



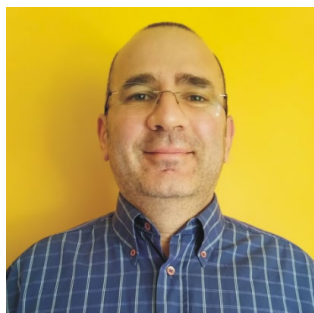
START

NEWSLETTER

RECOVER-REFORM-REUSE

for a Sustainable Future

WELCOME FROM COORDINATOR



Filipe Neves (LNEG)

Dear members of the **START** community

Welcome to the first issue of the biannual Newsletter of the **START** project 'RECOVER-REFORM-REUSE for a Sustainable Future'. The objective of the Newsletter is not only to provide a summary of the activities and results of the project but also to address a variety of topics related to these activities, such as those related

with raw materials sustainability, sustainable energy ecosystems and business-innovation opportunities. The Newsletter is then organized in different sections, some of them will be repeated in every issue. For this first issue we have five sections: a first section dedicated to a general presentation of the **START** project where we invite you to meet our robot **STARTY** that, through a comic story, will introduce the project in an readily comprehensible way; a second section called '**START CHRONICLES**', with news on the project's activities; a third section of '**TECHNICAL PILLS**', where you will have the opportunity to read two short technical documents, one dedicated to Minerals sustainability and another on what are Thermoelectric materials; the fourth section is the '**CONSORTIUM TOUR**', in which we will introduce each of the **START** partners, and in this issue you will have the opportunity to learn more about LNEG and SINTEF; the fifth section is the '**CONTACTS**' area, where you can find how to get in touch with us and how to follow our social media accounts.

Let's now take a look to some important details of the **START** project. **START**, which stands for 'Sustainable Energy Harvesting Systems Based on Innovative Mine Waste Recycling', is an Innovation project, co-funded by the European Union and its Horizon Europe programme, with a budget of around 9.2 M€ and a duration of 48 months (started in June 2022). Our main objective is to build an innovation ecosystem in the EU related to the development of sustainable and economically viable tellurium-free thermoelectric waste heat harvesting systems. This will be achieved by producing advanced sulphide p-type semiconductor materials that will incorporate discarded mining waste sulphides (mainly consisting of the tetrahedrite-tennantite mineral series – see in the Technical Pills in this issue for definition), as valuable secondary raw materials and present in many European mine wastes, to replace the tellurium-based p-type materials.

So, what were the specific needs that triggered this project and the creation of this Consortium? Allow me to highlight 5 aspects:

1. The demand for a sustainable use of mine tailings to reduce the environmental footprint of mines and their waste piles and to increase the economic potential of such sites.
2. The necessity of an efficient use of the EU resources and security of raw materials by converting discarded waste secondary sulphide materials into useful and valuable secondary raw materials.
3. The need for recovering waste heat losses from industrial processes through thermoelectrics to promote a sustainable development for a decarbonised society.
4. The exigency of producing tellurium-free thermoelectric devices and based on alternative sustainable elements available in Europe.
5. The need to move towards a greener society and economy through eco-innovation and more sustainable economic models to promote energy security and encourage energy citizenship.

A multidisciplinary Consortium was then formed, comprising 15 partners from 10 EU member states and 1 associated country, including 6 research organizations with strong background and knowledge on geology, materials science, and renewable energies, 7 SME's companies that guarantee the entire supply chain, from production, exploitation, and ecological footprint assessment, and 2 non-profit international associations with a consolidated network of partners and stakeholders.

In this context, and towards a more sustainable and resilient EU by building innovative value chains from raw materials to sustainable products, **START** proposes a unique technological solution based on the transformation of mining waste into materials for waste heat recovery, thus contributing to an efficient use of resources while promoting the use of green energy harvesting through thermoelectrics, in line with the strategies outlined in the European Green Deal and in the EU Action Plans on Critical Raw Materials and on Circular Economy.

As you can see, we are going to cover and address very interesting topics that are closely linked to today's societal challenges. The **START** Consortium thanks you in advance for your interest in the work that we will be developing, and of which you will also be an important part.

I hope you enjoy reading our first Newsletter and feel free to share it with anyone you think might be equally interested in these topics. Also, we are available for any further information, so please don't hesitate to contact us if you have any question.



