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A new approach on Sustainable Remediation for land management in a circular economy

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** Eni Rewind S.p.A. ** Fondazione Università Ca' Foscari *** GreenDecision s.r.l.*

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Eni Rewind at a Glance

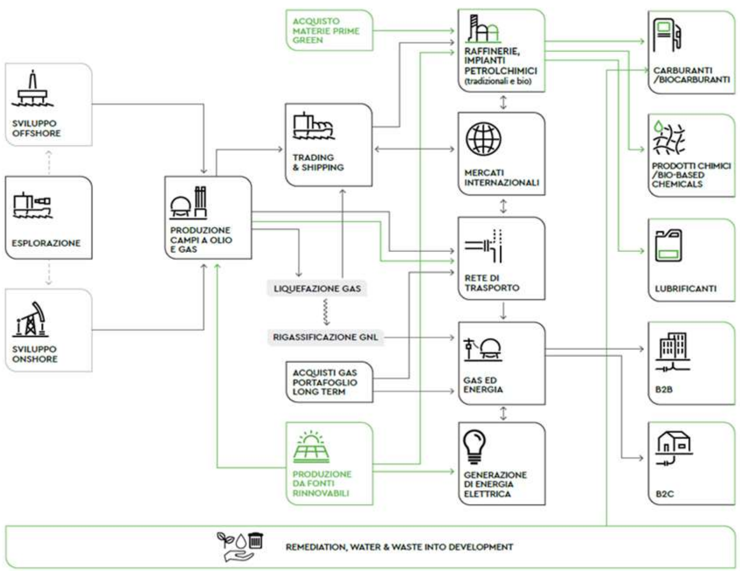
> 80
nr. of sites environmentally managed

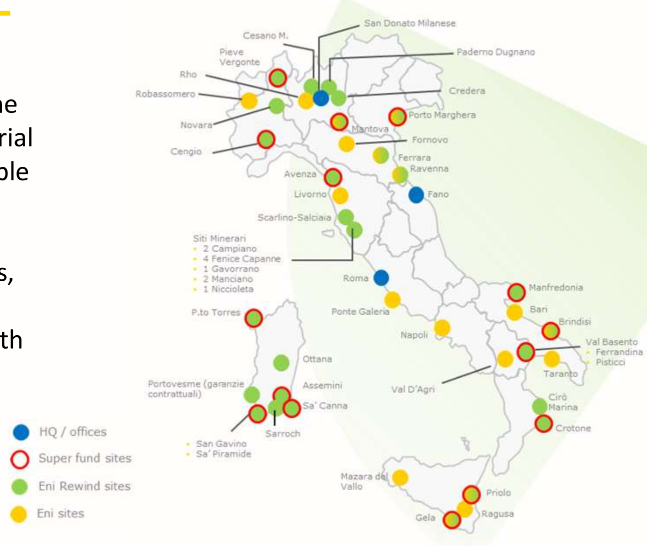
~ 1000
employees

3B€
spent in environmental interventions

We are Eni's environmental company.
We work according to the principles of the circular economy to give new life to industrial land and waste through efficient, sustainable remediation and revaluation projects.
We base our work on passion, skills and technological research to regenerate soils, water and recoverable resources.
We believe in dialogue and integration with the communities that host us.

Eni Value Chain





As of 2018, Eni Rewind has made available its expertise to Eni foreign subsidiaries, providing support in environmental engineering and management

REMEDIATION

~ 800 operative work sites
2000 ha of reclamation interventions

WATER

42 water treatment plants managed
> 30 Mm³/y treated water
1 Control room H24 7/7

WASTE

~ 2 M/y tonnes of industrial and remediation waste managed

DEVELOPMENT

400 ha destined to repurposing
(Eni programme for renewables in Italy: solar/wind parks)
Redevelopment initiatives
(Ravenna Progetto NOI)
Waste to Fuel
Eni proprietary technology for the transformation of OFMSW into bio-oil and water

