



Supporting Partner



5 - 8 DECEMBER 2022
DUBAI WORLD TRADE CENTRE

INNOVATION FOR A SUSTAINABLE GEOTECHNICAL INDUSTRY:

From bio-cementation to energy geostructures

Lyesse Laloui



OUTLINE

1 BACKGROUND

2 BIO-CEMENTATION

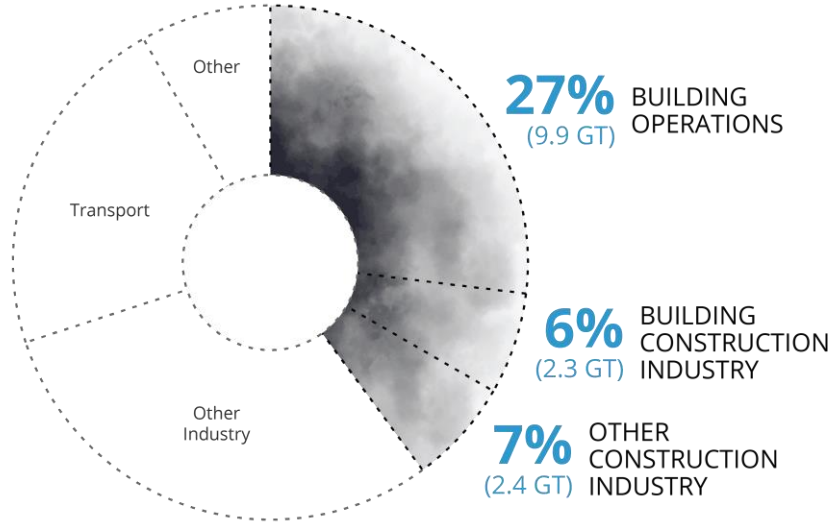
3 ENERGY GEOSTRUCTURES

4 CONCLUSION



CONTRIBUTION OF THE CONSTRUCTION INDUSTRY TO CO₂ EMISSIONS

Annual Global CO₂ Emissions



The built environment generates **40% of annual global CO₂ emissions**. Of those total emissions, building operations are responsible for 27% annually, while building and infrastructure materials and construction (typically referred to as embodied carbon) are responsible for an additional 13% annually.

© Architecture 2030. All Rights Reserved. Data Source: IEA (2022), Buildings, IEA, Paris

Building Construction Industry and Other Construction Industry represent emissions from concrete, steel, and aluminum for buildings and infrastructure respectively.

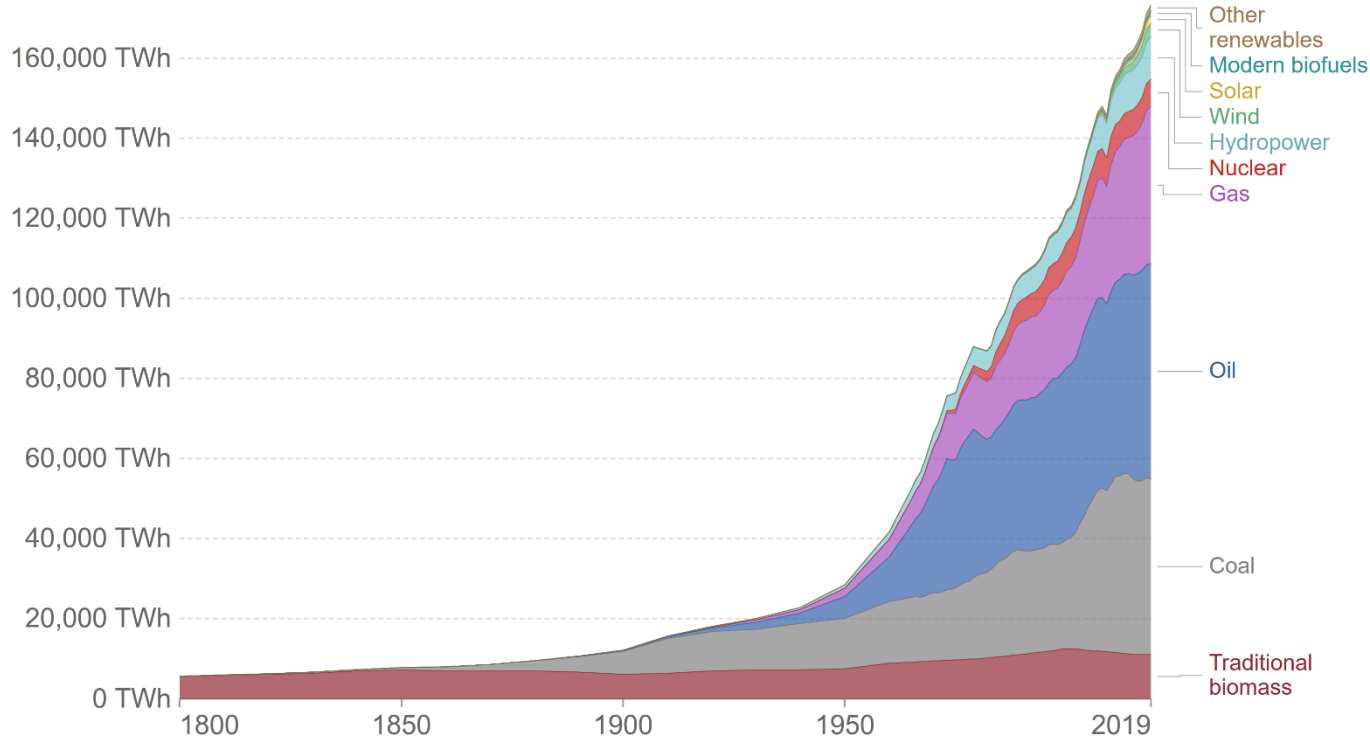
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ENERGY DEMAND



Source : Vaclav Smil (2017) & BP Statistical Review of World Energy
CC BY OurWorldInData.org/energy

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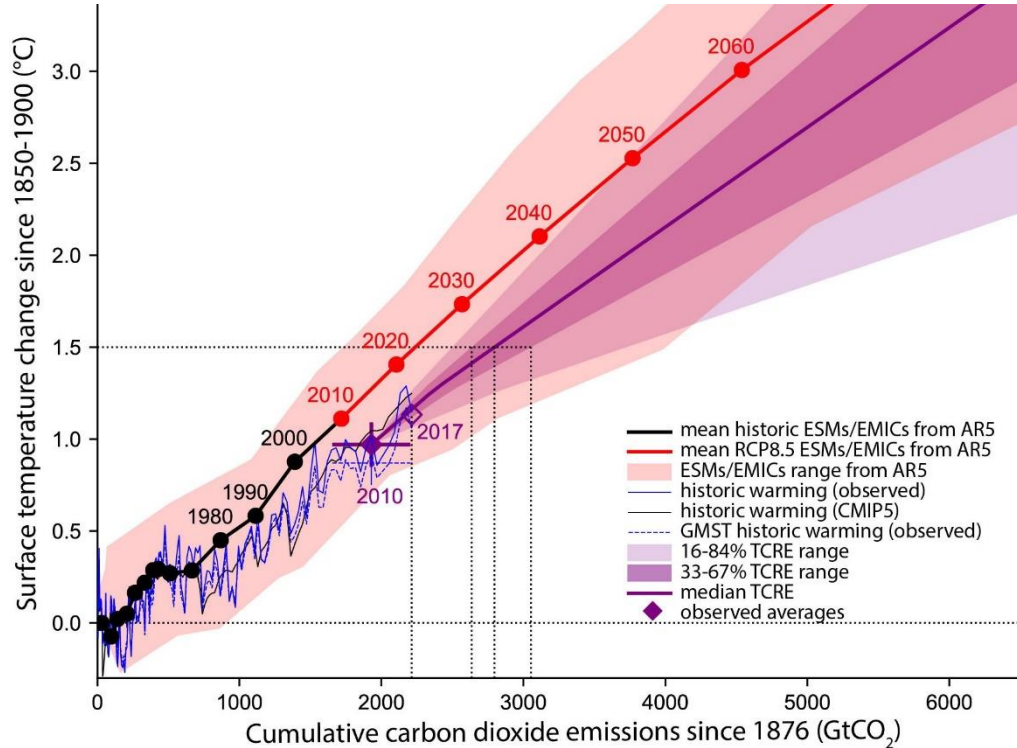
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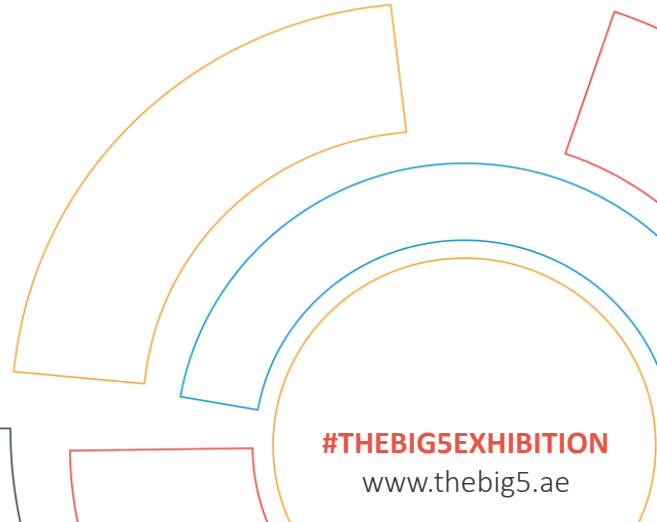
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CARBON DIOXIDE EMISSIONS



