SGO SST - General Assembly and Technical Conference 2026

FROM WASTEWATER TO STRATEGIC RESOURCES:

Industrial-Scale Metal Recovery for Sustainable Surface Treatment

Riccardo Momoli
Director Business & Corporate Development

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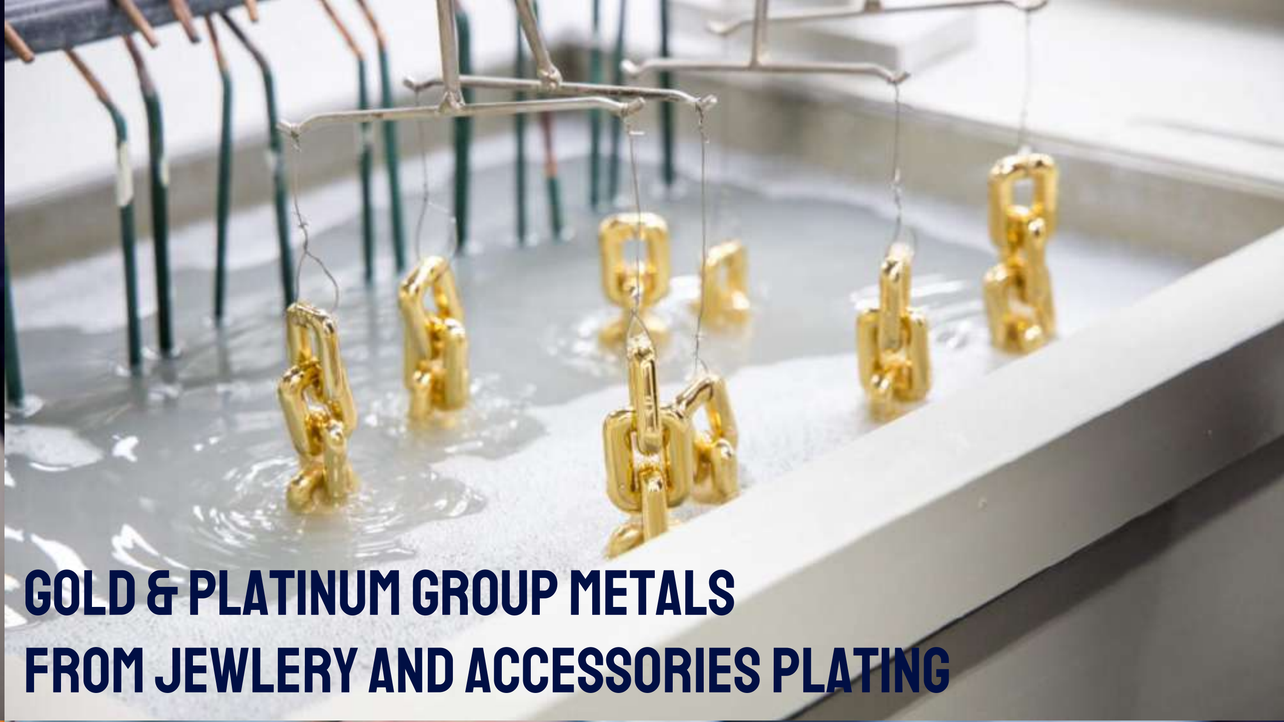
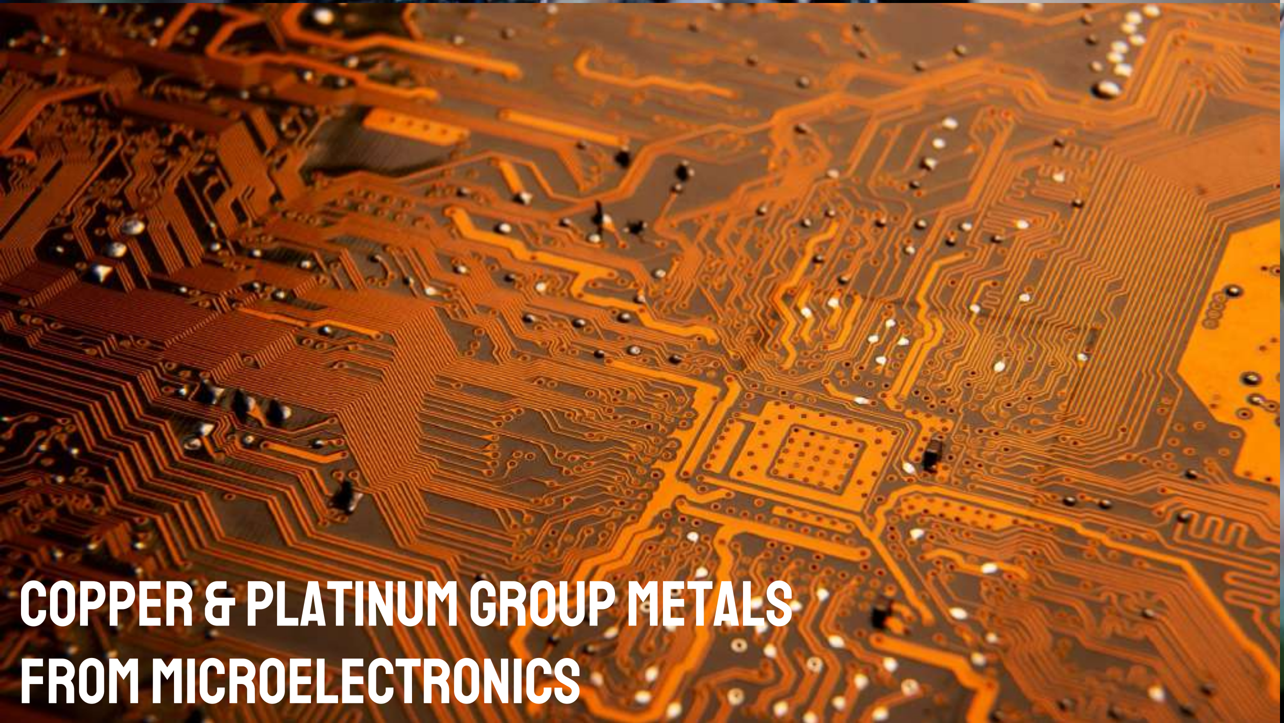
Biel, Switzerland

