WEBINAR

Maximize benefits of deep geothermal by minimising undesirable environmental impacts

30 June 2020 | 11:00-12:00 (CEST)

Review of problems and their technical solution

Preventive and corrective mitigation measures

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National Research Council of Italy

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MITIGATION MEASURES

A SYSTEM TO REDUCE, AVOID OR OFFSET THE POTENTIAL ADVERSE ENVIRONMENTAL CONSEQUENCES OF DEVELOPMENT ACTIVITIES

Mitigation is an integral regulatory procedure in all international interpretations of environmental impact assessment (EIA). It spans three forms of measures*:

- Prevention, which means that the potential impact is prevented or reduced before it occurs.
- Corrective measures, reducing the impact to a level which is acceptable**.

If preventive or corrective measures fail, then compensatory measures are applied. They will compensate for the unavoidable impact.

*European Environmental Impact Assessment Directive
** See regulation

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GENERATION TECHNOLOGIES

DEEP GEOTHERMAL DEVELOPMENT

A main aim is to have only positive impacts and no risks.

- 1st rule: prevention. The avoidance is made possible, in most cases, by considering potential negative effects in an early stage of the project design processes and avoiding them using alternatives and preventive tools

This is not always possible, hence

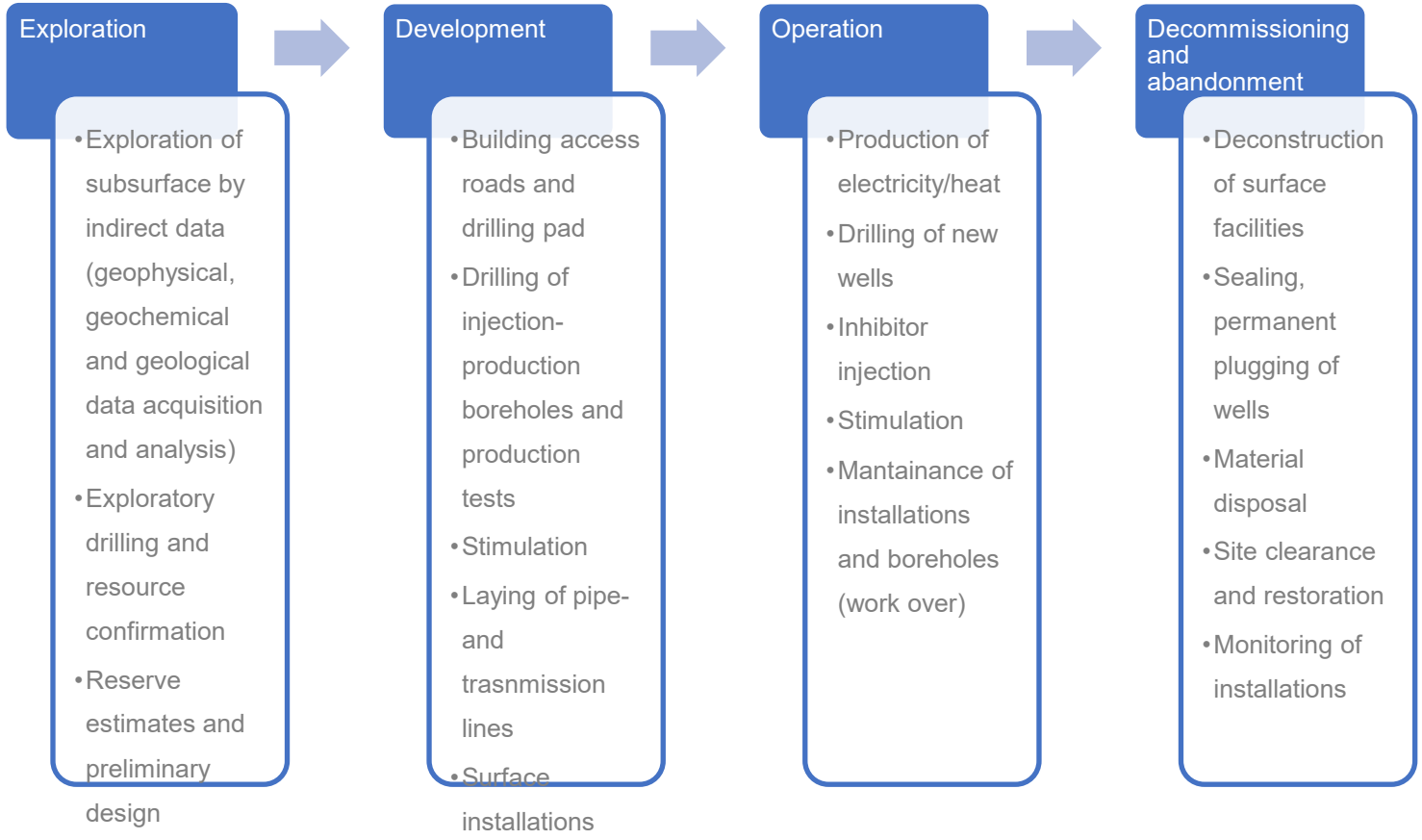
- 2nd rule: mitigate any possible risk and negative impact (environmental, economical) while maximising positive impacts (beside electrical power and heat production, increased touristic by-products or other, undirect, financial and societal benefits)

MITIGATION MEASURES

DEEP GEOTHERMAL DEVELOPMENT

Mitigation is practiced within or in the surrounding of the site of development. It affects the development, its construction and operation, and, in specific cases, its products and processes.

All phases of a geothermal project can potentially have an environmental implication, which requires to be accounted.



