SUSTAINABLE POLYMER AND PROCESS CHEMISTRY (SMART)

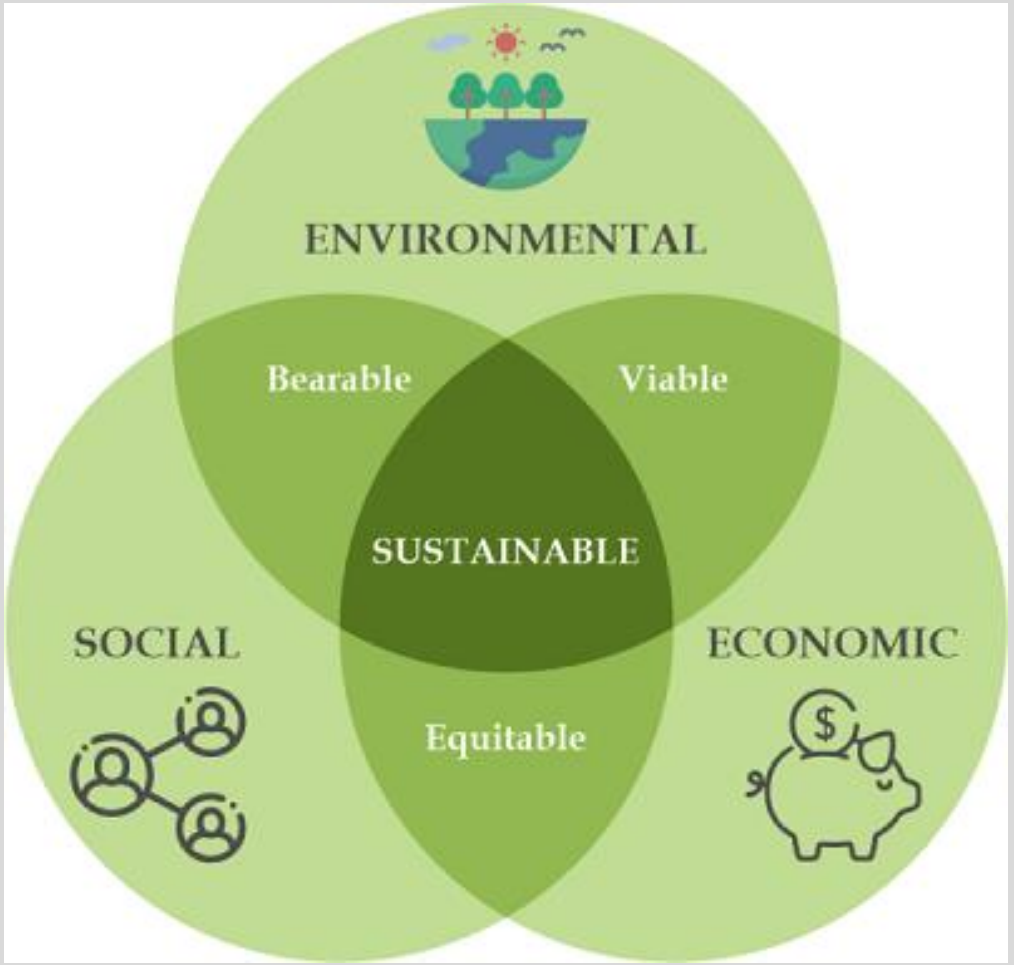
- LM 71 - Classe delle lauree magistrali in SCIENZE E TECNOLOGIE DELLA CHIMICA INDUSTRIALE
- NUMERO MASSIMO GESTIBILE: 25 posti (da ottenersi mediante opportuna selezione)

Davide Comoretto: Coordinatore_CCS_Chim_Ind@unige.it

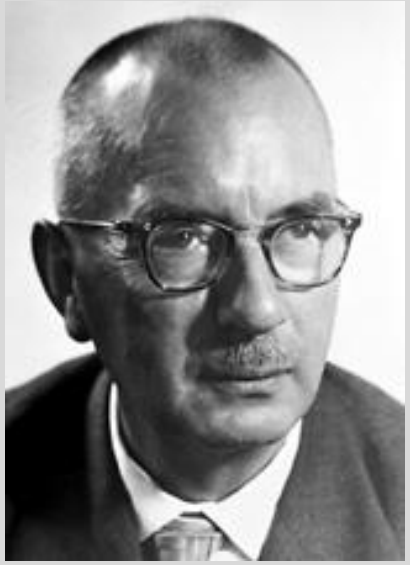
SMART: NEW OPPORTUNITIES

SMART

- Original and Innovative MSc in the national and international framework.
- International Appeal (> 80 international applications without any promotion).
- Internazional training environment.
- Strongly connected to Civil Society and Industry.
- Complementary and not competing with Chemical Sciences and Science and Technology of Materials.
- Strong local scientific background, dedicated infrastructures and labs, following the tradition (Rossi 1952).
- Basckground for future developments (green industrial processes, environment management, functional polymers, water, formulations…).

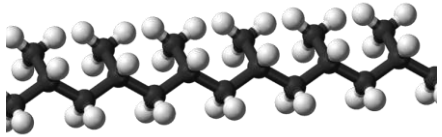


SMART: THE HISTORICAL TRADITION



The Nobel Prize in Chemistry 1963 was awarded jointly to Karl Ziegler and Giulio Natta

"for their discoveries in the field of the chemistry and technology of high polymers"



http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1963/

Giulio Natta

1903: Born in Porto Maurizio (Imperia, Italy)

1924: Graduated in Industrial Engineering (Chemistry) at Polytechnic of Milan (Italy)

1925-1932: Professor of **Analitical Chemistry** (Polytechnic of Milan)

1929-1933: Professor of **Physical Chemistry** (University of Milan)

1933-1935: Professor of **General Chemistry** (University of Pavia)

1935-1937: Professor of **Physical Chemistry** (University of Rome)

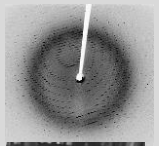
1937-1938: Professor of **Industrial Chemistry** (Politechnic of Turin)

1938-1973: Professor of **Industrial Chemistry** (Polytechnic of Milan)

SMART: THE HISTORICAL TRADITION

GIULIO NATTA: A MULTIDISCIPLINAR SCIENTIST

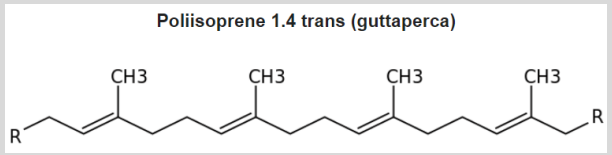
- Studies **sX-ray structures** (Freiburg, Hugo Seeman).

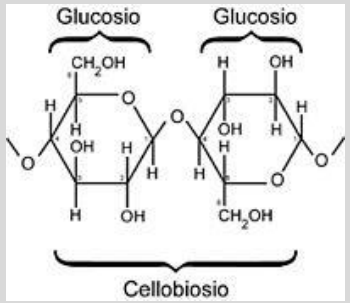


- Meets **H. Staudinger, Nobel 1953,** who invented the concept of **MACROMOLECULE**
- The chemistry of **carbon monoxide**, **of alcohols and formaldheyde** (C1 chemistry)

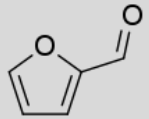
$$CO + 2H_2 \rightleftarrows CH_3OH \quad (\Delta H_{RT} = -90{,}7\ kJ/mol)$$

- Forefront on the **high polymers chemistry**





- **Furfurole and carbohydrates hydrogenation** (glycerol iso-octane, hydrogen from methane …)



The Nobel Prize in Chemistry 1963

Karl Ziegler
Giulio Natta

Share this

Giulio Natta Facts

https://www.giulionatta.it/ENG/archivio.html
https://www.nobelprize.org/prizes/chemistry/1963/natta/facts/

Photo from the Nobel Foundation archive.

