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Institute of Non-Ferrous Metals

Upscaling and Piloting of Metal Value Recovery in EIT Raw Materials

Naples, November 25th, 2025

Witold Kurylak

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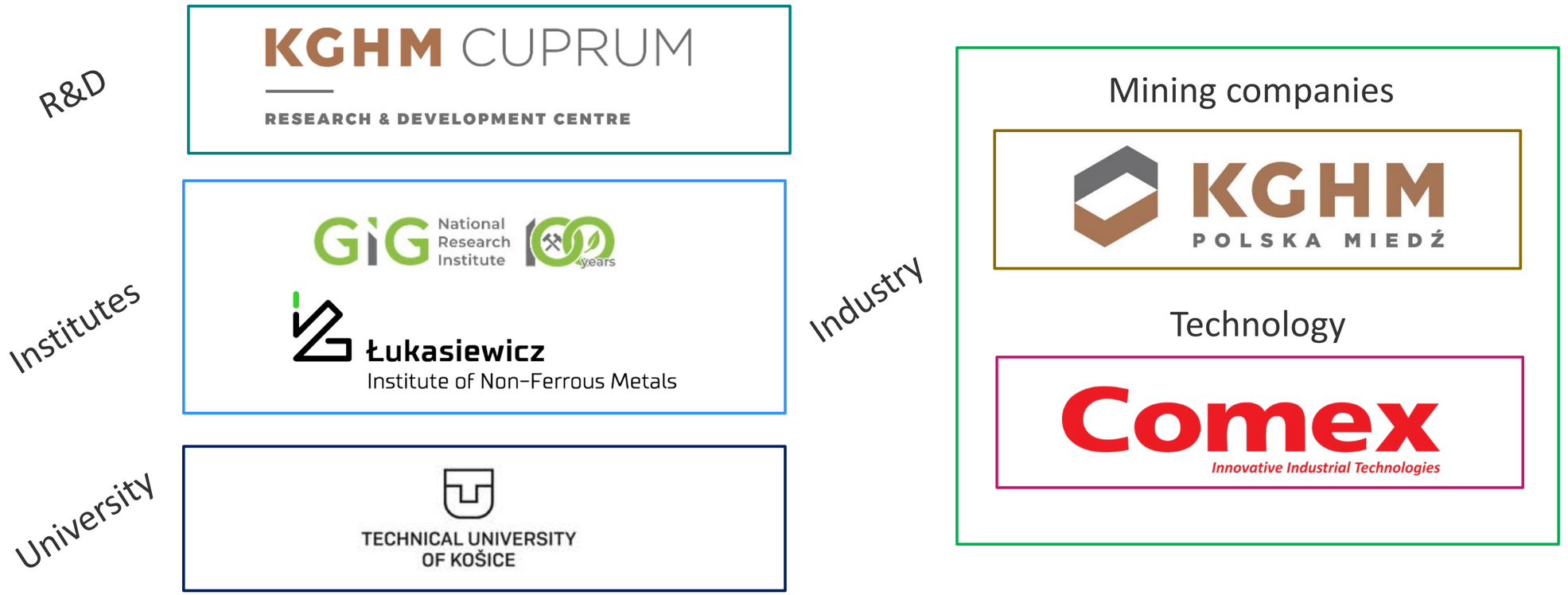
MineCuON. Mining pre-concentration system for copper ores based on XRT and XRF sensors