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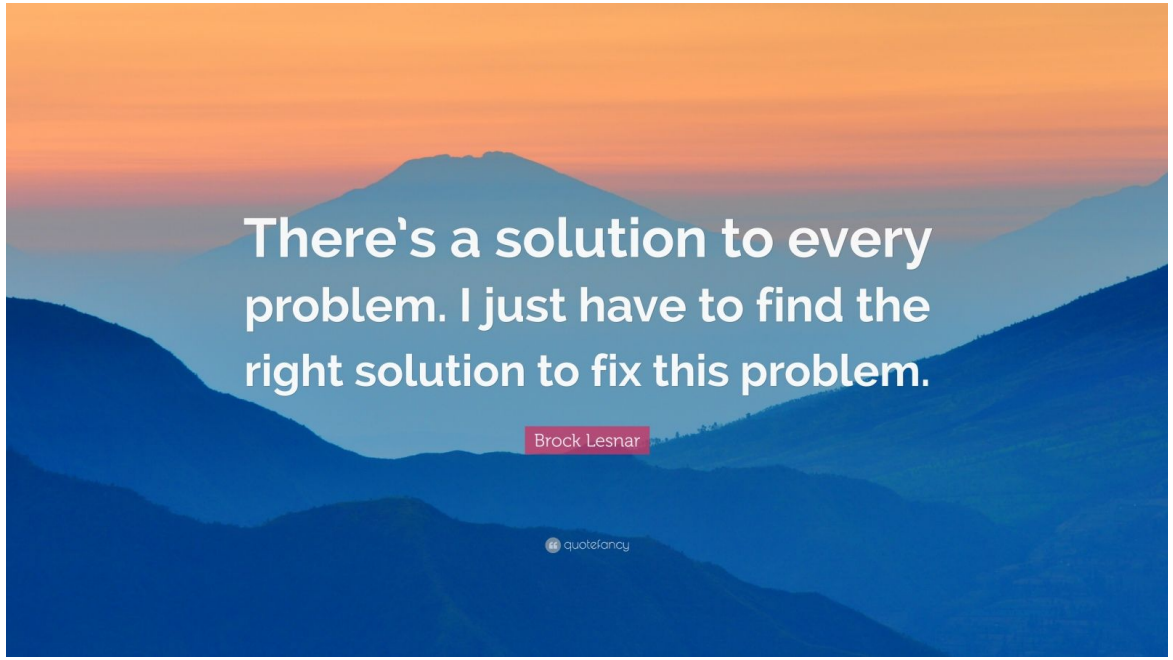
A REPORT ON MITIGATION MEASURES

ADOPTED SOLUTIONS TO OVERCOME ENVIRONMENTAL CONCERNS RELATED TO GEOTHERMAL DEPLOYMENT

A report from the GEOENVI project, reviewing the current best practices and available technologies to avoid, whenever, possible, or otherwise minimise the unavoidable effects to the environment produced by geothermal development

https://www.geoenvi.eu/publications/report-on-mitigation-measures/



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A REPORT ON MITIGATION MEASURES

ADOPTED SOLUTIONS TO OVERCOME ENVIRONMENTAL CONCERNS RELATED TO GEOTHERMAL DEPLOYMENT

Reviewing:

- Monitoring technologies, to establish the level and intensity of impacts and risks
- Controlling technologies to avoid that acceptable standards are not exceeded

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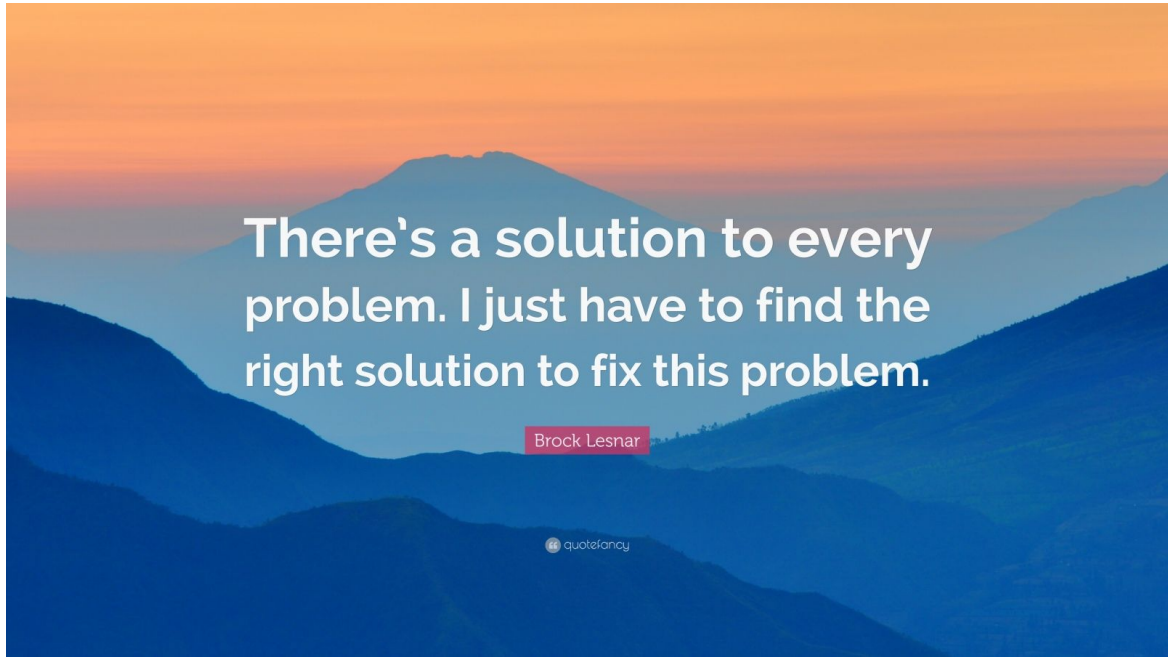