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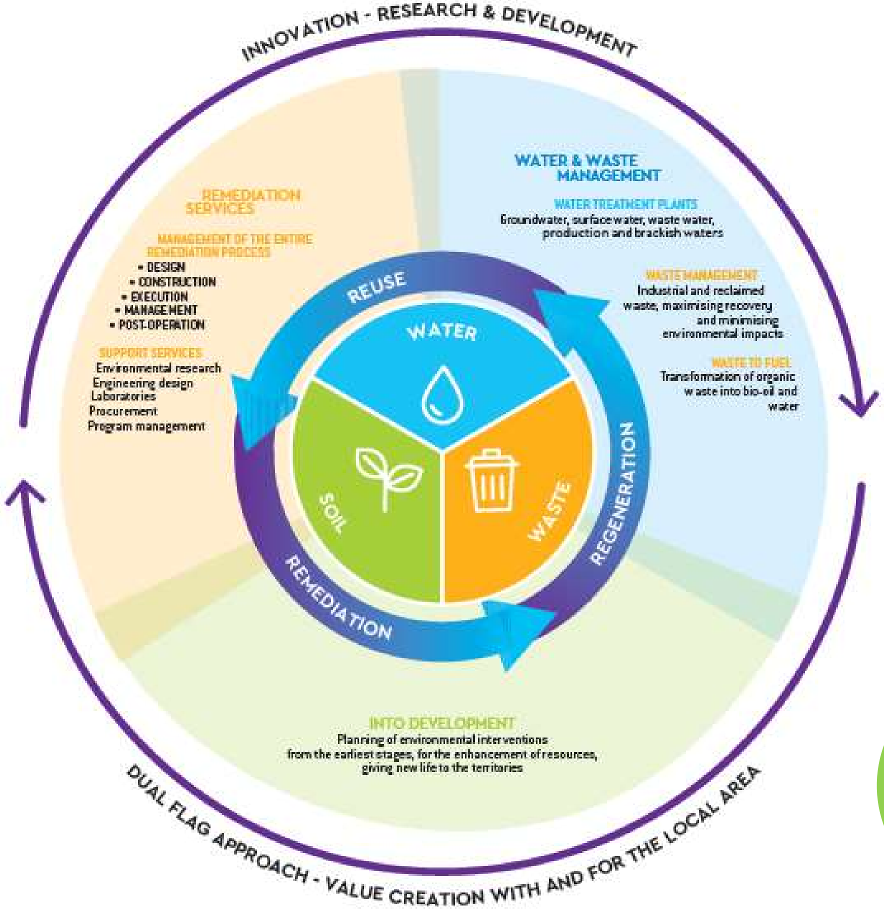
Eni Rewind – Integrated End-To-End Operating Model

Eni Rewind provides an integrated service in the field of environmental remediation as well as of water & waste management, covering the entire project cycle.

Collaboration with Universities: MIT (USA), Polytechnic of Milan, Polytechnic of Turin, Cà Foscari of Venice, University of Bologna

~ 700.000 hrs/yr of environmental engineering

3 in-house certified laboratories



Treatment of c. **32 million m³/yr** of water (hydraulic barriers and industrial and urban wastewater)

