

MINING THE FUTURE

UNTERSUCHUNGEN ZUR TUNNELAUSBRUCHVERWERTUNG AM BEISPIEL DES FUTURE CIRCULAR COLLIDER AM CERN

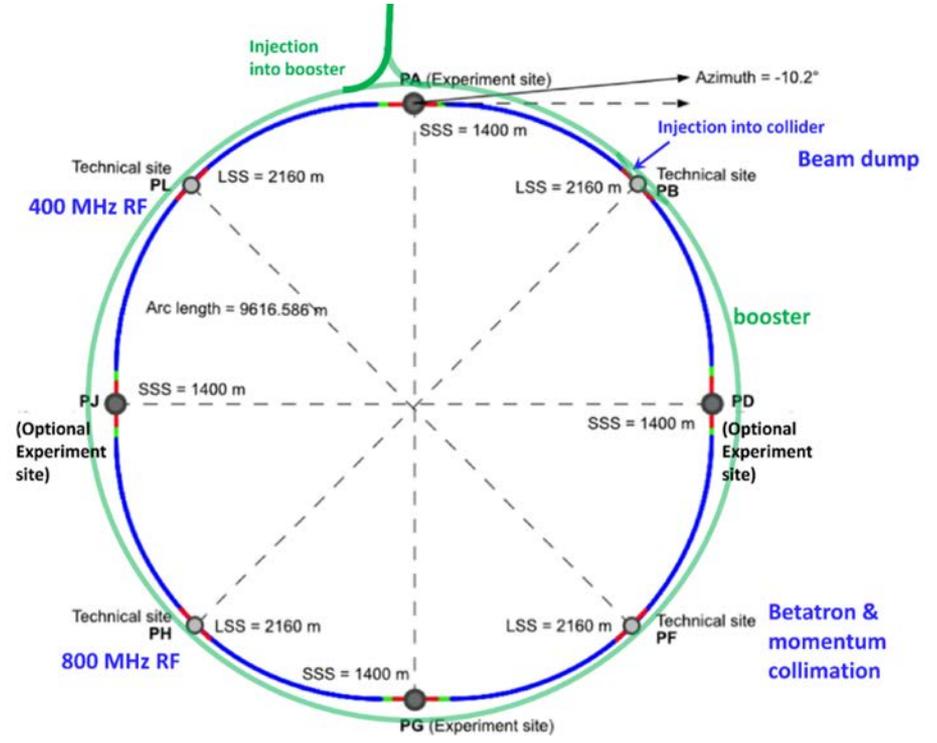
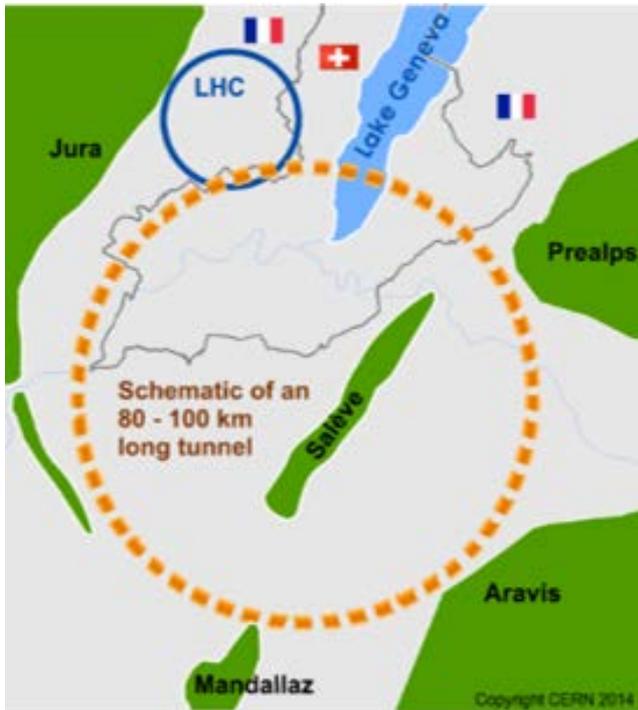
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Lehrstuhl für Subsurface Engineering und Department ZaB-Zentrum am Berg, Montanuniversität Leoben

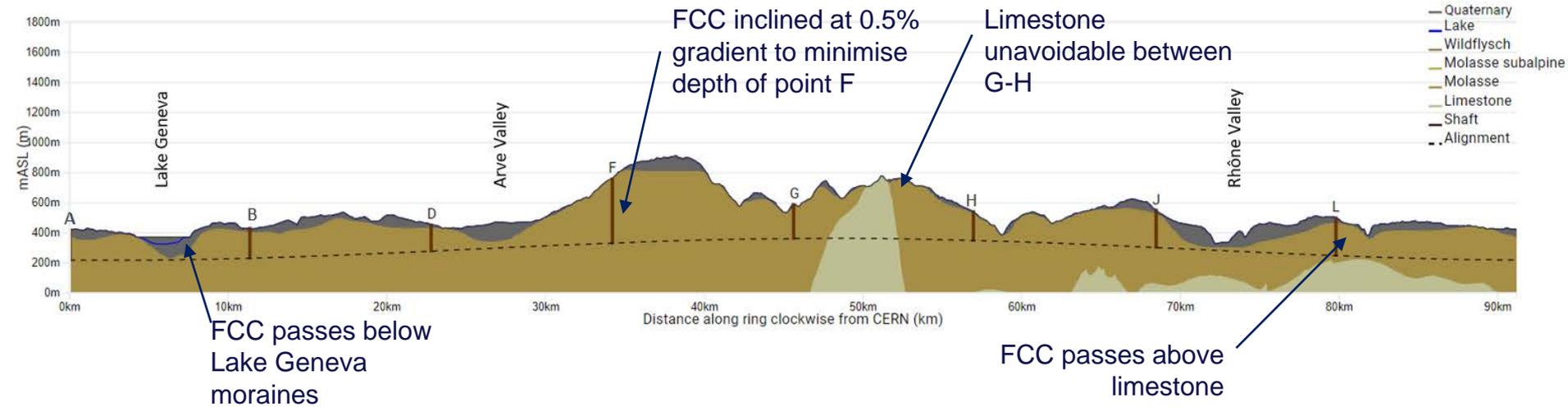


This project has received funding from the European Union's Horizon 2020 research and innovation programme under the European Union's Horizon 2020 research and innovation programme under grant agreement No 951754.