Co-funded by the European Union

WP PLAN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KGHM CUPRUM
RESEARCH & DEVELOPMENT CENTRE
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GIG National Research Institute
100 years
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Mining companies
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Technology
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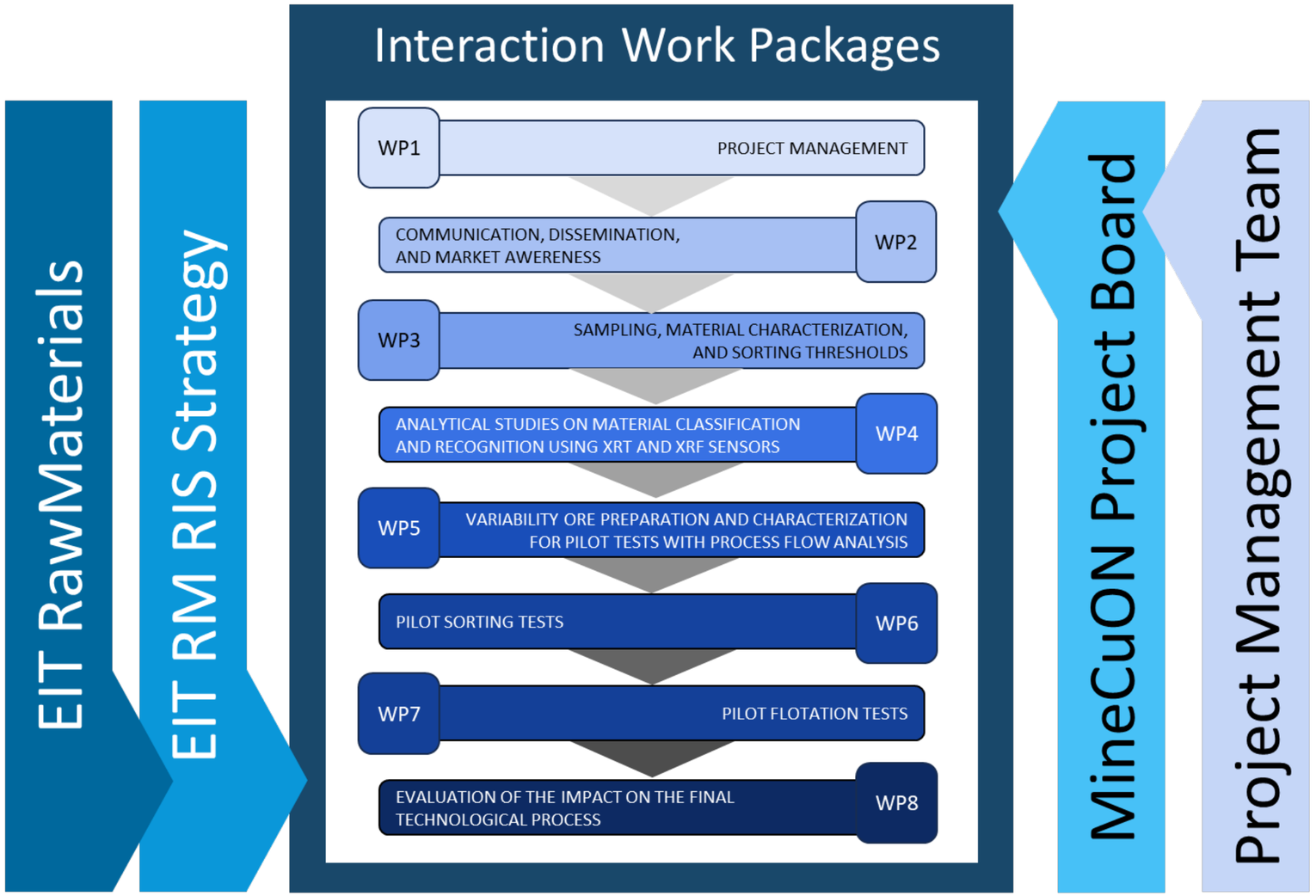
Innovative Industrial Technologies

WP PLAN


EIT RawMaterials
EIT RM RIS Strategy
Interaction Work Packages
WP1
PROJECT MANAGEMENT
COMMUNICATION, DISSEMINATION, AND MARKET AWERENESS
WP2
WP3
SAMPLING, MATERIAL CHARACTERIZATION, AND SORTING THRESHOLDS
ANALYTICAL STUDIES ON MATERIAL CLASSIFICATION AND RECOGNITION USING XRT AND XRF SENSORS
WP4
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VARIABILITY ORE PREPARATION AND CHARACTERIZATION FOR PILOT TESTS WITH PROCESS FLOW ANALYSIS
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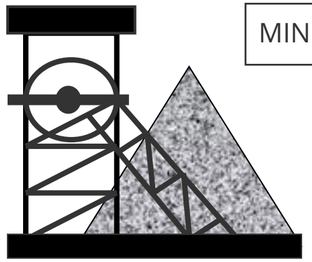
EVALUATION OF THE IMPACT ON THE FINAL TECHNOLOGICAL PROCESS
WP8
MineCuON Project Board
Project Management Team

ORE PROCESSING FLOWSHEET



MINED ORE

Comminution

SCREENING

CRUSHING

Flotation

ROUGHER

SCAVENGER

FINAL TAILS

I^{O} CLEANING

II^{O}-III^{O} CLEANING

I^{o} GRINDING

II^{o} GRINDING

HYDRO-CYCLONES

III^{o} GRINDING

GRAVITY CLASSIFIERS

HYDROCYCLONES

Grinding & classification

GRAVITY THICKENERS

FILTER PRESSES

THERMAL DRYING

Dewatering

FINAL CONCENTRATE

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Sampling, Material Characterization and Sorting Thresholds

Samples preparation and their delivery to the lab:

- sampling and sample preparation
- Standarization of samplings procedures to ensure reproducibility
- logistics of deliveries

Material characterization:

- mineralogy analysis (XRD, SEM)
- chemical assays (ore grade)
- physical properties (partical size distribution, hardness)
- data interpretation for sorting and flotation tests

Definition of sorting thresholds:

- definition of cut-off grades
- estimation of ore properties influence on sorting
- integration sorting tresholds with pre-concentration strategy
- preparation of reference materials for calibration

ANALYTICAL STUDIES ON MATERIAL CLASSIFICATION AND RECOGNITION USING XRT AND XRF SENSORS

The task focuses on the analytical evaluation of ore pre-concentration using advanced X-ray transmission (XRT) and X-ray fluorescence (XRF) technologies. This task involves the development of recognition and classification algorithms, laboratory sorting trials, and in-depth studies on the impact of preconcentration on the flotation proces.