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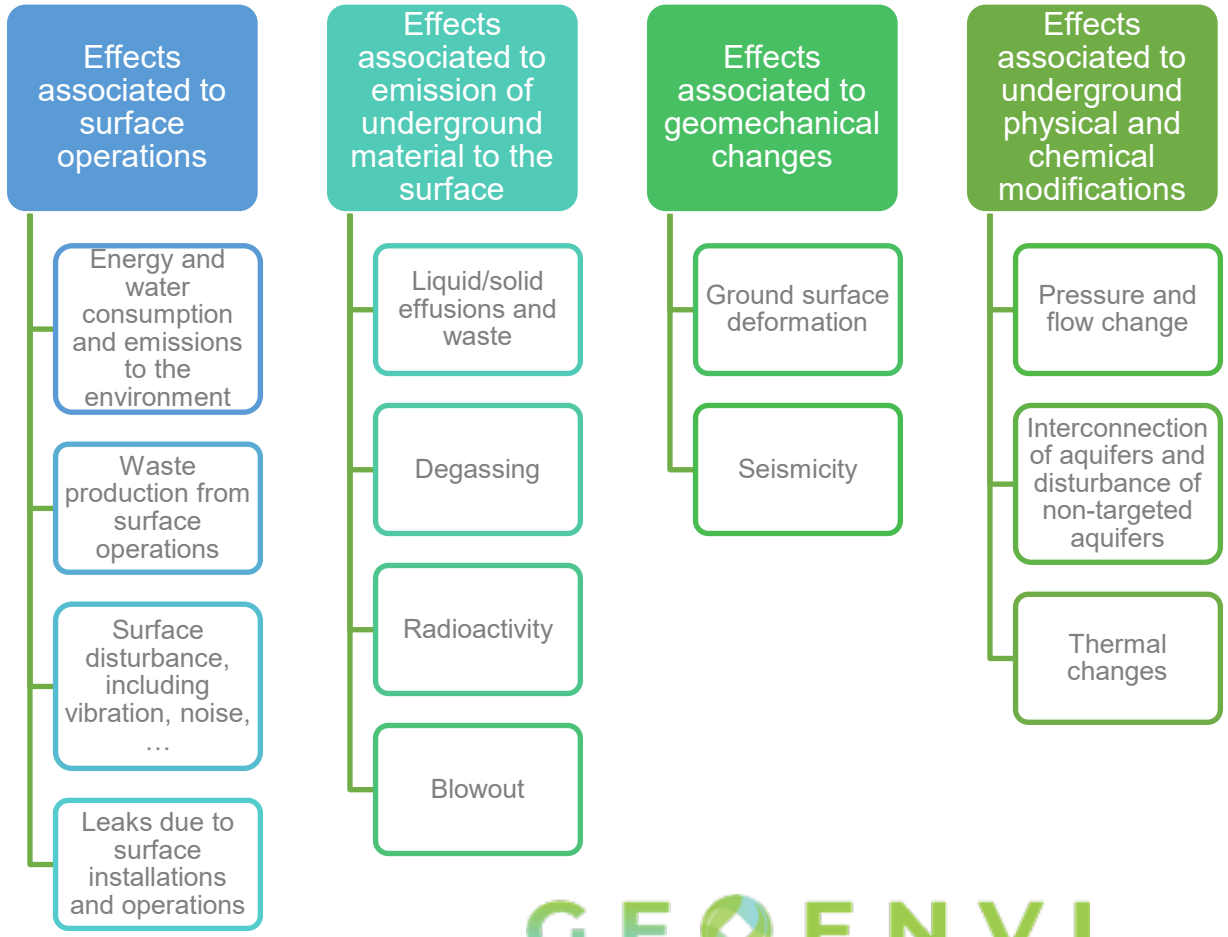
A REVIEW OF MITIGATION MEASURES

DEFINITION OF THE PROBLEM

Events that needs control and mitigation have been ranked and analysed.

The described scenario is a worst-case one, where all potential problems occur at the highest grade.

In reality ***this is far from representing a real case***, as many impacts and risks are accidental or restricted to very defined geological condition or technologies.



EFFECTS ASSOCIATED TO SURFACE OPERATIONS

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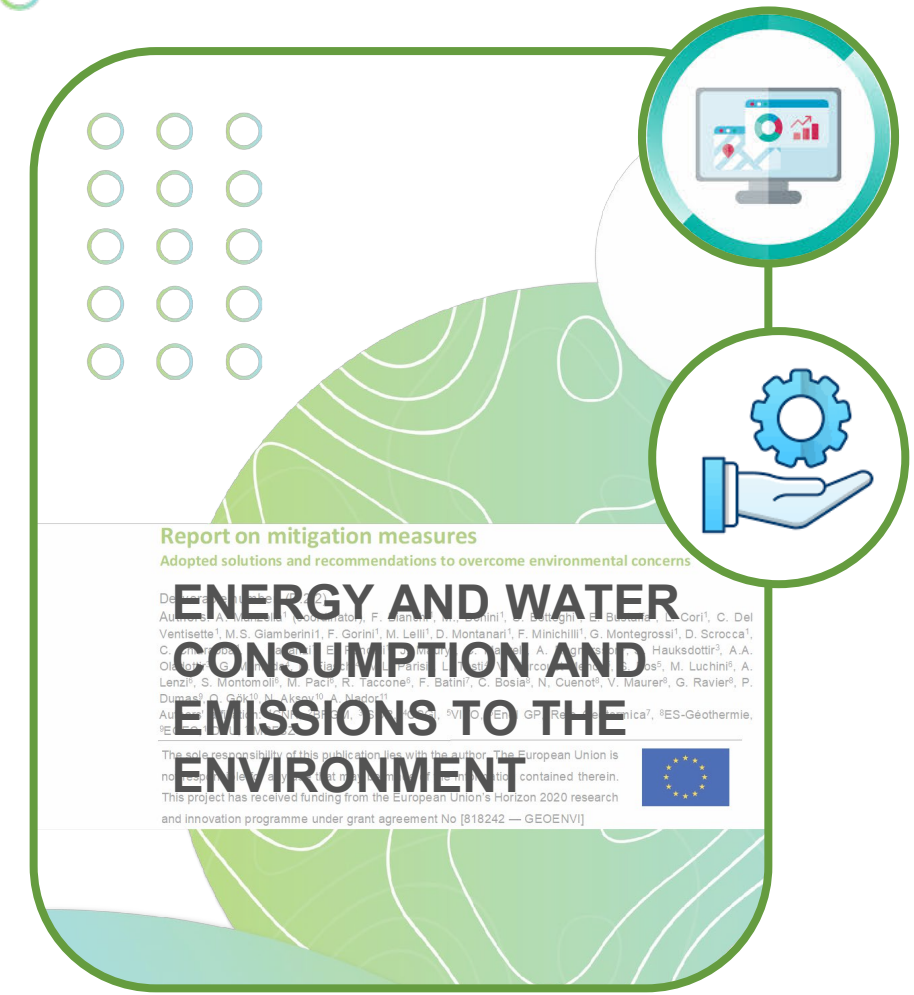