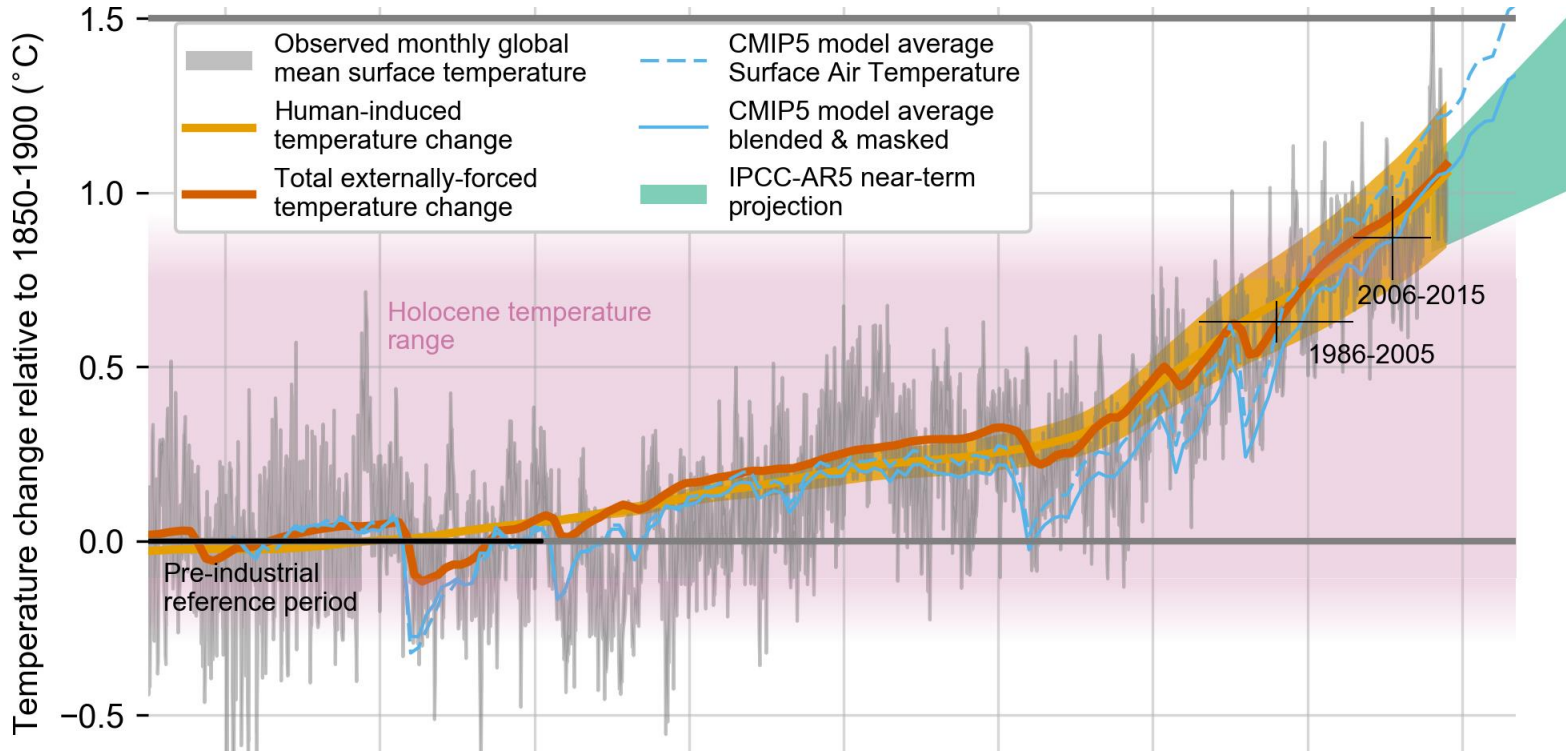
Atmospheric CO₂ is now reaching levels **50% higher** than before the **industrial revolution**.



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CLIMATE CHANGE



NEED FOR LOW CARBON CONSTRUCTION MATERIALS AND CLEAN ENERGIES

2 BIO-CEMENTATION

3 ENERGY GEOSTRUCTURES



SUSTAINABLE GROUND IMPROVEMENT SOLUTIONS FOR FOUNDATION & GEO- ENVIRONMENTAL WORKS

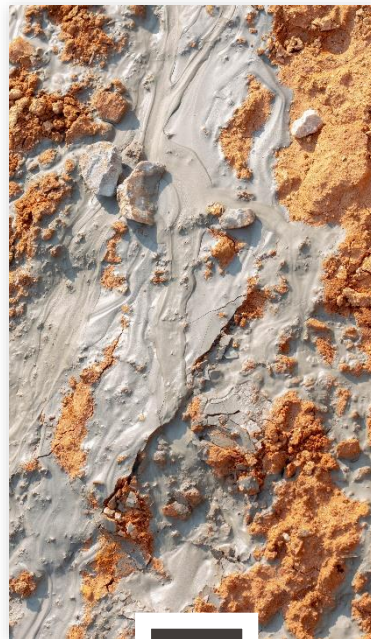
info@medusoil.com
EPFL Innovation Parc Bata
1015 Lausanne, Switzerland



WE PRODUCE BIO-BASED BINDERS FOR GEOTECHNICAL AND GEO-ENVIRONMENTAL WORKS



We offer contractors **innovative solutions** for **soil cementing** using **efficient** and **environmentally friendly** bio-grouts.



1

3

“Chemical grouts typically make groundwater highly alkaline, which can have a negative impact on soil. Older mixes, which are increasingly prohibited, also contain harmful alumina and other heavy metals”

Paul Pandrea, European Technical Director, Keller. March 2021



2

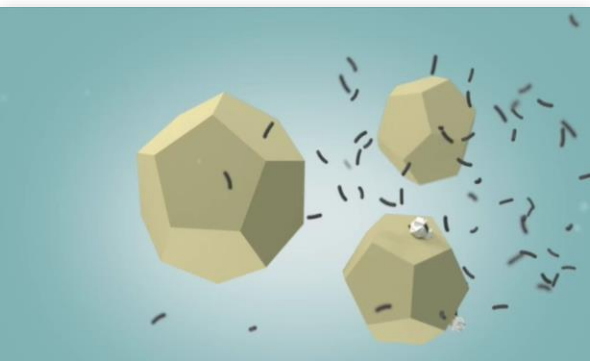
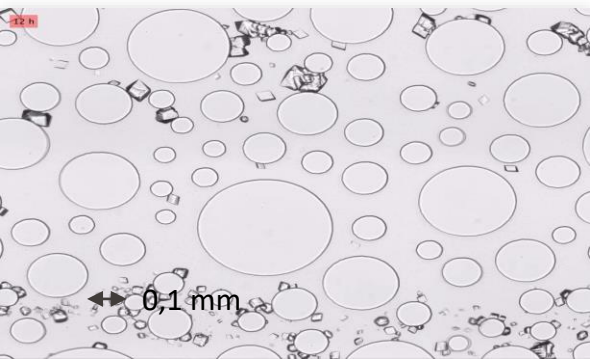
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OUR PRODUCTS BASED ON BIO-MINERALIZATION™



We produce **innovative ground stabilizers** based on **organic biomineralization**.

Our products react when mixed with the ground to produce **sandstone-like properties** out of sand.

Application is enabled through **minimally invasive** drillings and low injection pressures which result into **reduced labor and energy costs**.

With their neutral pH and environmental certifications, it is now possible to **use our products even in environmentally-sensitive zones** of water protection.

The **quality assessment** and **quick quality control** of our applications is possible via light equipment.

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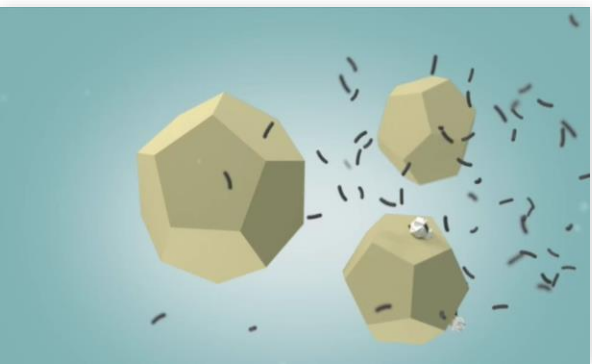
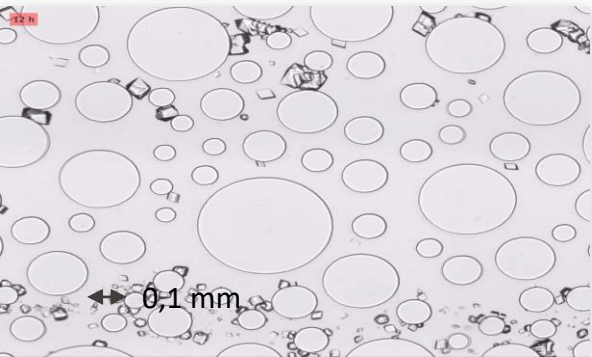
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OUR PRODUCTS BASED ON BIO-MINERALIZATION™



Our technique offers a sustainable, non polluting and cost-effective alternative to traditional soil improvement techniques which rely usually on introducing chemicals in soils as lime, cement, epoxy and/or polyurethane or on mechanical forces such as compaction and consolidation.

These traditional techniques are more costly in terms of energy, time and price and require extensive use of industrial fluids, microplastics, or heavy metals that are very harmful to the environment.

For instance, existing fly ash-, lime-, and cement-based solutions generate **pH-levels above 12**. Such conditions are above the typical values of soil pH causing irreversible damage to the groundwater and subsurface ecosystem.

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ENVIRONMENTAL IMPACT

Carbon footprint analysis carried out by



Our **innovations** inspire from the **direct use of CO₂** for the **production of bio-minerals**.



In close collaboration with environmental authorities and certification bodies we **comply with the CEN/TR 17105:2017 norm** which becomes **mandatory in France, Germany and in other territories**.



Through our participation in professional bodies and with the experience of case studies **we contribute to the dialogue for the future of norms for sustainable ground improvement**.

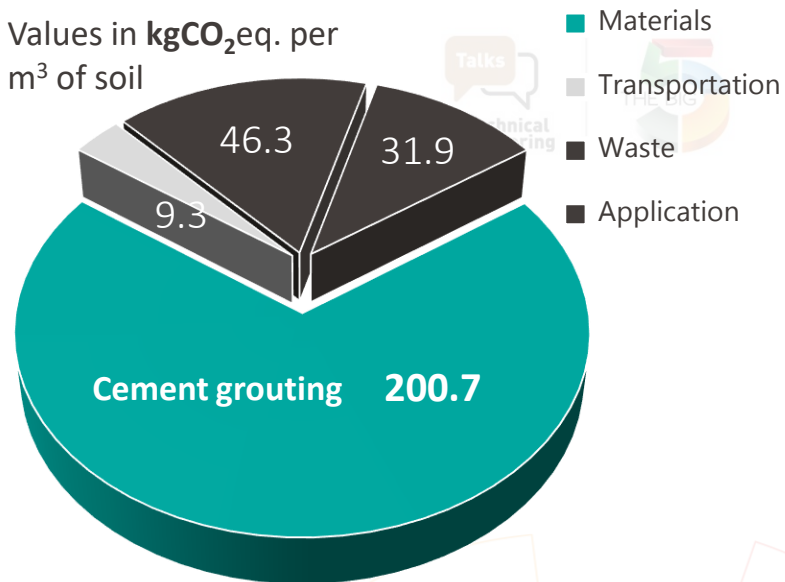


Through our **zero-waste production and zero-waste application** the problem of spoil management on-site is **finally solved**.