FCC Future Circular Collider – the principle layout



FCC tunnel – geological conditions

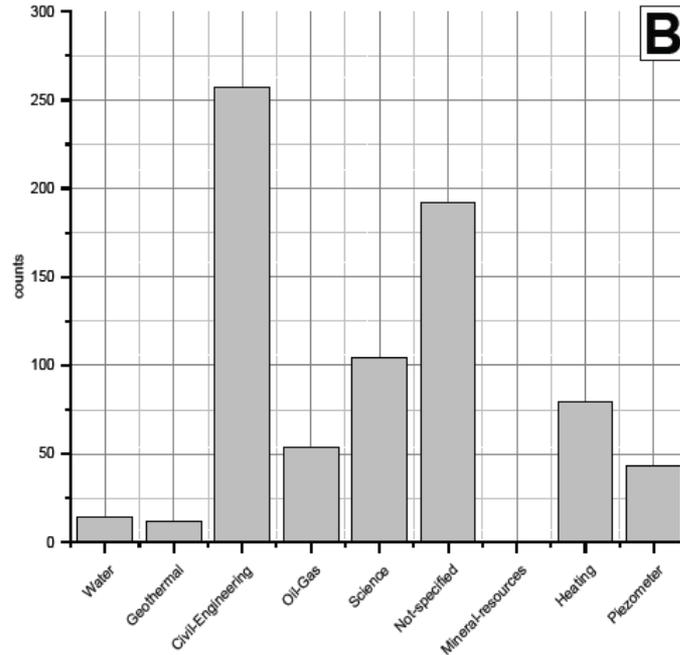
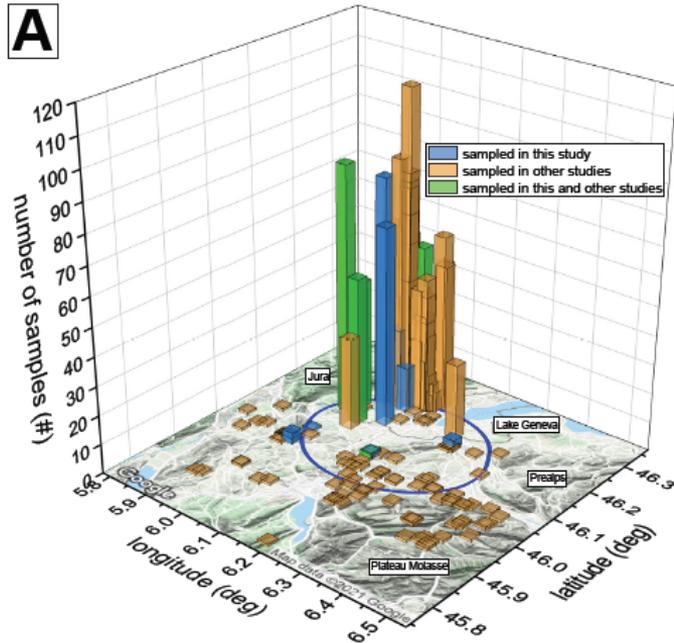


Shaft depth:

A: 202 m B: 200 m D: 177 m F: 399 m G: 228 m H: 139 m J: 251 m L: 253 m

Tunnelling mainly in molasse layer (soft rock), well suited for fast, low-risk TBM construction.

Sample locations



- (A) Total amount of samples per outcrop, well and excavation site location in the vicinity of the current FCC layout (blue circle)¹
- (B) Distribution of the 756 analysed locations grouped by their respective purposes¹

General conditions for reusing excavation materials



Technical

- Tunnel advance method, -length, -diameter
- Site organisation
- Material yield parameters
- Material analysis
- Processing technology



Geological

- Geological situation
- Chemistry/ mineralogy/ strength properties of excavated materials
- Customer specifications
- Processability



Legal

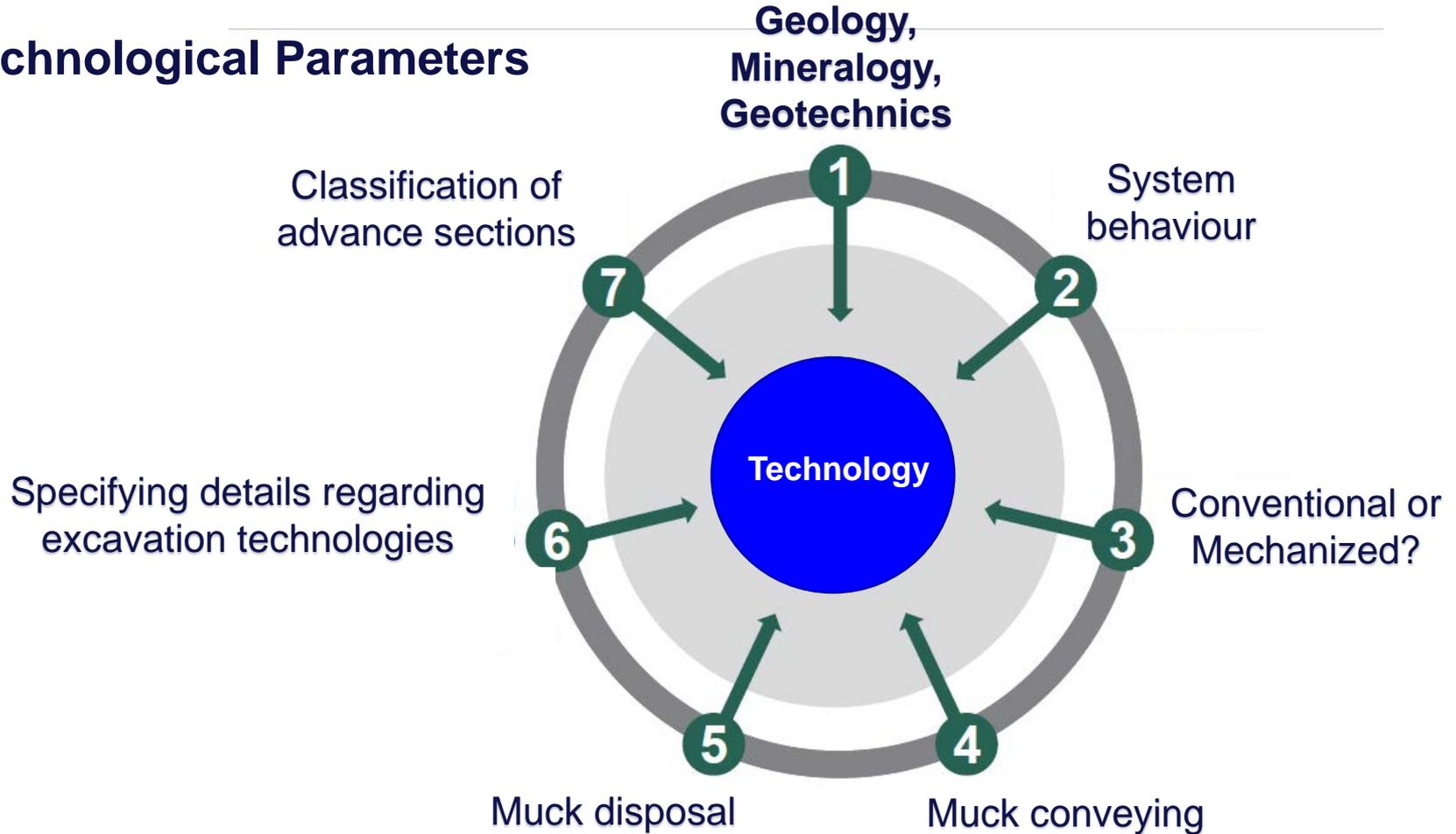
- Ownership
- Waste law
- End of waste character