Monitoring:

- Energy use and losses and water consumption

Prevention and corrective measures:

- Planning optimal use since the beginning.
- Use of local electricity generation, alternative power supply.
- Recirculation of drilling mud to reduce water consume, meteoric water collection, discharged geothermal fluids or low-quality water used as make up fluid

EFFECTS ASSOCIATED TO SURFACE OPERATIONS

Monitoring:

- Official log of waste production and periodical report to the regulating authority
- Regular inspection, to check for proper management and for the regular functioning of containment basins

Prevention and corrective measures:

- Careful design to minimise the waste and treatment of unavoidable waste during the operations
- Proper tanks, basins and areas, segregated from other materials and equipment
- Waste recycling or disposal toward the appropriate treatment plant
- Hazardous waste (such as oils and batteries) is stored in segregated and labelled containers
- Waste-water is either collected or connected to sewage

EFFECTS ASSOCIATED TO SURFACE OPERATIONS

Monitoring:

- Seismic sensors for vibration,
- Acoustic characterization before and during operations,
- Smell assessment (in development)

Prevention and corrective measures:

- Landscape planning, pipes' layout, choice of drilling rig to reduce the height of the rig and the pad's occupied land, cover for well-head.
- Planning for optimal noise reduction: muffled materials and insulation, activities' timing; information to population for unavoidable temporary emissions.
- Prevention of dust dispersion by cleaning, water spray, use of water channels for transport.
- …

EFFECTS ASSOCIATED TO SURFACE OPERATIONS

Monitoring:

- Periodical inspection of pipes and tanks
- Check the occurrence and evolution of corrosion and scaling

Prevention and corrective measures:

- Tanks big enough to avoid overflow and positioning tanks over concrete slab to avoid direct contact with soil
- Pipes and tanks' material chosen as to avoid corrosion problems, or use of coatings, anti-corrosion products
- Chemicals are stored in segregated areas with containment basins, to avoid and contain, in disastrous condition, any spill
- Proper choice (environmental benign) of secondary fluids and chemical inhibitors

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EFFECTS ASSOCIATED TO EMISSION OF UNDERGROUND MATERIAL TO THE SURFACE

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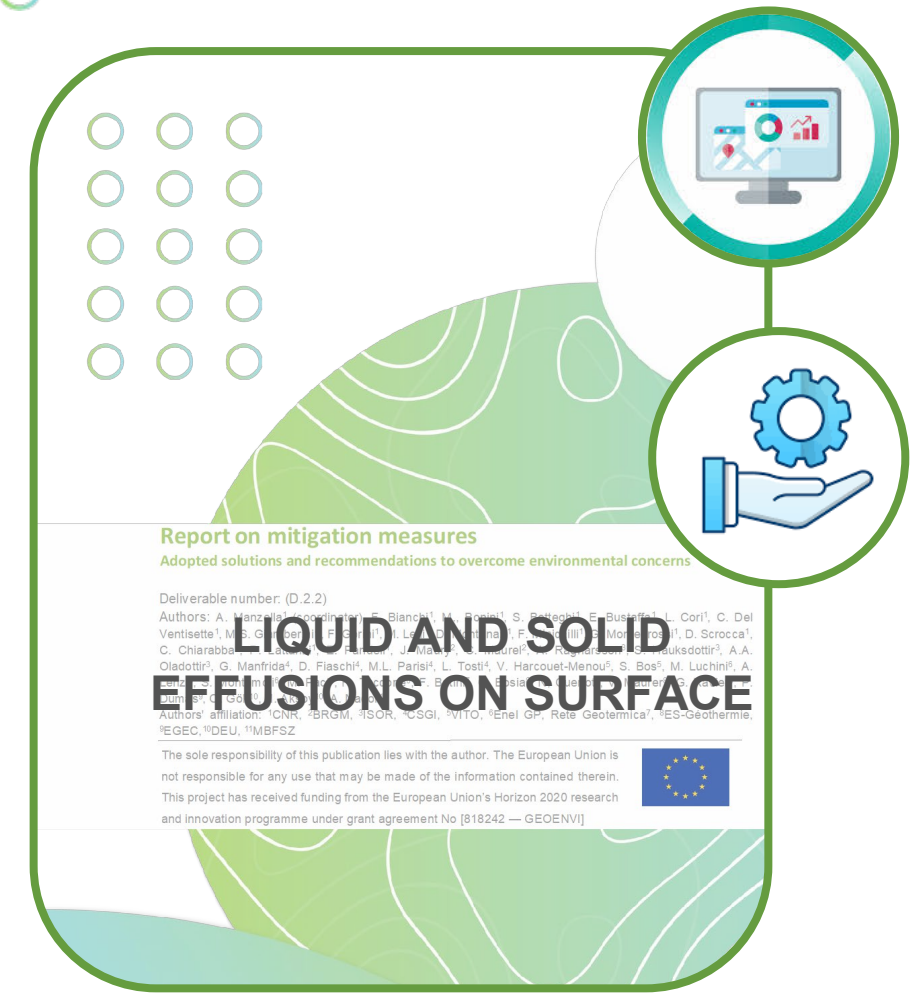

