

Be a magnet in the crowd

LIFELONG LEARNING COURSE

**RARE EARTH PERMANENT
MAGNET VALUE CHAIN**



Supported by



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European Union

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Why this course

Our aim is to educate professionals who work or intend to work in the field of permanent magnets along the whole value chain, including recycling and motor applications: Raw Materials, Technological Magnets, Circular Economy and Electromobility coming together. These specialists are essential to maintain and increase the resilience of the RE supply chain in Europe.

We develop a lifelong learning course with thematic orientation Rare Earth (RE) Magnets and Motors to educate professionals who work or intend to work in the RE industry. We provide a unique opportunity to get a knowledge on the whole permanent magnet value chain, in this way making it possible for the targeted learners to contribute to a more resilient EU industry, that is less dependent on external supplies of strategic raw materials.



Who we are

Our team of experts possesses the knowledge and experience required to provide training on the critical links in the Rare Earth permanent magnet value chain.

We are researchers, engineers, teachers, and business partners from Spain, Greece, and Sweden. KTH Royal Institute of Technology coordinates the activity, while SpinnX AB, a consulting company from Sweden, provides business support.

Our educational approach will help learners understand the details of the REM life cycle, which is essential for adapting to changing market conditions and contributing to the EU's green policy agenda.

The course will cover important aspects of the REM value chain, ensuring that the targeted learners acquire the necessary knowledge.



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How it works

This course starts with the module “Introduction to Magnetism: The Challenges of Rare Earth Magnets”, where you can explore the fundamental concepts of magnetism to better understand the value chain of rare earth magnets. This introductory course is placed on the [FutureLearn platform](#).

After that, thematic modules, each representing a critical link in the REM value chain: Mining, Production, Design, Recycling, Life Cycle Assessment, are introduced.

On the six-week course, you’ll delve into the rare earth magnet value chain to help you prepare for jobs in the industries involved.

The format of the course is blended learning, and it includes both theoretical and practical training to make the learner familiar with the details of the life cycle of Rare Earth Magnets.

The Basic Concepts of Magnetism course duration is 6 weeks, the study time is 2-4 hours per week.

This course is not mandatory but is highly recommended to learners who do not have knowledge in magnetism and magnetic materials.

Are you ready to explore magnetism?



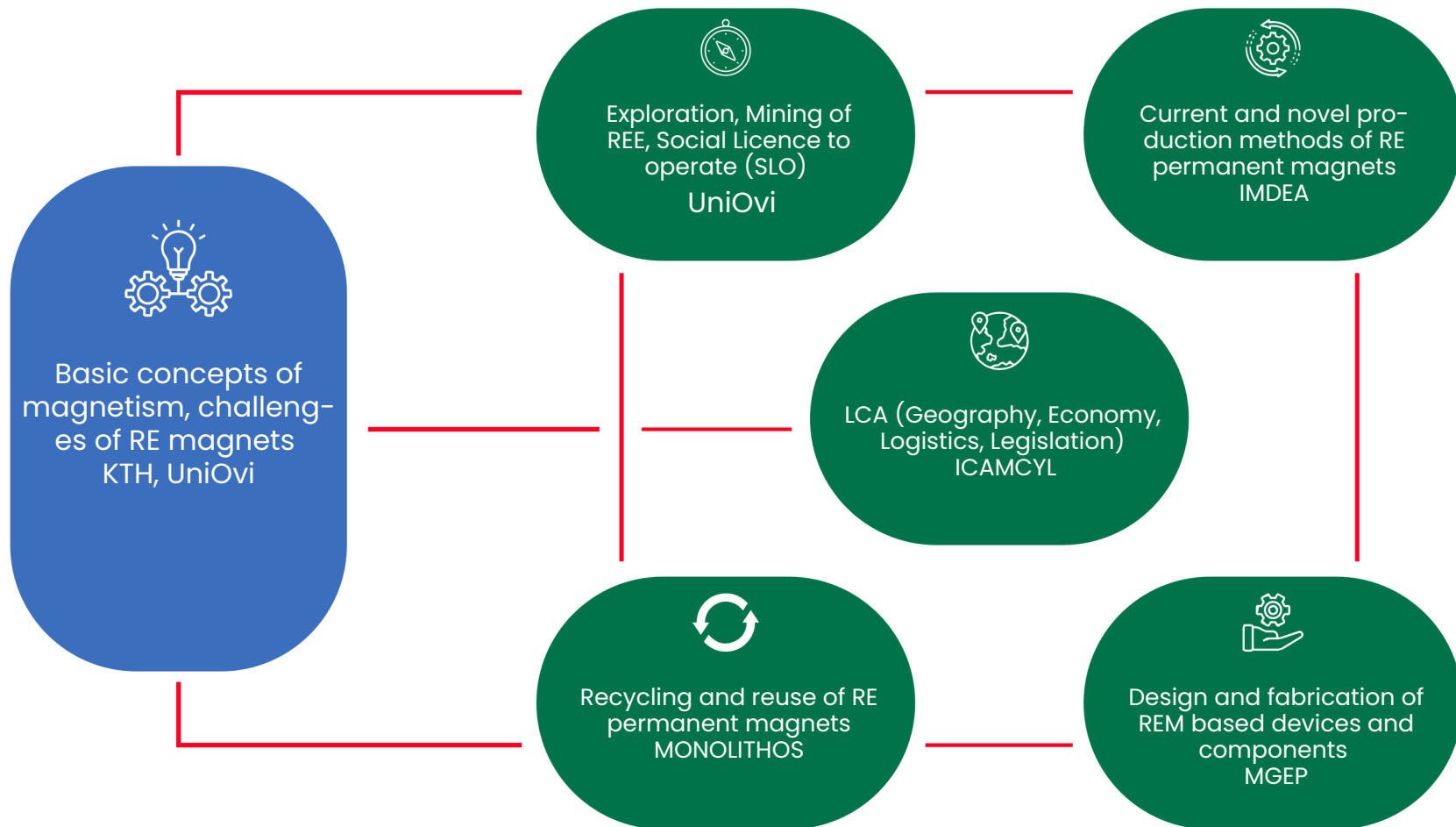
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course program