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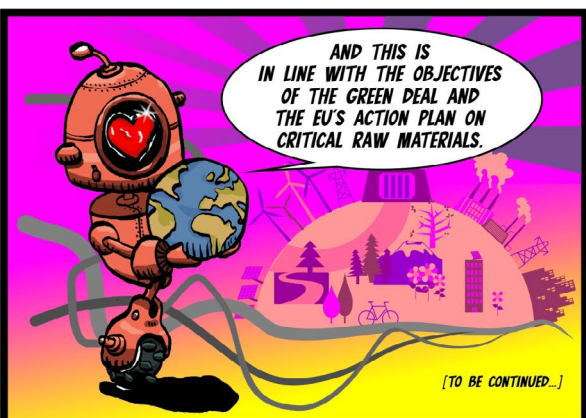
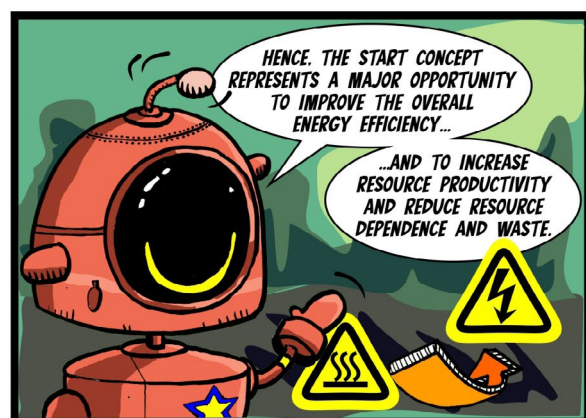
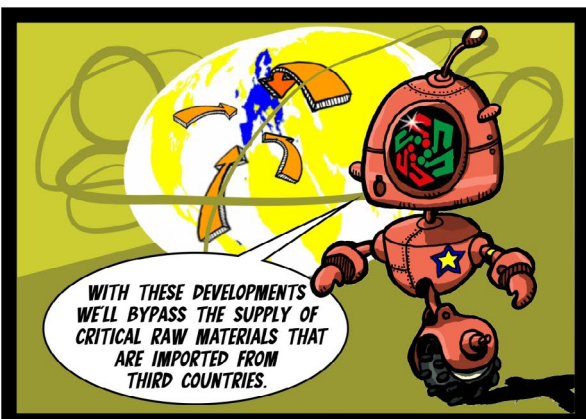
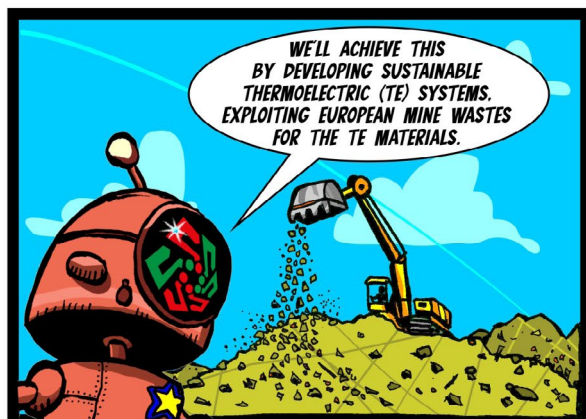
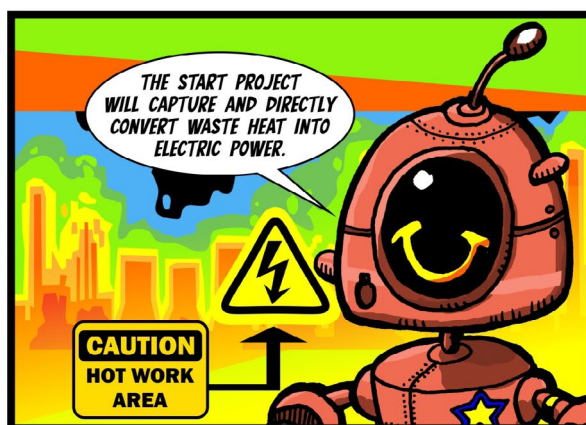
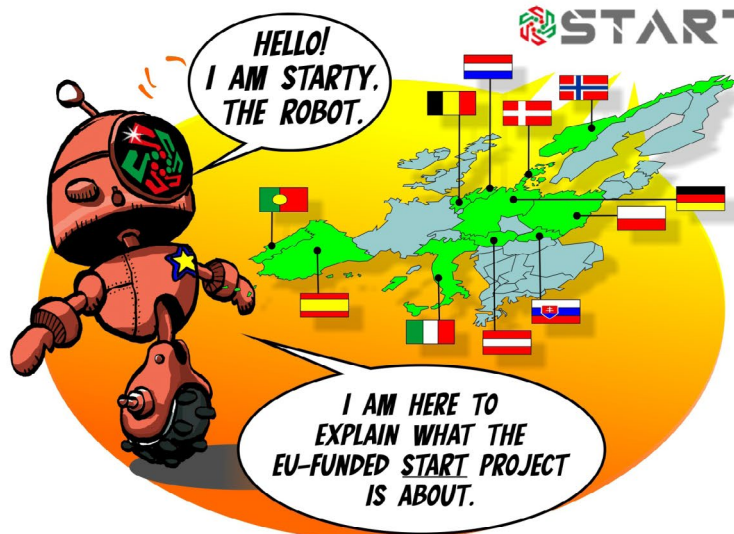
STARTY EXPLAINS START

EVERYTHING ABOUT START PROJECT
START COMICS
WITH STARTY, THE ROBOT



 **START**

 **START**



START CHRONICLES: START BEGINS AND PLANS BIG THINGS

LNEG HOSTED THE KICK-OFF MEETING

The official beginning of the **START** project occurred on 1st June 2022. On 20th-21st June, the Kick-Off Meeting was held in LNEG (**START**'s coordinator) premises in Lisbon, Portugal.

The meeting saw a large participation: 47 delegates from all 15 consortium partners were present, with the addition, on Monday, of the EU Project Officer Dr Marko Cacanowski, who could follow a thorough presentation about the project and its foreseen activities, results, and impact.

Following the main meeting, the first meetings of the General Assembly and of the Executive Committee also took place, and on 21st June a more operative meeting on the upcoming activities concluded the event. Some important decisions were taken and the activities of the first months were outlined.

The participants also enjoyed a consortium dinner on Monday night, that helped in making acquaintance with the other partners.

Here is a picture of the group that met in Lisbon, the first of a series of project General Assemblies!



