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REMIND Project

Renewable Energies for water Treatment and Reuse in Mining Industries

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Mid-Term Meeting Report

In Amantea (CS), Italy, on August 29-30, 2022, the Mid-Term Meeting of REMIND (Renewable Energies for water Treatment and Reuse in Mining Industries) has been hold.

The overall aim of REMIND is to develop an innovative framework of interplay between Renewable Energy Sources (RES) and innovative Water Treatment Technologies in the logic of a sustainable growth for mining industries. The novel paradigms explored are expected to drastically reduce the environmental impact due to extensive water and energy consumption, and to release of untreated wastewater during the production cycle of copper and gold. The REMIND collaborative network among European Union, Chile and Ecuador is in line with EU policy and strategy for raw materials supply; moreover, this partnership supports the economic and research efforts of Latin American countries towards a more eco-friendly and RES-driven development.

The bi-directional knowledge transfer activities implemented in REMIND aim to: i) implement a rational use of water resources in the logic of circular economy; ii) promote a carbon-free technological approach (water-energy nexus) for reducing conventional energy resources requirements, and iii) mitigate health environmental risk in two demonstration sites (mining districts of Antofagasta – CL and Regione de l'Oro – EC), and iv) exploit the intersectorial cooperation between academia and industry by setting best practices for knowledge transfer in analogous contexts.

REMIND brings together 12 leading High Education Institutions and Large Companies from 4 Countries (Italy, Spain, Sweden, Chile and Ecuador), and implements a multisectorial and transdisciplinary network that generates 64 secondments and 73 Knowledge Transfer Activities.

During the MTM, Partners have discussed about the work performed until now, and about advances regarding the Chilean and Ecuadorian research. Following the MTM Agenda (see Annex 1) each Work Package has been described in terms of weakness and strength points by the corresponding WP Leader.

WP1 - Ethic Requirements

The obligation to keep copies of import/export authorizations required under national and/or European law on file is not applicable to REMIND.

WP2- Project Management & Coordination

The network of REMIND is not only used to exchange expertise and to train young researchers, but also to promote the understanding and to support implementation of best practices identified by the project in order to ensure sustainably integrated local systems in South America. Research cases come mostly from the Antofagasta Region (Chile) and El Oro Province (Ecuador), given their potential for integrating renewable energies and water treatment processes in the mining sector.

During the REMIND secondments carried out in the Antofagasta Region, a few visits focused on selecting the best pilot-site to investigate and explore needed policies and technological solutions - through case-based research oriented towards the design of process layout for optimized water -energy nexus in the logic of Process Intensification and Circular Economy. Thanks to the willingness of the Mantos de la Luna Company to investigate their mines, the site of the latter company was selected as the pilot-site for REMIND. The exploited ore is porphyry copper with a high copper content, a mineral which has been processed in an open pit in the site for 13 years.

REMIND is implemented in Southern Ecuador too, selecting the area to investigate and explore in the quest for new policies and technological solutions - through case-based research - oriented towards the design of process layout for optimized water-energy nexus in the logic of Process Intensification and Circular Economy. The selected area is El Oro Province. During a field visit (June 2019; April-July 2022), the actual contamination of all the regional rivers and creeks, and possibly aquifers was verified (in situ samplings, interviews with local inhabitants); local inhabitants – both in urban and rural areas – being systematically exposed to the risk of heavy metals intake, via water drinking and crops irrigation. To date, it is unclear if the irrigation systems drain water from heavily polluted water sources or reserves, the irrigation water being used in world-class farming of banana, cacao, coffee, and shrimps, which eventually are sold to EU countries (Ecuador signed a Free Trade Agreement with EU in 2016). During the first part of the scientific implementation of the action, most of the time has been spent on selecting, collecting, and sharing all the relevant published articles and writings on heavy metals and Hg pollution due to gold mining in El Oro Province, Ecuador. Emphasis and sensibility have

been placed on social, economic, and political aspects caused by small-scale gold mining in the region, both formal/legal and informal/illegal.
In the following table, the secondment periods carried out within the Work Packages are listed:

#	Work Package Title	Description	Beneficiary leading	Secondment months
1	Ethic Requirements		ALL	-
2	Management and coordination	Project coordination and management Scientific and technical coordination Quality and risk management Selection of participants	UNICAL	-
3	Environmental Audit in Mines districts	Audit of mining operations Audit of the water pollution phenomena Analysis of mines in Chile Ecuador Socio-economic impacts of mining	POLITO	20,30
4	Reconstruction of water pollution maps	Analysis of surface/subsurface water samples Assessment of water pollution potential Reconstruction of the pattern pollution Spatial distribution maps of water-quality	UNICAL	19,15
5	NBLs in the Environment	Global Statistical Analysis Hydrogeological characterization of aquifer	UNICAL	2,53
6	Selection of wastewater treatment BAT	Analysis of water requirements Analysis of surface water treatments Analysis of in situ groundwater treatments Process intensification	POLITO	8,7
7	Selection of BARE for water treatment	Assessment of water and power technologies Selection of candidate commercial products Development of performance models Selection of BARE for water treatment Testing of commercial hollow-fiber membranes	USE	4,8
8	Design of the industrial process layout	Design of the water treatment plant Health and Safety Plan Techno-economics of membrane water treatment	USE	1,1
9	Dissemination, exploitation	International conferences Create international research network Training on IPR / Exploitation of results	UNICAL	-

The total secondments carried out by the REMIND Partners are shown in the following table:

Secondments done									
Institution	UNICAL	USE	POLITO	RINA	ABB	CAMIT	ESPOCH	UAI	sending
UNICAL	-	-	-	-	0	2,17	5,1	10,73	18,00
USE	-	-	-	-	0	0	1,1	1	2,10
POLITO	-	-	-	-	0	0	2,8	9,35	12,15
RINA	0	0	0	0	0	0	0	0	0,00
ABB	0	0	0	0	-	-	-	-	0,00
CAMIT	6,64	0	0	0	-	-	-	-	6,64

ESPOCH	9,39	0	1,07	0	-	-	-	-	10,46
UAI	5	0	1,03	0	-	-	-	-	6,03
Hosting	21,03	0,00	2,10	0,00	0,00	2,17	9,00	21,08	55,38

As the COVID-19 pandemic wave hit Europe since March 2020, and due to the aggressive evolution of the infection that brought about lockdown measures and travel restrictions, it was decided to suspend the REMIND project. As of the date of this suspension - June 10, 2020 – 41,53 secondment months had been carried out, what represents 31.23% of the planned 133 secondment months.
Overall, the difficulties already experienced several months in advance of the suspension (also due to some social strain in Chile and Ecuador) hindered the completion of the secondment plan according to the Grant Agreement. As a consequence of this, the project was suspended in June 2020, and an extension was granted until the end of February 2022.
In order to fulfil the original objectives of REMIND, and in addition to the petition to resume the project with effect from March 1st, 2022, an additional 18 month extension of the project was requested in conjunction with the following modifications to the Consortium and the Secondment Plan, to be formalized through an amendment to the Grant Agreement.

WP3 - Environmental Audit in Mines districts (POLITO)

The performed activities have foreseen the collection of information concerning the following districts:

- Chilean Antofagasta Region (Escondida, Zaldivar, Mantos Blancos);
- Ecuador artisanal gold mine (area Nambija, Portovelo, Ponce Enriquez).

The collected data are related to mine geology and hydrogeology, cultivation and mineral processes, pollutants emissions and distribution in groundwater.
Chilean Antofagasta Region
Concerning geology, the Andes represent a special example of subduction. Atacama Trench (or Chilean-Peruvian Trench), 160 km west of the Chilean coast: line where the South American plate subducts the Nazca Plate, extending from 6°S to 39°S lat. The difference in height between the highest point of the Andean Mountain range (the argentine Aconcagua, 6,962 m asl) and the deepest point of the Atacama Trench (abyss of Bartolomew, 7,960 m below sea level) is about 15,000 m. The main Chilean activity is mining, in particular copper (Chilean copper represents over a third of world demand). According to COCHILCO (Comisión Chilena del Cobre - *Chilean Copper Commission*) and SERNAGEOMIN (Servicio Nacional de Geología y Minería – *Geology and Mining National Service*) in 2016, 5,552,600 tons of copper were mined from the Chilean mines. The most important mines are those of Chuquicamata, Escondida, Centinela, Radomiro Tomic (all in the region of Antofagasta), El Teniente (Libertador General Bernardo O'Higgins) and Collahuasi (Tarapacá). This intense mining has a very high-water demand. COCHILCO estimates that in 2017 13.26 m^3/s of continental water, 3.16 m^3/s of sea water and 38.07 m^3/s of recirculation water, for a total of 54.5 m^3/s were used.
Antofagasta is a port city in northern Chile, about 1,100 km north of Santiago. It is the capital of Antofagasta Province and Antofagasta Region. According to the 2015 census, the city has a population of 402,669. The city of Antofagasta is closely linked to mining activity, being a major mining area of the country. The last decade has seen a steady growth in the areas of construction, retail, hotel accommodations, population growth, and remarkable skyline development. Antofagasta has the highest GDP per capita of Chile, US$47,000 and the 3rd place for Human Development Index just after Metropolitana de Santiago Region and Magallanes and Antártica Chilena Region. The high media temperature is 24,5ºC and the lowest is 17,1ºC. The rain is almost inexistent, with a high media of 3 mm.
Numerous literatures on groundwater and surface water quality of the Antofagasta mining region has been collected. Moreover, some important information about soil and sediments chemistry and the impact of mining on water and soil resources has been collected.
Two important articles published by Chilean Researcher on groundwater and surface water quality problems were collected.