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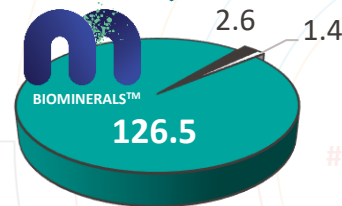


Values in **kgCO₂eq. per m³ of soil**



CO₂ footprint compared to cement stabilization

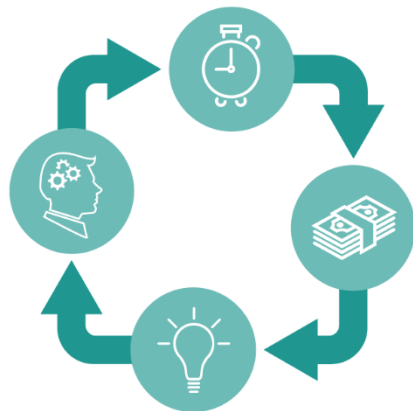
55% lower



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VALUE THROUGH INNOVATION



PATENTED SYSTEMS

Advanced manufacturing to produce soil admixtures of known stability and quality.

TAILORED PROJECT ENGINEERING

Close coordination with engineering consultants and contractors for end application characteristics.

FAST APPLICATIONS

Applications complete in days and often do not require heavy machines or traffic shutdowns.

CIRCULAR MODEL

Via zero-waste production and zero-waste application we reduce project costs and redistribute raw materials.

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TECHNICAL SPECIFICATIONS

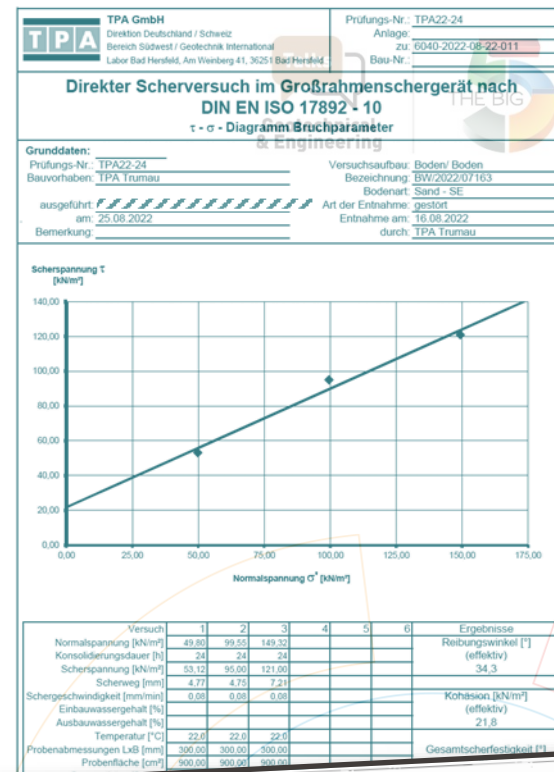


BEFORE medusoil

Cohesion - c' [kPa]	0 – 10	40 – 150
Friction Angle - ϕ' [°]	27 – 32	up to 43
Elastic Modulus E [MPa]	150 – 500	500 - 2000

Injection Parameters

Min. Borehole diameter (mm)	20 - 50
Distance between boreholes (m)	1.5 - 5
Injection pressure (bar)	0.2 - 2



Zusammenfassung

Carbonatgehalt (als CaCO₃): < 1,2 M-%

Trumau, 01. September 2022

Als Referenz werden den Untersuchungsergebnissen die Grenzwerte der Bodenaushubdeponie gemäß Deponieverordnung 2008 gegenübergestellt

CaCO₃ < 1.2%
 $c' = 21.8$ kPa
 $\phi' = 39^\circ$



Dipl.-Ing. B. Bollmann
 Zeichnungsberechtigter der akkr. Prüfstelle

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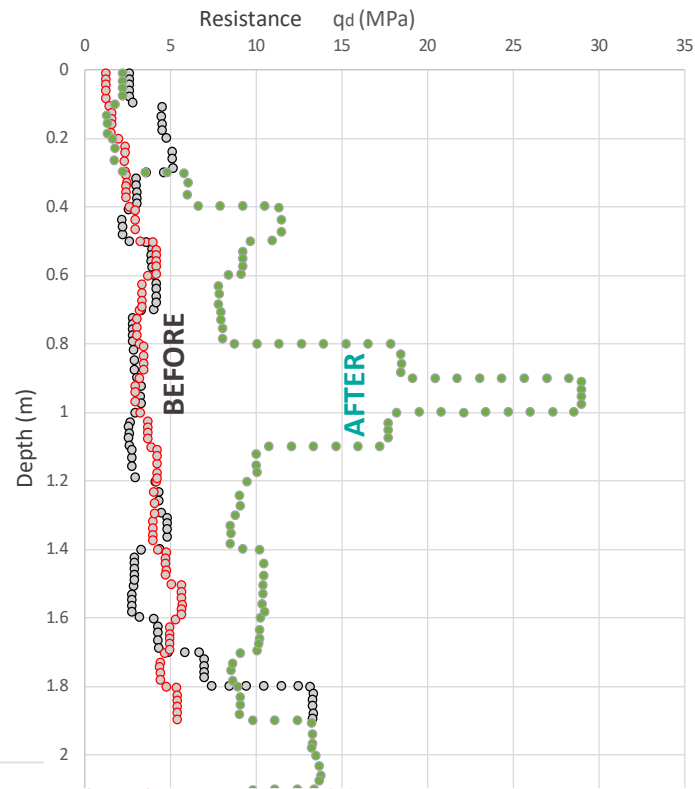
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REFERENCE PROJECTS

Slope stabilization in ski domain, Bern, CH



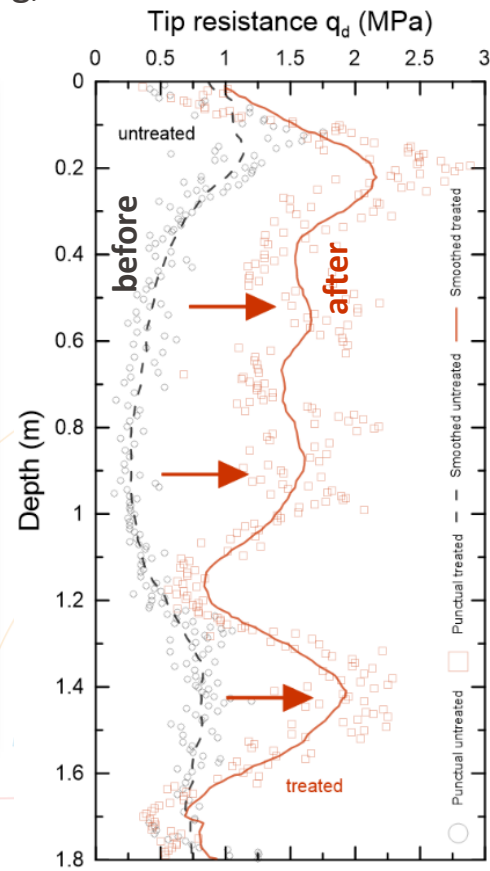
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REFERENCE PROJECTS

Bearing capacity increase, Fribourg, CH



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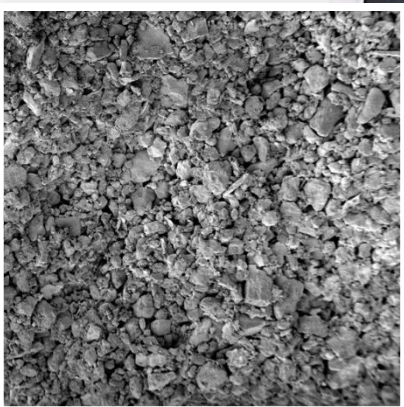


REFERENCE PROJECTS

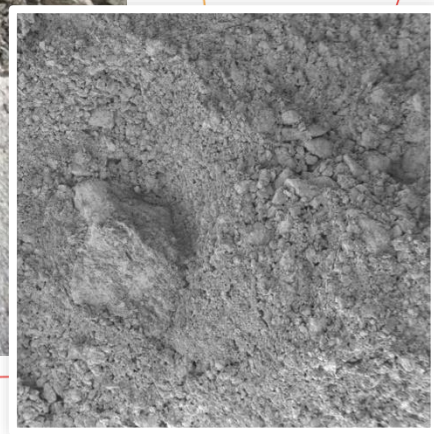
Stabilization of microtunneling excavation, Zürich airport, CH



BEFORE /
requiring additional
measures to ensure
stability of
excavation zone



AFTER /
sufficient stabilization
during excavation with
no extra mechanical
support