Monitoring:

- Sampling and analysis for target contaminants at each intermittent as well as continuous discharge points (wellheads, vents, and separators, cooling towers and spent liquid drains)
- Waste, surface waste-water monitoring,

Prevention and corrective measures:

- Collection and disposal of any material produced from drilling
- Any short-term and/or emergency liquid releases are accommodated in a special holding tank or a holding pond during all phases of geothermal development, which are emptied periodically
- Non-polluting drilling fluid additives and mud recycling
- Fluids are reinjected back into the underground or treated and disposed (if allowed by local regulation). Treated with biocides and/or oxygen scavengers in case of contact with oxygen
- Effective water management

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EFFECTS ASSOCIATED TO EMISSION OF UNDERGROUND MATERIAL TO THE SURFACE

Monitoring:

- At three main levels: emissions control at the power plant, air quality monitoring in the surrounding environment, and changes in natural gas/temperature emission from the soil
- Before and during operation
- Periodic (common) or continuous (permanent network)

Prevention and corrective measures:

- Preventers to avoid accidental releases
- Complete capture and reinjection of fluids, hybrid technologies
- Where total reinjection is beyond actual commercial technology, abatement systems
- CO_2 reinjected (low rate) or captured and utilised (e.g. for soda waters, agriculture etc.)
- Methane separated and burned for local electricity production
- Drift eliminators
- Minimum duration of unavoidable degassing (e.g. production tests) following the strictest maintenance protocol (well trained personnel)

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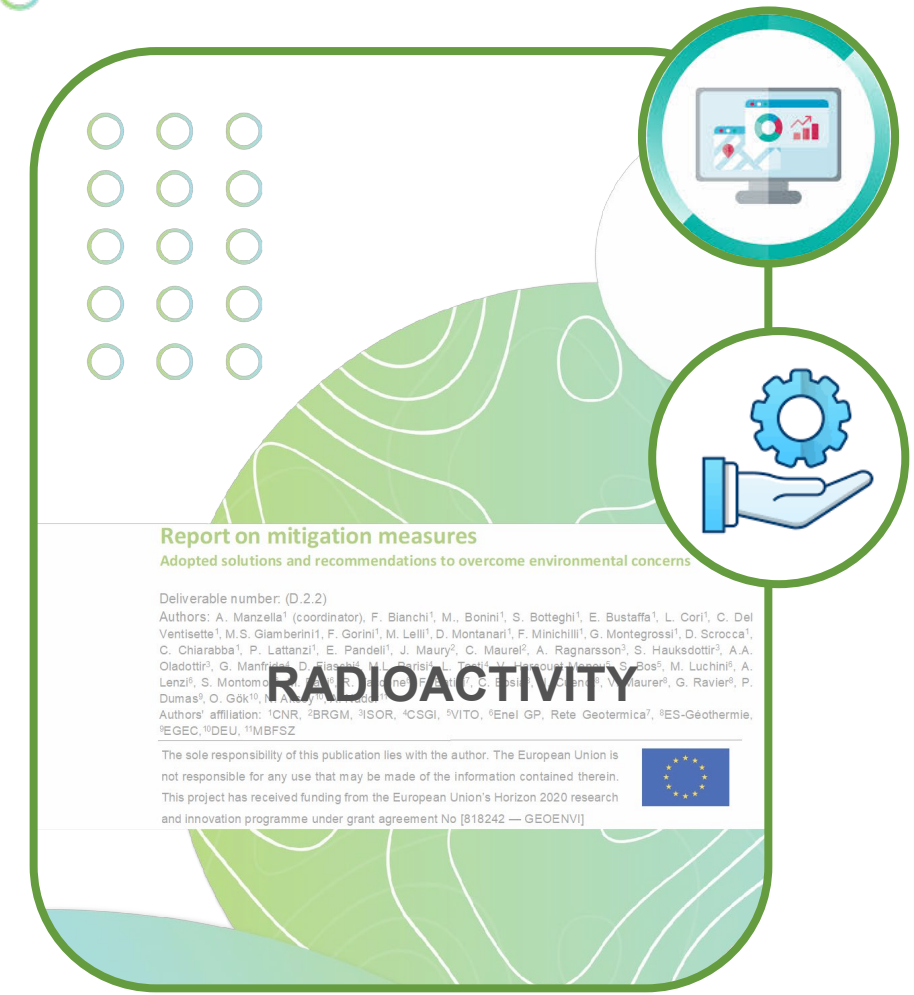
EFFECTS ASSOCIATED TO EMISSION OF UNDERGROUND MATERIAL TO THE SURFACE



Monitoring:

- Recording of background condition, possibly before the industrial development, and at the geothermal installations by radiometers, contamination detector
- Period monitoring of samples from the filter elements and the scaling as well as the geothermal water

Prevention and corrective measures:

- Adopting of radiation protection measures to guarantee a zero or minimum level of exposure to visitors
- NORM (Naturally Occurring Radioactive Material) are treated following the radioactive waste management rules of the country. Only specialized companies can manage these residues
- Total reinjection of fluids and prevention for scales