The task aims to optimize sorting performance, define technological limits, and assess the effectiveness of pre-concentration for different ore types. The results will support the integration of sensor-based sorting technologies into industrial applications, ensuring improved efficiency and selectivity

ANALYTICAL STUDIES ON MATERIAL CLASSIFICATION AND RECOGNITION USING XRT AND XRF SENSORS

The objectives of this task are:

- Developing advanced recognition and classification algorithms for XRT and XRF-based ore sorting,
- Conducting laboratory-scale sorting trials to define process stability and technological limits,
- Assessing the impact of ore preconcentration on flotation performance for domestic and international ore samples,
- Supporting the optimization of sensor-based sorting processes through material characterization and process modeling.

The execution of task is structured into key subtasks: algorithm development, sorting process assessment, and laboratory flotation trials for different ore types

VARIABILITY ORE SAMPLES PREPARATION AND CHARACTERIZATION FOR PILOT TESTS WITH PROCESS FLOW ANALYSIS

1. Samples Preparation and Delivery for Pilot Scale Tests

2. Sensors Calibration

- Densimetric analysis of feedstock and simulated sorting products,
- Development of enrichment curves to assess sorting efficiency,
- Preparation of reference samples for sorting sensor calibration,
- Continuous refinement of sensor settings to adapt to ore variability.

3. Possibility of Implementation of Sorting Processes Under Constraints of Existing Technological Schemes

- Evaluation of the rational implementation of sorting processes under current beneficiation constraints,
- Process modeling and scenario analysis for sorting implementation in existing technological schemes,
- Identification of potential bottlenecks and necessary process modifications,
- Development of integration strategies to maximize sorting efficiency while maintaining process stability.

PILOT SORTING TESTS

The objectives of this task are:

- Performing pilot-scale sorting of variability ore samples to validate pre-concentration technology,
- Evaluating sorting efficiency through material balance calculations and chemical analysis,
- Assessing the precision of the sorting process using densimetric studies and enrichment curves,
- Investigating the potential utilization of coarse waste as a mineral aggregate.

The execution of task is structured into three key subtasks: pilot sorting tests, efficiency analysis, and waste utilization assessment.

PILOT FLOTATION TESTS

The task focuses on conducting pilot-scale flotation tests for preconcentrated ores from **Poland, Czech Republic, Norway, Slovakia, Spain**, and **Portugal**. These tests aim to validate the:

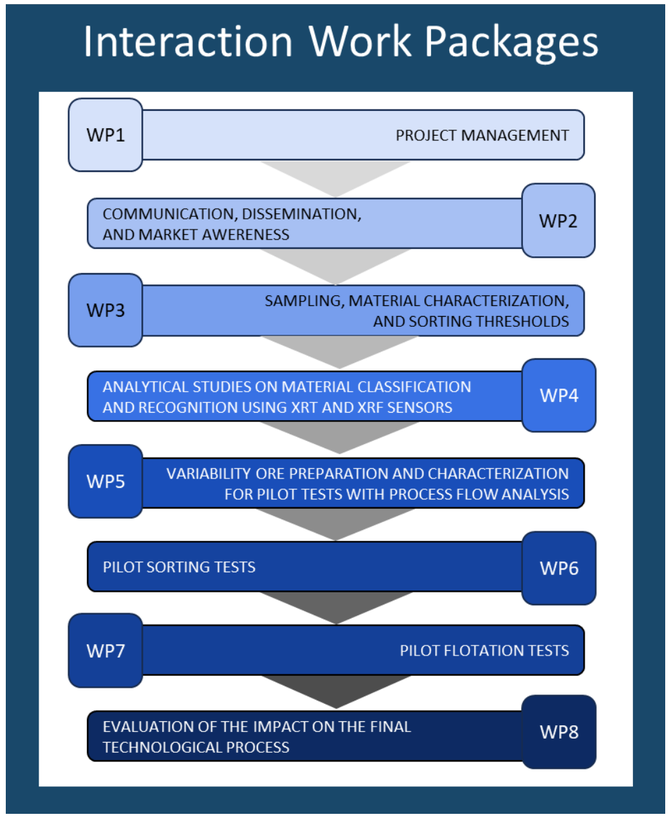
- efficiency of flotation processes on preconcentrated materials,
- assess recovery rates
- refine process parameters for industrial-scale implementation.

The task serves as a critical step in verifying the technological feasibility of pre-concentration, ensuring that flotation performance aligns with expected beneficiation outcomes. The results will support the optimization of flotation circuits and contribute to improving overall metal recovery.

The objectives of this WP are:

- Performing pilot-scale flotation tests on preconcentrated **Polish, Czech, Norwegian, Slovak, Spanish**, and **Portuguese** ores.
- Evaluating quantitative and qualitative flotation balances to assess recovery efficiency.
- Optimizing flotation conditions to maximize concentrate grade and yield.
- Supporting process refinement and industrial scalability of flotation technology.