Article 1: Romero, L., H. Alonso, P. Campano, L. Fanfani, Rosa Cidu, C. Dadea, T. Keegan, I. Thornton, and M. Farago. "Arsenic enrichment in waters and sediments of the Rio Loa (Second Region, Chile)." Applied Geochemistry 18, no. 9 (2003): 1399-1416.
Article 2: Godfrey, L. V., C. Herrera, C. Gamboa, and R. Mathur. "Chemical and isotopic evolution of groundwater through the active Andean arc of Northern Chile." Chemical Geology 518 (2019): 32-44.
The Loa River is an important river in the Antofagasta region, and it is contaminated by Arsenic, Boron, Lithium, Chloride and Sodium. The main contaminant is Arsenic (As) in the Loa River water of the area, and Romero et al. 2003 suggested that the natural, i.e. linked to the lithologies in the area is the main As source in the Rio Loa basin. Moreover, smelter emissions and mining wastes, as well as the As-rich effluents from the water treatment plants, possibly represent additional sources are also responsible for the As contamination in the Loa river water.
Ecuador artisanal gold mines.
The Republic of Ecuador is located on the northwestern coast of South America; it crosses the equator as it sits between latitudes 01º30´ N and 5º12´ S, and longitudes 75º20´ W and 91º W. The country is divided by the Andes Mountain range into three geographic regions: (i) Coast or Coastal Region, (ii) Inter-Andean or Sierra Region, and (iii) Eastern or Amazon Region. 600 miles from the coast is the fourth region, the Archipelago of Colón, or Galapagos. The total territorial extension of the country is 255,586.91 km^2, encompassing 24 provinces. Its main elevations are the Chimborazo volcano (the highest in the country, with 6310 m altitude) and the Cotopaxi volcano (second highest, 5897 m).
Main mining districts of Ecuador are Camilo Minero Ponce Enríquez District (DMCPE), Portovelo-Zaruma Mining District (DMPZ), and Nambija Mining District (DMZ).
The study area of interest is in the southern zone of Ecuador. The provinces Azuay, El Oro, Loja, and Zamora Chinchipe have a high mining potential, especially related to Au and polymetallic deposits. The production here represents 90% of the total mineral resources extracted in Ecuador. Between 1988 and 1992, about 13 t / y of Au was produced by Ecuador, 7 t extracted in the Zamora canton mines and 3 t of Portovelo-Zaruma (Requelme et al., 2002), the rest probably by other mining sectors located in the neighboring cantons. Most of Au production comes from artisanal mining operations. It was estimated that in Ecuador, approximately 40% of gold production derives from amalgamation processes and 60% from cyanidation
El Oro Province s located in the extreme southwest of Ecuador. Aquaculture, agriculture, and mining are common activities in this sector, but gold mining in the Portovelo and Zaruma provinces (known as Portovelo-Zaruma Mining District "DMPZ"), is the main activity responsible for the deterioration of the local ecosystem related to the severe decrease in biodiversity, particularly in the Puyango River, which comprises 3 main tributaries (Río Calera, Amarillo, and Pindo). The effects of the impact of mining activities are known: bioaccumulation of metals in biota; reduced quality of water for human consumption and irrigation due to the presence of heavy metals; international conflicts with Peru due to the contamination of the Tumbes River; concentration of mercury in the air exceeding the permissible limits and the consequent impact on human health (Decentralized Autonomous Government of El Oro, 2015).

WP4 - Reconstruction of pollution maps of surface and subsurface water

The performed activities have foreseen the collection of information concerning the following districts:

- Ecuador gold mine (area Sucumbios, Nambija, Portovelo, Ponce Enriquez).
- Chilean Antofagasta Region (Mantos Blancos);

During the first part of the research project, we've experienced many difficulties in samples collection due to i) suspicious of gold-seekings and artisanal miners for possible legal repercussions due to noncompliance with environmental regulations, and – mainly for the Chilean copper mines - ii) diffidence of industrial companies as it could lead to an increased concern of population about the environmental safety of mining activities. Because of to these difficulties, the Chilean copper mining reconstruction is still to an embryonal state.

Ecuador gold mine reconstruction

Artisanal and industrial gold mining is the largest consumer of mercury globally and the largest anthropogenic source of mercury emissions into the environment (Langeland et al., 2017). Environmental pollution disproportionately affects the poor and vulnerable; nearly 92% of pollution-related deaths occur in low- and middle-income countries (Steckling et al., 2017). Current impact estimates are limited by a lack of exposure data, and communities for which the least amount of information is available are at greatest risk. Informal resource extraction, including extraction of valuable metals, is a lucrative but dangerous option in poor and resource-rich countries (Bank et al., 2014). Artisanal and industrial gold mining is an important economic activity in rural communities (Mantey et al., 2017). The use of chemical compounds such as mercury is the preferred practice in gold extractive processes due to its ease of application, it is highly effective in capture, very accessible and easy to transport, in addition to its low operating costs compared to other methods. These processes have been practiced for decades and have increased in terms of intensity, scale, and scope (Pirrone & Mason, 2009). The frequent and inappropriate discharge of chemicals into the environment, has resulted in elevated levels of the metal in various media such as soils, surface water, sediments, sludge and slurry, crops, fish, plants, and humans (Owusu-Nimo et al., 2018). Artisanal and industrial mining techniques use large chemical inputs among them mercury. Miners mix liquid elemental mercury with soil or sediment to form gold-mercury amalgams, which they burn to produce a semi-pure gold alloy (Steckling et al., 2017). A fraction of this gaseous mercury is released into the global atmosphere. The remaining gaseous mercury is deposited on the terrestrial landscape and in surface waters, usually as oxidized inorganic divalent mercury; this aquatic contamination is exacerbated by miners disposing of unused liquid elemental mercury into local rivers (Bank et al., 2014). Artisanal gold mining is the source of approximately 20% of the world's gold, it is characterized as the largest source of mercury (Hg) pollution on earth. Approximately 10 to 19 million people use mercury to extract gold through artisanal processes in more than 70 countries, making it a major concern for government authorities and NGOs globally (Mantey et al., 2020). Like various local communities around the world, Ecuador, following the trend of other developing countries, has enormous mining potential that could constitute an important base for its economy, particularly oil and gold in its eastern and northwestern Amazonian and Andean provinces. However, the exploitation of these resources sometimes leaves many sites with soil and water that are potentially contaminated by various chemicals. Although it is widely recognized that the extent of environmental damage caused by mining depends on the method of extraction, beneficiation processes, operational scale, location, and characteristics of the receiving environmental media. Characterization of mining-related contamination of freshwater ecosystems is important for assessing exposure hazards and developing effective and realistic remediation plans.

In Ecuador the degree of mercury contamination caused to water and soil has not been adequately related to the types and processes of gold mining. So far, research efforts to assess the effects of mercury in the environment have been very generic and have failed to relate contamination levels to specific types of artisanal and industrial mining. Therefore, the extent or degree to which mercury affects biotic and abiotic components and the health of miners and their families is largely unknown.

The goal of WP4 is to provide the following contributions:

- To determine and characterize the current situation regarding artisanal and industrial gold mining in Ecuador.
- To reconstruct the pollution maps of surface and subsurface water
- Identify the main environmental impacts on rivers and aquifers in Ecuador, generated by artisanal and small-scale gold mining ASGM processes.

The research uses innovative methodologies according to the new trends of science in the field of study. It will provide comprehensive contributions that will strengthen the knowledge of the public and private sectors, NGOs, and academia, providing updated and verified information. Data that will serve to propose macro solutions in the processes of environmental control and monitoring at all hierarchical levels, both national and sectional, as well as contribute to the problems identified in countries of the region such as Brazil, Bolivia, Peru, and Colombia. Finally, it will be a tool that will allow to propose new policies and strategies oriented to the conservation and the correct management of the natural environment and its resources, centralized in the subject of study of artisanal and industrial gold mining.