Giulio Natta
The Nobel Prize in Chemistry 1963

Born: 26 February 1903, Imperia, Italy

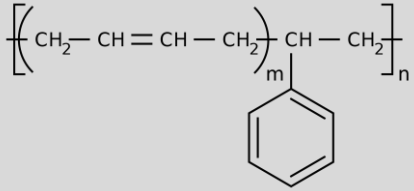
Died: 2 May 1979, Bergamo, Italy

Affiliation at the time of the award: Institute of Technology, Milan, Italy

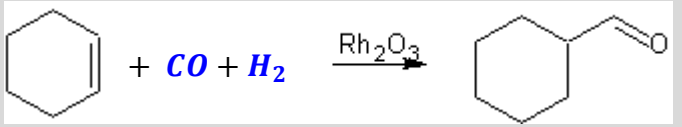
Prize motivation: "for their discoveries in the field of the chemistry and technology of high polymers"

Prize share: 1/2

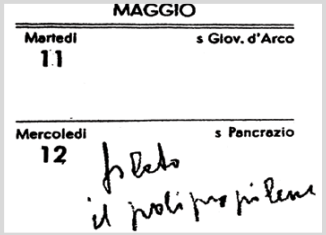
- **Synthetic Rubbers**

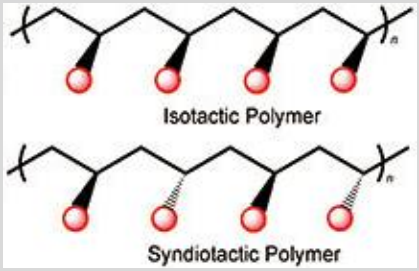


- **Oxoyinteshesis** (hydro-formilation): Aldehyds, Alcohols. Acids and their derivatives



- **Stereospecific polymerization**





SMART: THE HISTORICAL TRADITION

- sixties

The Nobel Prize in Chemistry 1963

Karl Ziegler
Giulio Natta

Share this

Giulio Natta
Facts

https://www.giulionatta.it/ENG/archivio.html
https://www.nobelprize.org/prizes/chemistry/1963/natta/facts/

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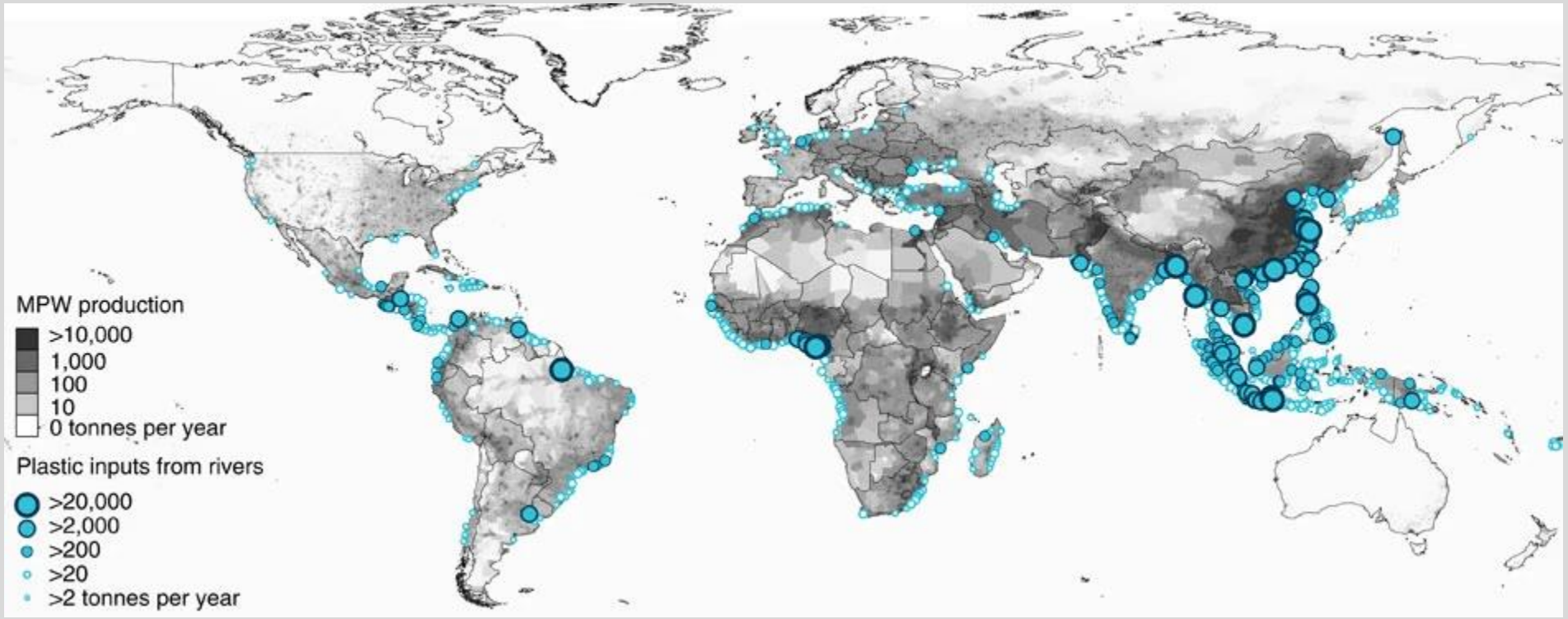
Prize share: 1/2

- now

SMART: PLASTICS MANAGEMENT



- Nature Communications 8, 15611 (2017)
- Nature Communications 9, 2157 (2018)
- Scientific Reports volume 8, 4666 (2018)

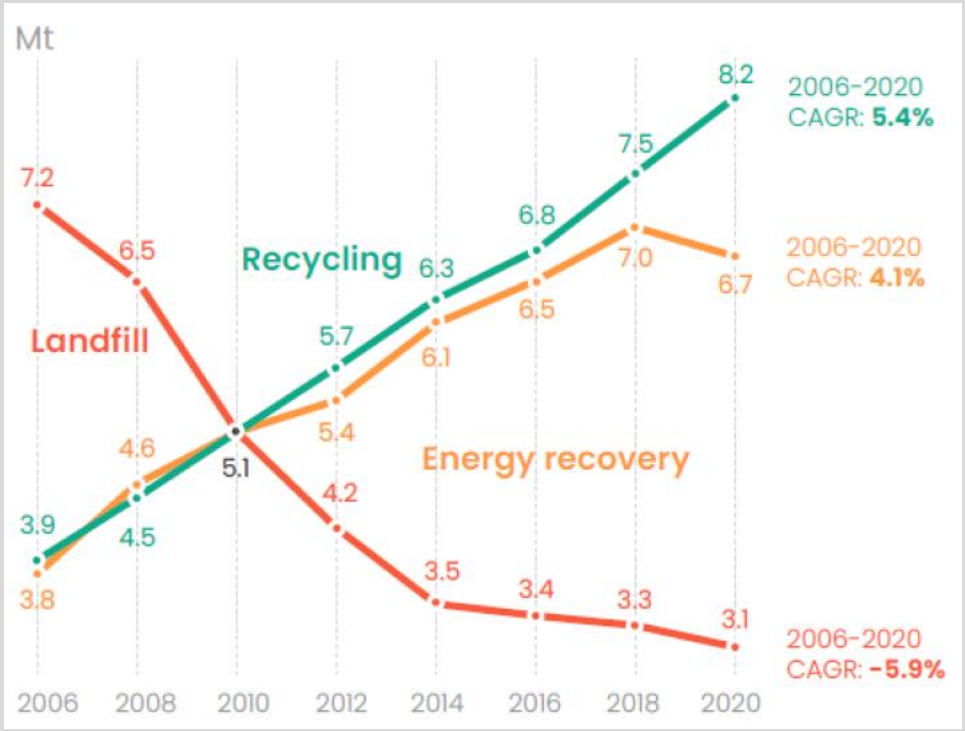
SMART: PLASTICS MANAGEMENT

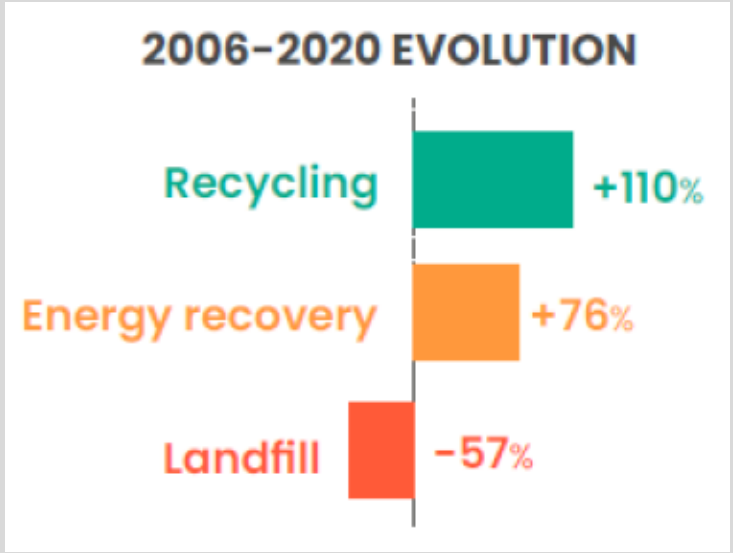
- "…five countries—China, Indonesia, the Philippines, Sri Lanka, and Vietnam—contribute more than half of ocean plastics…
- …Improve waste infrastructure (**and knowledge**) in these places, and significantly less plastic will escape into the ocean overall."