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REFERENCE PROJECTS

Gravel pit slope reinforcement against surface erosion

Turning erosion paths into biocementing paths



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REFERENCE PROJECTS

Sandstone cliff stabilization, CH



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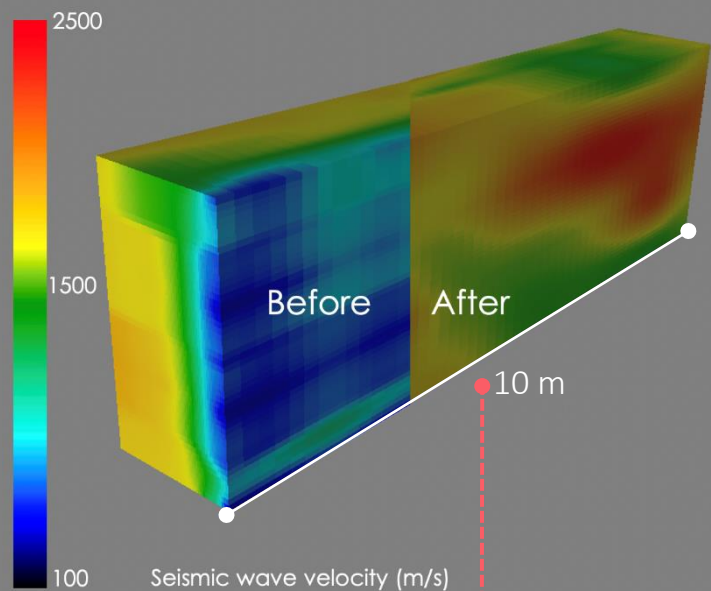
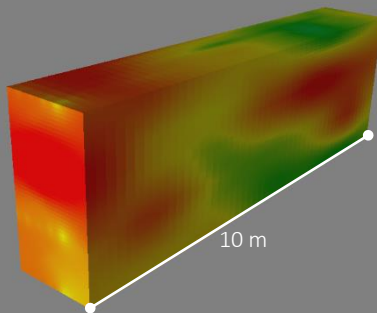
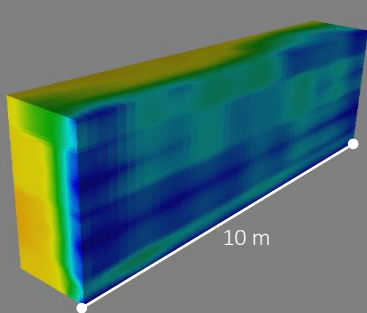
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REFERENCE PROJECTS

Sandstone cliff stabilization, CH



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OUR QUALITY CONTROL SERVICES



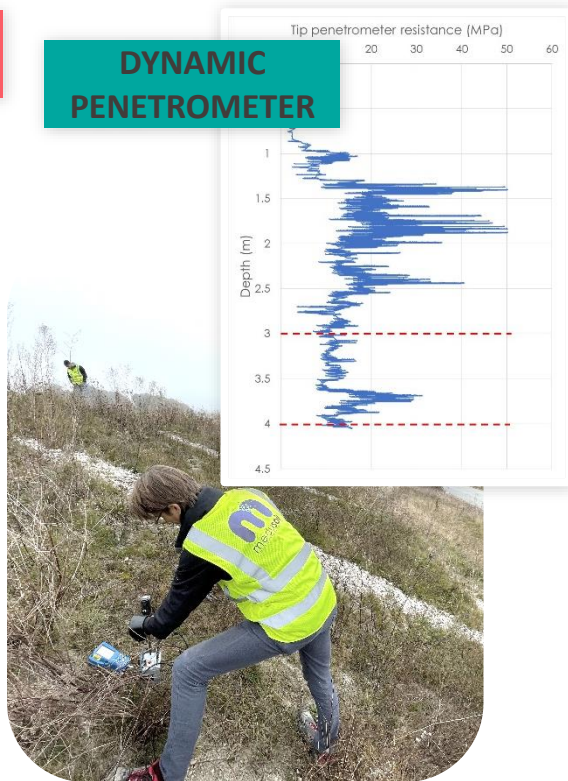
**NON DESTRUCTIVE INSPECTION/
Ground penetrating radar**



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**DYNAMIC
PENETROMETER**



UAVs AND LIDAR INSPECTION
for digital surface modelling



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2 BIO-CEMENTATION

3 ENERGY GEOSTRUCTURES

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Photo: SKB, Lasse Modin



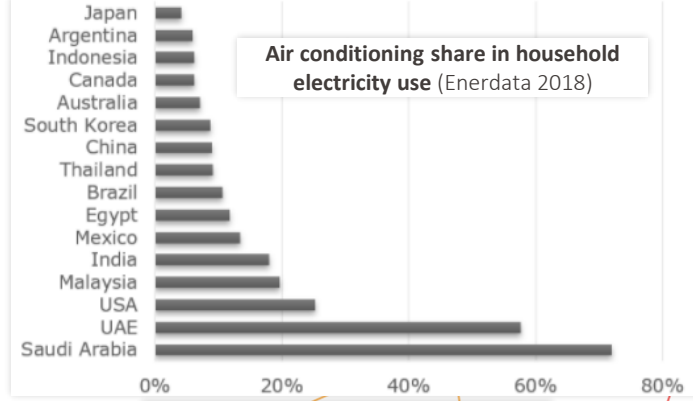

UNITED ARAB EMIRATES



Energy consumption

The residential sector is the major electricity consumer in UAE with 33% of total electricity consumption.

Most of the electricity consumption is for space cooling (50% of the total energy consumption in Dubai which is equivalent to 13700 kWh/year)

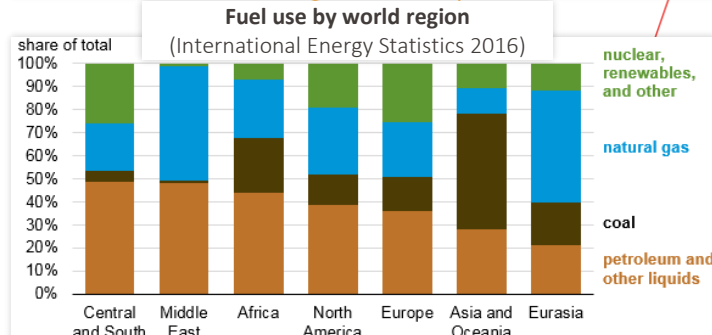



Space cooling represents **50%** of the **total energy consumption** in **Dubai**



Total CO₂ emissions of the **UAE** has increased with **243%** since 1990

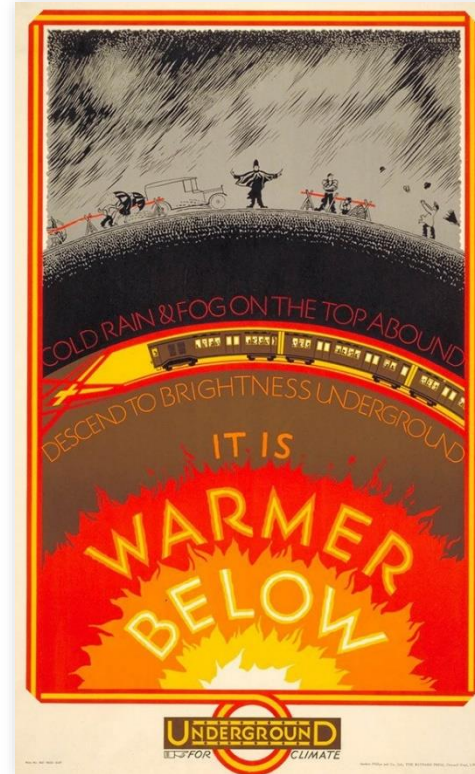
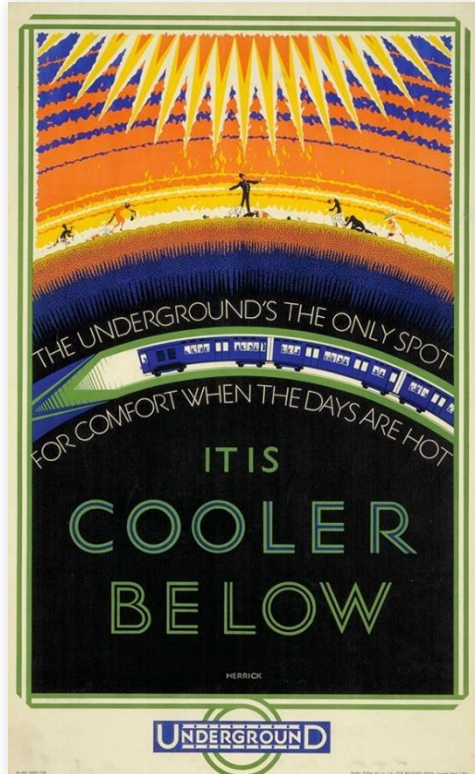
IAE(2019)



Source: U.S. Energy Information Administration, International Energy Statistics



SOILS: THE OLDEST MEAN FOR STORING/CAPTURING HEAT



Posters (1926-1927) of Frederick Charles Herrick for London Underground

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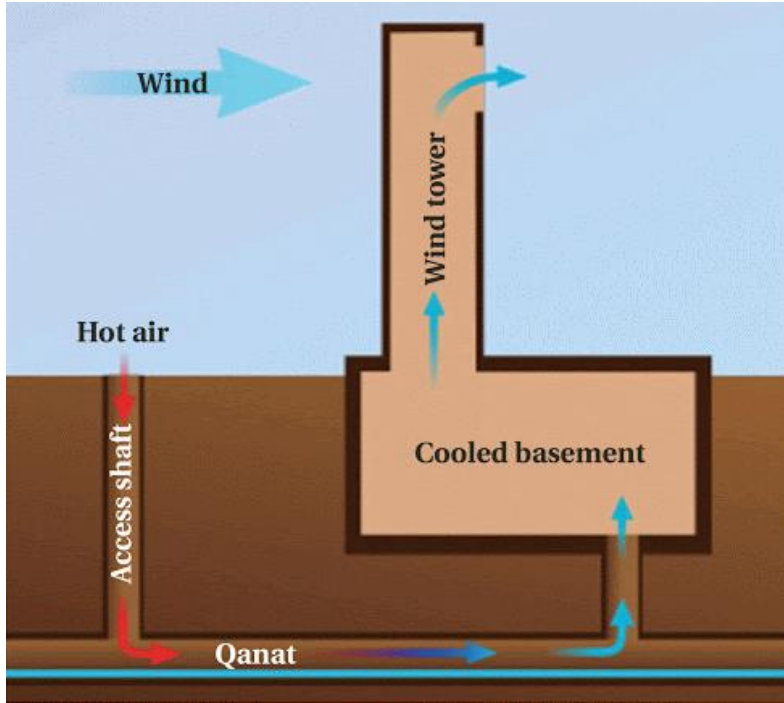
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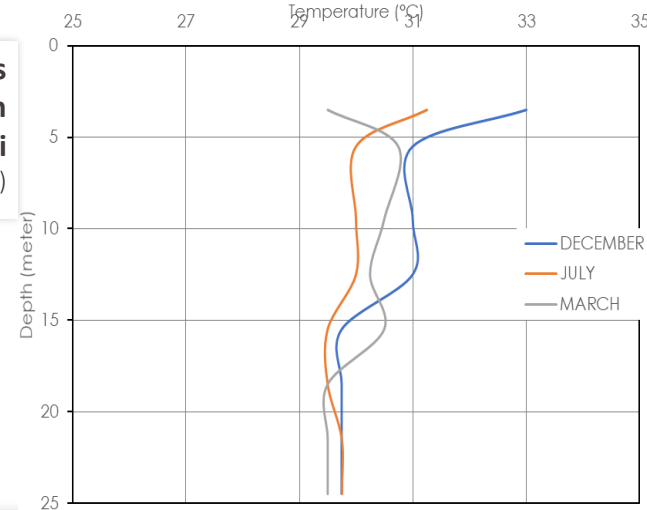