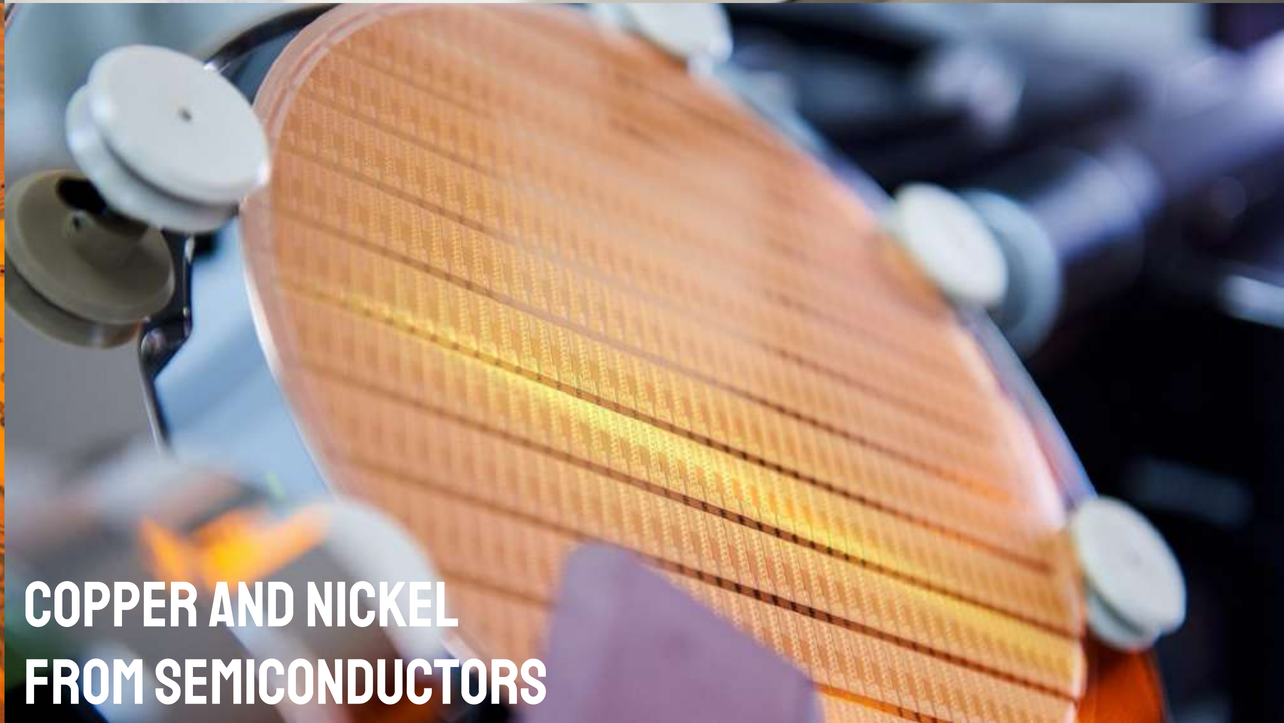
CIRCULAR MATERIALS

PROBLEM:
A PERFECT STORM OF 3 CHALLENGES


NICKEL AND COPPER
FROM SURFACE TREATMENT OF METALS

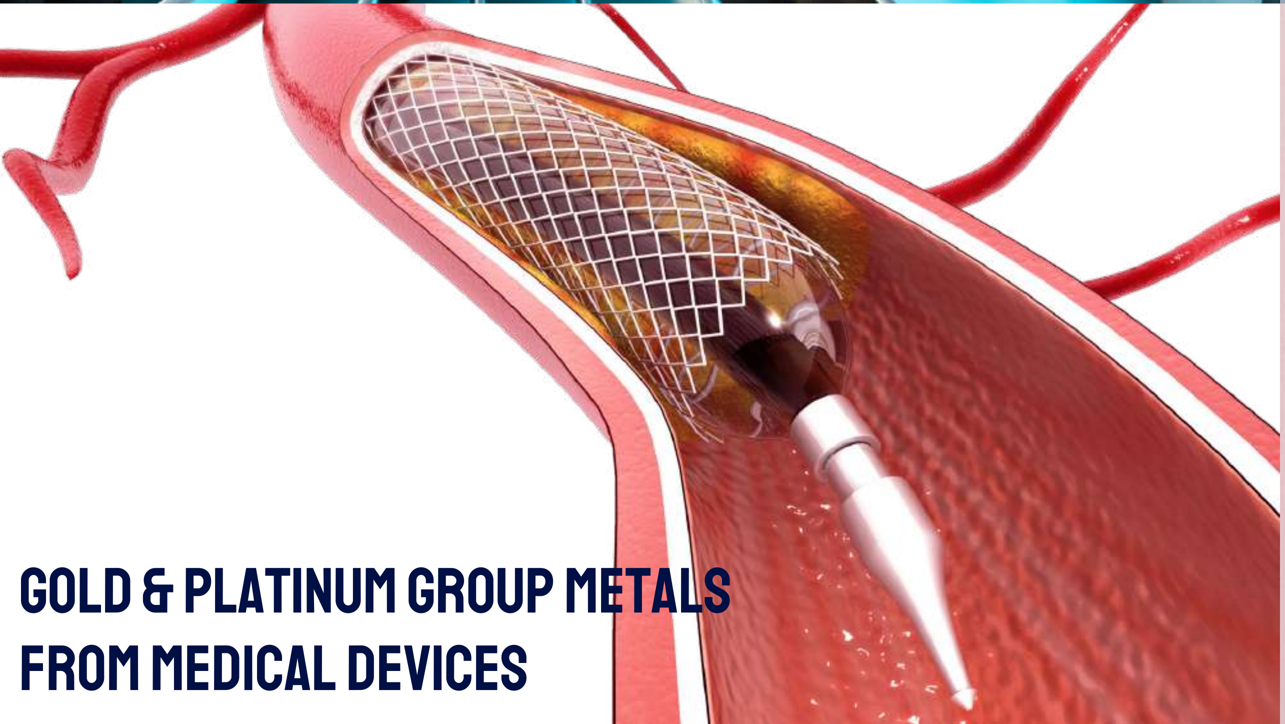

GOLD & PLATINUM GROUP METALS
FROM JEWLERY AND ACCESSORIES PLATING


COPPER & PLATINUM GROUP METALS
FROM MICROELECTRONICS


COPPER AND NICKEL
FROM SEMICONDUCTORS


NICKEL AND CROMIUM
FROM AVIATION AND DEFENCE


NICKEL, COPPER AND CHROMIUM
FROM AEREOSPACE


GOLD & PLATINUM GROUP METALS
FROM MEDICAL DEVICES


PLATINUM GROUP METALS, NICKEL AND CHROMIUM
FROM PHARMA & API MANUFACTURING

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CRITICAL RAW MATERIALS:
AT THE INTERFACE OF STRATEGIC & ENVIRONMENTAL

LOSS OF RESOURCES

INDUSTRIAL WASTEWATER
CRITICAL RAW MATERIALS

RECOVERY OF RESOURCES

ENVIRONMENTAL LIABILITY

UP TO 30% LOST IN LANDFILLS
AND NATURAL ECOSYSTEMS

ENVIRONMENTAL PROTECTION

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> 15 000 TPA	non-ferrous metals in wastewater
20%	released to surface water
80%	dissipated in landfill as sludge

« By transforming industrial wastewater into a resource, we open up a completely new pathway for the secure and sustainable supply of critical raw materials in Europe. »

