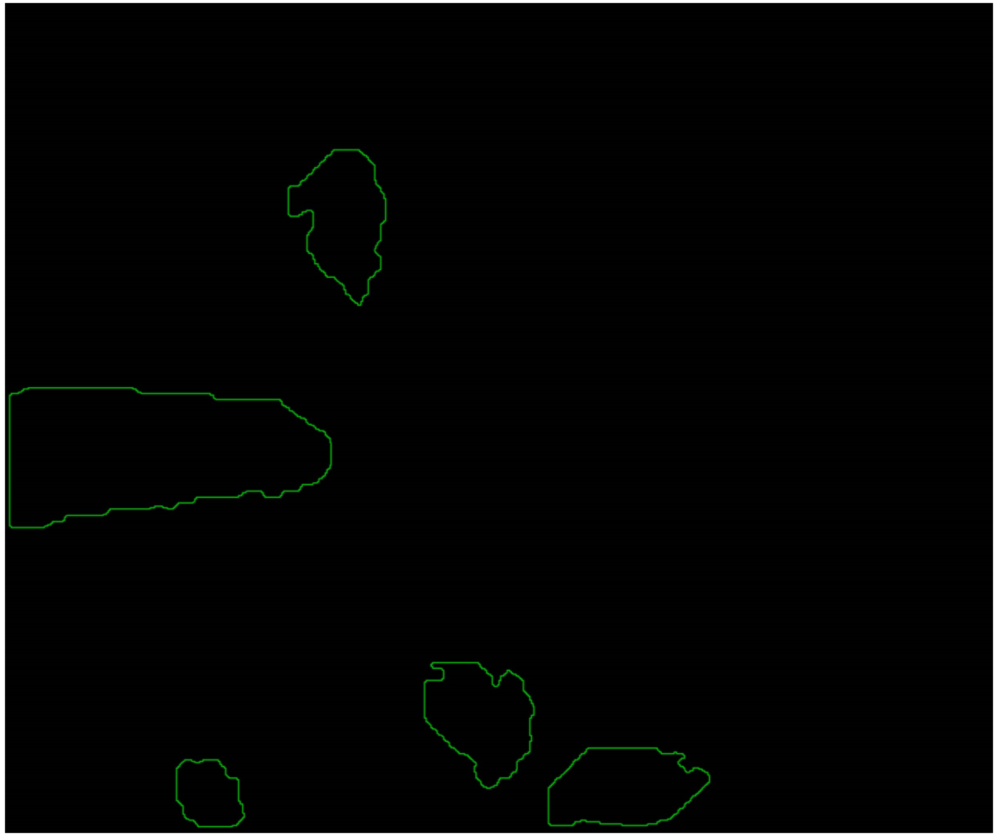




Abfallverwertungstechnik & Abfallwirtschaft

recAIcle – HMI & Augmentation

- Tracking of the waste objects
- HMI via a projector and augmentation masks



Abfallverwertungstechnik & Abfallwirtschaft

Sadržaj

- Cirkularna Ekonomija i (pred)uvjeti
- Use case „Plastika & Sortirnice“
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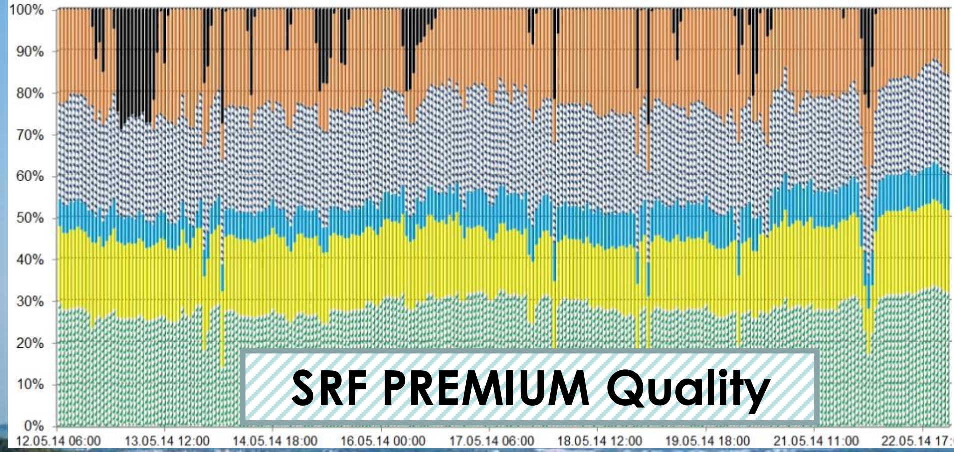
- Zaključci

Abfallverwertungstechnik & Abfallwirtschaft

Sarc, R. 2015: PhD at MUL => 100% Thermal Substitution Rate in Cement Industry was researched & technically realised!