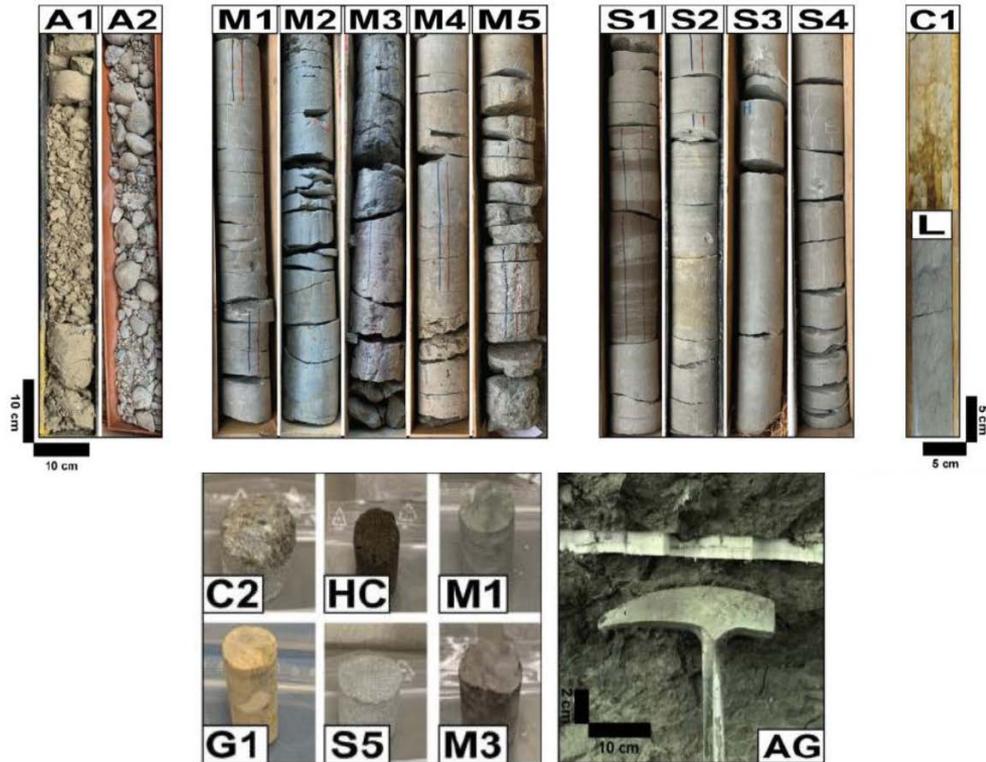
Economic

- Supply and demand
- Raw material price vs. landfilling costs
- Transport route/ -range to customers / landfills

Technological Parameters



Lithology



Lithotypes analysed in the field and on rock cores encountered along the FCC's planned perimeter ¹