EVALUATION OF THE IMPACT ON THE FINAL TECHNOLOGICAL PROCESS



- Verification of Compliance with Technological Requirements and Impact on the Final Technological Process
- LCA and Carbon Footprint Analyses

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Recycling of CRM for New High-Frequency Transformer Magnetizable Concrete Cores

Lead Partner: Łukasiewicz-IMN

Partner: MAGMENT GmbH

CoReCo PROJECT

A Circular Economy Revolution in SST Technology: CoReCo Project & Magnetic Composite Innovation

The project's objective is to create a commercial-ready technology for magnetizable concrete (MBC) cores for high-frequency solid-state transformers (SST) that cut core losses by at least 35% compared to silicon steel (20–100 kHz range)

Why is CoReCo a game-changer?

✅ Recovers critical raw materials (nickel and cobalt) from electronic waste, repurposing them into advanced magnetic composites for high-frequency (10–100 kHz) Solid-State Transformers (SSTs).

✅ Delivers transformers that dramatically reduce energy losses, eliminate water cooling needs, and significantly enhance Power Usage Effectiveness (PUE) for data centres.

✅ Demonstrates how circular economy principles can actively cut CO_2 emissions and lower energy costs.

✅ Integrates recycled nanocrystalline metals into sustainable urban energy infrastructure, reshaping future power distribution.

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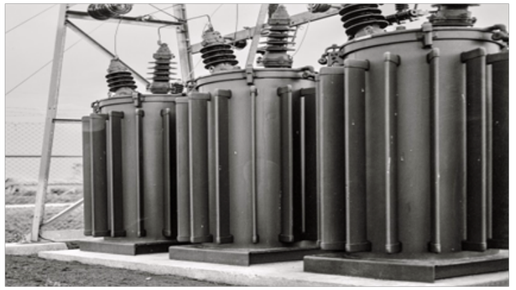
TRADITIONAL POWER TRANSMISSION SHORTCOMINGS

Distribution Transformers are unfit for the energy transition

01	**Supply Chain**	• Transformer lead times > 2 years • Increased demand for data centers, renewables, EVs	
02	**Environment**	• Legacy transformers waste 2.5% of generated power • Fire hazard: burning oil can cause power outages	
03	**Performance**	• No regulation of voltage, frequency or power • Significant maintenance costs and downtime	

The transformers market has experienced significant growth

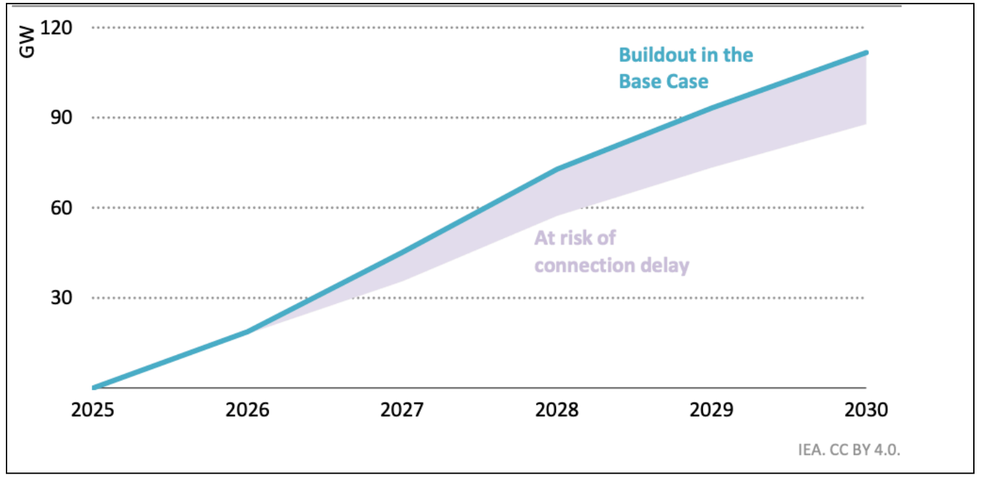
International Energy Agency special report “Energy and AI” (April, 2025)

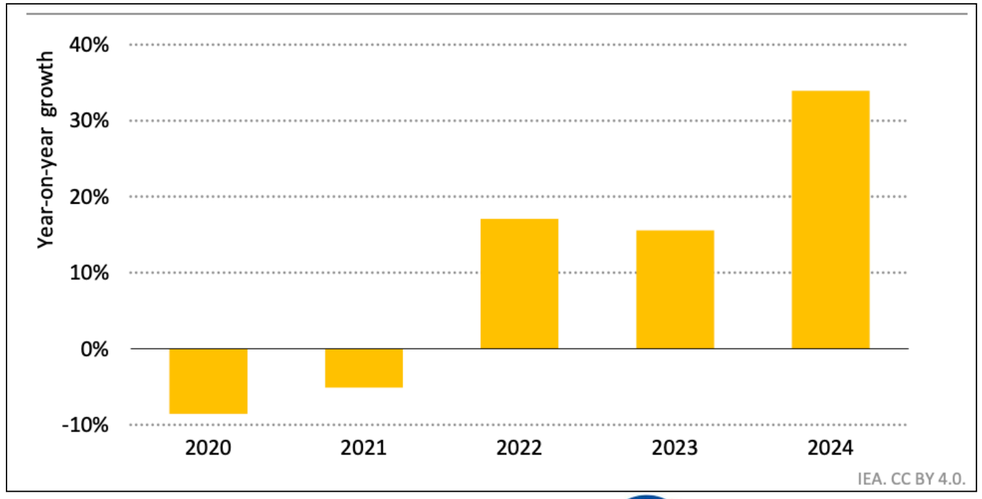
🌐 Data Centers & AI Growth

- 12,000+ data centers globally, 5,500 in USA
- 15% CAGR growth
- 1.5% of global electricity (2024); doubling by 2030