*Figure 1: Participants at the **START** Kick-off meeting in Lisbon*

WORKPACKAGE 2: INITIAL WORK IN AUSTRIA, PORTUGAL AND SPAIN

The technical activities started during the summer months. In particular, we will be reporting here on Work Package 2, that is dedicated to 'Selection of mine waste sites; physical minerals separation and concentration'. The WP2 activity of the first months was linked to the Austrian cluster and to the Iberic cluster of partners.

In Austria, after literature research, two mine sites were selected (Nöckelberg and Schwaz) and a first sampling campaign of the two sites took place between August and September 2022, **Figure 2**. Samples have been prepared to be analysed for whole rock geochemistry, mineralogy and ore mineralogy.



Figure 2: Images taken in the mine wastes in Nöckelberg and Schwaz, in Austria

In Spain, the fieldwork was started in mid-September, in the Northwest, in the Asturoccidental Leonesa and the Asturian zones of the Iberian Massif. The provisional results suggest that the tailings with the greatest interest are those of the Segunda Cobriza mine, in Riello (León, **Figure 3**). There was also a visit to the La Estrella mine near Guadalajara, where interesting samples have been collected (see **Figure 4**).

In Portugal, a massive/stockwork sulphide mineralization sampling (700 kg of complex sulphide ore rich in tetrahedrite-tennantite) from the lower part of the Corvo (from the Neves-Corvo mine) ore bodies has been achieved with the support of the Lundin Mining Company (**Figure 5**). Sulphide samples are being analysed via mineralogical and metallogenetic studies.



Figure 3: Sampling at the Segunda Cobriza mine (Riello, Spain)



Figure 4: Sampling at the La Estrella mine (Guadalajara, Spain)



Figure 5: Sampling at the Neves-Corvo mine (Alentejo, Portugal)

START JOINS SEVERAL EVENTS IN EUROPE AND SOUTH AMERICA

Despite the fact that the start of the activities happened in June, However, the consortium is keen on disseminating about the project's concept and preliminary activities. Clearly, in this initial phase every dissemination is just to raise the awareness about the project and the topics linked to it, like recovering waste heat, thermoelectric materials and devices, remining mine wastes to reduce materials dependence from third countries.

During the last weeks, many were already the events where **START** featured, one way or another, in Europe but also outside of Europe! Here is a short report for each of them.

1st Scientific-Technical Conference of the Geological and Mining Institute of Spain – National Center, Madrid (Spain), 12th-13th July 2022



E. Boixereu i Vila of IGME-CSIC presented the project at this event, that was hosted in the IGME headquarters in Tres Cantos, Madrid, Spain, in mid-July. This was done via a poster on show.

The proceedings of the event are available (<https://digital.csic.es/handle/10261/281251> and www.zenodo.org/record/7092555#.Y2O5R-TMKHs, page 100).

CEPAL Regional Event, Miraflores (Peru), 1st-4th August 2022



The ASGMI Mining Environmental Liabilities Expert Group Chair, F Guzman, participated on the event organized by CEPAL (Comisión Económica para América Latina, or Economic Commission for Latin America, one of five regional commissions of the UN, based in Santiago de Chile – www.cepal.org/en/about) and named 'Challenges for sustainable management of Mining Environmental Liabilities (MELs)'.

The event took place in Miraflores, Peru from 1st-4th August 2022 (www.cepal.org/es/eventos/evento-regional-desafios-la-gestion-sostenible-pasivos-ambientales-mineros, in Spanish).

In his presentation 'Gestión sostenible de los Pasivos Ambientales Mineros: Enfoque en Iberoamérica', held on 1st August, F. Guzman showed a few slides about the **START** Project (general description and objectives) in which experts of the Group are going to participate as experts in sampling methodology.

Perumin 2022, Arequipa (Peru), 26th-30th September 2022



Perumin (www.perumin.com/perumin35/public/) is one the largest and most relevant mining conventions in Latin America (+60.000 participants, +1,400 stands and 29,000 m²). Its 2022 edition took place on 26th-30th September at the Cerro Juli Convention Center, located in the city of Arequipa (Peru).

Under the umbrella of the EC stand of the Mineral Development Network Platform and thanks to the link to the EU project 'EU-Latin America Partnership on Raw Materials' (www.mineralplatform.eu/about/the-platform/background), **START** was selected as relevant EU project and was promoted at the stand with a specifically generated banner. It was a key event for the promotion of **START** thanks to the enormous audience and being under the umbrella of the EC stand reinforced the project appeal.

START JOINS SEVERAL EVENTS IN EUROPE AND SOUTH AMERICA (Continued)

International Workshop in Geochemistry, Medellin (Colombia), 19th-23rd September 2022



The hybrid Workshop 'Geochemical Information for Society' (www.asgmi.org/taller-informacion-geoquimica-para-la-sociedad-19-23-septiembre-medellin/) organized by ASGMI and the Colombian Geological Service was held on 19th-23rd September 2022.

The objectives of the workshop were to present the manual of procedures and methodologies for taking and preparing geochemical samples, prepared by the ASGMI Group of Experts in Geochemistry -GECEOQ-, to have an overview of the state of the art of geochemistry in Ibero-American countries and learn about the experiences of other Geochemistry Groups, such as those of IUGS, UNESCO and EuroGeoSurveys.

The **START** Project was briefly introduced by G. Olivenza (ASGMI) when talking about expert groups and projects.