QANAT - قناه

Inspired from the traditional natural cooling methods



Temperature versus depth in a site in Dubai (e. construct)



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<https://en.wikipedia.org/wiki/Qanat>



GEOSTRUCTURES

the oldest means for
supporting constructions

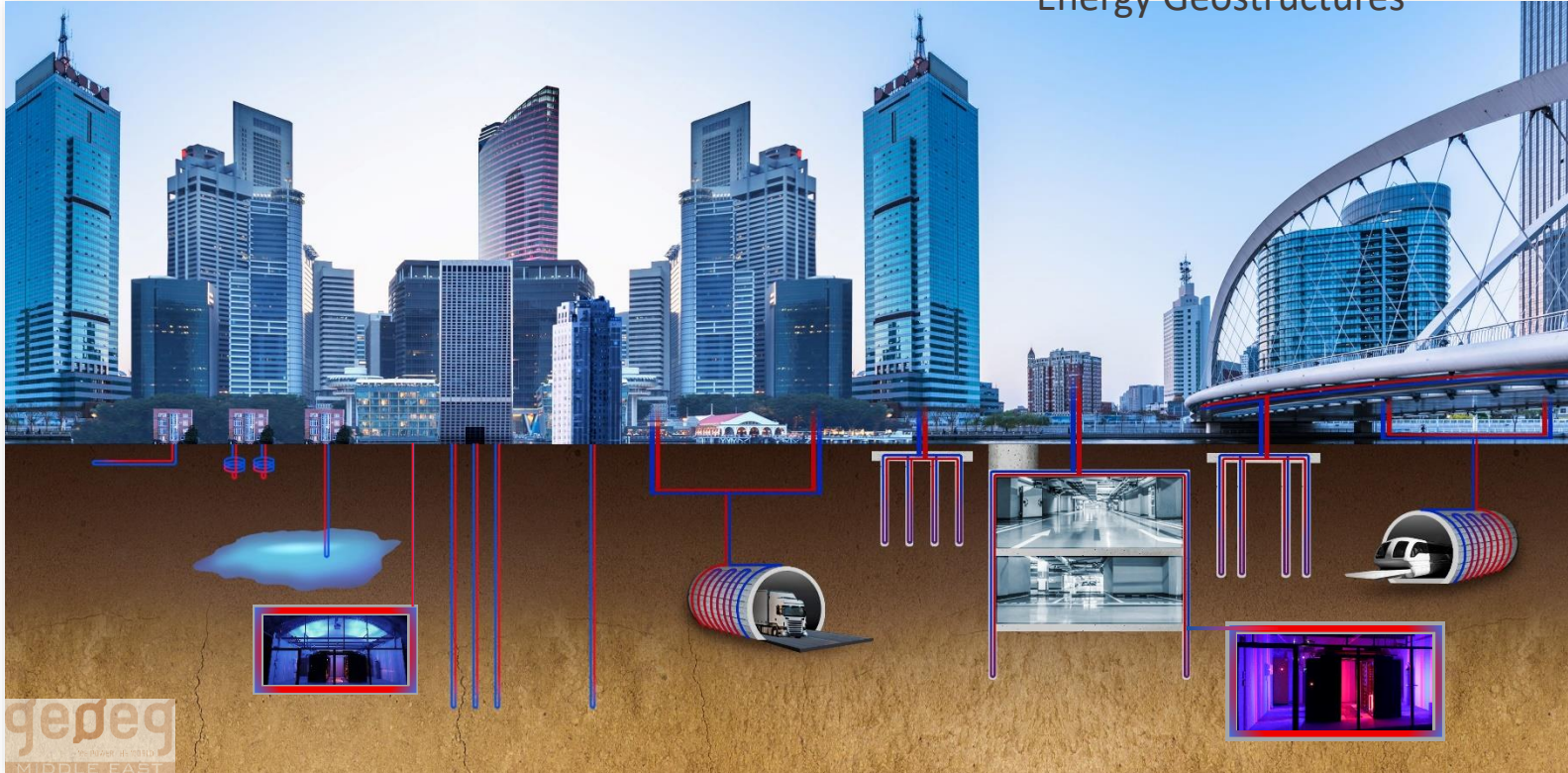
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GEO-ENERGY PRODUCTION

Energy Geostructures



gepeg
Middle East

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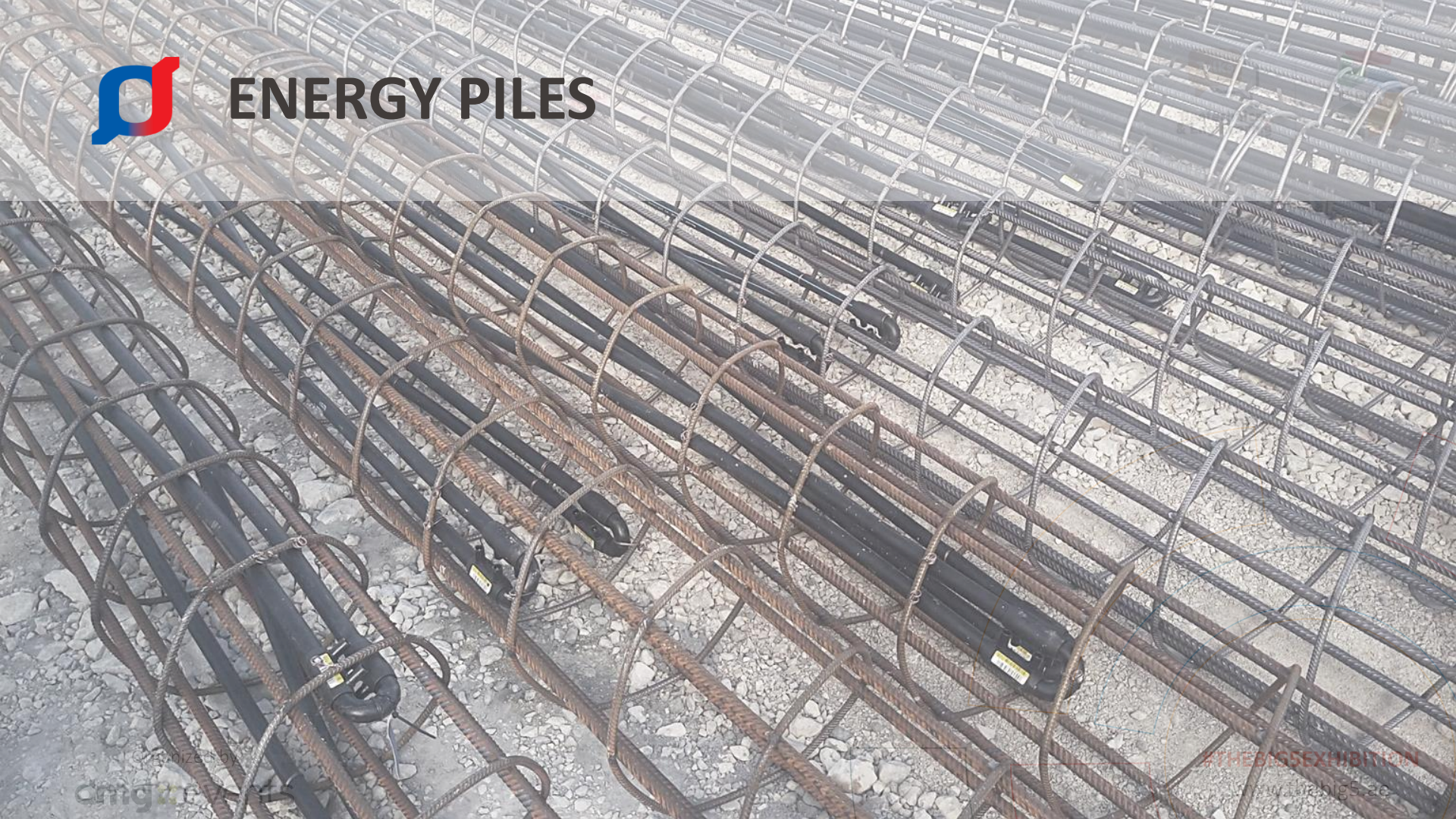
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ENERGY PILES