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STRATEGIC VALUE CHAINS

Chemical industry

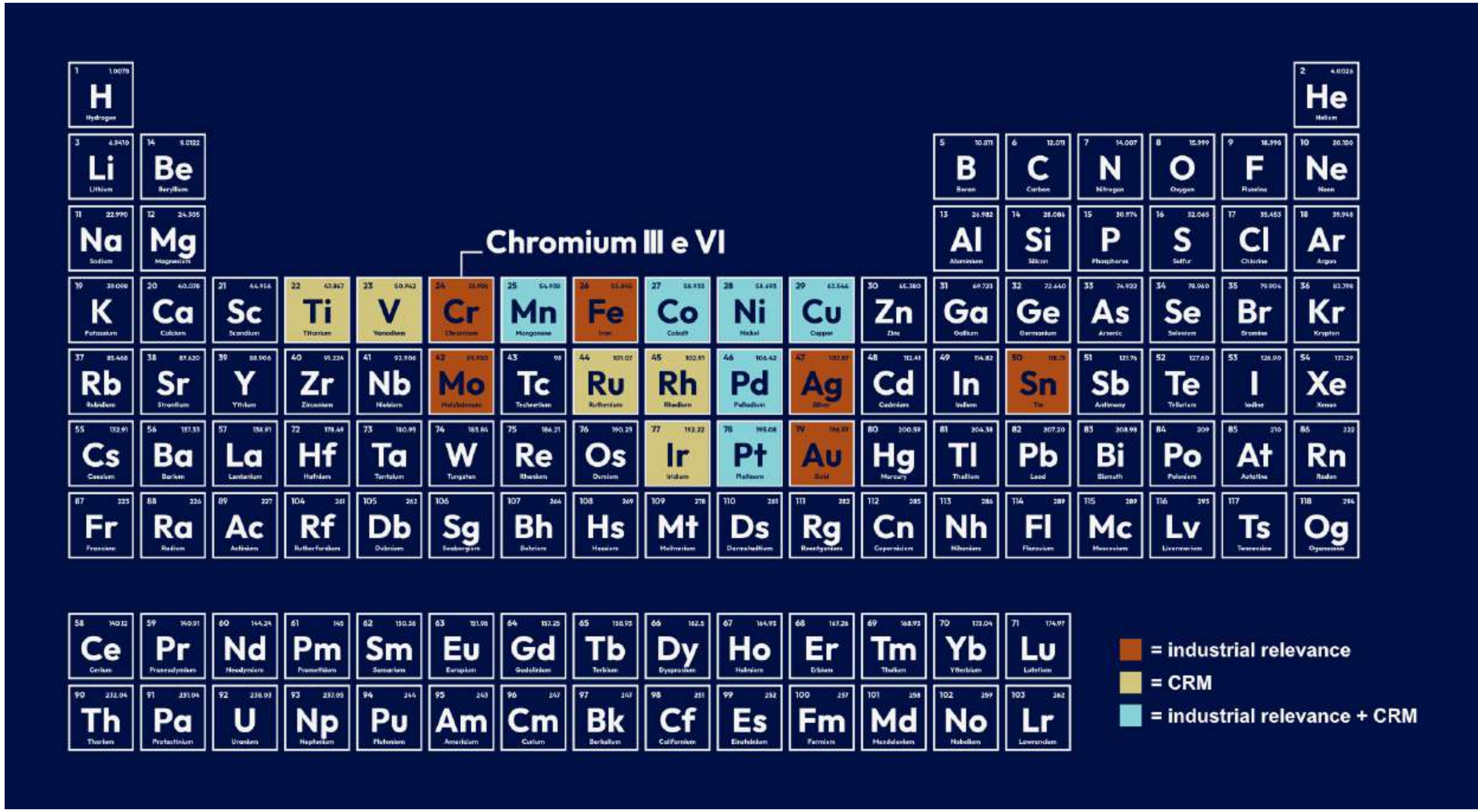
Synthesis of pharmaceutical APIs (active ingredients)

Electroplating and galvanics

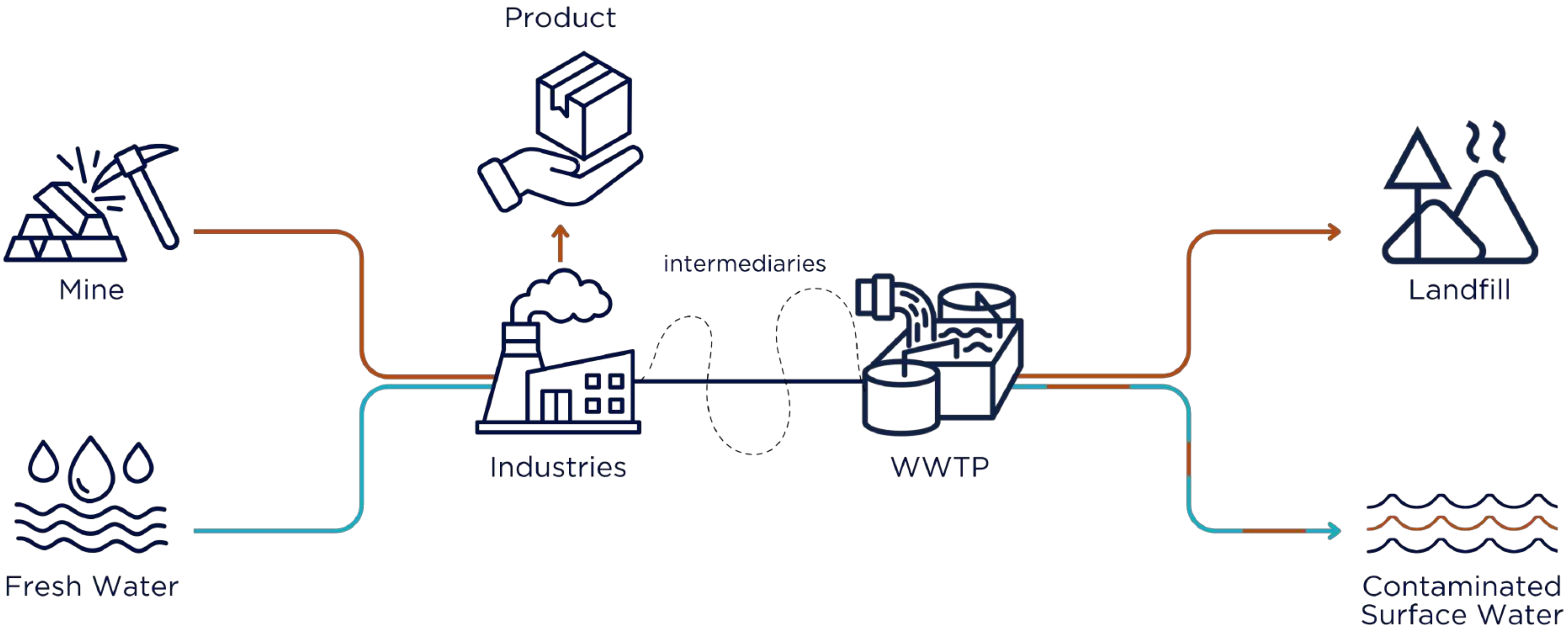
Semiconductor and electronics manufacturing

Metallurgical industry and refining

Defense and aerospace

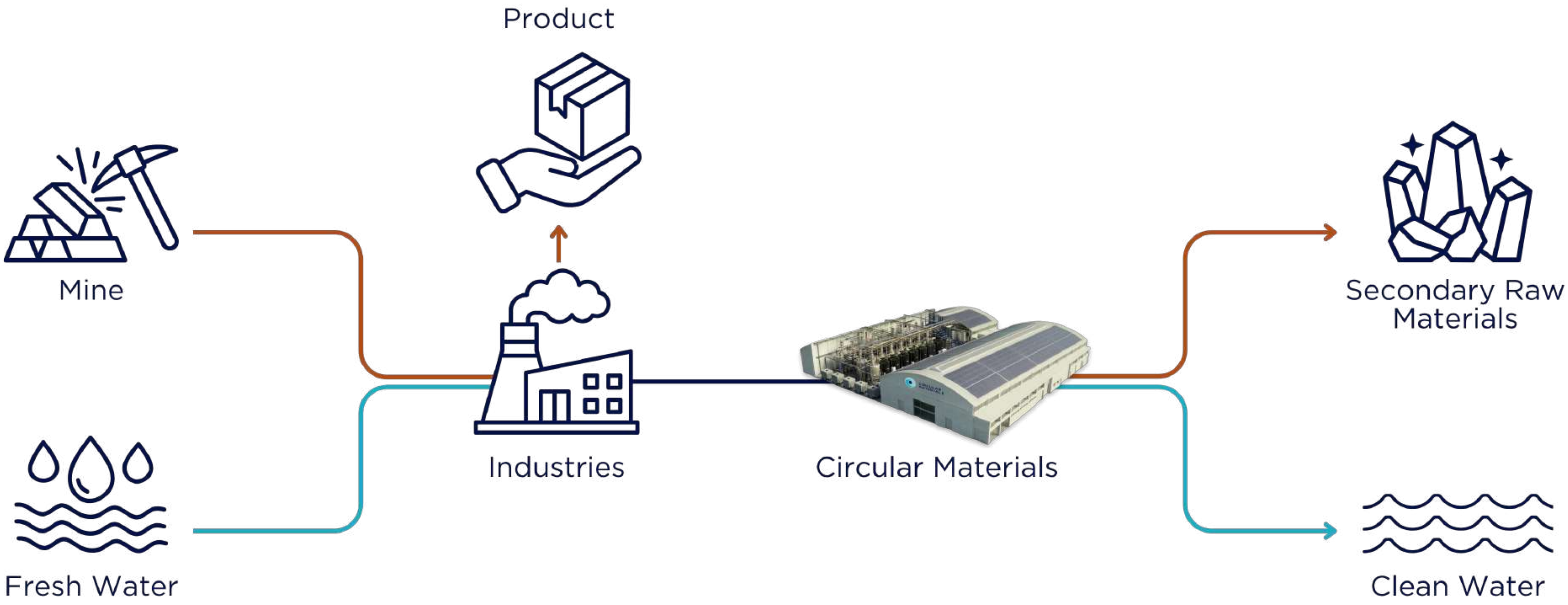


THE METAL JOURNEY



THE METAL JOURNEY

WITH CIRCULAR MATERIALS



TECHNOLOGY JOURNEY

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2019

- ✓ Company foundation
- ✓ 10L/h prototype
- ✓ Wastewater patent

2020

- ✓ First industrial pilot scaled to 50L/h
- ✓ Multiple metals validated

2022

- ✓ Scaled to 100L/h for deployment at wastewater treatment site
- ✓ Authorization to operate at test customers