„Co-processing“ = energy recovery & recycling of the minerals

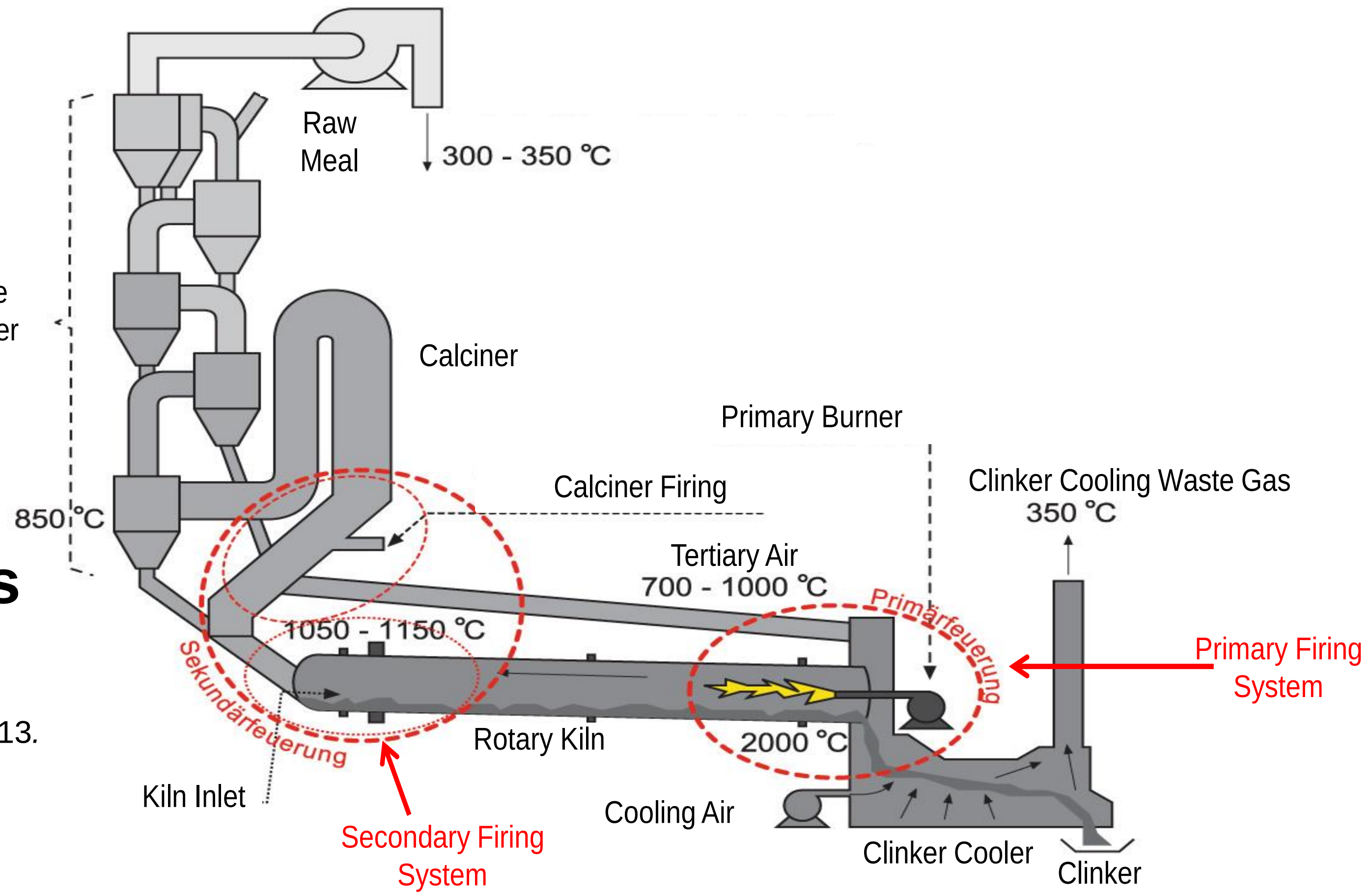
Co-processing

comprises industrial processes that simultaneously:

- **enable energy recovery** and
- **recycling of the mineral content** of waste material

thereby **substituting both fossil fuels and mineral resources**

Source: **Basel convention Technical guidelines 2012**, Lamas 2013.



Source: Sarc 2018.

Positive Development of Energy Recovery from RDF in Austrian Cement Industry: 1988 - 2023

- Thermal Substitution Rate:

2015: *76.1%*

2016: *78.2%*

2017: *80.6%*

2018: *81.2%*

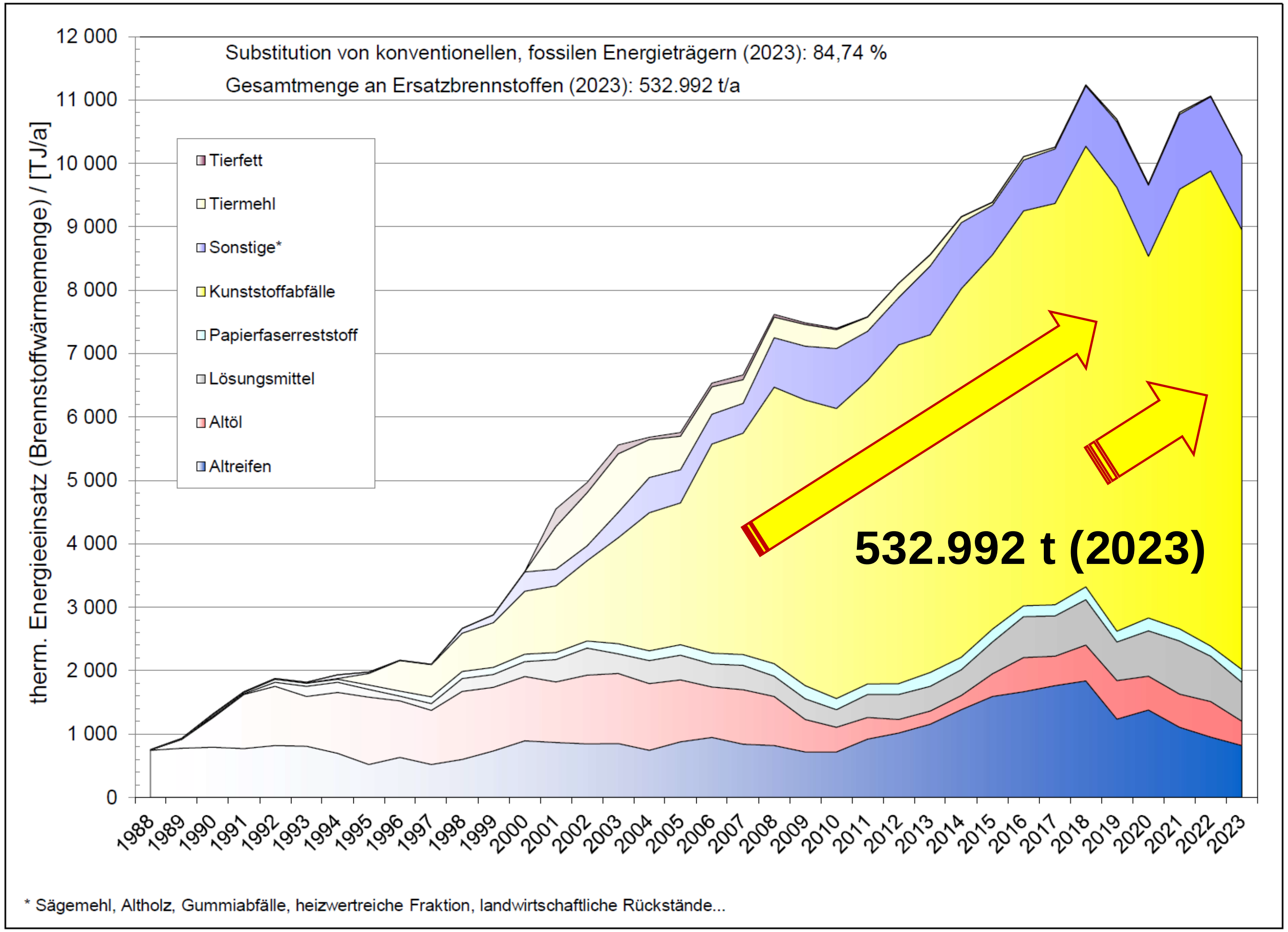
2019: *78.4%*

2020: *70.6%*

2021: *75.2%*

2022: *81.46%*

2023: *84.74%*



Quelle: Mauschitz 2024

Abfallverwertungstechnik & Abfallwirtschaft

State of the Art in Technology and Science on Co-Processing and Recycling Index (2020) => Key Milestones

MethodsX 7 (2020) 100837

Contents lists available at ScienceDirect

MethodsX

journal homepage: www.elsevier.com/locate/mex

Method Article

Methods for identifying the material-recyclable share of SRF during co-processing in the cement industry

Alexia Aldrian, Sandra A. Viczek, Roland Pomberger, Renato Sarc*

Chair of Waste Processing Technology and Waste Management, Montanuniversitaet Leoben, Franz-Josef-Strasse 18, 8700 Leoben, Austria

A B S T R A C T

Solid Recovered Fuels (SRF) include non-combustible mineral components (e.g. $CaCO_3$, SiO_2, Al_2O_3) that are required as raw materials for producing clinker and are completely incorporated into the clinker during the thermal recovery of SRF. This paper discusses simple and practicable ways of finding the relative amount of SRF that may be utilised as raw material (given as the recycling index). For this purpose, the entire mineral content of SRF was determined as the ash content and its main components were identified using different analytical methods.

- A fusion melt of the previously incinerated sample with subsequent measuring using ICP-OES and XRF as well as a total digestion of the incinerated and non-incinerated sample with subsequent measuring using ICP-OES/ICP-MS were applied.
- The results showed a good agreement of all four analytical methods for the elementary oxides Al_2O_3, CaO, Fe_2O_3, SiO_2, TiO_2, P_2O_5 and MgO (relative deviation from 6.6 to 38.9%) and slightly higher deviations for K_2O, Na_2O and SO_3 (14.2–96.0%).
- It was also shown that different incineration temperatures (550 °C, 815 °C and 950 °C) have no effect on the result of the recycling index unless it is assumed that the recycling index equals the ash content.