A1-A2: Quaternary glaciogenic deposits,

M1-M5: different marls (Molasse Rouge),

S1-S5: different sandstones (Molasse Rouge),

HC: hydrocarbon-bearing sandstone (Molasse Rouge),

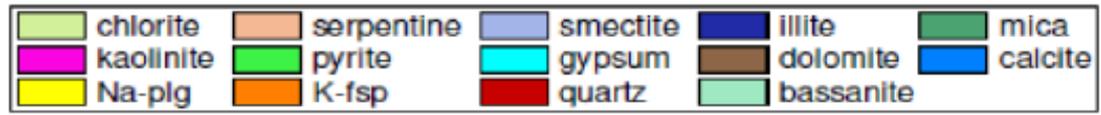
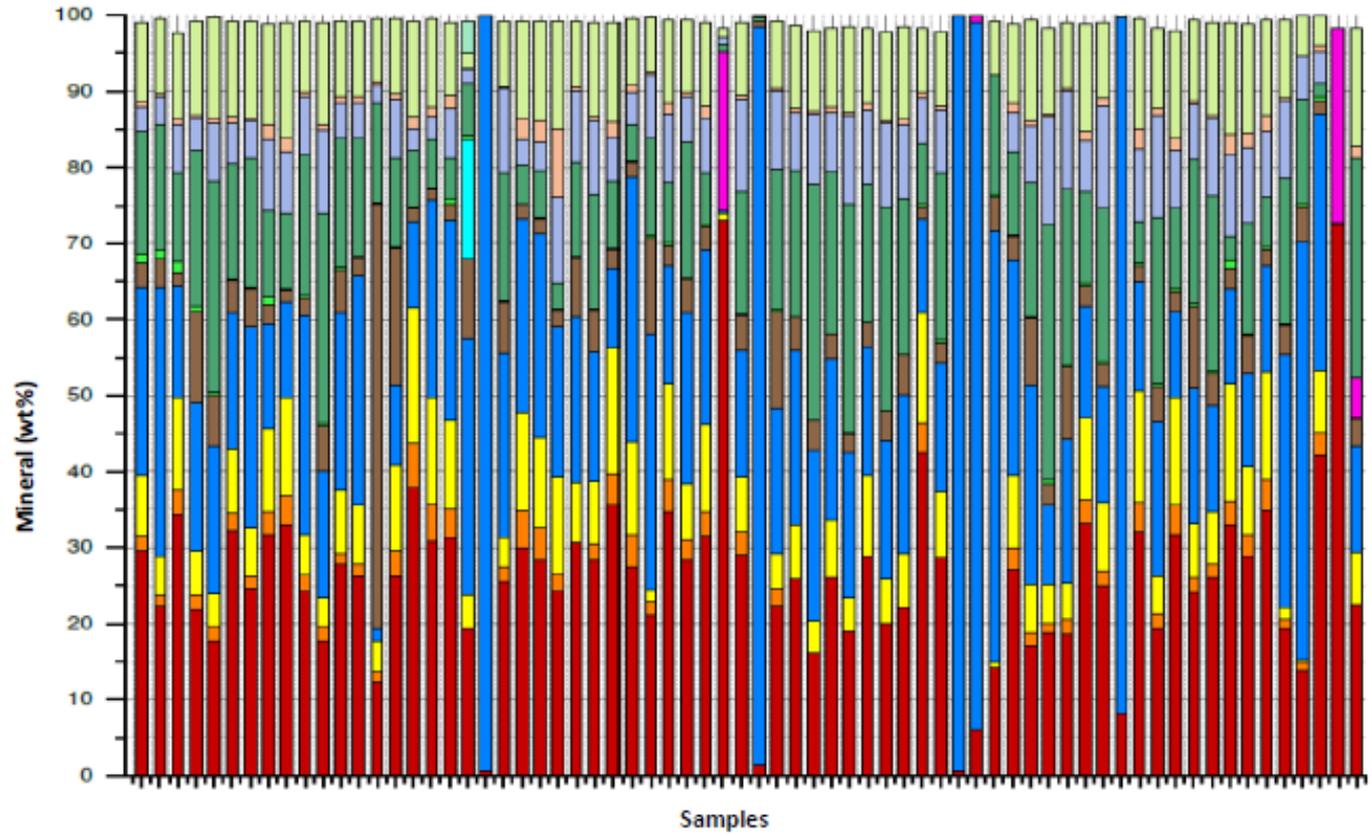
C1-C2: different conglomerates (Molasse Rouge),

L: freshwater limestone (Molasse Rouge),

G1: sandstone (Siderolithic formation),

AG: gypsum layer (Molasse Rouge)

Mineralogy



Major minerals based on XRD analyses¹

¹ Haas 2022

Available parameters for the competition

Aim of the contest is to find sustainable reuse solutions for about 9 million m³ (23.8 Mio. t) of excavated material, mainly molasse.

Several analysis on the FCC's expected geology were conducted¹

Geotechnical

- UCS
- Brazilian Tensile Strength
- CERCHAR Test
- Point Load Test
- LCPC Test

Geochemical & Petrophysical

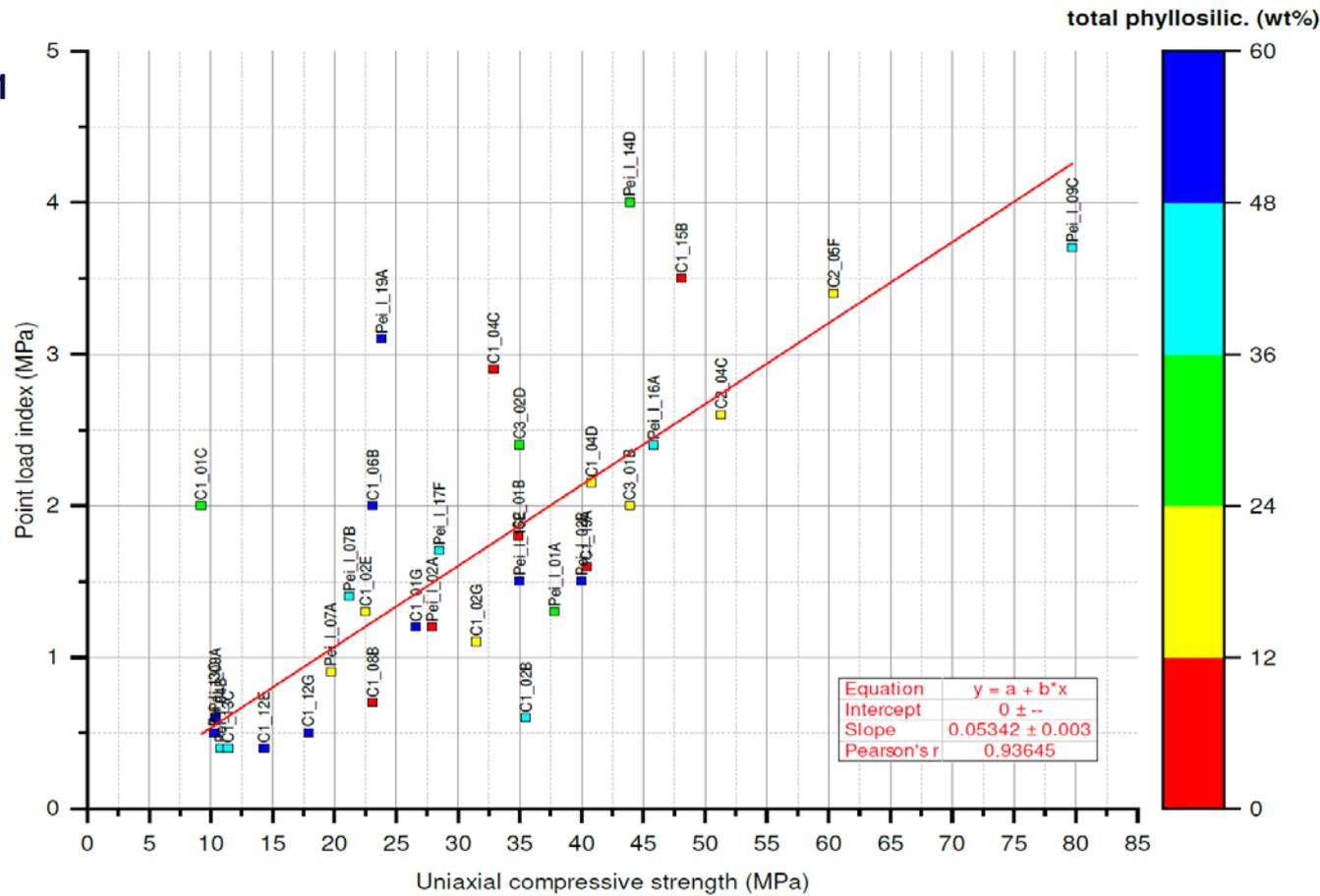
- Eluate Analyses
- Water absorption
- Porosity, Permeability
- Density
- Carbon content
- Shear wave velocity