2023

- ✓ New tech solutions enable 50% cost and size reduction
- ✓ Deployment at 4 customer sites under rental agreement
- ✓ Heat recovery

2024

- ✓ CM Hub Zero
- ✓ Fully authorized waste recovery site
- ✓ Fully automated and operational
- ✓ 5 lines, 1000sqm, 2Ktpa
- ✓ R&D Lab

2026 - 2032

- ✓ Deploy 5 hubs across EU by ‘30
- ✓ 3Ktpa metals recovered by ‘32
- ✓ 120Ktpa wastewater capacity

tpa = Tons per annum

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European Commission

EU Commission selects CM as the only Strategic Project focused on recovery of critical raw materials from wastewater.

1 OF 10 STRATEGIC PROJECTS SELECTED IN RECYCLING

Highly CAPEX efficient with 31M€ investments per 20ktpa site

From National Hub to EU Network

- Domestic supply of low carbon footprint Ni, Cu, Cr & PGMs
- 5,000 tpa CRMs from 130 ktpa wastewater
- Replicable across EU industrial clusters
- Building a European CRM recovery network
- Stockpiling support for Strategic Industries

RECOVER-IT STRATEGIC FACILITIES IN ITALY

2026

CMHO - CADONEGHE (PD)

- ✓ Authorized Waste Treatment & Recovery Facility Q3 24
- ✓ Operating at Industrial Scale since Q1 25 (2 kt/year)

- ✓ Full process automation since Q4 25
- ✓ End of Waste status by Q2 26
- ✓ REACH status by Q2 26
- ✓ Circular Materials' Qualification + R&D Center

2027

CMHI - FERRARA (FE)

- ✓ 20 kt/year industrial capacity (10× scale vs CMH0)
- ✓ Environmental permitting process initiated in Q1 26
- ✓ Front-End Engineering completed by Q2 26

- ✓ Final Investment Decision by Q2 26
- ✓ Start of procurement planned Q3 26
- ✓ Commercial operations by Q3 27

WHERE ARE METALS LOST?

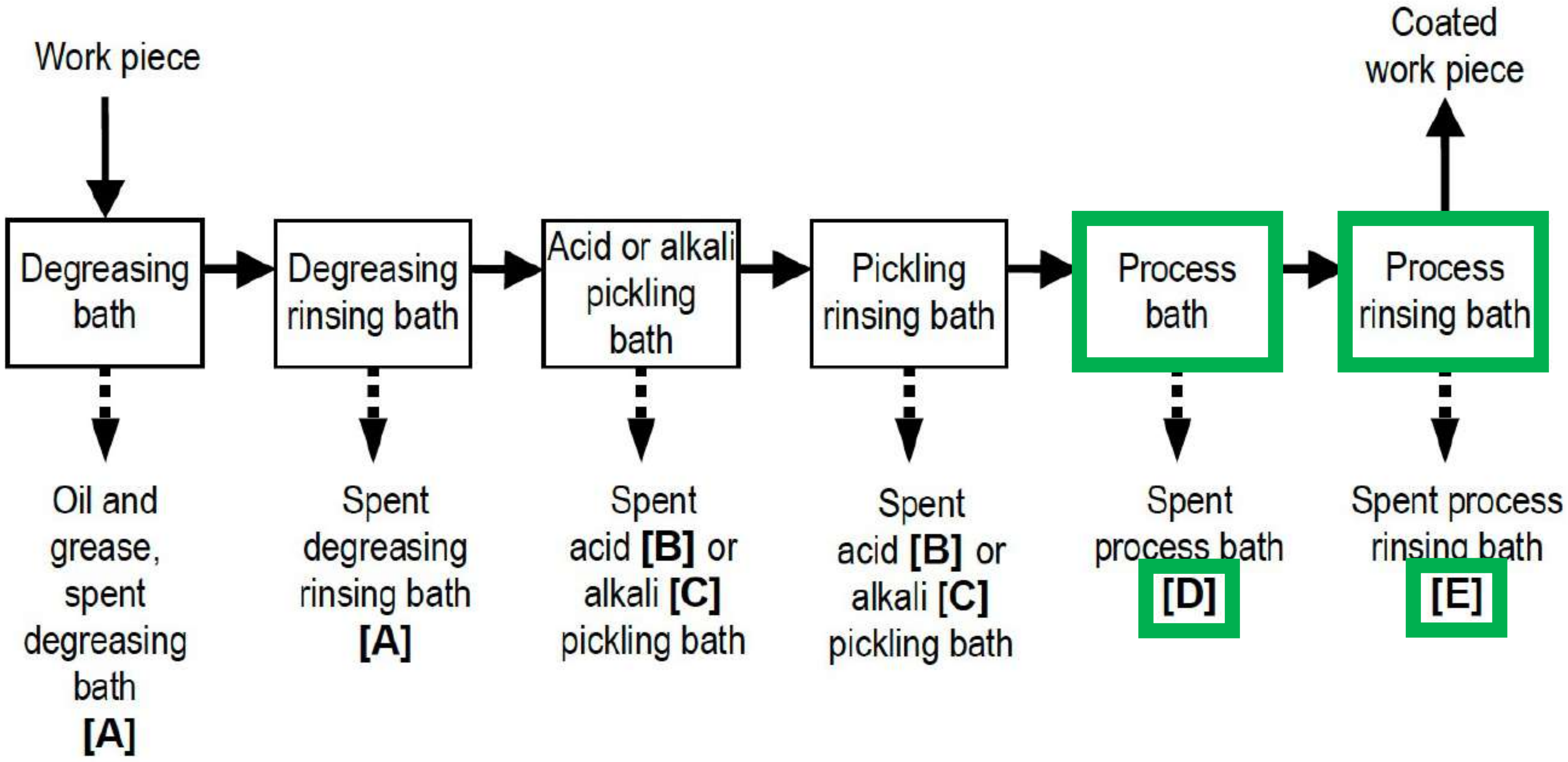


Fig 1: An example representation of a galvanising process line and the possible types of waste

HOW ARE WASTEWATER CURRENTLY TREATED?