⚡ Electricity Infrastructure Challenges

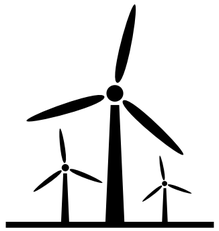
- Strained grids: 20% of planned data center delayed
- Transformer wait times have doubled since 2020
- Backlog 2020–2024 increasing

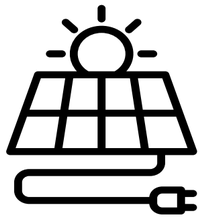


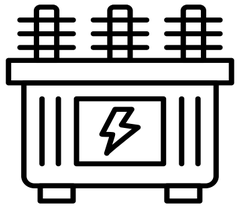


MATERIALS - where are we headed?

Solid-state transformer (SST) with magnetizable concrete





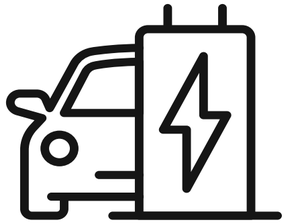


Development of nanocrystalline materials

Manufacturing of amorphous ribbons

Production of magnetizable concrete cores

Application



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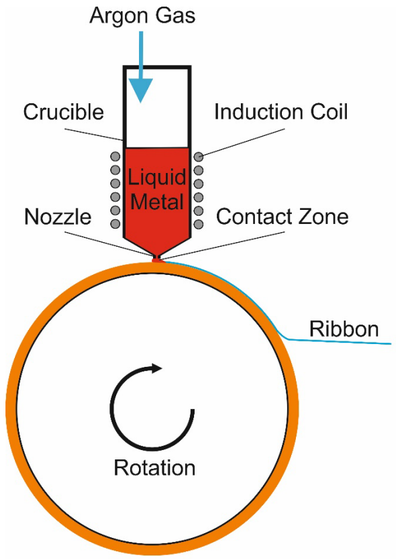
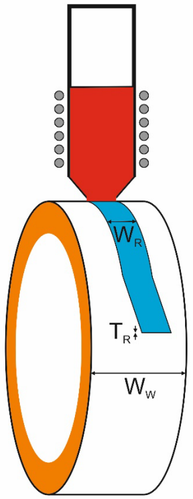
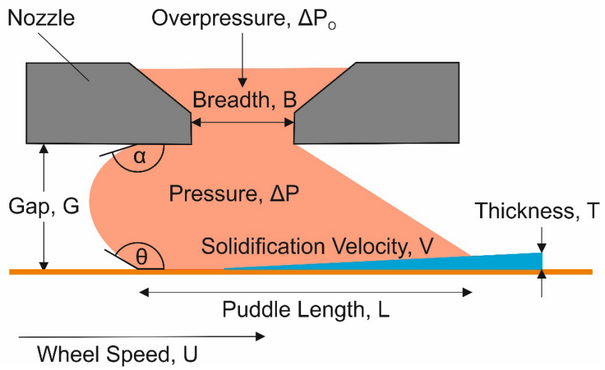
Manufacturing of amorphous ribbons







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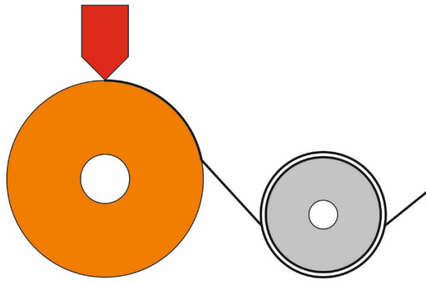
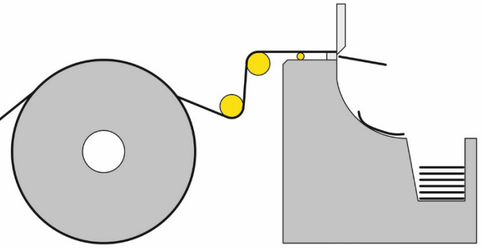
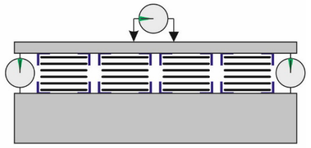
Heat and thermal-magnetic treatment



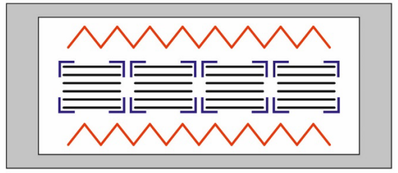
spool drive assembly with multi-strand amorphous tape