A R T I C L E I N F O
Method name: R-Index
Keywords: Solid recovered fuel, Recycling, Ash content, Mineral matter, Main components, Methods, Cement industry
Article history: Received 12 January 2020; Accepted 17 February 2020; Available online 21 February 2020

DOI of original article: 10.1016/j.resconrec.2020.104696

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https://doi.org/10.1016/j.mex.2020.100837

Resources, Conservation & Recycling 156 (2020) 104696

Contents lists available at ScienceDirect

Resources, Conservation & Recycling

journal homepage: www.elsevier.com/locate/resconrec

Full length article

Determination of the material-recyclable share of SRF during co-processing in the cement industry

S.A. Viczek, A. Aldrian, R. Pomberger, R. Sarc*

Chair of Waste Processing Technology and Waste Management, Montanuniversitaet Leoben, Leoben, Austria

A R T I C L E I N F O

Keywords:
Cement industry
Co-processing
Material recycling
Material recovery
Solid recovered fuel (SRF)

A B S T R A C T

Solid recovered fuel (SRF according to EN 15359) is frequently used to substitute primary fuels required for the clinker burning process in the cement industry. Since the ash that is formed during the combustion of the SRF is directly incorporated into the product portland cement clinker, this process is also referred to as "co-processing". While the use of SRF in cement plants is legally considered as energy recovery, the fact that mineral constituents are incorporated into the clinker implies that technically a certain share of SRF is recycled on a material level. The paper at hand aims at determining this share by analyzing 80 SRF samples representing SRF qualities that are currently available on the market in Austria, Croatia, Slovakia, and Slovenia. Results show that the SRF ashes on average consist of 76.8 % SiO_2, CaO, Al_2O_3 and Fe_2O_3, the main raw materials that are required for clinker production. Another 14.1 % consist of chemical compounds that are common clinker phases or frequently present in the primary raw materials used for clinker production. Different ways of calculating the recycling index, i.e. the share of SRF (referring to dry mass) that is used on a material level, are discussed, and recycling indices are found to range between 13.5 and 17.6 %. It is concluded that SRF ash represents a suitable secondary raw material for cement clinker manufacturing and that for the cement industry SRF-co-processing offers the possibility to contribute towards reaching the higher recycling rates specified by the European Union.

1. Introduction

The hydraulic binder cement is a crucial component for the manufacturing of mortar and concrete (Galvez-Martos and Schoenberger, 2014), the latter being one of the world's most important manufactured materials (Huntzinger and Eatmon, 2009). For the production of cement clinker, raw materials providing the four main chemical components of cement clinker or precursors thereof are required, namely calcium oxide CaO, silicon dioxide SiO_2, aluminum oxide Al_2O_3, and iron(III) oxide Fe_2O_3 (cf. section 2.1). Besides raw materials, the manufacturing of cement also requires large amounts of energy (Galvez-Martos and Schoenberger, 2014). In modern rotary kiln plants, the production of 1 metric ton of cement clinker requires between 3.0 and 3.8 GJ of thermal energy (under optimal conditions and depending on the technology used). Wet or shaft kilns, in contrast, may require up to 5.8 GJ of thermal energy per ton clinker (European Cement Research Academy (ECRA), 2016). To provide this energy, cement plant operators use increasing amounts of alternative fuels, i.e. solid recovered fuels (SRF) and other refuse-derived fuels (RDF),[1] thereby substituting fossil fuels (European Commission (EC), 2013; Sarc et al., 2014, 2019b). In the European cement industry, the use of RDF is already state of the art (European Commission (EC), 2013), and high thermal substitution rates (i.e. the degree to which fossil fuels are replaced by RDF in cement plants) are achieved in some countries. Austria features the highest substitution rate worldwide (Sarc et al., 2019b) with more than 80 % of the thermal energy demand of the Austrian cement industry being covered by alternative fuels: 30 % are covered by RDF, e.g. old tires, used oil and solvents, etc. and 50 % are covered by SRF from plastic rich waste fractions of industrial, commercial, and municipal solid waste (MSW), corresponding to 358,580 tonnes of SRF (year 2018) (Mauschitz, 2019). Sarc (2015) has demonstrated that even 100 % of thermal substitution is technically feasible when different types of RDF are used for energy generation in the clinker production process. International studies report that the use of SRF or RDF in the

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[1] SRF represent a subgroup of RDF. While RDF can be prepared of various non-hazardous and hazardous, liquid and solid waste materials (e.g. sewage sludge, waste wood, used solvents), the term SRF only refers to solid fuels made from non-hazardous mixed or sorted solid wastes, are furthermore quality assured, i.e. meet the criteria defined by EN 15359, and utilized for energy recovery.

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Abfallverwertungstechnik & Abfallwirtschaft

https://doi.org/10.1016/j.mex.2020.100837 https://doi.org/10.1016/j.resconrec.2020.104696

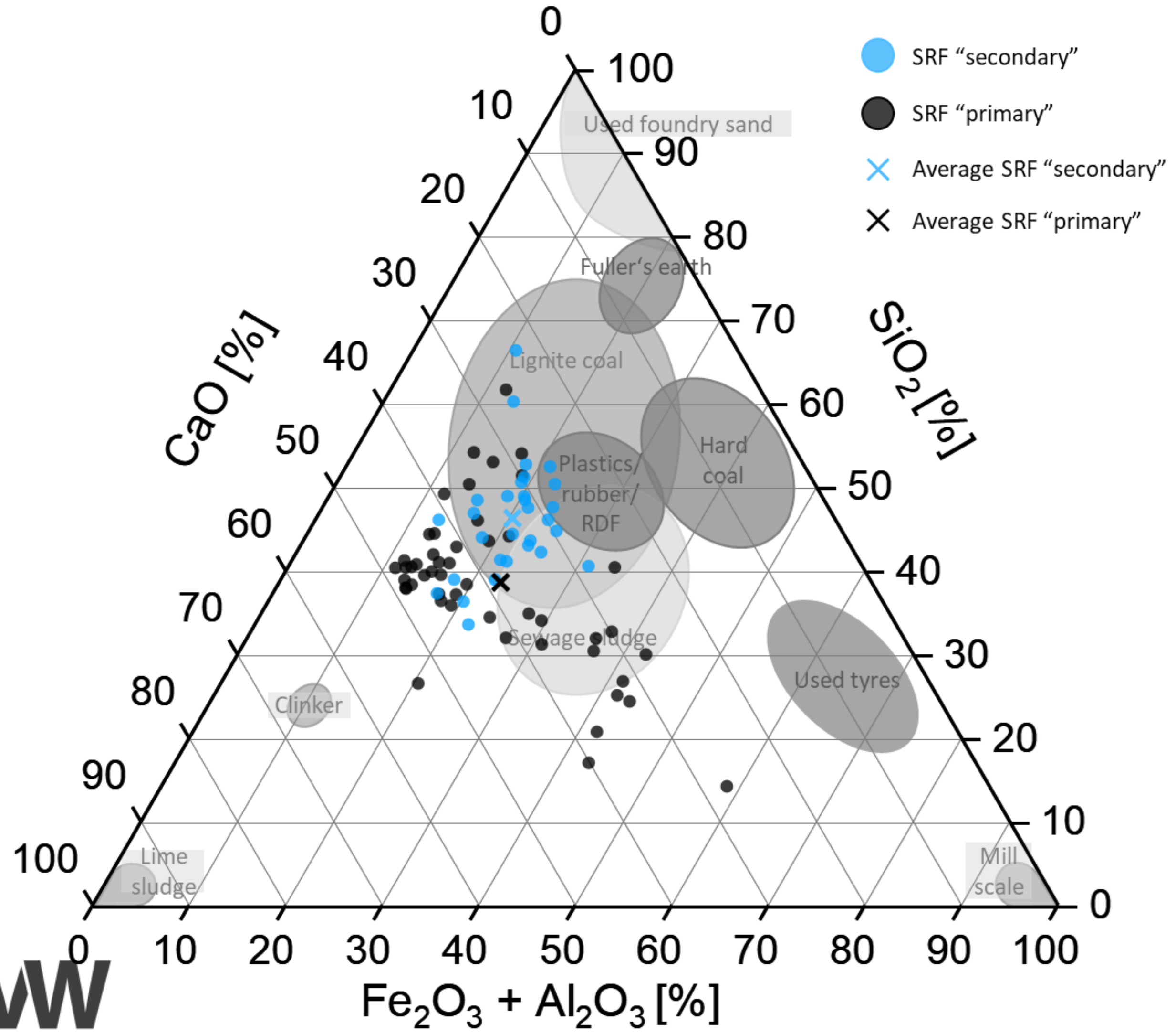
from SRF of „mixed household waste“ for energy recovery to ASH for Recycling