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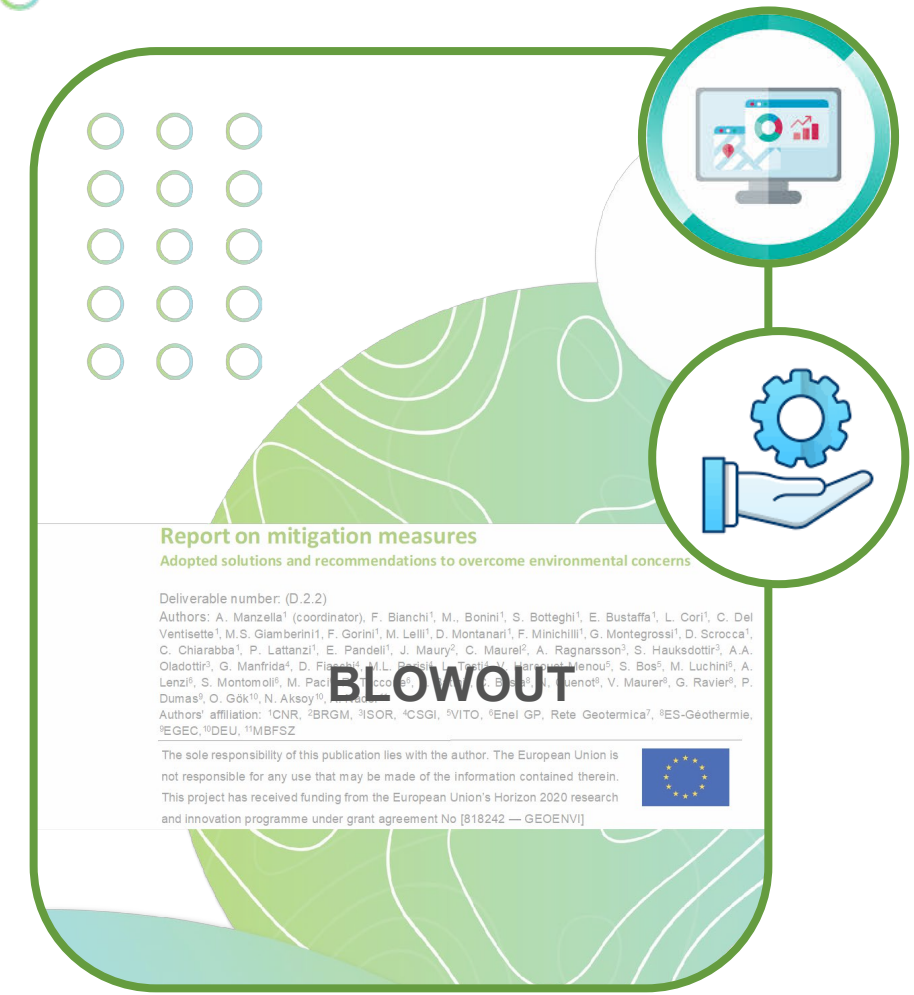

Monitoring:

- Sensors to display critical parameters during drilling operations
- Continuous check in order to notice early warning signs of potential blow-outs

Prevention and corrective measures:

- Blowout preventers (BOP) installed
- Good drilling practices and well-trained personnel
- Preventive measures (in the case of high ratio of non-condensable gases in the steam (mostly CO2), or where the geothermal reservoir is over pressurized, such as high density drilling mud, casing strategies

EFFECTS ASSOCIATED TO GEOMECHANICAL CHANGES

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Monitoring:

- Geodetic techniques (modern remote sensing technologies)
- Benchmarks installed throughout the geothermal field and surveyed at regular interval (GNSS, levelling, or total stations)

Prevention and corrective measures:

- Prediction based on the numerical modelling of reservoir performance
- Injection of fluids in the geothermal reservoir to control land subsidence
- Extraction rate control to mitigate surface deformation

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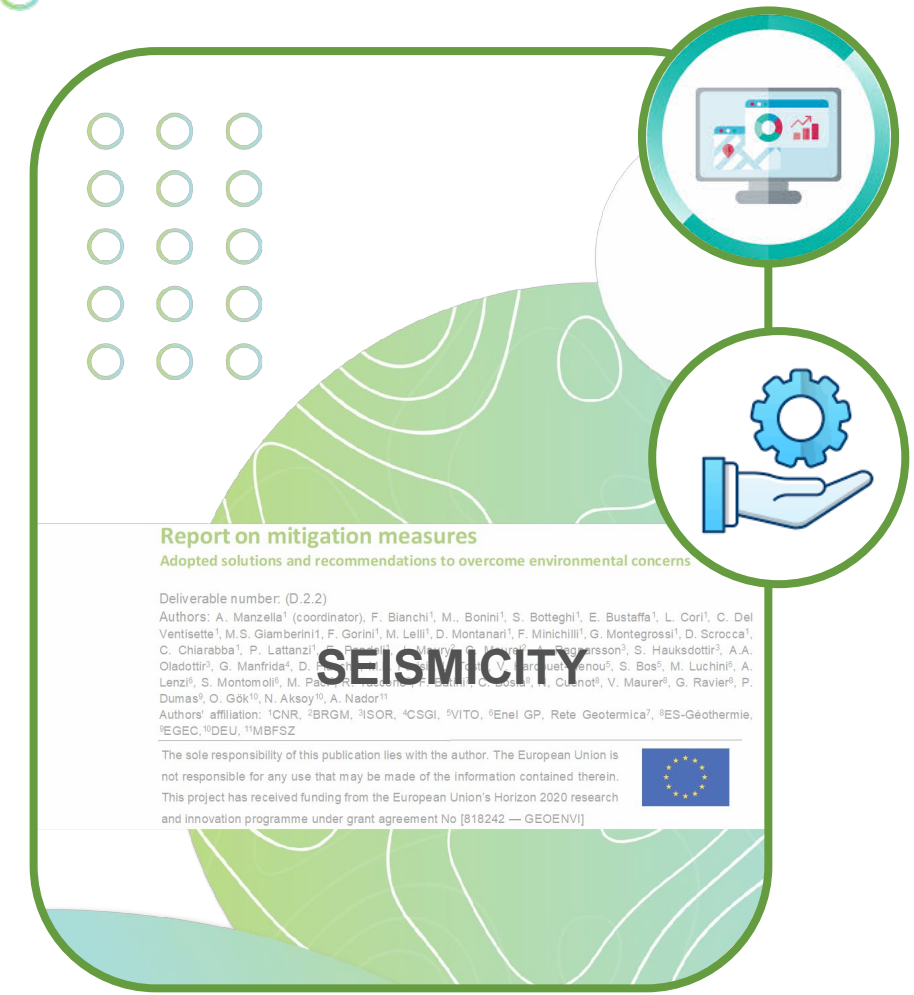
EFFECTS ASSOCIATED TO GEOMECHANICAL CHANGES