Mining management in Ecuador presents serious problems in its organizational processes, and in recent decades it has undergone several changes that make it difficult to understand how it works. Starting with its governing body, the name of this ministry has undergone several changes as new presidents have taken office. The functional organization chart is constantly changing, this has been justified because of staff optimization due to lack of budget. These problems prevent the development of adequate control and monitoring of mining activities in Ecuadorian territory. This has led to an increase in illegal and informal activities in the ASGM sector. Promoting training and education processes with artisanal and small-scale miners in Ecuador regarding the risks and impacts that can be caused by the indiscriminate use of Hg on health and the environment is a practical option for the application of new techniques and clean technologies to reduce the use of mercury in

ASGM and therefore the impact on water bodies and their biotic elements. In addition, it is important to socialize successful results where the application of new techniques where only cyanide is used allows obtaining higher purity and quantity of gold. In some cases, miners are aware of the risks of Hg, but the lack of trust and communication among them prevents the correct application of techniques. At this point it is necessary to encourage associative grouping that allows them to opt for social capital and socioeconomic benefits.
One of the main limitations of our study was the scarcity of information available on successful management processes to reduce the impact of ASGM activities on water bodies.
The main results obtained in the first part of the project are as follows:

- A scientific article was published that responds to the first objective of the research project on gold mining in Ecuador: Innovative recommendations for the management and remediation of mercury contaminated water (See appendix, article).
- An article was published that responds to the first objective: to analyze the historical and current situation and challenges of artisanal and industrial gold mining in the Amazon region of Ecuador by applying a literature review and field work to understand the evolution in political, socioeconomic and environmental aspects.
- An article was published that responds to the first objective: to analyze the historical and current situation and challenges of artisanal and industrial gold mining in the Andean region of Ecuador by applying a literature review and field work to understand the evolution in political, socioeconomic and environmental aspects.
- An article was published that responds to the first objective: to analyze the historical and current situation and challenges of artisanal and industrial gold mining in the Littoral region of Ecuador by applying a literature review and field work to understand the evolution in political, socioeconomic and environmental aspects.
- An article was published that responds to the third research objective: On the socioenvironmental impacts generated by gold mining: A case study in the Ecuadorian Amazon.

Results were obtained from water sampling regarding the presence of mercury from gold mining activities in Ecuador. For the Sucumbios province a first results are presented in the following table.

Mercury (Hg) Surface Water (SW)								
Province	SAM	Canton	Parroquia	River	SW (mg/L)	Latitud	Longitud	Observation
		Sucumbíos Alto	La Bonita	Sucio	<0,0005	0,484576	-77,585485	Inicio de concesión parte alta
Sucumbíos	1	Sucumbíos Alto	La Bonita	Sucio	**0,0042**	0,469104	-77,555416	Poblaciones indigenas en las riberas del río
	2	Sucumbíos Alto	La Bonita	Sucio	**0,0032**	0,461138	-77,531189	Actividades agropecuarias en las riberas del río
	3	Sucumbíos Alto	Rosa Florida	Palmar	<0,0005	0,457521	-77,593334	Inicio de río dentro de concesión
	4	Sucumbíos Alto	Rosa Florida	Palmar	**0,0017**	0,421433	-77,579952	Actividades agropecuarias en las riberas del río
	5	Sucumbíos Alto	Rosa Florida	Palmar	**0,0023**	0,420501	-77,5396	Actividades agropecuarias en las riberas del río
	6	Sucumbíos Alto	Rosa Florida	La Chispa	<0,0005	0,347825	-77,579649	Actividades agropecuarias en las riberas del río
	7	Sucumbíos Alto	Rosa Florida	La Chispa	**0,0007**	0,348308	-77,549588	Actividades agropecuarias en las riberas del río

	8	Sucumbíos Alto	Rosa Florida	La Chispa	**0,0013**	0,318334	-77,490367	Actividades agropecuarias en las riberas del río
	9	Sucumbíos Alto	Rosa Florida	Chingual	**0,0045**	0,370845	-77,5097	Parte Alta - Frontera con Colombia
	10	Sucumbíos Alto	Rosa Florida	Chingual	**0,0015**	0,320462	-77,488846	Luego de la desembocadura del Río Chispa caserios.
	11	Gonzalo Pizarro	Puerto Libre	Chingual	**0,0009**	0,277703	-77,456156	Mitad de concesiones
	12	Gonzalo Pizarro	Puerto Libre	Chingual	**0,0007**	0,235272	-77,505824	Previo a unirse con el río Cofanes y formar el río Aguarico / Piscicultura
	13	Sucumbíos Alto	La Sofía	Cofanes	<0,0005	0,373596	-77,638197	Previo a inicio de concesión minera aurífera
	14	Sucumbíos Alto	La Sofía	Cofanes	**0,0099**	0,190288	-77,669548	Antes de unirse con el río El Dorado / agricultura y caserios
	15	Gonzalo Pizarro	Gonzalo Pizarro	Cofanes	**0,0023**	0,231712	-77,509572	Previo a unirse con el río Chingual y formar el río Aguarico / Piscicultura
	9	Gonzalo Pizarro	Puerto Libre	Aguarico	<0,0005	0,185437	-77,49136	Inicio del río Aguarico, cerca al poblado de Puerto Libre / Piscicultura
	10	Cascales	Cascales	Puchuchoa	<0,0005	0,081728	-77,278572	Actividades agrícolas y piscicultura
	11	Cascales	Cascales	Loroyacu	**0,0006**	0,084463	-77,238393	Poblaciones indigenas en als riberas del río / piscicultura
	12	Cascales	Cascales	Loroyacu	<0,0005	0,072189	-77,233799	Poblaciones indigenas en als riberas del río y piscicultura
	13	Cascales	Cascales	Cascales	**0,0033**	0,112807	-77,229252	Actividades recreativas y piscicultura
	14	Cascales	Cascales	Cascales	**0,0008**	0,081009	-77,205655	A 2km desembocadura del río Agurico. Población aledaña Cabecera cantonal de Cascales
	15	Cascales	Cascales	Aguarico	<0,0005	0,072654	-77,179418	Sector poblado Cascales
	16	Cascales	Santa Rosa	Taruca	<0,0005	0,160974	-77,134179	Sitios turistico zonas de baño
	17	Lago Agrio	Jambelí	Taruca	**0,0073**	0,236426	-77,017984	Actividades recreativas y asentamientos humanos en las riberas
	18	Lago Agrio	Jambelí	Taruca	**0,0094**	0,264889	-76,986873	A 100m desembocadura del río San Miguel. Centros poblados ríos abajo y plnataciones agriolas
	19	Lago Agrio	Jambelí	La Bermeja	**0,0029**	0,222954	-77,190071	Inicio de conceciones, toma demuestra luego de la desembocadura del río Betano y Bodoquera

	20	Lago Agrio	Jambelí	La Bermeja	**0,0045**	0,276475	-77,152193	Punto medio de conceciones río la Bermeja
	21	Lago Agrio	Jambelí	La Bermeja	**0,0064**	0,286516	-77,081411	A 100m desembocadura del río San Miguel. Centro poblado y actividades agropecuarias. Asentamiento Cofan Avie
	22	Lago Agrio	Lago Agrio	Aguarico	<0,0005	0,060495	-76,87844	Ciudad
	23	Lago Agrio	Jambelí	San Miguel	<0,0005	0,303085	-77,090303	Paret alta del río San Miguel
	24	Lago Agrio	Jambelí	San Miguel	**0,0047**	0,26871	-76,959728	Poblados y activudades agrícolas
	25	Lago Agrio	General Farfan	San Miguel	**0,0021**	0,24585	-76,889332	Poblados y activudades agrícolas
	26	Lago Agrio	General Farfan	San Miguel	**0,0015**	0,238537	-76,844887	Pueblo de General Farfan
	27	Lago Agrio	General Farfan	San Miguel	**0,0007**	0,196939	-76,202099	Pobalciones indígenas y límite con áreas protegidas
	28	Lago Agrio	General Farfan	San Miguel	<0,0005	0,227588	-76,596344	Pobalciones indígenas y límite con áreas protegidas

Chilean copper mine reconstruction

Chile, currently, is the world's leading copper producer, which led the country towards higher levels of wealth, and prosperity while advancing its economy. Historically, the mining industry has been the most important driver of the Chilean economy. However, rising costs, declining productivity, and increasing social and regulatory pressure in the areas of community engagement and environmental sustainability are hampering the sector's profitability and ability to remain globally competitive (Simpson et al., 2014). In particular, intensive mining activities for copper extraction are threatening social and economic development in the northern regions of Chile. Mainly, this is due to several environmental issues related to the high water consumption of mining industry and its impact in communities living in dry regions with water scarcity (Aitken et al., 2016), and to the contamination of water resources by tailings leakage or acid mine drainage generation, among others.

Among the critical challenges, water quality and management have become a fundamental concern for the mining industry's future profitability and competitiveness (Pasten et al., 2017). Water is required at the mine sites for different uses such as dust suppression, mineral processing, particularly for grinding and flotation, and hydrometallurgical extractions. In general, surface water bodies and groundwater aquifers are preferred with respect to the sea (Lottermoser, 2010), but, in recent years, the over-exploitation of freshwaters in the arid/semi-arid regions urged into seeking new and largely available water sources such as seawater (Shao et al., 2015).

