Circularity of Lithium in Portuguese economy

Webinar/ Palestra LNEG ONLINE
5 julho 2023

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Resource Economics Unit
O webinar vai ser gravado e a apresentação será disponibilizada no website do LNEG

Por favor desligar os microfones
Colocar perguntas via chat / bate-papo do Zoom ou oralmente (após conclusão da apresentação)

Os slides estão em inglês mas a apresentação é feita em Português

CIRCULARIDADE DO LÍTIO NA ECONOMIA PORTUGUESA
Webinar / Palestra LNEG
5 julho 2023
LNEG’s RESOURCE ECONOMICS UNITS (UER)

The unit is **crosscutting the Energy and Geology areas** of LNEG.

Develops I&D&D activities and decision-support for both public policy-makers and the private sector on energy and geology resource economics, towards carbon neutrality and sustainable resource exploitation and use.

UER applies techno-economic & social analytical approaches in the following I&D domains:

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<td><strong>Sustainable energy systems</strong>&lt;br&gt;(decarbonization, systems modelling, climate change impacts)</td>
<td><strong>Resource use for energy production and consumption</strong></td>
<td><strong>Classification of geological deposits in a global economy</strong></td>
<td><strong>Economic and social impact of the energy transition</strong></td>
<td><strong>Circular economy, including design of products, services, systems and business models</strong></td>
<td><strong>Circular and sustainable public procurement</strong></td>
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[https://www.lneg.pt/unit/unidade-de-economia-de-recursos/](https://www.lneg.pt/unit/unidade-de-economia-de-recursos/)
Outline

I. Background
   I. Energy Transition and the Critical and Strategic Raw Materials
   II. Overview of the Critical Raw Materials Act – key aspects

II. Lithium in the Portuguese economy
   I. Methodology of eMaPriCE project and analysis of the main results
   II. Lithium value chain and flows in Portugal
   III. Limitations of the analysis

III. Circularity strategies for products with Lithium
   I. Overview and analysis of database of Examples of CE strategies
   II. New rules for batteries sold in the EU

IV. Final remarks
What are Critical Raw Materials? Why is it important?

- Critical Raw Materials are at the beginning of many industrial supply chains for many everyday life and high-tech products, their **global demand is increasing** due to a progressive shift to a digital and green economy which is intended to be accelerated.
- Critical Raw Materials **supply chains are vulnerable**
- Great **dependency of EU on imports** of Critical Raw Materials from a **number of third countries**
- Some of the Raw materials may also be of **high Strategic** importance.
## EU list of Critical and Strategic Raw Materials

<table>
<thead>
<tr>
<th>Antimony (Sb)</th>
<th>Indium (In)</th>
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<tbody>
<tr>
<td>Arsenic (As)</td>
<td>Lithium (Li) ★</td>
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<tr>
<td>Baryte (BaSO4 mineral)</td>
<td>Magnesium (Mg)</td>
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<td>Bauxite (Al &amp; Ga)</td>
<td>Manganese (Mn)</td>
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<td>Beryllium (Be)</td>
<td>Natural Graphite (C)</td>
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<td>Bismuth (Bi)</td>
<td><em>Nickel – battery grade (Ni)</em></td>
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<td>Boron (BOx compounds of BO3 or BO4)</td>
<td>Natural Rubber</td>
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<td>Cobalt (Co)</td>
<td>Niobium (Nb)</td>
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<td>Coking Coal (CCO)</td>
<td>Phosphate rock</td>
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<td>Copper (Cu)</td>
<td>Phosphorus (P)</td>
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<td>Feldspar (Fds)</td>
<td>Platinum Group Metals (PGM)</td>
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<td>Fluorspar (CaF2)</td>
<td>Scandium (Sc)</td>
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<td>Gallium (Ga)</td>
<td>Silicon Metal (Si)</td>
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<td>Germanium (Ge)</td>
<td>Strontium (Sr)</td>
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<td>Hafnium (Hf)</td>
<td>Tantalum (Ta)</td>
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<tr>
<td>Helium (He)</td>
<td>Titanium metal (Ti)</td>
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<td>Heavy Rare Earth Elements (HREE)</td>
<td>Tungsten (W)</td>
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<td>Light Rare Earth Elements (LREE)</td>
<td>Vanadium (V)</td>
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**industrial and construction minerals**
**iron metals and iron alloys**
**precious metals**
**rare earth elements**
**organic materials and others**