- SRF Original Sample

- SRF dried and prepared for investigation

- SRF Ash (950°C)

SRF ash composition – comparison with raw materials and other fuel ashes



- Ratio of parameters of SRF ash mostly similar to lignite coal ash
- Larger ratio of CaO, shifting **SRF ash closer to the composition of clinker**

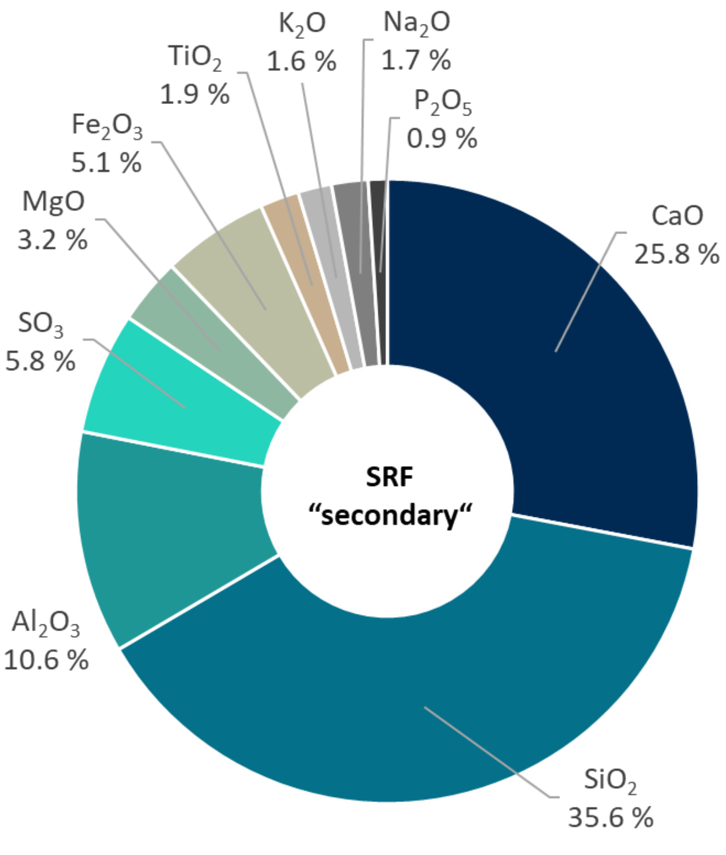
SRF position:

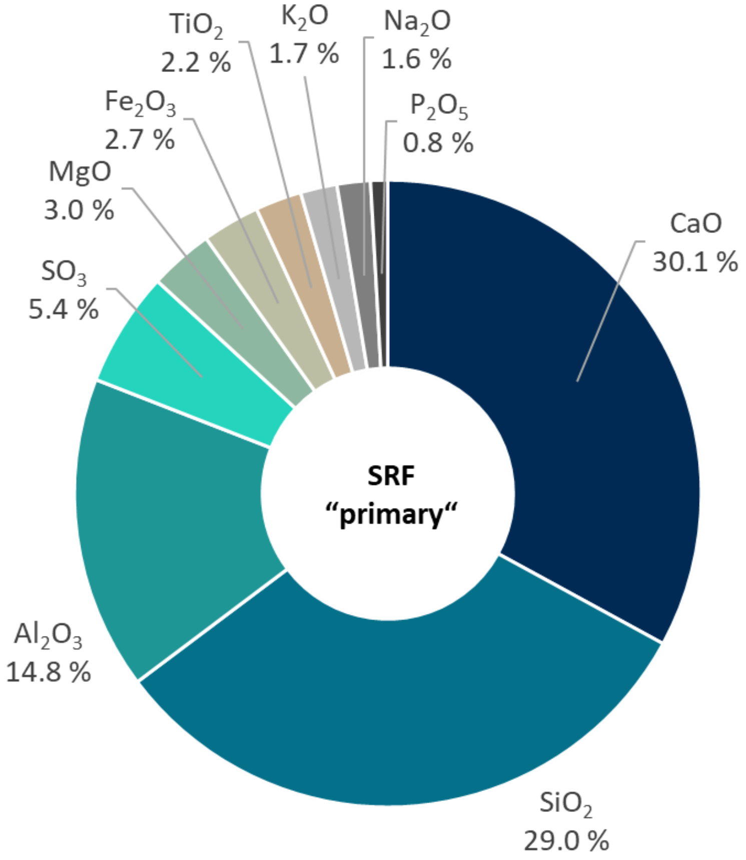
CaO:	**25 - 50 %,**
Al_2O_3+Fe_2O_3:	**10 - 25 %,**
SiO_2:	**35 - 55 %**

Ternary diagram ©vdz supplemented with own results for SRF samples

Abfallverwertungstechnik & Abfallwirtschaft

Material-recyclable share of SRF





R-index:

- 13.5 % (4 oxides)
- 16.0 % (9 oxides)

The average composition of the **30 SRF “secondary”** and **50 SRF “primary”** samples.