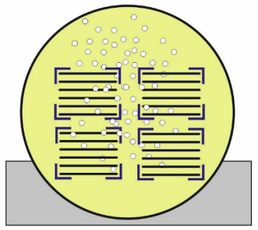
automatic guillotine transverse cutting assembly for tape



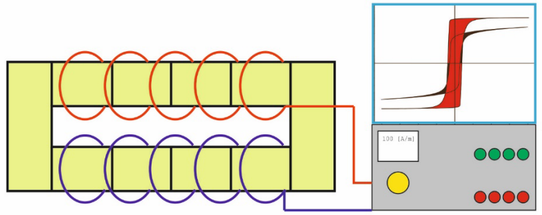
device for repeatable preparation of packets from cut tapes



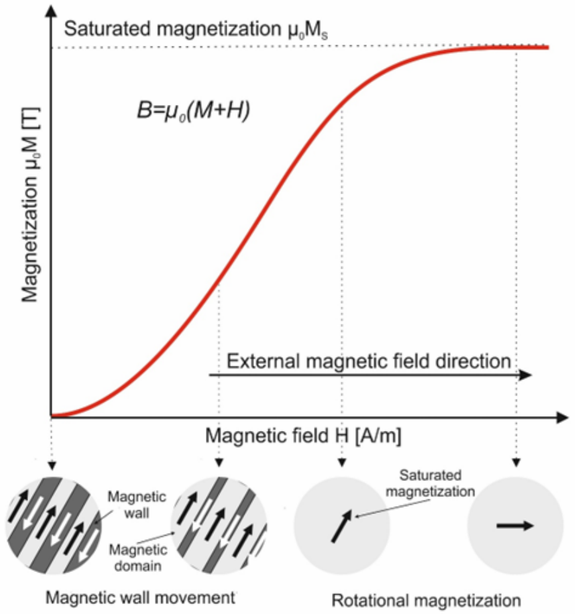
heat treatment and thermomagnetic processing subassembly

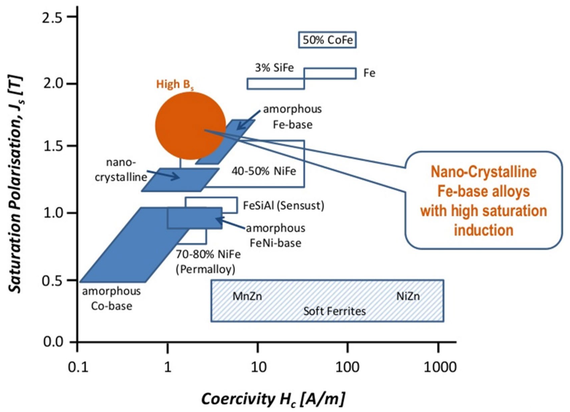


final packet forming subassembly



subassembly for testing magnetic properties





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CoReCo’s HYBRID MAGNETIC COMPOSITE

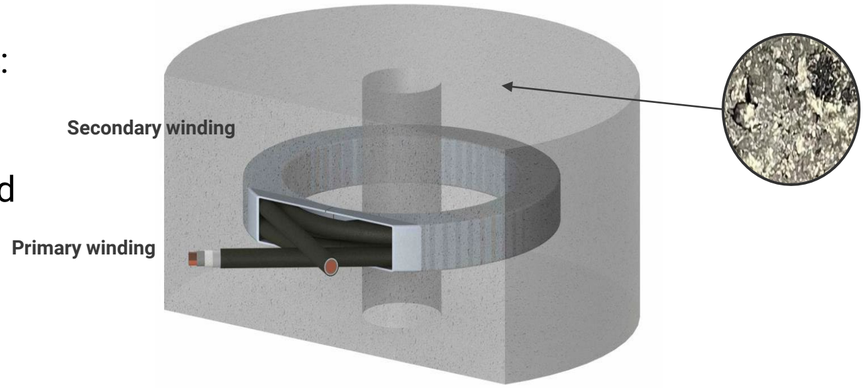
CoReCo brings together three innovations:

Recycling of critical raw materials
The project recovers nickel and cobalt from electronic and industrial waste, converting them into nanocrystalline metal powders, then reintegrating them into SMCs. This closes the loop on CRM usage and bypasses volatile raw-material markets.

Ferrite–nanocrystalline composite aggregates
These magnetically graded mixtures combine high-resistivity ferrite particles and high-flux nanocrystalline grains. CoReCo uses pragmatically optimized interfaces to balance saturation and loss across high-frequency operation.

Concrete embedding
Magment’s patented magnetizable concrete leverages these composite aggregates. Concrete provides:

✅ **Thermal mass and mechanical strength:** Critical for SSTs generating heat at high frequency.
✅ **Scalable manufacturing:** Uses common materials (cement, sand, recycled steel), reducing costs and enabling large cores via molding or casting.
✅ **Shielding and cooling**: Inherent damping and thermal stability enhance PUE, key for data centers, which CoReCo targets.