**New in the list 2023**
*in italic strategic raw materials*
**Removed from the list 2023**

34 raw materials

Bauxite still in discussion to be included as SRM

Proposal of new regulation
COM/2023/160 final – Annex II
Critical Raw Materials Act
Promoting a more sustainable and circular raw materials economy

"This Act will bring us closer to our climate ambitions. It will significantly improve the refining, processing and recycling of critical raw materials here in Europe. Raw materials are vital for manufacturing key technologies for our twin transition – like wind power generation, hydrogen storage or batteries. And we’re strengthening our cooperation with reliable trading partners globally to reduce the EU’s current dependencies on just one or a few countries. It’s in our mutual interest to ramp up production in a sustainable manner and at the same time ensure the highest level of diversification of supply chains for our European businesses.”

President Ursula von der Leyen - 15/03/2023

BENCHMARKS FOR EU SCRM

- **EU EXTRACTION**: at least 10% of EU annual consumption for extraction
- **EU PROCESSING**: at least 40% of EU annual consumption for processing
- **EU RECYCLING**: at least 15% of EU annual consumption for recycling
- **EXTERNAL SOURCES**: Not more than 65% of EU annual consumption of each SRM at any relevant stage of processing from a single third country

Promoting a more sustainable and circular raw materials economy

DOI:10.2775/613159
Identifying **Strategic Projects** in the EU and third countries that intend to become active in the extraction, processing or recycling, to benefit from **streamlined and predictable permitting procedures** in the Union and **coordination of support to improve access to finance**.

**Simplifying permitting procedures** for SCRM projects to speed them up, achieving **for strategic projects** permitting timeframes of just 24 months for extraction and 12 months for processing and recycling.

Developing **national exploitation programmes for geological resources** to boost knowledge on EU CRM resources (Art 18 CRMA).

**Monitoring CRM supply chains and stress testing for some large companies**;

**Coordinating stocks of strategic raw materials between Member States**;

**Creating conglomerates of collective MPC buyers**.

The role of the **European Geological Surveys** should include a generalized national prospecting program which should include the following points:

- **Mineral mapping**;
- **Geochemistry campaigns**;
- **Geophysical prospecting campaigns, data processing, for example, predictability maps**;
- **Placing data on publicly accessible sites free of charge**;
- **Use the UNFC classification**;
- **Seek to cooperate with neighboring countries**.

The role of **R&D** is key to ensure the **effective roll-out of projects** and to **facilitate technological scale-up**, particularly in the field of circularity. 3 years to have national programs with measures aimed at **increasing the technological maturity of CRM recycling technologies** and **promoting material efficiency** and **material substitution**.
I. Background

II. Lithium in the Portuguese economy

III. Circularity strategies for products with Lithium

IV. Final remarks
Li and other Critical Raw Materials flows in the Portuguese economy

for 21 representative products circa 311,000 t CRM+ were in Portugal in 2019

61 kt magnesium, 51 kt natural rubber, 23 kt borate, 14 kt cobalt, 2 kt lithium + 1.5 kt rare earths & platinum group metals

Identified circular economy options to avoid CRM becoming waste

https://emaprice.lneg.pt/
**Lithium value chain in Portugal**

*In Portugal, the extraction of pegmatite with lithium used in the ceramic industry occurs in several places. In 2019, 59 912t of pegmatite with lithium were produced (values varied between 17 120 and 76 818t of pegmatite with lithium in period 2015-'22). This corresponds to ~599 t of Li metal content. PT is the 7th largest producer of Li (included in pegmatites) in the world and the country with the largest reserves in the EU. Resources are estimated at ~1033 kt LCE, with new extraction locations planned.

**Li accelerates the hardening process of aluminous cement (niche application)**
9 regions with lithium potential in Portugal

the concentration and amount of Li is heterogeneous in the different occurrences

How much lithium resources in Portugal

Resource
601.5 kt LCE
($\text{Li}_2\text{CO}_3$ equiv.)

8 concessions with activity
1998-2017 (red)
Estimated Resources 22.7Mt lithium pegmatite (~1.07% Li$_2$O) ↔ 113kt Li metal ↔ 243kt Li$_2$O
Estimated Reserves 10.7Mt pegmatite (~1.06% Li$_2$O) ↔ 53kt Li metal ↔ 113kt Li$_2$O

Resource
1032.7 kt LCE
($\text{Li}_2\text{CO}_3$ equiv.)