Sites returned to local communities for re-use / investment

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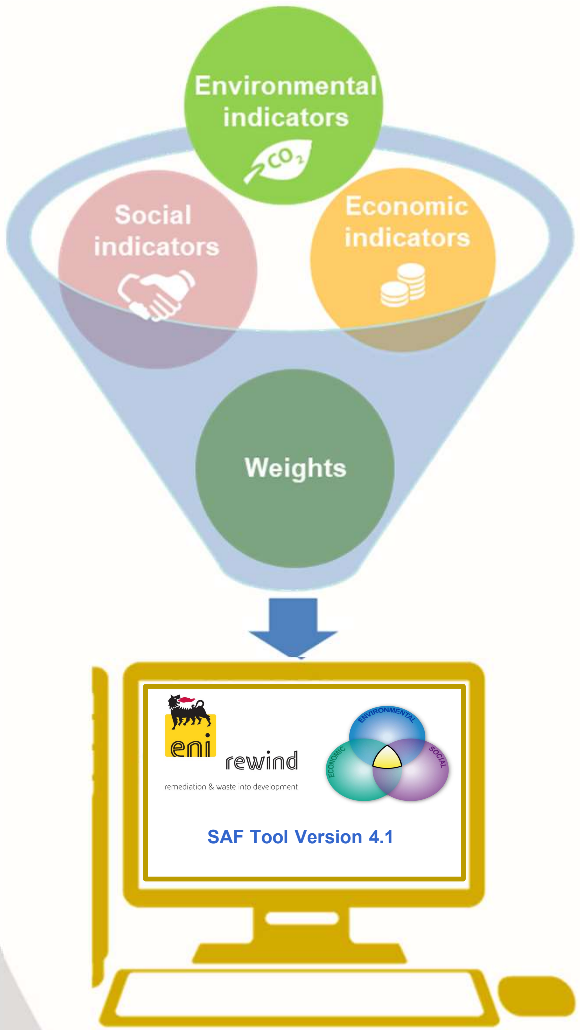
Circular Economy and Sustainable remediation

Soil can be considered a non-renewable resource, as processes such as its formation and the recovery of soil quality are extremely slow (Breure, Lijzen and Maring, 2018). Remediation processes can bring contaminated soils to a new life, giving them back to the local community, implementing the circular economy principles. However, remediation processes must include a sustainability assessment of the proposed remediation alternatives in order to demonstrate the minimisation of environmental, economic and social aspects.

Sustainability assessment of remediation alternatives



***Sustainability applied to remediation**: «a process for management and remediation of a contaminated site, aimed at identifying the best solution, that maximizes the benefits of its implementation when considering environmental, social and economic factors, through a balanced decision process, agreed by stakeholders» (SuRF Italy, 2015)*

Objectives of sustainable remediation:

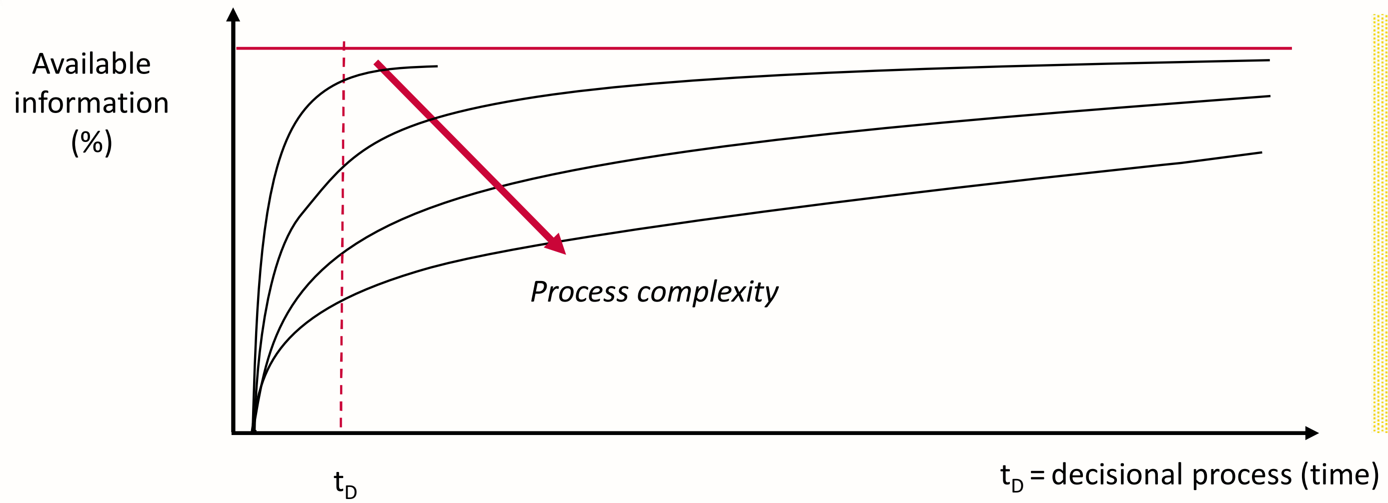
- ✓ *Optimize the management process of remediation interventions mitigating environmental, economic and social impacts.*
- ✓ *Safeguard natural and energy resources.*
- ✓ *Promote the process of remediation of contaminated sites.*
- ✓ *Create economic development*