Chile appears among the countries with the highest water risk. Worryingly, 76% of the surface of this country is affected by drought, desertification and degraded soil (Sud-Austral Consulting SpA, 2016), while 110 aquifers are currently exploited with a committed demand higher than their recharge (Ministerio del Interior y Seguridad Pública de Chile, 2015). Moreover, Chile has an uneven territorial distribution of water resources; in particular, the northern regions present a significantly low supply of water to provide the main activities carried out in their whereabouts (Fig. 1). Reserving very low amount of surface and subsurface water supply, northern regions such as Arica and Parinacota, Tarapaca, Antofagasta, Atacama and Coquimbo suffer from water scarcity to sustain the main mining activities (Fundacion Chile, 2018).

On the other hand, water is abundantly present in process effluents (tailings) generated in a mineral processing plant that are generally dumped as water-based slurries into large impoundment ponds and tailing dams. The last register of tailing deposits in Chile conducted by SERNAGEOMIN counted 742 total tailing deposits, containing more than 8300 million m3 of tail slurry currently deposited (Sernageomin, 2019); the active tailing deposits are 104, and the rest are inactive or abandoned. Excess water from tailing storage facilities represents a potentially exploitable “in-loco” source of recovered and re-used water.

Despite the great economic benefits generated by the mining activity, nearby communities have also suffered from the harmful effects of accidental release on health and the environment. Thus, over the last few years, organized and active environmental local movements have acted on the “integral state” (political and civil society), institutionalizing the concerns about the foot-print of the mining sector, resulting ultimately in limitations for mining companies and sometimes halting the mining operations (Furnaro, 2019). Consequently, environmental regulations have become increasingly stringent on wastewater, requiring mining companies to treat and reuse or dispose of this contaminated water properly.

The presence of dissolved metals in water tailing is the premise for a change of paradigm, from wastes to resources, according to the Circular Economy concept. This has boosted the execution of research and development projects to propose a feasible recovery of these elements, considering technical, environmental and economic aspects (Araya et al., 2020; Berkh et al., 2019); for example, possible recovery of uranium and rare metals were studied considering their increasing value (Chmielewski et al., 2016). In addition, countries having intensive mining activity started new incentive programs to regain precious metals from tailings (Corfo, 2017). Macías et al. (2017) assessed the environmental risk, the management strategies for land disposal and the potential valorization of metal-sludge waste generated by the neutralization of AMD in an active treatment plant. Sulfuric acid recovery from AMD by using membrane separation, crystallization, solvent extraction, and acid retardation was reviewed by Nleya et al. (2016). Active treatment technologies of effluents in which the valorization of wastes is possible through resource recovery is now recognized as non-debatable holistic approach to environmental sustainability and pollution reduction (Kefeni et al., 2017).

WP5 - Natural Background Levels and physical parameters of the environmental matrices

Estimation

In order to evaluate the natural background level in the Antofagasta region and in the provincial de l’Oro a guided software has been realized. This software can guide the user for estimating the natural background values of aquifers. In the following, the main parts of the software are depicted.

Organization Data

The input data is automatically reorganized and collected within each sampling station according to the chronological order of the sampling to which it relates. This is clearly shown in the software window. Clicking on the Next Step button takes you to the next window.

Calculation Medians

The medians of the concentration data are automatically calculated for each sampling station and collected in a table. Clicking on the Next Step button takes you to the next window.

Generation Classes

In this step, the software automatically calculates the size of the concentration classes and the corresponding relative frequencies required to interpret the data using the Separation of Components method. The optimal number of classes is determined by the software but can be changed by the operator via the scroll bar at the bottom left to facilitate the next calibration step. The number of classes and their width are calculated and updated in real time as well as the graph on the right, which helps the operator visualize the result of changes. It should be aimed at a non-chaotic and too 'scattered' arrangement of the points. One must consider that the software will have to force the representative function of the Separation of Components method to approximate the graph data as best as possible. Clicking on the "Next Step" button takes you to the next sub-window.

Separation of Components

Once the operator has defined the number of classes deemed suitable to be interpreted by the software. This step automatically starts the calibration process using the Separation of Components method. The procedure has a calculation time that can vary from a few seconds to a few minutes depending on the computing power of the processor used. The software signals that the processing is in progress by means of a small yellow window with an inscription. The calibration process can be complex depending on how the experimental data is arranged. If the calibration process does not produce any results after a few minutes, it is possible to interrupt the calculation using the Stop button, go back, change the number of classes, and return to the calibration window. When the software finds the optimal solution, the window changes from yellow to green and the estimated parameters appear in the relevant table, the calculated curve that best approximates the experimental data appears in the graph to appreciate the goodness of the processing. If you are not satisfied with the result, you can proceed as described above by changing the number of classes again. Clicking on the "Next Step" button takes you to the final sub-window.

Calculation of Natural Background Values

The probability density function of the Natural Component and the cumulative probability density function for the same Component appear in this window. The progression of these two functions is determined by the previously estimated parameters of the Natural Component. By clicking on the "Execute Step" button, the software proceeds to calculate the Natural Background Value by automatically determining the concentration value that corresponds to the 90th percentile of the cumulative probability curve. The VFN value is graphically highlighted in the graph by a red dotted line and numerically in a special window to the right of the graphs. Finally, by clicking on the "Generate Log" button, the software automatically creates the report of the entire processing containing the data used and the output obtained and saves it as a pdf file. A small window appears indicating the path where this file was saved.

Next steps will be the application of the software to the aquifers surrounding the copper mines in Chile, because for the Ecuadorian aquifers the anthropic origin of the Hg is overall recognized.

WP6 - Selection of the Best Available Technology (BAT) for the wastewater treatment

In order to develop WP6 this information is required:

1) Chile and Ecuador laws concerning water quality for environment, drinking purpose, agriculture employment.
2) Water and energy costs in Chile and Ecuador.
3) Available sources of energy in Chile and Ecuador: traditional and renewable.

Chilean Antofagasta Region

Aguas Antofagasta Group manages the processes / activities concerning the water cycle in the region of Antofagasta (Region II of Chile). The main towns in the region are Antofagasta (approx. 390,000 inhabitants), Calama (approx. 180,000 inhabitants), Tocopilla (approx. 25,000 inhabitants) and Mejillones (approx. 10,000 inhabitants). At present the group runs six operating WTPs:

- three WTPs, namely Planta de Filtros Cerro Topater (started operations in 1978), located in Calama, and the old (1970) and new (1989) plants of Salar del Carmen, located in Antofagasta; all three are fed with river water that comes from the Alta Cordillera;
- one WTP located in Taltal (namely O'Higgins, 1998, treatment capacity 32 l/s) that treats groundwater collected from the Agua Verde well field (70 km NE from Taltal);
- two desalination plants located in Antofagasta (La Chimba, 2003) and in Taltal (2008);
- a new desalination plant is being under construction in Tocopilla; in May 2019 60% of the works of the new plant were completed. The end of the construction is expected by end of the year 2019.

Quality parameters of waters treated in the WTPs of Calama and Antofagasta

	NCh409-2005 threshold value	**Toconce**	**Lequena**	**Quinchamale**	**San Pedro**	**Puente Negro**
As	0.01 mg/l	0.82 mg/l	0.25 mg/l	0.18 mg/l	0.5 mg/l	1.24 mg/l
Cl	400 mg/l	135 mg/l	163 mg/l	429 mg/l	235 mg/l	2144 mg/l
pH	6.5 – 8.5	8.17	8.37	8.00	8.64	8.14
Turbidity (*)	2 NTU	1.015 NTU	6.450 NTU	4.782 NTU		

It is interesting to note that, all waters have arsenic concentrations far higher than the threshold value fixed by the Chilean regulation. Moreover, all waters have, on average, a basic pH value, not favorable for the removal of arsenic.

For the treatment of Arsenic biosorption is a promising technology that recently gained more interest for removing heavy metals and toxic ions from industrial waste streams and natural water. Biosorption can also remove anions such as As (III) and As (V) from water. Biosorption of As involves a biomass to bind and remove As from water by physicochemical reactions. The common functional groups occurring in biosorbents include hydroxyl (-OH), carboxyl (-COOH), phenolic, amino (-NH2), sulphydryl (-SH), alcoholic and ester groups. These functional groups have high potential to remove As from water on the surface of the biosorbent through sorption, complexation, ion exchange, diffusion or co-precipitation reactions. (Shakoor et al., 2016).

Ecuador artisanal gold mines.

Actually, a recognition was performed concerning the Ecuador law for water quality (some examples in the following).

TABLA 1. Límites máximos permisibles para aguas de consumo humano y doméstico, que únicamente requieren tratamiento convencional.