Abfallverwertungstechnik & Abfallwirtschaft

4349 als ISO EN PUBLISHED

International Standard

ISO 4349

Solid recovered fuels — Determination of the recycling index for co-processing

Combustibles solides de récupération — Détermination de l'indice de recyclage pour le cotraitement

First edition
2024-05

Reference number
ISO 4349:2024(en)

ÖNORM EN ISO 4349

Ausgabe: 2024-10-15

Feste Sekundärbrennstoffe - Verfahren zur Bestimmung des Recycling-Index für die gemeinsame energetische und stoffliche Verwertung (Co-Processing) (ISO 4349:2024)

Solid recovered fuels - Determination of the Recycling Index for co-processing (ISO 4349:2024)

Combustibles solides de récupération - Détermination de l'indice de recyclage pour le cotraitement (ISO 4349:2024)

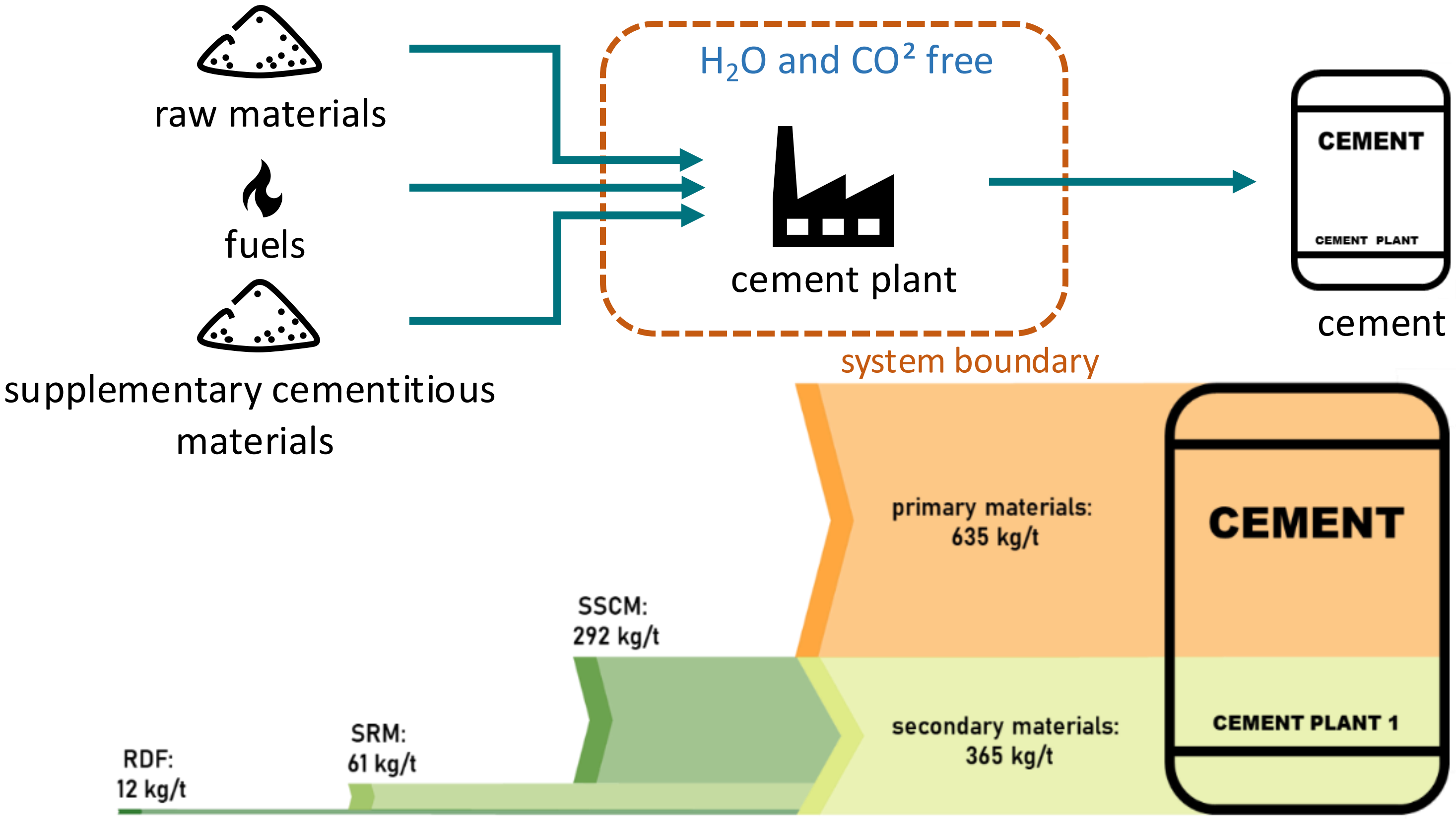
Diese österreichische Norm ist qualitätsgeprüft.

Diese österreichische Norm beinhaltet EN ISO 4349:2024 (idente Übernahme).

Komitee 157 – Abfallwirtschaft
ICS 75.160.10

Overall Recycled content in CI?

- **Mass balance based recycling content calculation** throghout the whole cement production process



https://doi.org/10.1016/j.resconrec.2023.107276

Resources, Conservation & Recycling 199 (2023) 107276

Contents lists available at ScienceDirect

Resources, Conservation & Recycling

journal homepage: www.elsevier.com/locate/resconrec

ELSEVIER

Full length article

Determining the recycled content in cement: A study of Austrian cement plants

M.J. Enengel *, S.A. Viczek, R. Sarc

Chair of Waste Processing Technology and Waste Management, Montanuniversitaet Leoben, Leoben, Austria

ARTICLE INFO

Keywords:
Cement production
Mineral components
Recycled content
Recycling
Refuse-derived fuel
Secondary raw materials
Supplementary cementitious materials

ABSTRACT

Waste materials and industrial by-products are increasingly used in the production of cement clinker and cement, serving as secondary fuels, secondary raw materials, and supplementary cementitious materials. As these waste-derived materials are partially or fully incorporated into the product, they are technically recycled. Consequently, a certain proportion of the cement consists of recycled materials. This paper presents a method to calculate this recycled content in cement not only based on mass streams, but also based on valuable chemical components and compares the results for both calculation methods in the course of a case study of two Austrian cement plants. It is demonstrated that one metric ton of cement consists of 365 kg and 387 kg of secondary materials, respectively. This results in an average recycled content of 37.6 %. In addition, the contribution of primary and secondary materials to the heavy metal content of cement is assessed.

1. Introduction

The recycled content in products is becoming increasingly important for resource efficient construction and is one of the main parameters considered in sustainable procurement (ASI, 2020; Wijayasundara et al., 2022) which has been on the advance for decades as several countries have adopted sustainable or green procurement policies, regulations, and tools (Migliore et al., 2020). Criteria for green public procurement may require a minimum recycled content for the materials acquired for a project. As a consequence, the recycled content is often included in environmental labels and is defined in ISO 14,021 (ASI, 2021). As an example, Italy has introduced minimum environmental criteria for the procurement of design and construction services for new construction, renovation and maintenance of public buildings. These criteria include a minimum and certified recycled content in major construction materials and products of 15 % referring to all materials used for the construction (Repubblica Italiana, 2017, 2015).

One of the most important construction materials is concrete, which is the most consumed material in the world after water (Makul, 2020). A key component required for concrete is cement (Locher, 2000), the recycled content of which largely depends on the availability and technical applicability of suitable secondary materials (see Section 1.1). Secondary materials, as opposed to primary materials, comprise any materials that are not the primary products of manufacturing or commercial processes, including scrap, post-consumer and post-industrial material (CFR, 2023), hence referring to both waste materials and industrial by-products. The recycled content in cement clinker can range from 0 %, when solely primary materials are used, up to 100 %, as Holcim recently reported the production of the world's first clinker made entirely of secondary materials, which will enable the company to produce 100 % recycled cement and 100 % recycled concrete (Holcim, 2022).

To consistently assess the content of recycled material in a product, definite criteria and methods are required (Migliore et al., 2020). A general equation is given in ISO 14,021 (ASI, 2021), according to which the recycled content expressed as a percentage of the mass of recycled material divided by the mass of the product. Furthermore, the standard explains that for the calculation "*the mass of material obtained from the recycling process, after accounting for losses and other diversions, shall be used*" (ASI, 2021).