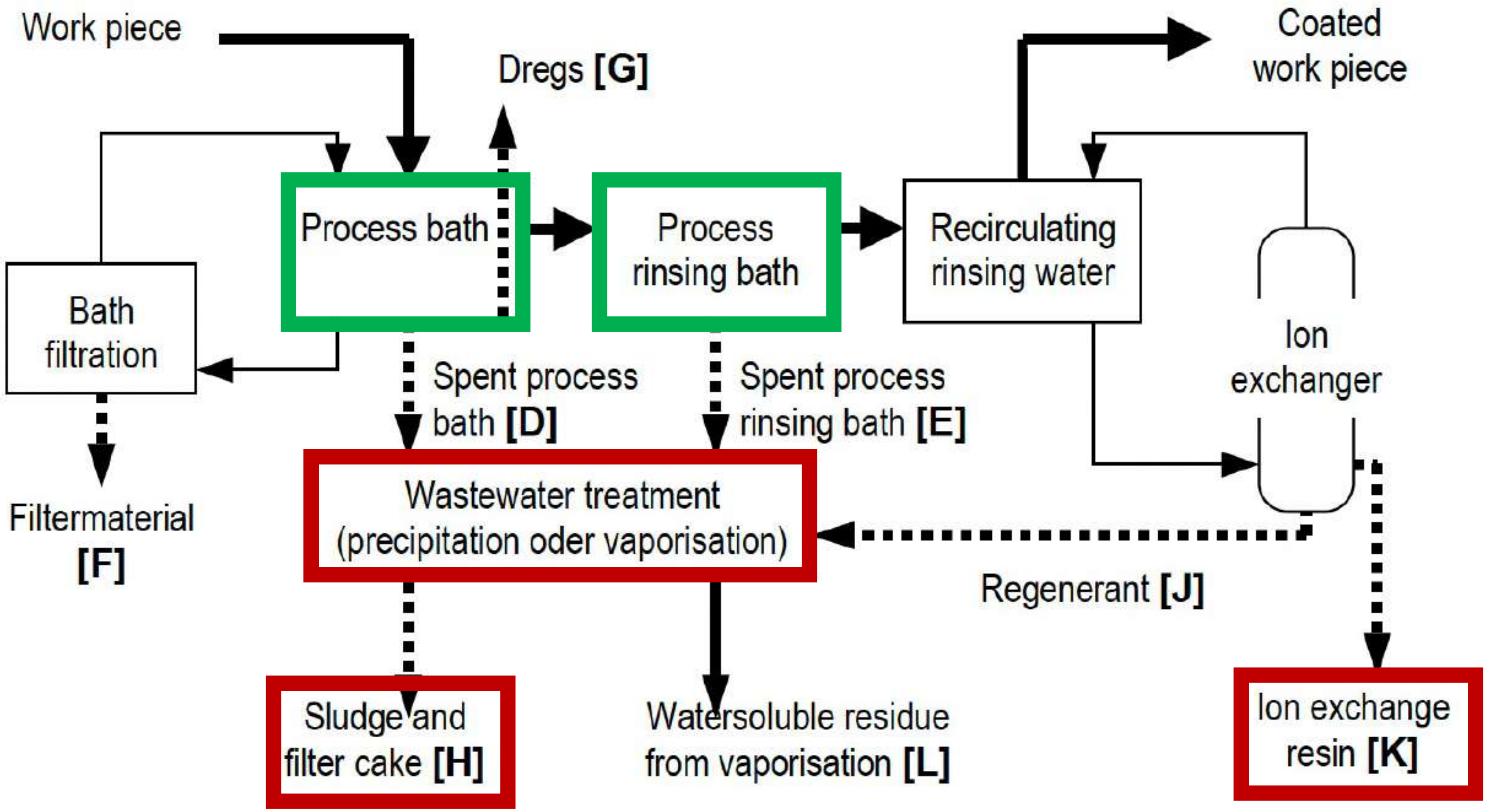
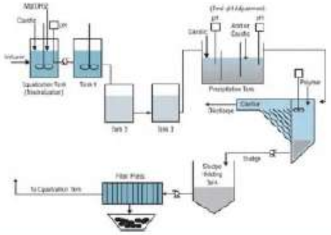
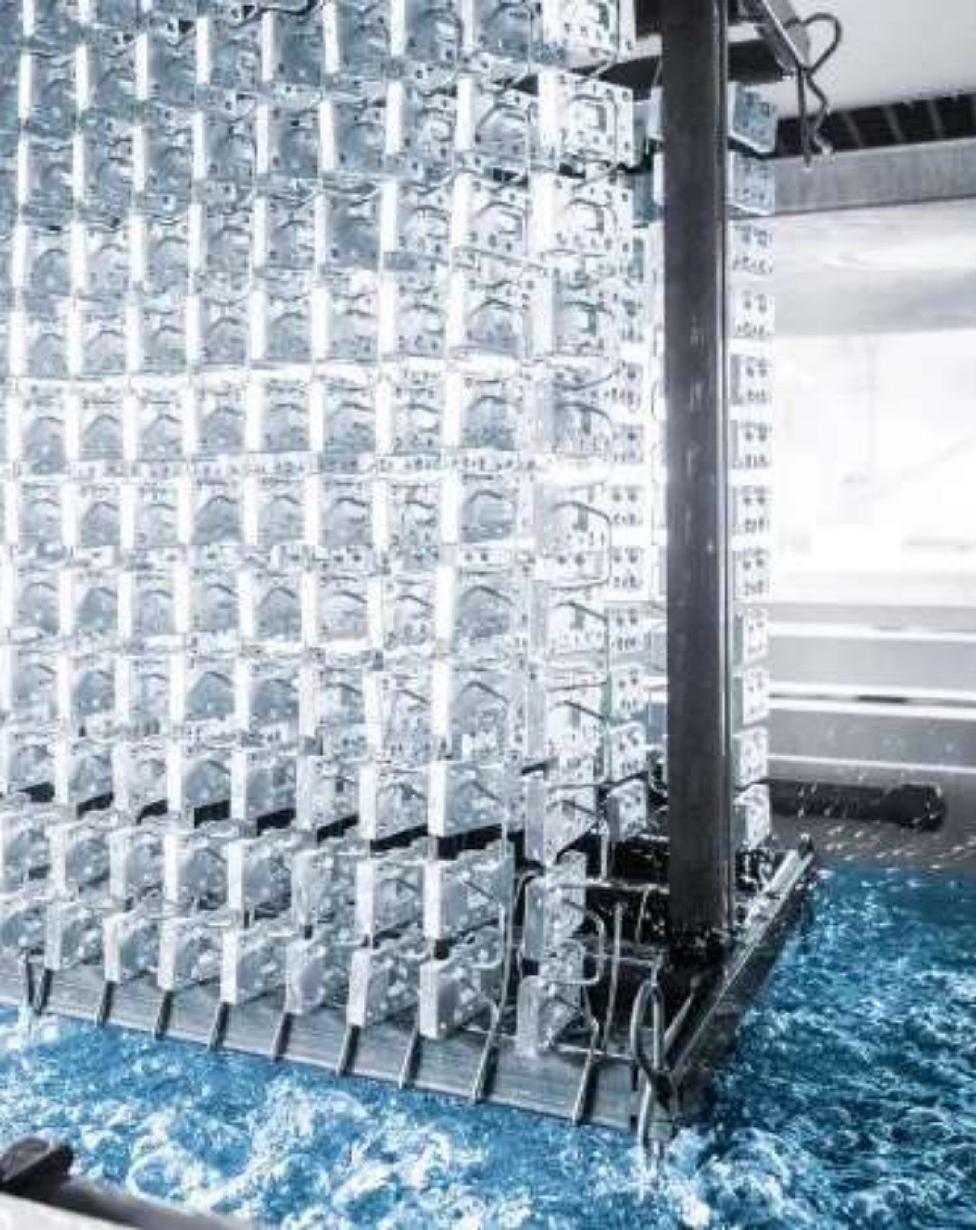


Fig 2: Waste production during wastewater treatment from chemical and electro-chemical metal treatment and coating

WHAT OPTIONS DO WE HAVE TODAY?