ENERGY WALLS AND BARRETTES

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INDUSTRIAL EXHIBITION

www.dmg-events.com



ENERGY SLABS AND TUNNELS

THE BIG

Courtesy of BG Engineers

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Courtesy of Zubair

THE BIG EXHIBITION

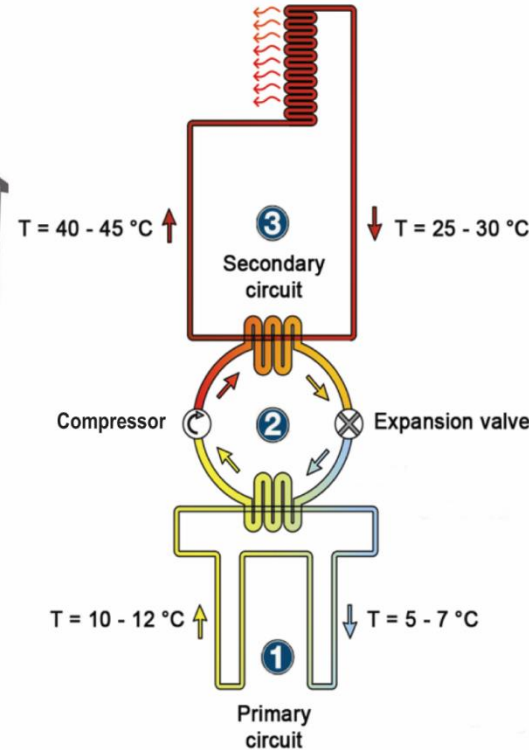
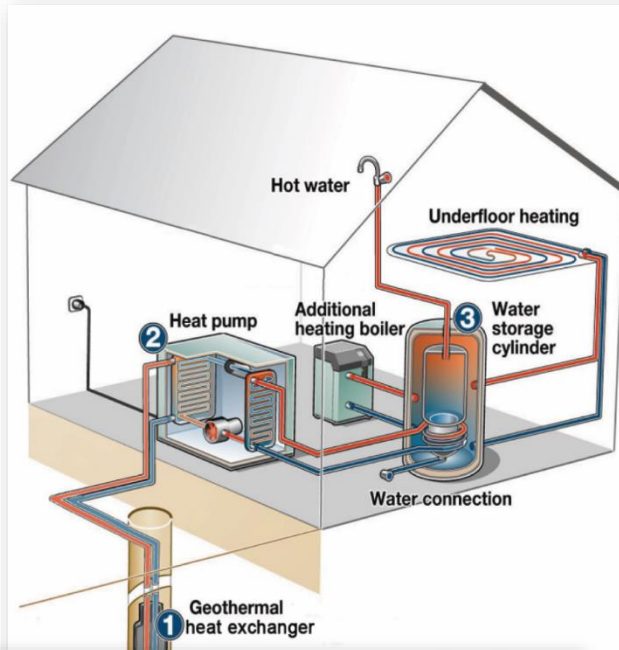
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ENERGY GEOSTRUCTURES

principles

The heat pump transfers energy from the ground to the building



1 kW provided

> 4 kW generated

¼ electricity



¾ heat from the ground

$$COP = \frac{Q}{W} \quad [-]$$

Q = Energy output after heat pump operation [kW]

W = Energy input for heat pump operation [kW]

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APPLICATIONS



A UNIQUE SOLUTION TO **COVER 100%** OF COOLING (AND HEATING) NEEDS OF BUILDINGS AND INFRASTRUCTURES **WITH RENEWABLE ENERGY**

Heating & cooling



Hot water production



Underground thermal energy storage

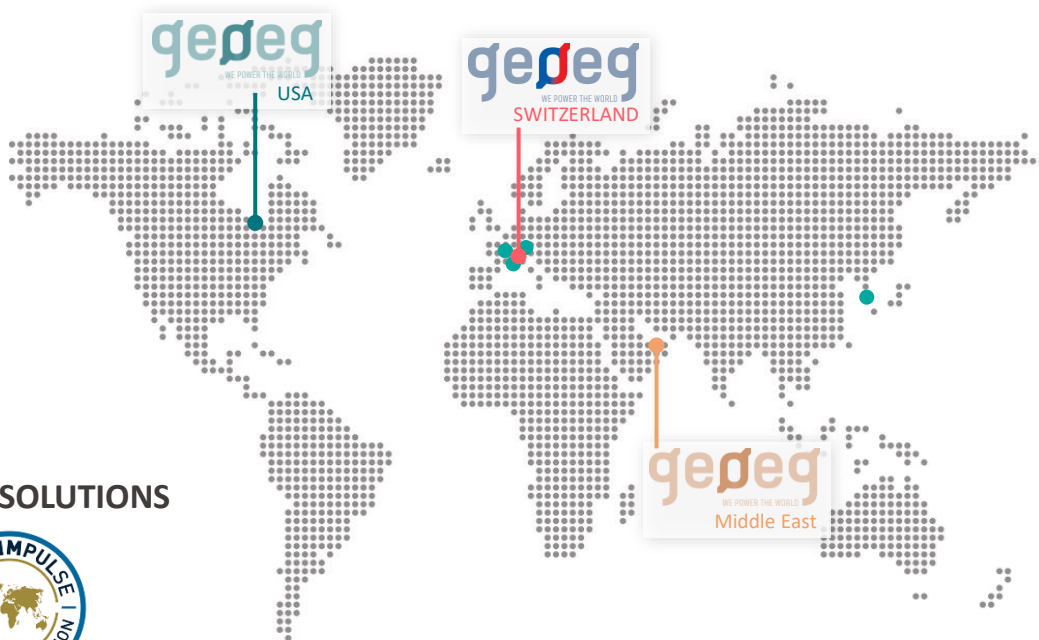


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Headquarters, Lausanne, Switzerland

Development Headquarters, Chicago, USA

Development Office, Dubai, UAE

Activities in 7 countries

LABELLED SOLUTIONS



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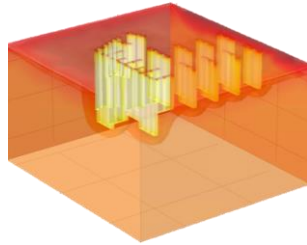
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OUR RECENT PROJECTS



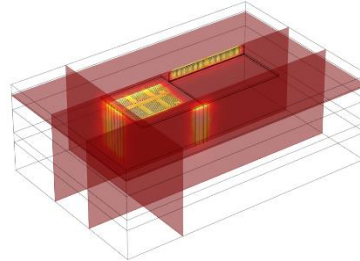
TESTIMONIO II
PRINCIPALITY OF MONACO



- ✓ Energy walls: **3370 m²**
- ✓ Energy piles: **165 of 10 m**
- ✓ Energy barrettes: **5800 m²**



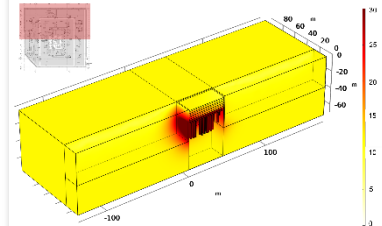
DISCOVERY LEARNING LAB
EPFL, LAUSANNE SWITZERLAND



- ✓ Micro-piles: **10 of 10 m**
- ✓ Energy walls and slab



THE ATRIUM 2
WARSAW, POLAND



- ✓ **53** Energy barrettes
- ✓ **7000 m²** of energy walls
- ✓ **1700 m²** of energy slabs

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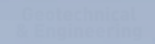
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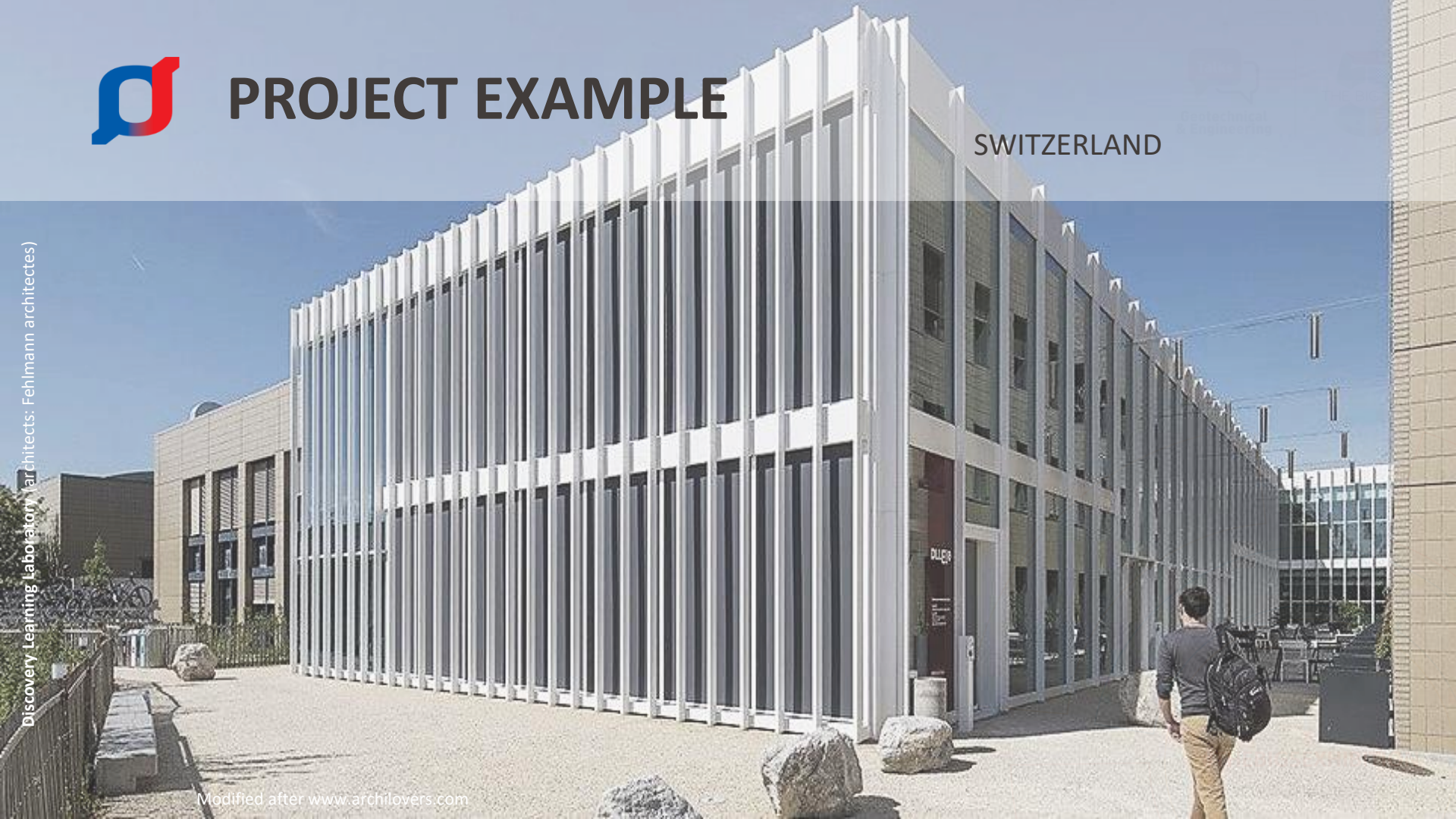


PROJECT EXAMPLE

SWITZERLAND



Discovery Learning Laboratory (architects: Fehlmann architects)