4 concessions with most recent resource estimate Li (¥)
→ Estimated Resources 48.4Mt pegmatite (~0.86% Li$_2$O) ↔ 194 kt Li metal ↔ 419kt Li$_2$O

Conversion factor of Li metal for Li$_2$CO$_3$ equivalent : 5.323

Caption: JALF: José Aldeia Lagoa & Filho, Lda.; SMC: Sociedade Mineira Carolinos, Lda./ Concessions with mining activity 1998-2017 / Concessions with exploration rights contracts / Concessions with contract for prospecting and research / (*) Concessions with most recent resource estimate | (*)
No Li concession in 2020. There are still +78 requests for concessions (9 exploração, 1 experimental exploration, 68 prospecting and search).

Value chain of products considered for quantification

Pre-consumption

National Production

Stock of finished product used including repair and maintenance

Exports of products

End of Life management of finished product

Pos-consumption

industrial waste
1. textile
2. ceramics
3. fertilizers P
4. automobile
5. cork
6. EEE

Exports of products

pre-consumption waste:
1. RU Resíduos Urbanos indiferenciados
2. REEE Resíduos de EEE
3. Resíduos de Embalagens
4. Resíduos de Embalagens produtos agrícolas
5. VFV veículos em fim de vida
6. Resíduos de pilhas e baterias
7. Pneus usados
8. RCD Resíduos de Construção e Demolição
9. Circuitos voluntários de recolha (rolhas, vestuário...)
Some unitary coefficients

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<tr>
<th>g/m²</th>
<th>2.11 Sb</th>
<th>30.78 BaSO₄</th>
<th>42.58 BOx</th>
<th>15.22 Co</th>
<th>0.5 LREE</th>
<th>0.5 LREE-Pr</th>
<th>5.00 V</th>
<th>3.00 Li</th>
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<td>g/equipment</td>
<td>6.30 Co</td>
<td>0.06 LREE</td>
<td>0.01 LREE-Pr</td>
<td>0.05 LREE-Nd</td>
<td>0.011 MGP</td>
<td>0.011 MGP-Pd</td>
<td>0.97 Li</td>
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<td>g/equipment*</td>
<td>0.07 BaSOx</td>
<td>0.06 Be</td>
<td>0.03 Bi</td>
<td>36.41 Co</td>
<td>1.19 LREE</td>
<td>0.0003 LREE-La</td>
<td>0.0005 LREE-Pr</td>
<td>0.006 LREE-Pr</td>
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<td>g/vehicle EV</td>
<td>7,250.44 Borr</td>
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<td>g/vehicle IC</td>
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<td>0.03 Be</td>
<td>8.83 Bi</td>
<td>25.07 BOx</td>
<td>6,444.80 Borr</td>
<td>8.89 Co</td>
<td>23.51 LREE</td>
<td>0.371 LREE-La</td>
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Li coefficients expressed in metal content

*Avrg for Laptops, Notebooks & Desktop

Substantial uncertainty in these values.

It was not possible to find coefficients for all the identified CRM+
Lithium flows in Portugal 2019

- Extraction of feldspars with Li
- Placement in the market
- Exports of feldspars with Li

Li within imported products:
- Vehícules: 207.63 t
- Ceramics: 24.44 t
- EEE: 6.30 t

Li within products manufactured in Portugal:
- Ceramics: 62.60 t
- Vehícules: 4.54 t
- EEE: 1.04 t

Li within products in “stock” in the economy:
- Ceramics: 1,495.76 t
- Vehícules: 193.23 t
- EEE: 6.30 t

Li in waste produced in 2019:
- Vehícules: 3.03 t
- EEE: 0.97 t
- Ceramics: 85.86 t
- Tiles in CDW: 17.48 t
- ELV*: 1.26 t
- WEEE*: ? t

Li tonnage is expressed in metal content

Lithium flows in Portugal 2019

* and ... flow not represented at scale
? Information not available

CDW: construction and demolition waste
ELV: End of life vehicles
WEEE: Waste from electrical and electronic equipment