World PM2022, Lyon (France), 9th-13th October 2022



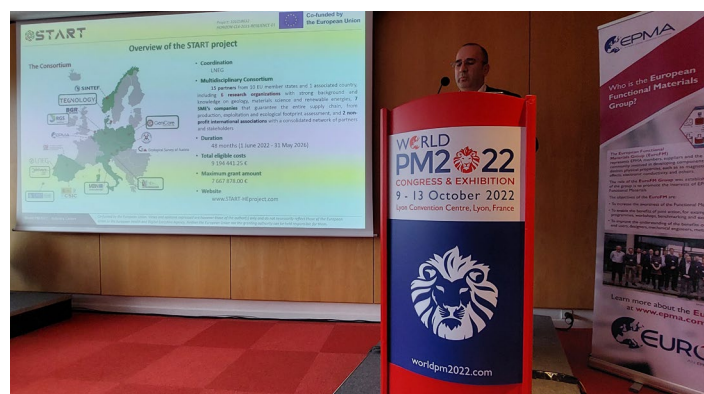
World PM 2022 (www.worldpm2022.com) is a world event on Powder Metallurgy organized by EPMA: in fact, every 6 years the European Powder Metallurgy Association organizes the world congress, including both a congress and an exhibition. The event was hosted at the Congress Centre in Lyon (France), 9th-13th October: about 1100 participants both from industry and academia took part in the event, a significant figure given the fact the two previous editions (European congresses) had to be run online because of the pandemic, the last physical edition being the event Euro PM2019 in Maastricht (NL).

EPMA prepared a 3m x 3m booth for the project that was decorated with posters, roller banners, leaflets, a set of significant samples in a showcase with explicative labels, and a screen with a rolling video presenting the project for the whole duration of the exhibition. EPMA personnel covered the exhibition time as much as possible.



The coordinator Filipe Neves of LNEG was invited to give two presentations:

- Industry Corner: 30' presentation slot in the Exhibition area. Title: 'Sustainable Energy Harvesting Systems Based on Innovative Mine Waste Recycling' Speaker F. Neves. Tuesday 11th October 2022, 13:15-13:45.
- EuroFM Sectoral Group Meeting: Title 'The **START** project'. F. Neves was invited to present during the open meeting of the EPMA Sectoral Group on Functional Materials on Tuesday 11th October 2022, 17:00-18:30.



START JOINS SEVERAL EVENTS IN EUROPE AND SOUTH AMERICA (Continued)

The Technical Managers of EPMA, B. Vicenzi and K. Boz, mentioned **START** in all their presentations during the so-called Sectoral Group meetings (6 meetings and presentations overall).

Two other consortium companies were exhibiting in the event: Genicore and MBN.

The agenda is too large to be reported here but can be found at the following address: www.worldpdm2022.com/technical-programme/. At page 69, an ad about **START** has been included in the technical guide.

As PM is one of the key technologies for **START**, participation was useful to raise the awareness in the PM community about these materials and application, and to start a networking activity for the project.

EU-Latin America RM Convention, and EU-Latin America policy dialogue on the identification of strategic and critical Raw Materials resources, Santiago de Chile, 2nd-4th November 2022



The 2022 EU-Latin America Convention on Raw Materials (www.mineralplatform.eu/events/eu-latin-america-convention-raw-materials-2022) took place on 3rd-4th November in Santiago, Chile and bringing together the mineral raw materials value chain community, including policymakers, industry, the private sector, and research and innovation actors, from the EU and Latin America under the following overarching theme: Mineral Raw Materials for the Clean Energy Transition. The Convention included a high-level (political) session on day 1, and panel sessions on days 1 and 2. On Friday 4th November, during the Panel session 'Downstream raw materials for the energy transition – refining, battery manufacturing & recycling', D. de Oliveira (LNEG) presented with the title '**START** project' the details of our project.

In connection with this convention, the 'EU-Latin America policy dialogue on the identification of strategic and critical Raw Materials resources' meeting took place (2nd-3rd November). This activity brings together

Geological Surveys from EU and Latin America together with key national and international organisations. The dialogue focused on the analysis of strategic and critical raw materials necessary for the clean energy and digital transition. The result of this dialogue will be a roadmap for the elaboration of the Critical and Strategic Raw Materials map in Latin America together with the Communication and Dissemination Strategy. The coordinator of the Mining Liabilities Expert Group, F. Guzman, participated in this physical meeting with a presentation of the group activities and also of the **START** project.



Raw Materials Week, Brussels (Belgium), 14th-18th November 2022



The seventh edition of the 'Raw Materials Week' took place from 14th-18th November 2022 as physical and hybrid, gathering a wide range of stakeholders discussing policies and initiatives in the field of raw materials. The programme included the ninth annual High-level Conference of the European Innovation Partnership (EIP) on raw materials and several complementary events on Critical Raw Materials, Trends in innovation and Skills for raw materials, EU-Ukraine Strategic Partnership on Raw Materials and batteries, EU Horizon technology success stories, EU-Canada Partnership, UNECE Resource management.

Some members of the consortium took part, with a good turnout in terms of networking, (200-300 attendees were present daily) and the introductory video and a poster of the project were shown on screen in the venue.

START JOINS SEVERAL EVENTS IN EUROPE AND SOUTH AMERICA (Continued)

Extraordinary General Assembly of ASGMI, Barcelona (Spain), 14th-18th November 2022



On 14th-18th November, the II Extraordinary General Assembly of ASGMI was held in Barcelona (Spain). Besides the Board of Directors meeting, an International Workshop was held on the topic 'The Role of Geological Surveys in the territorial planning and management', featuring the participation of the ASGMI Geological Surveys associated but also the participation of international organizations such as the EuroGeoSurveys, Geological Survey of Canada and United States, and the Organization of

Africans Geological Surveys. One of the presentations in the event, The Annual Report of Activities of the ASGMI Expert Groups, mentioned project **START** and showed the promotional video of the project.