https://www.acs.org/content/dam/acsorg/membership/acs/benefits/discovery-reports/plastics.pdf
Bourzac, K. "Floods can flush microplastic pollution from rivers into the sea." Chem. Eng. News, 2018, 96(12); 5.

SMART: PLASTICS MANAGEMENT

- Post-consumer plastic waste management in 2020 (EU27+3)



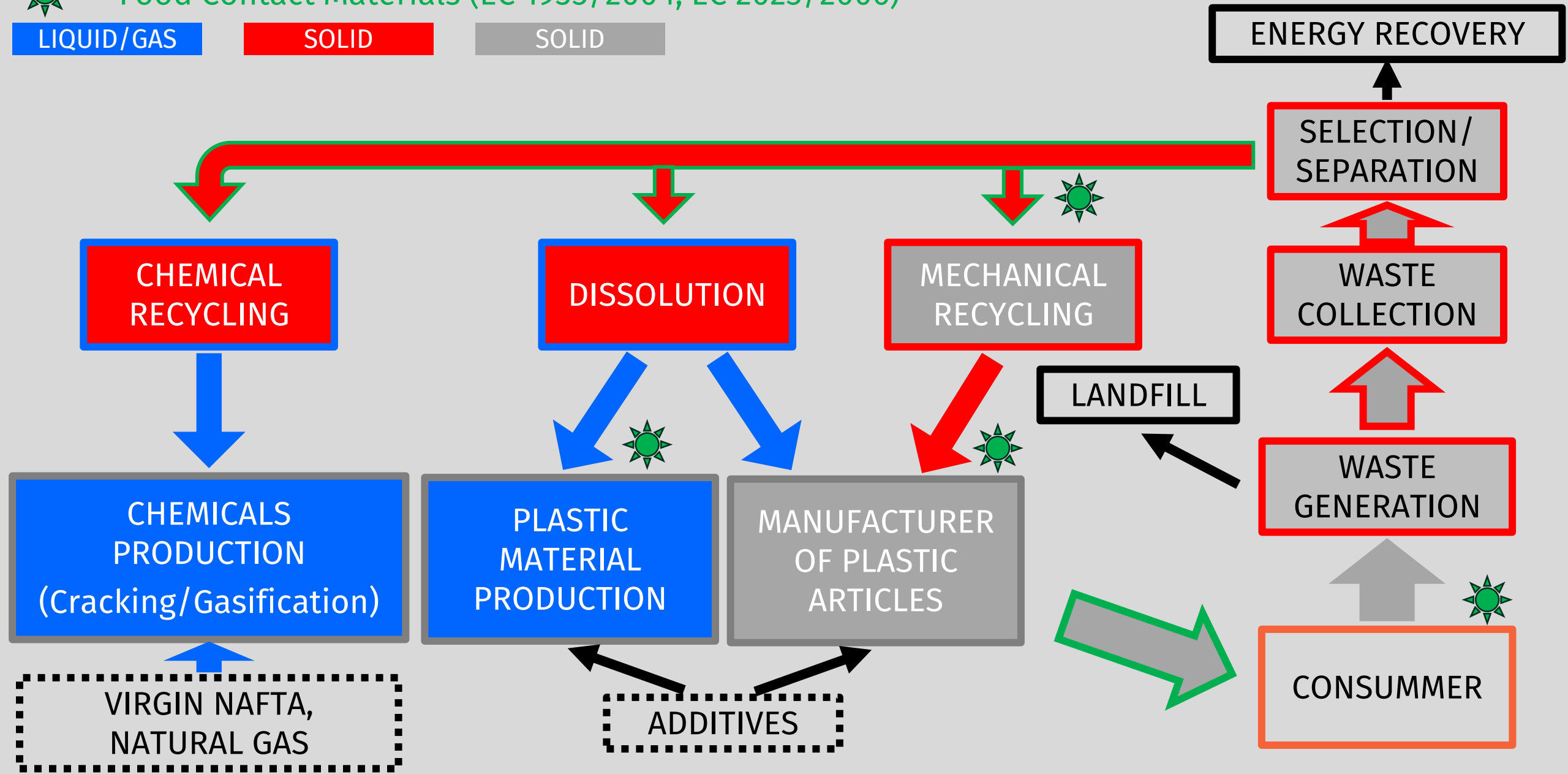


Università di Genova | DCCI DIPARTIMENTO DI CHIMICA E CHIMICA INDUSTRIALE

SMART: PLASTIC MATERIALS UPCYCLING

Food Contact Materials (EC 1935/2004; EC 2023/2006)

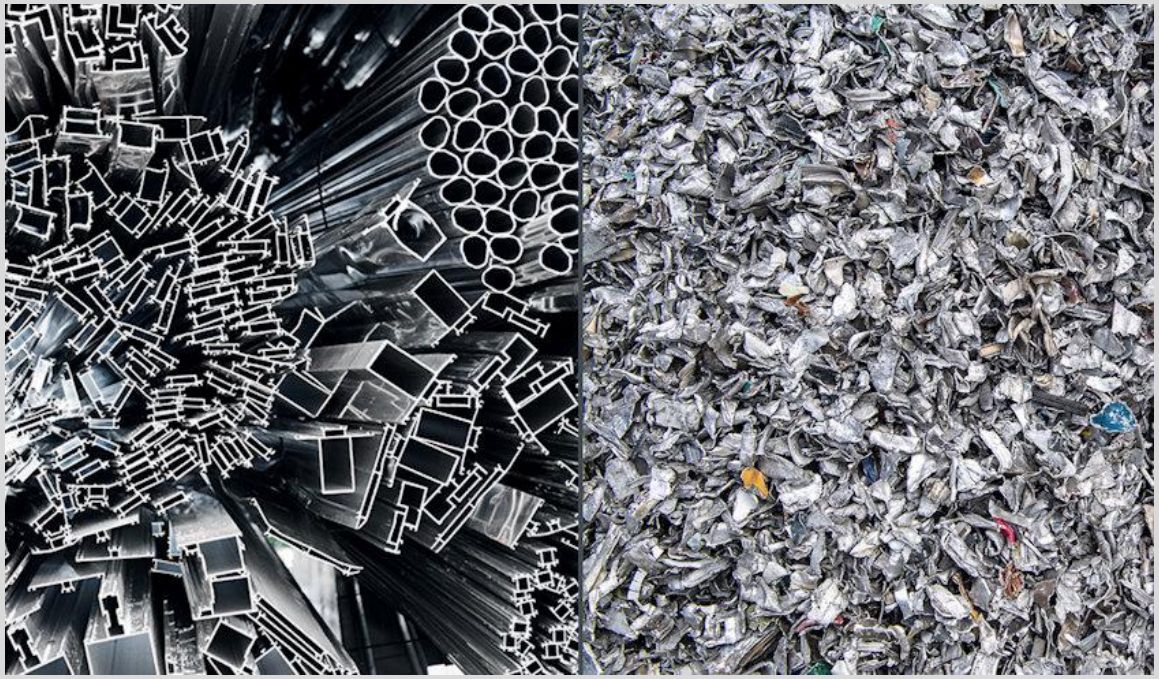
LIQUID/GAS SOLID SOLID



SMART: GLASS – ALUMINUM UPCYCLING

- Inorganic Materials Upcycling: **ALUMINUM**

- ...The recycling of aluminium scrap today utilizing a **REMELTING TECHNIQUE DOWNGRADES THE QUALITY OF THE ALUMINIUM**, and the final sink of this downgraded recycled aluminium is aluminium casting alloy.
- **To meet the demand for HIGH-GRADE ALUMINIUM in the future, a NEW ALUMINIUM RECYCLING METHOD CAPABLE OF UPGRADING SCRAP TO A LEVEL SIMILAR TO THAT OF PRIMARY ALUMINIUM IS REQUIRED....**