Hence, while the parameter "mass of the product" is conclusive, e.g., one kilogram of cement, there may be different approaches on what to count to the mass of recycled material, and especially regarding the "*losses and other diversions*" (ASI, 2021) that shall be subtracted. The first question that may be posed is whether or not industrial by-products that are incorporated into new products can be counted to the recycled content. The EU technical background report on green public procurement criteria (Dodd et al., 2016) specifies that industrial by-products as

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Available online 3 November 2023

Sadržaj

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- **Use Case „Energetska oporaba“**
- Zaključci

Abfallverwertungstechnik & Abfallwirtschaft


1 t PET dovoljna za
proizvodnju el. energije u WtE
za 1 osobu za cijelu godinu
https://www.vecernji.hr/vijesti/foto-pogledajte-slike-iz-zraka-vatrene-stihije-u-osijeku-ova-situacija-trajat-ce-dugo-1713980
Foto: Borna Jaksic/PIXSELL

EUWID 2022.

- Od 2012. – 2019. **novi prosječni izgrađeni kapacitet** je bio

  7.600 t/dnevno odnosno cca **3 mil. t godišnje**

- 2020. i 2021. => **34 nova projekta WtE u Europi** s kapacitetom od

  29.000 t/dnevno odnosno cca **10,5 mil. t godišnje**

- 2021. je u **svijetu bilo 104 WtE projekta** (novogradnja i modernizacija) s kojima je

  stvoreni kapacitet energetske obrade otpada od

  94.000 t/dnevno odnosno **cca 35 mil. t godišnje**

https://www.euwid-recycling.de/news/international/studie-zur-globalen-abfallverbrennung-europaeischer-anlagenmarkt-deutlich-aktiver-240522/

Hundertwasser WtE-postrojenje “Spittelau” u Beču

(Fernwärme Wien 2013)

Strateško okolišno planiranje //

Strategische Umweltprüfung

https://www.wien.gv.at/umwelt/ma48/beratung/umweltschutz/sup.html

Energetska oporaba: Trigeneracija (električna, toplinska i rashladna energija) i istovremena visoka zaštita okoliša

● = *WtE - plant*

(Fernwärme Wien 2013)

Abfallverwertungstechnik & Abfallwirtschaft

Kogeneracijsko postrojenje uz papirnu industriju u Bruck an der Mur otvoreno 2022. godine

- Otvorenje 2022. godine od strane “zelene” ministrice Gewessler
- https://www.youtube.com/watch?v=n5Mkxx9JDl4
- Smanjenje potrošnje prirodnog plina za 75%
- Smanjenje fosilnih CO_2 emisija na lokaciji za 150.000 t/godišnje
- Smanjenje ovisnosti o uvoznom plinu uz istovremeno jačanje lokalne proizvodnje !

https://www.meinbezirk.at/bruck-an-der-mur/c-wirtschaft/die-neue-energieanlage-k9-wurde-feierlich-eroeffnet-mit-video_a5308867#gallery=null

Kogeneracijsko postrojenje uz papirnu industriju u Bruck an der Mur otvoreno 2022. godine

Dokazana tehnička zaštita okoliša i niskih emisija

Granične vrijednosti po dozvoli

„Folgende Emissionsgrenzwerte (bezogen auf trockenes Abgas unter Normbedingungen und 11% Restsauerstoffgehalt im Abgas) dürfen im Abgas des Wirbelschichtkessels 9 nicht überschritten werden:

Schadstoffkonzentration (Normzustand, trocken)		HMW	TMW	Mittelwert über Messung	Häufigkeit der Messung
NOx	mg/m³	100	70		kontinuierliche Messung
CO	mg/m³	100	50		kontinuierliche Messung
SO_2	mg/m³	40	25		kontinuierliche Messung
Staub	mg/m³	8	5		kontinuierliche Messung
TOC	mg/m³	8	8		kontinuierliche Messung
HCl	mg/m³	7	6		kontinuierliche Messung
NH_3	mg/m³	5			kontinuierliche Messung
Hg	mg/m³	0,05	0,02	0,01 (Jahresmittelwert)	kontinuierliche Messung
HF	mg/m³	0,4		0,25	alle 6 Monate
∑SM*	mg/m³			0,3 (Mittelwert über Zeitraum von 0,5 bis 8 Std.)	alle 6 Monate
Cd + Tl	mg/m³			0,02 (Mittelwert über Zeitraum von 0,5 bis 8 Std.)	alle 6 Monate
PCDD/PCDF	ng I-TEQ/m³			0,04 (Mittelwert über Zeitraum von 6 bis 8 Std.)	in den ersten 12 Betriebsmonaten alle 3 Monate, danach alle 6 Monate
Benzo(a)pyren	mg/m³	-	-	-	einmal jährlich
N_2O	mg/m³	-	-	-	einmal jährlich

*…Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V+Sn"

https://www.umwelt.steiermark.at/cms/dokumente/12783064_9176022/ad5cbc94/003%20Bescheid_SIG.pdf

Stvarne izmjerene vrijednosti manje od dopuštenih graničnih vrijednosti

Stvarne izmjerene vrijednosti

Im Prüfbericht „EMISSIONSMESSUNGEN hinsichtlich AVV und Genehmigungsbescheid am Kessel 9 der NORSKE SKOG GmbH" vom 21.06.2023, Bericht Nr. RMU-PE-PR-0009-2022_23/13, durchgeführt von ZT Umweltkonsulenten, wurden im Rahmen der Abnahmemessung beim Einsatz von nichtgefährlichem Abfall folgende maximalen Emissionswerte, bezogen auf trockenes Abgas unter Normbedingungen und 11% O_2, ermittelt:

	TMW	HMW
Gesamtstaub	3,9 mg/m³	5,1 mg/m³
NOx	65 mg/m³	49 mg/m³
CO	41 mg/m³	68 mg/m³
Org. C	4,3 mg/m³	1,2 mg/m³
N_2O	-	2,9 mg/m³
SO_2	1,2 mg/m³	0,4 mg/m³
HF	0,2 mg/m³	< 0,1 mg/m³
HCl	0,46 mg/m³	0,4 mg/m³
NH_3	1,0 mg/m³	0,6 mg/m³ (0,5 – 8 h)
Benzo-(a)-pyren	-	< 0,01 mg/m³
Hg	0,0007 mg/m	0,0003 mg/m³
Cd + Tl	-	< 0,0009 mg/m³ (0,5 – 8 h)
Schwermetalle	-	0,0662 mg/m³ (0,5 – 8 h)
PCDD/PCDF	-	0,0083 ngTE/m³ (6 – 8 h)