Future events

START will surely take part in more events in the upcoming months. In particular, we are looking forward to the GENERA 2023 (international Energy and Environment Fair), that will take place in Madrid in February 2023.

We are also planning to run a free webinar, also around February 2023. The date, title and content have not been planned yet, so please check regularly for information on our website and social media, or even better, subscribe to our mailing list so that you will not miss any detail!

TECHNICAL PILLS

Some useful documents that cover topics that are linked to our project! We start with a document on raw materials issues in the EU and one on thermoelectric materials.

CRITICAL MINERALS AND RAW MATERIALS SUSTAINABILITY IN THE EU

Europe has the intention of becoming the world's first climate-neutral continent by 2050, meaning the implementation of the 'European Green Deal' by the European Commission (EC). Mineral resources are crucial to achieve this (green) transition.

Future projections indicate that resource demands could double between 2010 and 2030, mostly driven by demand in developing countries (European Commission, 2016) but also by green energy technologies, by the call for higher level of resource autonomy lately boosted by the energy price shock due to the Russian war against the Ukraine and the related embargo. The principal question is whether supply to meet these demands is adequate. Access to sustainable resources is a key for the EU's resilience in relation to raw materials. Achieving the much needed resources' security requires several actions to diversify supply from both primary and secondary sources, reduce the dependencies and to improve resource efficiency and circularity, including sustainable product design.

Mineral raw materials are crucial to the European economy. Non-energy mineral raw materials are linked to all industries in different key supply chains; technological progress relies on access to a growing number of raw materials.

Since 2011, the EU Commission has been concerned with the supply risk of these raw materials and has published triennial regular lists of Critical Raw Materials (CRM). The first list was published in 2011¹ with 14 materials, the

second in 2014², the third in 2017³ and the latest in 2020⁴ which now includes 30 CRM.

The two main parameters for determining criticality are economic importance (EI) and supply risk (SR) and are used to determine the criticality of the material for the EU. Critical Raw Materials are established on the basis of the raw materials which reach or exceed the thresholds for both parameters⁵. For the EU, CRM are those which display a high risk of supply shortage in the next ten years, and which are economically and strategically important for specific value chains. The mineral supply risk is linked to the concentration of production in a few non-European countries (e.g., USA (beryllium, helium), Brazil (niobium), DRC [cobalt], Rwanda [tantalum], South Africa [iridium, platinum, rhodium, ruthenium], Russia [palladium] and China (all CRM) (European Commission, 2018), and the low political-economic stability of some of the suppliers. This risk is compounded by low substitutability and low recycling rates¹.

The definition of a continuously updated list of CRM by the European Commission led to the first CRM Map of Europe in 2016. Following this, several countries have been surveying, preparing, and evaluating their mineral occurrences to create a resources/deposits database and, therefore, to create a CRM map of their own. With this purpose, LNEG created in 2021 the first Critical Raw Materials Deposit Map in Europe⁶.

A brief reference should be made to tellurium given its current relevance and weight in the production of thermoelectric materials. Tellurium is predominantly used in the production of cadmium telluride (CdTe) for thin-film solar cells. Another important end use is for the production of telluride-based materials (BiTe and PbTe), which are used in thermoelectric devices for both cooling and energy generation. About 30% of its global consumption by end use is for the production of thermoelectric materials⁷. Although not currently considered a CRM, tellurium is a relatively scarce element, with a terrestrial abundance of ca. 1 ppb and, at the same time, Europe is heavily dependent on imports, as China represents more than 60% of its production⁷. More than 90% of tellurium has been produced from anode slimes collected from electrolytic copper refining, and the remainder was derived from skimmings at lead refineries and from flue dusts and gases generated during the smelting of bismuth, copper, and lead-zinc ores. This fact represents a major drawback for the telluride-based thermoelectric technology, hampering its large-scale adoption in Europe.