	Pros	Cons	
Electrowinning	Go to solution for the recovery of precious metals	Typical recovery up to 80% Tails with several hundreds of ppms are sent for disposal Strict match between bath cemistry and EW operations	 
Chemical Physical Precipitation	Go to solution for the treatment of electroplating industrial wastewater	Zero or very limited recovery Multistep process High risk of penalties	
Third Party Disposal	Zero effort solution	Zero recovery High environmental impact	
Solvent Extraction	Very good for metal separation (i.e. Cu/Ni)	Used only at large scale facilities (refining sites) Not applicable to electroplating wastewater	



EVOLVIN
PLATING BATHS COMPLEXITY

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Dissolved Heavy Metals

Require multi-step removal to meet strict discharge limits

Stable Complexes (Chelators)

Chelated metals (ammonia, citrate, EDTA) resist precipitation, requiring advanced oxidation

Evolving Bath Chemistry

Additives (levelers, brightners) reduce predictability + interfere with treatment processes

Stream Variability & Commingling

Dilution and variability hinder optimization and increase treatment complexity

Sludge Generation

Generates hazardous waste requiring expensive disposal and handling

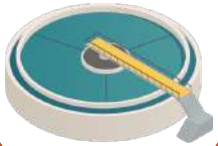
MORE COMPLEXITY?
MORE DIFFICULT TO TREAT AND/OR DISPOSE

PLATING BATH

The more a bath is designed to maximize lifespan and performance, the more complex and difficult its chemistry becomes to manage.

PHYSICO-CHEMICAL PLANT

- Higher number of internal operations to neutralize or treat metals
- Greater risk of exceeding regulatory limits
- Increasing technical complexity



EXTERNAL DISPOSAL

- Higher disposal costs
- Dependence on external suppliers
- Economic risk in case of complex baths

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MORE COMPLEXITY? ZERO PROBLEMS WITH CIRCULAR MATERIALS

PLATING BATH

Regardless of chemical complexity, our process treats baths with any metal and concentration, including hazardous reagents, recovering over 99% of materials and minimizing environmental impact.

- CIRCULAR
- VERSATILE
- EFFICIENT

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SWaP™

Supercritical Water Precipitation

Recovering any metal at any concentration.

> 99% recovery rate.

No special chemicals or consumables.

No hazardous sludges.

Inbound waste | **Analysis & Optimization** | **SWaP** | **Metal separation & Recovery** | **Metal valorization**

Inbound waste: Each batch of wastewater coming from our clients is tracked and analyzed in our facility.

Analysis & Optimization: Our internal analysis defines the best recipe to maximize the recovery rate and energy efficiency.

SWaP: Wastewater is mixed with supercritical water in a continuous flow reactor forcing metals to cluster and precipitate.

Metal separation & Recovery: Metal particles settle cleanly and rapidly, allowing for easy separation and recovery.

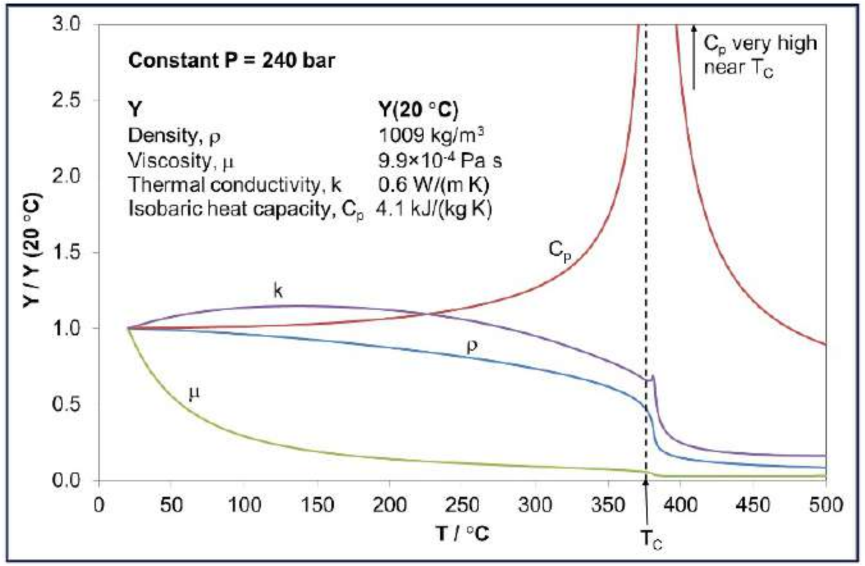
Metal valorization: Recovered metals are converted into high-quality secondary raw materials. Water is freed of metals and can be reused.

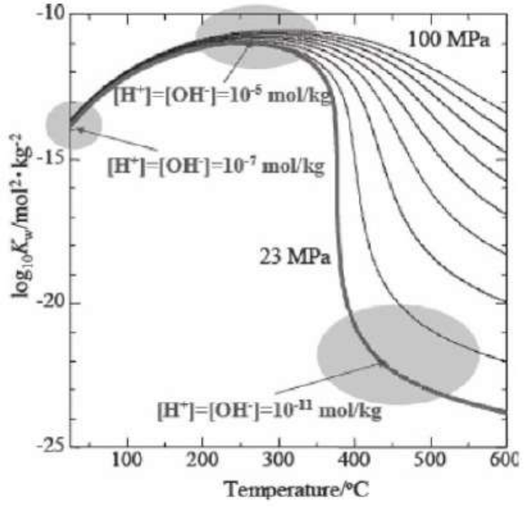
FINE TUNING OF PHYSICAL VARIABLES THROUGH SMART ENGINEERING

Supercritical Water Properties

Dramatic change of properties near its critical point resulting in the reduced solubility of polar inorganic salts

- Decrease of the fluid density (ρ)
- Decrease of the dielectric constant (ε)
- Decrease in Water Equilibrium Constant (K_w)
- Increase in Heat Capacity (C_p)





Metal Precipitation

Supersaturation & Precipitation are triggered

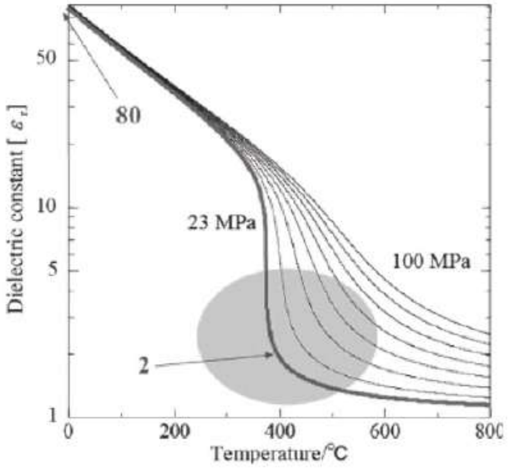
- by variation of the medium properties
- NOT by chemical reaction
- NOT by reagent addition
- NOT by pH/redox variation
- NOT by changes in ionic strength

Strong Oxidation Potential

Significant thermal and/or oxidative decomposition of organics and contaminants

Heat and Energy

SW is an excellent heat exchange fluid (high C_P), recovered and supplied via conventional heat exchangers technologies