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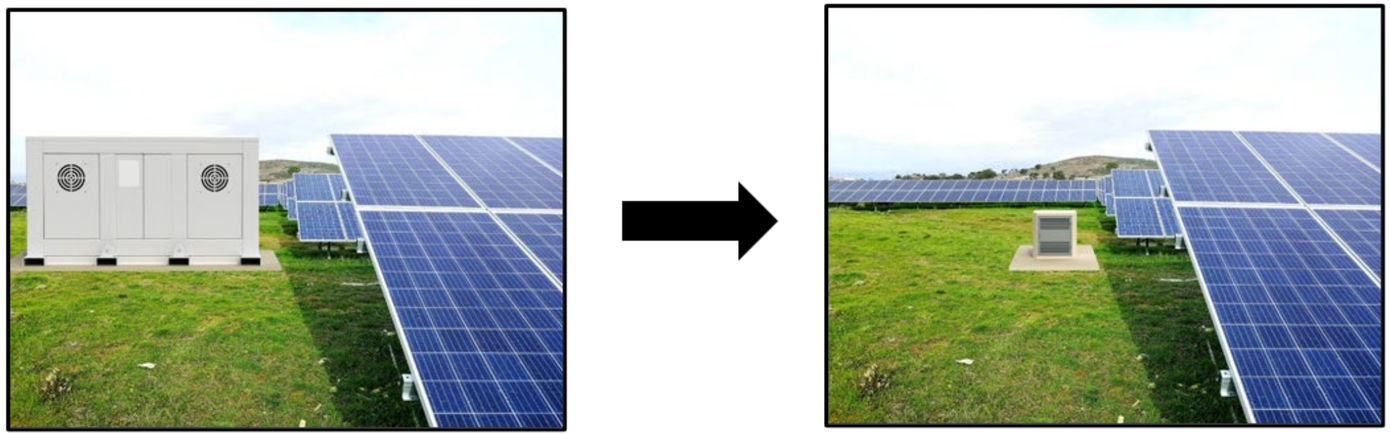
CoReCo’s HYBRID MAGNETIC COMPOSITE

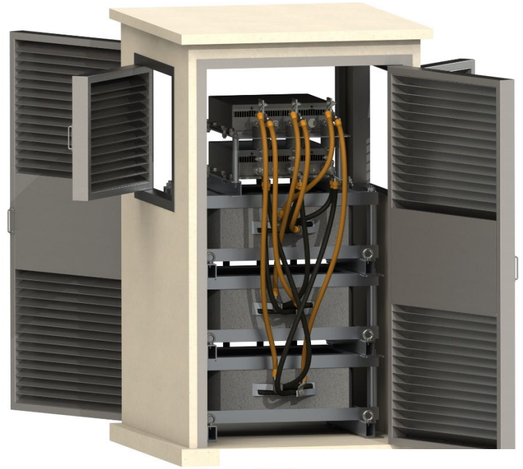
the cheaper, smaller and safer alternative

Solid-state transformer (SST) with magnetizable concrete



- Voltage, frequency & power quality control
- Smart transformer monitoring
- Proprietary converter with < 75% fewer semiconductors
- Easy installation requiring no transformer pad
- SST assembled in concrete enclosure
- Dry transformer with eco-friendly and fire- safe air cooling

SST has the same price as a traditional transformer, but is 100x smaller and 1-2% more efficient



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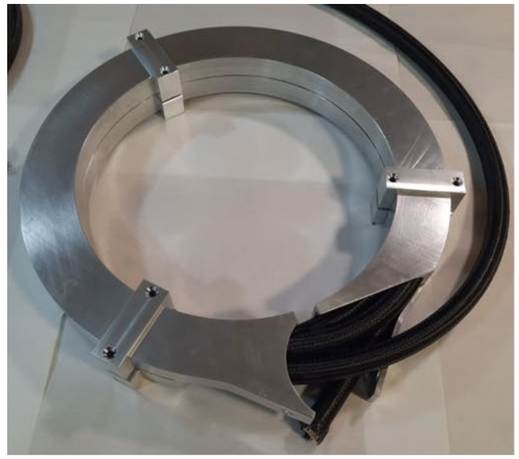
CoReCo’s HYBRID MAGNETIC COMPOSITE

the cheaper, smaller and safer alternative

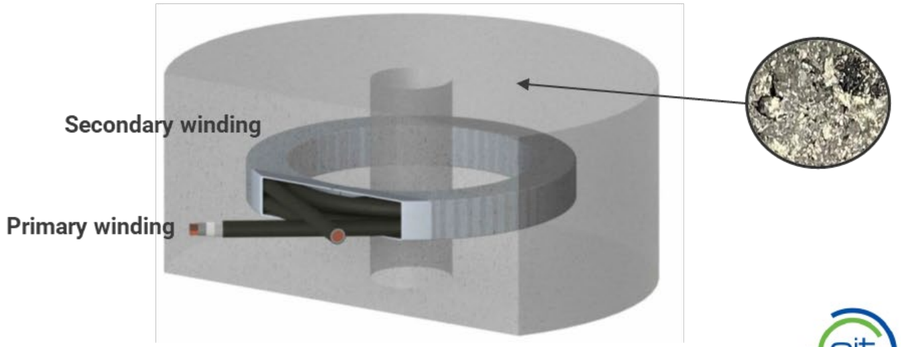
PROPRIETARY TECHNOLOGY FOR MAGNETIZABLE CONCRETE

Mixing cement and recycled magnetic particles can take any form and have many applications