Parámetros	Expresado Como	Unidad	Límite Máximo Permisible
Aceites y Grasas	Sustancias solubles en hexano	mg/l	0,3
Aluminio	Al	mg/l	0,2
Amoniaco	N-Amoniacal	mg/l	1,0
Amonio	NH_4	mg/l	0,05
Arsénico (total)	As	mg/l	0,05
Bario	Ba	mg/l	1,0
Cadmio	Cd	mg/l	0,01
Cianuro (total)	CN^-	mg/l	0,1
Cloruro	Cl	mg/l	250
Cobre	Cu	mg/l	1,0
Coliformes Totales	nmp/100 ml		3 000
Coliformes Fecales	nmp/100 ml		600
Color	color real	unidades de color	100
Compuestos fenólicos	Fenol	mg/l	0,002
Cromo hexavalente	Cr^{+6}	mg/l	0,05
Demanda Bioquímica de Oxígeno (5 días)	DBO_5	mg/l	2,0
Dureza	$CaCO_3$	mg/l	500

Contin

TABLA 3. Criterios de Calidad admisibles para la preservación de la flora y fauna en aguas dulces, frías o cálidas, y en aguas marinas y de estuario.

Parámetros	Expresados como	Unidad	Límite máximo permisible		
			Agua fría dulce	Agua cálida dulce	Agua marina y de estuario
Mercurio	Hg	mg/l	0,0002	0,0002	0,0001
Níquel	Ni	mg/l	0,025	0,025	0,1
Plaguicidas organoclorados totales	Concentración de organoclorados totales	µg/l	10,0	10,0	10,0
Plaguicidas organofosforados totales	Concentración de organofosforados totales	µg/l	10,0	10,0	10,0
Piretroides	Concentración de piretroides totales	mg/l	0,05	0,05	0,05
Plata	Ag	mg/l	0,01	0,01	0,005
Selenio	Se	mg/l	0,01	0,01	0,01
Tensoactivos	Sustancias activas al azul de metileno	mg/l	0,5	0,5	0,5
Temperatura	°C		Condiciones naturales + 3 Máxima 20	Condiciones naturales + 3 Máxima 32	Condiciones naturales + 3 Máxima 32
Coliformes Fecales	nmp/100 ml		200	200	200

TABLA 5. Criterios referenciales de calidad para aguas subterráneas, considerando un suelo con contenido de arcilla entre (0-25,0) % y de materia orgánica entre (0 - 10,0)%.

Parámetros	Expresado como	Unidad	Limite máximo permisible
Arsénico (total)	As	µg/l	35
Bario	Ba	µg/l	338
Cadmio	Cd	µg/l	3,2
Cianuro (total)	CN-	µg/l	753
Cobalto	Co	µg/l	60
Cobre	Cu	µg/l	45
Cromo total	Cr	µg/l	16
Molibdeno	Mo	µg/l	153
Mercurio (total)	Hg	µg/l	0,18
Níquel	Ni	µg/l	45
Plomo	Pb	µg/l	45
Zinc	Zn	µg/l	433
Compuestos aromáticos.			
Benceno.	C_6H_6	µg/l	15
Tolueno.		µg/l	500
Estireno		µg/l	150
Etilbenceno		µg/l	75
Xileno (Suma)[1]		µg/l	35
Fenol		µg/l	1 000
Cresol[2]		µg/l	100
Hidroquinona		µg/l	400
Hidrocarburos			

The point is that it is necessary to develop procedures and technologies capable of making Ecuador small artisanal mines profitable and conducting gold mining responsibly. Small mines must start producing with a greater degree of social acceptance, generating local opportunities; the use of Mercury-Free technologies can allow the reduction of the environmental impact. Alternative technologies can be easily used on a small scale.

WP7 - Selection of Best Available Renewable Energy (BARE) for water treatment

Work Package 7 has the objective to identify and assess the best available renewable energy technology that can be used to provide the mining industry with electric and, possibly, thermal energy to reduce both the consumption of primary energy and the carbon footprint.

Task 7.1 is focused on the assessment of candidate technologies. To carry out this work, it is important to bear in mind the specific features of the two mining regions considered:

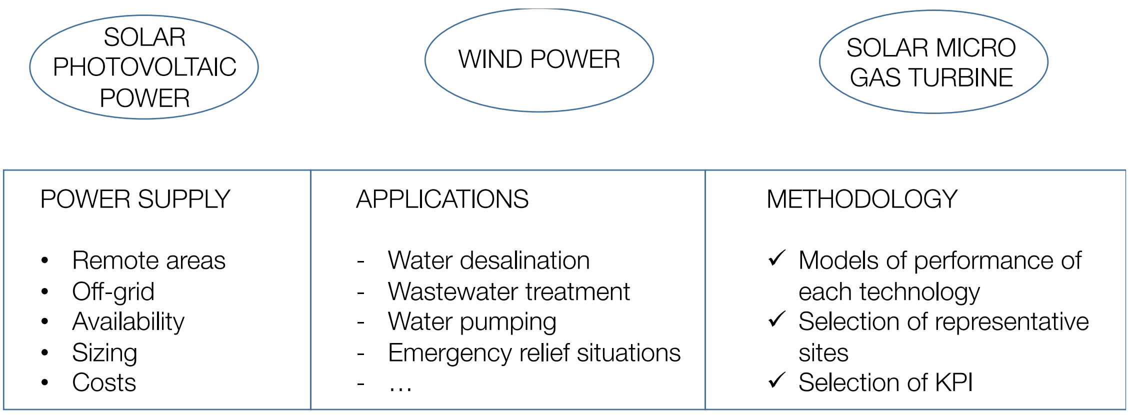
1. Ecuador, *Provincia del Oro*: the mining activity here classifies as small and artisanal which means that small power rating and portability are strong requirements, along with efficiency and overall energy utilization. Also, very importantly, the capacity of the power generation unit to provide power 24/7 without grid support is a strong requirement, given that very often the activity takes place in remote areas where access to the grid is not possible. This calls for solutions based on either fuel flexibility (hybridization) or battery storage.
2. Chile, Antofagasta: the mining activity in this region is based on very large facilities with power needs in the order of several megawatts. Portability is not a need here and neither is 24/7 supply of energy since the mining facility can rely on importing energy from the grid. Still, reductions of primary energy consumption and carbon footprint are mandatory.

With this boundary conditions, the following renewable energy technologies are taken into consideration:

a. Portable facilities based on photovoltaic panels, incorporating battery storage for (limited) extended operation.
b. Portable wind turbines, incorporating batter storage for (limited) extended operation.

c. Portable facilities based on solar micro gas turbines supported by battery storage for (limited) extended operation and enabling fuel hybridisation.
d. Mid-scale Concentrated Solar Power plants based on linear solar collectors, with or without thermal energy storage: these are considered for Chile only and do not incorporate battery storage. The output range of interest is 1 to 10 MWe.

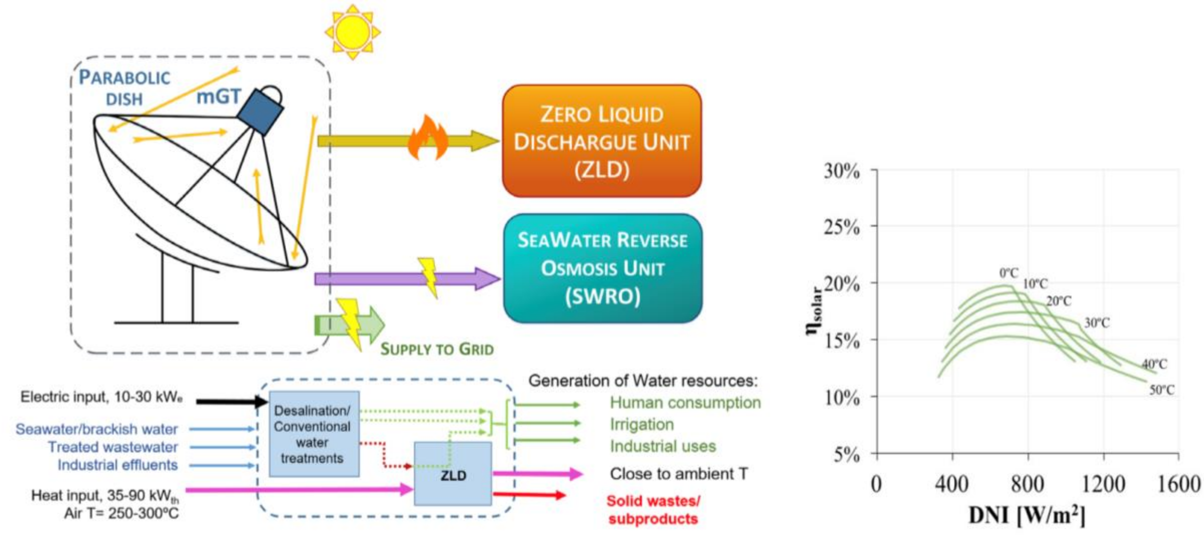
Either of the non-thermal options represents a low-cost technology with a wide range of power ratings, starting off at 0.5 kWe and scaling up easily thanks to the modularity of the technology. The installation cost of these systems is low given the high maturity and availability in the market, while maintenance costs are moderate and mostly due to the battery storage system. As a shortcoming, collection of the renewable energy source might be challenging in some areas with dense, tall vegetation.
Micro gas turbines are robust engines which have been trying to enter the market for the last twenty-five years. These engines are based on a compressor-turbine assembly coupled to a high-speed generator, a recuperator (heat exchanger) and combustor. The low firing temperature ensures virtually no NOx emissions. These engines are still not commercialized at mass scale given the somewhat high costs as opposed to reciprocating internal combustion engines but, with respect to these, micro gas turbines have the advantage of enabling solarization. This has been already demonstrated several times, with prototypes ranging from 3 kWe to 5 MWe and different type of collectors. Some of these engines have also demonstrated that it is possible to enable solar operation complemented with liquid/gas fuel combustion.
The integration of solar micro gas turbines and electrically and thermally driven processes has been studied conceptually and experimentally by University of Seville in the last five years, given the evident interest of having not only electric power production but also thermal energy available. This past and ongoing work is capitalized to support the activities carried out in REMIND.
The workflow of WP7 is presented in the schematic below. For the three technologies, boundary conditions, user requirements and specifications are set first. Then, sinergies with existing water-energy nexus applications (most notably, small-scale water desalination) is explored in order to import knowledge and existing technology into REMIND. Finally, models of performance specific to the project are developed and a systematic assessment of the different options is carried out.