Xin Lu et al., *Nature* **606**, 511–515 (2022)
https://en.wikipedia.org/wiki/Aluminium_recycling

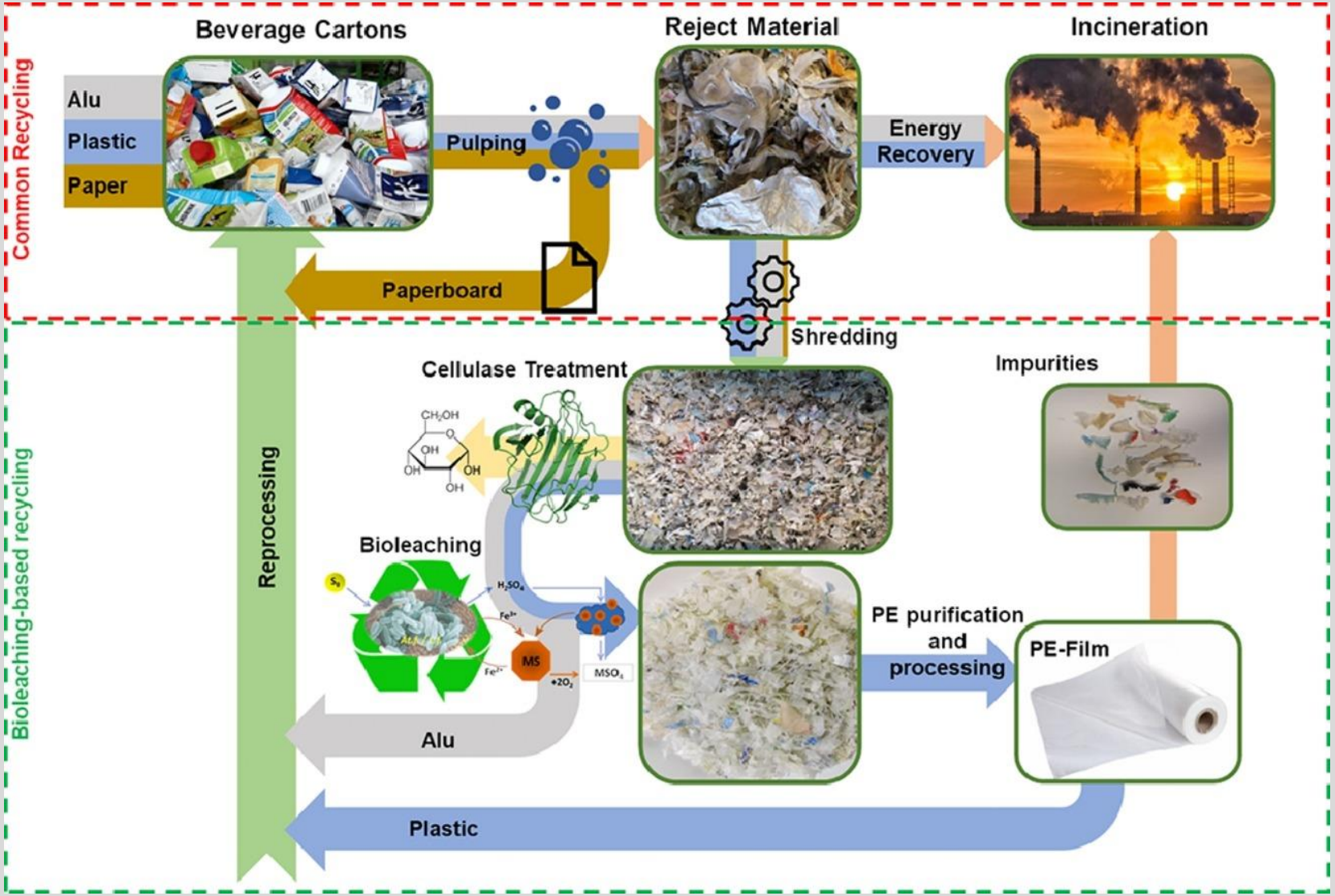
SMART: GLASS UPCYCLING

- Inorganic Materials Upcycling: **GLASS**

https://closetheglassloop.eu/
https://coreve.it/la-nuova-vita-del-vetro/
https://en.wikipedia.org/wiki/Glass_recycling

SMART: ECO-DESIGN OF MATERIALS AND SUSTAINABLE TECHNOLOGIES

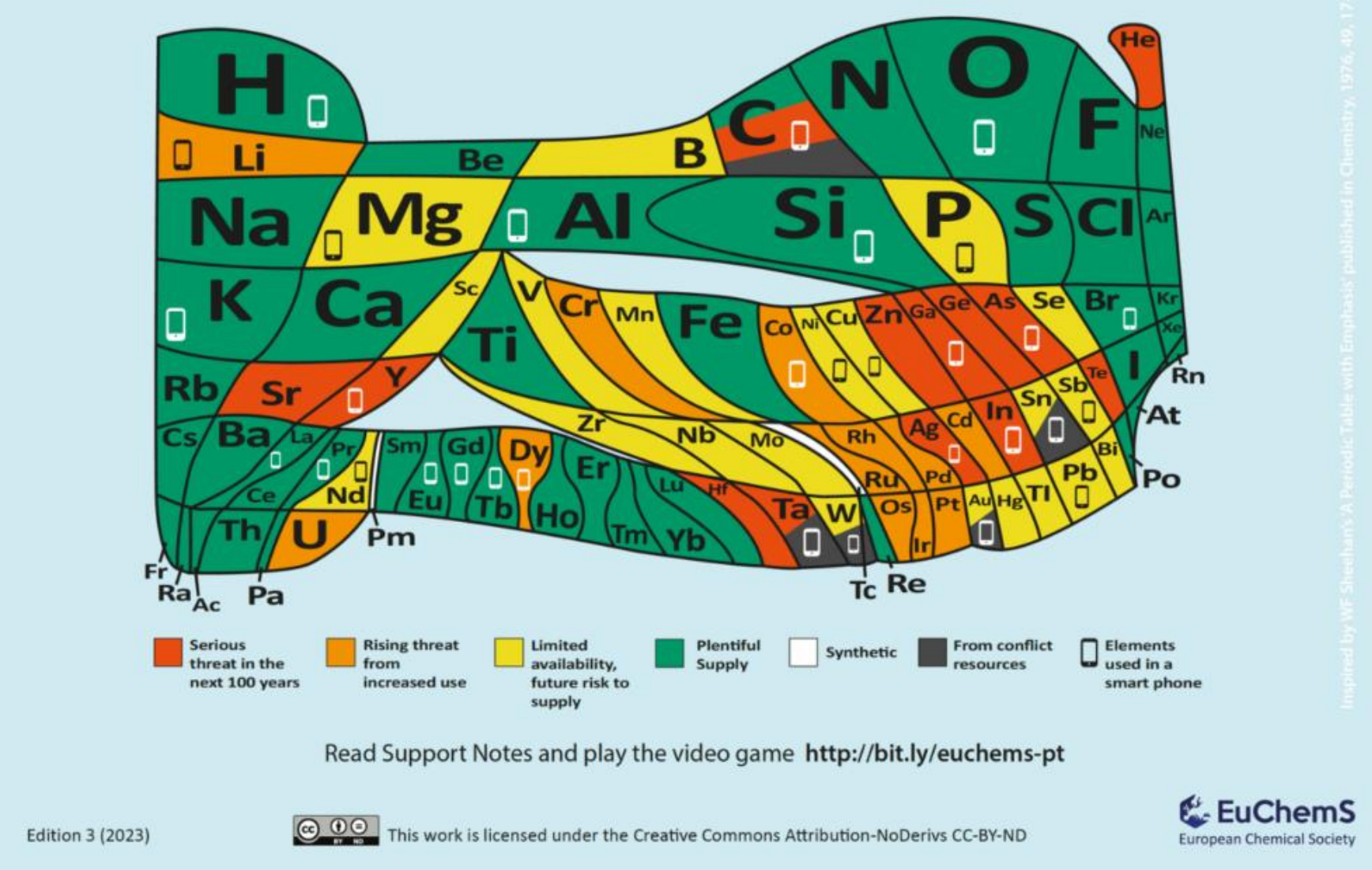
- Alternative Recycling of Mixed Waste: **Biological recycling of beverage cartons packaging waste**