Monitoring:

- Seismic network (seismometers), continuous recording
- Before and during operation

Prevention and corrective measures:

- Probability assessments of hazard and risk of induced seismicity
- Balance between produced and reinjected fluid and minimize pore pressure changes at depth
- Reactive protocols (e.g. traffic light systems) and operational protocols to mitigate the effects of an event if one should occur, by further control or, in some case, suspending activities

UNDERGROUND PHYSICAL AND CHEMICAL MODIFICATIONS

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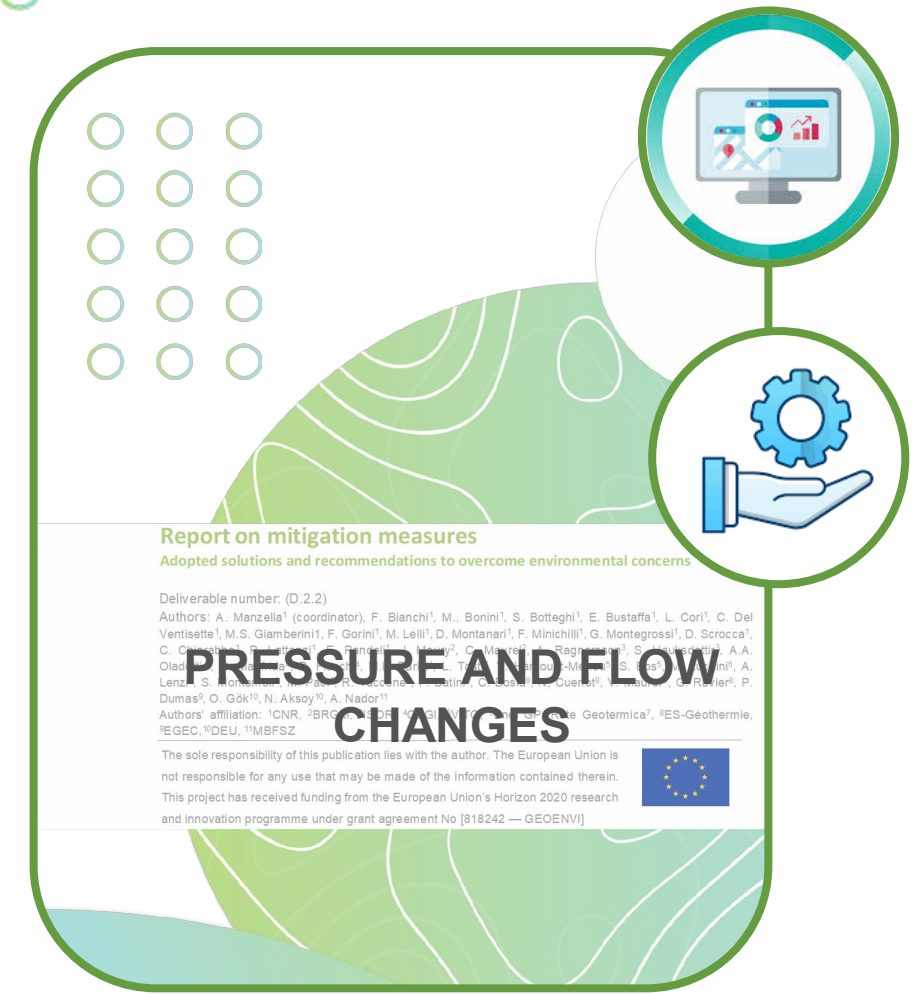

Monitoring:

- Regular monitoring of pressure, temperature and production in geothermal wells, chemical samples and tracer tests
- Specialised tests (e.g. step tests) to verify evolution of reservoir conditions, for decision making
- Periodic wells shut-down for pressure check and pipe cleaning

Prevention and corrective measures:

- Injection and re-injection of fluids in the reservoir to replace the volume of extracted fluids; injection strategy
- Prevention of reinjection failures (accumulation tank to guarantee a constant injection flow rate, pipe cleaning)
- Recovery of pressure by letting some wells to rest while others are used, exchanging modes with time (“harnessing” the resource)