A summary of the models of performance is provided below:
1. Photovoltaic: meteorological datasets for ambient temperature and pressure, global horizontal irradiance, diffuse horizontal irradiance and global radiation on a tilted surface) are taken from METENONORM v.7 in first instance, but are later complemented with data retrieved locally by the team at ESPOCH. Then, PVSyst is used to carry out performance analysis, with a focus on the daily production of electricity throughout the year.
   The first set of simulations considered have not accounted for shading of neighbouring elements, which will be considered in the next batch of analyses (for specific sites).
2. Wind power: meteorological datasets for ambient temperature and pressure as well as wind speed and direction are taken from METEONORM v.7 again. A power function based on wind speed and pole

height is implemented, accounting for cut-in and cut-off wind speeds at which the turbine starts producing power or goes into safe position due to very high wind speeds.

3. Solar micro gas turbine: for this case, a very complex design and simulation platform is used to size and model the power generation unit. This is a proprietary code developed at University of Seville in the course of development of other projects and is adapted to REMIND. Given the simgularity of the concept, this is presented in the figure below.



Schematic representation of a Solar Micro Gas Turbine (SMGT) for power generation and water treatment -left- and performance of the power conversion unit as a function of ambient temperature and solar availability -right-.

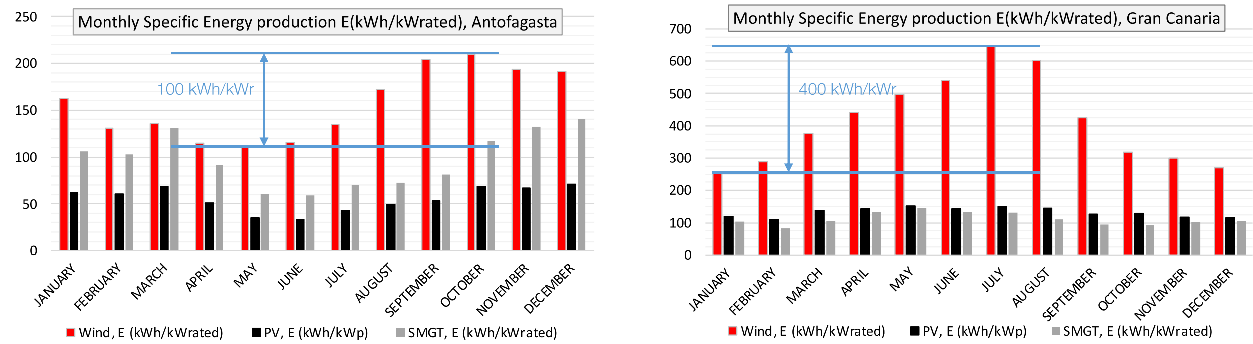
A parabolic dish collector collects solar energy that is concentrated onto a receiver coupled to a micro gas turbine at the focal point of the collector. The engine in turn produces power and a stream of hot air at ~250ºC in the exhaust. Electric power is used to drive equipment, including a reverse osmosis unit for either water desalination (in the original project) or water treatment (REMIND). Available thermal energy is used in either the mining process itself or is fed into water treatment. The model is able to size the components and to provide both design and off-design performance characteristics.

4. For larger scale Concentrated Solar Power, dedicated models of design and performance are implemented in Thermoflex, a full-flexible simmulation platform specific to the power generation industry which is currently used by University of Seville in other renewable energy projects.

All this models, hence Task 7.3, are currently complete and ready to use. The only caveat us that, for the last category, the system is tailored to the needs of the plant. Therefore, even if models of system components are already available, they are site-specific and will have to be fine-tuned at a later stage of the project.

A review of commercially available technologies (Task 7.2) is currently ongoing, to create a detailed database of systems already available in the market. This review is completed for micro gas turbines and larger Concentrated Solar Power systems and is ongoing for photovoltaics and wind turbines, given the larger number of manufacturers of the latter systems.

Task 7.4 is about assessing the different renewable technologies. Several activities have been carried out in this regard, for smaller-scale systems in either Ecuador (most likely case) but also in Chile (less likely but where a more detailed database of renewable energy sources is available). As a first step towards validation, the performance of a representative system in Antofagasta (Chile) has been benchmarked against the same system in the Canary Islands (Spain), given the representativity of this latter location for small-scale, renewable energy technologies and for water treatment processes, amongst which water desalination. This comparison is shown below:

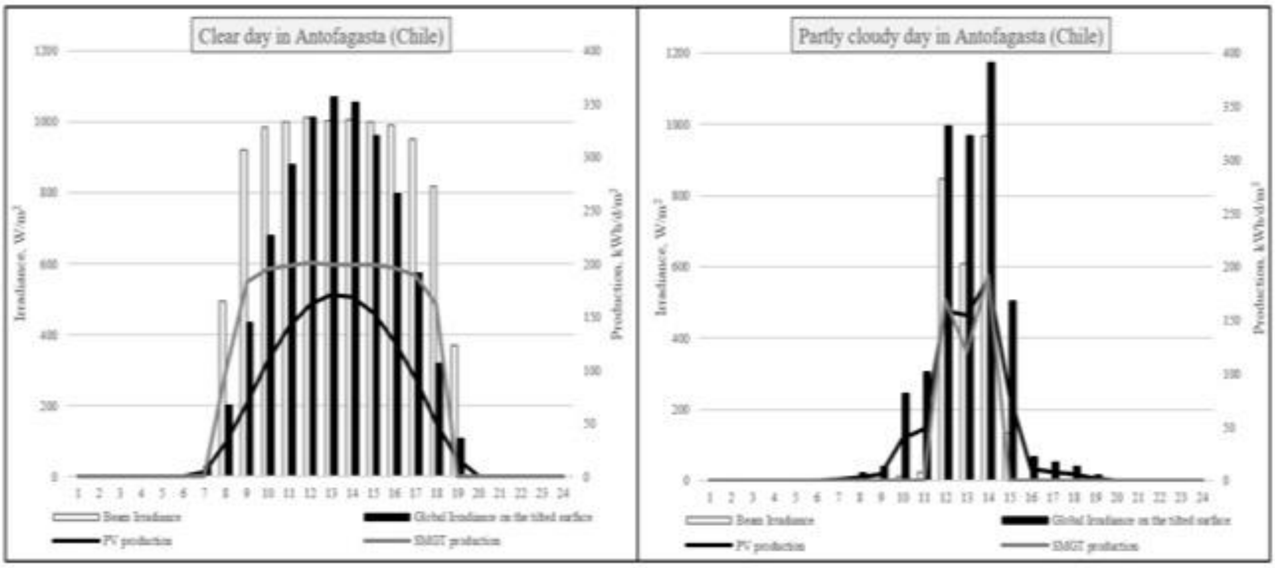


Specific Energy Production of small facilities based on wind, photovoltaic and solar micro gas turbines located in Antofagasta -left- and Gran Canaria -right- (note different scales). Data correspond to typical meteorological year.

The chart above shows Specific Energy Production SPE, defined as the energy produced in a month monthly per installed capacity: kWh per kilowatt peak. There are some noteworthy observations:

- The charts are symmetrical because Gran Canaria and Antofagasta are in the Northern and Southern hemispheres respectively.
- Wind seems to enable a lower oversizing of the system, given that SEP is much higher in either location.
- There are larger variations between the most and least favourable months in Gran Canaria. This is positive for Antofagasta since it reduces the need to oversize the system. It also enables a higher utilisation of battery storage systems throughout the year.
- Given the high normal irradiance in Antofagasta (latitude and elevation are favourable), solar micro gas turbines seem to represent a very interesting option in this location. Interestingly, for this location, photovoltaic systems are less interesting.