K. Kremser et al. **2022**, *Res.Cons. Rec.*, 185, 106444

SMART: ECO-DESIGN OF MATERIALS AND SUSTAINABLE TECHNOLOGIES

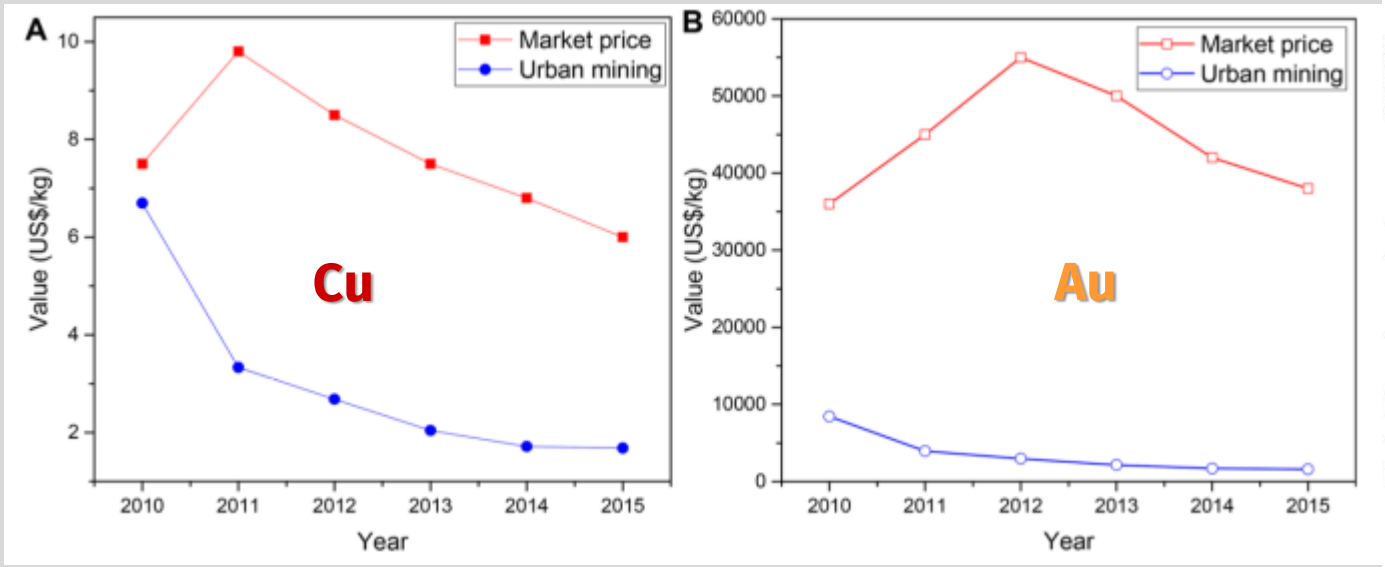
- Periodic table view on raw materials availability: **URBAN MINING**

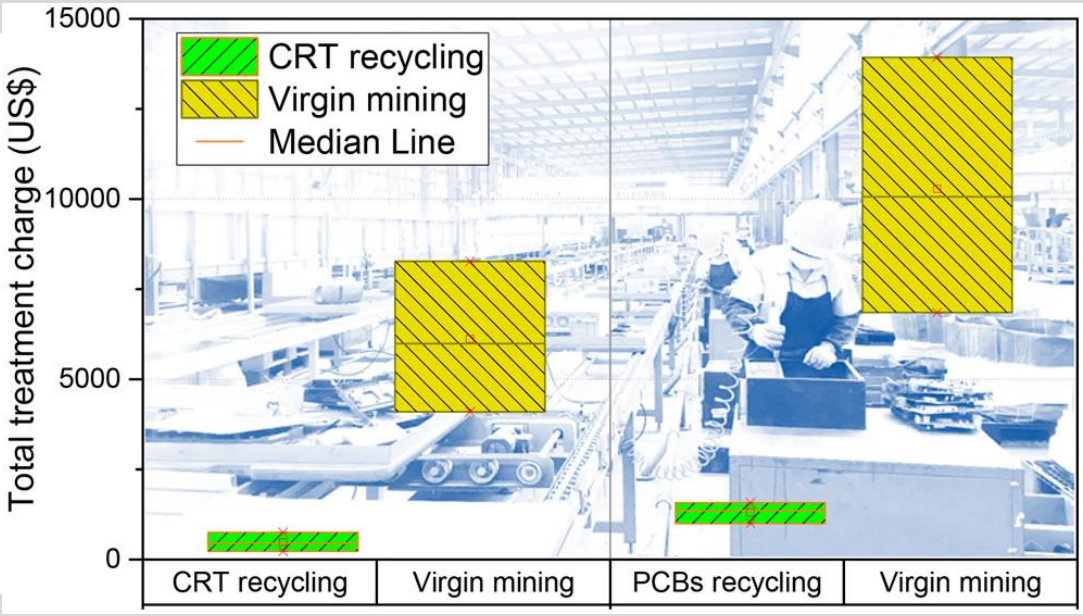


SMART: ECO-DESIGN OF MATERIALS AND SUSTAINABLE TECHNOLOGIES

- **Urban Mining** and **NOBLE AND PRECIOUS WASTE**

- **Without government subsidies**, the urban mining of precious metals like copper and gold is financially competitive to mining fresh minerals the old-fashioned way.