Eni Rewind has developed a decision-making tool (**Sustainability Assessment Framework Tool – SAF Tool**), to perform **Multi-Criterial Analysis** and compare different remedial alternatives based on sustainability criteria. SAF uses environmental, economic and social indicators and weights which are selected considering site specific conditions and priorities.

Life Cycle assessment (LCA) applied to remediation (1/2)

LCA – ISO 14040	Quantification of the environmental impacts of a remediation project	Simplified procedures
• SimaPro • Gabi • OpenLCA • Umberto • ……………		• Spreadsheet for Environmental Footprint Analysis (SEFA) developed EPA • SiteWise developed by NAVFAC et al. • Sustainable Remediation Tool (SRT) developed by AFCEE • ………………..

Life Cycle assessment (LCA) applied to remediation (2/2)



LCA can be a very demanding evaluation methodology and can take a long time, especially when applied to complex situations.

Objective: To achieve reliable results in a time suitable for the decision making processes, based on ISO guidelines, and to develop a suitable tool which is applicable to the Italian and European context.

Feasibility

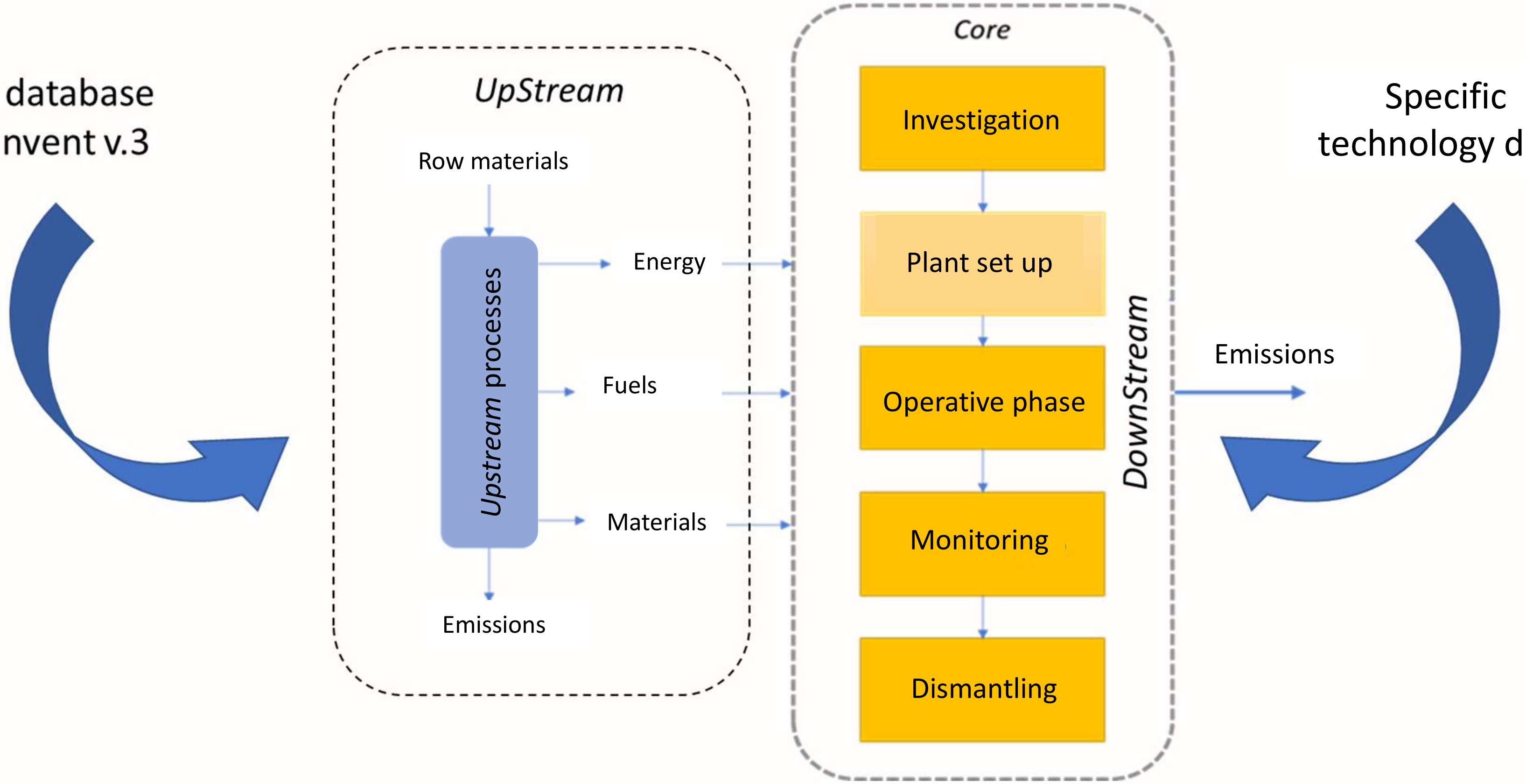
Reliability

Collaboration between Eni Rewind and Ca' Foscari University

- *Objective*: *to include the principles of LCA (ISO 14040 standard series) in the analysis of the environmental impacts associated to the different remediation technologies through the development and application of a tool to assess the specific impacts of the remediation technologies according to information on the Italian and European context (technologies and energy resources).*

LCA model applied to remediation technologies

LCA database
Ecoinvent v.3



Specific
technology data

Environmental Product Declaration, Product Category Rules (PCR)for “Site remediation and clean up services, soil and groundwater” (EPD, 2019).

Processes included in the model

UPSTREAM

- *Production of fuels, heat and electricity supply*