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We save your time!

Optimal course structure



Basic concepts of magnetism: Challenges of Rare Earth Magnets

The introductory module on magnetism is the basis for better understanding the full course content. Learners get familiar with terminology, units, definitions related to the physics of permanent magnets. Topics included:

- Origin of magnetism. Magnetic moments of atoms and units
- The Periodic Table: 3d and 4f elements
- Types of magnetic materials: Behaviour of materials in magnetic field. Paramagnets, diamagnets, ferromagnets. Experimental techniques to measure magnetic properties
- Hysteresis loops: Saturation, remanence magnetisation, energy product (BH max). Units
- Crystal structure vs magnetism. Symmetry, magnetic anisotropy, applications of magnets
- 3d vs 4f Metals for industrial magnets. Advantages and drawbacks
- Introduction to the critical links of Rare Earth Magnet Value Chain

EDUCATORS

Prof. Dr. Pavel A. Korzhavy, Professor in Materials Technology, Materials Science and Engineering KTH Royal Institute of Technology, Stockholm, Sweden

Dr. Inna L. Soroka, Docent in Materials Chemistry, CEO SpinnX AB, Sweden

Dr. Roberto Iglesias, Associate professor, Department of Physics, University of Oviedo, Spain

Dr. Cristina Echevarria-Bonet, Assistant professor, Department of Physics, University of Oviedo.

Exploration and Mining of RE ELEMENTS

LESSON 1

Rare Earth Element Exploration (REE).

The main aspects of REE ores exploration are introduced, along with cases of study from both inside and outside the EU.

LESSON 2

Rare Earth Element Mining (Part I):

A review of mining and metallurgical aspects of REE ores is presented, with a special focus on best available technologies (BAT).

LESSON 3

Rare Earth Element Mining (Part II)

- Mineral Processing Techniques
- Extractive Metallurgy techniques

LESSON 4

Safety and Environmental Aspects of REE Mining.

Quick review of Society & Environment issues in REE ores mining and metallurgy.

LESSON 5

Social Licence to Operate (SLO) in mining of Rare Earth elements.

A practical activity focused on the SLO issues found in REE mining projects at the EU, including a self-critical-analysis exercise.

LESSON 6

Socio-technical toolbox: A practical and ludic activity designed to suggest responsible actions with the aim to change how mining projects are approached, including socio-technical aspects.

EDUCATORS

Dr. Roberto Iglesias, Associate professor, Department of Physics, University of Oviedo, Spain

Dr. Begoña Fernández-Pérez, University professor, Department of Materials and Metallurgical Science, University of Oviedo.

Dr. Álvaro Rubio-Ordóñez, Associate professor, Department of Geology, University of Oviedo.

Dr. Juan María Menéndez-Aguado, Professor, Department of Mining Exploitation and Prospecting, University of Oviedo.

Current and novel production methods of **REM**

LESSON 1

Fully dense REPM production techniques (Part I): The main aspects of the production chain and characteristics of fully dense magnets obtained through sintering routes.

LESSON 2

Fully dense REPM production techniques (Part II)

- Production of hot-formed Nd-Fe-B magnets
- Production of Sm-Co magnets: Sintering

LESSON 3

Bonded REPM production techniques (Part I): Here, we will show the production line and characteristics of bonded magnets.