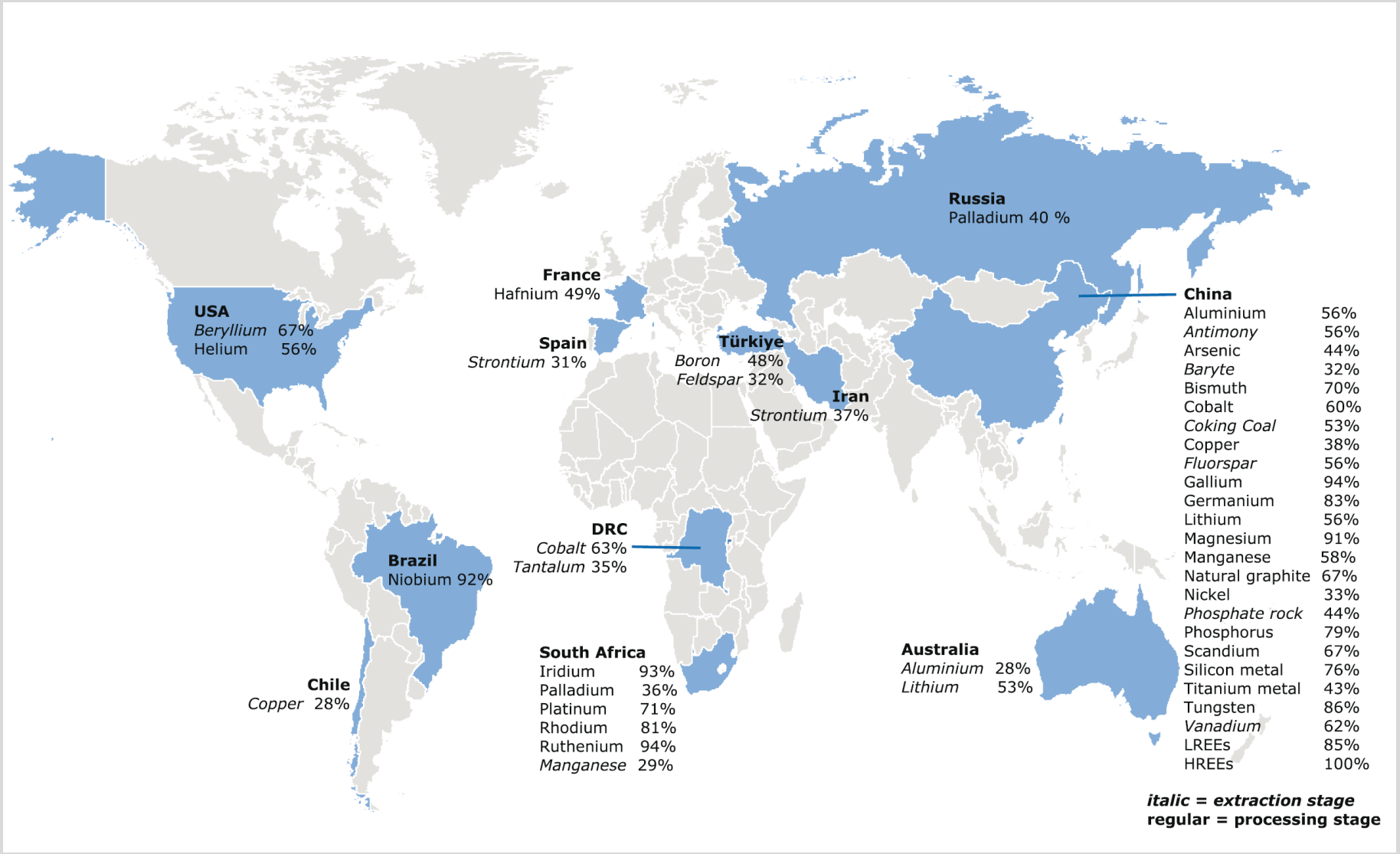


https://www.alphr.com/environment/1008974/urban-mining-makes-financial-sense/

Environ. Sci. Technol. 2018, 52, 8, 4835−4841

SMART: ECO-DESIGN OF MATERIALS AND SUSTAINABLE TECHNOLOGIES

- Critical Raw Materials for EU: **IMPORT GEOGRAPHICAL DEPENDENCE**



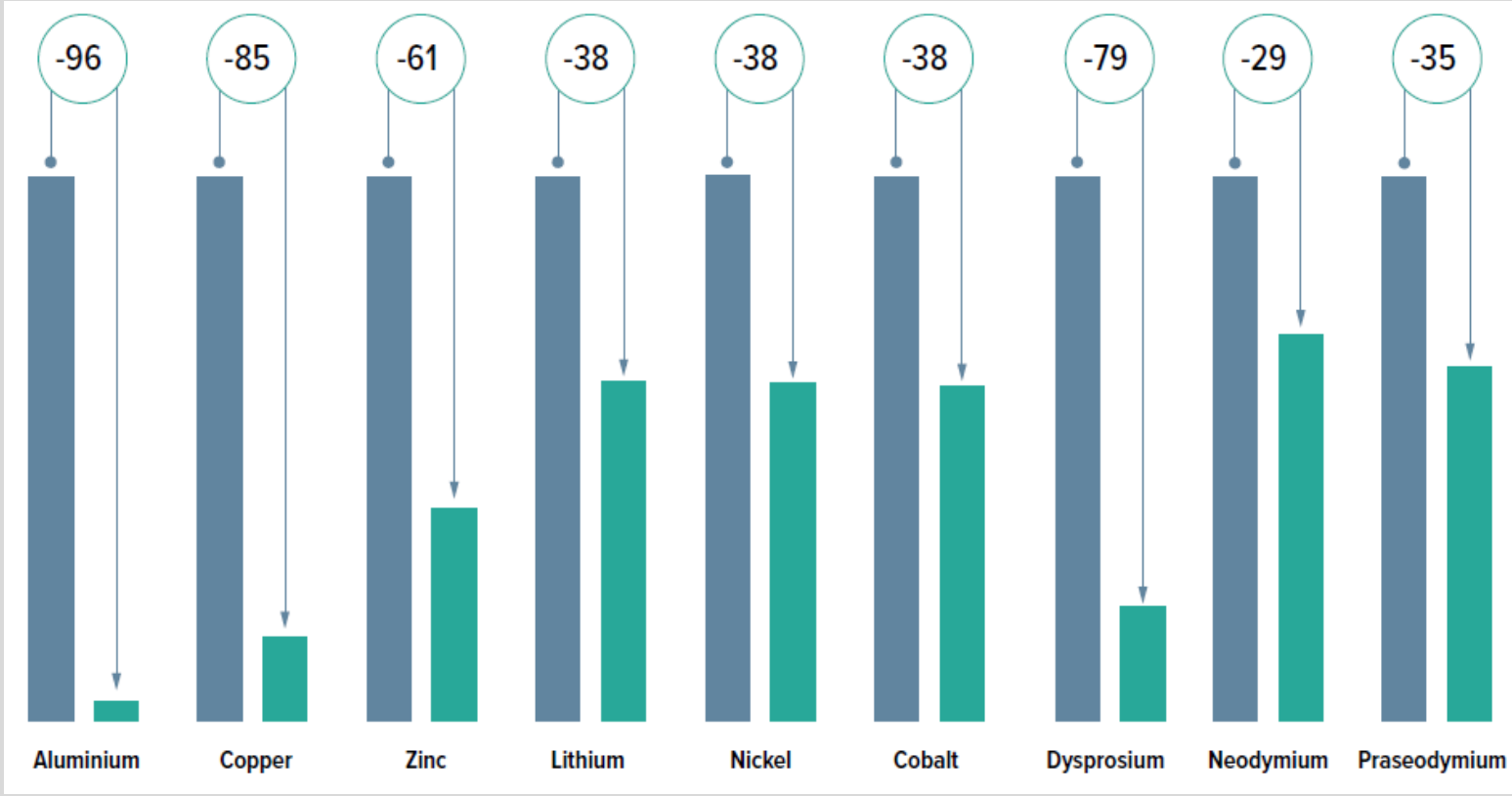
- LREE have in common increasing unpaired electrons. LREE include the atomic number 57 through 64.
- HREE have paired electrons (a clockwise and counter-clockwise spinning electron). HREE include the atomic number 65 through 71 plus number 39.
- Scandium (Sc number 21) forms a group in itself as its properties cannot be classified as either a LREE or HREE.

European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Grohol, M., Veeh, C., *Study on the critical raw materials for the EU 2023 – Final report*, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2873/725585

SMART: INORGANIC MATERIALS UPCYCLING

- **URBAN MINING: RAEE**

- Replacing primary metal with secondary metal allows for **CO_2 savings of between 29-96%**, depending on the waste stream and its complexity.
- Recycling also prevents the need for new mining, **saving resources and avoiding the environmental impacts associated with extraction**.