- *Extraction, transport and refining of materials and components used in the core processes (concrete, gravel, piping)*
- *The manufacturing of the primary and secondary packaging used for components needed for the service*
- *Transports needed for the upstream processes*

CORE

- *External transportation to the core processes*
- *Remediation plant setup and dismantling*
- *Equipment installation and dismantling*
- *Storage*
- *Operation of the service*
- *Maintenance of buildings more frequent than every three years*
- *Chemicals and consumables (oxidants, active carbon) used in the core processes*
- *Business travel of personnel, if relevant*
- *Waste treatment of waste generated in the core processes;*
- *Impacts due to the electricity production according the proper energy mix hypotheses*
- Monitoring
- Post remediation

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Simplified LCA software - structure

Technologies

Solutions for the removal of contaminants (e.g. thermal desorption)

Components

Processing stages that compose the technologies, a component can be used in different technologies (e.g. excavations)

Elements

Single operations included in the components, an element can be used in different components (e.g. excavator)

Input classes

Each element is quantified by selecting its quantitative class (e.g. LOW, MEDIUM, HIGH)

LCA Processes

Processes in the Ecoinvent LCA database that can be linked to specific elements and classes (e.g. diesel, burned in building machine)

Impacts

Impacts are estimated on the basis of the selected classes and corresponding LCA Processes values

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Simplified LCA software - use

Thermal desorb. ▼

- Dig & Dump
- Pump & treat
- Soil Washing

Technologies selection

- Excavation
- Backfilling [X]
- Transport [X]
- Extraction and draining system [ ] [X]
- Interconnecting [ ]

Components selection

Excavator	High ▼
TIR	Low ▼
Pipelines	Medium ▼

Elements classification

Indicators	Impacts
Global warming	22
Freshwater ecotoxicity	45
Particulate matter	12
Marine ecotoxicity	78