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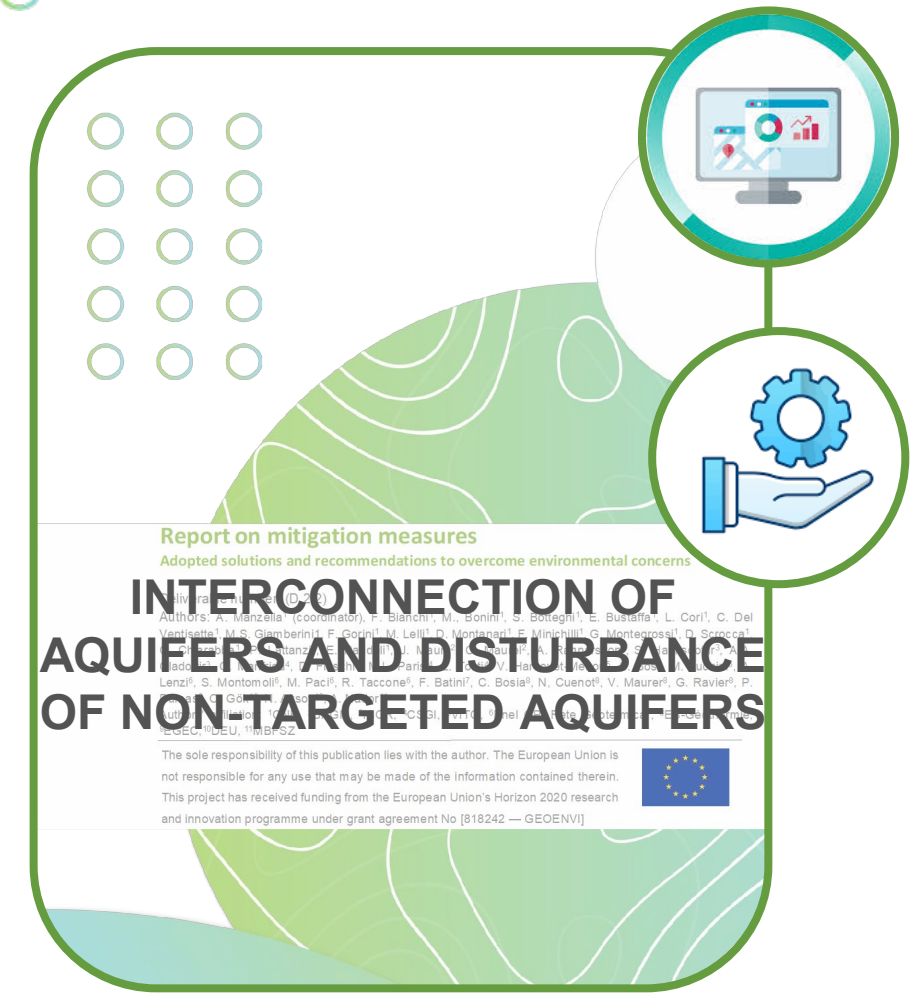
UNDERGROUND PHYSICAL AND CHEMICAL MODIFICATIONS



Monitoring:

- Casing condition (effects of corrosion, thermomechanical and other disturbances on the casing in the wellbore)
- Flow rate, pressure and water quality are monitored during the operation phase to identify potential leakage
- Quality of cementing work during and after drilling
- Piezometric and water quality control of the aquifers above the developed geothermal reservoir

Prevention and corrective measures:

- Optimal well design (material, casing)
- Optimal drilling work, cementation and casing implementation
- Corrective well operations and work-over using patch or new casing

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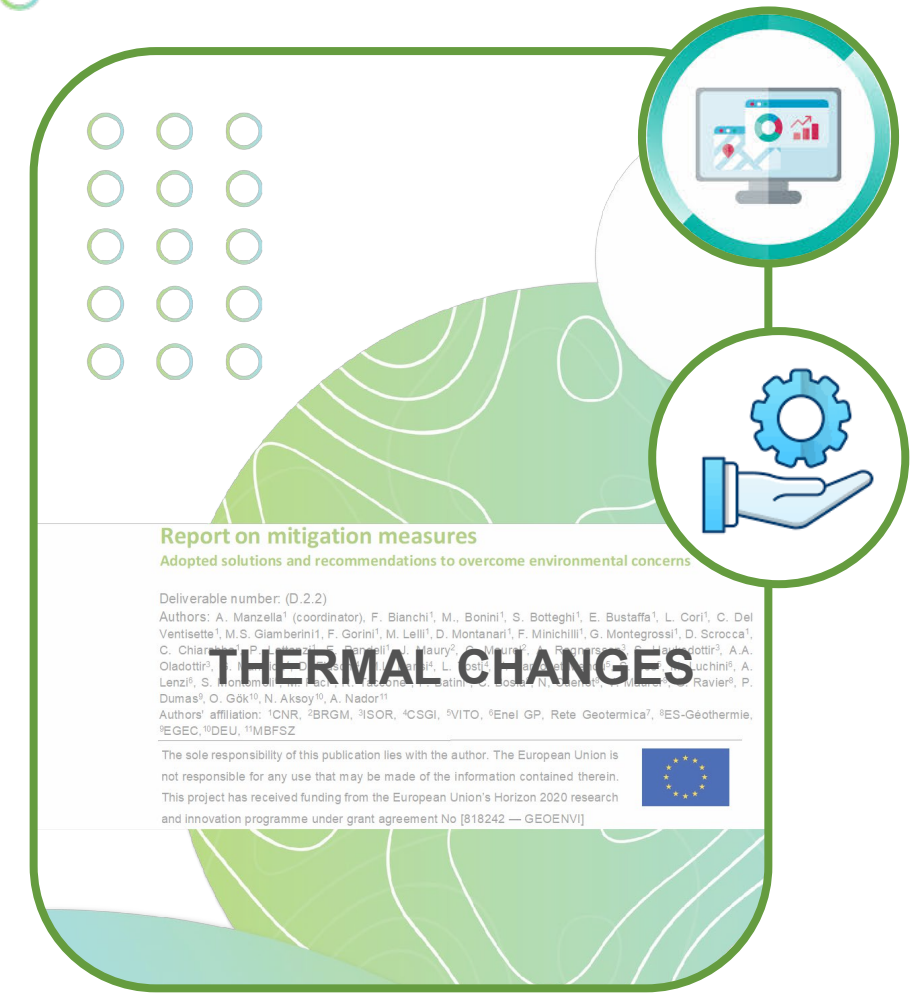
UNDERGROUND PHYSICAL AND CHEMICAL MODIFICATIONS



Monitoring:

- Temperature logs in monitoring wells

Prevention and corrective measures:

- Balance of fluid extraction with the natural inflow of water and reinjection
- Careful siting of injection wells

FINAL COMMENTS

- Monitoring is common practice, and data are checked against established limit values
- All the environmental effects analysed are well documented and mitigation measures have proven to be effective.
- Research and Innovation is proceeding and innovative solutions are continuously improving the environmental friendliness of the geothermal technologies.
- It is possible to keep geothermal industrial development safe and sound.

Thank you for your attention

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