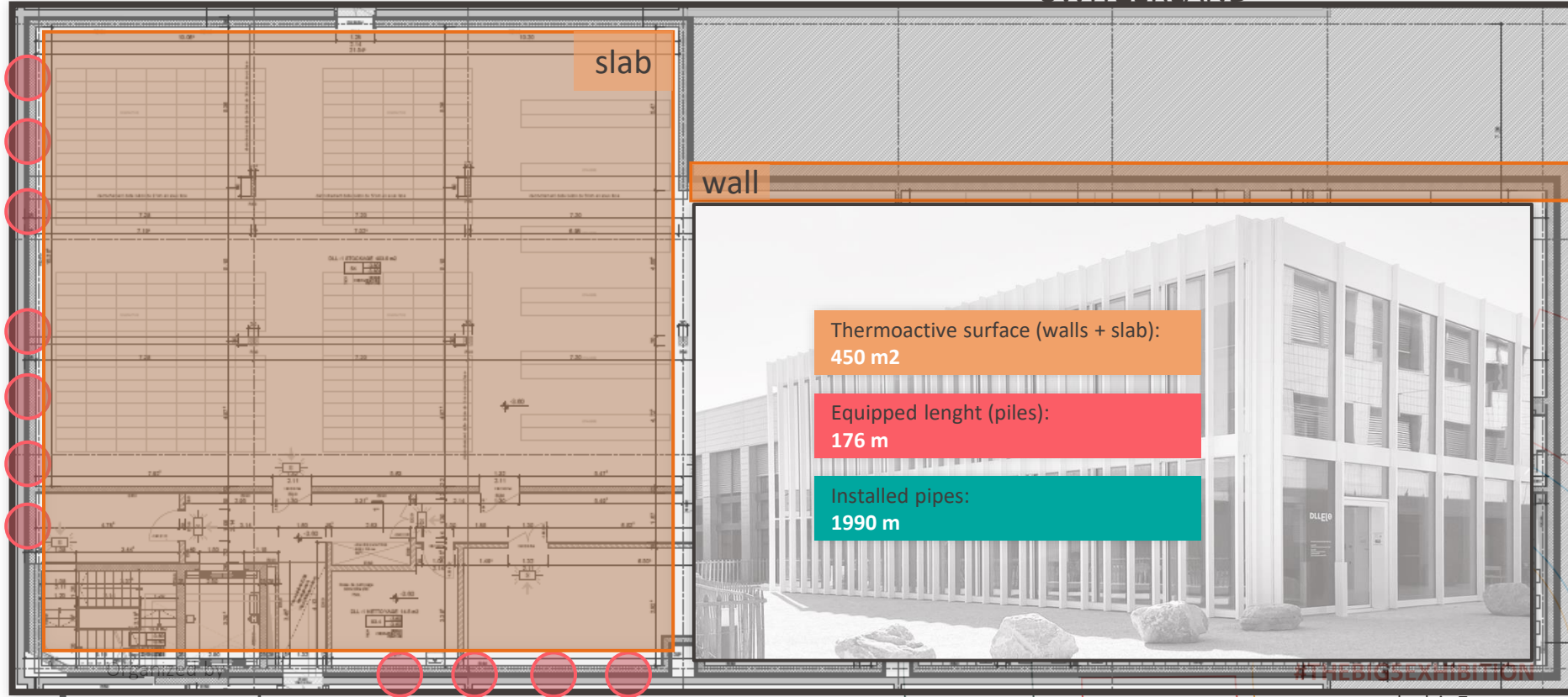
Modified after www.archilovers.com



PROJECT EXAMPLE



SWITZERLAND



micropiles

slab

wall

Thermoactive surface (walls + slab):
450 m²

Equipped length (piles):
176 m

Installed pipes:
1990 m



INSTALLATION OF ENERGY WALLS

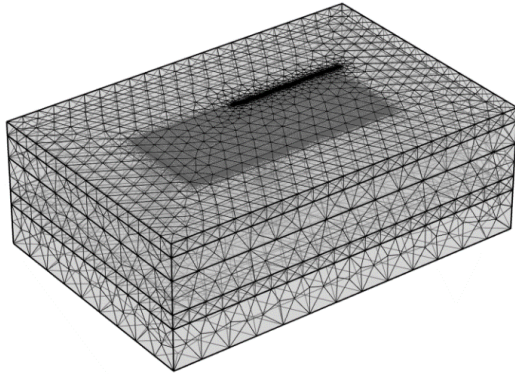


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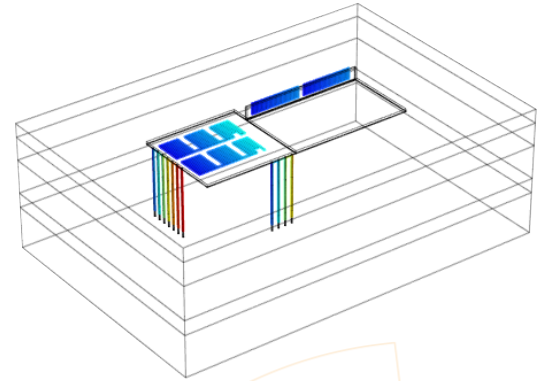
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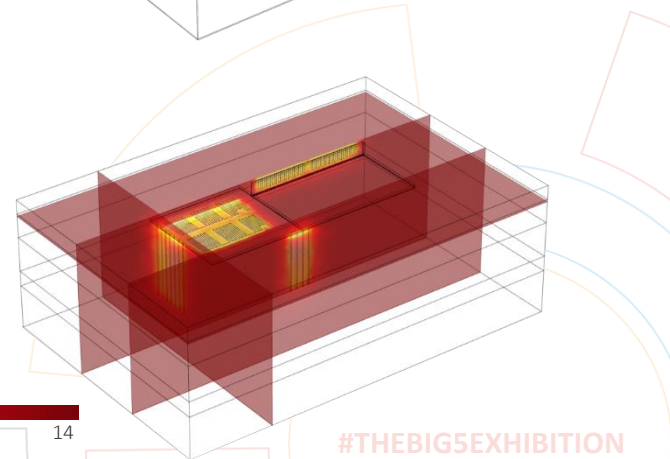
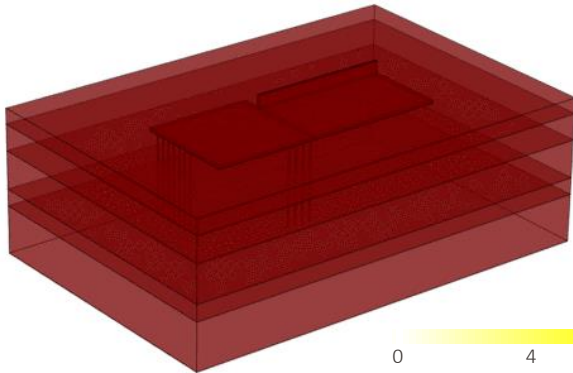
DESIGN CONCEPT



Definition of a **3D model** of the **heat exchanger systems** in accordance with the **site conditions**

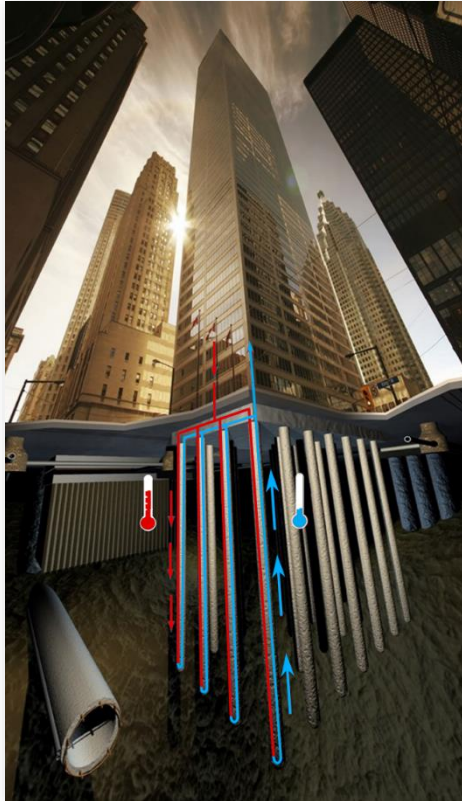


Dynamic assessment of heat and **cooling supply potential**





ENERGY PILES IN ARID AREAS



INJECTING
HEAT



EXTRACTING
COOLING ENERGY



Heat released in the soil mass which cools down the water

This **innovative technology** can help **reduce CO₂** emissions for space **cooling** purposes in **arid and semi-arid regions**, where cooling demands are high

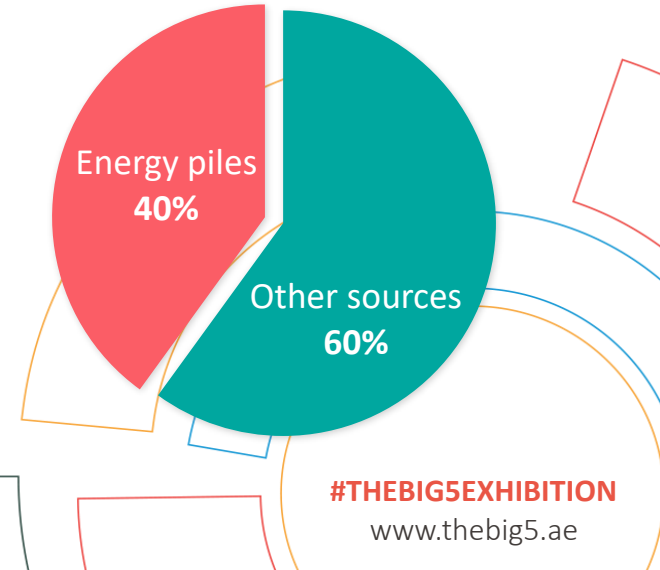


CASE STUDY DUBAI



Target is **providing 40%** of the total **cooling demand** of a typical villa through the energy foundation