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Case study application

- *Contaminated site with metals/metalloids and persistent organic pollutants (approx. 650,000 m^3 excavation of contaminated soil).*
- *Comparison of remediation alternatives using SAF-tool, i.e. through the evaluation environmental, social and economic:*

1. DIG & DUMP
2. THERMAL DESORPTION
3. REMEDIATION WITH MISP

- *Use of weights for the integration of sustainability aspects:*

Environmental Footprint Reduction: 40%	Social acceptability: 40%	Economic viability: 20%

Case study application- Environmental Footprint Reduction

Environemental indicators included in SAF 4.1 which are estimated by LCA are:

Mineral resources scarcity (t Cu eq)	**Water use (m^3)**
Fossil resource scarcity (t oil eq)	**Terrestrial acidification (kg SO_2 eq)**
Climate change (t CO_2 eq)	**Photochemical ozone formation (kg CFC11 eq)**
Cumulative Energy Demand (MJ)	**Fine particulate matter formation (t)**

<u>Modelling intervention alternatives and data collection for LCAs</u>

E.g. Alternative 3: Soil washing with MISP

For each technology the relevant components (individual processing stages) are identified and for each of them information is collected on PRIMARY DATA to be used in the LCA analysis.

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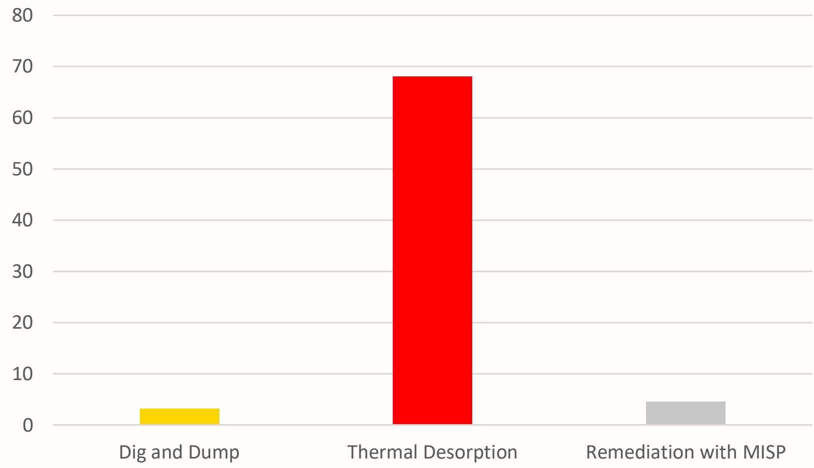
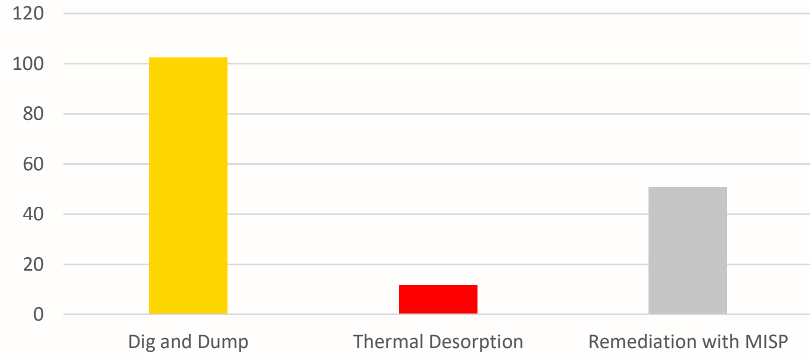
LCA Results (1/3)

Mineral resources scarcity (t Cu eq)