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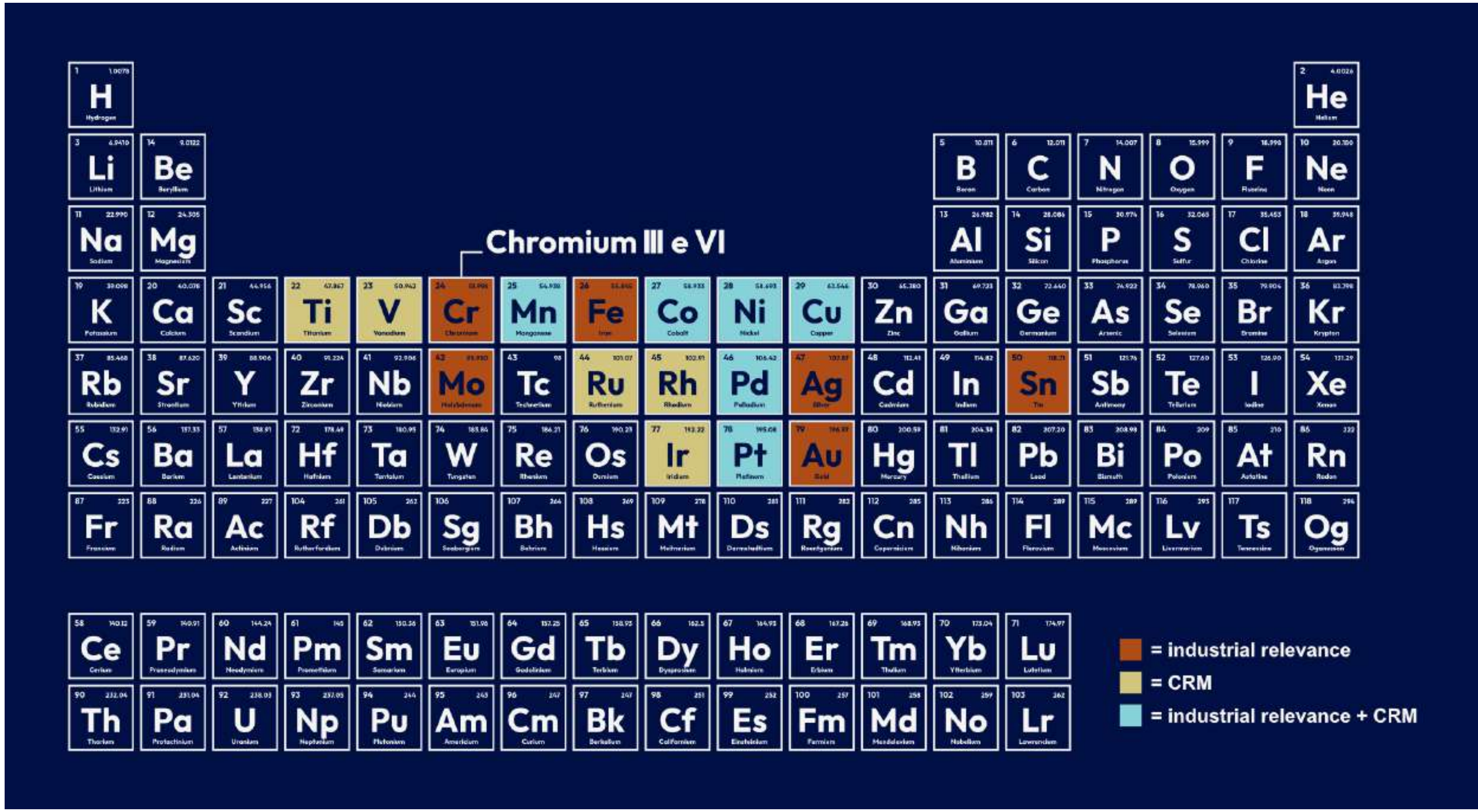
STRATEGIC VALUE CHAINS

- Chemical industry
- Synthesis of pharmaceutical APIs (active ingredients)
- Electroplating and galvanics
- Semiconductor and electronics manufacturing
- Metallurgical industry and refining
- Defense and aerospace



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HOW WE WORK

PHASE I: MAPPING OF PROCESSES AND METAL-BEARING STREAMS

- Identification of metal-containing waste streams suitable for recovery, starting from Cu, Ni, Cr and PGMs
- Preliminary screening of technical and economic recovery potential through CER code analysis
- Sampling and laboratory analysis of selected effluents at Circular Materials facilities

PHASE 2: INDUSTRIAL TESTING AND VALIDATION

- Industrial trials on selected streams at CMH0 – Cadoneghe (PD)
- Technical and economic validation of the treatment service
- Assessment of ESG and LCA impacts

PHASE 3: BUSINESS CASE AND ESG VALORISATION

- Quantification of critical raw material recovery
- Economic business case vs conventional disposal
- Support for circularity strategy, traceability and sustainability for ESG reporting

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FROM WASTE TO CRMS

Industrial Process	End-use sectors
Electroless nickel plating	Automotive, Oil and Gas, Aerospace, Defense, Machinery, Electronics, Tools, Food, Fashion, Furniture
PTFE (Teflon) nickel plating	
Electrolytic nickel plating	
Nickel stripping	
Acid copper plating (sulfuric)	Electronics, PCB, Fashion, Automotive, Mechanics, Aerospace, Defense, Agricolture, Furniture
Cyanide copper plating	
Nitric acid copper stripping	
Ruthenium acidic plating	Fashion, Furniture, Electronics
Ruthenium alkaline plating	
Chromium III plating (sulfate-based)	Automotive, Oil and Gas, Aerospace, Defense, Machinery, Electronics, Tools, Food, Fashion, Furniture, Pharma
Chromium III plating (acetate-based)	
Chromium VI plating	
Chromium stripping	

Nickel sulfate ($NiSO_4$) Nickel oxide (NiO)

Nickel hydroxide ($Ni(OH)_2$) Other organic or inorganic salts*

Copper sulfate ($CuSO_4$) Copper oxide (CuO)

Other organic or inorganic salts*

Chromium sulfate ($Cr_2(SO_4)_3$) Chromium oxide (Cr_2O_3)

Other organic or inorganic salts*

Ammonium hydroxide (NH_4OH)

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CASE STUDIES

LEM

Through this collaboration, we have:

- Treated 11 m³ of industrial wastewater, including: 7 m³ of ruthenium acid effluents and 4 m³ of nickel-based effluents
- Achieved recovery rates of >90% for ruthenium and >95% for nickel
- Delivered the recovered ruthenium to Italrecycling for refining into secondary raw materials, later reintroduced into LEM's production cycle
- Supported the recovery of the first kilogram of ruthenium within the EU Critical Raw Materials Act (CRMA) strategic project
- Mapped 3 out of 6 production sites

« A shared vision in which every employee recognizes that waste, when properly managed, is not just a cost to be borne, but a resource to be enhanced, capable of generating both environmental and economic benefits for the company. »

Other aspects not to be overlooked:

- **Diversification of sources**: reduced dependence on the supply of virgin raw materials
- **Reduced environmental impact** – recycled metals vs. mined metals – preservation of land and ecosystems
- **Development of a new way of doing business**, **where supply chain transparency is closely linked to the reputation of major market players**: more conscious consumers → sustainable products → brand-driven demand → virtuous supply chains.
  This leads to greater reporting of ESG impacts and company classification through ESG ratings
- **Awareness and proactive alignment with increasingly stringent European standards** aimed at protecting the end consumer

Wastewater	Volume (L)	Extracted metal(kg)	Recovery (%)	Net impact per 1 kg of metal (kg CO_{2eq})	Net impact for total metal recovery (kg CO_{2eq})
Nickel phosphorus	2665	196	96.2%	- 271	- 53.120
Electroless Nickel	783	2.4	92.74%	- 153	- 370
Acid ruthenium	15059	2.5	87.44%	- 20.380	- 50.950

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CASE STUDIES

ARGOS SURFACE TECHNOLOGIES

Argos Surface Technologies is an Italian industrial group and a leader in surface treatments and coatings – including nickel plating, anodizing, cataphoresis, industrial painting, polymers, metallization, and electroplating – for metals, plastics, and carbon fiber.