COOLING DEMAND



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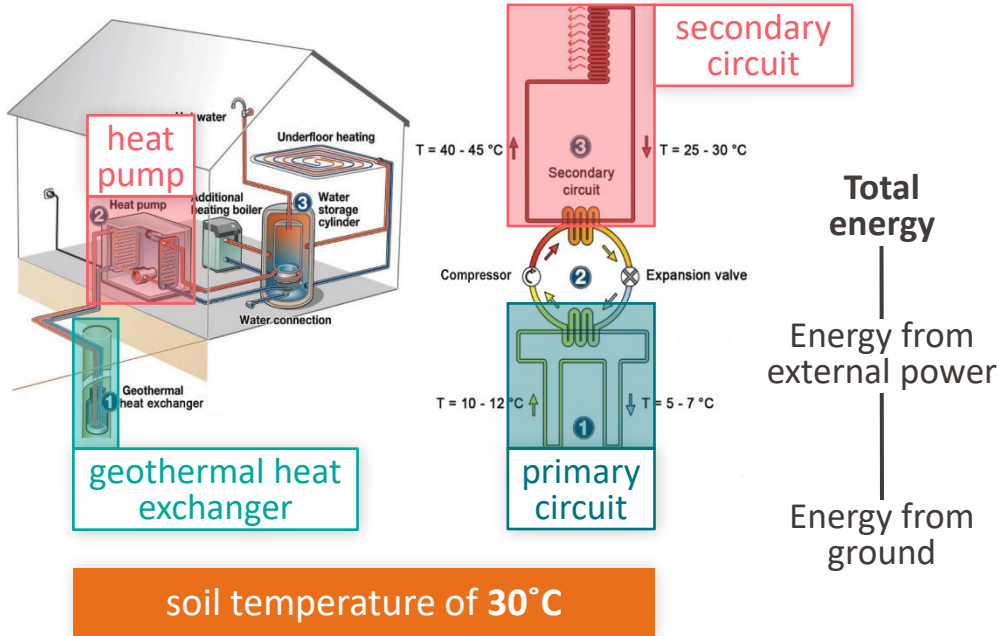


REVERSE HEAT PUMP



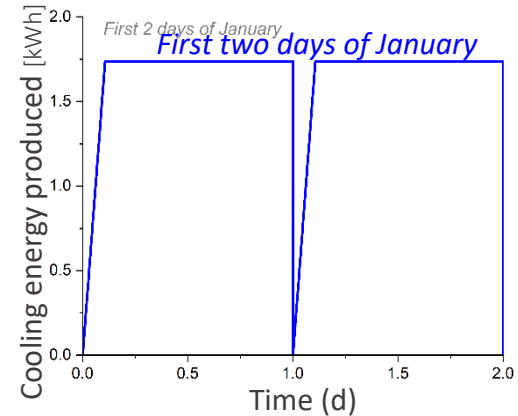
IN THE MODEL

$$T_{in} = T_{out} - \frac{P}{\rho_f c_f \dot{V}}$$



Model is simulating a **daily pattern**

- Heat injection until the daily demand is extracted
- When this demand is reached, the injection is stopped



HIBITION

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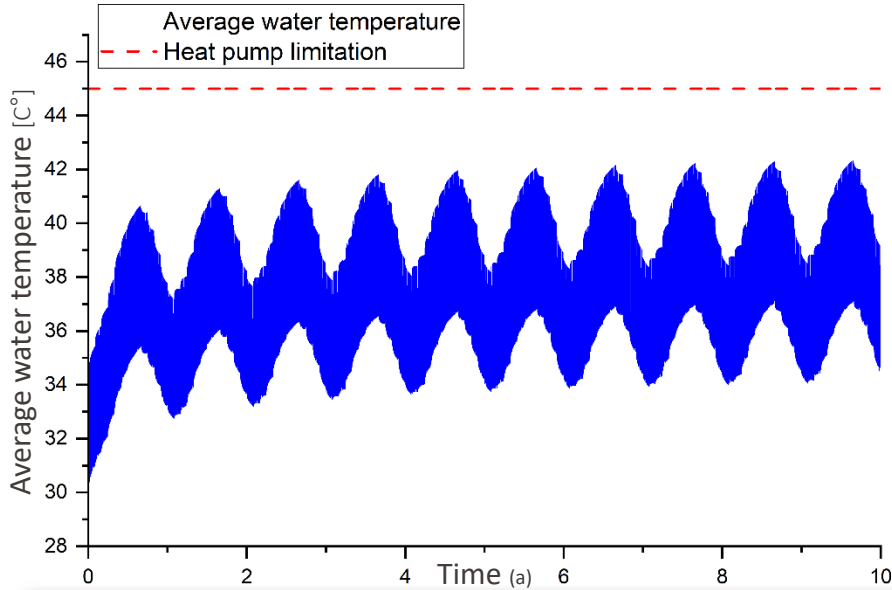
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LONG TERM EVALUATION

10 YEARS

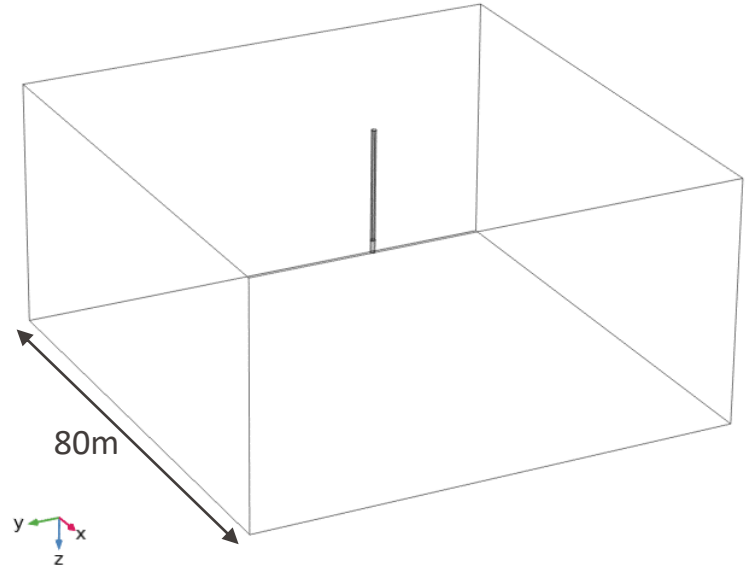


Energy piles can help provide **cooling energy** in arid and semi-arid regions, where space cooling is often one of the main energy consumers

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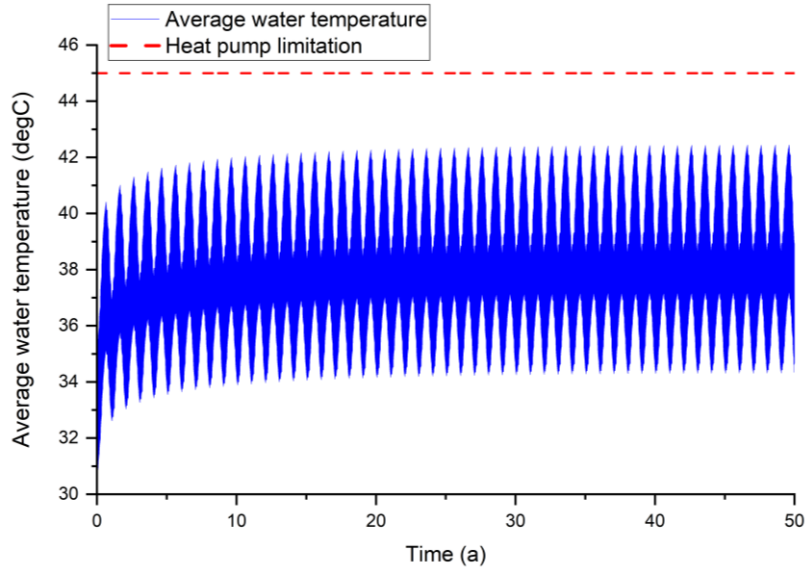
- Strongest increase in temperature in the first year, after this much lower rate of increase.
- Within the limit of the heat pump.





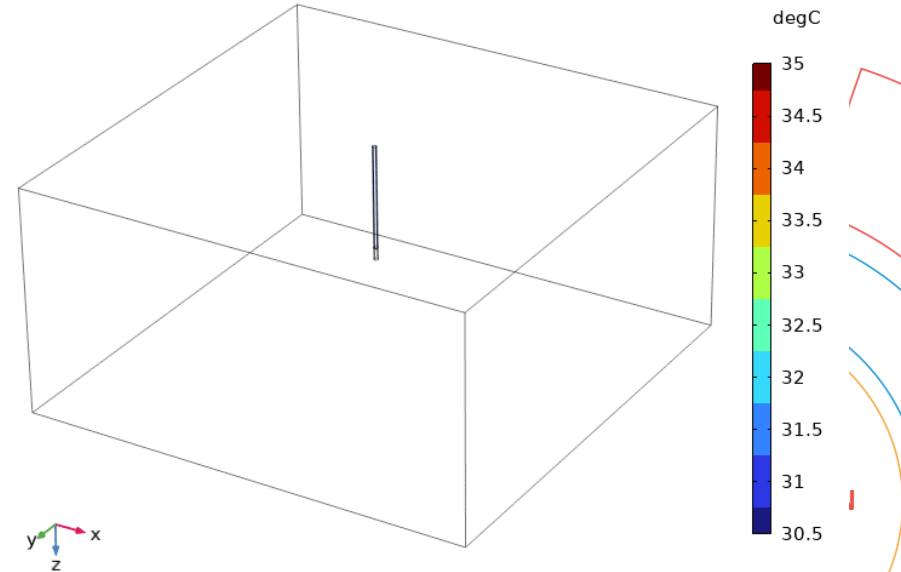
LONG TERM EVALUATION

50 YEARS



- Strongest increase in temperature in the first year, after this much lower rate of increase.
- Within the limit of the heat pump.

Energy piles can help provide cooling energy in arid and semi-arid regions, where space cooling is often one of the main energy consumers



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CONCLUSION

The challenges posed by **climate change** and **global energy demand** are great.

However **solutions** and **opportunities** do exist, particularly through **geo-technologies**.

Energy Geostructures as well as **bio-cementation** are sustainable solutions for low carbon footprint.

Lyesse
Laloui

THANK YOU



Concrete



Facilities
Management



Geotechnical
& Engineering



HVAC R



Offsite
& Modular



Project
Management



Solar



Stone Design



Technology



Urban Design
& Landscape



OUR TEAM



“ Our vision is to disrupt an industry that hasn’t been disrupted in decades and reach 15% of market share driven by the need to offer sustainable solutions in special foundation and earthworks that combine elements of economic efficiency, technical innovation and environmental responsibility ”

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