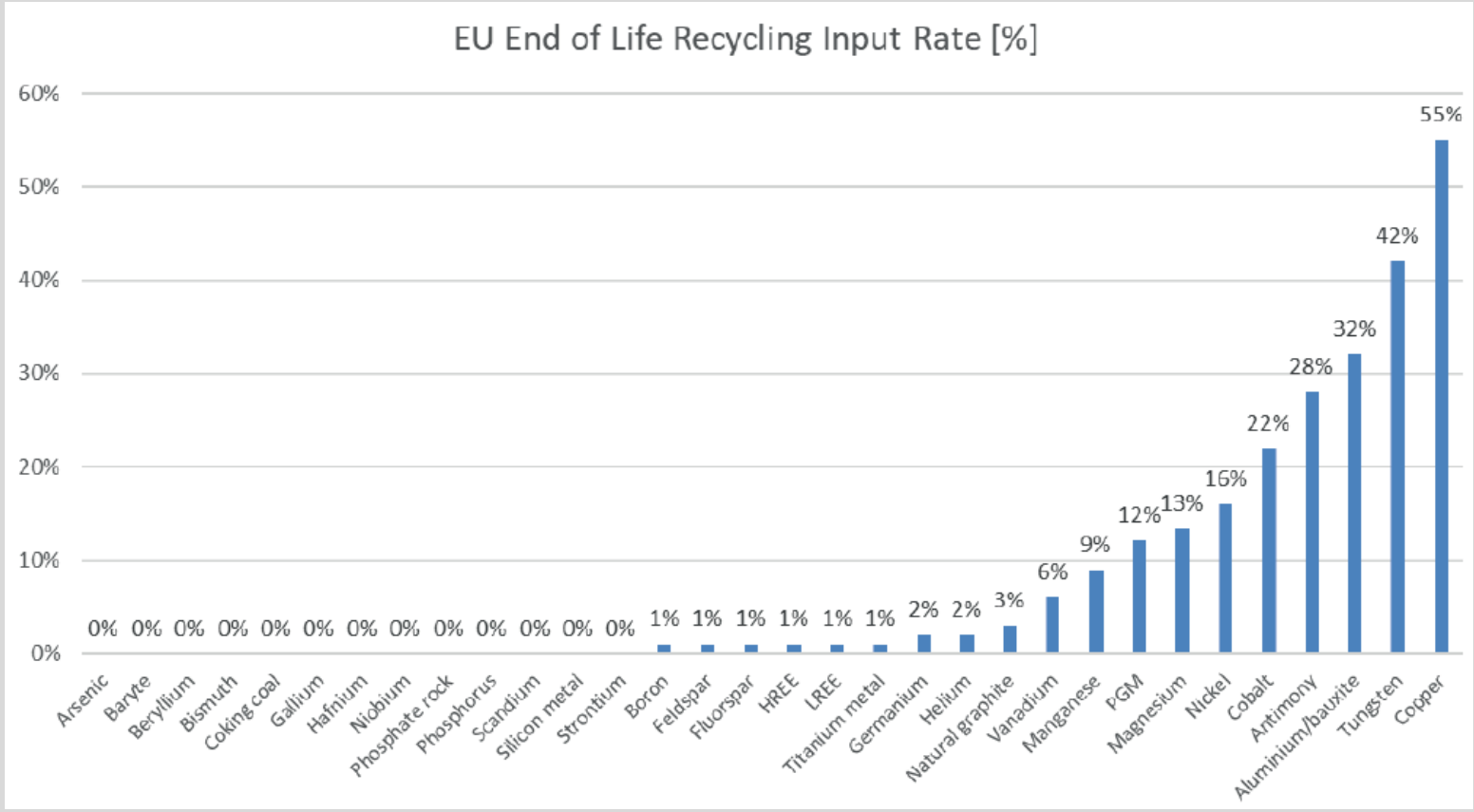


https://en.wikipedia.org/wiki/Electronic_waste
https://www.cdcraee.it/
https://eurometaux.eu/media/20ad5yza/2022-policymaker-summary-report-final.pdf

SMART: INORGANIC MATERIALS UPCYCLING

- **URBAN MINING: RAEE**

- **The EU is at the forefront of the circular economy and has already increased its use of secondary raw materials.**
- **More than 50% of some metals such as iron, zinc, or platinum are recycled** and they cover more than 25% of the EU's consumption.
- For others, however, **especially those needed in renewable energy technologies or high-tech applications such as RARE EARTHS, GALLIUM,** or **INDIUM,** secondary production makes only a marginal contribution.



https://en.wikipedia.org/wiki/Electronic_waste
https://www.cdcraee.it/
https://op.europa.eu/en/publication-detail/-/publication/57318397-fdd4-11ed-a05c-01aa75ed71a1

SMART: THE CORE BUSINESS

- Huge problem to solve: **A DEEP FUNDAMENTAL KNOWLEDGE ON CHEMISTRY AND CHEMICAL PROCESSES IS REQUIRED.**
- **SMART FOCUSES ON SUSTAINBILITY, UPCYCLING AND AND CIRCULAR ECONOMY FOR MATERIALS AND CHEMICAL PROCESS MANAGEMENT**

EU CIRCULAR ECONOMY ACTION PLAN GOALS:

- **70% of packaging waste within 2030**

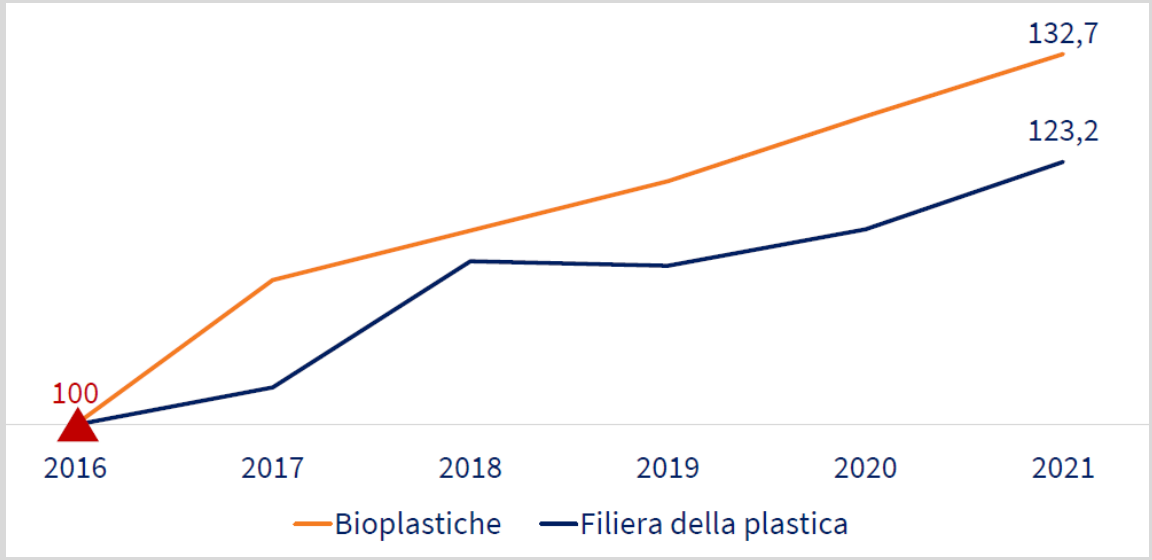
TARGETS FOR DIFFERENT MATERIALS:

- 30% wood,
- **55% plastics**
- **60% alluminum**
- **75% glass**
- **80% ferrous materials**
- **85% paper**
- **65%** urban waste (witihn 2035)
- **To landfill <10% within 2035**

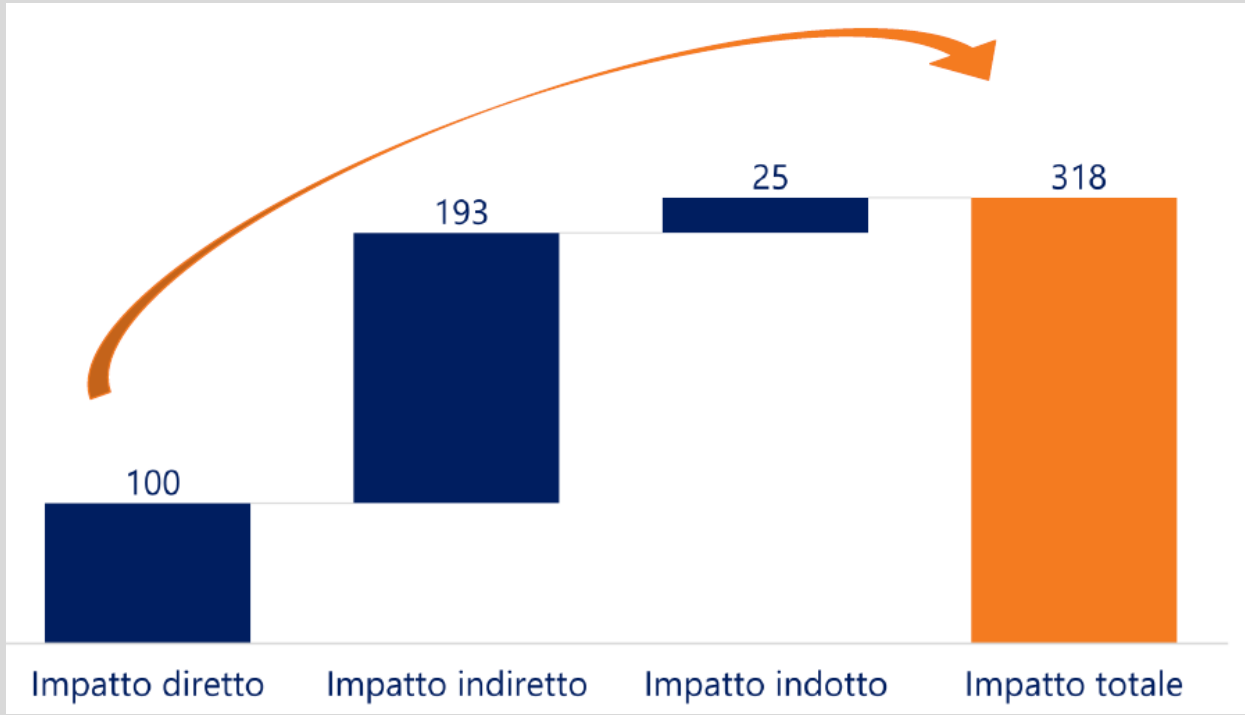
SMART: PLASTICS MANAGEMENT

- **The Italian plastics supply chain employs around 180,000 employees**
- With a 12 share of total employment in the EU, **Italy ranks second among the European Big 5**
- **Italy ranks 2nd in the EU in terms of value added by plastics**
- **The Italian plastics supply chain shows high growth rates in the recycling phase and in bioplastics**