Low to very high uncertainty on estimate

Li lithium
6.96

3
Limitation of the analysis

- Values for current situation as of 2019 and is based on selected products per sector
- Lack of knowledge was found in general among sectorial associations, technological centres and companies about the accurate presence of CRM in their products / sectors value chains and data made available was very limited
- High uncertainty about unitary coefficients used to quantify the flows (does not consider different models of the studied products);
- High uncertainty about the values estimated in “stock” overall, but particularly for ceramics and textile sectors
- Uncertainty about the presence of CRM in the waste streams in the analysed sectors given that the reporting structure is currently oriented towards other environmental areas priorities (such as dangerous substances)
- Focus in representative products per sector, so overall quantities must be underestimated

Despite all above, values presented are considered an important and reliable starting point to further estimates.
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### Circular economy strategies identified

- **Product category**
- **Presence of CRM+**
- **Quantified CRM+**
- **Description of strategy**
- **Saving potential of CRM+**
- **Product design intervention**
- **Technological maturity, in 3 levels**
- **Environmental Impact**
- **Impact on employment**
- **Changes to the system: new actors**
- **Changes to the system: new activities**
- **Observations**
- **Bibliographic sources**


CRM+: total of ~140 examples of strategies

<table>
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<tr>
<th>Brand</th>
<th>Strategy</th>
<th>Description</th>
<th>CRM+ potential of strategies</th>
<th>CRM+ quantified</th>
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<td>Monitoring and scheduling</td>
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## Classification of circular strategies considered

<table>
<thead>
<tr>
<th>Extração e transformação</th>
<th>Fabricação</th>
<th>Utilização</th>
<th>Pós-utilização</th>
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</thead>
<tbody>
<tr>
<td>Aumentar a produção/extração</td>
<td>Substituir a MPC+ por não crítica</td>
<td>Reparação, manutenção, atualização</td>
<td>Reutilização</td>
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<tr>
<td>A</td>
<td>S1</td>
<td>R5</td>
<td>R4</td>
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<tr>
<td>Maximizar a eficiência dos processos</td>
<td>Substituir a MPC+ virgem por secundária</td>
<td>Utilização partilhada do produto</td>
<td>Restauro e atualização</td>
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<tr>
<td>R2</td>
<td>S2</td>
<td>R1</td>
<td>R6</td>
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<tr>
<td>Valorização de subprodutos</td>
<td>Maximizar a eficiência dos processos</td>
<td>Compra de desempenho</td>
<td>Remanufatura</td>
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<tr>
<td>V</td>
<td>R2</td>
<td>R1</td>
<td>R7</td>
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<tr>
<td>Simbiose industrial</td>
<td>Reciclagem interna</td>
<td>Valorização de subprodutos</td>
<td>Reciclagem</td>
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<td>R2</td>
<td>R2</td>
<td>V</td>
<td>R8</td>
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<td>Aumentar a durabilidade (intrinsic) dos produtos</td>
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<td>R3</td>
<td></td>
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<tr>
<td>Valorização de subprodutos</td>
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</tr>
<tr>
<td>V</td>
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**A:** aumentar  
**S1/S2:** substituir  
**R1:** repensar | **R2:** reduzir | **R3:** retardar | **R4:** reutilizar | **R5:** reparar | **R6:** recondicionar | **R7:** remanufatrar | **R8:** reciclar

---

**Inovação tecnológica**

**Inovação / design de produto**

**Inovação / modelo de negócio**

**Mudança socioinstitucional**
Number of circular strategies collected applicable to products that contain Li (Total 57), per type of strategy

- Valorização de subprodutos
- Reciclagem
- Restauro e atualização
- Reutilização
- Utilização partilhada do produto
- Reparação, manutenção, atualização
- Aumentar a durabilidade (intrínseca) dos produtos
- Simbiose industrial
- Reciclagem interna
- Maximizar a eficiência dos processos
- Substituir a MPC virgem por MPC secundária
- Substituir a MPC por MP não-critica

Automóveis elétricos
- Baterias de íons de Li
Computadores
Telemóveis
Ladrilhos
Louça sanitária
Telhas vidradas
Vestuário

https://emaprice.lneg.pt/
Number of circular strategies collected applicable to products that contain Li (Total 57), per tech. maturity

https://emaprice.lneg.pt/
Example of circular strategies collected applicable to products that contain Li, per lifecycle stage

1. **Maximizar a eficiência dos processos**
   - Padronização das conexões mecânicas das células individuais das baterias (parafusos, adesivos, soldas, etc).
   - Reduz-se a quantidade de adesivo e cabos. Facilita a desmontagem e a posterior reciclagem.
   - Solução “blade battery” apresentada pelo fabricante chinês de baterias BYD [MERCADO]