Technical advantages	Strong coupling & low losses for high efficiency	17 patents on material tech and applications
Ecological advantages	Recycled aggregates from scrapped materials	**90%** lower CO_2 vs. conventional magnetics
Economical advantages	Local production and low maintenance costs	Robust durability and environmental resistance



Embedded windings form a coaxial transformer



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APPLICATION - examples

Optimal core properties for SST maximize reduction of size, weight, and cost, as well as overall SST efficiency:

Low core losses, high saturation flux density, high permeability, and temperature stability **FeSiBNbCu-nanocrystalline**, **ferrite,** and **Fe-amorphous** cores are the main alternatives.

DATA CENTRES

SST-based MV supply with facility-level DC distribution

Replacement of conventional AC distribution with facility-level DC distribution reduces losses and improves reliability

OFFSHORE WIND PARKS

SST-based AC boost and isolation through HF transformer

Compact and efficient offshore substations equipped with SST to transport HVDC over long distances

SMART GRID AND EV CHARGING

SST-based configuration for DC Microgrid

Does not require low-voltage DC conversion, resulting in higher efficiency and lower costs

SST-based configuration for bidirectional MV interface

Creates energy hub for efficient energy management, peak load shaving and grid stabilization

Solid State Transformers - application

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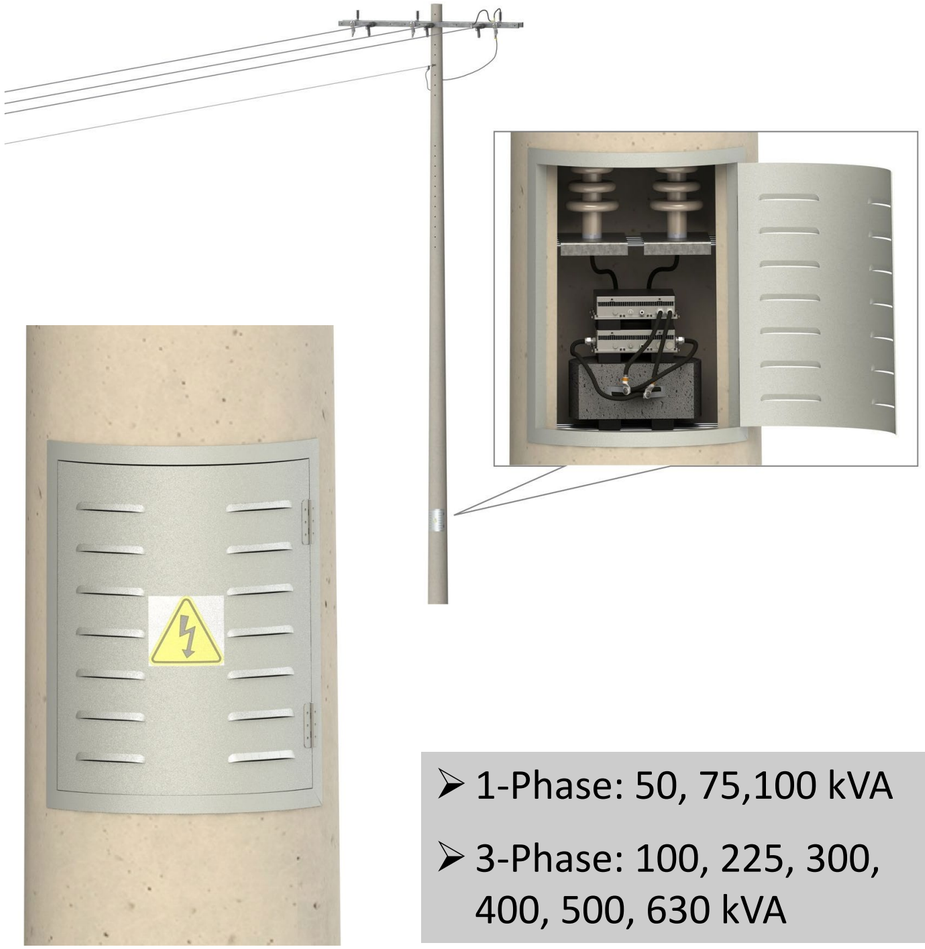
MagPole™- safe and silent distribution transformers

Solid-state transformer (SST) integrated in concrete poles

A transformer weighing approximately 300 kg fell from a height of about 3 meters and struck a male worker (54), who later died. The incident occurred while he was working on a utility pole in Bunkyo Ward, Tokyo.

April 2, 2025



- 1-Phase: 50, 75,100 kVA
- 3-Phase: 100, 225, 300, 400, 500, 630 kVA

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Thank you for your attention.