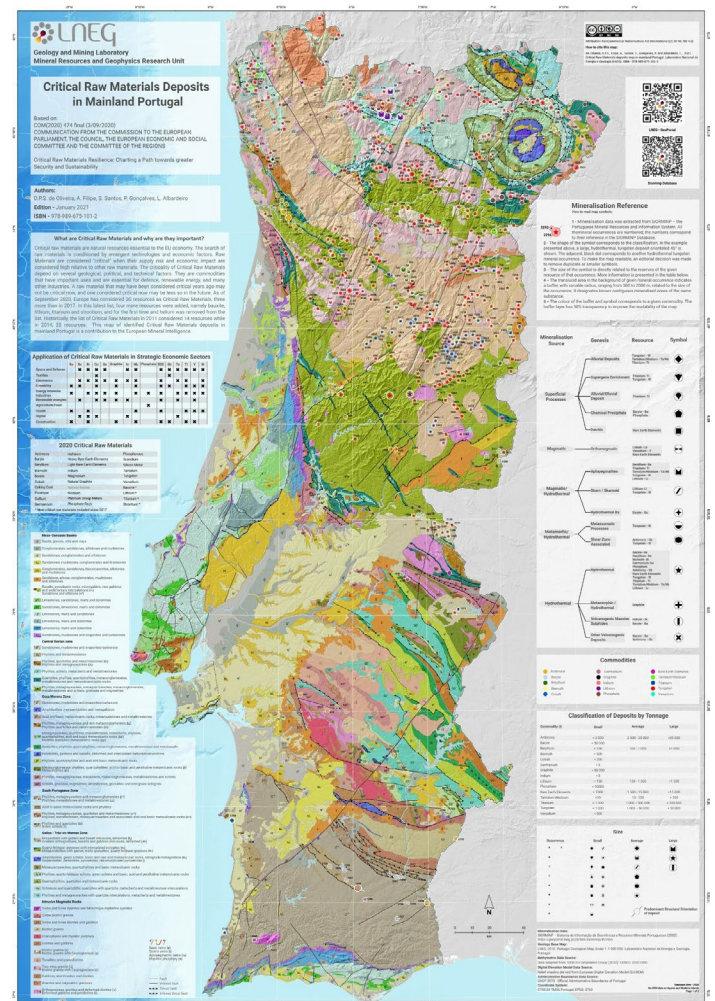


Figure 7: Critical Raw materials deposits map in mainland Portugal⁶

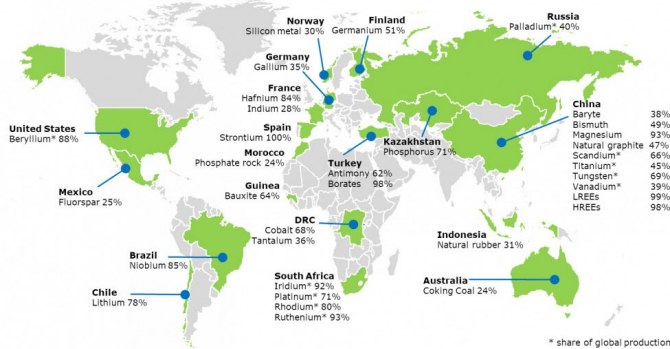


Figure 6: Countries according for largest share of EU sourcing of CRMs⁴

WHAT IS A THERMOELECTRIC MATERIAL?

Thermoelectric (TE) materials are functional materials which have the ability of a direct conversion of thermal energy into electricity. Built into a TE device or a TE Generator these materials have attracted tremendous interests in the recent years, especially against the background of global energy shortage and surging of new materials.

When a TE device is loaded with a source of waste heat, for example in an industrial plant, a certain portion of this waste heat sources is converted in electricity, representing a direct saving of energy. **Figure 8** provides a few examples from industrial waste heat, where huge amounts of high temperature energy is lost through radiation or in exhaust ducts.

The TE device is a robust and highly reliable solid-state energy converter with unique features: no moving parts, no maintenance, quiet operation, and absence of production of environmental deleterious waste. Due to this green behaviour, TE devices are expected to play a key role in clean and sustainable energy technologies.

TE materials work in a temperature gradient. Heat is the only input of a thermoelectric generator which produces electrical potential, or electricity if connected in a closed circuit. Heat can be generated either directly from the sun or the geothermal heat, or as a by-product of the consumption of fossil fuels.

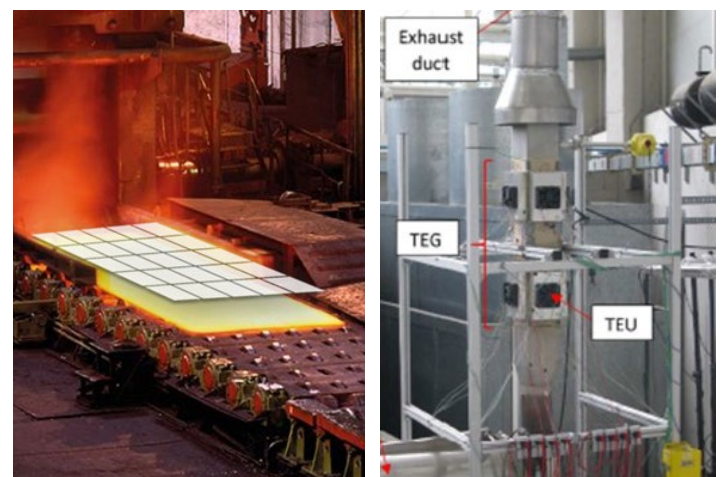


Figure 8: Example of waste heat recovery from an industrial process via a TE generator (TEG)

WHAT IS A THERMOELECTRIC MATERIAL? (continued)

The maximum efficiency of a thermoelectric material is determined by its figure of merit,

$$zT = TS^2 \frac{\alpha}{\kappa}$$

where S is the Seebeck coefficient or thermopower, α the electrical conductivity, κ the thermal conductivity and T the absolute temperature. The best thermoelectrics are heavily doped semiconductors with high thermoelectric power factors ($S^2\alpha$) and low thermal conductivities, known as 'Phonon Glasses Electrical Crystals'. **Figure 9** depicts the dependence of the conversion efficiency dependent on the thermoelectric figure of merit zT , which is defined by the physical properties of the material as outlined above.