- Employees trends (**EMPLOYEES multiplier: 2,77**)



- Economical impact generated by investments in plastics (**ECONOMICAL multiplier: 3,18**)



The European House Ambrosetti

F. Galletti, PLAST2023, 06.09.2023

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MANIFESTO SMART: COMPULSORY

1° Year (52 credits)

Code	Descriptive Title	SSD	Type/Area	Teacher
114426	**OTHER TRAINING ACTIVITIES 1**		2 CFU	PhysMatCompSci RECAP
114427	**INDUSTRIAL CHEMISTRY**	CHIM/04	8 CFU CAR	Comoretto Davide Castellano Maila
114449	**UNIT OPERATIONS, REACTOR ENGINEERING AND CHEMICAL TECHNOLOGIES**	ING-IND/25 CHIM/04	10 CFU CAR	Servida Alberto Comite Antonio Monticelli Orietta
80198	**ECONOMY AND MANAGEMENT OF PRODUCTIVE PROCESSES**	ING-IND/26	6 CFU AFF/INT (5t+1p)	Vocciante Marco
114422	**PRINCIPLES OF POLYMER SCIENCE**	CHIM/04	8 CFU CAR (4t+4p)	Comoretto Davide Dario Cavallo
61837	**THEORY OF INDUSTRIAL CHEMICAL PROCESS DEVELOPMENT**	ING-IND/26	6 CFU CAR	Reverberi Andrea
66402	**CHEMISTRY AND TECHNOLOGY OF CATALYSIS + LABORATORY**	CHIM/04	6 CFU CAR (4t+2p)	Comite Antonio
NA	**OPTIONAL COURSE**	CHIM/04	6 CFU AFF/INT (5t+1p)	

2° Year (68 credits)

Code	Descriptive Title	SSD	Type/Area	Teacher
114439	**SYNTHESIS AND INDUSTRIAL PRODUCTION OF POLYMERS**	CHIM/04	9 CFU CAR (6t+3p)	Monticelli Orietta Vicini Silvia
114441	**ECO-DESIGN OF MATERIALS AND SUSTAINABLE TECHNOLOGIES**	CHIM/03 CHIM/06	5 CFU AFF/INT (4t+1p)	Colombara Diego Pellis Alessandro
114440	**SUSTAINABLE DESIGN & RECYCLING OF INORGANIC MATERIALS**	CHIM/02	5 CFU CAR (4t+1p)	Peddis Davide
114444	**CIRCULAR ECONOMY PROCESSES FOR PLASTICS AND THE ENVIRONMENT**	CHIM/04	6 CFU CAR (5t+1p)	Lova Paola
NA	**OPTIONAL COURSE**		6 CFU OPT (5p+1t)	
114448	**FOCUS GROUP**		2 CFU OPTIONAL	Student seminars on topics of their choice in line with the training project (soft skills, flipped classroom, focus group)
114445	**OTHER TRAINING ACTIVITIES 2 (intellectual properties and patenting)**		1 CFU	SEMINARS
114446 100274	**OTHER TRAINING ACTIVITIES 3-4**		3 CFU	Advanced English / Italian for Foreigners
114447	**FINAL EXAM**		31 CFU	

MANIFESTO SMART: OPTIONAL CLASSES

Optional courses

Code	Descriptive Title	SSD	Type/Area	Teacher
111302	**CARBON DIOXIDE CAPTURE, UTILIZATION, AND STORAGE**	CHIM/04	5t+1p CFU AFF/INT	Pagliero Marcello Antonio Comite
111303	**MEMBRANE SEPARATION TECHNOLOGY**	CHIM/04	5t+1p CFU	Pagliero Marcello Antonio Comite
114428	**POLYMER MANUFACTURING: FROM CLASSICAL PROCESSING TO 3D PRINTING**	CHIM/04	5t+1p CFU AFF/INT	Cavallo Dario Lova Paola
114435	**PROPERTIES OF POLYMER-BASED MATERIALS, BIOMATERIALS AND COMPOSITES**	CHIM/04	5t+1p CFU AFF/INT	Castellano Maila Alloisio Marina
94802	**POLYMERS FOR ELECTRONICS AND ENERGY HARVESTING**	CHIM/04	5t+1p CFU AFF/INT	Comoretto Davide
114432	**SPECTROSCOPY FOR PROCESS ANALYTICAL TECHNIQUES (PAT)**	CHIM/04 ING-IND/25	5t+1p CFU AFF/INT	Comoretto Davide Servida Alberto

SMART: REQUIREMENTS

CURRICULAR REQUIREMENTS:

- at least 50 credit points (CFU) or equivalent knowledge in the scientific subject areas (SSD) CHIM/01-12 and/or ING-IND/21-27;
- at least 15 CFU or equivalent knowledge in the SSD MAT/01-09, FIS/01-08 and INF/01;
- of the total of 15 CFU, at least 6 CFU must be in the SSD MAT/01-09 and at least 6 CFU in the SSD FIS/01-08.

INDIVIDUAL REQUIREMENTS:

- Italian diploma or a degree considered equivalent with a final grade of at least 90/110.
- In all other cases, applicants must take a test in the form of a public/telematic interview or a written test .

SMART: LANGUAGE

- **Knowledge of the English language, including specialized lexicons, at level B2 or higher is required.**
- In the absence of such a certificate, **by passing the B2 test offered by the Department for the Development of Language Skills at the University of Genoa**.
- The language proficiency requirement is also **considered fulfilled if the applicant has a degree in English,** attested by an official document or a letter from the university that awarded the degree stating that the course of study was conducted entirely in English.
- **If none of the above conditions are met, language proficiency must be determined by the relevant examination board as part of the personal preparatory examination.**

SMART: LANGUAGE

- **FIRST SEMESTER: 23/09/2024 - 24/01/2025.**
- **SECOND SEMESTER: 24/02/2025 - 13/06/2025.**
- **Some class depends on different MSc programs: Be careful to the following subjects:**
- - Proprietà di polimeri e compositi a matrice polimerica
- - Polymers for Electronics and Energy Harvesting
- - Modeling the Optical Response of Polymer Films and Industrial Coatings
- - Modeling and Numerical Simulation of the Behavior of Materials in Process Industries

SMART: MASTER THESIS

- Università di Genova — DCCI Dipartimento di Chimica e Chimica Industriale
  - **31 CFU, ≥ 6 months**
- Erasmus+
- Nanyang Technological University Singapore
- Evonik Leading Beyond Chemistry
- lyondellbasell
- Maastricht University
- IPLOM
- Solvay
- Infineum
- eni
- biochemtex
- Lamberti
- proplast Plastics Innovation Pole
- Boero
- Ecospray Technologies

SMART: CONCLUSIONS

SUSTAINABLE POLYMER AND PROCESS CHEMISTRY (SMART)

- To tackles **SUSTAINABILITY** and **EFFICIENCY** challenges **MODERN SOCIETY** imposes on the chemical industry in a **RIGOROUS** and **RESPONSIBLE** way.

UniGe

DCCI