The results in the foregoing chart are monthly aggregates, what is interesting for systems connected to the grid. For off-grid systems though, the power generation system must supply energy continuously and, therefore, hourly analyses are mandatory. A sample of this for PV vs. SMGT in the same reference location (Antofagasta) is illustrated below, showing that solar SMGTs outperform PV in clear days but the opposite is true when skies are hazy. This is because hazy skies reduce the amount of direct irradiance drastically, hence favoring the operation of those power generation systems able to harvest diffuse radiation.



Energy production (kWh/d/m²):				
	- PV:	1298.1	- PV:	707.1
	-Solar mGT:	2021.9	-Solar mGT:	481.0

Task 7.4 on the selection of Best Available Renewable Energy technologies is ongoing, since this requires techno-economic assessments for specific locations. This is the object of upcoming secondments and site visits to Latin America. On the other hand, a recent secondment carried out by personnel of University of Seville at University of Antofagasta has launched the analysis of larger-scale facilities in Chile. Site visits have confirmed the interest of mining companies and the margin for reducing primary energy consumption and increasing the share of renewable energy sources.
Task 7.5 has not been started yet, except for the planning phase. University of Calabria is currently evaluating the modifications of their existing facilities at the laboratory to accommodate the tests with hollow fiber membranes.

WP8 - Design of the industrial layout to reuse the process water in the mining activities

The activities of WP8 have not been initiated yet given the aforelisted causes hindering the development of the project before the pandemic. The three tasks in the work package will be launched simultaneously in June 2023.

WP9 - Impact, exploitation, standardization & dissemination progress

The activities carried out in WP9 aim at implementing regular, engaging, and innovative European wide dissemination to identified target audiences to maximize the impact of the results and benefits from the REMIND project.
Project **website** is active at url: https://www.remindproject.eu/ and it is regularly updated with relevant content, including dissemination activities. Following the decisions taken at the MDM, info (official logo, short description of the University/Company/Research Center and link to the official website, contact) about new REMIND partners [Universidad de Antofagasta (UANTOF), Federico Santa María Technical University (UTFSM), Circular Water Technologies AB (CWT), Canary Islands Institute of Technology (ITC)] have been collected by the Coordinating Institution and are going to be integrated in the relevant webpages [Task 9.5].
The proactive use of **social media** platforms aims at increasing the visibility of REMIND project; communication of the technological concepts, research advancements and main results are being channeled by:

	https://m.facebook.com/profile.php?id=100068824202151&eav=AfYtYhIsgQ-nebkiBjzAiv0fOPg8tGo9LHd9hEIc-L9rZB0LcyJWCo411IkhVFM5m08&paipv=1&_rdr
	https://www.instagram.com/remindproject_eu/
	https://twitter.com/RemindprojectE

A new version of the project **flyer** was designed and printed.

Among the other communication activities planned, following the decision taken during the MTM, a project poster was exposed within a dedicated EU corner during the **European Researchers' Night** at University of Calabria, Italy (H2020 MSCA- NIGHT "SuperScienceMe", September 30, 2022 - >10,000 visitors).

According to activities planned in Task 9.1, project results were presented to the international conference SIDISA 2020 "XI International Symposium on Environmental Engineering" – held and conducted by physical attendance in Turin (Italy) on June 30-July 3, 2022, despite the persistence of Covid pandemic emergency. Deliverable 9.2 will collect the proceedings of international conferences in Europe and Latin America.

Below a summary of main dissemination activities implemented within REMIND project:

ACADEMIC PAPERS (With acknowledgement to REMIND project)	Sergio Santoro, Humberto Estay, Ahmet H.Avci, Lorenzo Pugliese, René Ruby-Figueroa, Andreina Garcia, Marco Aquino, Shahriyar Nasirov, Salvatore Straface, Efrem Curcio. Membrane technology for a sustainable copper mining industry: The Chilean paradigm. Cleaner Engineering and Technology 2 (2021) 100091 Sergio Santoro, Paola Timpano, Ahmet Halil Avci, Pietro Argurio, Francesco Chidichimo, Michele De Biase, Salvatore Straface, Efrem Curcio. An integrated membrane distillation, photocatalysis and polyelectrolyte-enhanced ultrafiltration process for arsenic remediation at point-of-use. Desalination 520 (2021) 115378 Carlos Mestanza-Ramón, Demmy Mora-Silva, Giovanni D'Orio, Enrique Tapia-Segarra, Isabel Dominguez Gaibor, José Fernando Esparza Parra, Carlos Renato Chávez Velásquez, Salvatore Straface. Artisanal and Small-Scale Gold Mining (ASGM): Management and Socioenvironmental Impacts in the Northern Amazon of Ecuador. Sustainability 14/11 (2022) 6854 Carlos Mestanza-Ramón, Jefferson Cuenca-Cumbicus, Giovanni D'Orio, Jeniffer Flores-Toala, Susana Segovia-Cáceres, Amanda Bonilla-Bonilla, Salvatore

	Straface. Gold Mining in the Amazon Region of Ecuador: History and a Review of Its Socio-Environmental Impacts. Land 11/2 (2022) 221 Carlos Mestanza-Ramón, Robinson Ordoñez-Alcivar, Carla Arguello-Guadalupe, Katherin Carrera-Silva, Giovanni D'Orio, Salvatore Straface. History, Socioeconomic Problems and Environmental Impacts of Gold Mining in the Andean Region of Ecuador. Int J Environ Res Public Health 19/3 (2022) 1190 Carlos Mestanza-Ramón, Selene Paz-Mena, Carlos López-Paredes, Mirian Jimenez-Gutierrez, Greys Herrera-Morales, Giovanni D'Orio, Salvatore Straface. Istory, Current Situation and Challenges of Gold Mining in Ecuador's Litoral Region. Land 10/11 (2021) 1220
WORKSHOP	Title: «CIRCULAR ECONOMY AND SUSTAINABLE DEVELOPMENT» Date: October 17, 2019 Location: University of Calabria Number of participants: >50
SEMINARS (10-20 participants)	March 15, 2019. Mobility: UNICAL>UAI (Chile) March 21, 2019. Mobility: UNICAL>ABB (Chile) March 22, 2019. Visit: UNICAL>Universidad Tecnologica Metropolitana (Chile) October 9, 2019. Mobility: UAI>UNICAL (Italy) January 21, 2020. Mobility: UAI>UNICAL (Italy) June 22, 2022. Mobility: ESPOCH>UNICAL (Italy)
REPORTS & RECOMMENDATIONS	Carlos Mestanza-Ramón, Giovanni D'Orio, Salvatore Straface. Gold mining in Ecuador: Innovative recommendations for the management and remediation of mercury-contaminated waters. Green World Journal https://doi.org/10.53313/gwj42028 *Objective: describe techniques and strategies to improve the management and treatment of mercury in gold extraction processes, applying a bibliographic review to reduce its impact on the natural environment*

According to Task 9.2, REMIND project aims to create and **establish an international research network** to exploit synergies and amplify collaborative efforts beyond the duration of the project itself. Fruitful interactions with colleagues from University of Chile, originated as a fallout of secondments of UNICAL researchers in Chile, resulted in the collaborative project PIA CONICYT n° AFB180004 "Development of membrane separation processes applied to mining issues" funded by the Ministerio de Educacion – Gobierno de Chile. (2020-2022). Moreover, the scientific experience maturated in REMIND consolidated the technological background of UNICAL in view of its participation to the H2020-SC5-2019-2 "SEA4VALUE: Development of radical innovations to recover minerals and metals from seawater desalination brines" (Grant Agreement n. 869703).

Conclusions and outlooks

Presently, the delays in the full development of the Secondment plan and Deliverables are mainly due to difficulties emerged on two fronts: 1) internally to the institutions partner of the project, having an organizational nature; 2) externally, having a socio-economic nature. About the former, the greatest mishaps occurred during the recruitment of ERs and/or ESRs secondees. The cause is twofold: i) as far as ERs are concerned, teachers and researchers were hindered in carrying out long-term mobility abroad due to their numerous teaching obligations, and ii) as regards ESRs' mobility, the main problem occurred due to the difficulty in defining the "link" between the sending Institution and the ESR to be sent in secondment. With respect to this second problem, there have been many exchanges of information between the institutions, the PO and the Italian National Contact Point to resolve this delicate issue. Only in the last few months have these conditions been clarified for ESRs to go in secondment, but this difficulty in identifying these criteria has obviously led to a delay in the implementation of activities and secondments by ERS.

In addition to these problems internal to the functioning of the institutions, there were several difficulties encountered in the individual countries of Chile and Ecuador, as below detailed.