Mineralogical

- XRD
- XRF
- ICP-MS
- Optical Microscopy

¹ Haas 2022

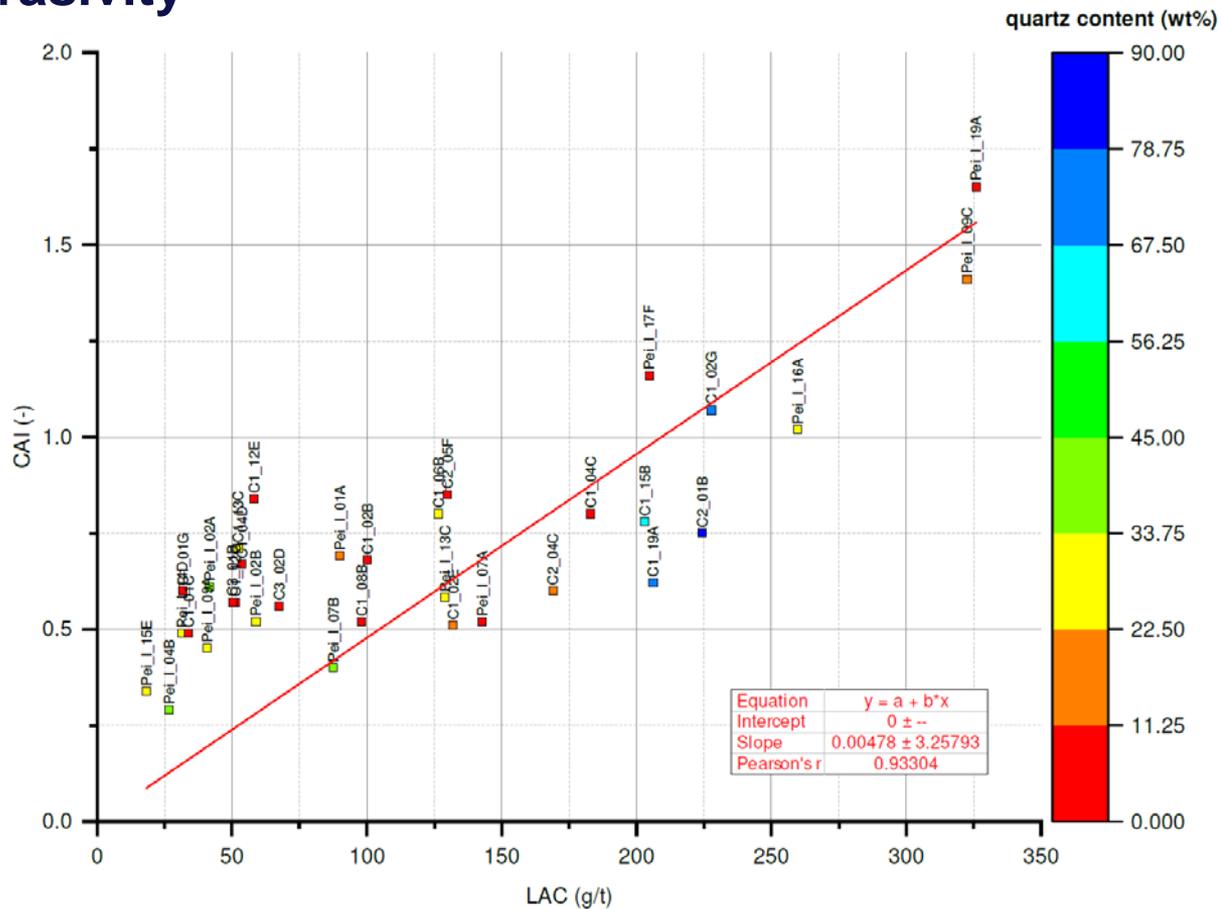
Correlation of Point Load Index and UCS¹



¹ Haas 2022

Correlation of Cerchar Abrasivity Index and LAC

(LCPC Abrasivity Index)¹





THE COMPETITION

The Jury Members

The Judging Panel – Evaluation of Applications



Prof. Robert Galler, Austria
 Montanuniversität Leoben,
 Head of the Jury



Guillaume Attard, France
Agathe Denot, France
Julie Paciello, France
 Cerema, Lyon



Jacques Burdin, France
 Consulting engineer, Les Deserts



Laetitia D'Aloia Schwartzentruber, France
 CETU, Lyon



Cédric Thalmann, Switzerland
 B+G SA, Bern

Prof. Herbert H. Einstein, USA
 Massachusetts Institute of Technology



Manuela Rocca, Italy
 Sustainability and Safety director
 for Tunnel Euralpin Lyon Turin



Alexander Wyss, Switzerland
 Simatec Maschinenbau AG



Severin Seifert, Germany
 Fraunhofer Institute for Building
 Physics IBP



Klaus Marhold, Austria
 Institute for Entrepreneurship and
 Innovation
 Vienna University of Economics and
 Business



Participation & evaluation criteria

Participation Criteria

Persons and companies who were allowed to apply:

- Natural Persons
- Academic organisations
- International organisations of European interest
- For-profit organisations

Technological maturity of applications

- TLR 3 at the time of submission
- TLR 9 at start of construction in 2030

Applications were submitted on

- Stage 1: 30 April 2021 to 31 October 2021
- Stage 2: 01 January 2022 to 31 July 2022

Evaluation criteria

Jury awards points for each of the following criteria:

**Technical
feasibility**

**Economic
viability**

**Societal
value**

**Project
relevance**

THE APPLICATIONS

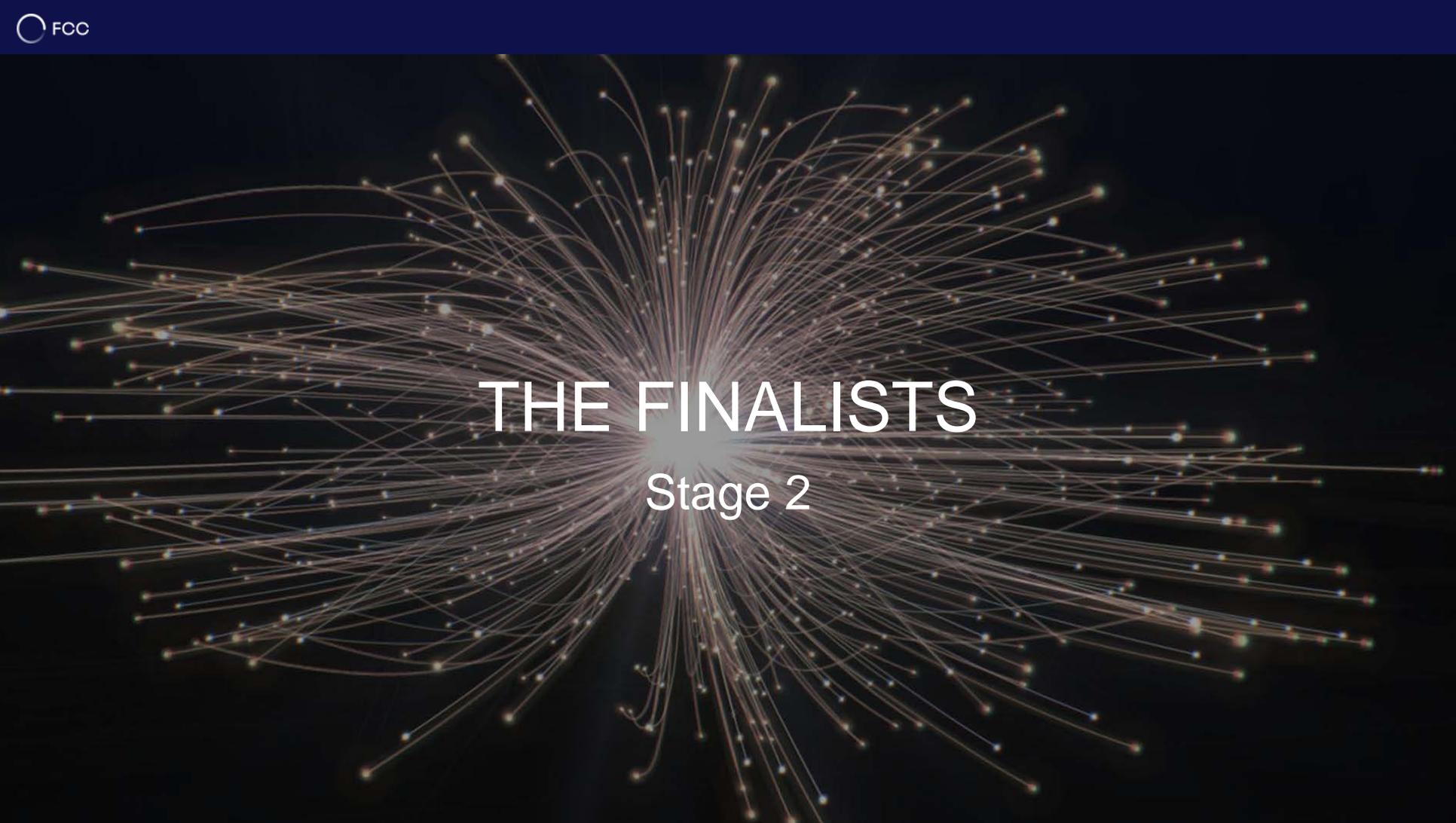
Stage 1



Submitted proposals

#	Submitter	Country	Description
1	AMBERG	CH	System zur Sortierung, Charakterisierung und Verteilung des Materials in Fraktionen bekannter Zusammensetzung
2	Arcadis	FR	Herstellung von Roherde-Ziegeln
3	BG Ingénieurs	CH+FR	Trennung der Molasse in granulometrische oder petrographische Fraktionen via online Analyse
4	RISE	AT	Algorithmische Plattform zur Unterstützung der Logistik und Verkauf des aufbereiteten Materials
5	EDAPHOS	CH+FR	Innovatives Bodeningenieurwesen
6	IRD	FR+CH	Aufwertung des Materials durch bodentechnische Maßnahmen zur Errichtung grüner Infrastruktur

#	Submitter	Country	Description
7	FORSTER	DE	Konstruktion von Deponiesilos mit Sandwich-Wänden
8	LOMBAR DI SA	CH	Methodik zur Prognose, Quantifizierung und Charakterisierung von Aushubmaterial
9	MONTAN TEC	AT	Aufbereitung von Ausbruchsmaterial für Permakultur auf deponiertem Material
10	NEO-ECO	FR	Entwicklung von Eco-Materialien aus dem Ausbruchsmaterial
11	VOLKME R MiV	DE	Sortierung und Aufbereitung von Ausbruchsmaterial
12	KONOVAL OV	RUSSIA	Herstellung von Arbeitskörpern (Lasten) aus Ausbruchsmaterial für ein 1200MV Gravitations-speicher-kraftwerk



THE FINALISTS

Stage 2

The Finalists

**Amberg
Engineering AG**

Concrete
production

**BG
Ingenieurs**

Production of building
raw materials

**Briques Technic
Concept**

Arcadis
Manufacture of
molasse bricks

**Edaphos
Engineering**

Production of fertile soil
materials

Submitter	Country	Description
AMBERG	CH	System to sort , characterize and redistribute the molasse into fractions of known composition
BG Ingénieurs	CH+FR	Treatment to separate the molasse into granulometric or petrographic fractions by online flow analysis
Briques Technic Concept ARCADIS	FR	Manufacturing of compressed earth bricks
EDAPHOS	CH+FR	Innovative soil engineering concept