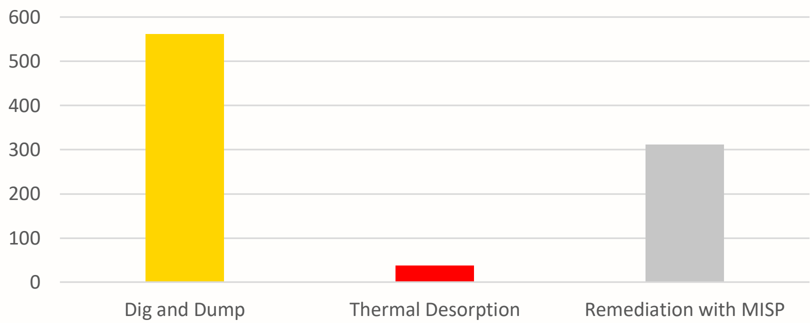
ReCiPe method

Fossil resource scarcity (t oil eq)



ReCiPe method

Climate change (t CO_2 eq)



ReCiPe method

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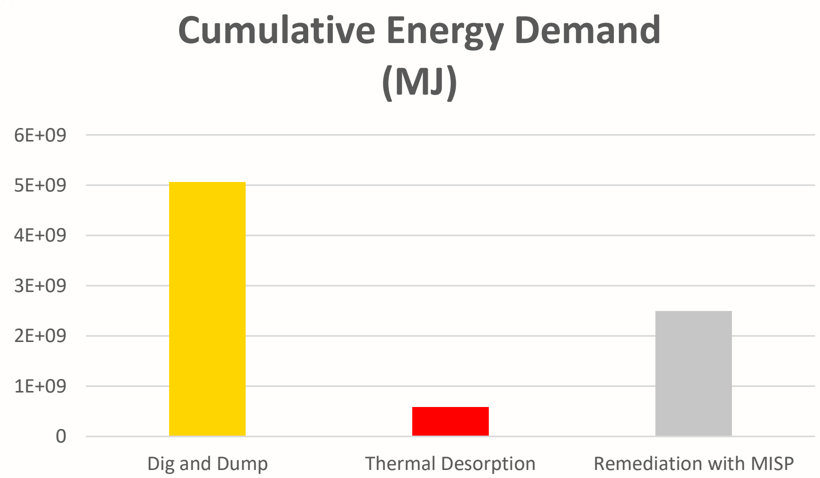
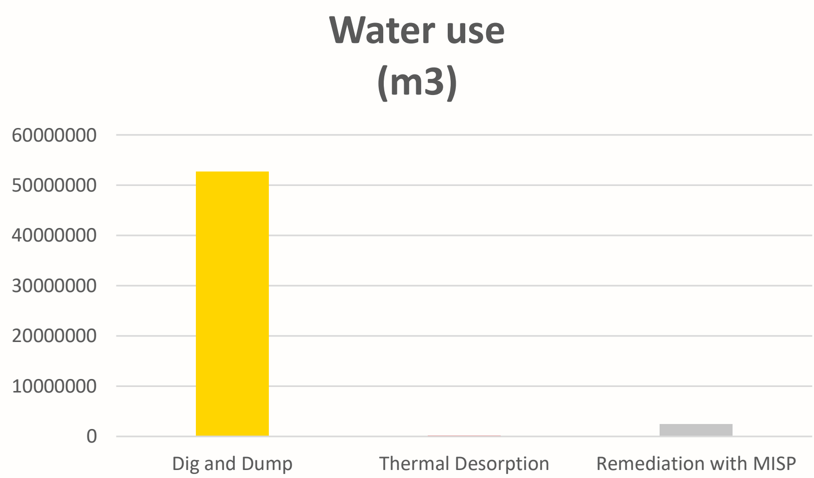
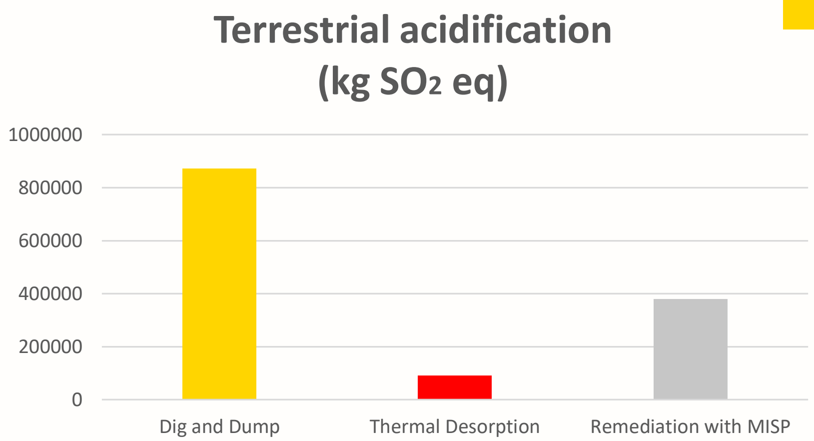
LCA Results (2/3)