Our partnership

August 2024:

- inauguration our wastewater treatment plant & shipment of the first batch of nickel-containing effluents from Argos

2025:

- shipment of 34 batches of nickel-containing effluents
- mapping group sites, sample analysis, and technical evaluation
- start of recovery of nickel concentrate batches

Site	Mapping	Sample analysis	Technical evaluation	CMH0 treatment	Validated for CMH1
Calcio	Yes	Yes	Yes	Yes	Yes
Cambiago	Yes	Yes	Yes	No	Yes
Valsamoggia	Yes	Yes	Yes	No	Yes
Opera	Yes	Yes	In progress	-	-
Ciriè	Yes	Yes	In progress	-	-
Imola	Yes	In progress	-	-	-
Ag technical (Montanaso, Cavenago, Crema)	Yes	In progress	-	-	-
Origgio	Yes	No	-	-	-
Minerbio	Yes	No	-	-	-
Villanova	-	-			

** Many facilities generate multiple types of wastewater, each requiring its own technical assessment and industrial testing.*

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CASE STUDIES

ARGOS SURFACE TECHNOLOGIES

Through this collaboration, we have:

- Treated 43 m³ of industrial wastewater from electroless nickel and PTFE nickel processes, recovering over 95% of the dissolved nickel
- Reduced the environmental impact compared to traditional extraction and industrial wastewater treatment processes
- Recovered the first ton of nickel within the framework of the EU's CRMA (Critical Raw Materials Act) strategic project (just three months after Circular Materials' official designation, marking the first concrete CRMA result in Europe: recovery and reintroduction of nickel into the market)
- Mapped and analyzed relevant streams across all group facilities

Impact

Wastewater	Volume (L)	Extracted metal(kg)	Recovery (%)	Net impact per 1 kg of metal (kg CO_{2eq})	Net impact for total metal recovery (kg CO_{2eq})
Electroless and PTFE Nickel	7799	37,8	90.9%	- 125	- 4731
Electroless Nickel	22656	131	91.5%	- 207	-27114

** Net impact is calculated as the sum of emissions generated by the Circular Materials precipitation process, minus the emissions avoided from virgin raw material extraction and conventional waste treatment.*

A POSITIVE ENVIRONMENTAL IMPACT

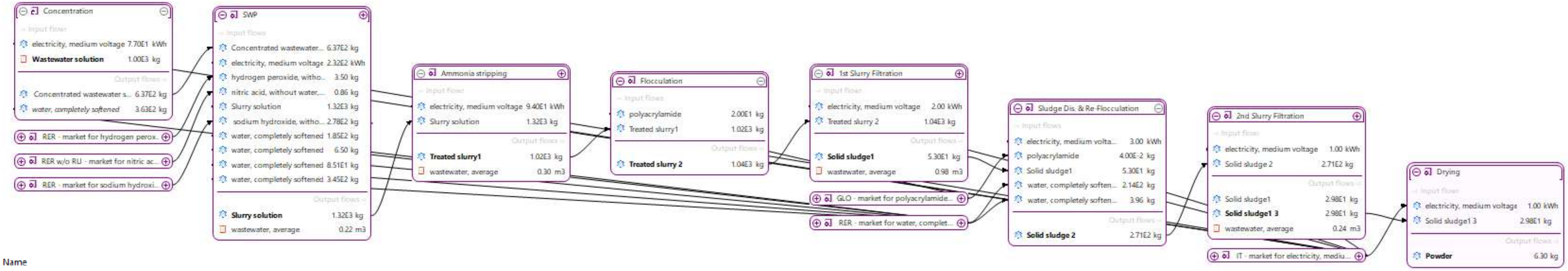
Circular materials vs **traditional process: CO_2 emissions avoided** in the recovery of 1 kg of metal and in the treatment of the corresponding volume of wastewater.

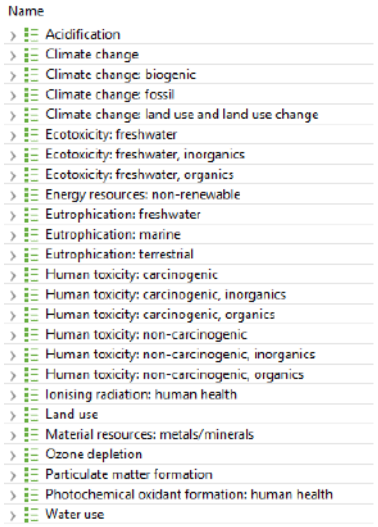
Nickel Oxide

Copper Oxide

Ruthenium

LCA ANALYSIS AND SUSTAINABILITY





Dedicated in-house team for sustainability analysis of Circular Materials' processes and partners.

Examples from Surface Treatement Industry

Extreme recovery efficiencies from a large variety of metals and processes

Our current main segments are customers active in the functional plating of metals such as Ni, Cu, Sn and Cr as well as decorative plating of Au, Pd, Ru and other precious metals.

The objective is to provide them with convenient & sustainable recovery solutions of spent electroplating effluent streams.

Moreover, we generate a value stream from the recovered metals by placing them in the market as low carbon footprint Secondary Raw Materials.

We also valorize the ESG impact our clients' processes and products.

The application of CM technology results in the direct and efficient recovery of the different metals dissolved in the plating and rinsing baths from multiple surface treatment waste streams.

Plating of gold for fashion industry

Plating of copper for the electornics industry

Target Metal		INFLOW [mg/L]	OUTFLOW [mg/L]	Recovery Rate [%]
Ruthenium	Ru	564	1,3	99,4%
Palladium-Nickel	Pd	4700	18,7	99,2%
Rhodium	Rh	1160	4,7	99,1%
Gold Cyanide	Au	60	1	>99.9%
Palladium Cyanide	Pd	433	1	>99.9%

Target Metal		INFLOW [mg/L]	OUTFLOW [mg/L]	Recovery Rate [%]
Electroless Nickel	Ni	5500	24	99,6%
Nickel	Ni	60270	3	>99.9%
Copper	Cu	35263	1	>99.9%
Tin	Sn	20290	17	>99.9%
Chromium	Cr	123850	67	>99.9%

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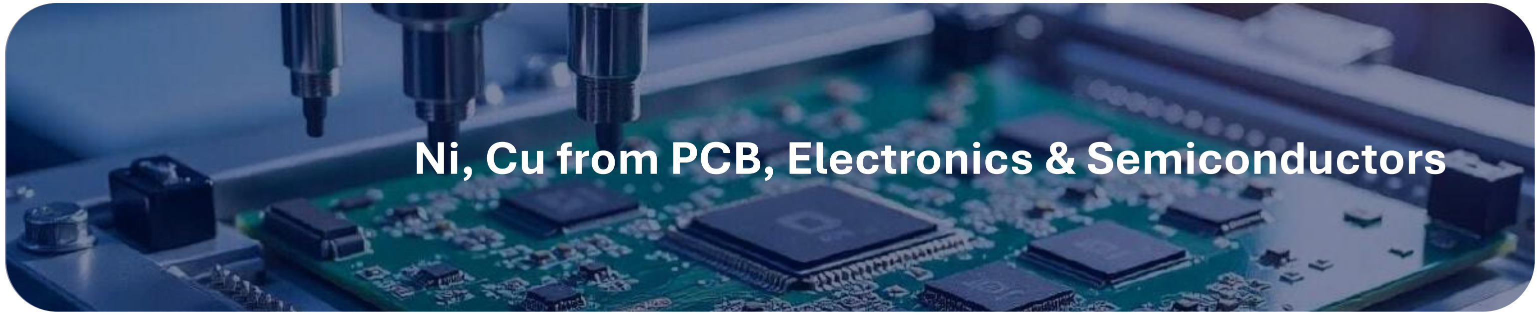

WHERE DO WE KEEP LOOSING CRMs TODAY?

CIRCULAR MATERIALS

Everything Can Be Recovered
circularmaterials.it

JOIN US TO UNLOCK VALUE LOST IN WASTEWATER.

FOLLOW US ON LINKEDIN!

Riccardo Momoli
Director BD & Strategic Partnerships
+39 347 68 62 085

OUR TEAM


CIRCULAR MATERIALS
Circular Materials Hub
CIRCULAR MATERIALS

We recover what the world **needs most**

Don’t waste another drop.

info@circularmaterials.it

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