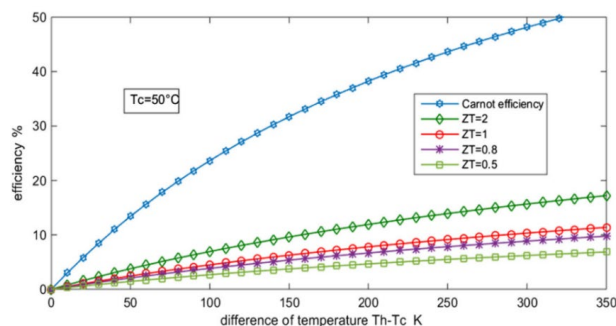


Figure 9: Dependence of conversion efficiency from zT and temperature difference

The tetrahedrite-tennantite series $(\text{Cu}_6[\text{Cu}_4(\text{TM})_2](\text{Sb,As})_4\text{S}_{13})$, with TM a transition metal, are p-type semiconductors with high Seebeck coefficient, and extremely low κ due to the complex cubic crystal structure. By adjusting the content of the doping element, competitive zT values, higher than 1, have been obtained between 300°C and 450°C, making tetrahedrites one of the bulk materials with the highest TE performance in this temperature range. **Figure 10** compares tetrahedrites with current commercial TE materials.

Materials	Current commercial materials			Tetrahedrite
	Bi_2Te_3	PbTe	SiGe	
Figure of merit (zT)	>1	>1	>1	>1
Operational temperature	< 300 °C	< 500 °C	< 900 °C	< 550 °C
Toxicity	Red	Red	Green	Green
Environmental aspects	Red	Red	Green	Green
Raw materials availability	Red	Red	Red	Green
Large scale manufacture	Yellow	Yellow	Green	Green
Favourable Green Less favourable Yellow Not favourable Red				

Figure 10: Characteristics of commercially relevant thermoelectric materials and comparison with tetrahedrites

A scheme of a simple thermoelectric device is shown in **Figure 11**. Carriers (electrons in n-type material and holes in p-type) drift from the hot surface to the cold surface due to the higher average speed of the carriers in the hot surface. This builds an electrical potential across the materials which eventually counterbalance the drift. The proportionality of the created potential (ΔV) over the temperature gradient (ΔT) is defined as the thermopower of the Seebeck coefficient S . Real thermoelectric devices are built by connecting a certain amount of this p-n junction in series.

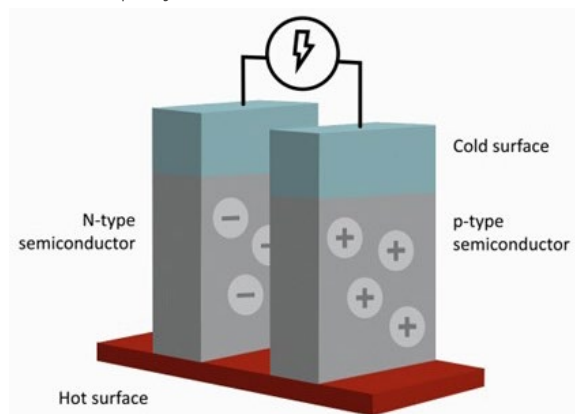


Figure 11: Scheme of a thermoelectric device: a temperature difference generates a difference of electric potential in coupled p-type and n-type thermoelectric materials

In a following Technical Pill we will see how to use this effect to build actual devices that can be used to harvest heat in practical environments.

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CONSORTIUM TOUR

We will introduce to you all consortium members, starting with the coordinator LNEG (Portugal) and the RTD partner SINTEF (Norway).

LNEG – NATIONAL LABORATORY OF ENERGY AND GEOLOGY



National Laboratory of Energy and Geology (LNEG) is a state laboratory that carries out advanced Research, Development, and Demonstration in the areas of Energy and Geology in Portugal, under the tutelage of the Ministry of Environment and Climate Action. LNEG actively participates in national and international projects and technological assistance and consultancy contracts

with the business community, as well as providing support to public policies.

LNEG is scientifically organized into two laboratories: Laboratory of Energy (LEN) and Laboratory of Geology and Mines (LGM). LEN operates in the areas of renewable endogenous resources of energy and energy efficiency. It has the responsibility of knowing the potential of renewable energy resources and exploring innovative and strategic technologies to support the optimized use of resources with a view to decarbonization and the circular economy. LGM performs permanent functions of the State in the development of geoscientific knowledge of the emerged territory, the continental shelf and deep-water zones. It performs functions of National Geological Service. It is also responsible for the systematic geological survey of geological risks and resources, including resources in geothermal energy, geological storage, namely CO₂, and geological heritage.



The various international partnerships position the institution as a dynamic partner for internationalization and a source of privileged information in its areas of intervention. As an example, LNEG is a full member of international networks such as the European Energy Research Alliance (EERA), the European Sustainable Energy Innovation Alliance (ESEIA) and the EuroGeoSurveys (EGS). This is the context of LNEG's participation in European projects and its acceptance by international research entities.

LNEG promotes the implementation of Management Systems through standardization and continuous process improvement using tools to measure the efficiency and verify the effectiveness of actions. As such, LNEG hosts accredited laboratories within its structure, as a means to efficiently demonstrate the quality of the execution of the essays and in general, show technical competence. The set of laboratories accredited by the Portuguese Institute for Accreditation (in accordance with NP EN ISO 17025) includes the Laboratory of Biofuels and Biomass, which focuses its activity on the analytical methodologies for biofuels and solid and liquid fuels, Laboratory of Materials and Coatings, which is a centre specialized in the areas of characterization, corrosion / degradation and corrosion protection materials and the Laboratory of Solar Energy, which focuses on testing the Solar Thermal Collectors and Systems.

In addition, LNEG was awarded the certification NP4457:2007 for the Research, Development and Innovation Managing System for the activities in the fields of Energy and Geology, as well as the certification NP EN ISO9001:2015 of its Quality Management System for knowledge transfer activities in Energy and Geology. LNEG was the first institution in Portugal distinguished with 'Excellence in Human Resources Research' (HR Excellence in Research).