AMBERG KONSORTIUM

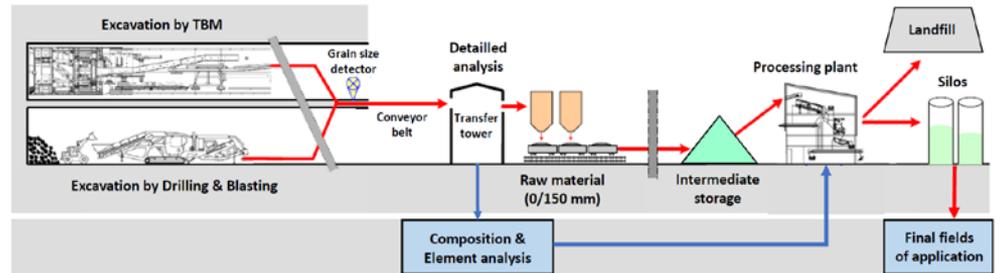
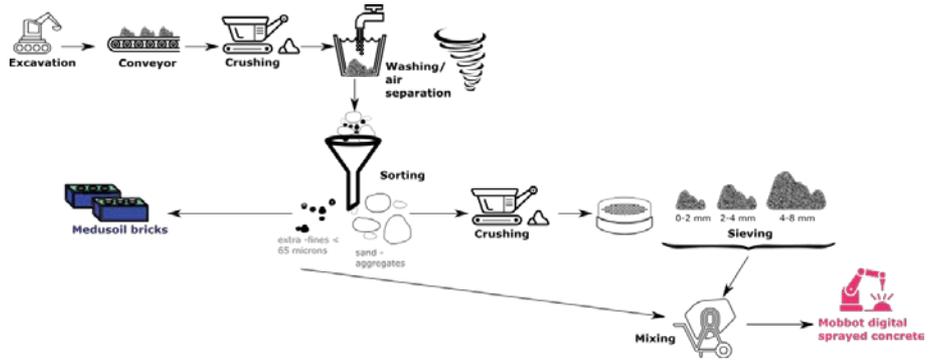


Konsortium: MEDUSOIL; MOBBOT, HOLCIM, VERSUCHSSTOLLEN HAGGERBACH, PAGANI LANFRANCHI, BILGER

Prozess: In-situ Charakterisierung (Crossbelt elemental analyzer) und Aufbereitung des Materials

Anwendung: Spritzbeton, Bindemittel aus Bio-Mineralstoffen zur Verwendung vor Ort

Innovation: Einsatz von Hightech-Lösungen zur Herstellung von Bauelementen ohne Zement oder Beton



ARCADIS KONSORTIUM



Konsortium: ARCADIS, BRIQUES TECHNIC CONCEPT

Prozess: Aufbereitung von tonigem, schluffigem und sandigem Material mit Zugabe von Kalk als Stabilisierungsmittel für gepresste Rohmauerziegel

Anwendung: Ersatz von Baumaterialien mit hohem Kohlenstoffausstoß

Innovation: mobile Produktionseinheiten für gepresste Lehmziegel zur Produktion vor Ort



BG KONSORTIUM

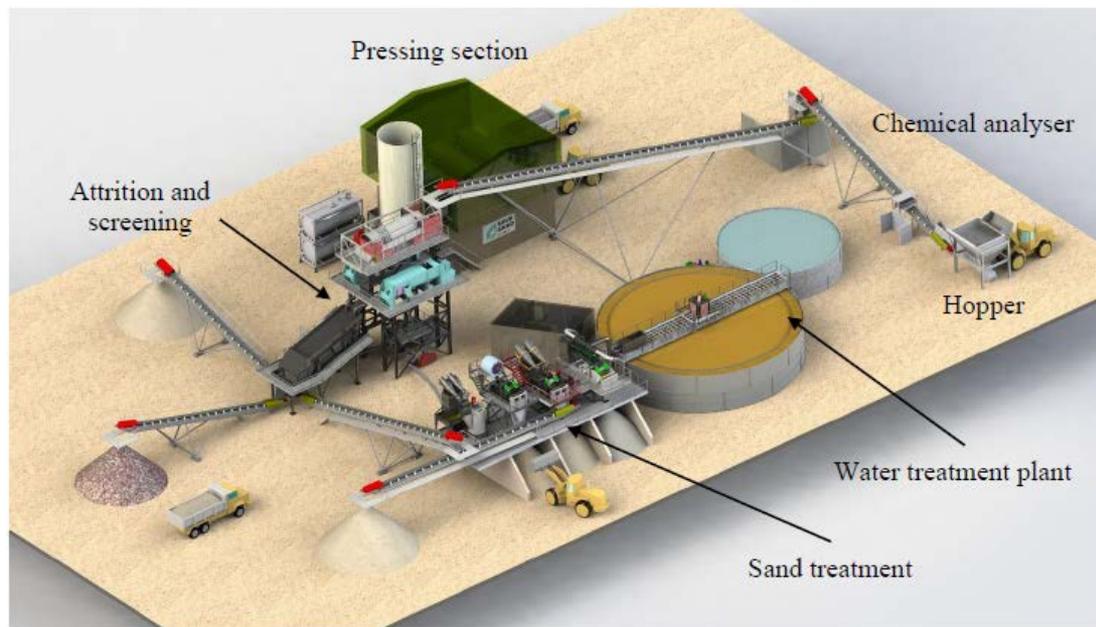


Konsortium: BG, VICAT, CIRCULÈRE, SIGMA-BETÓN, VIGIER, MS, INDUNI, INGÉNIEURS CONSEILS SA

Prozess: Online-Analyse und Aufbereitung von Molassematerial und Behandlung von Kohlenwasserstoffen durch Bioremediation

Anwendung: Bausteine aus Sandstein, Kiese, Sande, Füllstoffe für Zement, kohlenstoffarmer Zement, Ziegel aus Terrakotta

Innovation: online-Analyse basierend auf KI & reduzierte Lagerkapazitäten vor der Aufbereitung



EDAPHOS KONSORTIUM



Konsortium: EDAPHOS ENGINEERING, INDUNI, MONT-BLANC VALORISATION, MICROHUMUS

Prozess: Kombination von mineralischem und organischem Material zur Herstellung von Mutterboden auf Transformationseinheiten vor Ort

Anwendung: Produktion von Oberbodenmaterial für die Landwirtschaft und Rekultivierung

Innovation: Einsatz von Bodenmikrobiologie zur Beschleunigung des natürlichen Prozesses der Humusbildung



Storage of approx. **140 tonnes of CO2** in the newly created land (average storage of 15gCstable/kg)