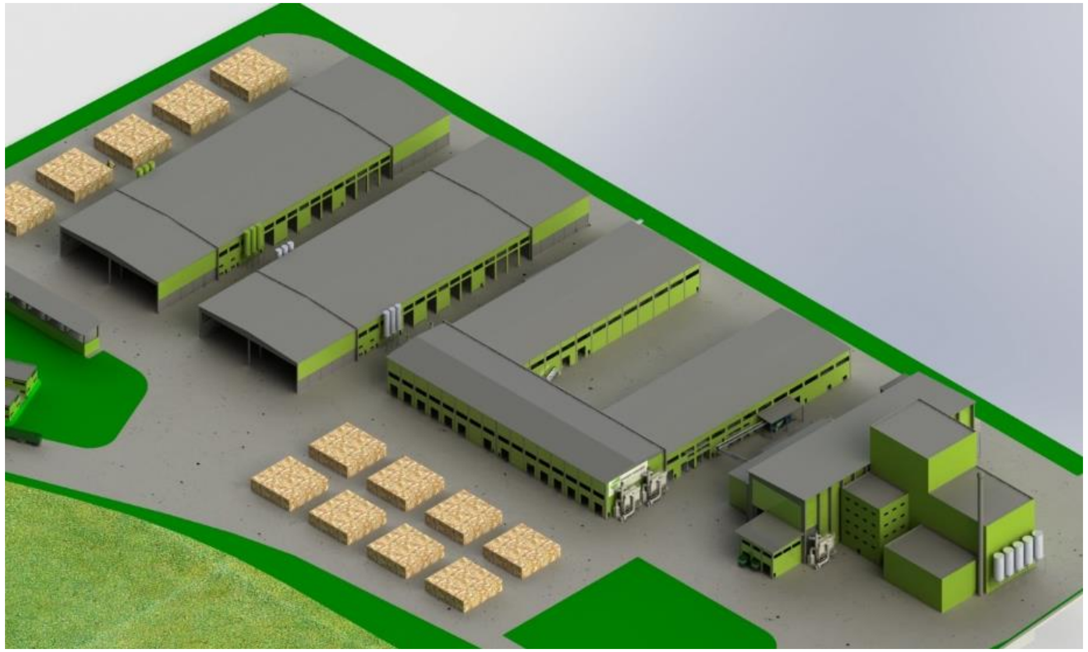
https://www.umwelt.steiermark.at/cms/dokumente/12783064_6392227/c93158ac/UVP%20Abnahmebescheid.pdf

RH treba energetsku oporabu i **JAVNU & PRIVATNU** infrastrukturu! Dva konkretna, inovativna i zdrava projekta u RH

CIOS ENERGY d.o.o.

https://www.tehnoeko.com.hr/4123/Sinergija-za-novu-sisacku-energiju?cctest&

Eko Reciklažni Park d.o.o.



https://www.kutina.hr/Sluzbeni-dio/ArticleId/37610/oamid/1501

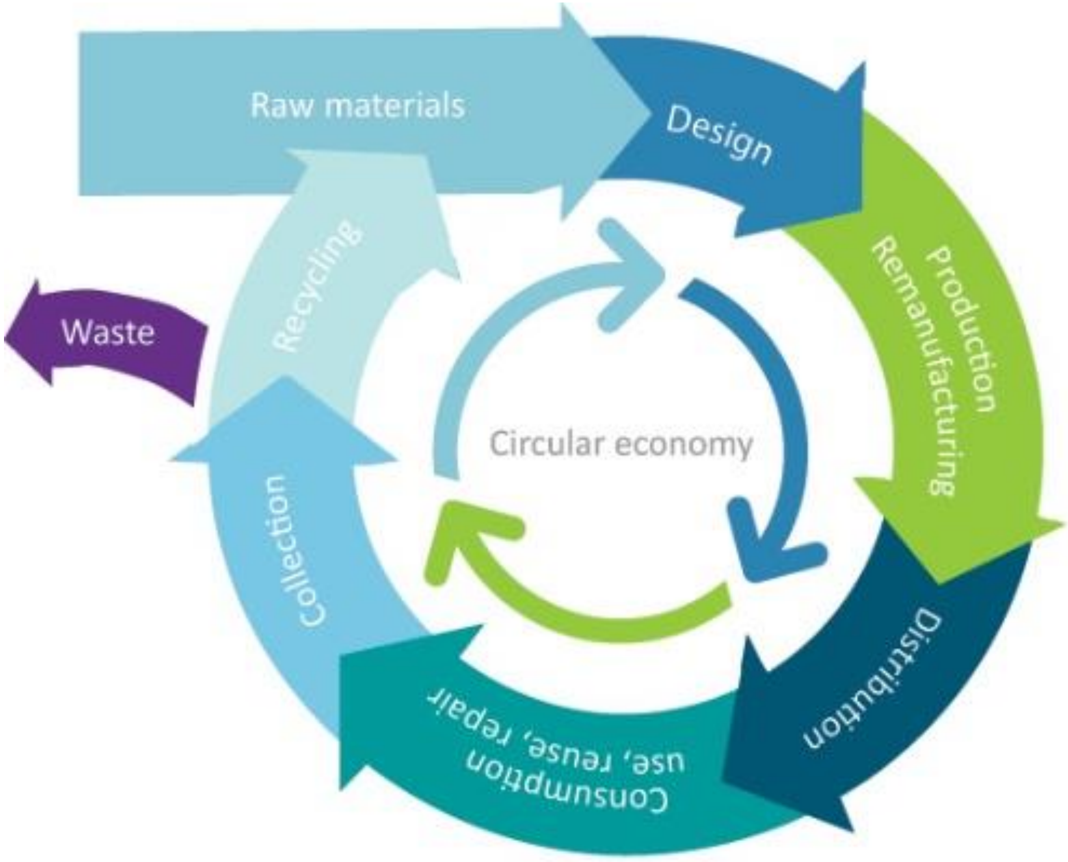
Abfallverwertungstechnik & Abfallwirtschaft

Sadržaj

- Cirkularna Ekonomija i (pred)uvjeti
- Use case „Plastika & Sortirnice“
- Use case „Smart Waste Factory & Digitalizacija“
- Use Case „Reciklaža kroz energetsku oporabu“
- Use Case „Energetska oporaba“
- **Zaključci**

Abfallverwertungstechnik & Abfallwirtschaft

Cirkularna ekonomija je "više od samo otpada", a gospodarenje otpadom sastavni je dio kružnog gospodarstva.



Održivo gospodarenje otpadom

+ LCA
+ eko dizajn
+ kaskadno korištenje
+ više reciklaže
+ supstitucija primarnih materijala
+ Rješavanje ekoloških problema kroz instalaciju modernih i visoko učinkovitih postrojenja za obradu otpada
+ ...

Circular Economy

Abfallverwertungstechnik & Abfallwirtschaft

Circular Economy – “svedena na ono najbitnije”