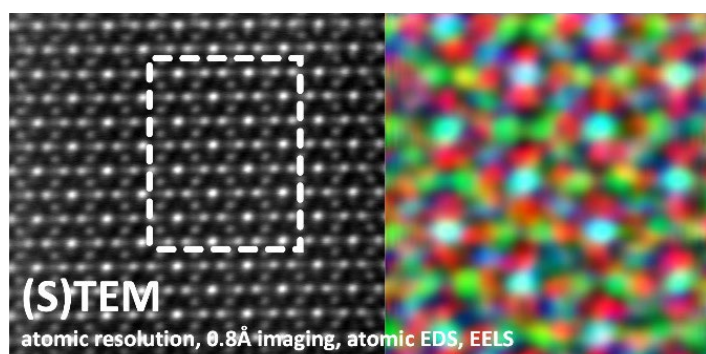
In **START**, LNEG is the coordinating institution of the project. LNEG is also responsible for the selection of mine waste sites; physical minerals separation and concentration work package, and it will be involved on research-based lab activities related with the mechanochemical synthesis production and materials characterisation. LNEG will also collaborate on the elaboration of the life cycle assessment task and will be responsible for the **START** serious game.

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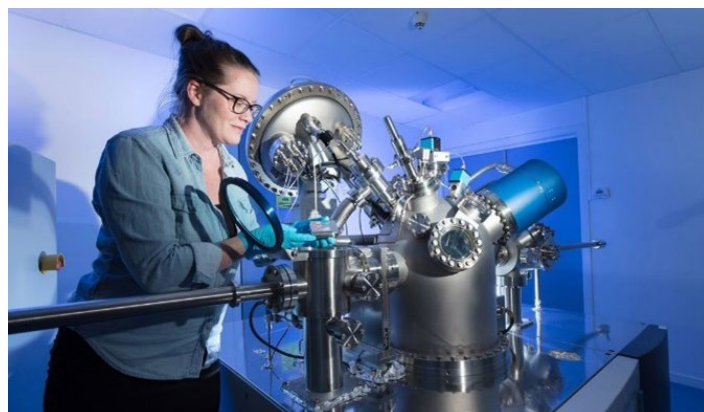
SINTEF AS is an independent, not-for-profit research Institute

and part of the SINTEF Foundation. SINTEF is one of the largest independent research foundations in Europe, with about 2150 employees. The foundation earns the majority of its income from contract research for industry and the public sector in Norway as well as internationally. Contract research carried out by SINTEF ranges from basic through applied research to commercialisation of results in the engineering, physical and social sciences. SINTEF is represented in this consortium by the department of Sustainable Energy, with the Material Physics-Oslo (MFO) located in Oslo.



The MFO group has extensive expertise in materials characterization and modelling, using advanced electron microscopy/spectroscopy, mass spectrometry, surface topography techniques separate or in combination with atomic scale modelling based on quantum mechanics. The MFO group research activities lie mainly in materials for renewable energy, and in projects related to climate and environment. MFO is a central partner in the national infrastructures The Norwegian Transmission Electron

Microscopy Laboratory-NORTEM' and the 'National Surface and Interface Analysis Laboratory-NICE'. MFO owns and/or has access to advanced characterization instruments (www.sintef.no/en/all-laboratories/advanced-materials-characterisation-laboratory/) such as both state-of-the-art and modern workhorse TEMs (FEI Titan G2 60-300, JEOL ARM200F, JEOL 2100F, JEOL 2100, JEOL 2010), a FEG-SEM (FEI Nova NanoSEM 650), a FIB-SEM (FEI Helios Dual Beam FIB-SEM), three XPS spectrometers (2 KRATOS Axis-ULTRADLD, Thermo Fisher ThetaProbe), an AES/AEM Microprobe (JEOL JAMP-9500F FE), a ToF SIMS equipped with FIB (PHI nanoTOF), a WLI (Veeco Wyko NT-9800), various AFM, XRD, RAMAN, FT-IR instruments.



In **START**, SINTEF is responsible for the Materials Characterization work package and its state-of-the-art infrastructure with advanced characterization tools will enable to establish the structure and chemical behaviour of metal sulphides at the atomic scale, as well as thermoelectric properties. SINTEF is also responsible for the materials modelling task and the device simulation task in **START**.

www.sintef.no

CONTACTS

START regularly updates its website and social media with news about its activities, but also with more general documents and info on the topics of relevance for the project. Thermoelectricity, waste heat recovery, mine waste remining, sustainability, raw materials and critical raw materials, energy efficiency, and many others.

If you are interested in receiving this newsletter and other special news from the project directly in your mailbox, consider subscribing our mailing list on the website ('Contacts' page, 'subscribe' section)! Clicking on the 'Subscribe' button, you will fill a form generated by SendinBlue, our mailing system, and will subsequently receive an E-Mail to confirm your address. Your data will be treated and stored in accordance with the EU GDPR Regulation. And do not forget to follow all our social media accounts!

Here is the list of the important links to click to reach our news:

Website: www.start-heproject.com

Twitter: [www.twitter.com/START_HEproject](https://twitter.com/START_HEproject)

LinkedIn: www.linkedin.com/company/86266991

YouTube: www.youtube.com/channel/UCHVjEhpVz9uaEgzlCj2lnPA

SlideShare: <https://es.slideshare.net/StartProject/>

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