2. **Reparações**
   - de módulos e baterias em 3 fases:
     1) teste e diagnóstico;
     2) se há reparação são substituídas as peças;
     3) se não, são enviados para remanufatura ou reciclagem;
     4) retorno ao VE.
   - Renoeos Rede Europeia de recolha, reutilização e reciclagem de baterias de VE e híbridos [MERCADO]

3. **Reutilização**
   - das baterias de ião de lítio no final do seu ciclo de vida automóvel para armazenamento de energia estacionária [MERCADO]

4. **Reutilização & Reciclagem**
   - associados a tecnologia hidrometalurgica. Devido a ocorrer a baixas temperaturas esta tecnologia poderá permitir também a separação de grafite e de compostos de lítio, para além do que já sucede com metais de cobre, alumínio, níquel e cobalto. O lítio é passível de ser reprocessado e ser depois usado no fabrico de novas baterias. [CONCEITO]
new rules for the design, production and waste management of all types of batteries sold in the EU

Key measures foreseen in the regulation; agreement approved by Parliament on 14 June 2023:

- A **compulsory carbon footprint declaration and label** for electric vehicles (EV) batteries, light means of transport (LMT) batteries (e.g. for electric scooters and bikes), and rechargeable industrial batteries with a capacity above 2kWh;

- **Designing portable batteries in appliances** in such a way that consumers can themselves easily remove and replace them;

- A **digital battery passport** for LMT batteries, industrial batteries with a capacity above 2 kWh, and EV batteries;

- A **due diligence policy** for all economic operators, except for SMEs;

- **Stricter waste collection targets**: for portable batteries - 45% by 2023, 63% by 2027 and 73% by 2030; for LMT batteries - 51% by 2028 and 61% by 2031;

- **Minimum levels of materials recovered from waste batteries**: lithium - 50% by 2027 and 80% by 2031; cobalt, copper, lead and nickel - 90% by 2027 and 95% by 2031;

- **Minimum levels of recycled content** from manufacturing and consumer waste **for use in new batteries**: in eight years: 16% for cobalt, 85% for lead, **6% for lithium** and 6% for nickel; in 13 years: 26% for cobalt, 85% for lead, **12% for lithium** and 15% for nickel.

Outline

I. Background

II. Lithium in the Portuguese economy

III. Circularity strategies for products with Lithium

IV. Final remarks
Final remarks

Lithium is a Critical and Strategic Raw Material for EU and its value chain should be strengthened.

Lithium circulates in many products in the Portuguese economy particularly in sectors of the ceramics, textile, automobile, EEE, chemistry and mineral extraction.

Our estimates quantified in 2019 2kt of lithium contained in 6 representative products in the economy (1 ceramics, 3 automobile, 2 EEE): in stock, produced nationally, imports, exports and in the amount of waste produced.

The values estimated have huge uncertainties and many limitations were found to conduct this study, but this is a reliable good starting point to further quantification work.

Circular economy strategies opportunities are key, need to be developed and help to soften the expected increased the dependency of primary lithium resources.
LNEG Lithium and other Critical Raw Materials

Project

Matérias-Primas Críticas em Portugal
Quais são as Matérias-Primas Críticas (MPC)?

- A Corrida é uma Matéria-Prima Estratégica para Portugal?
- De onde vêm as MPCs?
- Quantos MPCs existem em produtos selecionados?
- Como podemos evitar que os MPCs se transformem em resíduos?

https://emaprice.lneg.pt/

Maps

MAP OF CRITICAL RAW MATERIALS DEPOSITS IN PORTUGAL MAINLAND AND BY DISTRICT

Policy briefs

CRITICAL RAW MATERIALS DEPOSITS IN PORTUGAL MAINLAND
COMPETITIVENESS OF PORTUGUESE LITHIUM
LITHIUM ION BATTERIES MATERIALS, COMPONENTES, INTEGRATION AND CHALLENGES

Webinars

Lithium - European Sourcing and Skills
Palestra “Uso de materiais para a descarbonização do sistema energético português”
Palestra “Modelos de negócio para a economia circular”

https://youtube.be/v2mgNmbmyFTY

https://emaprice.lneg.pt/
Thank you for your attention!

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BUILDING A STRONGER AND CLEANER FUTURE

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