ReCiPe method



ReCiPe method

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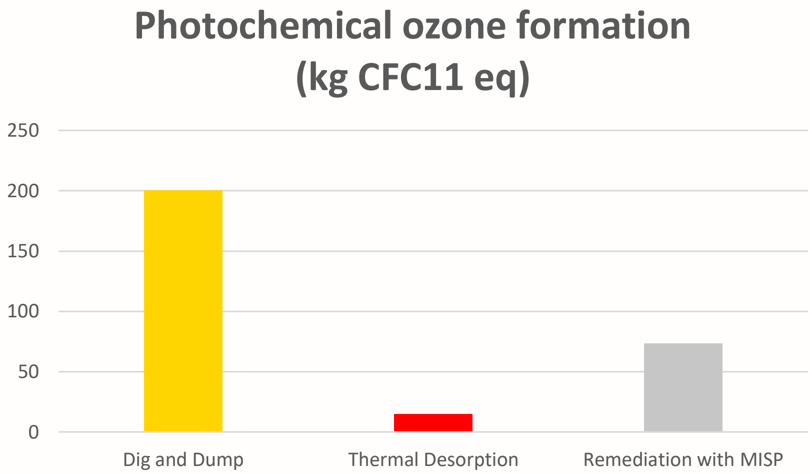
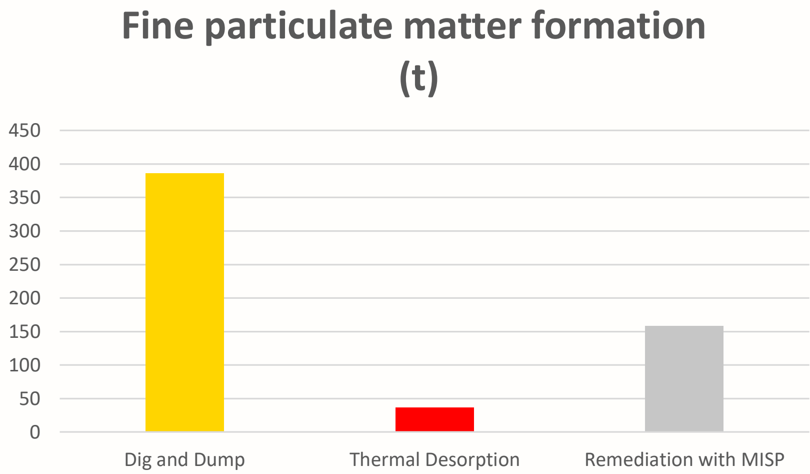
LCA Results (3/3)



ReCiPe method



ReCiPe method

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Conclusions

- *Circular Economy is a driving factor to correctly approach the remediation of contaminated sites.*
- *To this end, Eni Rewind "is committed to identifying the most sustainable remediation alternative" that is able to combine the protection of human health and the environment with social and territorial aspects.*
- *Eni Rewind has developed a decision support tool (SAF) to compare remediation alternatives on the basis of environmental, social and economic indicators.*
- *A simplified Life Cycle Analysis (LCA) has been implemented in SAF to quantitatively estimate the environmental impacts of remediation alternatives.*
- *The methodology for the Life Cycle Analysis has been applied to a case study demonstrating that the use of LCA indicators helps the in-depth analysis of technological solutions.*

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Thank you for the attention

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remediation & waste into development

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