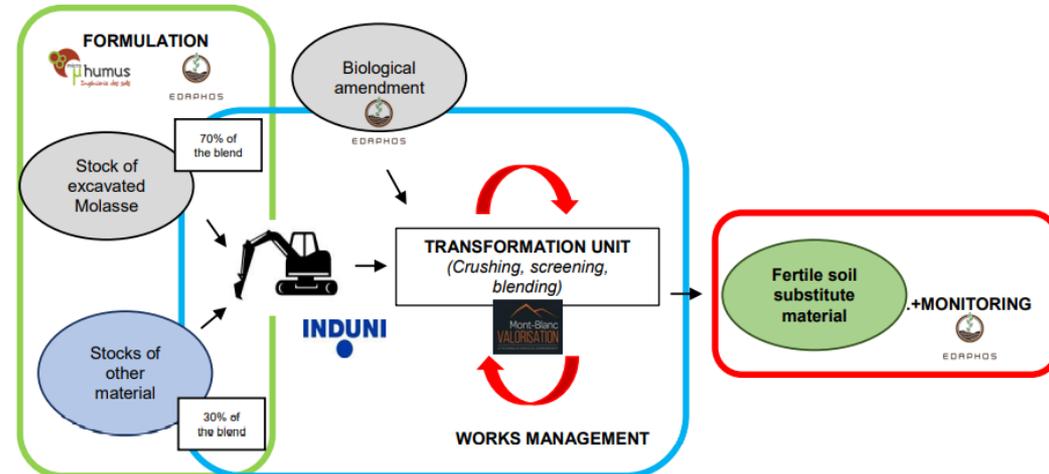
Use of recycled **plant material** for urban green spaces



Multiplication of soil **biodiversity** (x10.000)

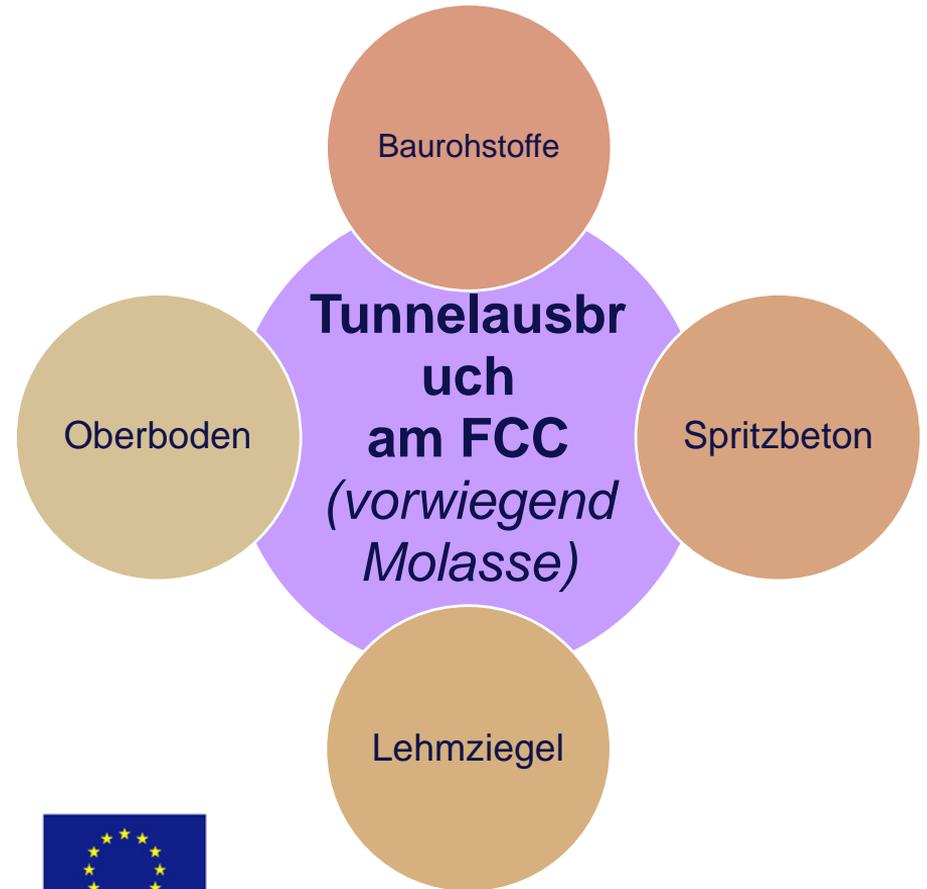


Saving on landfill and transport equivalent of over **450 trucks**



Nächste geplante Schritte

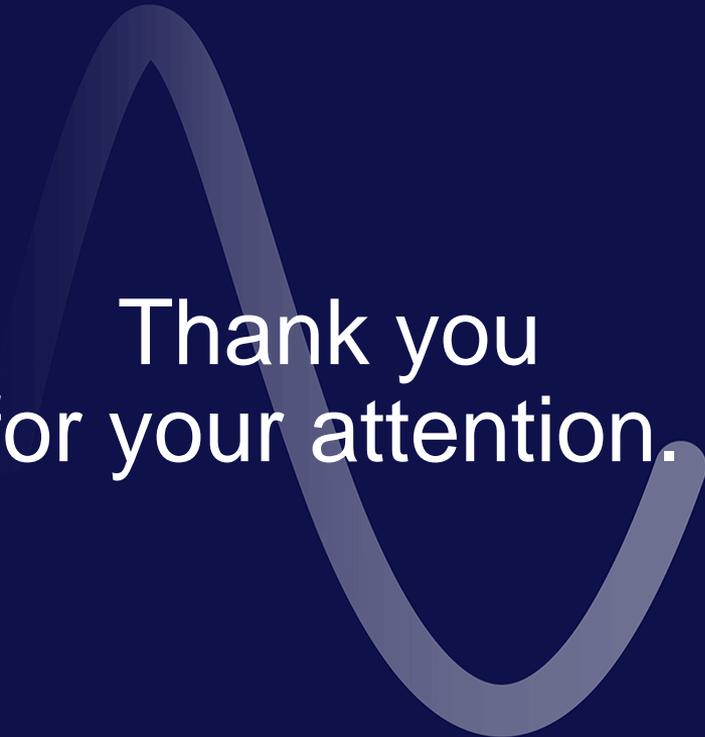
- Kombination der Lösungsvorschläge der Finalisten zur optimalen Verwertung der 9 Mio. m³ an Tunnelausbruch
- Entwurf eines internationalen Leitfadens zur Verwendung von Tunnelausbruch innerhalb der EU



Acknowledgement

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Thank you
for your attention.