LESSON 4

Bonded REPM production techniques (Part II)

- Bonded Sm-Fe-N magnets

LESSON 5

Permanent magnet coating: Corrosion protection of REM

LESSON 6

Advanced REPM fabrication techniques (Part I): This activity will cover novel fabrication techniques, mainly focused on metal injection molding (MIM) and additive manufacturing technologies.

LESSON 7

Advanced REPM fabrication techniques (Part II)

- Additive manufacturing

EDUCATORS

Dr. Andres Martin-Cid, Researcher, Group of Permanent Magnets and Applications, IMDEA Nanociencia, Spain

Dr. Ester Palmero, Researcher, Group of Permanent Magnets and Applications, IMDEA Nanociencia, Spain

Design and fabrication of magnet-based devices and components

LESSON 1

Introduction to electric motors: Main aspects of EVs motors and wind turbine generators.

LESSON 2

Main design equations for permanent magnet electric motors: Open circuit \boxtimes Basic equations that help to understand how main design parameters affect the performance of the motor.

LESSON 3

Magnetic materials in the electric motor applications

- Soft magnetic materials
- Hard magnets

LESSON 4

Permanent magnet performance calculation: Here we demonstrate how to calculate parameters characterizing performance of permanent magnets.

LESSON 5

Demagnetization problems in electric motors

- Demagnetization curve
- Calculation of demagnetization curve parameters

LESSON 6

Practical issues on size calculation: Demonstration of practical issues for calculating and optimizing machine dimensions.

EDUCATORS

Dr. Gaizka Ugalde Rosillo, private University professor, Group of drive systems applied to traction and the generation of electric energy, Mondragon University

Recycling and reuse of REM

LESSON 1

Introduction to Rare Earth permanent magnets (Part I)

- Rare-earth Elements, REEs
- Why are REEs defined as Critical Raw Materials

LESSON 2

Introduction to Rare Earth permanent magnets (Part II)

- Main applications of REEs
- Permanent Magnets
- Why are permanent magnets important

LESSON 3

Recycling of REE's from permanent magnets (Part I)

- Why is recycling important
- State-of-the-art of the REE Recovery Methods
- Pyrometallurgy

LESSON 4

Recycling of REEs from permanent magnets (Part II)

- Hydrometallurgy
- Challenges

LESSON 5

Social Licence to Operate (SLO) in mining of Rare Earth elements.

A practical activity focused on the SLO issues found in REE mining projects at the EU, including a self-critical-analysis exercise.

LESSON 6

Hydrometallurgical recovery of REEs from permanent magnets based on MONOLITHOS' recycling method

EDUCATORS

Dr. Anastasia Maria Moschovi, Head of Research & Innovation, MONOLITHOS Catalysts & Recycling Ltd, Greece

Dr. Olga Thoda, Chemical Engineer, Principal Investigator of Waste Valorization R&I division MONOLITHOS Catalysts & Recycling Ltd. Greece

Life Cycle Analysis (LCA)

LESSON 1

Rare Earth Element Exploration (REE).

The main aspects of REE ores exploration are introduced, along with cases of study from both inside and outside the EU.

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Rare Earth Element Mining (Part I):

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LESSON 3

Safety and Environmental Aspects of REE Mining.

Quick review of Society & Environment issues in REE ores mining and metallurgy.

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Social Licence to Operate (SLO) in mining of Rare Earth elements.

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EDUCATORS

Dr. J. Vanessa Nava, Project manager, ICAMCyL Foundation, Spain

MSc. Vasiliki Alexiou, MSc in Materials Science, project manager, MONOLITHOS Catalysts & Recycling Ltd. Greece

MSc. Marta Alonso, Engineer & Project manager, ICAMCyL Foundation, Spain



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Who can apply

The targeted learners are those who work or intend to work in the RE value chain industry as engineers, consultants, managers, technicians, and other actors of the R&D sector, as well as innovators who plan to launch their own start-ups.



**Industrial
Companies
(Giants & SMEs)**



**Consulting
Companies**



**Unemployment
Agencies**



Individuals

Certificate



By enrolling in this course, you are not only expanding your knowledge and skills, but you are also investing in your future. Upon successful completion of the course, you will be awarded a personalized certificate signed by the coordinators of the course. This certificate is not only a testament to your hard work and dedication, but it is also a valuable addition to your resume and professional portfolio.

Don't miss out on this opportunity to distinguish yourself and take your career to the next level.

Beyond the course

After finishing the course, you may apply your knowledge in permanent magnets to look for the exciting opportunities to work in the EU Rare Earths value chain industry as engineers, consultants, managers, technicians, and other actors of the R&D sector, as well as innovators who plan to launch their own start-ups, and this way to contribute to the EU Green Transition.





Lifelong Learning
Course 2024