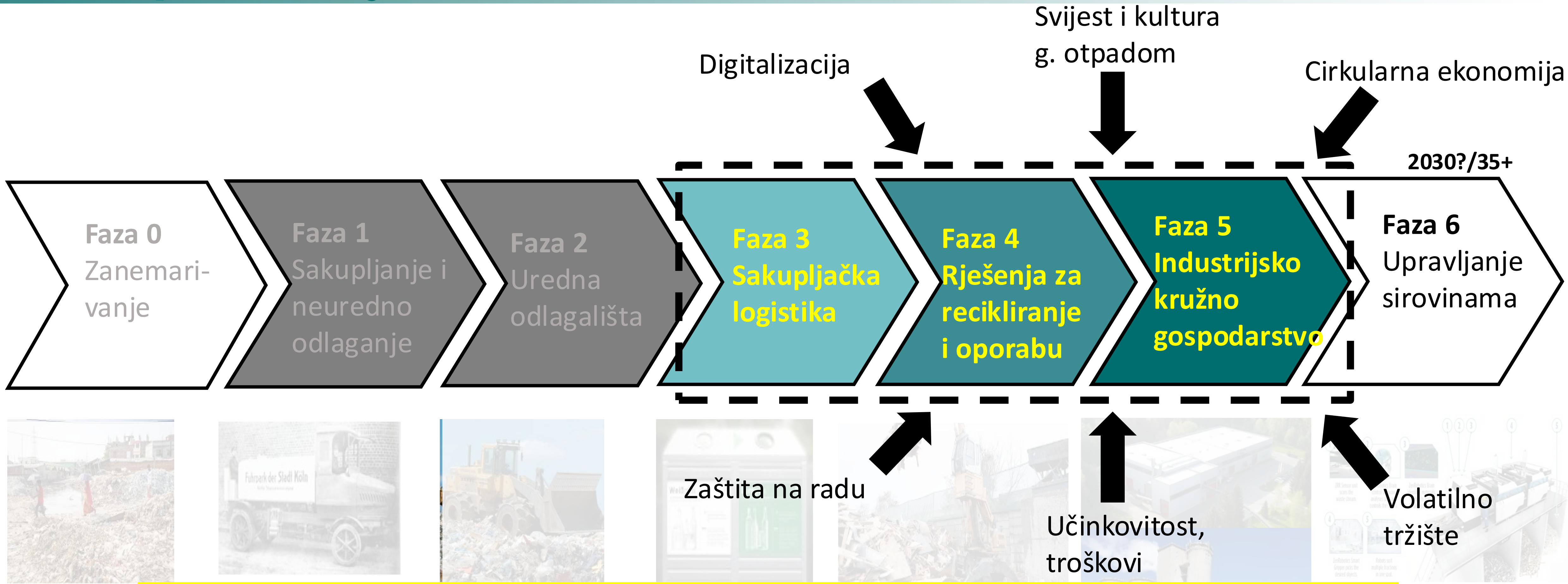
Što više i što dulje je moguće zadržati sirovinu u vrijednosnom krugu!

Value chain => value CIRCLE

= KORISTITI proizvode što dulje

= SEKUNDARNE SIROVINE moraju imati kvalitetu i svoja „PRAVA“!

Cirkularna ekonomija treba infrastrukturu i kompetencije!



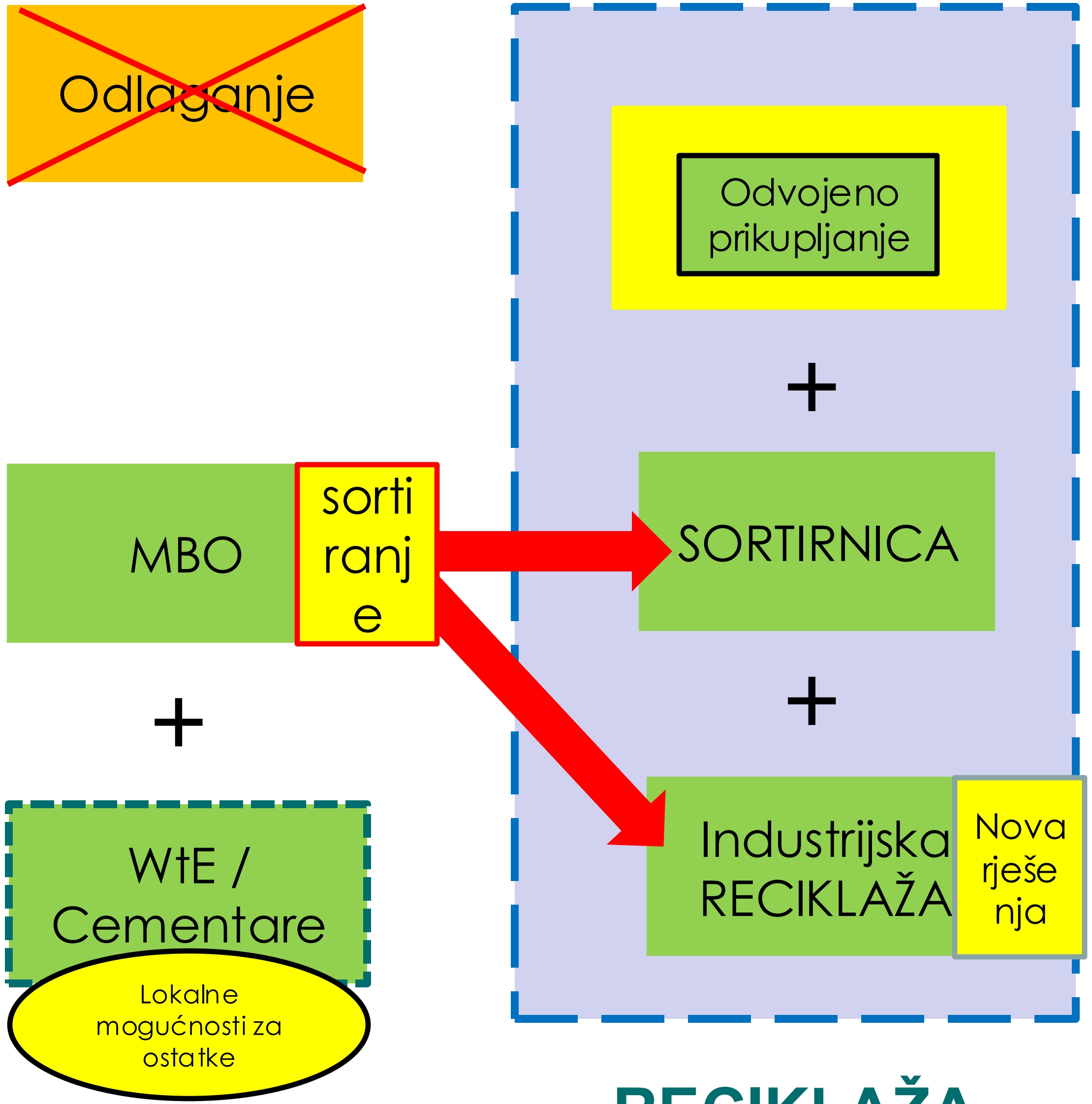
Phasenmodel nach
Klampfl, 2010

Velike promjene dolaze u sljedećih 10-15 godina!
=> Trebamo instalirati kvalitetnu i digitaliziranu infrastrukturu!
=> Trebamo razvijati tehničke i digitalne kompetencije!

AVW
Abfallverwertungstechnik & Abfallwirtschaft

Sustav gospodarenja komunalnim otpadom zahtijeva intenzivnije odvojeno prikupljanje i mehaničku obradu.

- **Unaprjeđenje odvojenog prikupljanja**
- **Mehaničko odvajanje materijala za reciklažu prije spaljivanja otpada.**
- **Unaprjeđenje postojećih MBO postrojenja**
- **Lokalne pravne i tehničke mogućnosti za ostatke**



RECIKLAŽA

In cooperation with Prof. Roland Pomberger

Gospodarska transformacija prema cirkularnoj ekonomiji zahtijeva

***ODGOVORNU SURADNJU** svih dionika duž vrijednosnog kruga svakog*

pojedinog proizvoda koji će postati otpad

(samo je pitanje vremena)!

Prelazak na transparentno i održivo kružno gospodarstvo nije samo

mogućnost već nužnost i poslovna prilika!

Abfallverwertungstechnik & Abfallwirtschaft

Razvijajmo zajedno KULTURU cirkularne ekonomije.

Socijalna inteligencija odraz je naše društvene odgovornosti i svjesne brige za okoliš, očuvanje sirovina te osiguranje kvalitete života sadašnjih i budućih generacija.

Abfallverwertungstechnik & Abfallwirtschaft

Hvala

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