Corrective measures for Chile

Concerning Chile, the greatest difficulty was encountered in identifying mines in the Antofagasta region that could be considered as a Pilot-Site according to the provisions of REMIND. The difficulty is due to the unwillingness by the mining Companies to cooperate within a research project having as main objective the use of renewable energies and the modification of the production layout both as regards the electricity supply and wastewater treatment and reuse. This analysis is viewed with diffidence by the Company as it could lead to an increased concern of population about the environmental safety of mining activities, to a limitation of current resource-intensive practices and, ultimately, to a lower profit. During the various secondments carried out in Chile, some companies which manage the copper mines in the Antofagasta region were contacted through the Italian Chamber of Commerce in Chile and the Adolfo Ibanez University of Santiago. However, there was no possibility of visiting any mine or identifying one for the purpose of the project. However, through contacts between Italian researchers from the Polytechnic of Turin with researchers from the University of Antofagasta, it was possible to activate a profitable communication channel with the Mantos de la Luna Company which operates several mines in the Antofagasta region. This company has allowed us to visit the Mantos de la Luna mine, in the Antofagasta region, and given maximum willingness to study to apply our research on this all the mines. All this happened with the help of the University of Antofagasta which also holds a lot of data on the environmental impact of the Antofagasta region mines, so, as corrective measure, we have included the University of Antofagasta as a project partner.

Corrective measures for Ecuador

Regarding Ecuador, corrective measures have been discussed with Espoch (a partner of REMIND) leading representatives. It is now clear that, in order to fulfil the action's objectives, it will be necessary to devote fresh new resources to : a) internal mobility from Espoch to mining districts and field sampling of water sources and reserves, both of surface and subsurface types, including oceanic areas and mangroves; b) investing in lab hardware and software (whenever needed) specifically required to analyse sample concentrations of Hg and other heavy metals caused by gold mining extraction; c) promote an innovative policy of recruitment of more researchers and technicians involved in the action, which requires a change of labour and bureaucratic approach by Espoch: researchers and personnel, presently burdened with 40-hours weekly teaching, can hardly devote themselves to the action's scientific performance and mobility schedule without risking not delivering the deliverables in time. In this respect, corrective measures have been partially implemented. Despite this unfavourable situation, Ecuador and its El Oro Province represent a huge opportunity for scientific study and deliverance.

However, since these protests have not yet fully returned, the REMIND project partners are concerned for their development and monitoring the protests to assess the risks associated with the secondments expected in the coming months in the partner institutions of Chile and Ecuador. In fact, while on the one hand the socio-economic conditions in Chile and Ecuador have prevented some secondments and therefore research activities of the REMIND project, the persistence of these conditions could lead to the impossibility of realizing the next secondments.

COVID-19 Pandemic

As COVID-19 pandemic wave hit Europe since March 2020, due to the aggressive evolution of the infection, consequent lockdown measures and travel restrictions, REMIND project was suspended. As of the date of the suspension - June 10, 2020 – 41,53 secondment months were carried out within the project, i.e. 31.23% of the planned 133 secondment months.

Overall, these difficulties prevented the completion of the secondment plan in coherence with the Grant Agreement: the project was suspended on June 2020, and an extension has been granted until the end of February 2022.

In order to fulfil the originally planned objectives of REMIND, along with the request of resumption with effect from 1st March 2022, we asked for an 18 month extension of the project duration and the following modifications to Consortium and secondment plan, to be formalized by an amendment to the Grant Agreement:

- Strengthening the scientific and technological capacity of the project, and promoting the diversification of mobilities in partner Countries, through the entry of four new partners in the REMIND Consortium:
    - Universidad de Antofagasta (UANTOF) is a public University. The Antofagasta Region is one of the two demonstration sites of REMIND and this University holds a lot of data on the environmental impact of the Antofagasta region mines.
    - Federico Santa María Technical University (UTFSM) is a Chilean university founded in 1926 in Valparaíso, Chile. In this University, the potential for achieving more sustainable copper production in Chile by means of analysing circularity measures is thoroughly investigated.
    - Circular Water Technologies AB (CWT) is a spin off company from Scarab group dedicated to providing solutions to industries with demand of water purification, including heavy polluted waters originated at mining plants
    - Canary Islands Institute of Technology (ITC), is a Technology public body of the Regional Government of the Canary Islands from 1992. The Institute carries out projects and services in the areas of Research, Development, and Innovation, and has 25 years' experience developing know-how and technology in renewable energies.

The plan of secondments has been revised as:

- some Third Countries partners in Chile and Ecuador are still unable to host international visitors due to national COVID-19 restrictions;
- some beneficiaries are subjected to local social distancing requirements, restricting the number of researchers that can be hosted;
- new beneficiaries join the Consortium.

Specific details of the re-distribution of seconded person months are:

- Beneficiary UNICAL: 12 person months transferred to Partner UTFSM; 4 person months transferred to Partner UANTOF.
- Beneficiary USE: 5 person months transferred to Partner UANTOF; 5 person months transferred to Partner UTFSM
- Beneficiary POLITO: 10 person months transferred to Partner UANTOF
- Beneficiary RINA: 5 person months transferred to Beneficiary CWT

The total number of secondments to realize will remain the same, but their distribution will change as follows:

- Beneficiary UNICAL - from 86 to 70
- Beneficiary USE - from 31 to 21
- Beneficiary POLITO - from 53 to 43
- Beneficiary RINA - from 12 to 7
- Beneficiary CWT – from 0 to 5
- Beneficiary ITC – 0 (no PM)
- Partner ABB – 30 (no changes)
- Partner CAMIT – 31 (no changes)
- Partner ESPOCH – 23 (no changes)
- Partner UAI – 23 (no changes)
- Partner UANTOF – from 0 to 19
- Partner UTFSM – from 0 to 17

This redistribution has been proposed with the aim to credibly achieve the project goals and to accomplish pending reports and deliverables. The revised secondment plan includes:

- changes in the staff: some researchers originally assigned to undertake the secondments are currently no longer within the Institution concerned, or they are on parental leave etc., while new researchers are included.
- lack of availability for some staff members originally envisaged to undertake the secondments, due to concerns on travel restrictions due to COVID-19.

Nevertheless, if If the COVID-19 pandemic wave will hit Europe and South America, with consequent lockdown measures and travel restrictions again, the persistence of these conditions could lead to the impossibility of realizing the next secondments and in this case, it will be necessary to evaluate, together to the European Commission the corrective actions to be taken so that the research envisaged by the project can still be carried out.

Annex 1: Mid-Term meeting Agenda

Grant Agreement 823948
Marie Sklodowska-Curie Actions (MSCA)
Research and Innovation Staff Exchange (RISE)
H2020-MSCA-RISE-2017

REMIND Project

Renewable Energies for water Treatment and Reuse in Mining Industries

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Mid-Term Meeting

Agenda

August 29-30, 2022
AMANTEA (CS) ITALY

Agenda

Sunday, 28th August 2022	
21:30	Dinner at LIDO MEDITERRANEO Lungomare Amantea

Monday, 29th August 2022		
Time	Action	Speaker
9:00	Welcome	
9:30	Project Management & Coordination (WP2) - Resumption of REMIND project - New Consortium composition - Project overview, present status and outlook	Project coordinator
	- Revised secondment plan	Technical coordinator
10:30	Message from PO	Project Officer
11:00	Coffee break	
11:20	WP3 progress - Summary of activities implanted and planned in WP3 - Status of deliverables & milestones - Technical discussion	WP3 leader
12:00	WP4 progress - Summary of activities implanted and planned in WP4 - Status of deliverables & milestones - Technical discussion	WP4 leader
12:45	Group photo	
13:00	Lunch	
15:00	WP5 progress - Summary of activities implanted and planned in WP5 - Status of deliverables & milestones - Technical discussion	WP5 leader
15:40	WP6 progress - Summary of activities implanted and planned in WP6 - Status of deliverables & milestones - Technical discussion	WP6 leader
16:20	Coffee break	

16:45	WP7 progress - Summary of activities implanted and planned in WP7 - Status of deliverables & milestones - Technical discussion	WP7 leader
17:15	WP8 progress - Summary of activities implanted and planned in WP8 - Status of deliverables & milestones - Technical discussion	WP8 leader
17:45	Bilateral meeting between Project Officer and three Researchers/Secondees of REMIND	Project Officer
18:30	End of first day	
20:30	Social Dinner	

Agenda

Tuesday 30th August 2022		
Time	Subject	Speaker
9:30	Technical reporting: procedure	Project coordinator
10:00	WP9 progress - Summary of activities implanted and planned in WP9 - Status of deliverables & milestones - Technical discussion	Scientific Coordinator
11:00	Coffee break	
11:20	Joint Discussion - Organizational aspects - Financial Aspects - Decisions and Actions	Chaired by Project Coordinator
13:00	Lunch	
14:30	Excursion in Pizzo Calabro (VV)	
20:30	Dinner	